

# **The impact of blockchain technology on insurance business models**

Stress testing the insurers' business models using the STOF Model

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## Abstract

As the insurance industry engages in numerous processes which are characterized by the exchange of data which is updated by multiple parties; a blockchain, as a single source of truth, has the potential to increase efficiency and reduce the complexity of these processes. However, the complexity, uncertainty, transforming potential and barriers to adoption associated with blockchain technology make it hard to assess its impact on insurers. Therefore, this research aims to help insurance industry business decision makers to anticipate the impact of blockchain technology on their business models, by finding the most important parts of the business model that need to be addressed. It does so by means of expert interviews and a business model stress test workshop. In this workshop, experts assess the impact of uncertain future developments on an insurance reference business model which is described using the STOF business model ontology.

It has been found that currently, enterprise-grade blockchain solutions that meet the requirements of the insurance industry regarding governance, privacy, scalability, identity and access management, security and reliability are not available. Besides no concrete insurance use cases that will actually realize benefits have been found. Therefore, it is hard to justify investments that are specifically targeted at blockchain technology. However, there are two investments insurers should make that are not specifically targeted at blockchain technology, but will prepare insurers for technological innovation, whether blockchain will reach maturity in the near future or not. The first and most important investment is related to standardization. The workshops led to the insight that the most crucial uncertainty outcome is the strength of cooperation. The standardization of data formats and field descriptions is a prerequisite for this cooperation. Insurers just started this standardization in order to facilitate data exchange with other insurers. Insurers should continue their standardization efforts, as it will facilitate data exchange in the insurance value chain and being compliant with GDPR, regardless whether blockchain will be implemented. The second investment is related to rationalization, it will enable insurers to respond more quickly to changes in IT and be compliant with regulation. Blockchain can be a driver for thinking about how systems can be developed to support decentralization, a division of roles and agility, however, the rationalization process should not be targeted to a specific blockchain platform, as it is hard to choose from the scattered field of blockchain platforms.

## Acknowledgements

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*Laurens Klomp,  
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# 1 Introduction

In this research, the impact of blockchain technology on insurers' business models will be analysed, therefore, this chapter starts with a description of the main characteristics of the insurance industry and blockchain technology. In the problem statement, the practical problem that this research aims to solve and the academic literature that will be used to solve the problem will be described. After the problem statement, the research objective will be described and the research questions will be formulated. This chapter concludes with a description of the structure of the thesis.

## 1.1 Blockchain technology and the insurance industry

As this research project is a response to developments in blockchain technology, a definition and description of the main characteristics of the technology would add to the clarity of this report. The following definition of "blockchain" is used in this research (Swan, 2015, p. 1):

*"The blockchain is the decentralized transparent ledger with the transactions records – the database that is shared by all network nodes, updated by miners, monitored by everyone, and owned and controlled by no one. It is like a giant interactive spreadsheet that everyone has access to and updates and confirms that the digital transactions transferring funds are unique."*

Section 2.1 explains the basic principles and characteristics of blockchain technology. From this section, an overview of the most important characteristics can be made. This overview helps to understand why the application of blockchain could have potential in the insurance industry. The main characteristics of blockchain technology are:

- The *need for a trusted third party* is eliminated, as the blockchain protocol describes how consensus on the validity of a transaction is reached. Transactions in a blockchain are unique and are authorized by linking a digital signature to an identity.
- *Controllability* of data is improved by linking transactions to each other and establishing an immutable "single source of truth". This "single source of truth" is shared in a peer-to-peer network. Regulators could monitor this audit trail in near real-time, which could reduce the costs of regulatory compliance.
- It is *not necessary to (manually) combine data*, the risk of errors is reduced, transactions are settled quickly and do not require arbitrage, which makes risk management less difficult and improves liquidity.
- Blockchain offers *high resiliency*, as it does not depend on central infrastructure. It will continue to work in case of local system failures.
- Blockchain facilitates the use of so-called "*smart contracts*", these contracts execute predefined lines of computer code when certain conditions are met.

As this research focuses on the impact of blockchain technology on the insurance industry, a definition of insurance would add to the clarity of this report. The following definition of “insurance” is used in this research (Insurance Europe, 2012, p. 5):

*“Insurance is the transfer of risk. It transfers the risk of financial losses as a result of specified but unpredictable events from an individual or entity to an insurer in return for a fee or premium. If a specified event occurs, the individual or entity can claim compensation or a service from the insurer. Insurance is therefore a means of reducing uncertainty. In return for buying an insurance policy for a smaller, known premium, the possibility of a larger loss is removed. By pooling premiums and insured events, the financial impact of an event that could be disastrous for one policyholder is spread among a wider group.”*

Key concepts in this definition are pooling of risks and underwriting. Pooling is spreading the risk of financial losses among a large group of policyholders. Underwriting is using statistics about past events for assessing the level of policyholders’ risks and their associated costs, on which premiums will be based; premiums also include a margin for the variation of costs from year to year, expenses and a profit for the insurer. Insurance enables people and organizations to engage in activities that have the potential to incur financial losses that they would not be able, or willing to bear without insurance (Insurance Europe, 2012).

Section 1.2.1 describes how the characteristics of blockchain that have been described in this section relate to the insurance industry.

## 1.2 Problem statement

### 1.2.1 Practical problem

As the insurance industry engages in numerous processes which are characterized by the exchange of data which is updated by multiple parties; a blockchain, as a single source of truth, has the potential to increase efficiency and reduce the complexity of these processes. It could result in disintermediation as it reduces the need of data reconciliation for (re-)insurance contracts and resolving disputes. Auditability is improved as it could provide regulators with (near) real-time information on financial activities and fraud could be reduced by providing a full transaction history and asset provenance. The term “blockchain”, or “distributed ledger technology (DLT)” is used to refer to a variety of technology concepts related to databases, value exchange, security and identity among others. The technology comes with barriers to large-scale implementation; e.g. related to the early stage of development of standardization efforts, platform development, scalability and the absence of legal frameworks (Gartner Inc., 2016; World Economic Forum, 2016). The complexity, uncertainty, transforming potential and barriers to adoption associated with blockchain technology make it hard to assess its impact on insurers.

Several high-level blockchain-enabled insurance use cases can be identified by an online search. These use cases are described in scientific publications, online publications of consultancy firms and publications of blockchain software developers. They are mostly considered with a limited part of the value chain, the number of publications is limited and they present diverging views, which makes it hard for business managers to anticipate the uncertain development of the technology. This research aims to help business managers deal with the proliferation of blockchain technology by assessing its

impact on insurance business models. It does so by means of scenario planning and stress testing, a tool for assessing the impact of uncertain future developments. The insights that result from this research will not only help insurers with assessing the impact on their business models, but also with improving their future robustness.

### 1.2.2 Academic problem

In this section, a brief overview of scientific literature that will help in solving the research problem will be described, a detailed description of this literature can be found in chapter 0.

#### **The business model concept and changes in the external environment**

The business model concept is often used to describe the logic of a firm; how the different components of a business (network) work together in order to create and capture value from a product or service (Afuah & Tucci, 2003; Casadesus-Masanell & Ricart, 2010; Chesbrough & Rosenbloom, 2002; Linder & Cantrell, 2000; Magretta, 2002; Timmers, 1998). In order to be sustainable, a business model should “fit” within its external environment, as this environment changes, the business model might require adaptation in order to maintain its sustainability (Morris, Schindehutte, & Allen, 2005). External factors that impact the business model can be summarized into: market drivers, technology drivers and regulation drivers (Bouwman, de Vos, & Haaker, 2008). This research will focus on a technology factor: blockchain technology. Technological innovations are challenging firms as they affect their current business models, therefore assessing the future impact of these innovations is crucial to secure future profitability and long-term survival of the firm (Pateli & Giaglis, 2005; Teece, 2010). Incumbent firms are typically challenged by technological innovations when these conflict with their existing business models and resource configurations; incumbent firms tend to serve their current customers and often experience difficulties in exploring new opportunities (Chesbrough, 2010; Christensen, 2013).

#### **E-business models: classifications and design approaches**

The high speed of development of Information and Communication Technology (hereafter referred to as “ICT”), such as the internet, has been an important factor for recent developments in the business model concept in relation to Information Systems (Al-Debei & Avison, 2010; Pateli & Giaglis, 2005). ICT technologies like the internet and blockchain facilitate new, previously impossible or unattractive, business model configurations (Al-Debei & Avison, 2010; Amit & Zott, 2001; McGrath, 2010; Osterwalder, 2004; Swan, 2015; Tapscott & Tapscott, 2016; Timmers, 1998). Bouwman et al. (2012); Hedman and Kalling (2003); Zott, Amit, and Massa (2011) distinguish two levels of conceptualization: one level that describes classifications of e-business models (e.g. Rappa (2000); Timmers (1998)) and another level that describes e-business components and provides business model design approaches (e.g. Afuah and Tucci (2003); Ballon (2007); Bouwman et al. (2008); El Sawy and Pereira (2013); Gordijn, Akkermans, and van Vliet (2001); Osterwalder (2004); Osterwalder and Pigneur (2010); (Rappa, 2000); Shafer, Smith, and Linder (2005)).

Compared to literature that focuses on the classification business models, the business model design approaches, which mainly originate from information systems research, provide more practical conceptual frameworks for guiding business model design by concrete organizations (business model ontologies). Well-known business model ontologies are: Business Model Ontology (BMO) (Osterwalder, 2004; Osterwalder, Pigneur, & Tucci, 2005) Business Model Canvas (based on BMO) (Osterwalder & Pigneur, 2010), the STOF (Service, Technology, Organization and Finance) Model

(Bouwman et al., 2008) , the e<sup>3</sup>-value ontology (divided in three viewpoints: global actor, detailed actor, value activity) (Gordijn, Akkermans, & Van Vliet, 2000; Gordijn et al., 2001), the Business Model Design Matrix (Ballon, 2007) and the VISOR (Value Proposition, Interface, Service Platforms, Organizing Model, and Revenue) Model (El Sawy & Pereira, 2013).

### **Business model design approaches and scenario analysis**

An important application of the business model design approaches is the assessment of the impact of a technological innovation on the reference business model of a firm or an industry (Bouwman et al., 2012; Cavalcante, 2013; De Reuver, Bouwman, & Haaker, 2013; Demil & Lecocq, 2010; Pateli & Giaglis, 2005). A specific approach in this field of study is using the combination of business model ontologies and scenario analysis to come to a structured approach, called business model stress testing, towards evaluating business model change in a changing and uncertain business environment. These approaches evaluate the impact of multiple alternative scenarios for business model change under the impact of the technological development under study (Bouwman et al., 2012; Pateli & Giaglis, 2005).

This research contributes to the field of business model tooling by demonstrating its practical usability in analysing a new technology. Due to the novelty of blockchain technology, academic literature on concrete blockchain-enabled business models is very scarce. Therefore, this research advances the knowledge in the business model domain by applying a structured approach to the assessment of the impact of a technological innovation on a reference business model of the insurance industry, i.e. stress testing based on scenario analysis.

### **1.3 Research objective and scope**

The research objective of this study is:

*Help business decision makers in the insurance industry to anticipate the impact of blockchain technology on their business models, by finding the most important parts of the business model that need to be addressed.*

Based on a qualitative scenario analysis, the research will make recommendations to business decision makers and help them understand the potential impact of blockchain technology from a business model perspective; this will help them to manage blockchain innovation.

This research takes the perspective of Dutch insurers. It does not include the design of a specific blockchain-enabled business model, nor does it include a quantitative analysis of the implementation cost of blockchain technology. This research includes a description of the insurance industry reference business model. This reference business model is a generic business model which describes the processes and parts of the insurance business model which are most important for the impact analysis. The research will analyze how the components of the reference model might be impacted by blockchain technology. This will be done by using the STOF business model ontology in a business model stress test.

## 1.4 Research questions

The research question is structured by first defining the main research question (RQ) and then breaking it down into several research sub-questions (RSQs). When these questions are answered, the research objective as stated in section 1.3 will be achieved.

### 1.4.1 Main research question

The main research question (RQ) that will be answered in this research, in order to achieve the research objective is:

*RQ: How will blockchain technology impact the insurers' business models?*

This comprehensive main research question is broken down into several research sub-questions in section 1.4.2, this will help to divide the research in more delineated parts which together will help in answering the research question, thereby in achieving the research objective and solving the research problem.

### 1.4.2 Research sub-questions

*RSQ1: What are the main characteristics of blockchain technology relevant for application in the insurance industry?*

A basic understanding of what blockchain technology is, what its working principles and most important characteristics are, is important for this research. It will help to find the advantages, disadvantages and use case selection criteria of blockchain technology; blockchain technology facilitates new business models, therefore an insight into the characteristics of the technology provides the researcher and future decision makers with guidance on deciding on technology-specific aspects of business models. Besides it is important to have a global understanding of the transformational potential of blockchain in the financial services industry and the requirements that blockchain has to meet for the application in this industry. The insights that will be gained from answering this research question will be used for making a protocol for semi-structured expert interviews (see RSQ3). Due to the novelty of blockchain technology, the availability of literature on the technology is limited, therefore, it will be complemented by other data sources: websites and online publications of consultancy firms and collaborative initiatives.

*RSQ2: Which business model ontology is suitable for describing the insurance reference business model?*

A business model ontology will be selected from scientific literature. This ontology will help with structuring the description of the insurance reference business model against which the impact of selected uncertainties will be tested. The selected business modeling ontology should enable the researcher to describe the business model in terms of its most important components and their interrelationship. The reference business model is a generic business model that will be mainly based on the qualitative analysis of expert interviews and partly based on a literature review. The model serves as a common ground for discussion with the experts that will participate in a business model stress test workshop. In this workshop they will discuss how the business model will be impacted by blockchain technology.

*RSQ3: Which uncertainties, against which the different components of the reference business model will be tested, are most relevant according to experts and literature?*

In order to improve the relevance of the research, a selection of the most relevant uncertainties related to the proliferation of blockchain technology in insurance has to be made. These uncertainties will first be selected from publicly available sources. These selected uncertainties will be used for making a protocol for semi-structured expert interviews. The experts will have different expertise in fields that are relevant to the research, namely insurance, financial services consultancy, IT consultancy and insurance standardization. The transcripts of these interviews will be analyzed by using qualitative data analysis software. The analysis of the transcripts will be compared with the uncertainties that were selected from publicly available sources and finally a selection of the most relevant uncertainties will be made. These uncertainties are the stress factors that will be used in the business model stress test workshop.

*RSQ4: Which components of the reference business model are, according to experts and literature, most important for the assessment of the impact of the selected uncertainties?*

In the analysis of the transcripts of the semi-structured expert interviews, the qualitative data analysis software will also be used to identify the components of the business model which are most important for the assessment of the impact of the selected uncertainties in the business model stress test workshop. This should be done with a level of detail that does not result in a level of complexity that is so high that it will be too hard for the researcher and the experts to oversee possible choices and their consequences in the business model stress test workshop. However, it should have enough richness to facilitate a meaningful analysis.

*RSQ5: What are core standard service processes that should be included in the business model description?*

The potential of blockchain technology in the insurance industry is related to the numerous processes that are characteristic for the industry. The reference business model should therefore include the most important processes that realize the operationalization of the model. Here, too, a balance has to be found between reducing complexity and facilitating a meaningful analysis. The processes will be based on publicly available sources.

*RSQ6: How do the selected stress factors relate to the different components of the business model?*

Relating selected uncertainties to the different components of the business model will help to structure the analysis of their impact on those components. This research sub-question will be addressed in the business model stress test workshop with experts.

*RSQ7: What will the future impact of the stress factors on the different components of the reference business model be?*

Now the relation between the selected uncertainties and business model components has been established, it is possible to qualitatively assess the impact of those uncertainties on the components. In order to answer this research sub-question, estimates of the impact will be made by experts in the business model stress test workshop. The workshop will result in a description of the impact of the stress factors on the components of the reference business model and a so-called heat map, a table that provides an overview of this impact.

*RSQ8: What are the weak points of the reference business model?*

The answer to this research sub-question follows from the analysis of the results of the business model stress test workshop. These results will lead to an insight into the weak points of the reference business model. The weak points need to be addressed in order to maintain the robustness of the model.

*RSQ9: Which steps could be taken in order to improve the future robustness of the reference business model?*

Based on the insights that are gained from the literature research, expert interviews and business model stress test workshop, recommendations are made by the researcher to the insurance industry business decision makers. These recommendations will provide suggestions on how to mitigate weak points of the business model.

## 1.5 Structure of the thesis

Figure 1 on this page provides an overview of the structure of the thesis.

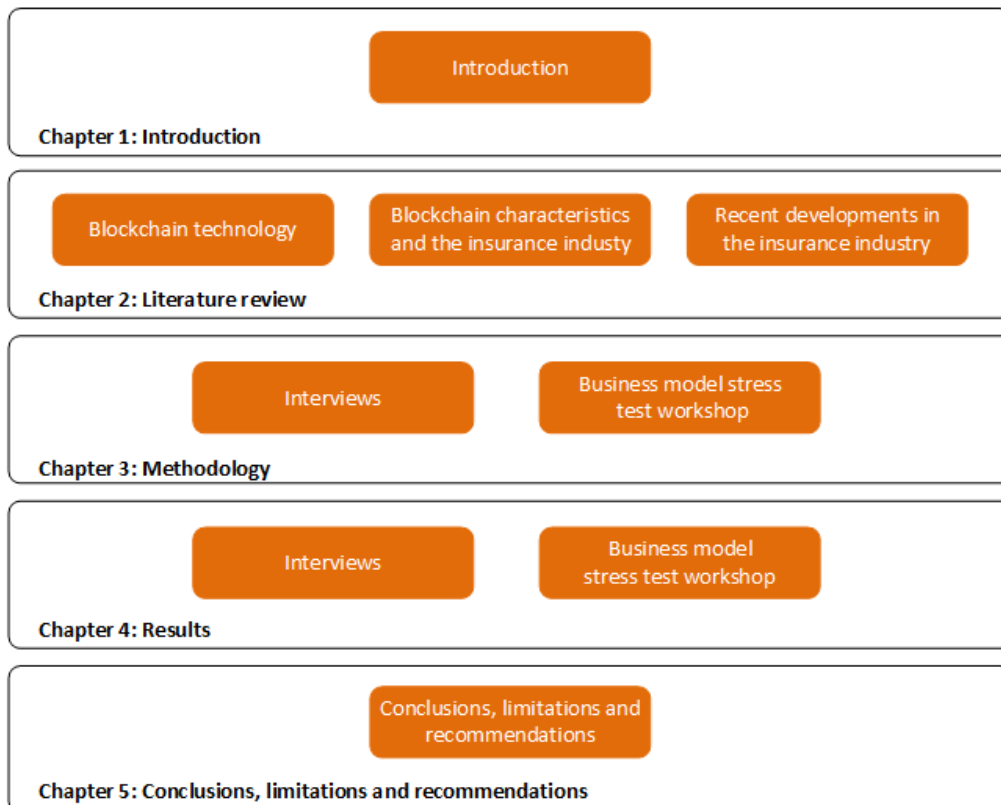


FIGURE 1: STRUCTURE OF THE THESIS



## 2 Literature review

### 2.1 Blockchain technology

This section aims to provide a basic understanding of what blockchain technology is and what its working principles and most important characteristics are. This will help to find the advantages, disadvantages and use case selection criteria of blockchain technology. An insight into the characteristics of the technology provides the researcher and future decision makers with guidance on deciding on technology-specific aspects of their business models.

This chapter is structured by using the categorization of blockchain technology in the three categories that are proposed by Swan (2015). It starts with an explanation of how the first generation of blockchain applications, cryptocurrencies, works. This generation forms the basis for more advanced blockchain applications, which will be briefly described as well in the remaining part of this chapter. Blockchain is the underlying technology, on which the protocols run that describe how value transactions take place (Swan, 2015). The following definition of “blockchain” is used in this explanation (Swan, 2015, p. 1):

*“The blockchain is the decentralized transparent ledger with the transactions records – the database that is shared by all network nodes, updated by miners, monitored by everyone, and owned and controlled by no one. It is like a giant interactive spreadsheet that everyone has access to and updates and confirms that the digital transactions transferring funds are unique.”*

The literature on blockchain technology that has been reviewed consists of scientific articles published in scientific journals, books, websites of blockchain developers and publications of consultancy firms. The databases that have been searched by means of keywords are: Scopus, TU Delft WorldCat Discovery, IEEE Xplore, JSTOR, Google and Google Scholar. The literature review was done by using the “snowball principle” (Verschuren & Doorewaard, 2010). The literature was selected based on its relevance for this research; the relevance was first based on reading the abstracts, the publications that seemed relevant were studied in detail, after which a second selection was made. The same procedure was applied to the reference lists of this second selection.

The following keywords led to the most relevant results for section 2.1.1 and section 2.1.2:

- “bitcoin”;
- “blockchain”;
- “smart contract”;
- “cryptocurrency”;
- “distributed ledger”.

The following keywords led to the most relevant results for section 2.2:

- “blockchain” AND “insurance”;
- “distributed ledger” AND “insurance”;
- “blockchain” AND “financial services”;
- “distributed ledger” AND “financial services”.

The following keywords led to the most relevant results for section 2.3:

- “insurtech”;
- “fintech” AND “insurance”;
- “blockchain” AND “regulation”;
- “development” AND “insurance”;
- “distributed ledger” AND “regulation”.

### 2.1.1 Overview of blockchain technology

#### Introduction to “blockchain 1.0”: cryptocurrencies

While internet protocols enable information exchange, blockchain protocols describe the exchange of value on the internet. The first category of blockchain technology is blockchain 1.0, a technology stack that exists of three layers: the decentralized ledger that holds the transaction history, the protocol that conducts financial transactions and a digital currency (cryptocurrency) (Swan, 2015). This category goes beyond cryptocurrencies that can be used for speculations, online payments, point-of-sale payments and the storage of value (OECD, 2016), but can also be used for exchanging other assets that they represent, such as fiat currencies, stocks and bonds (Euro Banking Association, 2015; OECD, 2016). This section describes the history and working principle of this category of blockchain technology.

Blockchain technology first appeared in a whitepaper written by a group or individual under the pseudonym of Satoshi Nakamoto. Blockchain is the underlying technology of the cryptocurrency Bitcoin, a peer-to-peer electronic form of cash. Bitcoins can be sent directly from one party to another, without the need for a trusted third party like a bank to prevent double spending. The double spend problem is also known under the name of the Byzantine Generals’ Problem, a problem that has been considered to be unsolvable in distributed computing science before the publication of the whitepaper of Nakamoto (2008). The Byzantine Generals Problem boils down to a failure to agree on a collective course of action among components of a network that spread conflicting information around the network by communicating over an unreliable connection (Lamport, Shostak, & Pease, 1982). Nakamoto (2008) describes a practical solution to this problem by introducing the concept of proof-of-work and cannot only be applied to currency, but also to asset registries, notary services and more (Antonopoulos, 2014). It should be noted that the solution is not perfect, but the development of the Bitcoin blockchain has been important as it has not yet been compromised in a low-trust environment; it has been operating on a large scale, while being challenged by hackers, businesses and law

enforcement agencies. This showed the potential of the technology and has attracted the interest of organizations (M. Mainelli, 2015).

As long as the Byzantine Generals problem cannot be solved, a trusted third party is needed; trusted third parties perform the following three roles (M. Mainelli, 2015):

- Validation: guaranteeing validity of entries;
- Safeguarding: preventing double-spending;
- Preserving: keeping an immutable and accurate record of all transactions.

Next, it will be explained how the blockchain solves the Byzantine Generals' Problem by relying on cryptographic proof instead of trust and thereby removes the need for a trusted third party. Removing the need for a trusted third party could reduce transaction costs, which could impact organizations in which providing trust in transactions is a key part of their business model. This explanation takes the basic working principles of the Bitcoin blockchain as an example, as its solution to the aforementioned problem served as a basis for the development of other blockchains.

### **Hashing**

Cryptography is crucial for the functioning of the blockchain and hashing on its turn is crucial for the functioning of cryptography. A hashing algorithm basically takes a certain input (the data one wishes to hash) and converts it by means of a mathematical operation (an algorithm) to an output (the hash, also called digest, a code with a predetermined bit length). In order for the algorithm to be both secure and practical, the mathematical operation should meet the following requirements (Sarkar, 2011):

- Identical inputs should result in identical outputs (hashes) and a given input should always result in the same output.
- The output should have a fixed bit length, regardless of the formatting of the input;
- Even the slightest change in the input changes the output. Identical outputs for different inputs are called "hash collisions", a good hashing algorithm has a high collision resistance.
- The mathematical operation is directional and almost irreversible; calculating an output from an input is feasible, but calculating in the opposite direction is unfeasible. Computing an input, given a certain output, should require considerable effort in terms of time and computational power. This direction of computation is considered cracking and should be made nearly impossible (i.e. the algorithm should have a high collision resistance).

The hashing algorithm that is widely used in cryptography related to blockchain technology is SHA-256, which stands for Secure Hash Algorithm with a digest size of 256 bits.

## Digital signatures

Digital signatures are based on Public Key Infrastructure (PKI), in which a key pair is used for signing data. The first key is kept secret, while the other key is spread publicly on the network. The public key is mathematically derived from the private key and is used as an address to receive bitcoins, but it is nearly impossible to derive the private key from the public key. The private key is used for digitally signing a message; the receiver of the message uses the public key to verify that the data was signed with the private key of the sender, thus authenticity can be verified. It should be noted that the private key is not revealed in the verification process. In order to speed the signing process up, only the hash of the block header (see: Reaching consensus), is signed. Besides, signing the hash ensures that the original message has not been altered, thus data integrity is provided as well (Antonopoulos, 2014; CGI Group Inc., 2004).

## Digital currency

Ownership of a digital currency coin can be proven by using a digital signature, the coin can be transferred by adding the payee's address (his/her public key) to the hashed previous transaction before signing it (see Figure 2 on this page). In that way, the payee can verify that the sender of the coin indeed was the previous owner, however, this still doesn't eliminate the possibility of double spending and therefore a trusted third party which knows the entire history of all transactions is still needed. The possibility of double-spending would allow for hyper-inflation, which renders the digital currency worthless (Nakamoto, 2008).

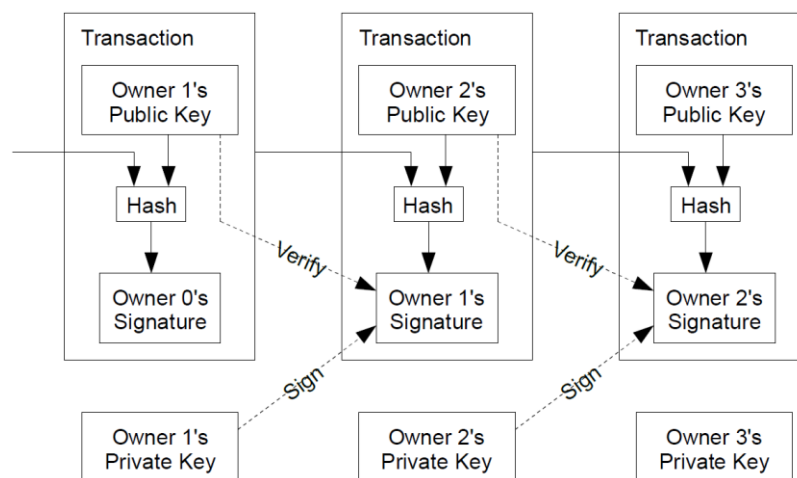


FIGURE 2: THE CHAIN OF OWNERSHIP OF A DIGITAL COIN (NAKAMOTO, 2008)

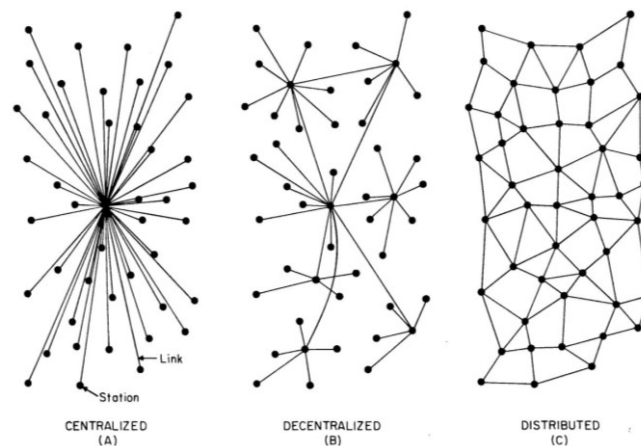
## Reaching consensus

### *Proof-of-Work (PoW)*

The members in the network have to agree on a single transaction history, in other words, reach consensus. Bitcoin transactions are grouped, hashed and put into a block, together with the hash of the previous block (this creates the link between the blocks), a timestamp and a so called nonce. Consensus is reached by a mechanism called proof-of-work. So-called miners compete in a process in which they perform calculations in order to be the first to find a nonce that, when the block header is hashed, results in a hash beginning with a predetermined number of zero bits (see Figure 4 on page 13). The work that is required to find this solution, scales exponentially with the required number of

zero bits. This allows for matching the difficulty (and therefore the time needed to find the solution) with the progression of computational power. The computational power in the network increases because of new participants, investments in mining equipment and the ongoing development of computational power. Every 2016 blocks, the difficulty is set at such a level, that a new block is generated at a predetermined time interval (10 minutes in case of the Bitcoin blockchain). When a miner finds a solution, it publishes the block, so it can be verified by other nodes in the network. This verification is done by executing a single hash computation, after validation, they add the new block to the chain of previous blocks. As a timestamp is included in the block header of both the current and the previous block, proof-of-work provides computational proof of the order in which transactions took place and creates a public ledger (Antonopoulos, 2014; Nakamoto, 2008).

An important characteristic of the bitcoin blockchain is that all nodes in the network are equal: every node can independently take part in mining, block verification and peer-to-peer block distribution. As opposed to centralized and decentralized networks, there are no central nodes in the distributed network. A full copy of this public blockchain ledger is held by multiple full nodes. This ledger contains all transactions that ever took place in the network; from the first transaction that is recorded in the first block (which is called the “genesis block”), to the most recent transaction that is recorded in the most recent block (Swan, 2015). The redundancy of the network and the equality of the nodes is graphically represented by the distributed network in Figure 3 on this page.

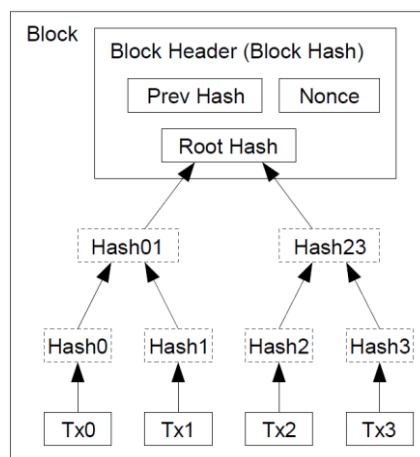


**FIGURE 3: CENTRALIZED, DECENTRALIZED AND DISTRIBUTED NETWORKS (BARAN, 1962)**

The miner that found the solution for the new block, is rewarded for his effort with newly created bitcoins, this is called the block reward. This block reward decreases every 210,000 blocks, or approximately every four years. Each miner adds this reward as the first transaction to the new block that he is working on, this transaction is called the coinbase. As every miner has his own address, the root hash is different for the blocks the different miners are working on, resulting in different block hashes and different nonces that produce a valid block for each miner. Next to the block reward, the miner may be rewarded with a transaction fee that is included in the transaction, this fee is the remainder of the difference between the inputs and outputs of a transaction. So even if the block reward has decreased to zero, the miners will still be rewarded for their work. The bitcoin is scarce, as it cannot be spent twice, a limited number of bitcoins will ever be issued at a diminishing rate (21

million by the year 2140) and resource-consuming work has to be done in order to earn bitcoins. This makes the Bitcoin a deflationary currency (Antonopoulos, 2014).

Hashing the transactions into a root hash eliminates the need for rehashing all transactions in each attempt to find the right nonce. The root hash has a fixed bit length, so the difficulty of the calculations is independent of the number of transactions in the block. The fixed time interval between publishing new blocks, the link between blocks and the Proof-of-Work secure the blockchain; an attacker that possess more than half of the computational power in the network will consistently be able to find the next block, which would only allow the attacker to double-spend its most recent transactions and cause a denial-of-service in the creation of future blocks. However, a lot more computational power is required for rewriting a larger part of the chain (a deep fork). With a smaller share of the computational power in the network, the likelihood that the fraudulent blocks will be included in the longest chain of blocks diminishes very quickly after new blocks are added to the blockchain (Antonopoulos, 2014; Nakamoto, 2008). Thus, the record of transactions is virtually immutable and can be used by network participants for taking action and verifying actions of other network participants at a later moment in time.



**FIGURE 4: PROOF-OF-WORK AND THE MERKLE TREE (NAKAMOTO, 2008)**

### *Proof-of-Stake (PoS)*

The proof-of-work consensus mechanism requires considerable resources in terms of hardware and electrical energy, this creates a disincentive to cheating and enables the network to function in the absence of trust (King & Nadal, 2012; Pilkington, 2016). However these resource requirements also raises sustainability concerns; for example, the energy consumption of the bitcoin network in 2015 cost \$100 million dollar (for protecting approximately \$3 billion) and is rapidly growing (Tapscott & Tapscott, 2016). Besides, economies of scale apply to the investments that are required for proof-of-work, which will result in centralization. A proposed alternative that is being developed is called proof-of-stake, where consensus is reached by “voting” with the financial stakes that network members have; members vote by proving ownership of a certain amount of currency. The larger the financial stake, the more likely it is that the member votes for a valid block to be added to the blockchain. This consensus mechanism reduces energy consumption and has the potential to increase the transaction speed that a blockchain can handle (King & Nadal, 2012; Pilkington, 2016).

## Overview of network activity when using proof-of-work

The following steps summarize the activities that have to be performed in the network in order to facilitate the transactions on the blockchain (Nakamoto, 2008):

1. Transactions are published and received by the nodes in the network.
2. The nodes put these transactions into a potential new block.
3. The nodes compete in finding a solution for the proof-of-work for their unique potential new block.
4. When a proof-of-work has been found by a node, it will publish it to the other nodes.
5. The proof-of-work is validated by the other nodes, which means that the transactions in the newly created block are valid.
6. Nodes accept a new block by using the hash of it for the creation of the next block, when a majority of nodes does so, consensus is reached.

A graphical representation of the process in which validated transactions are added to an immutable blockchain can be found in Figure 5 on this page.

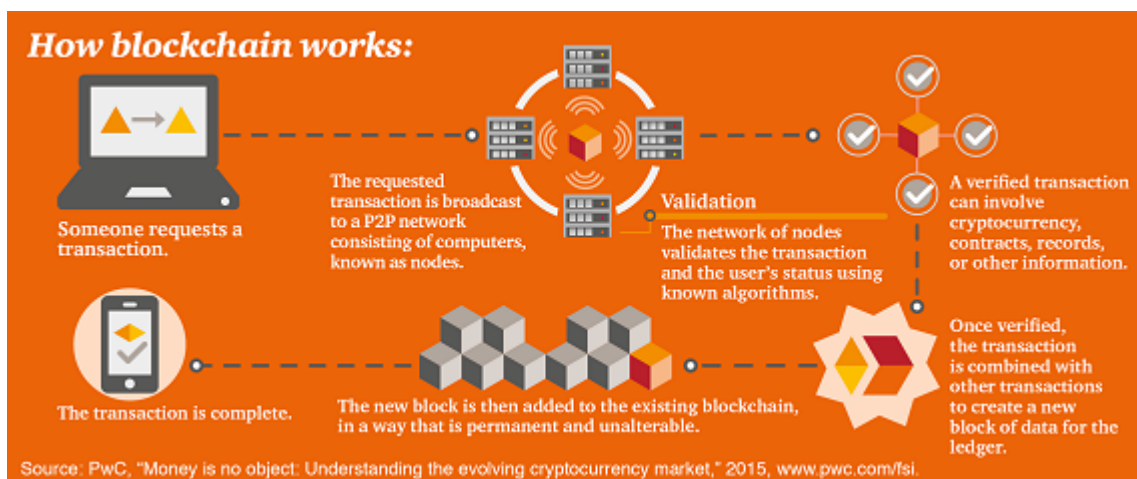


FIGURE 5: A GRAPHICAL REPRESENTATION OF A BLOCKCHAIN TRANSACTION (PWC, 2016A)

If nodes simultaneously publish different next blocks, some receiving nodes will receive one version before the other. The receiving nodes will add the first block they receive to the chain and continue working on that chain, while they save the other possible "chain ends" that result from adding the other blocks to the chain. The different possible "chain ends" are called branches; the nodes always consider the longest chain to be the correct one, as it represents the largest amount of proof-of-work. They save these other branches, as another chain than the one they initially considered to be the longest, might turn out to be the longest chain, to which the nodes will then switch (Nakamoto, 2008).

## **Exchanging value**

A distinguishing feature of blockchain technology is that it allows different parties to maintain a consistent state of a database by enforcing the rules for modifications to that database, in the absence of complete trust. It provides a way to deal with interdependent transactions without the need for a trusted third party. A Bitcoin transaction allows for combining and splitting value and contains multiple inputs and outputs. When parties are transacting value, there are interdependencies with other transactions; an input is connected to both the output of a previous transaction and the output of the current transaction. Each output contains a quantity and public address of the new owner. The total quantity of inputs is equal to or larger than the total quantity of outputs (one of these outputs might be changed). The difference between input and output is a mining fee. The previous outputs are digitally signed with the private keys of the previous owners and can only be spent in one subsequent transaction. The transaction either fails or succeeds as a whole and thus there is no need to check it against a full transaction history (Greenspan, 2016; Nakamoto, 2008).

## **“Blockchain 2.0”: smart contracts**

A blockchain consists of a peer-to-peer protocol, which describes the contract between the users of the network, and the decentralized distributed ledger on which its transaction data and protocol are stored. The use of blockchain technology is not limited to cryptocurrencies, other protocols can be built on top of the protocols of the Bitcoin blockchain, or on top of other blockchains. The properties of the blockchain can also be used for the registration, confirmation and transfer of records, property and contracts. A trustworthy registration is created by referring to changes in records in a small transaction (Euro Banking Association, 2015; OECD, 2016; Swan, 2015). Besides, blockchain enables the development of other distributed applications, for these more advanced applications, a platform and programming language, which preferably is Turing complete, is required (OECD, 2016; Swan, 2015). A Turing complete platform, like the most widely adopted platform Ethereum, is able of running any cryptocurrency, blockchain, or protocol. Besides, Ethereum delivers a Turing complete scripting language, which makes programming on the platform more accessible (Swan, 2015). The programming code that can run on the blockchain is referred to as smart contracts. Smart contracts act on behalf of one or more parties by executing predefined rules when certain conditions are met. The programming code does leave no room for ambiguity, execution of the code will exactly tell a node what it should do. As opposed to “traditional” contracts, once the smart contract is put on a blockchain, trust between the parties is not needed in order for the agreement to function; none of the parties is able to change the lines of code and the smart contract will execute exactly as it was programmed to do. Thus, the smart contract is autonomous. The blockchain provides coordination and trust when human or machines interact; trust is put into the security and audibility of the underlying code of the smart contract. In order to sustain its execution, it is necessary for the smart contract to be able to obtain the right resources, e.g. computational power, thus smart contracts have to be self-sufficient. Decisions that concern changes to the protocol are taken on the basis of consensus (Swan, 2015). The concept of smart contracts can be developed further, in order to create organizations that are able to act with a high degree of autonomy, these organizations are called “decentralized autonomous organizations” or DAOs. These organizations consist of a variety of interacting smart contracts, these contracts describe the rules and procedures that the organization follows. The transactions of the DAO can be recorded to a blockchain, which reduces operational costs



and creates an audit trail. Corporate governance can be realized by using multiple signature technology, which means that a predetermined number of signatures is required in order for a decision to be executed (PwC, States of Alderney, & Cardano foundation, 2016; Swan, 2015; Tapscott & Tapscott, 2016; Wright & De Filippi, 2015).

Smart contracts run on a blockchain, they are decentralized, which means that they run on all nodes in the network and there is no single point of failure (Swan, 2015). Mainly the autonomy of smart contracts raises concerns, as they are less flexible than “traditional” contracts; once put on the blockchain, smart contracts cannot be changed and compliance is decided by code. While it is possible to include a self-destructing function in the smart contract, it can be concluded that smart contracts should be reviewed very carefully before they are put on the blockchain. This contrasts with the existing law, in which human intervention is possible within the legal framework of a country (Swan, 2015). Besides they depend on external data feeds and require liquidity in order to guarantee a proper contract execution (PwC et al., 2016).

Table 1 on this page provides an overview of the categories of blockchain technologies that have been described in section 2.1.1, besides the last column provides examples of these categories.

**TABLE 1: CATEGORIES OF BLOCKCHAIN TECHNOLOGY**

Swan (2015)	OECD (2016)	Euro Banking Association (2015)	Examples (Euro Banking Association, 2015)
Blockchain 1.0	Financial transactions	Currencies	<ul style="list-style-type: none"> <li>• Bitcoin;</li> <li>• Dash;</li> <li>• Dogecoin;</li> <li>• Litecoin;</li> <li>• Peercoin.</li> </ul>
		Asset-centric technologies	<ul style="list-style-type: none"> <li>• Ripple;</li> <li>• Stellar.</li> </ul>
Blockchain 2.0	Record and verification systems	Asset registry	<ul style="list-style-type: none"> <li>• Colored Coins;</li> <li>• Counterparty;</li> <li>• Everledger;</li> <li>• Mastercoin.</li> </ul>
	Smart contracts	Application stacks	<ul style="list-style-type: none"> <li>• Eris;</li> <li>• Ethereum;</li> <li>• Hyperledger;</li> <li>• NXT.</li> </ul>

### “Blockchain 3.0”

The latest generation of blockchain describes how blockchain technology can bring justice to broad areas such as governments, science, health and markets. Several scholars describe this generation on a high-level of abstraction (e.g. Swan (2015); Tapscott and Tapscott (2016)) , they seem to describe a distant future in which blockchain realizes utopias in the broad areas mentioned before. The analysis of this generation of blockchain technology is outside of the scope of this research.

## 2.1.2 Key considerations for using blockchain technology

This section aims to provide insight into the key considerations for using blockchain technology. It does so by first comparing centralized databases and blockchains, then providing an overview of characteristics of high-potential use cases and finally providing an overview of possible blockchain configurations.

### 2.1.2.1 Blockchain vs. centralized databases

Blockchains can be seen as a database, in which consensus on the current state of the database is reached in a situation where there is (very) limited trust between the network participants, without the need for a trusted third party. This feature sounds very promising; however, it comes at a premium, compared to a more traditional centralized database that is controlled by a central administrator. Therefore, the choice between a centralized database and a blockchain database should be made deliberately. The trade-offs that are presented by Table 2 on this page and the next page are inherent to blockchain technology and therefore still hold when making long-term decisions on the use of blockchain technology in an organization (Greenspan, 2016). It can be concluded from Table 2 on this page and the next page, that blockchains are more likely to be the preferred solution when disintermediation and robustness are more important, while centralized databases are more likely to be the preferred solution when confidentiality and performance are more important. It can be concluded that the disintermediating potential of a blockchain comes at the cost of confidentiality. Maintaining confidentiality requires the use of complex solutions which are still under development (Greenspan, 2016).

TABLE 2: COMPARISON BETWEEN CENTRALIZED DATABASES AND BLOCKCHAINS (GREENSPAN, 2016)

	Centralized databases	Blockchains
<b>Disintermediation</b>	<i>Weakness:</i> Centrally administrated databases require the development of human organization and processes in order to maintain a database, which is time consuming and costly.	<i>Strength:</i> A blockchain enables multiple nodes that do not fully trust each other to verify transactions, process transactions and agree on the current state of the database. This disintermediation might lead to a cost reduction.
<b>Confidentiality/privacy</b>	<i>Strength:</i> Centrally administrated read/write permissions eliminate the need for full visibility of the contents of the database to the network members. A centralized database will reveal less information than a blockchain.	<i>Weakness:</i> Imposing read restrictions requires the use of complex, computationally intensive solutions that are still under development, e.g. zero knowledge proof; a blockchain will reveal more information than a centralized database.
<b>Robustness</b>	<i>Weakness:</i> Reaching robustness in a centralized database requires high-end hardware in different physical locations that has to be closely monitored, which is complex and expensive.	<i>Strength:</i> Blockchains are characterized by a high level of redundancy, this gives blockchains their high fault tolerance, which means that a large part of the network has to fail before it stops functioning. Adding or removing nodes to the network requires little effort. However, the hardware and energy costs should be carefully considered.

	Centralized databases	Blockchains
<b>Performance</b>	<b>Strength:</b> Multiple transactions can be processed once a transaction has been established, therefore centralized databases are able to reach higher transactions speeds.	<b>Weakness:</b> As every node independently processes transactions, reaching consensus requires considerable computational work and communication. These performance drawbacks are inherent to the way blockchains work. However, alternative consensus mechanisms are being developed, in which global consensus is not required. These mechanisms could increase the transaction speed of blockchains.

### 2.1.2.2 Public, hybrid and private blockchains

A fundamental choice that has to be made when the application of blockchain technology is considered, is the choice between a public, private, or hybrid blockchain. Table 3 on this page provides an overview of the characteristics of these blockchains. The Bitcoin blockchain is an example of a public blockchain: anyone is allowed to read or modify the blockchain, it is decentralized (no single entity has control over the network) and the state of the network is secured by incentivizing a contribution to reaching consensus through a cryptographic consensus mechanism.

TABLE 3: COMPARISON OF PUBLIC, HYBRID AND PRIVATE BLOCKCHAINS (BUTERIN, 2015; CREDIT SUISSE, 2016; PILKINGTON, 2016)

	Public blockchains (permissionless)	Hybrid (consortium) blockchains (permissioned)	Fully private blockchains (permissioned)
<b>Read permission</b>	Public	Public, or pre-selected set of members	Single organization authorizes read access: public, restricted to pre-selected set of members, or restricted to single organization
<b>Write permission</b>	Public	Pre-selected set of nodes	Single organization
<b>Consensus participants</b>	Anyone	Pre-selected set of nodes	Single organization
<b>Consensus mechanism</b>	Proof-of-work Proof-of-stake	Voting by digitally signing blocks	N/A
<b>Costs of consensus</b>	Highest	Lower	Lowest
<b>Influence on consensus determined by</b>	Economic resources	Pre-determined	N/A
<b>Security based on</b>	Crypto-economics	Cryptography	Cryptography
<b>Security level</b>	Highest	Lower	Lowest
<b>Incentive</b>	Reward	Stake	Stake
<b>Token</b>	On-ledger token	On-ledger token	Off-ledger token
<b>Centralization</b>	Fully decentralized	Partially decentralized	Fully centralized
<b>Regulatory compliance</b>	Difficult	Less difficult	Least difficult
<b>Validation speed</b>	Lowest	Higher	Highest
<b>Level of required trust</b>	None	High	Very high
<b>Reversibility</b>	Low	High	Very high



## 2.2 Blockchain characteristics and the insurance industry

Section 2.1 has discussed blockchain technology in general. This section aims to provide a global understanding of the transformational potential of blockchain in the financial services industry and the requirements that blockchain has to meet for application in this industry. This section is based on the research of two leading financial industry cooperatives.

World Economic Forum (2016) compared characteristics of the current financial infrastructure with a blockchain-enabled infrastructure, see Table 5 on this page. This helps in the initial analysis of the impact of blockchain technology on insurers.

**TABLE 5: CURRENT FINANCIAL INFRASTRUCTURE VS. BLOCKCHAIN-ENABLED INFRASTRUCTURE, ADAPTED FROM (WORLD ECONOMIC FORUM, 2016)**

Characteristics of current centralized financial infrastructure	Transformational potential of blockchain	Impact on financial service providers
<ul style="list-style-type: none"> <li>• Information silos drive the need for detailed reconciliation activities;</li> <li>• Lack of a single version of the truth and audit trails creates arbitrage concerns.</li> </ul>	<p><b>Immutable and distributed record-keeping</b></p>	<ul style="list-style-type: none"> <li>• Data is replicated among participating nodes;</li> <li>• Provides near real-time reconciliation, this eliminates the need for inter-firm reconciliation, which reduces the fear of arbitrage;</li> <li>• Eliminates the need for central intermediaries (trusted third parties) and the fear of arbitrage is reduced;</li> <li>• Provides an immutable and replicated historical single version of the truth (audit trail), this reduces disputes.</li> </ul>
<ul style="list-style-type: none"> <li>• Asymmetric information between market participants drives the proliferation of central authorities;</li> <li>• Lack of transparency increases regulations on financial institutions, the resulting complexity increases compliance costs;</li> <li>• Limited asset provenance.</li> </ul>	<p><b>Transparency</b></p>	<ul style="list-style-type: none"> <li>• Eliminates imbalance of information among market participants;</li> <li>• Increases cooperation between regulators and regulated entities;</li> <li>• Allows for near real-time data sharing of (sub)sets of data with regulators (on-demand and immediate, instead of post-transaction monitoring);</li> <li>• Reduces compliance costs significantly;</li> <li>• Challenges actors that leverage information asymmetry (e.g. insurers);</li> <li>• Reduces spending on risk hedging and liquidity guarantees;</li> <li>• Tokenization of assets improves visibility of assets, which improves risk quantification and pricing accuracy.</li> </ul>
<ul style="list-style-type: none"> <li>• Lack of trust between counterparties creates the need for central authority oversight in contract execution;</li> <li>• The complexity of these agreements has given rise to intermediaries that resolve disputes.</li> </ul>	<p><b>Autonomy</b></p>	<ul style="list-style-type: none"> <li>• Financial agreements can be codified in a shared platform and automated execution can be guaranteed;</li> <li>• Ensures agreements are executed to agreed upon business outcomes (reduced counterparty risk);</li> <li>• Disintermediates supporting entities established to resolve disputes.</li> </ul>

In order to realize the potential of blockchain technology and realize the positive impact in the financial services industry, the technology should meet the requirements which are typical for the IT systems of the industry. Table 6 on this page and the next page provides an overview of requirements

that have to be met for the adoption of blockchain technology in the industry and to which degree they currently are met.

**TABLE 6: REQUIREMENTS FOR BLOCKCHAIN APPLICATIONS IN FINANCIAL SERVICES (SWIFT & ACCENTURE, 2016; WORLD ECONOMIC FORUM, 2016)**

Requirement (SWIFT & Accenture, 2016)	Requirement(World Economic Forum, 2016)	Description	Current state (SWIFT & Accenture, 2016)
<b>Strong governance</b>	<b>Governance</b>	Oversight in administration and responsibilities of the parties.	Even permissioned ledgers provide limited support for read/write profiles. More granularity is required for financial services.
<b>Data Controls</b>	<b>Data sources</b>	Data availability and data access control ensure confidential data storage.	Access control on the shared ledger can be realized by encrypting data, which adds an operational challenge by requiring key management. Data encryption may hamper transaction verification, zero-knowledge proof is a solution to this problem, but is still under development.
<b>Compliance</b>	<b>Compliance</b>	The ability to comply with regulations such as KYC.	There is a lot of regulatory uncertainty related to blockchain technology. It is not clear whether existing regulations will be adapted.
<b>Standardization</b>	<b>Implementation dependencies</b>	Standardization is needed to realize fast processing and ease implementation (interoperability and backward compatibility are required).	Blockchain technology has been developed in isolation of standards, which makes it hard to implement blockchain technology in existing IT systems and to exchange data.
<b>Identity framework</b>	<b>Digital identity</b>	Identification of parties is an enabling capability, as it provides trust, accountability and non-repudiation in transactions.	Pseudo-anonymity does not comply with regulations; a central authority is required to authorize parties. There should be the possibility to revoke or recover lost or stolen keys. This functionality is still under development.
<b>Security and cyber defense</b>	<b>Security</b>	Blockchains should be able to resist attacks.	The proof-of-work consensus mechanism on which public blockchains typically rely, comes at high costs. While permissioned blockchains improve scalability and latency, data security of the distributed ledger still is the responsibility of each party. Solutions that address this risk are still under development.
<b>Reliability</b>	<b>Safeguarding against errors</b>	Blockchains should be safeguarded against errors and be reliable enough to support the critical role of financial services.	Availability depends on participant availability, which cannot be centrally controlled. E.g. solving bugs has resulted in so-called “forks” which are conflicting versions of a ledger. Also, infrastructural problems might result in a division of a network. The reliability limits of blockchain are not yet clear for business users.

Requirement (SWIFT & Accenture, 2016)	Requirement(World Economic Forum, 2016)	Description	Current state (SWIFT & Accenture, 2016)
<b>Scalability</b>	<b>Scalability</b>	Blockchain solutions should be able to deal with the large number of transactions that typically take place in the financial services.	More real-world testing is required to assess the throughput of different consensus mechanisms.

Table 7 on this page presents the concepts that are described by the requirements that can be found in Table 6 on the previous page and this page. Firstly, both resources describe the concept of governance, in the financial services, it is important to monitor the power and responsibilities of people and organizations. Secondly, both resources describe the requirements data controls and data sources. These requirements describe that the use of encryption for identity and access management ensures privacy. Thirdly, both resources describe the importance of compliance, it is not clear whether blockchain is able to comply with regulations that apply to the financial services industry. Fourth, both resources describe how a lack of standardization makes it hard to implement blockchain in legacy IT systems and use it for the rapid exchange of data. This is translated into the concepts of legacy IT systems, standardization and compatibility. Fifth, both resources describe the concept of identity and access management, in the financial services, the establishment of identities is crucial for providing trust and accountability. Sixth, both resources describe the concept of security, blockchains should be able to withstand attacks and securely store the distributed data. Seventh, both resources describe how blockchains should be reliable in order to guarantee an error-free availability of financial services. This is translated into the concept of reliability. Finally, both resources describe the concept of scalability, blockchains should be able to process the large number of transactions that are made in the financial services industry.

**TABLE 7: COMBINED LABEL FOR TECHNICAL REQUIREMENTS**

Requirement (SWIFT & Accenture, 2016)	Requirement(World Economic Forum, 2016)	Concepts
Strong governance	Governance	Governance
Data Controls	Data sources	Identity and access management, privacy
Compliance	Compliance	Compliance
Standardization	Implementation dependencies	Standardization and compatibility, legacy IT systems
Identity framework	Digital identity	Identity and access management
Security and cyber defense	Security	Security
Reliability	Safeguarding against errors	Reliability
Scalability	Scalability	Scalability

### 2.3 Recent developments in the insurance industry

This section provides an overview of recent developments and the importance of regulatory compliance in the insurance industry; this overview will help to understand the dynamics and most important uncertainties of the context in which the insurers operate. Besides the insights that will be gained from this section will be used for making a protocol for semi-structured expert interviews.

Innovation in the financial technology (hereafter referred to as “FinTech”) domain is considered to be one of the most important developments, with a high impact on the financial services firms in the near future. FinTech innovations lead to increased competition, increasingly from new entrants in the market, while insurers experienced several difficulties for the last years (De Nederlandsche Bank, 2015). Some important difficulties that insurers are facing are:

- The individual life insurance market is shrinking due to low interest rates (CB Insights, 2016; De Nederlandsche Bank, 2015);
- Tax law amendments resulted in increased competition of bank saving products (De Nederlandsche Bank, 2015);
- Consumer trust is low (CB Insights, 2016), in the Netherlands this is partially a result of unit-linked insurance mis-selling (De Nederlandsche Bank, 2015);
- Shrinking profitability (CB Insights, 2016): The non-life insurance and pensions markets are not shrinking, but their profitability is under pressure; they experience fierce competition, with new pension providers entering the market and legislation that allows for variable pension benefits is proposed (De Nederlandsche Bank, 2015);
- Financial services are characterized by high levels of uniformity, which leaves room for FinTech firms to specialize in a particular service. This reduces profitability of financial institutions, as possibilities for cross-subsidization and cross-selling are reduced (De Nederlandsche Bank, 2016);
- New legislation, e.g. PSD2 reduces barriers of entry for FinTech firms. Competition from new entrants makes the high fixed cost of the administration of closed book portfolios of insurers more problematic (De Nederlandsche Bank, 2016).

This situation leads to an increased awareness of Dutch insurers of the impact of FinTech innovations on their business models and strategies. FinTech brings opportunities to individual firms and the financial system as a whole; e.g. in the case of insurers, sensor networks and big data have the potential to improve risk analysis and allow for increasingly personalized insurance products, automatic claim handling is taken a step further and new sales channels are being developed. However, these developments also pose an operational risk, as the insurers’ legacy systems need to be adapted to support the new business models that arise from these developments (De Nederlandsche Bank, 2016).

Research by PwC has indicated that the CEOs of Dutch financial services firms are mainly interested in the potential of FinTech to: reduce costs, differentiate business activities and improve customer retention (PwC, 2016c). Incumbents are exploring opportunities to leverage FinTech through investing in in-house R&D, acquiring firms or experimenting in innovation labs. These labs support the rise of



co-creation, where incumbent firms facilitate the cooperation between FinTech firms and provide them with support for further development of their business. This co-creation also results in so-called proof-of-concepts, in which ideas are developed into demonstrations of possible real-world applications. Some insurance technology (hereafter referred to as “InsurTech”) firms are competing by offering new, or more specifically targeted, personalized products, while others are looking for opportunities for helping traditional insurers to solve their problems and meet the needs of their clients. In partnering, they gain access to resources like a large customer base, sales channels, (regulatory) knowledge, capital and therefore scalability (CB Insights, 2016). In the Netherlands, an important initiative where this takes place, is in the Dutch Association of Insurers’ Innovation Lab (De Nederlandsche Bank, 2015).

InsurTech e.g. wearables, data analytics and the “Internet of Things”, accounted for large worldwide investments in the second quarter of 2016 from both venture capital investors and corporates. Blockchain technology attracted the largest share of investments. Some InsurTech firms are using blockchain technology for running smart contracts that facilitate automatic claim-handling, this is the technology that is used to provide peer-to-peer insurance (CB Insights, 2016). The technology is expected to transform the financial services industry, which raises awareness in the financial services sector. SWIFT states that blockchain technology has the potential to (SWIFT & Accenture, 2016): *“bring new opportunities and efficiencies to the financial industry”*. The World Economic Forum states that it (World Economic Forum, 2016, p. 14) *“captured the imaginations, and wallets, of the financial services ecosystem”*.

The insurance industry engages in numerous processes which are characterized by the exchange of data which is updated by multiple parties; a blockchain, as a single source of truth has the potential to increase efficiency and reduce the complexity of these processes. It could result in disintermediation as it reduces the need to for data reconciliation for (re-)insurance contracts and resolving disputes. Auditability is improved as it could provide regulators with (near) real-time information on financial activities and fraud could be reduced by providing a full transaction history and asset provenance (World Economic Forum, 2016).

The impact of blockchain solutions will be increased when incumbents, innovators and regulators will closely work together (World Economic Forum, 2016). Expectations of blockchain technology in the financial services industry are high. The term “blockchain”, or “distributed ledger technology” is used to refer to a variety of technology concepts related to databases, value exchange, security and identity among others. The technology comes with barriers to large-scale implementation; e.g. related to the early stage of development of standardization efforts, platform development, scalability and the absence of legal frameworks (Gartner Inc., 2016; World Economic Forum, 2016). In October 2016, a group of the five biggest European insurers (Aegon, Allianz, Munich Re, Swiss Re and Zurich) announced that they launched a consortium called the Blockchain Insurance Industry Initiative (B3i). In this initiative, the actors in the network combine their resources and capabilities in order to explore the potential and viability of a blockchain-enabled transaction platform. This platform should streamline the entire value chain. The initiative recognizes the need for innovating in a network in which industry-wide standards and processes are developed (Betlem, 2016). The complexity of the ecosystem in which FinTech innovation takes place is graphically represented by Figure 7 on page 25.

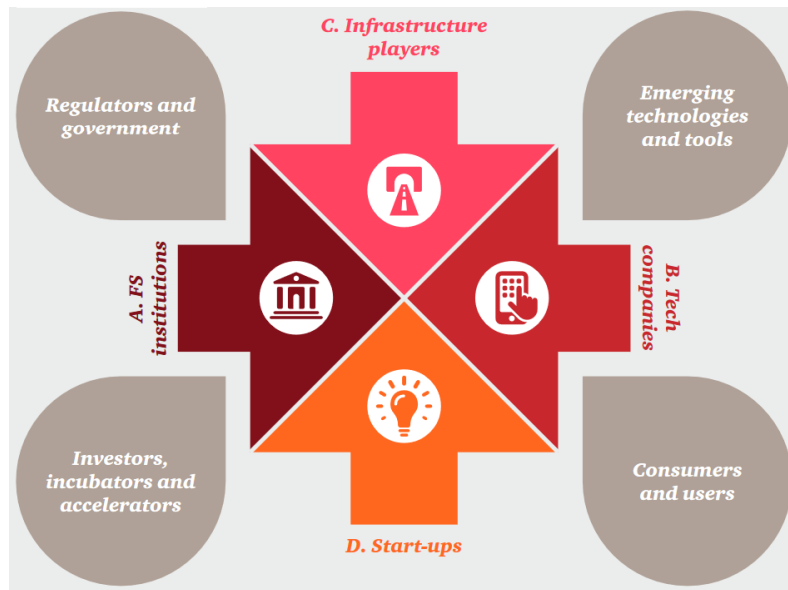


FIGURE 7: THE COMPLEXITY OF THE FINTECH ECOSYSTEM (PwC, 2016B)

### 2.3.1 Regulatory compliance

While a detailed regulatory analysis is outside the scope of this research, this section provides a short overview of important regulatory frameworks that apply to insurers; government regulation is an important factor for the development of blockchain technology in the heavily regulated insurance industry; regulators are exploring how they should deal with the development of this cross-border technology; countries are struggling to apply their existing regulations to blockchain technology (Swan, 2015; Tapscott & Tapscott, 2016). An important reason for this struggle is the pseudo-anonymity and disintermediation that can be provided by blockchain technology; the disintermediation eliminates the possibility to enact regulation like it is currently done on individuals or organizations (Wright & De Filippi, 2015). This especially is problematic in case of public blockchains, where regulation could only apply to the system where anyone has access to; in a private blockchain, the insurer could have access control. In that case, the insurer can choose to only allow known parties when they meet certain regulatory requirements. Currently, under Solvency II regulation, when parts of their operations are outsourced, insurers are responsible for the compliance of third parties (Mainelli & Manson, 2016). Another problem arises from EU data protection laws (General Data Protection Regulation, or GDPR) (PwC et al., 2016); data must only be used for specific purposes, should not be kept longer than is necessary and must only be used in the EU. Besides people have the “right to be forgotten”. The immutability of the blockchain is an important issue, as the data, once put on the blockchain will stay on there. A possibility for this issue could be data encryption, however, key management will quickly get complex, especially if data contains references to data that belongs to another person (Mainelli & Manson, 2016). Besides, developments in computer science, quantum computing in particular, have a big impact on the future of blockchain technology; a quantum computer combines quantum mechanics and theoretical computation to solve mathematical problems, like cryptographic algorithms with much greater speed than classical computers. When these developments surpass developments in cryptography, regulatory compliance cannot be guaranteed in future (Mainelli & Manson, 2016; Tapscott & Tapscott, 2016).

## Know Your Customer (KYC)

For securing the integrity of business operations of the financial institutions, they should know who they are dealing with and what the purpose of the business relationship is; the Wft (“Wet op het financieel toezicht” in Dutch, or Financial supervision act in English) and Wtt (“Wet toezicht trustkantoren” in Dutch, or Act on the supervision of trust offices in English) require financial institutions to have an adequate Customer Due Diligence (CDD) system, in order to secure the integrity of their business operations; in this system, KYC describes the process of verifying customer identity and assessing the risk associated with the clients. Not only should this system secure business operations integrity and maintaining trust in the financial institution, but it also is important for anti-money laundering (AML) and preventing terrorist financing. In the Netherlands, the EU directive for AML and preventing terrorist financing is implemented in the Wwft (“Wet ter voorkoming van witwassen en financieren van terrorisme” in Dutch, or Anti-Money Laundering and Anti-Terrorist Financing Act in English). The CDD system should also incorporate customer, accounts and transactions monitoring (Bank, 2015).

## 2.4 Conclusion

This section describes the conclusions that can be drawn from section 2.1, 2.2 and 0. These conclusions will be used for making a protocol for semi-structured expert interviews.

From section 2.1 and 2.2 the following value proposition for the financial services industry can be derived:

- The *need for a trusted third party* is eliminated, as the blockchain protocol describes how consensus on the validity of a transaction is reached. Transactions in a blockchain are unique and are authorized by linking a digital signature to an identity.
- *Controllability* of data is improved by linking transactions to each other and establishing an immutable “single source of truth”. This “single source of truth” is shared in a peer-to-peer network. Regulators could monitor this audit trail in near real-time, which could reduce the costs of regulatory compliance.
- It is *not necessary to (manually) combine data*, the risk of errors is reduced, transactions are settled quickly and do not require arbitrage, which makes risk management less difficult and improves liquidity.
- Blockchain offers *high resiliency*, as it does not depend on central infrastructure. It will continue to work in case of local system failures.
- Blockchain facilitates the use of so-called “*smart contracts*”, these contracts execute predefined lines of computer code when certain conditions are met.

However, blockchains are not always the preferred solution over centralized databases. Blockchains are more likely to be the preferred solution when disintermediation and robustness are more important, while centralized databases are more likely to be the preferred solution when confidentiality and performance are more important. Besides section 2.1.2 provided guidance in

identifying high-potential use cases (Table 4 on page 19) and choosing a blockchain configuration (Table 3 on page 18).

Finally, the application of blockchain in the financial services industry puts several requirements on the technology, which currently are not fully met. These requirements are related to:

- Privacy;
- Security;
- Reliability;
- Scalability;
- Compliance;
- Governance;
- Legacy IT systems;
- Identity and access management;
- Standardization and compatibility.

From section 2.3, it can be concluded that FinTech innovation is considered to be one of the most important developments for the financial services industry. Dutch CEOs of financial services firms see the potential for FinTech to reduce costs, differentiate business activities and improve customer retention. But it also leads to increased competition in the insurance industry, increasingly from new entrants. Therefore, Dutch insurers are increasingly aware of the impact of FinTech innovation on their business models.

Insurers are especially interested in the impact of blockchain technology as they see the potential for blockchain in:

- Automating and increasing the efficiency of insurance processes;
- Reducing the complexity of insurance processes;
- Increasing the transparency of insurance processes;
- Reducing the need for intermediation and dispute resolution.

However, insurers experienced the following difficulties for the last years, which makes it difficult for them to anticipate on FinTech developments:

- The profitability of the life insurance, non-life insurance and pensions markets all decreased and competition from bank-saving products increased.
- There is room for FinTech firms to specialize in specific insurance services and disintegrate the insurance value chain.
- New legislation, e.g. PSD2 reduces barriers of entry for FinTech firms, which makes the fixed costs of insurers' closed book portfolios more problematic.
- The insurers' legacy IT systems need to be adapted in order to support changes in their business models that will be caused by FinTech innovation.
- Consumer trust is low.

A successful implementation of blockchain solutions requires a cooperation between incumbents, innovators and regulators. The most important blockchain-specific problems they have to solve for large-scale implementation are:

- Regulatory uncertainty;
- A lack of standardization;
- The absence of legal frameworks.

Government regulation is an important factor for the development of blockchain technology in the heavily regulated insurance industry. The following factors add to the uncertainty regarding the ability of insurers to be compliant in future blockchain applications:

- Governance;
- Quantum computing;
- New laws and regulations such as GDPR;
- Being compliant with current laws and regulations such as Solvency II, Wft and Wwft.

FinTech firms are cooperating with insurers, in order to gain access to the following resources:

- Large customer base;
- Sales channels;
- Knowledge on the industry and regulation;
- Investment capital.

## 2.5 Business models

For finding the position of business models in literature, a basis for the research and the knowledge gap that this research aims to fill, a literature review of primary publications has been conducted. The literature that has been reviewed consists of scientific articles published in scientific journals, books and conference proceedings. The databases that have been searched by means of keywords are: Scopus, TU Delft WorldCat Discovery, IEEE Xplore, JSTOR and Google Scholar. The literature review was done by using the “snowball principle” (Verschuren & Doorewaard, 2010). The literature was selected based on its relevance for this research; the relevance was first based on reading the abstracts, the publications that seemed relevant were studied in detail, after which a second selection was made. The same procedure was applied to the reference lists of this second selection. Some publications aimed to provide an overview and classification of recent studies in the field of business models, these publications were helpful in structuring the perspectives of several scholars (Al-Debei & Avison, 2010; DaSilva & Trkman, 2014; Hedman & Kalling, 2003; Osterwalder et al., 2005; Pateli & Giaglis, 2004; Shafer et al., 2005; Zott et al., 2011). The selection procedure was repeated up to the point where a comprehensive overview of the field of study was reached and additional publications would not lead to new valuable insights. The following keywords yielded the most relevant results:

- “business model”;
- “business modelling”;
- “business model tooling”;
- “business model impact”;
- “business model innovation”;
- “business model technology”;
- “business model stress testing”.

Due to the novelty of blockchain technology, academic literature on blockchain-enabled business models is very scarce, therefore this literature review describes business model literature in general. Section 2.5.1 provides a clear working definition of the business model concept for this research; a clear working definition important in this research, as this research aims to contribute to the body of knowledge without adding to the confusion. Section 2.5.2 describes the role of the business model concept in technological innovation. Next, an overview of the theoretical foundations of the business model concept in two important literature streams is provided; strategic management in section 2.5.3 and information systems research in section 2.5.4. Section 2.5.6 describes how business model ontologies can be used to perform stress tests on business models in a dynamic environment.

### 2.5.1 Business model definition

There is not one single definition of the business model in the growing body of knowledge of the concept, this may be the result of the different research perspectives that contributed to a part of the body of knowledge (Al-Debei & Avison, 2010; Mahadevan, 2000; Michael E Porter, 2001; Shafer et al., 2005; Zott et al., 2011), it could create confusion and makes it harder for scholars to build on prior research (Zott et al., 2011). Scholars often omit to clearly define the working definition for their research (Zott et al., 2011), the lack of a single definition makes it hard to assess how technological innovations impact businesses (El Sawy & Pereira, 2013), therefore, it is important to clearly describe which definition of the business model is used in this research. An overview of business model definitions that are often cited in scientific literature is provided in Table 26 on page 163. Key components in these definitions are creating and capturing value, financial arrangements and the network structure. The terms business model and revenue model should not be used interchangeably, as they are different concepts; the generation of revenue is a part of a business model and is described by the revenue model (Amit & Zott, 2001).

(Bouwman et al., 2008, p. 33) integrate key components for this research that can be found in these definitions and add a focus on services that are delivered by a network of business actors, their comprehensive definition of “business model” is used as the working definition in this research:

*“A business model is a blueprint for a service to be delivered, describing the service definition and the intended value for the target group, the sources of revenue, and providing an architecture for the service delivery, including a description of the resources required, and the organizational and financial arrangements between the involved business actors, including a description of their roles and the division of costs and revenues over the business actors.”*

Now a working definition of the business model is given, the role of the business model concept in technological innovation, strategic management, information systems (IS) research and scenario analysis is described.

### 2.5.2 The business model concept as a mediator between technological innovation and economic value

The business model concept is used as a holistic framework for describing the logic of value creation and capturing value from new technological potential (Chesbrough & Rosenbloom, 2002; DaSilva & Trkman, 2014). Technological innovation often requires a business model change (Chesbrough & Rosenbloom, 2002; Pateli & Giaglis, 2005); when a firm is not able to find the right business model, the firm is not able to capture the full potential of a technology, which also might discourage the firm to engage in innovation in the future (Chesbrough & Rosenbloom, 2002). Technological innovations are challenging firms by impacting their current business models, therefore assessing the future impact of these innovations is crucial to secure future profitability and long-term survival of the firm (Pateli & Giaglis, 2005; Teece, 2010). Incumbent firms are typically challenged by technological innovations when these conflict with their existing business models and resource configurations (Chesbrough, 2010; Christensen, 2013). Business models can be seen as mediators between technological innovation and firm performance, technology and business models interact; technological innovation can facilitate new business models. Sophisticated information technology and platform technologies made it more important to consider the complementarity between

business models and technology (Baden-Fuller & Haefliger, 2013). Baden-Fuller and Haefliger (2013); Chesbrough (2010); Chesbrough and Rosenbloom (2002); Teece (2010) argue that a key feature of good business model is, that it provides the logic that enables a firm to unlock technological potential and turn it into economic value. This mediating function is visualized in Figure 8 on this page. In this view, the business model ultimately should support a sustained competitive advantage, in order to do so, firms should ensure that their business models, which often are observable, are differentiated and hard to imitate (Teece, 2010).



**FIGURE 8: THE BUSINESS MODEL AS A MEDIATOR BETWEEN TECHNOLOGICAL POTENTIAL AND ECONOMIC VALUE (BADEN-FULLER & HAEFLIGER, 2013; CHESBROUGH, 2010; CHESBROUGH & ROSENBLUM, 2002; TEECE, 2010)**

### 2.5.3 The business model from the perspective of strategic management

A correct use of business models forces managers to put considerable thought into how different parts of a business are working together and therefore are a tool for guiding and evaluating strategic decision making. The terms business models and strategy should not be used interchangeably, as they are different concepts; business models do not focus on competition, while strategy is about doing things better by being different than competitors and focusses on competitive threats (Magretta, 2002). Strategy can be seen as a set of choices regarding the way in which the firm competes, the business model can be seen as the activity system that reflects the firm's realized strategy (Casadesus-Masanell & Ricart, 2010). Two concepts that have been important in the analysis of competitive advantage in strategic management will first be described in this part: industry positioning and the resource-based view/dynamic capabilities (McGrath, 2010). More recently, the perspective of transaction cost economics has been added to strategy literature, in order to explain the increasing popularity of the business model concept in recent years (DaSilva & Trkman, 2014; McIvor, 2009; Morris et al., 2005).

#### *Industry positioning*

An industry positioning framework that has been very influential in both academic research and business practice is the "Porter's Five Forces" model. This externally focussed model not only assesses competition among existing competitors, but also takes into account competition from new entrants, buyers, suppliers and substitute products. Thereby it extends the view from existing rivalry to industry-wide rivalry, by providing insight into structural industry conditions that shape industry profitability, based on the position of a firm in its industry. This framework can be used to assess medium and long term profitability in any industry and guide decision making (Michael E. Porter, 2008).



### *The resource-based view (RBV)*

The resource-based view is an internally focussed strategy framework which builds on the theory of Schumpeter (1934), he has been very influential in the field of innovation and entrepreneurship. He argued that five different sources of innovation led to the creation of new value: the introduction of a new good, the introduction of a new method of production, the opening of a new market, the conquest of a new source of supply, and the new organization of industries. These types of innovation are the result of technological development and result in discontinuous change and a disequilibrium (Amit & Zott, 2001; Bouwman et al., 2008; DaSilva & Trkman, 2014; Hedman & Kalling, 2003). In his theory, novel and unique combinations of sources are important for value creation (Amit & Zott, 2001; Morris et al., 2005). The term “creative destruction” that he introduced refers to the value that could be extracted by entrepreneurs, this value diminishes as an innovation diffuses (Amit & Zott, 2001).

The RBV provides a framework for assessing the potential of the firms’ resources for creating value and realizing a sustained competitive advantage, this potential is high when both the tangible and intangible firm resources are valuable, rare, not perfectly imitable and not substitutable. The unique combination of resources and capabilities enable to firm to create value (Amit & Zott, 2001; Barney, 1991). Innovations in ICT facilitate new ways of value creation and new business model configurations, however, the ICT-related resources and capabilities that are required for their realization, are characterized by a high mobility (Amit & Zott, 2001).

### *Dynamic capabilities*

An addition the resource-based view (RBV), which is better suited to deal with the mobility of ICT-related resources and capabilities, is the theory of dynamic capabilities; the dynamic capabilities theory recognizes that in order to realize sustained competitive advantage, a firm not only needs the right traits and processes, but it should also be able to sense and seize opportunities and recognize threats. Besides, it states that the firm and the configuration of its resources should be transformed when the market or the technology changes; the firm should transform continuously in order to stay competitive over time. Defending against competition is not enough, firms should also shape competition and market outcomes in order to stay competitive in markets that are characterized by rapidly changing technology (Cavalcante, Kesting, & Ulhøi, 2011; DaSilva & Trkman, 2014; Teece, 2007, 2010; Teece, Pisano, & Shuen, 1997)

### *Transaction cost economics (TCE)*

The RBV remains relevant in recent literature, however it does not explain the increasing popularity of the business model concept in recent years. The transaction cost economics states that transaction efficiency and boundary decisions can generate value (DaSilva & Trkman, 2014; McIvor, 2009; Morris et al., 2005). The combination of the resource-based view and transaction cost economics helps understanding how the adoption of the internet and e-businesses led to the proliferation of the business model concept; the Internet significantly reduced transactions costs. Besides, the Internet reduced the costs of search by providing information about products and services, which led to dis-intermediation and facilitated new ways of creating value (Amit & Zott, 2001; DaSilva & Trkman, 2014; Mahadevan, 2000). This reduction of transactions costs can also be realized by blockchain technology (Tapscott & Tapscott, 2016). The “creative destruction” that results from the rise of e-business is characterized by a reduction in transaction costs and spans industry boundaries; next to the five

sources of innovation that are defined by Schumpeter, new exchange mechanisms and transaction architectures are two additional sources of innovation in e-business (Amit & Zott, 2001). DaSilva and Trkman (2014) argue that the combination of sources of a firm create value for both the firm and its customers through transactions.

### **The business model concept vs. strategy**

Casadesus-Masanell and Ricart (2010) and McGrath (2010) criticize the concepts of industry positioning and the resource-based view/dynamic capabilities. These concepts advise a firm to choose certain position in its industry and strengthen its resource accumulation, which inherently makes them less able to change the strategic direction of the firm. Besides, when decisions on resources and capabilities are made, managers are guided by the constraints that apply at that point in time, however, these constraints are not static and change due to technological developments (McGrath, 2010). Structural changes, especially the development of ICT resulted in a dynamic competitive environment and a growing interest in business model innovation (Al-Debei & Avison, 2010; Casadesus-Masanell & Ricart, 2010). Compared to strategy, business models have a more external focus, they facilitate experimentation in a dynamic environment where the focus is on how resources lead to customer value creation and where competitive advantage is temporary, instead of sustainable (McGrath, 2010). The business model concept can be seen as a tool that helps strategists in assessing the potential of the large amount of possible business model configurations that organizations can choose from, as a result of recent ICT developments (Al-Debei & Avison, 2010; McGrath, 2010). These organizations operate in a fast-moving and unpredictable environment where the time that is needed for strategic decision making based on a detailed analysis might render the decisions irrelevant; these organizations could benefit from continuously experimenting with business modeling in order to learn fast and develop insights into new developments in the environment (McGrath, 2010) as decisions regarding the commercialization of new technologies are often made based on limited information (Chesbrough & Rosenbloom, 2002). The ability to experiment and quickly develop business models can strengthen the competitive advantage of the firm (McGrath, 2010).

Section 2.5.4 describes the position of the business model in the field of information systems research, in which there is a focus on the development of business model ontologies, design approaches and tooling for experimentation.

#### 2.5.4 The business model concept and information systems (IS) research

##### The business model concept as a mediator between business strategy and business processes

A business process can be defined as (Davenport, 2013, p. 5):

*“a specific ordering of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs: a structure for action”.*

A business model can be seen as the mediator between the strategy and processes of an organization, including its information systems; it describes how the organization can achieve its strategic goals. Besides, the business model forms the starting point for developing the information systems that support the business model (Al-Debei & Avison, 2010; Hedman & Kalling, 2003; Osterwalder & Pigneur, 2002; Pateli & Giaglis, 2004). This mediation function is visualized in Figure 9 on this page; the intersection point of the business model with the business processes represents the operationalization of the business model by the underlying business processes (Al-Debei & Avison, 2010).

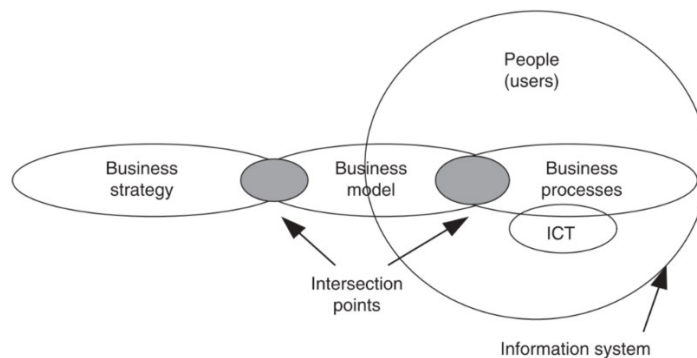


Figure 9: The business model as a mediator between business strategy and business processes (Al-Debei & Avison, 2010, p. 370)

##### E-business and the proliferation of the business model concept

The business model concept is often used to describe the logic of a firm; how the different components of a business (network) work together in order to create and capture value from a product or service (Afuah & Tucci, 2003; Casadesus-Masanell & Ricart, 2010; Chesbrough & Rosenbloom, 2002; Demil & Lecocq, 2010; Linder & Cantrell, 2000; Magretta, 2002; Timmers, 1998). The concept is often used for describing e-businesses (Amit & Zott, 2001; Hedman & Kalling, 2003; Timmers, 1998). E-business refers to business that takes place on the Internet, therefore, the rapidly increasing number of e-business and the increasing popularity of the business model concept among practitioners and scholars starting from the late 1990s, is fueled by the wide adoption of the internet (Amit & Zott, 2001; DaSilva & Trkman, 2014; Demil & Lecocq, 2010; Mahadevan, 2000; Osterwalder et al., 2005). The internet made communication and the exchange of information faster and cheaper (McGrath, 2010); the high speed of development of ICT, such as the internet, has been an important factor for recent developments in the business model concept in relation to Information Systems (Al-Debei & Avison, 2010; Pateli & Giaglis, 2005) as they facilitate new, previously impossible or unattractive, business model configurations (Al-Debei & Avison, 2010; Amit & Zott, 2001; McGrath, 2010; Osterwalder, 2004; Timmers, 1998). Bouwman et al. (2012); Hedman and Kalling (2003); Zott et al. (2011) distinguish two

levels of conceptualization: one level that describes classifications of e-business models (e.g. Rappa (2000); Timmers (1998)) and another level that describes e-business components and provides ontologies (e.g. Afuah and Tucci (2000); Ballon (2007); Bouwman et al. (2008); El Sawy and Pereira (2013); Gordijn et al. (2001); Osterwalder (2004); Osterwalder and Pigneur (2010); Rappa (2000); Shafer et al. (2005)).

Compared to literature that focusses on the classification business models, the business model ontologies, which mainly originate from information systems research, are more practical conceptual frameworks for guiding business model design by concrete organizations. Gordijn et al. (2000, 2001) developed e<sup>3</sup>-value, a business modelling method that helps to define the realization and exchange of economic value in a network of actors. It is suitable for analysing multi-enterprise relationships, e-business scenarios and operational requirements; the analysis can be both quantitative and qualitative and serves as an input for the formulation of requirements of the information systems that support the business model. The integration of the business modelling and information systems modelling provides some strengths in modelling e-businesses: a clear description of the essential elements of the e-business model and a clear description of the supporting processes and system requirements, realized by scenario analysis and quantitative analysis (Gordijn et al., 2001). The e<sup>3</sup>-value methodology especially is suitable for assessing the economic feasibility of a business model, which means that each actor is able to make a profit or increase its utility. It does not aim for a precise calculation of profits or increased utility, but it provides a first quantitative analysis of the business case for each actor with a satisfactory confidence level for a business model under development. The confidence level of this analysis can be improved by proceeding to perform a quantitative scenario analysis, in which the financial robustness of a business model towards a future change of business model design parameters is analysed (Bouwman et al., 2012; Gordijn et al., 2001). The e<sup>3</sup>-value methodology is less useful in a situation where it is hard to assess the value of the exchange of tangible values. Besides, the methodology is less useful for the analysis of the exchange intangible values, as it generally is hard to determine their value (De Reuver et al., 2013).

Ballon (2007) developed a framework for the design and analysis of ICT business models by describing the most important control and value parameters in the business model of a product or service. Rather than focussing on a single firm, these parameters refer to a value network, which consists of actors that deliver the product or service. The framework aims for an operationalisation of existing literature streams on business models. It addresses the following two questions (Ballon, 2007):

*“Who controls the value network and the overall system design?”*

*“Is substantial value being produced by this model (or not)?”*

In order to reduce the complexity of the multi-actor setting, only generally applicable parameters which are most relevant to ICT business model design are included in the framework. A drawback of the reduction of the complexity is that it results in a model that can be used to describe business models on a high level of abstraction, but is less suitable for the design of business models. It does not describe a design process for business model design and it offers little freedom in the design parameters (Bouwman et al., 2012).

Well-known business model ontologies that will be described in more detail are: Business Model Canvas (based on Business Model Ontology) (Osterwalder, 2004; Osterwalder & Pigneur, 2010; Osterwalder et al., 2005), the STOF (Service, Technology, Organization, Finance) model (Bouwman et al., 2008) and the VISOR Model (El Sawy & Pereira, 2013).

### 2.5.4.1 Business Model Canvas (Osterwalder & Pigneur, 2010)

The Business Model Canvas is a tool that facilitates discussions on business model design, it provides a shared language for describing how an organization is able to create and deliver value and capture a part of it. The Canvas, as shown in Figure 10 on this page, can be printed on a large sheet of paper and be used for describing and visualizing the logic of business models (Osterwalder & Pigneur, 2010).

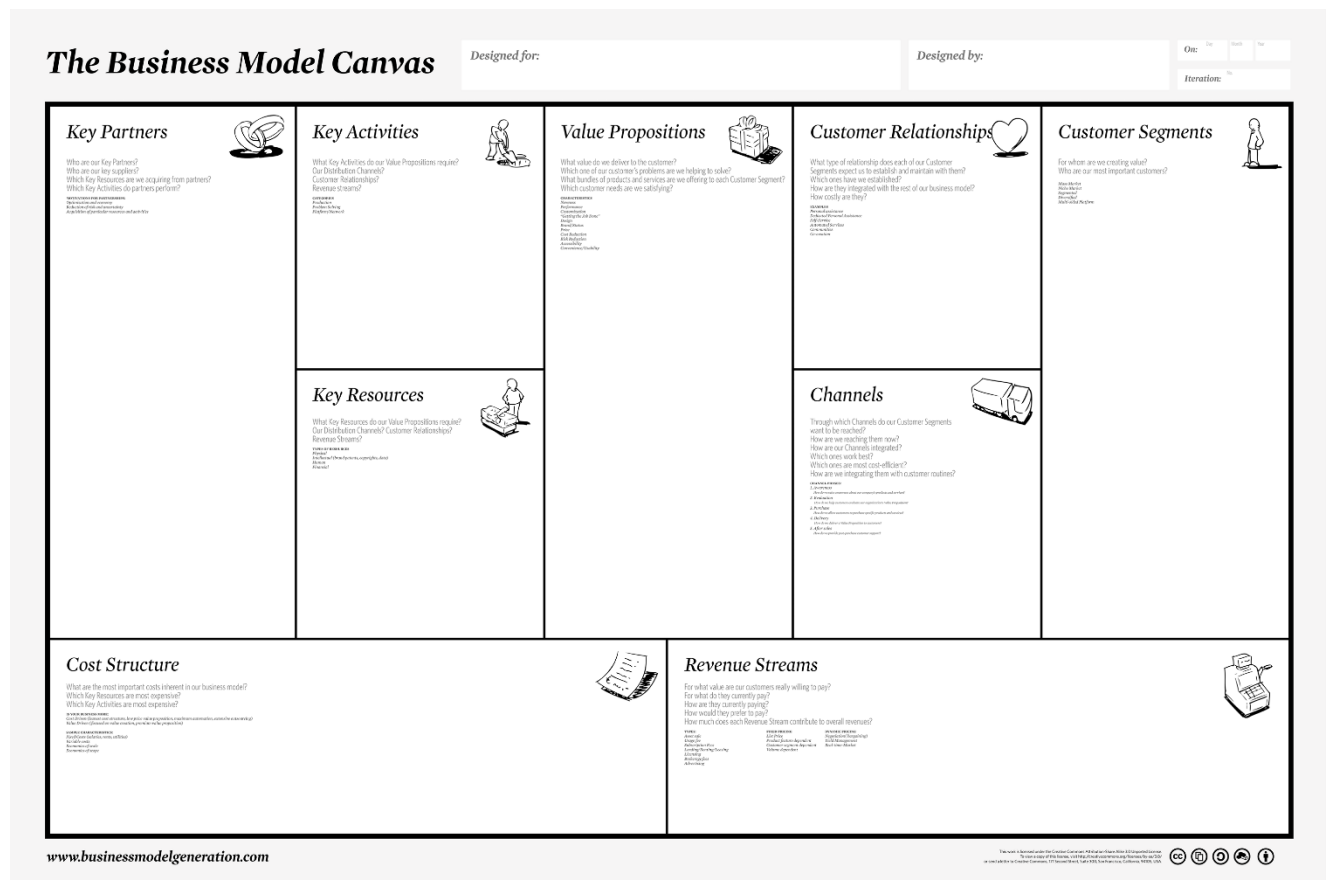


FIGURE 10: THE BUSINESS MODEL CANVAS (OSTERWALDER & PIGNEUR, 2010)

The framework consists of four main areas with nine basic building blocks (Osterwalder & Pigneur, 2010):

- Infrastructure
  - Key Partnerships: This building block describes the network of organizations that are working together in order to create and deliver value to the targeted customer segments. Organizations are looking for optimization, spreading risks among partners and access to partner resources (Osterwalder & Pigneur, 2010).

- Key Activities: The key activities are the most important activities for operating a business model. They enable the organization to offer the value propositions, run the distribution channels, maintain customer relationships and finally earn revenues from its business model (Osterwalder & Pigneur, 2010).
- Key Resources: The key resources are the most important assets for operating a business model. They enable the organization to offer the value propositions, run the distribution channels, maintain customer relationships and finally earn revenues from its business model. An organization can own or lease resources, or acquire them from partners (Osterwalder & Pigneur, 2010).
- Offer
  - Value Propositions: This building block describes how the bundle of products/services that is offered by an organization creates value for the customers, solves their problems and fulfils their needs (Osterwalder & Pigneur, 2010).
- Customers
  - Customer Segments: The choice on which distinctive customer segment(s) an organization targets, determines the customer needs that the organization aims to fulfil by creating and delivering value. The organization can target individuals (business to consumer), as well as organizations (business to business) (Osterwalder & Pigneur, 2010).
  - Customers Relationships: An organization has to choose which type of relationships it would like to establish with their customer segments. These relationships can be personal or automated (Osterwalder & Pigneur, 2010).
  - Channels: This building block describes the communication with the customers segment(s) and the delivery of value via direct or indirect channels. These channels can be owned by the organization itself or by a partner organization (Osterwalder & Pigneur, 2010).
- Financial Viability
  - Cost structure: This building block describes the most important costs of operating the business model. A large share of the costs are determined by the following building blocks: key partnerships, key resources and key activities (Osterwalder & Pigneur, 2010).
  - Revenue Streams: An organization has to determine how and how much customers are willing to pay for the delivered value. The revenue streams consist of cash from the customer to the

organization, transactions can occur a single time or can be recurrent. Prices can be fixed or dynamic. Earnings are calculated by subtracting costs from the revenue (Osterwalder & Pigneur, 2010).

#### 2.5.4.2 The STOF Method (Bouwman et al., 2008)

##### The STOF Model

The STOF Model describes four core domains of business model design and their interdependencies, namely Service, Technology, Organization and Finance (hence the name STOF). The method has been developed in the context of (mobile) service design. The model provides a detailed description of the interdependencies of the design variables and Critical Design Issues (CDIs) per domain and between the domains. The CDIs are design variables that are considered to be crucial for the viability and sustainability of a business model that is being analysed, see Figure 11 on this page. The method also takes the Critical Success Factors (CSFs) into consideration and describes how they are related to the CDIs. The CSFs are required for the creation of customer and network value. The domains are visualized in the framework in Figure 11 on this page, the design variables in each of them and their related CDIs are described in Table 8 on page 39.

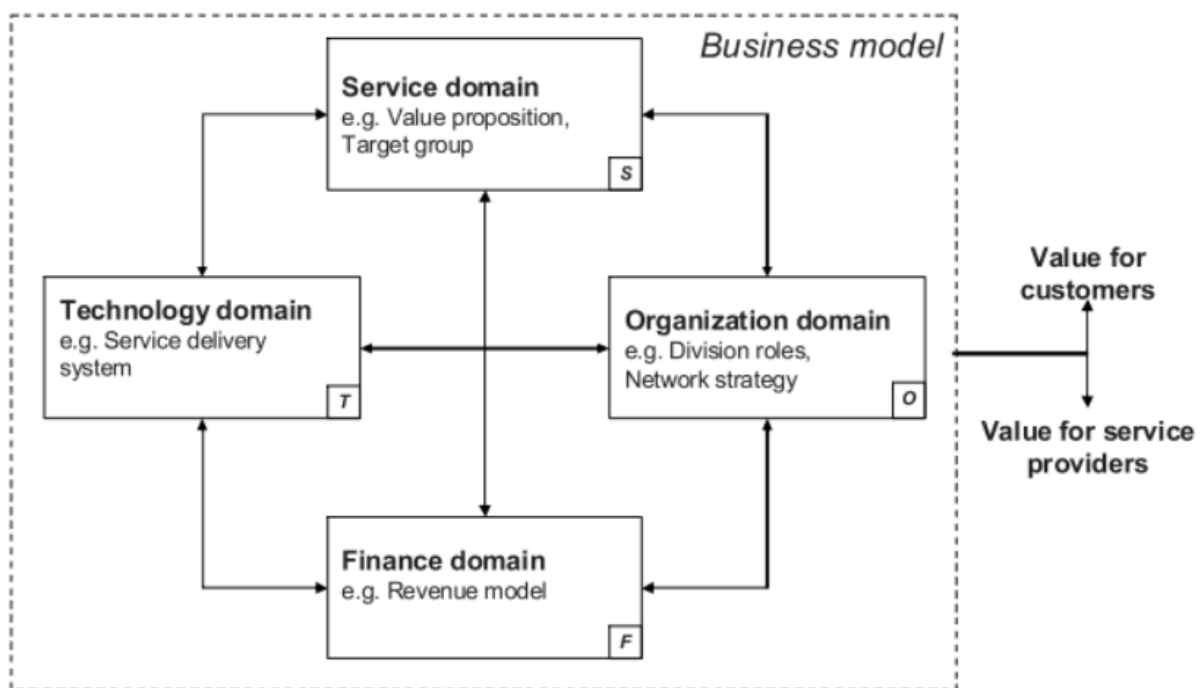


FIGURE 11: THE STOF BUSINESS MODEL DOMAINS (BOUWMAN ET AL., 2008)

TABLE 8: THE STOF MODEL DOMAINS AND THE RELATED CRITICAL DESIGN ISSUES (CDIs) (BOUWMAN ET AL., 2008)

Domain	Concepts in service design	Critical Design Issues (CDI)
<b>Service</b> Describes the delivery of value propositions to the targeted customer.	<ul style="list-style-type: none"> <li>• Intended Value;</li> <li>• Delivered Value;</li> <li>• Expected Value;</li> <li>• Perceived Value;</li> <li>• Customer or End-user;</li> <li>• Context;</li> <li>• Tariff and Effort;</li> <li>• Bundling.</li> </ul>	<ul style="list-style-type: none"> <li>• Targeting;</li> <li>• Creating Value Elements;</li> <li>• Branding;</li> <li>• Customer Retention.</li> </ul>
<b>Technology</b> Describes the technical architecture that is required for the service offering	<ul style="list-style-type: none"> <li>• Technical Architecture;</li> <li>• Backbone Infrastructure;</li> <li>• Access Networks;</li> <li>• Service Platforms;</li> <li>• Devices;</li> <li>• Applications;</li> <li>• Data;</li> <li>• Technical Functionality.</li> </ul>	<ul style="list-style-type: none"> <li>• Security;</li> <li>• Quality of Service;</li> <li>• System Integration;</li> <li>• Accessibility for Customers;</li> <li>• Management of User Profiles.</li> </ul>
<b>Organization</b> Addresses issues related to resources, capabilities and collaboration.	<ul style="list-style-type: none"> <li>• Actors;</li> <li>• Value Network;</li> <li>• Interactions and Relations;</li> <li>• Strategies and Goals;</li> <li>• Organizational Arrangements;</li> <li>• Value Activities;</li> <li>• Resources and Capabilities.</li> </ul>	<ul style="list-style-type: none"> <li>• Partner Selection;</li> <li>• Network Openness;</li> <li>• Network Governance;</li> <li>• Network Complexity.</li> </ul>
<b>Finance</b> Describes how the actors in the network capture value from the service.	<ul style="list-style-type: none"> <li>• Investment Sources;</li> <li>• Cost Sources;</li> <li>• Performance Indicators;</li> <li>• Revenue Sources;</li> <li>• Risk Sources;</li> <li>• Pricing;</li> <li>• Financial Arrangements.</li> </ul>	<ul style="list-style-type: none"> <li>• Pricing;</li> <li>• Division of investments;</li> <li>• Valuation of contributions and benefits;</li> <li>• Division of costs and revenues.</li> </ul>

### The STOF Method

The STOF method is a scientifically grounded business modelling method that has been based on the STOF framework, which consists of 4 steps, as can be seen in Figure 12 on page 40. The step-by-step process that is described by the STOF method should result in a balanced choice in design variables in the four core domains, which is guided by the CDIs and CSFs. The creation of customer and network value is important for the viability of the business model that is being analysed. These four domains



need to be balanced, so that value is captured by all actors that are part of the value network. A balanced choice increases the viability, feasibility and robustness of the business model design for a service.

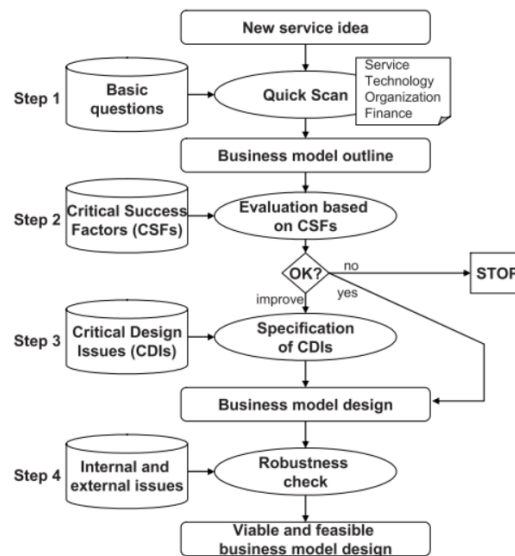


FIGURE 12: THE STOF METHOD (BOUWMAN ET AL., 2008)

The STOF model can be used to assess how a business model is impacted by external factors and which adaptations are required to maintain a fit with its competitive and macro-environment over time. Figure 13 on this page provides a graphical representation of this process. In the STOF model, the following three types of external factors are distinguished:

- Market drivers: Suppliers, customers and competitors;
- Technology drivers: Changing technology and innovations;
- Regulation drivers: Regulation related to privacy, intellectual property rights, competition and other subjects.

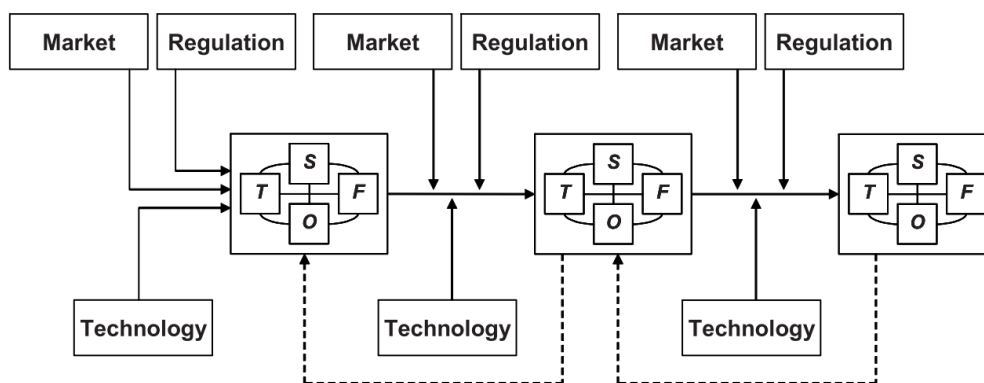


FIGURE 13: THE EXTERNAL FIT OF THE BUSINESS MODEL WITH ITS DYNAMIC ENVIRONMENT OVER TIME

### 2.5.4.3 The VISOR Model (El Sawy & Pereira, 2013)

El Sawy and Pereira (2013) propose a business model ontology for IT-intensive business models with five components that are classified as follows: “Value proposition”, “Interface”, “Service Platform”, “Organizing Model” and “Revenue Model”. The VISOR Model aims to integrate different business model development approaches and describe service provision or product delivery in a so-called “networked digital industry”. A successful business model should align the five components, in order to maximize the value proposition (which justifies a higher price setting), while minimizing the costs of service provision (which is realized by the alignment of the interface, service platform and organizing model) (El Sawy & Pereira, 2013), this is depicted in Figure 14 on page 42.

The VISOR Model describes five components, called business model drivers, that describe what value is delivered to the customer and how a profit can be made by doing so in a so-called “networked digital industry”. The five business model drivers are (El Sawy & Pereira, 2013):

- **Value Proposition:** This driver describes why customer segments value a firm’s products or services and why they would be willing to pay for them. It describes the value that is created by satisfying a customer demand. The following descriptors are provided for this driver: compelling, cohort, complementarity and co-creatability (El Sawy & Pereira, 2013).
- **Interfaces:** This driver describes the interaction between the customer experience and the service platform in terms of software and hardware. The interface should generate a “wow” experience, be easy to use, simple, convenient and generate positive energy. The following descriptors are provided for this driver: functionality, form factor, fluidity and forgiveness (El Sawy & Pereira, 2013).
- **Service Platform:** This driver describes the IT platforms that facilitate the business processes and relationships that are needed for the provision of products and services and improving the value proposition. It is important to be aware of the technology infrastructure of the platform ecosystem in which a service is delivered. Choosing a service platform is of strategic importance. The following descriptors are provided for this driver: architecture, agnosticity, acquisition and access (El Sawy & Pereira, 2013).
- **Organizing Model:** This driver describes how business partners will organize processes, value chains and partner relationships to deliver products and services efficiently and effectively in a turbulent environment. These partners can be complementors, competitors, customers and a community. The following descriptors are provided for this driver: processes, partnerships, pooling and project management (El Sawy & Pereira, 2013).
- **Revenue Model:** This driver describes how the value proposition, service provision, product delivery and IT investments are arranged in such a way that the revenues cover the costs and is attractive to all business partners. The following descriptors are provided for this driver: pricing, partner revenue sharing, product cost structure and potential volume (El Sawy & Pereira, 2013).

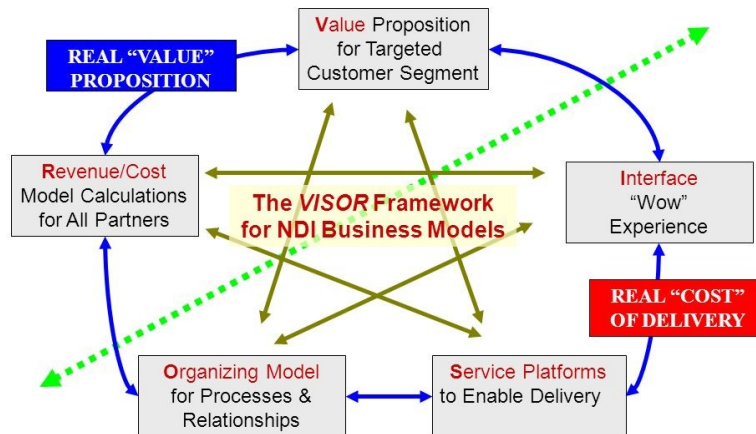


FIGURE 14: THE VISOR MODEL (EL SAWY & PEREIRA, 2013)

### 2.5.5 Conclusion

In this section, the business model ontology that is most suitable for describing the reference business model will be chosen. Table 9 on page 43 provides an overview of the comparison between the ontologies.

The Business Model Canvas is well-known and facilitates a relatively straightforward visualization of the logic of business models. Because the selected business model ontology will be used for the analysis in a business model stress test workshop, the low degree of complexity and the fact that the ontology is well-known are taken into consideration. It will reduce the time that is needed for elaboration during the workshop and increase the likelihood that the participants have similar interpretations of the ontology. This will increase the quality of the workshop results. However, the Business Model Canvas has been developed as a representation of choices regarding strategy and marketing in which the individual firm is the unit of analysis (Bouwman et al., 2012). This focus on the individual firm makes it less suitable for the analysis of a service that is delivered by a network of business actors. Besides, the framework provides little insight into the technological aspects of service delivery in a networked environment. Therefore, it is not pre-eminently suitable for describing the reference business model and analysing the impact of blockchain technology on this model.

The VISOR Model is suitable for describing service provision or product delivery in a so-called “networked digital industry” (El Sawy & Pereira, 2013) and provides more insight into the technological aspects of service delivery than the Business Model Canvas. Therefore, it is more suitable for describing the reference business model than the Business Model Canvas. However, the ontology is relatively new and less known than the Business Model Canvas and therefore requires more elaboration in the workshop.

The STOF method is often used for the analysis of innovative technologies (Bouwman, Heikkilä, Heikkilä, Leopold, & Haaker, 2017) and it is most suitable for exploring new service ideas. It has specifically been developed as a tooling-focussed design method for ICT-enabled services, where the service that is delivered by a value network is the unit of analysis (Bouwman et al., 2012). Besides, it includes the most detailed analysis of the technology architecture and technology design issues.

Therefore, this ontology is most suitable for describing the reference business model. This ontology is lesser-known and more complex than the Business Model Canvas and therefore requires more elaboration in the workshop.

TABLE 9: COMPARISON OF THE BUSINESS MODEL ONTOLOGIES

Business model ontology	Components	Industry	Strength(s)	Weakness(es)
<b>Business Model Canvas</b>	<ul style="list-style-type: none"> <li>• Key Partnerships;</li> <li>• Key Activities;</li> <li>• Key Resources;</li> <li>• Value Propositions;</li> <li>• Customer Segments;</li> <li>• Customer Relationships;</li> <li>• Channels;</li> <li>• Cost Structure;</li> <li>• Revenue Streams.</li> </ul>	Generic	<ul style="list-style-type: none"> <li>• Well-known ontology with a low degree of complexity;</li> <li>• Facilitates strategic analysis of individual firm;</li> <li>• Visually supports discussions on business model design.</li> </ul>	<ul style="list-style-type: none"> <li>• Limited description of design variables;</li> <li>• Less suitable for analysis of a service that is delivered by a network of actors;</li> <li>• Limited guidance on technological aspects of service delivery.</li> </ul>
<b>STOF Model (selected for the reference business model)</b>	<ul style="list-style-type: none"> <li>• <b>Service domain;</b></li> <li>• <b>Technology domain;</b></li> <li>• <b>Organization domain;</b></li> <li>• <b>Finance domain.</b></li> </ul>	ICT services	<ul style="list-style-type: none"> <li>• <b>Tooling-focussed design method for innovative ICT-enabled services;</b></li> <li>• <b>Includes a detailed analysis of technology-related design issues and a description of the technology architecture;</b></li> <li>• <b>Detailed description of design variables, CDIs and CSFs.</b></li> </ul>	<ul style="list-style-type: none"> <li>• <b>The ontology is more complex and less known than Canvas.</b></li> </ul>
<b>VISOR Model</b>	<ul style="list-style-type: none"> <li>• Value Proposition;</li> <li>• Interfaces;</li> <li>• Service Platform.</li> <li>• Organizing Model.</li> <li>• Revenue Model</li> </ul>	ICT services	<ul style="list-style-type: none"> <li>• Provides guidance on technology-related choices;</li> <li>• Includes network analysis.</li> </ul>	<ul style="list-style-type: none"> <li>• The ontology is less known than Canvas;</li> <li>• Compared to STOF, the model provides a less detailed insight into the technological aspects of service delivery.</li> </ul>

### 2.5.6 Business model tooling: stress testing in a dynamic environment

Now the business model ontology for describing the reference business model has been chosen, a method for determining the impact of blockchain on this model has to be found. This method will determine the sustainability of this model in its future environment. In order to be sustainable, a business model should “fit” within its external environment, as this environment changes, the business model might require adaptation in order to maintain its sustainability (Morris et al., 2005). External factors that impact the business model can be summarized into: market factors, technology factors and regulation factors (Bouwman et al., 2008).

In this study, scenarios describe possible future developments for an insurance firm, they are not future predictions. Scenarios analysis are particularly useful in situations where decision makers are confronted with a high level of uncertainty in future developments; it helps them to anticipate the impact of future developments on their business models. Relevant developments that can be found in previous research can be used to determine the primary axes along which the scenarios are described (Bouwman, Faber, & Van der Spek, 2005; Pateli & Giaglis, 2005; Van der Heijden, 1996). Scenario analysis should be: complete (at least two scenarios should be included), plausible, internally consistent, relevant to the issues of concern to the client and they should lead to an original perspective on the problem under study (Van der Heijden, 1996).

The business model concept can be used as a tool for managing business model change in which firm performance is sustained by maintaining consistency among the components of the business model in a dynamic environment. The static representation of the business model could serve as a common ground for a discussion with stakeholders on how the business model will continuously evolve in the future (Demil & Lecocq, 2010). Demil and Lecocq (2010) provide the following three main tasks for managing business model dynamics:

- A regular analysis of the environment for risks and uncertainties that could permanently impact the business model of the firm;
- A systematic analysis of how internal and external changes could impact the business model of the firm;
- Implement actions in order to maintain the consistency between the business model components in order to maintain or improve firm performance.

Several scholars changed their focus from business model definitions, its elements, typologies and conceptual frameworks to more concrete tooling; an important application of these tools is the assessment of the impact of changes in the external environment on the reference business model of a firm or an industry (Bouwman et al., 2012; Cavalcante, 2013; De Reuver et al., 2013; Pateli & Giaglis, 2005). A specific approach in this field of study is using the combination of business model design frameworks and scenario analysis to come to a structured approach towards evaluating business model change in a changing, uncertain business environment. These approaches evaluate the impact of multiple alternative scenarios for business model change under the impact of the technological development under study (Bouwman et al., 2012; Pateli & Giaglis, 2005).

Pateli & Giaglis (Pateli & Giaglis, 2005) propose the following methodology consisting of three phases and six steps:

- *Phase I: Understand*

- *Step 1. Document the Current Business Model:*

An analysis of the existing business model is required to understand the situation against which the impact of technology innovation will be assessed. The business model will be depicted by using an existing business model framework.

- *Phase II: Identify Technology's Influence*

- *Step 2. Assess the influence of technology innovation:*

In this step, the impacts that a technology could have on the key elements of the business model will be identified.

- *Step 3. Identify missing roles:*

In this step, requirements for one or multiple roles that fulfil a new business function will be identified. This forms the basis for forming partnerships, as a single firm is often not able to deliver an end-to-end service on its own.

- *Phase III: Change*

- *Step 4. Define Scenarios:*

In this step, a set of scenarios with different ways for cooperation between new and existing business partners will be defined. This step helps the firm to experiment with different future business model configurations.

- *Step 5. Describe the New Business Models:*

Based on the set of scenarios from step 4, the current business model can be changed. In this step the exchange of value and information will be described.

- *Step 6. Evaluate the Impact of Changes:*

The business model descriptions from step 5 can be used to estimate the impact of the changed business model on the structure and dynamics of the market in which the firm operates.

Bouwman et al. (Bouwman et al., 2012) propose a tool for testing the robustness of business models in the long-term; the tool is called business model stress testing and aims for testing the viability and feasibility of business models against changes in the environment. A viable business model creates customer value and enables the firm to capture value from it (this refers to long-term profitability), a feasible business model delivers as it is intended (this refers to barriers to market adoption) (Bouwman et al., 2012; Bouwman et al., 2008). Business model stress testing validates the strong and the weak parts of business models by means of scenario analysis. The testing results in a heat signature that

indicates the robustness of a business model when it is confronted with scenarios that describe uncertain future developments (Bouwman et al., 2012). The stress test provides a structured approach consisting of six steps (Bouwman et al., 2012):

1. Selection and description Business Model: The first step that is to be taken is the selection of a of business modelling approach with enough richness to facilitate a meaningful analysis.
2. Selection of uncertainties: In this step, the uncertainties against which the business model will be tested are selected. They can be selected from publicly available sources, or they can be determined with domain experts. The selection should be limited and proper in order to keep the stress test manageable.
3. Mapping of Business Model to uncertainties: A clear picture of how the selected uncertainties relate to the different components of the business model is constructed.
4. Heat Signature:
  - Red: Possible showstopper: it should be addressed from a strategy perspective;
  - Yellow: Negative or positive cannot not be excluded: attention is required;
  - Green: No negative impact;
  - Grey: No relevant impact.
5. Analysis: In this step the 'Heat Map' will be analysed in order to find gain more insight into the weak points of the business model; explanations of why certain choices in the business model result in weak points can be used for improving the robustness of the business model.
6. Conclusions: Based on the insights that are gained from the previous step, recommendations can be made that will address the weak points and improve the consistency of the business model.

### 2.5.6.1 Determining the boundaries of the business model

An important step in business model analysis is determining the level of detail that is represented by the model; a full representation of the business model, if even feasible, is likely to result in a high level of complexity that will not help a researcher in overseeing possible choices and their consequences (Casadesus-Masanell & Ricart, 2010). Casadesus-Masanell and Ricart (2010) present two ways of reducing the level of detail of the model which increase its practicality:

- **Aggregation:** Some choices and consequences can be grouped, in order to reduce the level of detail and complexity. However, a balance should be struck between reducing complexity to realize an overall understanding of how the model works and losing important details. This can be done by selecting the key choices and connecting the main consequences by using theories, beliefs or assumptions. This results in a business model representation of the interaction of the most important elements.
- **Decomposition:** Choices and consequences that do not interact can be analyzed separately; in this case it might be sufficient to only represent a part of the firm's business model.

Cavalcante et al. (2011) describe how two requirements of the business model, providing a stable basis for decision making in the firm, while being flexible enough to deal with dynamics in technological innovation and the market, are linked to each other. They apply a process-based strategic abstraction to the business model concept (Cavalcante et al., 2011):

- Only the core standard processes are included, these processes are crucial to the business and take place continuously.
- A detailed description of process operationalization is not required.
- Processes which do not yet exist also should be considered, as they could have a lot of potential for business model improvements.

The first point implies that only the business model components that can be described by its underlying processes should be included in the business model representation; this rule helps identifying possibilities for changes in the business model and the impact of these changes. The repeated core standard processes therefore determine the boundaries of the business model under study, as changes in these processes imply a change in the reference business model. This means that not all changes lead to business model changes, which conserves the business model's function of stable basis for decision making. The degree of disruption that a change represents to an individual firm is determined by its impact on its core processes (Cavalcante et al., 2011).



### 2.5.6.2 Conclusion

From the scenario analysis tools that have been described in section 2.5.6, a general six-step approach for business model stress testing can be derived:

1. Select a business model ontology to describe the reference business model within the boundaries of the core standard service processes with a sufficient richness to allow for a meaningful analysis.
2. Select the uncertainties against which the different components of the business model will be tested.
3. Describe how the selected uncertainties relate to the key components of the business model.
4. Estimate the future impact of the selected uncertainties on the different components of the business model and construct a heat map.
5. Analyze the heat map in order to gain insight into the weak points of the business model in order to improve the robustness of the business model under the future impact of blockchain technology.
6. Based on the insights that were gained in step 5, recommendations can be made to business managers in insurance firms that will help to improve the consistency of the business model.

### 3 Methodology

This chapter describes the research methodology that has been followed in this research project; it followed a qualitative approach and used both primary and secondary data sources. The objective of this research is helping business decision makers to anticipate the impact of blockchain technology on their business models, by finding the most important parts of the business model that need to be addressed. In order to realize a satisfactory level of depth of analysis and a holistic view on the business model, several methods and sources were used for intensive data generation. This approach is called triangulation of methods and sources (Verschuren & Doorewaard, 2010; Yin, 2009).

Table 10 on this page and the next page provides an overview of the steps that have been taken in this research project. The steps follow from the six-step approach that can be found in section 2.5.6.2 on page 48.

**TABLE 10: THE SIX-STEP APPROACH FOR BUSINESS MODEL STRESS TESTING**

Step	Data source(s)	Output
<b>1.a. Select a business model ontology.</b>	Business model literature	A business model ontology that is most suitable for describing the reference business model, see section 2.5.5 on page 42
<b>1.b. Describe the reference business model.</b>	Desk research	<ul style="list-style-type: none"> <li>• An initial analysis of the impact of blockchain and the most important components of the reference business model, see section 2.4 on page 26;</li> <li>• The interview protocol for semi-structured expert interviews, see appendix B1 on page 126;</li> <li>• The core standard insurance processes, see workshop design in section 4.2.2 on page 82.</li> </ul>
	Semi-structured expert interviews	<ul style="list-style-type: none"> <li>• An initial analysis of the impact of blockchain and the most important components of the reference business model, see section 4.1.2 on page 75;</li> <li>• A selection and description of the most important components of the reference business model. See workshop design in section 4.2.2 on page 82.</li> </ul>
<b>2. Select the uncertainties for the stress test.</b>	Desk research	<ul style="list-style-type: none"> <li>• An initial analysis of the uncertainties, see section 2.4 on page 26;</li> <li>• The interview protocol for semi-structured expert interviews, see appendix B1 on page 126.</li> </ul>
	Semi-structured expert interviews	A selection and description of the most important uncertainties, see section 4.2 on page 79.
<b>3. Relate the selected uncertainties to the key components of the business model.</b>	Business model stress test workshop	<ul style="list-style-type: none"> <li>• A heat map with in which different colours indicate the expected impact of the selected uncertainties on the reference business model;</li> <li>• A description of the impact of the selection uncertainties on the components of the reference business model.</li> </ul>
<b>4. Estimate the future impact of the selected uncertainties and construct a heat map.</b>		
<b>5. Analyse the heat map and find weak points of the business model.</b>	Business model stress test workshop	An overview of the components of the reference business model that have to be addressed.

Step	Data source(s)	Output
6. <b>Make recommendations to improve the business model.</b>	Business model stress test workshop	Based on the insights that are gained from the previous step, recommendations can be made that will address the weak points and improve the robustness of the business model.

### 3.1 Interviews

This section describes how the primary data has been collected by conducting semi-structured expert interviews. Blockchain is an emerging technology and its development is associated with a large degree of uncertainty, therefore the focus of this research is on gathering and analyzing insights of experts from various organizations. The interviews have been used for an initial analysis of the impact of blockchain, the most important components of the reference business model and the most relevant uncertainties. The protocol that guided the interviews can be found in appendix B1 on page 126. The protocol is based on the results of a desk research which can be found in section 2.4 on page 26. The insights that were gained from this initial analysis have been compared with the results from the desk research and served as an input for the next stage of the research, the business model stress test.

The interviews took between one and one and a half hour and were semi-structured; the interview protocol describes the topics of discussion, but additional questions might arise during the course of the interview. The interviews have been recorded and transcribed, this reduced the chances for error in making notes and did not rely on the memory of a single researcher. As the interviews were semi-structured, the interviews were not identical and attention had to be paid to limiting the differences in the topics which were discussed; otherwise, the information that can be deducted from the interviews from them varies greatly. That would negatively impact the comparability and the possibility to validate the different sources of information by triangulation. An important step in mitigating this problem was sending the interview protocol together with the invitation to the interviewees. Next to describing the topics that will be discussed, it introduces the research and summarizes blockchain characteristics. This helped to structure the thoughts of the interviewees and increased the comparability of their answers.

### 3.1.1 Selection of the interviewees

Interviewees were selected based on the relevance of their experience to solving the research problem; the selection was made in consultation with the supervisor of PwC Netherlands as well as the first supervisor of Delft University of Technology. This selection procedure contributed to the diversity of the interviewees, as they are not selected from a single business network. The key selection criterium was expertise in the use of blockchain technology in the insurance industry. The selection of interviewees represents four different sectors that are considered to be relevant to the implementation of blockchain technology in the insurance industry: insurance, IT consultancy, financial services consultancy and insurance standardization. This selection of interviewees generated insights from different points of view: business, technology and a combination of those two respectively. The interviews were conducted at the offices of the organizations. An overview of the interviewees is provided by Table 11 on page 52.

The identities of the interviewees have been anonymised, but are known by the supervisor of PwC Netherlands as well as the first supervisor of Delft University of Technology.

#### *Insurance*

Four employees (interviewee no. 1, 2, 4 and 8) of three different large Dutch insurers have been interviewed, the fact that these firms operate in the same national market controls for differences in market circumstances and regulations that the firms have to comply with. The interviewees are closely involved in the exploration of blockchain technology in their organizations and they all have an IT background. The years of experience of these interviewees represent the years that they have been working in the insurance industry. These interviewees contributed to this research by using their experience in and knowledge of both blockchain and the insurance industry.

#### *IT consultancy*

Three founders (interviewee no. 5, 6 and 7) of three different small Dutch IT consultancy firms have been interviewed. They are experienced in helping corporates with exploring the potential of blockchain technology in their business. More specifically, they already have explored several insurance cases. The years of experience of interviewees 6 and 7 represent the years that they have been working in the IT industry. The years of experience of interviewee 5 represents the years that he has been working in the insurance industry. Blockchain technology is in an experimental stage of development, therefore these technology experts contributed to this research by providing up-to-date and in-depth knowledge on blockchain technology and entrepreneurial experience in exploring blockchain use cases in insurance.

#### *Financial services consultancy*

One employee (interviewee 3) of a large Dutch financial services consultancy firm has been interviewed. The years of experience of this interviewee represent the years that he has been working in the insurance industry. This interviewee contributed to this research by using his experience with and knowledge of both blockchain technology and the insurance industry.

### Standardization institute

One executive (interviewee 5) of a Dutch insurance standardization institute has been interviewed. The years of experience of this interviewee represent the years that he has been working in the insurance industry. This interviewee contributed to this research by using his experience with and knowledge of data exchange and interoperability in the insurance industry and blockchain technology.

### 3.1.2 Analysis

The interviews have been recorded, transcribed and coded in qualitative data analysis software (ATLAS.ti). This facilitated an in-depth analysis of 53 pages of transcriptions. The interviews were conducted in Dutch, but English summaries can be found in appendices B2 on page 130 to B8.

TABLE 11: OVERVIEW OF THE INTERVIEWEES

Interview no.	Interviewee no.	Sector	Position	Experience (in years)	Organization
1	1	Insurance	Manager IT	12	Large Dutch insurer A
	2	Insurance	DevOps Engineer	14	Large Dutch insurer A
2	3	Financial services consultancy	Director	26	Large Dutch consultancy firm
3	4	Insurance	Lead IT architect	29	Large Dutch insurer B
4	5	Insurance	<ul style="list-style-type: none"><li>• Founder</li><li>• Executive</li></ul>	30	<ul style="list-style-type: none"><li>• Small Dutch blockchain consultancy firm A;</li><li>• Dutch insurance standardization institute.</li></ul>
5	6	IT consultancy	Founder	10	Small Dutch emerging IT consultancy firm
6	7	IT consultancy	Founder	2	Small Dutch blockchain consultancy firm B
7	8	Insurance	R&D director	13	Large Dutch insurer C

## 3.2 Business model stress test workshop

This section provides a description the participants and time schedule of the business model stress-test workshop.

### 3.2.1 Participants

The aim of the workshop was the participation of all interviewees. Therefore, the interview protocol that was sent together with the invitation to the interviewees introduced the workshop to them. Besides, the interviewees were invited at the end of the interview. This was done well in advance of the workshop, however, interviewee 1, 3 and 5 were not available for the workshop. They were not able to find time in their busy schedules for the workshop that takes at least four hours excluding travel time. Table 12 on this page compares the interview and workshop participants. It can be concluded from this table that large Dutch insurer C and the Dutch insurance standardization institute were not represented in the workshop. The bold text in this table shows the differences in group compositions. The workshop participants who were not interviewed and only participated in the workshop are labelled “workshop participant”. Table 13 on page 54 provides an overview of this group. The years of experience of these interviewees represent the years that they have been working in the insurance industry. These interviewees contributed to this research by using his experience with and knowledge of both blockchain technology and the insurance industry.

TABLE 12: COMPARISON OF INTERVIEW AND WORKSHOP GROUP COMPOSITIONS

Interview group composition	Workshop group composition
Interviewee no. 3 <ul style="list-style-type: none"> <li>Large Dutch consultancy firm A</li> </ul>	<b>Workshop participant no. I and II</b> <ul style="list-style-type: none"> <li><b>Large Dutch consultancy firm A</b></li> </ul>
Interviewee no. 1 and 2 <ul style="list-style-type: none"> <li>Large Dutch Insurer A</li> </ul>	<b>Interviewee no. 2</b> <ul style="list-style-type: none"> <li><b>Large Dutch insurer A</b></li> </ul>
Interviewee no. 6 <ul style="list-style-type: none"> <li>Small Dutch emerging IT consultancy firm A</li> </ul>	Interviewee no. 6 <ul style="list-style-type: none"> <li>Small Dutch emerging IT consultancy firm</li> </ul>
Interviewee no. 7 <ul style="list-style-type: none"> <li>Small Dutch blockchain consultancy firm A</li> </ul>	Interviewee no. 7 <ul style="list-style-type: none"> <li>Small Dutch blockchain consultancy firm</li> </ul>
Interviewee no. 4 <ul style="list-style-type: none"> <li>Large Dutch insurer B</li> </ul>	<b>Interviewee no. 4 and workshop participant no. III</b> <ul style="list-style-type: none"> <li><b>Large Dutch Insurer B</b></li> </ul>
Interviewee no. 5 <ul style="list-style-type: none"> <li>Small Dutch blockchain consultancy firm A;</li> <li>Dutch insurance standardization institute.</li> </ul>	<b>Workshop participant no. IV</b> <ul style="list-style-type: none"> <li><b>Small Dutch blockchain consultancy firm A</b></li> </ul>
Interviewee no. 8 <ul style="list-style-type: none"> <li>Large Dutch insurer C</li> </ul>	<b>Not available</b>

**TABLE 13: OVERVIEW OF THE WORKSHOP PARTICIPANTS**

Workshop participant no.	Sector	Position	Experience (in years)	Organization
I	Financial services consultancy	Manager	9	Large Dutch consultancy firm
II	Financial services consultancy	Senior manager	15	Large Dutch consultancy firm
III	Insurance	Lead consultant	20	Large Dutch insurer C
IV	Insurance	Founder	29	Small Dutch blockchain consultancy firm A

### 3.2.2 Time schedule and stress test group composition

Appendix C on page 162 provides a time schedule of the business model stress-test workshop and the supporting activities that had to be done. The time schedule follows from the six-step approach that can be found in section 2.5.6.2 on page 48.

As the group of workshop participants was considered impractically large for the stress testing, the group was divided in two, the composition can be found in Table 14 on this page. In this division, attention was paid to the creation of a diversity of backgrounds. The stress-test of group 1 was hosted by Laurens Klomp (the researcher), the stress-test of group 2 was hosted by dr. Timber Haaker (senior advisor at InnoValor and senior researcher at Delft University of Technology). Dr. Timber Haaker is an experienced researcher in the field of business model stress testing and is knowledgeable on blockchain technology. Because the time that was available for the stress test was limited, the groups analysed the impact of the selected uncertainties in opposite directions. This decreased the chance that some parts of the heat map would not be covered due to time constraints.

**TABLE 14: STRESS TEST GROUP COMPOSITION**

Group 1 (heat map from left to right)	Group 2 (heat map from right to left)
Workshop participant no. I	Workshop participant no. II
Workshop participant no. III	Interviewee no. 2
Workshop participant no. IV	Interviewee no. 4
Interviewee no. 6	Interviewee no. 7
Laurens Klomp (workshop host and researcher)	Timber Haaker (workshop host)

The selection of the uncertainties (stress factors) and the design of the reference business model will be described after the analysis of the interviews in chapter 4.

# 4 Results

## 4.1 Interviews

### 4.1.1 Results of the interviews

This section describes the analysis of the results of the interviews that have been guided by the interview protocol that can be found in appendix B1 on page 126.

This analysis presents an overview how blockchain-related regulatory and technological uncertainties, blockchain value propositions, insurers' resources and capabilities and macro-environmental developments impact the insurers' business model. A graphical overview of the overall structure that has been found in this analysis can be found in Figure 15 below.

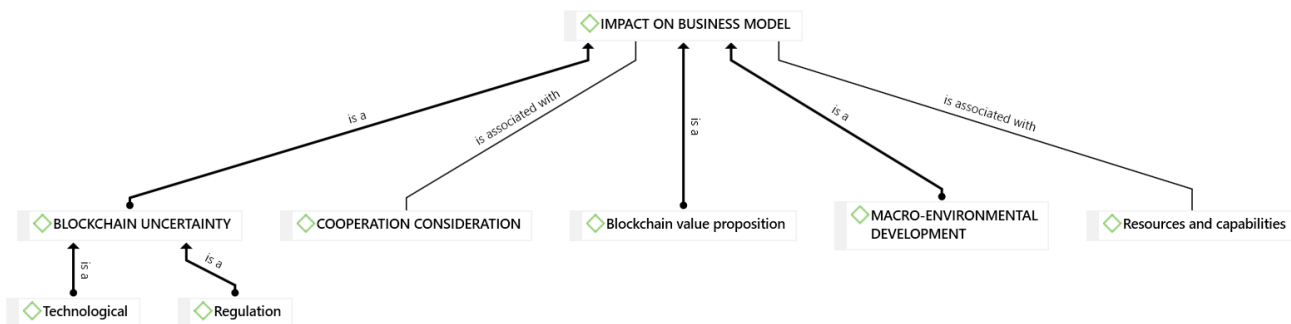


FIGURE 15: OVERALL STRUCTURE OF THE ANALYSIS

#### 4.1.1.1 Macro-environmental developments in the insurance industry

This section describes the macro-environmental developments that have an impact on the insurers' business model. A graphical overview of the macro-environmental components and their relationships can be found in Figure 16 on page 58.

#### A. Use of technology results in decreasing premiums received in non-life insurance

Recent technological developments reduce the insurability of objects, which results in a decrease of premiums received in non-life insurance. In this regard, the emergence of cars that are equipped with a large number of connected sensors (often referred to as the “Internet of Things”) and in some cases, are self-driving, is seen as an important factor. Not only are these cars able to reduce damage in case of an accident, but also to prevent accidents from happening at all. In a competitive market, the reduction of risks results in lower premiums (Interviewee 3, 2017; Interviewee 4, 2017; Interviewee 5, 2017). Several car manufacturers are starting to offer insurances for their products, as the risk of damage is decreasing by the use of sensors and self-driving capabilities (Interviewee 4, 2017; Interviewee 5, 2017). The statement that 50% of the revenue of non-life insurance is generated by car insurance stresses the importance of this factor (Interviewee 3, 2017). Further reasons for decreasing premiums received are increased traceability of so-called “smart products” (which prevents theft), a reduced number of insurable objects as a result of the emergence of the so-called “sharing economy” and finally the development of 3D printing (which makes it easier to replace objects)(Interviewee 4, 2017).



## **B. Gaining market access**

Insurers are transforming into multi-channel organizations (Interviewee 1 & Interviewee 2, 2017; Interviewee 5, 2017), as insurers are struggling financially, they try to gain access through various channels such as intermediaries, directly and through banks. Insurers are developing portals to support this transformation (Interviewee 5, 2017). An additional reason for insurers to think about future market access is that they could lose a part of their customer relationships due to PSDII (Interviewee 3, 2017). Interviewee 1 and Interviewee 2 (2017) state that foreign investors are interested in how insurers are using a multi-channel approach to deal with a saturated market. The statement that the Dutch insurance market is saturated is supported by Interviewee 5 (2017).

Insurers increasingly offer multiple labels to facilitate a finer-grained segmentation and personalized service offerings (Interviewee 1 & Interviewee 2, 2017; Interviewee 5, 2017). They increasingly try to position their brands for specific target customer groups by optimizing actuarial processes, while reaping the benefits from the shared platform of the main organization (Interviewee 5, 2017). The freedom of choice that this specific targeting offers might seem to benefit the customer, however it contradicts the principle of solidarity (Interviewee 4, 2017; Interviewee 5, 2017); customers who know how to compare insurances will pay lower premiums. Besides, comparison websites enable the insurers to attract a specific group of customers who they consider to be attractive (Interviewee 5, 2017).

## **C. Declining sales of life insurance policies**

Life insurance policies used to be important money-makers for insurers, less of these policies have been sold in recent years due to changes in regulations and reduced consumer trust caused by mis-sold unit-linked insurances. Insurers have large, declining portfolios of these policies, the so-called “closed-book portfolios” (Interviewee 3, 2017; Interviewee 5, 2017). Costly systems are needed for the administration of these portfolios, reducing the costs of this administration is the only thing insurers can do to improve this situation (Interviewee 3, 2017). The declining sales reduces the amount of capital that insurers can invest and therefore reduces the interest they receive (Interviewee 5, 2017).

## **D. Low interest rates**

The current revenue model of insurers consists of two parts. The first part is a profit on daily operations, this is the case when premiums received exceed the sum of the incurred losses and expenses (Interviewee 4, 2017; Interviewee 5, 2017). The second part is interest on investments that are made with premiums received (Interviewee 1 & Interviewee 2, 2017; Interviewee 4, 2017; Interviewee 5, 2017; Interviewee 8, 2017). The most important income source of insurers is this interest, next to the declining number of sold life insurance policies, this source also has been declining because of low interest rates (Interviewee 5, 2017). This view is supported by Interviewee 8 (2017), who states that the revenue model of insurers always has been based on collecting and investing premiums. The current financial climate is not as attractive as it used to be and government yields are considerably lower.

### **E. Financial crisis**

In general, the financial crisis has severely worsened the financial position of the insurers (Interviewee 5, 2017).

### **F. Innovating for current customer base reduces profitability**

Innovation is difficult for insurers, as new value propositions always are price-driven; when new value propositions, based on new actuarial data, are offered to the customer base, the profitability of this customer base decreases. This is a crucial problem which leads to competition, as insurers will offer better value propositions to new customers. This is enforced by the fact that customers are price sensitive and insurances are substitutable, comparable and low involvement products. Therefore, it is hard to justify the costs of innovation for the current customers (Interviewee 5, 2017).

### **G. Solvency II requirements**

Solvency describes an organizations' ability to meet its long-term financial obligations. European regulation requires insurers to increase their financial reserves (Interviewee 3, 2017; Interviewee 5, 2017). The decrease of consumer trust that is caused by the mis-sale of unit-linked insurance policies is an important driver for this stricter regulation. The reservations that insurers have to make to meet Solvency II requirements reduce the capital that insurers can invest and therefore reduces the interest they receive. In reaction to these reservations, insurers focus on cost reductions (Interviewee 5, 2017).

### **H. Disintegration of the value chain**

Insurers increasingly outsource activities of the insurance value chain (Interviewee 3, 2017; Interviewee 5, 2017). This development is also referred to as unbundling and describes a situation in which an increasing number of parties specialize in a part of the value chain; this part typically will be fulfilled in a both better and cheaper way. It threatens insurers in their current role, as their total role in the value chain will be reduced (Interviewee 5, 2017; Interviewee 7, 2017). An example of a part of the value chain that often is outsourced, to parties like CED, is claim handling. These parties offer economies of scale, steering and a pleasant customer journey (Interviewee 5, 2017).

### **I. Costly regulatory compliance**

As mentioned before, in reaction to Solvency II reservations, insurers focus on cost reductions. However, also the implementation cost of regulatory changes like Solvency II are very high. The IT agenda of insurers is being filled for 60 to 70% with the implementation of regulatory changes. Implementation costs are high because insurers have to deal with legacy IT systems; they use different IT systems that fulfil the same functionality. Insurers acknowledge the need for innovation, but this situation limits the possibilities for innovation; insurers are forced to focus on cost reductions. While some of these innovations, like data analysis, new actuarial models, peer-to-peer insurance and chatbots could actually reduce costs, it is difficult to invest in them (Interviewee 5, 2017).

Now the macro-environmental developments are described, the context in which insurers operate has become clearer. The next section is more specific to the application of blockchain in the insurance industry, it describes the considerations of insurers regarding cooperation.

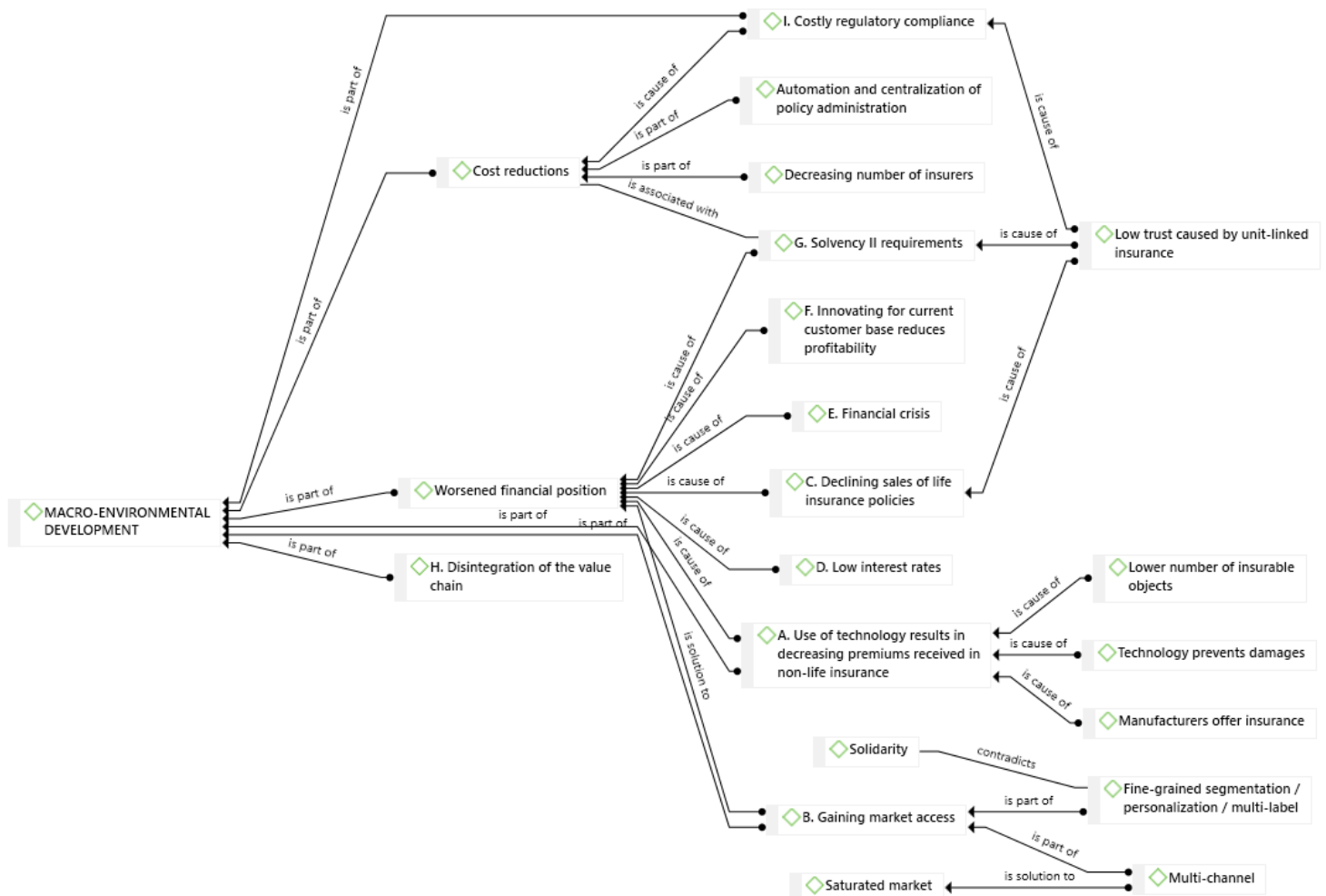


FIGURE 16: MACRO-ENVIRONMENTAL DEVELOPMENTS

#### 4.1.1.2 Cooperation considerations

A graphical overview of the cooperation considerations and their relationships can be found in Figure 17 on page 60.

#### A. Blockchain selection criteria

From the nature of blockchain technology, several selection criteria for potential use cases can be derived. One interviewee stated that in the short-term, business-to-business or consumer-to-consumer use cases will be the first to be realized, as in these cases the equality of the parties preserves Byzantine fault tolerance (Interviewee 8, 2017). However, also the state of development of blockchain technology determines the selection of the most potential use cases; one interviewee stated that the largest impact of blockchain is to be expected in business-to-business use cases, as the technology is not accessible, user-friendly and scalable enough for consumer applications (Interviewee 6, 2017). The interviewees seem to reach a large degree of consensus on the following, more specific, properties of potential blockchain use cases:

- *A1. Interdependency between transactions:*  
Blockchain is suitable for use cases in which (a large number of) interdependent transactions have to be facilitated (Interviewee 1 & Interviewee 2, 2017; Interviewee 3, 2017; Interviewee 5, 2017; Interviewee 8, 2017).
- *A2. Lack of full trust / need for intermediary:*  
Blockchain is suitable for use cases in which parties do not fully trust each other and often need an intermediary to establish trust (Interviewee 1 & Interviewee 2, 2017; Interviewee 3, 2017; Interviewee 6, 2017; Interviewee 8, 2017).
- *A3. Multiple parties exchange / edit data and share a single source of truth:*  
Blockchain is suitable for use cases in which parties exchange and/or edit data, this data should represent a single source of truth for all parties involved (Interviewee 1 & Interviewee 2, 2017; Interviewee 3, 2017; Interviewee 4, 2017; Interviewee 5, 2017; Interviewee 6, 2017; Interviewee 7, 2017; Interviewee 8, 2017).

### **B. Acquire knowledge**

Interviewee 1 and Interviewee 2 (2017) describe how they developed a prove of technology together with a blockchain consultancy firm. The main purpose of this endeavour was finding a way to explain blockchain technology in the insurance firm. They needed the external knowledge of the consultants and after a period of 6 weeks they were able to independently validate blockchain propositions.

Another interviewee, Interviewee 7 (2017) thinks that cooperative initiatives serve the purpose of acquiring knowledge and motivate people to develop new ideas. However, from his own experience, he can tell that these initiatives often do not go past the theoretical stage.

### **C. Exchange experiences and establish standards in a large value chain**

Interviewee 1 and Interviewee 2 (2017) state that it is very important to externally acquire knowledge from technology leaders, but also give those leaders something in return. Insurers can give technology firms validation on their experiments.

Blockchain can be seen as a collaborative technology which requires multiple parties for realizing a value proposition. An open approach toward other parties reduces the chances that the so-called “not invented here syndrome” will develop in a later stage (Interviewee 7, 2017). Interviewee 6 (2017) states that the very nature of blockchain is the reason that high potential use cases are to be found in situations in which numerous parties are working together, are exchanging data and have to share a single source of truth; these use cases call for standardisation. The importance of standardisation as a cooperation goal is also emphasized by Interviewee 8 (2017).

### **D. Large cooperation initiatives could slow down progress**

While blockchain, as a collaborative technology, typically can be exploited in multi-party settings, large cooperation initiatives have some drawbacks; parties are reluctant to share sensitive data and large initiatives tend to develop inertia (Interviewee 6, 2017; Interviewee 7, 2017). A possible solution could be that insurers first independently develop a product and approach other parties in a later stage of development. In this way, the initial development may take less time and parties may be more motivated to join the insurer’s product development. Innovation is a process of trial and error and

getting feedback, cooperation initiatives tend to spend too much time on just talking (Interviewee 7, 2017).

One interviewee, Interviewee 4 (2017), similarly describes that it is important to include enough parties to develop a valuable service, but also to ensure that the coordination of the cooperation does not get too complex. This balance also has to be found in the selection of the type of parties. The early involvement of parties like the tax authorities and regulators would increase the chances of a new service reaching the next stages of development, but only when the complexity of the cooperation does not severely slow down the development. The complexity that each party adds to the cooperation determines when it is the right moment to involve them.

### E. Lock-out

When a group of insurers decide to cooperate, they might reach a point on which they will not allow new members into the group. Joining cooperation might not only be relevant to stay up-to-date on the technology, but it could also prove to be strategically important to be a frontrunner. This lock-out effect could have a large impact on insurers (Interviewee 3, 2017). Another interviewee, Interviewee 8 (2017), also refers to a lock-out by mentioning that maximizing the number of insurers in a cooperation will reduce the competitive advantage of the existing group members.

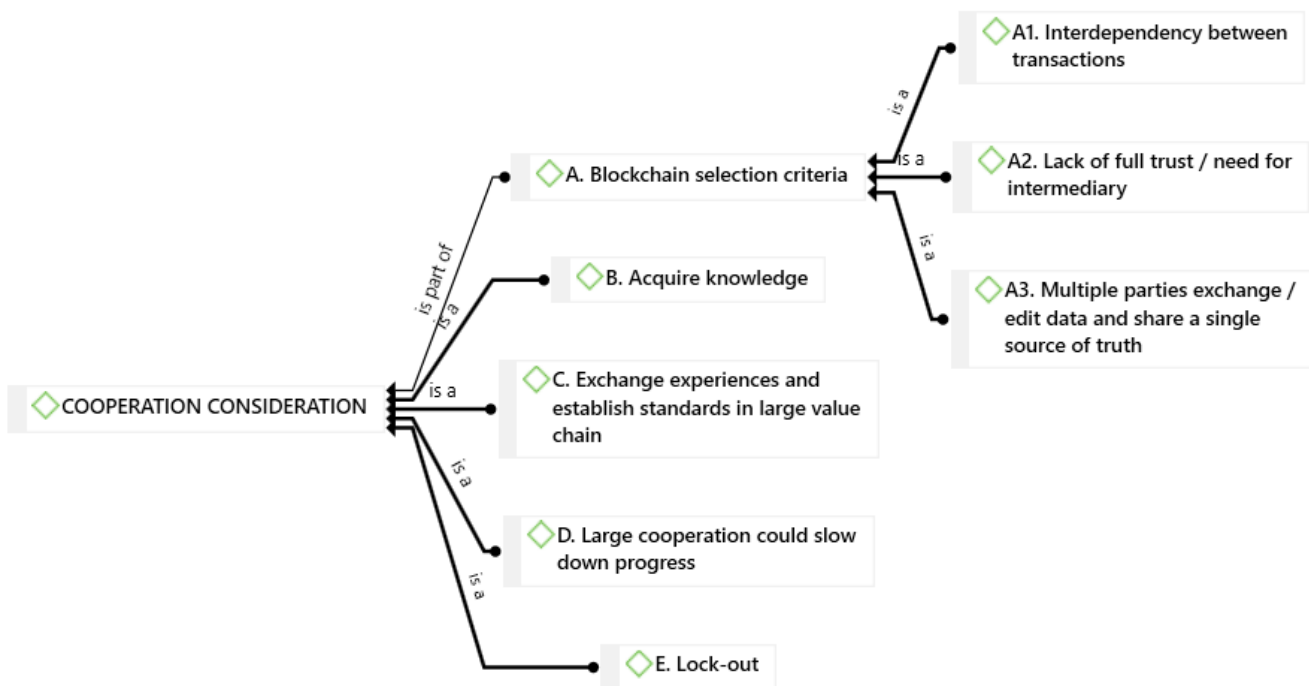


FIGURE 17: COOPERATION CONSIDERATIONS

This section provided insight into how the nature of blockchain technology shapes the cooperation considerations of insurers. The next two sections describe how uncertainties, which are more related to the early stage of development of blockchain, are perceived by insurers. It describes both the technological and regulatory uncertainties of blockchain.

#### 4.1.1.3 Technological uncertainties of blockchain technology

A graphical overview of the technological (and regulatory) uncertainties of blockchain technology can be found in Figure 18 on page 65.

##### **A. Governance**

Legislation of the European Union prohibits the storage of data of its inhabitants outside its geographical borders. When insurers use cloud services, the services provider has to guarantee that this requirement will be met, the same applies to Blockchain as a Service (BaaS) providers (Interviewee 3, 2017). By the nature of the technology, blockchain data is stored on multiple locations (Interviewee 3, 2017; Interviewee 4, 2017). This especially holds for public blockchains, but private and hybrid blockchains offer more options for control. The interviewees do not agree on the maturity of the technology in this regard. Two interviewees state that the technology is developing rapidly, it is likely that a blockchain technology will be developed that facilitates the creation of a zone in which data can be contained in a public blockchain. This development is driven by large companies like IBM (Hyperledger), Microsoft (Ethereum) and Intel (Ethereum). These companies created a blockchain consortium to answer the demand for enterprise-grade solutions. Their solutions already offer governance over the geographical location of data storage. The pace in which these solutions are developed is high enough to eliminate data governance as a barrier to implementation (Interviewee 1 & Interviewee 2, 2017). However, another interviewee states that at the moment, there are more than 700 cryptocurrencies and therefore blockchains; there is no clear winner among the blockchains, it is bleeding edge technology and there is a lack of governance (Interviewee 5, 2017). This point is supported by the notion of a fourth interviewee that insurers are experimenting in a sandbox, as they are not willing to take the risk of data leaks. He states that the required levels of security and predictability of data storage on multiple locations are not provided by the current state of blockchain technology. Developers are struggling with the selection and configuration of blockchains and it is not clear which low-level code knowledge is required to end this. However, it is expected that assembling blockchain applications will be easier in the future, as it will be possible to translate applications to a blockchain or virtual machine. This problem is relevant for governance, because compared to traditional configurations, it is harder to make changes to (public) blockchains once they are running; errors in blockchain applications often have financial consequences. It will be important to check whether smart contracts executed as intended, this will probably require a new IT-audit role for legal/domain experts and software experts (Interviewee 6, 2017).

##### **B. Privacy**

One interviewee states that in a blockchain data is stored on multiple locations and it is often used to improve data transparency, securing privacy by key management adds complexity and lowers performance (Interviewee 3, 2017). A second interviewee, Interviewee 5 (2017) confirms that blockchain has been developed to improve transparency of transactions across a network, but depending on the application, developers can choose whether it makes sense to increase the transparency of identities in a transaction. Therefore, according to this interviewee privacy as a concern is linked to transactions, not necessarily to blockchain. A third interviewee, Interviewee 6 (2017) describes that confusion exists on whether blockchains offer privacy and anonymity, in his view, when identities and accounts are linked together, blockchains are perfectly suitable for offering transparency. Whether this linkage intentionally takes place depends on the knowledge and skills of

the people involved. Regarding the state of development, this interviewee does not recommend to store private data on blockchains, as the technology is in its infancy and privacy solutions are being explored. This recommendation is supported by a fourth interviewee, Interviewee 7 (2017), who describes his experiments in an insurance company, these experiments took place in a so-called sandbox. In his view, this measure was necessary, because the level of privacy that can currently be offered by blockchain is not high enough to couple the blockchain to existing IT systems. This allows for freedom in early experiments, however this way of working postpones dealing with important challenges on the integration with existing IT systems. A fifth interviewee, Interviewee 8 (2017), describes that several large parties have roadmaps to guarantee privacy, however, these parties have not passed the proof of concept stage. They are still learning and there are no standard tools to guarantee privacy and offer transparency to the right parties in a blockchain, in his view, ideas are being developed faster than the technology. Two interviewees are less sceptic on the state of development regarding privacy, according to them, from a technical perspective, privacy is not a concern. In their experience, enterprise-grade solutions will be developed by large companies like IBM (Hyperledger), Microsoft (Ethereum) and Intel (Ethereum) when there is a demand for them (Interviewee 1 & Interviewee 2, 2017).

### **C. Identity and access management**

Identity and access management is very important in every exchange of value, besides, in a blockchain, data is stored in multiple locations, so access management should offer control of authorization for data access (Interviewee 4, 2017). It has been mentioned before in this section that identity and access management could enhance privacy by controlling the level of transparency that is offered in a blockchain, however this could add complexity and reduce performance. Identity and access management is relevant for meeting the requirements of GDPR, which gives customers more control over their data on a blockchain (Interviewee 3, 2017; Interviewee 8, 2017). Establishing an identity on a blockchain and exchanging personal attributes are often crucial to facilitate service offerings, therefore large parties like Dutch Digital Delta and TNO are looking into this (Interviewee 5, 2017). Identity and access management is a very important facilitator for every financial blockchain application, especially in the consumer market; insurers currently offer support when consumers experience difficulties, but current blockchain identity and access management solutions are not accessible, user-friendly and reliable enough to offer the same degree of support. For backend systems it is less of a problem if the (professional) user has to deal with keys (Interviewee 6, 2017). Two interviewees are sceptical about the potential of blockchain as a facilitator of identity and access management; solutions like iDin are already supported by many organizations, the added value of a blockchain solution is not clear and it would be a lesser-known and probably more complex solution (Interviewee 5, 2017). Another widely supported solution for giving users control over their data is LastPass (Interviewee 3, 2017).

#### **D. Security**

The fact that data on a blockchain is stored on multiple locations creates a security risk by increasing the susceptibility to surface attacks (Interviewee 3, 2017; Interviewee 6, 2017). Blockchain software in itself might not be unsecure, but the visibility and accessibility generally are greater than those of a closed system, so the impact of implementation errors can be rather large. Besides, blockchain is bleeding edge technology, it is not secure, it is not recommended to use a public blockchain other than the Bitcoin blockchain for value transactions. The fact that the Bitcoin blockchain has not been hacked to date indicates that it is secure enough for value transactions. However, securely running smart contracts on, for example, Ethereum is quite difficult (Interviewee 5, 2017). There are no off-the-shelf security solutions available and that it is rather difficult to develop them in-house, therefore it is advisable for insurers to experiment in so-called “sandboxes”. Choosing the most suitable blockchain from a scattered field of possibilities and configuring it is difficult for developers, they currently are developing on a low level, which increases the chances of creating bugs and security issues. Solutions for easier assembly of blockchain applications would help them with securely translating smart contracts to blockchain platforms (Interviewee 6, 2017). Solutions for more secure blockchain applications will be driven by market demand (Interviewee 6, 2017; Interviewee 7, 2017).

#### **E. Reliability**

It is not yet clear whether blockchain is suitable for insurance applications with typically long lifespans; this is uncertain, the life span of insurance products often exceeds the age of blockchain technology. Blockchain might be more suitable for applications in which settlement is reached, such as negotiation processes and claim handling (Interviewee 6, 2017).

#### **F. Legacy IT**

One interviewee states that legacy IT is problematic in the insurance industry, but despite low investments in rationalization (a process in which functionality that is currently provided by multiple applications will be provided by a single application), it will be completed within 20 years (Interviewee 5, 2017). A second interviewee confirms that existing IT systems of insurers consist of old systems that are linked together. A rationalization of these systems is needed to be able to respond more quickly to changes, this process is already taking place and will be completed within 5 to 10 years (Interviewee 3, 2017). A third and fourth interviewee confirm that legacy IT is a temporary problem, legacy IT is being replaced very quickly (Interviewee 1 & Interviewee 2, 2017). A fifth interviewee supports the notion that rationalization is taking place quickly in order to enhance the ability to react to changes in IT and convert data. This interviewee states that blockchain is incorrectly considered as a solution to the rationalization of legacy IT, it will be the other way around, it will be challenging to make (new) infrastructure blockchain compatible. Blockchain can be a driver for thinking about how systems can be developed to support decentralization, a division of roles and agility (Interviewee 6, 2017).



## **G. Quantum computing**

It is hard to assess the impact of quantum computing on the development of blockchain technology in insurance; quantum computing is in a very early stage of development, but it will put requirements on encryption (Interviewee 1 & Interviewee 2, 2017; Interviewee 5, 2017; Interviewee 6, 2017). Over time, the development of quantum computing will drive the development of cryptographic technologies that are resistant to quantum computing (Interviewee 1 & Interviewee 2, 2017).

## **H. Standardization and compatibility**

Due to the nature of blockchain, use cases in which multiple parties are working together, exchanging data and sharing a single source of truth, have the most potential. Therefore, standardization and compatibility would help to leverage the potential of blockchain, as it would facilitate cooperation (Interviewee 1 & Interviewee 2, 2017; Interviewee 3, 2017; Interviewee 6, 2017). Insurers just started to standardize data formats and field descriptions, in order to streamline the exchange of data among insurers (Interviewee 1 & Interviewee 2, 2017; Interviewee 3, 2017). This standardization is driven by GDPR (Interviewee 3, 2017). One interviewee describes that realizing uniformity in data quality, integrity and interpretation might be the toughest barrier that insurers have to take. Even internally this uniformity has not yet been realized, let alone among insurers (Interviewee 4, 2017). Another interviewee supports this view, he states that the absence of widely-adopted standards for labelling data limits the exchangeability of data and is problematic for blockchain implementations (Interviewee 8, 2017). However, it might be too soon to develop blockchain-specific standards, as those standards would emerge before relevant use cases (Interviewee 6, 2017).

It is a challenge to keep up with the pace of development of blockchain technology, insurers are experimenting with different platforms in order to stay up to date (Interviewee 1 & Interviewee 2, 2017; Interviewee 8, 2017). New off-the-shelf solutions are being developed in an open-source market and it is important to assess which solutions will become dominant. However, it is unrealistic to think that it is possible to choose the right blockchain platform for the next 5 years, therefore it is not recommended to heavily invest in a single platform. It makes more sense to invest in flexibility and blockchain projects with a short return on investment time. For this flexibility, insurers depend on the creativity and flexibility of their employees, but also the development of low-code platforms will enable insurers to translate required functionality to a blockchain platform of their choice. For technologies other than blockchain these low-code platforms already exist (fifth-generation programming language) and for blockchain these platforms might be available within 2 years from now. This would imply that insurers will be able to port between blockchain platforms with little effort (Interviewee 1 & Interviewee 2, 2017). This view is similar the view of another interviewee who states CIOs and CTOs will probably push the use of adapters which facilitate the move to a blockchain platform and convert data of the existing IT systems for use on a blockchain. He confirms the existence of solutions for moving to another platform without lots of programming or data conversion, which will probably be developed for blockchain platforms as well (Interviewee 6, 2017).

## I. Scalability

One interviewee states that on a blockchain, operations that previously ran on a single system, will be running on multiple systems, this results in high costs. Besides, it is very important to assess scalability in terms of storage, transaction speed and energy consumption in insurance use cases, scalability is the most important factor (Interviewee 3, 2017). A second interviewee similarly states that the largest challenge for nation-wide implementation of blockchain is getting a grip on maturity and scalability of the technology. A third interviewee, Interviewee 6 (2017), also confirms that the scalability of blockchains is limited, but solutions are being developed; it is important to be aware of the limitations of the technology, select suitable use cases and try to time the scalability requirements of a use case. The development of solutions will be driven by numerous parties that encounter its limitations. This notion is supported by Interviewee 7 (2017), he states that solutions will be provided to improve scalability, he mentions BigchainDB as an example of a party that increases scalability by reducing the degree of centralization without compromising safety too much. Interviewee 4 (2017) states that blockchain cannot yet meet transaction speed and volume requirements for payments, however he thinks that scalability will not be problematic in the future.

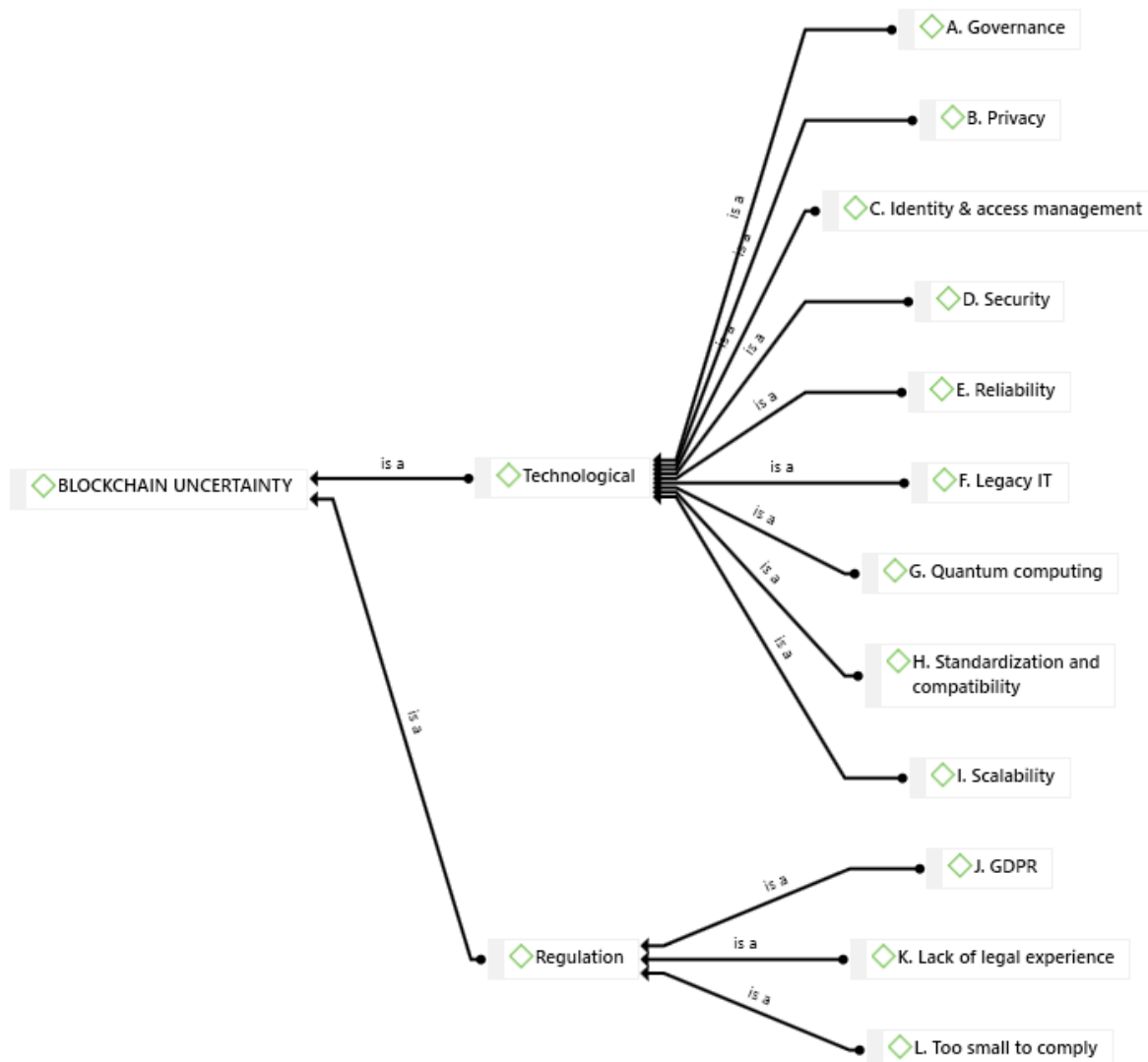


FIGURE 18: BLOCKCHAIN UNCERTAINTIES

#### 4.1.1.4 Regulatory uncertainties of blockchain technology

A graphical overview of the regulatory (and technological) uncertainties of blockchain technology can be found in Figure 18 on page 65.

Interviewees differ in their view of regulation as an obstacle for blockchain innovation in the insurance industry. One interviewer states that regulations is not yet an obstacle, but will be in the future (Interviewee 8, 2017). Regulation is seen as a temporary problem by two other interviewees, in their view, regulation will be adapted to market requirements (Interviewee 1 & Interviewee 2, 2017). This view is supported by a fourth interviewee who states that insurers should be concerned about regulations, but first should explore opportunities without being held back by regulatory compliance. In his view, blockchain could even render regulation obsolete (Interviewee 7, 2017). Regulators like the DNB, AFM and Autoriteit Persoonsgegevens are adapting their supervisory frameworks in reaction to digitalisation; they are exploring how they can provide room for technological experimentation. At the same time, however, new regulations that put strict requirements on the use of technology are introduced. Insurers are trying to balance the protection of consumers and the facilitation of experimentation in a dynamic environment (Interviewee 4, 2017). However, several developments have been identified that stress the importance of regulatory uncertainty in the analysis of the impact of blockchain on insurers.

#### **J. GDPR**

The first important development is the introduction of GDPR. GDPR requires organisations to be able to guarantee customers data ownership and insight, data portability and the right to be forgotten (Interviewee 3, 2017; Interviewee 4, 2017; Interviewee 5, 2017). It will be challenging for insurers to comply with GDPR, as they do not only gather basic personal information, but often also information on payment behaviour, online behaviour and communication (Interviewee 3, 2017). One interviewee provided an example of how technological innovation could increase the complexity to comply with GDPR; when insurers use artificial intelligence to advise customers, they have to be able to reconstruct how the technology arrived at the advice (Interviewee 4, 2017). Another interviewee provided a blockchain-specific example of an uncertainty related to GDPR; would throwing away an encryption key sufficiently guarantee the right to be forgotten (Interviewee 8, 2017)?

It is very challenging to keep track of where customer data is stored and insurers have to check whether it is legal to delete customer data for each request (Interviewee 3, 2017). Besides, data is not described consistently throughout the insurers' IT systems and data is also scattered among other parties in the value chain like intermediaries, authorised representatives and banks. Data portability among insurers is very complex, insurers have to improve the standardisation of data field descriptions in order to be able to absorb each other's data (Interviewee 3, 2017; Interviewee 5, 2017). The data standardisation model that is currently used by most insurers contains 27.000 different data labels (Interviewee 5, 2017). When insurers are not able to comply with GDPR, this could lead to fines up to 4% of their revenue or 20 million euros (Interviewee 3, 2017).

## **K. Lack of legal experience**

Next, three interviewees mention the potential of blockchain to automate compliance by the use of smart contracts, however, they also acknowledge that this application of blockchain would require a new role for IT-auditors who will operate at the intersection of legislation and blockchain software (Interviewee 1 & Interviewee 2, 2017; Interviewee 6, 2017). These auditors should verify whether a smart contract will execute as it is intended. This especially applies to public blockchains, in which the options to correct mistakes are rather limited (Interviewee 6, 2017).

Another concern related to the use of smart contracts is raised by a fourth interviewee; smart contracts have not yet juridically been tested, there is no case law on the use of a smart contract in insurance. Because legal disputes in business-to-business insurance cases tend to be complex, judges often decide that parties should try to settle outside the court. This means that it will take even longer before there will be business-to-business case laws. Regulators are exploring how they will deal with blockchain (Interviewee 8, 2017).

## **L. Too small to comply**

Compared to (smaller) FinTech firms, insurers have the advantage that they have insurance licenses and regulatory expertise; FinTech firms often are “too small to comply”. FinTech firms often need insurers for launching their products or services on the heavily regulated insurance market (Interviewee 4, 2017; Interviewee 6, 2017).

The last two sections described the technological uncertainties related to blockchain technology. The next section will describe why insurers are willing to deal with these uncertainties by describing the potential of blockchain that insurers see.

### **4.1.1.5 Blockchain value proposition and insurance use cases**

This section first describes the possibilities that the application of blockchain technology in the insurance industry has to offer, next it proceeds with describing possible specific insurance use cases that utilize these value propositions.

A graphical overview of blockchain use cases in insurance and the blockchain value propositions can be found in Figure 19 on page 73.

## **A. Blockchain value proposition**

### *A1. Automation and smart contracts*

One interviewee considers blockchain to be the next step in the automation revolution, as a new layer over the internet or business processes. Main advantages of this automation are for example: user friendliness, speed and low costs (Interviewee 8, 2017). More specifically, several interviewees describe blockchain as a platform that offers a total automation solution. Blockchain could be used to create a shared infrastructure for all parties involved in the insurance value chain, the complete value chain could be run on this infrastructure. On this infrastructure, the agreements and the roles and (read- and write) permissions of the parties involved are defined. This could be a total solution for risk sharing processes for the insurance value chain (Interviewee 5, 2017; Interviewee 8, 2017); this is an interesting solution, especially considering that the number of parties on this chain is increasing due to unbundling. Blockchain would facilitate a distributed workflow management system between

organisations (Interviewee 5, 2017). This view is supported by three other interviewees; they state that blockchain could facilitate a platform on which numerous parties, which are part of the insurance value chain, could coordinate and exchange contractual agreements. It enables those parties to cooperate on the basis of the same dataset on which they have reached consensus (Interviewee 1 & Interviewee 2, 2017; Interviewee 4, 2017).

One of those interviewees adds that blockchain is eminently suitable to handle data requests, validate data, facilitate data sharing and manage data permissions. These properties are relevant for being compliant (Interviewee 4, 2017). A similar view is shared by Interviewee 8 (2017) who describes that it is very important that a blockchain platform only shares automatically generated reporting (by executing smart contracts) with the right parties.

One interviewee notes that the use of smart contracts would probably require parties to draft contracts further in advance, as the smart contract will execute itself based on incoming data once it has been drafted (Interviewee 7, 2017). Blockchain differentiates itself from other database platforms in an important aspect; when blockchain applications have been developed, they are native on the same platform. This means that modular applications can be built from components like identity management, financial data, assets and management, this speeds up the development of applications (Interviewee 6, 2017).

Smart contracts introduce the concepts of business rules to blockchain, this creates many possibilities for introducing new functionalities to a blockchain. Insurance processes and agreements can be programmed in smart contracts; the claims that can be made by all parties are stored immutably and payments can be processed automatically. This could increase the operational excellence and reliability of insurers (Interviewee 1 & Interviewee 2, 2017). It is important that the blockchain on which the smart contract runs is decentralised and that parties reach consensus on it; only then they can be sure that contracts will execute as they are intended and that the payments that follow from them are correct (Interviewee 7, 2017). The possibility to make financial reservations on smart contracts is promising, especially when these contracts are able to be executed by an oracle. Smart contracts can be used to make claim reservations on the balance sheet of customers, this could reduce the capital that insurers are required to reserve for being compliant with Solvency II (Interviewee 5, 2017).

Blockchain could also facilitate risk sharing between man and machine and the associated value transactions by storing agreements in smart contracts (Interviewee 5, 2017). This the potential of blockchain as a facilitator of man-machine interactions is also mentioned by another interviewee. He states that blockchain could advance automation when it is used in combination with other technologies such as machine learning and artificial intelligence. These technologies can be used to analyse data and provide a fine-grained segmentation, while the blockchain can be used to safeguard privacy and data ownership (Interviewee 7, 2017).

## *A2. Cost reduction*

Several interviewees mention the cost reducing potential of blockchain (Interviewee 1 & Interviewee 2, 2017; Interviewee 4, 2017; Interviewee 5, 2017; Interviewee 8, 2017). This potential is closely related to the operational efficiency that follows from blockchain's potential for automation and

running smart contracts (Interviewee 1 & Interviewee 2, 2017; Interviewee 4, 2017; Interviewee 8, 2017). Two interviewees also relate this potential to the possibility to eliminate a trusted third party that is currently required for fraud prevention (Interviewee 1 & Interviewee 2, 2017). Currently this potential is not realized, which is unsurprising considering the state of development of blockchain technology; another interviewee states that blockchain requires large investments in tooling and education before this potential could be realized (Interviewee 6, 2017).

Cost reduction can be realized, while at the same time service quality can be improved. In case of reinsurance, fast settlement will free up capital from claims reserves. Missing yield from these reserves is a very significant problem that insurers are trying to solve by using blockchain in the reinsurance industry. However, the customer will ultimately benefit most from this application; a part of the insurance premium is used for claims, but a considerable part is used for paying overhead costs. Risks are often shared among multiple insurers, this results in complex processes in large business-to-business chains. Blockchain could facilitate data sharing in these processes, which would reduce overhead costs and insurance premiums (Interviewee 8, 2017).

### *A3. Transparency*

Increased transparency in insurance processes in which numerous parties exchange data is often mentioned as a blockchain value proposition (Interviewee 1 & Interviewee 2, 2017; Interviewee 3, 2017; Interviewee 4, 2017; Interviewee 5, 2017; Interviewee 6, 2017; Interviewee 7, 2017; Interviewee 8, 2017). This will especially be valuable in situations in which complex (manual) processes are performed and contractual agreements have to be made (Interviewee 1 & Interviewee 2, 2017; Interviewee 5, 2017; Interviewee 6, 2017). Besides blockchains are able to record all data edits that are made in insurance process, this results in an audit trail that will show fraudulent activities (Interviewee 3, 2017). Blockchains could also be used to directly share data with external auditors to increase operational efficiency (Interviewee 4, 2017; Interviewee 8, 2017). One interviewee states that customers will benefit the most from blockchain implementation in insurance, as the improved transparency creates a more level playing field in which insurers and customers fulfil honest roles. This transparency works in both ways and offers possibilities for reputation management; fraudulent activities will be recorded and customers will know what their premiums are based on (Interviewee 5, 2017). Another interviewee shares a similar view and states that blockchain could facilitate trustworthy reputation management, as information that is relevant to reputation is stored transparently, decentralized and immutable (Interviewee 7, 2017).

### *A4. Redundancy / resiliency*

In a blockchain, data is stored on multiple locations (Interviewee 3, 2017; Interviewee 6, 2017), this contributes to the use of blockchains to provide data transparency (Interviewee 3, 2017). The decentralized and immutable storage of data also (partly) facilitates reputation management, as was described in the previous value proposition (transparency) (Interviewee 7, 2017).

The fact that blockchains are run in a distributed network also provides resiliency, when a node malfunctions, the blockchain will stay functional (Interviewee 4, 2017). Besides the infrastructure is shared by all parties and not owned by a single party (Interviewee 1 & Interviewee 2, 2017). Another interviewee mentions a type of resiliency that is provided by the current state of development of

blockchain as an architecture; the existing peer-to-peer network provides a decentralized infrastructure; numerous software libraries are available and a large share of blockchain software is open source. Firms do not have to rely on a central infrastructure (Interviewee 6, 2017).

#### *A5. Establishment of trust*

Several blockchain value propositions contribute to the establishment of trust, this section describes the contributions of transparency, decentralization, immutability and smart contracts.

The transparency of blockchains facilitates the establishment of trust; when an immutable audit trail is formed and is visible to the parties that are involved in an insurance process, fraud will be visible (Interviewee 3, 2017). Besides, as mentioned before (see the previous section “*Transparency*”), it offers possibilities for reputation management (Interviewee 5, 2017; Interviewee 7, 2017). It should be noted that transparency and immutability in itself do not establish trustworthy reputation management, that requires the combination of these propositions with decentralization. When information from the physical world has to be transferred to a blockchain, trust is still required, reputation management could be valuable in this step (Interviewee 7, 2017). The decentralized character of blockchain provides resiliency and increases the reliability of a blockchain network, this increases the trustworthiness of the blockchain as a system (Interviewee 4, 2017).

In co-insurance, large risks are covered by multiple insurers, this type of insurance is characterized by bespoke and complex policies and processes. The insurers have to work together, but do not trust each other; they do not necessarily doubt each other’s good intentions, but the error-proneness of the complex forces them to check their counterparties. The establishment of a blockchain in which all parties agree on a single version of contractual agreements would reduce the need for checks (Interviewee 8, 2017). Smart contracts facilitate risk sharing and the associated value transactions in the insurance industry; parties can immutably store agreements in smart contracts (Interviewee 1 & Interviewee 2, 2017; Interviewee 5, 2017; Interviewee 7, 2017). It will be clear upfront to all parties involved how a contract will execute and no one will be able to deviate from the agreement. In this way, blockchain adds trust to contractual agreements. Several interviewees mention the potential of blockchain to add trust to man-machine interactions (Interviewee 1 & Interviewee 2, 2017; Interviewee 5, 2017; Interviewee 7, 2017). Blockchain could add trustworthiness to fraud prevention by combining blockchain with the “Internet of Things” and artificial intelligence (Interviewee 1 & Interviewee 2, 2017).

### **Insurance use cases**

#### *B. Asset provenance*

Blockchains can be used for asset provenance (Interviewee 1 & Interviewee 2, 2017; Interviewee 5, 2017; Interviewee 8, 2017). Information on an insurable object can be stored on a blockchain, this would make the provenance of the object accessible for all parties involved in the insurance value chain (Interviewee 1 & Interviewee 2, 2017; Interviewee 8, 2017). Asset provenance on a blockchain works by so-called “tokenization” of assets and removes the need for controls of ownership, which saves time (Interviewee 8, 2017).

### *C. Co-insurance and reinsurance*

Blockchain could facilitate a business-to-business backend platform for co-insurance and re-insurance processes. On this platform, parties are able to work on the basis of the same dataset. This application will especially be valuable in situations in which complex (manual) processes are performed and contractual agreements have to be made by numerous parties which do not trust each other. When a risk fires, it will be clear how claims follow from it. This application will provide transparency into, automate and speed up these processes (Interviewee 1 & Interviewee 2, 2017).

A third interviewee also sees the potential of blockchain for applications in backend re-insurance processes; blockchain could be used in business-to-business processes to manage contractual agreements, provide transparency in agreements and reach settlement (Interviewee 6, 2017). A fourth interviewee also recognizes the potential of blockchain in these business-to-business insurance processes; large risks often are reinsured, this is characterized by bespoke and complex processes. Insurers have to work together in these processes while they do not trust each other. This lack of trust is caused by the complexity, insurers do not expect that they themselves, or their counterparts, are able to work error free. Therefore, counterparty checks are very cumbersome; the checks take place in a chain in which risk, compliance and legal departments and regulators are involved. When reinsurance takes place on a blockchain, agreements are unambiguously described in computational rules, the need for counterparty checks could be reduced and reconciliation and settlement times could be reduced; insurers will receive reporting, which enables them to check which information went into the smart contract calculations and to which outcome they led. This outcome will be compared with the outcomes of the insurers' own nodes. When outcomes seem odd, there is no need for cumbersome data comparisons, because the nodes in principle operate on the basis of the same data. Fast settlement will free up capital from claims reserves. Missing yield from these reserves is a very significant problem that insurers are trying to solve by using blockchain in the reinsurance industry (Interviewee 8, 2017).

### *D. Fraud prevention*

Currently, fraud-related data is centrally stored in the CIS and FISH databases and shared by Dutch insurers, in this system, fraud is not a significant problem. Fraud is human behaviour that is detected by data-analytics. If fraud-related data would be shared on a blockchain, the data has to move from the physical world to the blockchain, this step would still require the establishment of trust. So blockchain would not be the right answer to insurance fraud. Blockchain is not pre-eminently suitable for fraud prevention, but rather for preventing errors in shared databases (Interviewee 3, 2017).

A similar view is shared by (Interviewee 4, 2017), he thinks blockchain is pre-eminently suitable for data exchange; large amounts of fraud-related data are exchanged with external parties in the processes of new risk acceptance and claim handling, blockchain could provide consensus on this data. Besides, blockchain is able to guarantee compliance by handling data requests, validating data, facilitating data sharing and managing data permissions. He also states that data analytics is more suitable for fraud prevention.

Interviewee 1 and Interviewee 2 (2017) do not think blockchain as a standalone technology is pre-eminently suitable for fraud prevention, they rather think that the combination of blockchain, the



“Internet of Things” and artificial intelligence could be more suitable. Blockchain could add a layer of trust to a shared infrastructure on which parties use these technologies to cooperatively deliver a service. The fact that no single party owns this infrastructure is an important aspect of this arrangement. The trusted third parties, like CIS, were established for fraud prevention. These parties do offer more services than just fraud registration, so they could not easily be eliminated by blockchain. However, if they could be eliminated, the IT systems which are currently required for using the services of these parties (and often also are installed locally at the insurers’ offices), could be used to run blockchain applications instead. This could reduce overhead costs.

#### *E. Mutual insurance*

Interviewee 1 and Interviewee 2 (2017) and Interviewee 5 (2017) describe how smart contracts could facilitate mutual risk sharing and the associated automatic value transactions; parties can immutably store agreements in smart contracts. Interviewee 1 and Interviewee 2 (2017) explain what it means when insurance processes are described in smart contracts; the claims that can be made by all parties are stored immutably and no one will be able to deviate from the agreement. This could increase the operational excellence and reliability of mutual insurances. This arrangement would be less suitable for sharing large risks such as legal liability, these risks need to be shared by a rather large number of insurees (Interviewee 1 & Interviewee 2, 2017; Interviewee 3, 2017); insurers are experienced in calculations related to this type of risks and therefore could add value to this process. Smart contracts also eliminate the need for capital reserves on the insurers’ side, as the claims reserves are made in the contract on the insuree’s side. An interesting effect of thinking of this use case is that it forces insurers to re-evaluate the core of insurance; what is their added value (Interviewee 1 & Interviewee 2, 2017)?

Interviewee 5 (2017) similarly describes how this use case could imitate the mutual insurance model; in this model, premiums are not collected before they are paid out to a claimant. Instead, when a claim is made, money is directly transferred from the participants to the claimant. An insurer could receive an administration fee for developing and running the mutual risk sharing platform that this use case requires. He also recognizes that smart contracts can be used to make claim reservations on the balance sheet of customers, this reduces the capital that insurers are required to reserve. Insurers could fulfil a role as an “oracle”; from being an institutional investor, they could return to their original role of risk assessors and “speakers of the truth”.

Interviewee 6 (2017) states that the mutual insurance use case is suitable for explaining how blockchain (with its block hashes, smart contracts and mining) works and how it can be used for insurance purposes. Compared to complex backend processes which are only understood by few experts, mutual insurance is a more straightforward use case. He does not think the use case is considered to be commercially viable by the insurers.

The discussion of the blockchain value proposition and insurance use cases led to some insights into the role that insurers, with their resources and capabilities, could fulfil in a blockchain-enabled future. These insights will be described by the next section.

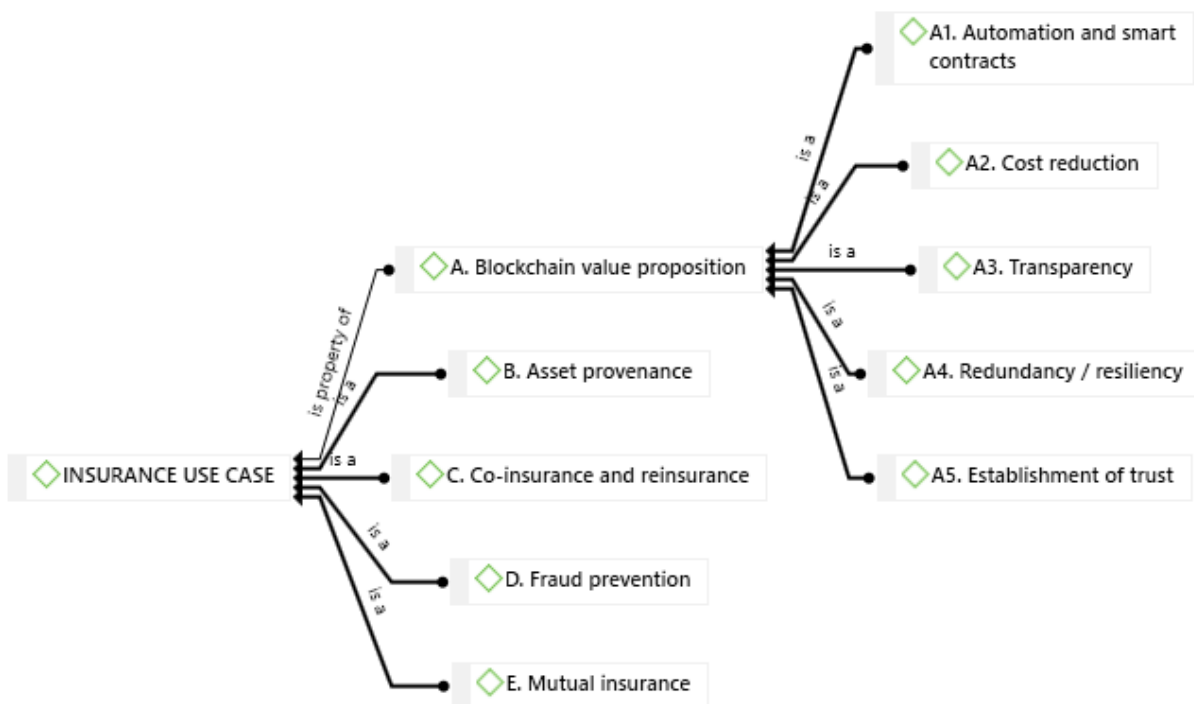


FIGURE 19: INSURANCE USE CASES AND BLOCKCHAIN VALUE PROPOSITIONS

#### 4.1.1.6 Resources and capabilities

Smart contracts eliminate the need for collecting premiums, as reservations can be made on the balance sheet of insurees. This could impact the role that insurers will fulfil in the future; currently insurers are investors and risk bearers. When premium collection is no longer necessary, insurers could return to their original roles of risk assessors and claim handlers. However, it would also imply that a large part of the insurance organisation becomes obsolete. When large risks are insured, the risks could be too large for the insurees to bear. In that case, they need a reinsurer; this case also requires risk platform that both facilitates the insurance construction and provides risk assessment. Money directly flows to the reinsurer and the owner of the platform, the remainder of the money remains a reservation on a smart contract. This arrangement does not require the reinsurers to make large capital reservations on a smart contract; reinsurers are more trustworthy than individuals, so blockchain does not solve a trust problem in this part of the construction (Interviewee 5, 2017).

The role of insurers as claim handlers in a blockchain future is also recognized by Interviewee 1 and Interviewee 2 (2017); it is difficult to translate this role into business rules. Therefore, the experience and skills of insurance employees could still be valuable. The role of insurers as risk assessors in a blockchain future is also recognized by Interviewee 1 and Interviewee 2 (2017); they state that it is their core business. Insurers are able to assess risks based on a wealth of historical data. It is possible that insurers in a blockchain future will fulfil complex roles and provide advice, or maybe they will just facilitate the insurance process on a fee basis (Interviewee 1 & Interviewee 2, 2017). Interviewee 1 and Interviewee 2 (2017) also describe that smart contracts eliminate the need for collecting claims, which reduces main income of insurers; interest on investments. However, they add that in a blockchain future with claims reservations, solvability should probably be guaranteed as well. Regarding mutual insurance, they mention that this type of insurance is not suitable for insuring large risks like legal liability. These risks need to be shared by a rather large number of insurees; insurers

are experienced in calculations related to this type of risks and therefore could add value to this process (Interviewee 1 & Interviewee 2, 2017).

FinTech firms often need the regulatory expertise of insurers on the heavily regulated insurance market, they are “too small to comply” (Interviewee 4, 2017). Interviewee 6 (2017) mentions that the following resources and capabilities distinguish insurers from FinTechs: strong brand recognition, customer base, customer data (for example data on claiming behaviour) and regulatory advantages. He also states that it is hard for new firms to enter the heavily regulated insurance market. Insurers are considering whether they could offer their knowledge, platform and data without making an end product; they could offer facilities that help other to make insurance products (Interviewee 6, 2017).

## 4.1.2 Conclusion

### 4.1.2.1 Macro-environmental developments

Several important macro-environmental developments have been identified in the interviews. Several reasons for a worsened financial position of insurers have been identified. First, the declining sales of life insurance policies, important reasons for this are low consumer trust and changes in regulation. In this market, there is a strong focus on cost reductions. Secondly, in the future, the emergence of the “Internet of Things” and self-driving cars is expected to reduce the premiums received in non-life insurance. Thirdly, interest on investments have declined. And finally, as a result of low trust, Solvency II requires insurers to increase their financial reserves. These developments both reduce the amount of capital that insurers can invest and the interest they can expect.

In reaction to their worsened financial position, insurers are trying to gain market access by transforming into multi-channel organizations. Besides, they increasingly offer multiple labels in order to facilitate a finer-grained segmentation and personalized service offerings. However, several developments make it difficult for insurers to innovate, because they limit their budget for innovation. First, new value propositions tend to be price-driven; new customers tend to pay less for these value propositions, this reduces future profitability. Secondly, insurers have to make considerable investments in order to make their legacy IT compliant with new regulations. Finally, Solvency II regulation requires insurers to increase their financial reserves.

Finally, the disintegration of the value chain has been identified, an increasing number of parties typically specialize in doing a part of the value chain in a both better and cheaper way. This threatens the insurers in their current role, as their total role in the value chain will be reduced.

### 4.1.2.2 Cooperation

Several considerations for working together with external parties have been identified in the interviews. Three important reasons are a consequence of the nature of blockchain technology. First, blockchain is suitable for use cases in which (a large number) of transactions have to be facilitated. Secondly, it is suitable for use cases in which parties do not fully trust each other and often need an intermediary to establish trust. Finally, blockchain is suitable for use cases in which parties exchange and/or edit data, this data should represent a single source of truth for all parties involved.

While acquiring knowledge of the relatively new blockchain technology has been identified as a motivation for cooperation with external parties, other considerations are strongly related to the realization of a blockchain with external parties. First, as can be derived from the use case selection criteria, blockchain can be seen as a collaborative technology. It requires the cooperation of multiple parties to realize its value proposition. Therefore, the exchange of experiences and realization of standardization is an important consideration for cooperation. A second consideration is related to the selection of the type and number of cooperation partners; while the value of blockchain in a large cooperation initiative may be high, the development of inertia and the complexity that additional parties add reduce the viability of a blockchain implementation. Finally, a cooperation could be used strategically in order to lock-out competitors, this maintains the competitive advantage of existing group members in a successful cooperation initiative.

#### 4.1.2.3 Technological uncertainties of blockchain technology

Several uncertainties regarding governance, privacy, identity and access management and security have been mentioned. Firstly, blockchains store data on multiple locations, while European legislation requires insurers to store their data within the borders of the European Union. The interviewees do not agree on the maturity of blockchain in regard to the governance that it offers. However, it is clear that currently there are no enterprise-grade governance solutions that meet the requirements of the insurance industry and it is not clear how long it will take to develop those solutions. Secondly, blockchains are often used to improve transparency. There is no consensus among the interviewees on how long it will take before solutions that maintain privacy will meet the insurers' requirements. However, it is clear that currently there are no enterprise-grade privacy solutions that meet the privacy requirements of the insurance industry. Thirdly, identity and access management are very important in every exchange of value. More specifically, they are relevant for meeting the governance requirements of GDPR. Access management is also required to enhance privacy on blockchains, however it is under development and adds complexity. Besides, identity and access management for blockchains is not user-friendly enough for consumers. Finally, blockchains are characterized by a large visibility and accessibility, they therefore are susceptible to surface attacks. Blockchain is a bleeding edge technology and it is difficult to realize a secure configuration. Related to security is long-term reliability; blockchain is a new technology, time will tell whether it is suitable for insurance applications with typically long lifespans. Quantum computing is an example of a threat that is hard to assess, it will be important to be able to update a blockchains security measures against such threats.

Several uncertainties regarding legacy IT, standardization and compatibility have been mentioned. Firstly, interviewees mention that legacy IT systems will be problematic for the next 5 to 20 years. After these systems have been rationalized, they will enhance the ability of insurers to react to changes in IT. Secondly, as mentioned before, blockchain can be seen as a collaborative technology, therefore, standardization and compatibility would help to leverage its potential. However, even internally, insurers are still struggling with standardizing data formats, this limits the exchangeability of data and is problematic for blockchain implementations. Besides, different blockchain platforms are under development, so it will be important for insurers to invest in flexibility.

The last technological uncertainty that is been identified in the interview is scalability. There is no consensus among the interviewees on how long it will take before blockchains will meet the insurers' scalability requirements. However, it is clear that currently there are no blockchains that meet the scalability requirements of the insurance industry.

#### 4.1.2.4 Regulatory uncertainties of blockchain technology

Several regulatory uncertainties have been identified in the interviews. Firstly, GDPR requires insurers to be able to guarantee customers data ownership, insight, portability and the right to be forgotten. This regulation is challenging for insurers, as they process large amounts of scattered customer data. Besides there is a lack of standardisation of data field descriptions. One interviewee provided a practical example of a blockchain specific uncertainty, he questioned whether throwing away an encryption key will sufficiently guarantee the right to be forgotten. The fines for not being compliant with GDPR can be as high as 4% of the insurer's revenue or 20 million euros, which makes compliance very important. Secondly, there is a lack of legal experience in using blockchain. Three interviewees

mentioned the potential of blockchain to automate compliance by the use of smart contracts, however, they also acknowledge that this application of blockchain would require a new role for IT-auditors. The auditors should have expertise in both blockchain software and legislation, in order to ensure compliance. A fourth interviewee mentioned that smart contracts have not yet been juridically tested, there is no case law in the use of smart contracts in insurance. However, insurers have an advantage over FinTech firms in this situation, as they possess insurance licenses and have regulatory expertise.

#### 4.1.2.5 Blockchain value proposition, insurance uses cases and resources and capabilities

##### *Value proposition*

The interviewees reached a large degree of consensus on the value proposition of blockchain. The first part of the value proposition of blockchain that has been identified is related to the automation of insurance processes. Blockchain can facilitate a platform on which numerous parties can exchange data, reach consensus on this data and run smart contracts. Programming agreements and processes into smart contracts creates many possibilities for developing new applications on a blockchain. An advantage of blockchain over other database platforms is that these applications are native on a shared platform. This means that modular applications can be built by combining existing applications. Besides, it is possible to make claim reservations on smart contracts, this reduces the capital that insurers are required to reserve.

The second part of the value proposition on which the interviewees reached a large degree of consensus is related to cost reductions. This potential is closely related to the operational efficiency that follows from blockchain's potential for automation and running smart contracts. Besides, this potential is related to the possibility to eliminate a trusted third party by two interviewees. One interviewee specifically mentions the use of blockchain in complex reinsurance processes; fast settlement will free up capital from claims reserves and reduce overhead costs, this will ultimately benefit the customer.

The third part of the value proposition on which the interviewees reached a large degree of consensus is related to transparency. Blockchains are able to immutably record all data entries on multiple locations, this results in an audit trail that will show fraudulent activities. This will especially be valuable in situations in which complex (manual) processes are performed and contractual agreements have to be made. Two interviewees mention how this transparency could create a level playing field between insurers and customers by facilitating reputation management.

The fourth part of the value proposition which has been mentioned by multiple interviewees is related to resiliency. The fact that blockchain data is stored on multiple locations in a distributed network contributes to transparency, but also to resiliency. Local failures will not cause network failures and the network is not owned by a single party.

Finally, the establishment of trust has often been mentioned as a part blockchain's value proposition by the interviewees. The combination of transparency, immutability, decentralization and smart contracts enable blockchain to establish trust. An immutable audit-trail makes it hard to commit fraud, decentralization provides resiliency (reliability) and distributed control. Smart contracts facilitate unambiguous automation of complex, immutably programmed agreements and processes. This adds trust to contractual agreements.

#### *Insurance use cases*

Several insurance use cases have been identified in the interviews. Firstly, four interviewees described how blockchain offers the possibility to immutably store information on an insurable object, this makes the provenance of the asset easily accessible for all parties involved in the insurance value chain. Secondly, four interviewees described how blockchain could facilitate a business-to-business backend platform for complex co-insurance and reinsurance processes. They describe how it could be used to share data, manage unambiguously programmed contractual agreements, provide transparency and quickly reach settlement. One interviewee mentions that fast settlement will free up capital from claims reserves. Thirdly, four interviewees reached a large degree of consensus of the potential of blockchain for fraud prevention. They all state that blockchain as a standalone technology is not pre-eminently suitable for fraud prevention. They state that data analytics (one interviewee mentions the combination of artificial intelligence and blockchain), is more suitable for fraud prevention. Finally, three interviewees described how blockchain could facilitate mutual risk sharing and the associated automatic value transactions. This is done by immutably storing agreements in smart contracts. This mutual insurance arrangement is less suitable for sharing large risks, that would probably still require insurers. When insurers facilitate such an arrangement, they do not have to make claims reservations, this forces insurers to re-evaluate their added value. One interviewee states that the mutual insurance use case probably is not commercially interesting, but is more suitable for explaining how blockchain can be used for insurance purposes than complex backend use cases.

#### *Resources and capabilities*

One interviewee described how smart contracts eliminate the need for collecting premiums and how this could change their role from being investors and risk bearers to risk assessors, claim handlers and owners of a reinsurance platform. The elimination of the need to collect premiums and these roles of insurers in a blockchain future are also recognized by two other interviewees. They state that it is difficult to translate claim handling into business rules and insurers are able to assess risks based on a wealth of historical data. The latter is their current core business. Besides they state that insurers will remain relevant for insuring large risks and guaranteeing solvency. Finally, two interviewees mention how insurers have lots of regulatory expertise in the heavily regulated insurance market, one of them adds that insurers also have additional competitive advantages over FinTech firms: strong brand recognition, a customer base and customer data.

## 4.2 Business model stress test workshop

This section first describes the design of the business model stress test workshop, the design follows the steps that have been described in section 2.5.6.2. Next, it describes the results of the workshop.

### 4.2.1 Selected uncertainties (stress factors)

Bouwman et al. (2017) recommend a limited selection of uncertainties in order to keep the business model stress test manageable. Besides they recommend a selection of contrasted uncertainties which are at the opposite or extreme ends of possible scenarios. Based on the results of the literature study and the interviews, the three most important uncertainties are selected. These uncertainties are the stress-factors against which the different components of the reference business model will be tested in the workshop.

#### 4.2.1.1 Uncertainty 1 – Cooperation

The first uncertainty is cooperation. It has been found in the interviews that due to the nature of blockchain technology, the realization of the value proposition is closely related to degree to which insurers are able to cooperate with external parties. This was to be expected from the evaluation of the selection criteria for high-potential use cases that was provided in the literature review (World Economic Forum, 2016):

- *Shared repository:* A shared repository of information is used by multiple parties.
- *Multiple writers:* More than one entity generates transactions that require modifications to the shared repository.
- *Minimal trust:* A certain degree of mistrust exists between entities that generate transactions.
- *Intermediaries:* One (or multiple) intermediary or a central gatekeeper is present to enforce trust.
- *Transaction dependencies:* Interaction or dependency between transactions is created by different entities.

Therefore, the realization of standardization and the exchange of knowledge and experience are important considerations for cooperation. However, insurers should carefully select the type and number of cooperation partners; while the value of blockchain in a large cooperation initiative may be high, the development of inertia and the complexity that additional parties add reduce the viability of a blockchain implementation. Finally, insurers could strategically use a cooperation to lock-out competitors in order to maintain a competitive advantage. Therefore, the cooperation that will be realized is expected to have a significant impact on a blockchain-enabled business model.

#### **Weak: stagnating cooperation**

The large number of parties involved in the cooperation initiative slows the innovation process down. In this situation, the envisaged cooperation will not be realized. The cooperation that actually has been realized is of low value and is stagnating, because the value proposition of blockchain can only be realized to a limited extent.



### **Strong: pre-competitive cooperation**

Parties in the value chain are able to cooperatively develop and implement blockchain solutions. Next to exchanging knowledge and experience, steps are made in order to improve standardization and compatibility. In this situation, the value proposition of blockchain can be realized to a large extend.

#### **4.2.1.2 Uncertainty 2 – Technical complexity and uncertainty**

The second uncertainty is technological complexity and uncertainty. Several uncertainties regarding governance, privacy, identity and access management and security have been mentioned in the interviews. These were very similar to the uncertainties regarding the technical requirements that been found in the literature review. Firstly, currently there are no enterprise-grade data governance blockchain solutions that meet the requirements of the insurance industry and it is not clear how long it will take to develop these solutions. Secondly, currently there are no enterprise-grade privacy blockchain solutions that meet the privacy requirements of the insurance industry. There is no consensus among the interviewees on how long it will take before these solutions will become available. Besides the existing solutions add complexity. Thirdly, identity and access management blockchain solutions are under development and they add complexity. Besides they are not user-friendly enough for consumers. Finally, blockchain is bleeding edge technology and it is difficult to realize a secure configuration. Besides blockchains are susceptible to surface attacks. Time will tell whether blockchains will be able to offer long-term reliability and security, this ability could be enhanced by having the possibility to update a blockchain's security measures. Several uncertainties regarding legacy IT, standardization and compatibility have been mentioned. Firstly, legacy IT systems should be rationalized in order to enhance the ability of insurers to react to changes in IT. Besides, different blockchain platforms are under development, so it will be important for insurers to invest in flexibility. Secondly, insurers are struggling with standardization and compatibility, this limits the exchangeability of data and is problematic for blockchain implementations. Finally, an uncertainty regarding scalability has been mentioned, currently there are no blockchains that meet the scalability requirements of the insurance industry. Therefore, the degree to which blockchain is able to meet the requirements of the insurance industry is expected to have a significant impact on a blockchain-enabled business model.

### **Blockchain technology is hard to manage**

The situation that is described above is not controllable within the next 5 years. Meeting the technical requirements requires very complex technical solutions. Blockchain will not be mature enough for large-scale implementation in the insurance industry and will get fragmented.

### **Blockchain technology is manageable**

The situation that is described above is controllable within the next 5 years, because several (large) parties cooperate with the insurance industry on blockchain implementations. Blockchain will be mature enough for large-scale implementation in the insurance industry and will not get fragmented.

#### 4.2.1.3 Uncertainty 3 – Regulation

The third uncertainty is an increasing regulatory complexity. In the literature review it has been found that the insurance industry is heavily regulated, therefore, government regulation is an important factor for the development of blockchain technology in the insurance industry. Several uncertainties that have been found in the interviews support this view. Firstly, GDPR is a challenging regulation that requires insurers to be able to guarantee customers data ownership, insight, portability and the right to be forgotten. Besides it prescribes that data can only be used for specific applications, data cannot be stored longer than strictly necessary and that data cannot be stored outside the European Union. The fines for not being compliant with GDPR can be as high as 4% of the insurer's revenue or 20 million euros. Secondly, Solvency II requires insurers to increase their financial reserves and it holds insurers accountable for the regulatory compliance of outsourcing partners. Thirdly, there is a lack of legal experience in using blockchain. Blockchain has the potential to automate compliance by the use of smart contracts, however, this application of blockchain would require a new role for IT-auditors. Smart contracts have not yet been juridically tested, there is no case law in the use of smart contracts in insurance. Finally, there is a tension between the increasing cost of IT (updating legacy IT), caused by the pressure of rules imposed on insurers on one hand and the need to innovate for gaining access to the market and reducing costs on the other hand. Therefore, the degree to which regulatory complexity increases, is expected to have a significant impact on a blockchain-enabled business model.

##### **Moderately increasing regulatory complexity**

The level of complexity of laws and regulation is increasing, but compliance can be safeguarded by blockchain; blockchain applications can be programmed in such a way that compliance is enforced by the code of the smart contracts. It will also be possible to increase the transparency of transactions that have been carried out.

##### **Strongly increasing regulatory complexity**

The increasing level of complexity of laws and regulation makes it hard to develop blockchain implementations which are compliant with continuously changing laws and regulations like GDPR and Solvency II. Jurisprudence on the use of blockchain in the insurance industry is lacking. Depending on the type of blockchain, it can be hard to make changes afterwards, this creates the need for a careful evaluation of the code of an implementation.

#### 4.2.2 Reference business model design

In section 2.4, it has been determined that the STOF Model is the most suitable business model ontology for describing the business model. As was described in section 2.5.6.1, a full representation of the business model, if even feasible, is likely to result in a high level of complexity that will not help the workshop participants in overseeing possible choices and their consequences. Two ways of reducing the level of detail of the model to increase its practicality are proposed: aggregation and decomposition. The former is done by grouping business model elements. The latter is done by only representing a part of the reference business model (Casadesus-Masanell & Ricart, 2010). In the same section a similar approach described how a business model can provide a stable basis for decision making, while being flexible enough to deal with dynamics in technological innovation and the market (Cavalcante et al., 2011):

- Only the core standard processes are included, these processes are crucial to the business and take place continuously.
- A detailed description of process operationalization is not required.
- Processes which do not yet exist also should be considered, as they could have a lot of potential for business model improvements.

This section describes how the approaches mentioned above have been used to determine which components of the business model are most important for the assessment of the impact of blockchain technology. This selection follows from the analysis of the interview transcripts with qualitative data analysis software (ATLAS.ti) that has been done in section 4.1.1.

##### **Service domain**

In the STOF Model, this domain describes the delivery of value propositions to the targeted customer. It describes the following concepts: Intended Value, Delivered Value, Expected Value, Perceived Value, Customer or End-user, Context, Tariff and Effort and Bundling (Bouwman et al., 2008).

The first four concepts of the STOF Model are combined into one overarching concept, the value proposition. This is done because of the lack of concrete business models and the fact that the aim was to construct a reference business model. In this situation, it is very hard to distinguish four different concepts of value. The same holds for the concepts context, tariff and effort and bundling; the lack of concrete services descriptions also makes the description of these concepts too specific for the aim of this research.

##### *Value proposition*

Several potential use cases for the insurance industry have been shortly described by the interviewees, this provided an insight on how blockchain could improve existing processes, or facilitate new services. However, no detailed service descriptions have been provided by the interviews, because they have not yet been developed. However, the interview and literature review aimed for an insight in how blockchain as a technology could impact a reference business model, instead of a specific business model. In this regard, the interviews and literature review provided an overview of the blockchain technology value proposition. This value proposition is largely shared by the different use cases. Therefore, it is suitable for the description of the value proposition of a reference business model which allows for a meaningful analysis in the absence of a concrete business model.

### *Customer and end-user*

The concepts customer and end-user will be part of the model, because it is crucial to understand for which persons the value proposition than can be realized by blockchain technology is intended. In case the value proposition is intended for consumers, the paying person is the same as the person that uses the services (Bouwman et al., 2008). Whether blockchain facilitates business-to-business, business-to-consumer, or consumer-to-consumer services, the value proposition will ultimately benefit the consumer. The consumer is both paying and using the services of the insurers that have been interviewed.

### **Technology domain**

In the STOF Model, this domain describes the technical architecture that is required for the service offering. It describes the following concepts: Technical Architecture, Backbone Infrastructure, Access Networks, Service Platforms, Devices, Applications, Data and Technical Functionality (Bouwman et al., 2008).

### *Technical requirements*

The technical architecture that is required for the service offering, is a blockchain that is shared by parties in the insurance value chain. From the interviews and the literature review, several technical requirements and technical functionalities that this blockchain has to fulfil in order to deliver the value proposition in the insurance industry have been found. Therefore, the assessment of these requirements and functionalities provides a valuable insight into the robustness of the reference business model. The backbone infrastructure, access networks, service platforms, devices, applications and data concepts are considered to be too specific for this research. This research does not aim for a detailed analysis of the technical architecture of a specific business model, as concrete business models have not yet been developed. The concepts technical requirements, architecture and functionality are combined into the single concept technical requirements.

### **Organization domain**

In the STOF Model, this domain addresses issues related to resources, capabilities and collaboration. It describes the following concepts: Actors, Value Network, Interactions and Relations, Strategies and Goals, Organizational Arrangements, Value Activities and Resources and Capabilities (Bouwman et al., 2008).

The potential of blockchain technology in the insurance industry is related to the numerous processes that are characteristic for the industry. The reference business model should therefore describe the most important processes that realize the operationalization of the model. As has been mentioned in section 1.3, this research does not include the design of a specific blockchain-enabled business model, the aim was to construct a reference business model for the insurance industry. Therefore, this domain should describe the most important activities, the core standard service processes, that have to be performed by the network of parties in the insurance value chain in order to deliver insurance products.

### Activities

In order to find the core standard services that have to be performed by the network of parties in the insurance value chain, a small literature search has been performed. The databases that have been searched by means of keywords are Google and Google Scholar.

The following keywords led to the most relevant results:

- “insurance” AND “value chain”;
- “insurer” AND “value chain”.

This resulted in three publications of consultancy firms and a report of the World Economic Forum. In these papers, very similar descriptions of the insurance value chain have been found, Table 15 on this page provides a comparison of these value chains. The first row, labelled “BMST” describes the general insurance value chain that can be derived from the four publications. This value chain description represents the value activities.

**TABLE 15: A COMPARISON OF INSURANCE VALUE CHAINS**

BMST	Product development	Marketing	Sales & distribution	Underwriting & risk management	Policy administration	Claims management	Investment management
<b>Tata Consultancy Services (2011)</b>	Product management	Marketing	Sales & distribution	Underwriting & risk management	Policy acquisition & servicing	Claims management	Finance & accounts
<b>Bain &amp; Company (2017)</b>	Product development & monitoring	Distribution & marketing		Underwriting & new business processes	Policy administration	Claims management	
<b>Catlin, Hartman, Segev, and Tentis (2015)</b>	Product development	Marketing	Sales & distribution	Underwriting	Policy issuance & servicing	Claims management	
<b>World Economic Forum (2015)</b>	R&D / Product manufacturing		Distribution	Underwriting		Claims	Risk capital & investment management

### Resources and capabilities

In the interviews and literature review, several important resources and capabilities for delivering insurance products have been identified. However, also more specific blockchain-related resources and capabilities have been identified that should be available to insurers if they have the intention to deliver the blockchain value proposition.

### Use cases

An overview of the use cases that were considered to be interesting for the insurance industry in the interviews has been added to the organization domain. This is not a concept that fits within this domain of the STOF Model, but it stimulates the thinking process of the participants; the uses cases help the participants with envisioning how blockchain could improve existing processes, or facilitate new services and processes.

A more specific description of the actors, value network, interactions and relations, strategies and goals and organizational arrangements is difficult in the absence of concrete business models. Again, this would also not fit the aim to construct a reference business model with a limited complexity that is suitable for the business model stress test workshop.

### **Finance domain**

In the STOF Model, this domain describes how the actors in the network capture value from the service. It describes the following concepts: Investment Sources, Cost Sources, Performance Indicators, Revenue Sources, Risk Sources, Pricing and Financial Arrangements (Bouwman et al., 2008).

The lack of concrete business models makes it difficult to analyze the financial details of a blockchain-enabled service delivery. As has been mentioned in section 1.3, this research does not include the design of a specific blockchain-enabled business model, nor does it include a quantitative analysis of the implementation cost of blockchain technology. The aim was to construct a reference business model for the insurance industry. Besides, including the finance domain in the business model stress test workshop could change the group dynamics. Omitting the financial domain will probably result in a more open discussion among the workshop participants who are working for different (and in some cases competing) organizations. Therefore, a financial analysis was not part of the interviews and the literature review and the finance domain is not included in the reference model.

The four domains that have been described above together form the reference business model, this model can be found in Table 16 on page 86. This model was printed twice on paper format A1 (one poster for each group) and put on two walls in the stress testing room.

TABLE 16: THE REFERENCE BUSINESS MODEL

Service domain	Technology domain
<p><b>Customer and End-user</b></p> <ul style="list-style-type: none"> <li>• Consumer</li> </ul> <p><b>Value proposition</b></p> <ul style="list-style-type: none"> <li>• Blockchain increases the transparency of the insurance process and current value propositions for customers.</li> <li>• Extensive automation makes insurance processes cheaper and faster. This will result in lower premiums.</li> </ul>	<p><b>Technical requirements</b></p> <ul style="list-style-type: none"> <li>• Standardization and interoperability;</li> <li>• Identity- and access management with limited complexity;</li> <li>• Data governance (control over geographical storage location);</li> <li>• Compatibility with existing IT systems;</li> <li>• Long-term security and reliability;</li> <li>• Scalability;</li> <li>• User-friendly for consumers;</li> <li>• The ability to facilitate data-exchange, value transactions and smart contracts.</li> </ul>
Financial domain	Organization domain
<p>N/A</p>	<p><b>Activities</b></p> <ul style="list-style-type: none"> <li>• Product development;</li> <li>• Marketing;</li> <li>• Sales &amp; distribution;</li> <li>• Underwriting and risk management;</li> <li>• Policy administration;</li> <li>• Claims management;</li> <li>• Investment management.</li> </ul> <p><b>Use cases</b></p> <ul style="list-style-type: none"> <li>• Reinsurance;</li> <li>• Co-insurance;</li> <li>• Mutual insurance;</li> <li>• Asset provenance.</li> </ul> <p><b>Resources and capabilities</b></p> <ul style="list-style-type: none"> <li>• Customer data;</li> <li>• Knowledge on regulation and the insurance industry;</li> <li>• Brand recognition;</li> <li>• Expertise on blockchain platforms and smart contracts.</li> </ul>

### 4.2.3 Heat map template

The combination of the most important business model components of section 4.2.2 and the stress factors of section 4.2.1 results in the heat map template that is represented by Table 17 on this page. Separate heat maps were constructed for each stress factor in the workshop for practical reasons, it offered more room to the participants for adding sticky notes. These three heat maps were printed twice (one set of three heat map template posters for each group) on paper size A1 and put on two walls.





TABLE 17: THE HEAT MAP TEMPLATE

Business model components	Most relevant uncertainties (stress factors)					
	Cooperation		Technological complexity and uncertainty		Increasing regulatory complexity	
	Weak	Strong	Hard to manage	Manageable	Moderately	Strongly
Value proposition						
Technical requirements						
Activities						
Resources & capabilities						

### Legend

The legend that can be found in Table 18 on this page was printed twice on A4 paper format (one poster for each group). This legend explains the participants how the colours of their sticky notes represent the expected impact of an uncertainty outcome on a business model element.

TABLE 18: THE LEGEND OF THE HEAT MAP, ADAPTED FROM BOUWMAN ET AL. (2017)

Legend of the heat map	
Red indicates a possible <b>showstopper</b> ; the business model will not be feasible.	
Yellow indicates a <b>negative impact</b> ; action is required.	
Green indicates that there is <b>no negative impact</b> .	
The absence of a sticky note indicates that the uncertainty has <b>no relevant impact</b> .	



#### 4.2.4 Results of group 1

Table 19 on this page shows the heat map that that resulted from the workshop session of group 1. The codes in the coloured heat map scores refer to the description below; each coloured cell with a code represents a sticky note that has been put on the heat map template in the workshop. As the participants put sticky notes between the two contrasted scenarios, the columns labelled “Both” have been added. The impacts on these sticky notes are relevant in both scenarios.

TABLE 19: HEAT MAP GROUP 1

Group 1	Most relevant uncertainties (stress factors)								
	Cooperation (C)			Technological complexity and uncertainty (T)			Increasing regulatory complexity (I)		
	Weak (W)	Both (B)	Strong (S)	Hard to manage (H)	Both (B)	Manageable (M)	Moderately (M)	Both (B)	Strongly (S)
<b>Business model components</b>									
<b>Value proposition (V)</b>	VCW-1 VCW-2 VCW-3 VCW-4		VCS-1 VCS-2 VCS-3 VCS-4	VTH-1 VTH-2 VTH-3		VTM-1 VTM-2	VIM-1		VIS-1
<b>Technical requirements (T)</b>	TCW-1	TCB-1 TCB-2	TCS-1 TCS-2 TCS-3	TTH-1		TTM-1	TIM-1		TIS-1 TIS-2
<b>Activities (A)</b>	ACW-1	ACB-1 ACB-2	ACS-1	ATH-1 ATH-2 ATH-3 ATH-4		ATM-1 ATM-2 ATM-3	AIM-1 AIM-2		AIS-1 AIS-2
<b>Resources &amp; capabilities (R)</b>	RCW-1		RCS-1 RCS-2 RCS-3	RTH-1 RTH-2 RTH-3 RTH-4		RTM-1 RTM-2	RIM-1		RIS-1

#### Cooperation (weak)

##### Value proposition

- VCW-1 The intended transparency will not be realized.
- VCW-2 There will be a high barrier of entry for small parties.
- VCW-3 Network effects could actually be realized with blockchain in this situation?
- VCW-4 Blockchain especially works in the absence of full trust → good behaviour is enforced by the algorithm.

It is fairly evident that when few parties are cooperating in the realization of an insurance blockchain, it is difficult to realize transparency throughout the complete value chain; when a limited number of parties in the value chain participate, the audit trail on the blockchain will be incomplete. However, especially in a situation with a lack of full trust and limited cooperation, blockchain is pre-eminently suitable to provide transparency nonetheless. So, once a blockchain solution has been realized in this less than ideal situation, future business between parties in the value chain will be facilitated and network effects might still be realized. There seems to be a trade-off between the viability of the value proposition (transparency) on the one hand and the actual value of the realization of a blockchain solution in the insurance value chain on the other hand. When the cooperation is weak, there will probably be a high barrier of entry for small parties, as their influence on the process is rather small; this might result in a lock-out of these parties. This limits the potential value of a blockchain implementation, but maintains the competitive advantage of insurers.

### *Technical requirements*

- TCW-1 Standardisation is difficult in this situation, but the emergence of competing standards could result in a rapid initial development.

Developing standards is difficult when the cooperation is weak, as it requires close coordination. However, it could also stimulate individual parties, or small groups, to develop their own standards. Compared to large cooperation initiatives, it is less likely that they develop inertia and the emergence of competing standards could result in a rapid initial development. However, this lack of cooperation might result in fragmentation, as the standards are less likely to be widely supported. There seems to be a trade-off between the viability and speed of development of standards on the one hand and fragmentation on the other hand.

### *Activities*

- ACW-1 Blockchain-related problems have to be solved on an individual basis.

A drawback of a weak cooperation is that parties have to solve numerous problems related to the relatively new blockchain technology on an individual basis or in small groups. The possibilities to share resources and capabilities and reach synergy in solving problems are rather limited.

### *Resources & capabilities*

- RCW-1 Knowledge of regulation will remain a competitive advantage of the insurer.

Generally speaking, insurers are more knowledgeable on the complex insurance industry and regulations than smaller parties and new entrants. As the diffusion of this knowledge will be rather limited when the cooperation is weak, it will continue to provide them with a competitive advantage. It is not very likely that smaller parties and new entrants are able to develop a compliant platform without close cooperation with insurers.

## **Cooperation (both)**

### *Technical requirements*

- TCB-1 The user-friendliness is low → the use of blockchain will be limited to backend processes (“under the hood”).
- TCB-2 Smart contracts enforce transparency without the need for full trust between parties.

Irrespective of the strength of the cooperation, at this moment the user-friendliness of blockchain is low and customers are not interested in it, so insurers would probably not want to confront them with it. Therefore, the use of blockchain will be limited to backend processes. Besides, blockchain has the capability to enforce transparency in the absence of full trust by means of smart contracts irrespective of the strength of the cooperation. However, as mentioned before, there seems to be a trade-off between the viability of enforcing transparency on the one hand and the actual value of the increased transparency on the other hand.

### *Activities*

- ACB-1 A sub-optimization will be developed which puts the insurer at the centre.
- ACB-2 In combination with for example the “Internet of Things” continuity of products and services can be guaranteed for the customer. Besides more data that can be used for fraud detection will become available.

Regardless of the strength of the cooperation, insurers will likely try to maintain their dominant position and they probably have the resources and capabilities to do so. This situation limits the optimizing potential of using blockchain in insurance, as different blockchain optimization efforts will not be supported equally by the insurers. Probably only parts of the value chain will be optimized.

Irrespective of the strength of the cooperation, blockchain has the capability to facilitate insurance services based on the “Internet of Things”, it is able to coordinate the data that flows from numerous devices. Besides, the resiliency that blockchain provides will improve the continuity of these services. The “Internet of Things” uses numerous connected devices to collect data which could be used for fraud detection.

### **Cooperation (strong)**

#### *Value proposition*

- VCS-1 A level playing field will emerge and a high level of transparency will be realized → it is questionable whether blockchain is required in this situation.
- VCS-2 A strong network effect will be realized.
- VCS-3 The insurance paradox can be solved (for example, see the insurance firm “Lemonade”).
- VCS-4 The costs of insurance will approach the risk premium.

When the cooperation is strong, blockchain creates a level playing field and a high level of transparency. It will be easy to join the cooperation as the road has been paved by numerous parties that have already joined, in this situation strong network effects will be realized. However, as mentioned before, there seems to be a trade-off between the viability of the value proposition (transparency) on the one hand and the actual value of the realization of a blockchain solution in the insurance value chain on the other hand. One could question if a blockchain is required to enforce transparency in a situation where the cooperation between parties is strong.

Blockchain could be used to facilitate peer-to-peer insurance like the company Lemonade does, in this type of insurance, customers pay a flat fee for a peer-to-peer insurance platform. Claim pay-outs are covered by an insurance premium, when premiums exceed the pay-outs, the premiums are reimbursed to the customers. Therefore, the insurance company (the owner of the platform), does not have an incentive for refusing claim pay-outs.

When cooperation is strong, an insurance blockchain platform will realize a high degree of automation, easy data exchange and therefore cost reductions; the overhead costs of insurers will decline and eventually approach the risk premium.

### *Technical requirements*

- TCS-1 Compatibility problems will require large-scale modifications of legacy IT.
- TCS-2 On the one hand, strong cooperation could result in inertia, on the other end, it could prevent the emergence of separate standards.
- TCS-3 When an identification error is made on one location, it could result in errors on all locations.

When cooperation is strong and blockchain is more likely to be widely adopted in the insurance industry, this would require insurers to adopt their legacy IT systems to support a blockchain implementation. It is not likely that insurers are willing to do so, because of the complexity and costs of such an operation. Large cooperation initiatives are more likely to develop inertia, however when they succeed do develop standards nonetheless, they are more likely to be widely supported and fragmentation is less likely. Again, there seems to be a trade-off between the viability and speed of development of standards on the one hand and fragmentation on the other hand. It is important to be aware of the fact that in the insurance industry, identification is a crucial functionality that IT has to fulfil, when errors are made in this functionality on a blockchain, the error could easily spread throughout the network.

### *Activities*

- ACS-1 Modularity will facilitate a rapid development of new, or derived use cases.

When the cooperation is strong, a blockchain platform can be the result, this allows for the development of applications which are native on the same platform. This means that applications can be easily combined to form new applications. This modularity could speed up the development of new blockchain applications.

### *Resources & capabilities*

- RCS-1 Insurers are reluctant to exchange customer data, however, they have to in a blockchain.
- RCS-2 It will be difficult for insurers to differentiate themselves from their competitors.
- RCS-3 Best practices could easily be exchanged.

Insurers are reluctant to exchange customer data, which limits the potential of a blockchain implementation; insurers have lots of customer data that is crucial for providing and developing new services. When cooperation is strong and a blockchain platform will be developed which is accessible to numerous parties, numerous parties will have more or less the same possibilities for delivering services. Therefore, it will be harder for insurers to differentiate themselves. An advantage of a strong cooperation is that lines of communication are short, experiences will be will be easily exchanged and development will take place more rapidly.

## **Technological complexity and uncertainty (hard to manage)**

### *Value proposition*

- VTH-1 Investments in the development of blockchain could be cancelled.
- VTH-2 Mainly “low-hanging fruit” will be picked.
- VTH-3 Interesting applications of blockchain might exist in a niche market, for example in short-term services.

When blockchain is not able to meet the requirements for IT in the insurance industry in the near future, investments in the development in the development of the technology could be cancelled. When the investments are not cancelled, the application of blockchain will be limited to less complex use cases and mainly “low-hanging fruit” will be picked. However, this might stimulate insurers to find interesting application of blockchain in a niche market. For example, the consequences of blockchain applications in short-term services are easier to oversee.

### *Technical requirements*

- TTH-1 Insurers will take a more critical look at blockchain.

The participants stated that this part of the heat map is dictated by the description of the stress factor and therefore did not lead to interesting insights. It is evident that in this scenario insurers will be very critical of blockchain applications. Therefore, it will be ignored as a showstopper.

### *Activities*

- ATH-1 Innovation will take place at the edge of the organisation, in parts of the value chain. Especially with regard to policy administration, claims management and underwriting & risk management.
- ATH-2 Parallel systems will emerge, this will prevent a rapid transition to blockchain from taking place.
- ATH-3 Mainly business-to-business applications will be developed.
- ATH-4 It is more likely that new concepts will be developed, developing blockchain applications in the current value chain will be an uphill struggle.

When the technology is hard to manage, it is safer to first apply it at the edge of the organisation, in parts of the value chain where it is less risky. The parts of the value chain which are most suitable for innovation in this scenario are: policy administration, claims management and underwriting & risk management. A consequence of this development is that some parts of the value chain will have made the transition to a blockchain platform, while others will still be run on centralized IT systems. The fact that parts of the value chain do not simultaneously transition to blockchain platform might result in integration problems later on. In that case, it will take longer before a transition to an all-encompassing blockchain platform for the entire value chain will be realized. Insurers will consider it to be too risky to use blockchain in a business-to-consumer market, so applications will be limited to business-to-business applications. Developing blockchain applications of in the current value chain with a technology that does not meet the insurers’ requirements will be rather difficult. Therefore, insurers and FinTechs will be stimulated to find solutions outside the current value chain, which is more likely to lead to the development of new concepts.

### *Resources & capabilities*

- RTH-1 Customer data will hardly be shared.
- RTH-2 In this scenario, a private blockchain will likely be the preferred blockchain configuration.
- RTH-3 It will be difficult to be compliant with complex regulations.
- RTH-4 Brand recognition of insurers probably gives consumers the confidence to purchase blockchain services from them.

In this scenario, insurers will even be more reluctant to share their customer data, as they will consider the lack of manageability of blockchain as a large risk. As mentioned before, this limits the potential of a blockchain implementation; insurers have lots of customer data that could be valuable for delivering and developing new services. The potential of blockchain in a situation where data is not shared is very limited.

Insurers will likely choose for a private blockchain configuration, as this provides them with more control and options to correct mistakes.

As regulations in the insurance industry require strict control of the insurers over their data and processes, it will be hard to be compliant with a technology that is hard to manage.

Generally speaking, insurers are well known for years and trusted by their customers. In a situation in which blockchain is hard to manage, they are more likely to gain the confidence of their customers than other parties. This enables them to maintain a competitive advantage over new entrants.

### **Technological complexity and uncertainty (manageable)**

#### *Value proposition*

- VTM-1 The algorithm or smart contract that assesses the risk is probably more accurate.
- VTM-2 Risk tokenization is possible (for example, see the firm “Bancor”).

When the complexity of blockchain technology is manageable, smart contracts that will be used to automate risk assessment will probably be more accurate. Therefore, insurers will be more comfortable with using the blockchain for this purpose. Besides it would enable insurers to tokenize risks that are associated with issuing insurance policies. When risks are tokenized, insurance policies exist as smart contracts, which can be turned into a digital asset. This creates the possibility to trade small parts of this risk, which will facilitate an easy and transparent transfer of risks.

#### *Technical requirements*

- TTM-1 From a technical point of view, blockchain could be the solution to everything (this is dictated by the description of this scenario)?

The participants stated that this part of the heat map is dictated by the description of the stress factor and therefore did not lead to interesting insights. It is evident that in this scenario the blockchain meets the requirements that insurers put on their IT systems and could be used for multiple purposes. Therefore, this impact will be ignored.

#### *Activities*

- ATM-1 Blockchain could also be used for business-to-consumer and consumer-to-consumer applications.
- ATM-2 Core processes (the entire value chain) could run on a blockchain.
- ATM-3 Risk bearing can be hedged.

When the technology is manageable and mature, core processes (the entire value chain) could be automated and made more transparent. Insurers will not only feel confident about using it for business-to-business applications, but also for business-to-consumer applications and consumer-to-consumer use cases. The tokenization of risks makes it easier for insurers to hedge risk bearing; parts of risks can be moved to investors with different risk profiles and appetites.

#### *Resources & capabilities*

- RTM-1 In this scenario, it is more likely that a public blockchain will be the preferred configuration.
- RTM-2 As blockchain technology turns out to be manageable, technical expertise in this field becomes commonplace.

In this scenario, it is more likely that insurers have the confidence to choose for a public blockchain configuration. When blockchain technology is manageable and more mature, it will not be difficult for the insurers to attract blockchain experts. These experts will be able to deal with the degree of complexity of blockchain implementations.

#### **Increasing regulatory complexity (moderate)**

##### *Value proposition*

- VIM-1 There will be plenty of room for experimentation.

When regulatory complexity increases moderately, there will be more room for experimentation, because being compliant is less of a challenge.

##### *Technical requirements*

- TIM-1 Parties should be able to protect themselves to a large degree (self-sovereignty).

Regulators do not strictly enforce regulation and standards, but insurers will be motivated to carefully consider the requirements they put on the use of blockchain in their business environment nonetheless. They want to be sure that they will be able to safely implement blockchain. For example, they really want to ensure that they do not do business with malicious parties, so they have to carefully configure their “Know Your Customer” processes. This offers insurers more freedom, but it comes with a responsibility.

##### *Activities*

- AIM-1 Blockchain could also be used for both business-to-consumer and consumer-to-consumer applications.
- AIM-2 There will be more entrants and cross-fertilization between them could take place.

Compliance is less challenging and insurers will not only feel confident about being compliant in business-to-business applications, but also in business-to-consumer applications and consumer-to-consumer use cases.

There will be more new entrants and cross-fertilization will take place. In that scenario, there will be low barriers of entry for FinTech firms; it will be easier for them to become part of the insurance value chain. It will be easier for insurers to experiment outside their regular activities, with or without new entrants.

### *Resources & capabilities*

- RIM-1 It will be easier to gain access to customer data.

When there is less regulation such as GDPR, insurers could have better access to customer data and are allowed to use it for a wider variety of purposes. This could be valuable for developing and delivering new services.

### **Increasing regulatory complexity (strong)**

#### *Value proposition*

- VIS-1 There will be a greater necessity for reporting, which could make the use of blockchain more interesting and possibly obligatory.

When the complexity of regulation strongly increases, the realization of a blockchain implementation will be more difficult, however, also the value of it increases; blockchain pre-eminently suited for creating an automated audit trail that could prove regulatory compliance. This not only makes blockchain an interesting solution, but also could motivate regulators to make the use of it obligatory. Here, too, there seems to be a trade-off between the viability of the value proposition on the one hand and the actual value of the realization of a blockchain solution in the insurance value chain on the other hand.

#### *Technical requirements*

- TIS-1 Being compliant with complex regulation will be difficult from a technical point of view.
- TIS-2 Standards can be enforced.

While being compliance can be automated when a blockchain implementation has successfully been realized, the actual configuration of it is more difficult from a technical point of view in a complex and heavily regulated environment. An advantage of an increasing regulatory complexity is that standards might be enforced by regulators, the time and effort that otherwise would have been required to develop industry standards can be used for developing applications instead.

#### *Activities*

- AIS-1 Innovation could be inhibited.
- AIS-2 In this scenario, blockchain applications will probably be business-to-business.

Being compliant is challenging (especially for new entrants), even without the development of a new technology, this will inhibit innovation. Insurers will probably only feel confident about being compliant in business-to-business use cases, because it will provide them with more control.

### *Resources & capabilities*

- RIS-1 In this scenario, knowledge of regulation provides insurers with a competitive advantage.

The insurers' knowledge of regulation becomes even more relevant than it is today, so in a complex regulatory environment, their competitive advantage will be maintained.



#### 4.2.4.1 Conclusion of workshop results group 1

##### *Cooperation*

A weak cooperation might be a showstopper for the intended transparency; if a limited number of parties join the blockchain, it provides an incomplete audit-trail of insurance processes. However, in this scenario, trust is probably low and a blockchain is pre-eminently suitable for enforcing transparency and still realizing networks effects. When the cooperation is strong, barriers of entry are low and a level playing field will emerge, therefore, a high transparency and strong network effects will be realized. Besides, an efficient exchange of data and automation will reduce the cost of insurance. However, it is questionable whether blockchain is required for realizing transparency in this scenario. Therefore, there seems to be a trade-off between the viability of transparency on a blockchain on the one hand and the actual value of it on the other hand. In both scenarios, the use of blockchain will be limited to backend processes, as blockchain's user-friendliness is low.

It is difficult to coordinate the development of standards when the cooperation is weak, however the emergence of competing standards could result in a rapid initial development. When the cooperation is stronger and more parties jointly try to develop standards, standards could be more widely supported, however they tend to develop inertia. Therefore, there seems to be a trade-off between the viability and speed of development of standards on the one hand and fragmentation on the other hand. When an insurance blockchain is widely adopted, it would require large-scale modification of IT, this has been identified as a showstopper. Besides, identification errors on widely adopted blockchain could easily spread throughout the network.

When the cooperation is weak, the possibilities to share resources and capabilities and reach synergy in solving problems are rather limited, this has been identified as a showstopper. While in a scenario of strong cooperation, a blockchain platform that facilitates the modular development of applications could be realized. In both scenarios, it is likely that a sub-optimization will be developed which puts insurers at the centre and blockchain will enable insurers to collect customer data and guarantee continuity in combination with the "Internet of Things".

In a scenario of weak cooperation, knowledge of regulation will remain a competitive advantage of large insurers over smaller parties and new entrants. In a scenario of strong cooperation, best practices could easily be exchanged and a blockchain platform could be accessible to numerous parties, however it will be more difficult for insurers to differentiate themselves from competitors. Besides the reluctance of insurers to share valuable customer data limits the potential for developing and providing new services in this scenario.

##### *Technological complexity and uncertainty*

When blockchain technology is hard to manage in the near future, a potential showstopper could be the cancellation of insurers' investments. Applications will be limited to less complex use cases or niche markets such as short-term services. When it is manageable, it could facilitate accurate risk assessment and a trade in digital assets that represent small parts of risks.

When the technology is hard to manage, innovation in the current value chain will mainly take place in business-to-business applications and more specifically will be limited to policy administration, claims management and underwriting and risk management. When this limited innovation proves to be too difficult, the development of new concepts could be stimulated. When the technology is manageable, innovation is not limited to business-to-business applications and could take place in the entire value chain. Besides, risk tokenization could make it easier for insurers to hedge risk bearing.

When the technology is hard to manage, it will be hard for insurers to ensure compliance. They are more likely to choose for the control that private blockchains provide them. In this scenario, insurers will be even more reluctant to share their valuable customer data, this has been identified as a showstopper, because it limits the potential for developing and providing new services. If an insurance blockchain will be realized nonetheless, the strong brand recognition of insurers provides them with a competitive advantage over new entrants, because consumers are more likely to purchase blockchain services from them in this scenario. When the technology is manageable, it is more likely that insurers have the confidence to choose for a public blockchain configuration. In this scenario, blockchain expertise becomes commonplace and the implementation of a blockchain should not be a problem from a technical point of view.

#### *Increasing regulatory complexity*

There seems to be a trade-off regarding regulatory complexity and the value proposition. When regulatory complexity is moderately increasing, there will be more room for experimentation and the realization of a blockchain implementation will be less difficult than in a scenario in which it strongly increases. However, in the latter scenario, there will be a greater need for reporting, which makes the use of a blockchain more interesting and possibly obligatory.

Being compliant when regulatory complexity strongly increases will be difficult from a technical point of view. However, standards might be enforced by regulators in this scenario, this reduces the technical challenges of the development of a blockchain. When the regulatory complexity moderately increases, insurers have a larger responsibility for a safe blockchain implementation.

In a less complex scenario, blockchain could be used for both business-to-consumer and consumer-to-consumer applications, while in a more complex scenario its use will be limited to business-to-business applications. In the latter scenario innovation might be very difficult, especially for new entrants, this has been identified as a showstopper. In a less complex scenario, there will be more new entrants and cross-fertilization between them could take place.

In a less complex regulatory scenario, insurers could have better access to customer data and are allowed to use it for a wide variety of services. In a more complex scenario, the insurers' knowledge of regulation provides them with an even stronger competitive advantage than it currently does.

### 4.2.5 Results of group 2

Table 20 on this page shows the heat map that that resulted from the workshop session of group 2. The codes in the coloured heat map scores refer to the description below; each coloured cell with a code represents a sticky note that has been put on the heat map template in the workshop. As the participants put sticky notes between the two contrasted scenarios, the columns labelled “Both” have been added. The impacts on these sticky notes are relevant in both scenarios.

TABLE 20: HEAT MAP GROUP 2

Group 2	Most relevant uncertainties (stress factors)								
	Cooperation (C)			Technological complexity and uncertainty (T)			Increasing regulatory complexity (I)		
	Weak (W)	Both (B)	Strong (S)	Hard to manage (H)	Both (B)	Manageable (M)	Moderately (M)	Both (B)	Strongly (S)
<b>Business model components</b>									
<b>Valueproposition (V)</b>	VCW-1		VCS-1	VTH-1		VTM-1	VIM-1	VIB-1	VIS-1
	VCW-2		VCS-2	VTH-2		VTM-2		VIB-2	VIS-2
			VCS-3						
<b>Technical requirements (T)</b>	TCW-1		TCS-1	TTH-1	TTB-1	TTM-1	TIM-1	TIB-1	TIS-1
	TCW-2		TCS-2	TTH-2	TTB-2				TIS-2
									TIS-3
<b>Activities (A)</b>	ACW-1		ACS-1	ATH-1		ATM-1	AIM-1	AIB-1	AIS-1
				ATH-2		ATM-2		AIB-2	
						ATM-3		AIB-3	
<b>Resources &amp; capabilities (R)</b>				RTH-1				AIB-4	
								AIB-5	
								RIB-1	RIS-1
							RIB-2		

#### Cooperation (weak)

##### Value proposition

- VCW-1 When parties are innovating independently, the “not invented here syndrome” could be developed.
- VCW-2 The existence of distrust provides an opportunity for the use of blockchain.

When cooperation is weak and innovation takes place in separate initiatives, the results of this innovation process might be less widely supported. Considering the nature of blockchain as a cooperative technology, this severely limits the potential value of a blockchain implementation.

However, in this scenario it is more likely that a certain degree of distrust exists, which increases the value of a blockchain implementation. It will be hard to find a use case within a single organization that makes sense.

##### Technical requirements

- TCW-1 A standard for data exchange could probably not be realized.
- TCW-2 An “Identity of Things” is required for objects that are insured on a blockchain.

While a weak cooperation and lack of full trust provides an opportunity for blockchain, developing standards for data exchange is difficult in this scenario, as it requires close coordination. A lack of cooperation might result in fragmentation; when one or two parties develop a standard that could be

adopted by other parties, these parties are less inclined to adopt these standards. It will be difficult to intensively exchange data when data exchange standards will not be realized.

When insurers have the ambition to use devices to collect data on insurable object on a blockchain (the so-called “Internet of Things”), it will require the development of an “Identity of Things” as well. This will ensure that the data is actually coming from the device that it should come from.

#### *Activities*

- ACW-1 Peer-to-peer use cases do not require a strong cooperation and could therefore be realised in this scenario.

Peer-to-peer use cases do not require cooperation, as customers will interact without the involvement of insurers or intermediaries. Only the customers will interact on a platform once it has been realized by an insurer. This is an interesting point, as it shows that not all use cases require a strong cooperation between insurers and intermediaries.

#### **Cooperation (strong)**

##### *Value proposition*

- VCS-1 When cooperation is strong, it is more likely that a successful blockchain will be realised, however, it will be less relevant because of the existence of trust.
- VCS-2 A high level of transparency will be realized when the cooperation is strong.
- VCS-3 An insuree will be able to build a good reputation.
- VCS-4 A finer segmentation of insurance products based on behaviour can be stored on blockchains.

The technology makes it possible to realize the value proposition, but a strong cooperation is what actually creates the value. In this cooperation, it is more likely that a successful blockchain will be realized. This blockchain provides a high level of transparency, in which reputation management plays a crucial role. Because parties in the value chain are working together and share databases with customer information, having a good reputation is valuable to customers. Based on this reputation, a finer segmentation based on customer risk profiles can be stored on a blockchain. However, there seems to be an interesting trade-off between the viability of the value proposition on the one hand and the actual value of the realization of a blockchain solution in the insurance value chain on the other hand. When parties are closely cooperating, they will likely trust each other, therefore solutions other than blockchain might be more interesting.

##### *Technical requirements*

- TCS-1 A finer segmentation of insurance products based on behaviour can be stored on blockchains.
- TCS-2 It is more likely that a sufficient degree of data exchange will be realized.

It is more likely that standards of data exchange will be developed in close cooperation. This will reduce fragmentation; the standards are more likely to be widely adopted. Therefore, it is more likely that a sufficient degree of data exchange will be realized. A result of this improved exchange of data is that risk profiles of customers will be more complete and facilitate a finer segmentation of insurance products.

### *Activities*

- ACS-1 In this scenario, blockchain is an enabler for use cases such as co-insurance and risk pooling.

When insurers are able to closely cooperate on a blockchain, it provides them transparency and enables them to share risks.

### **Technological complexity and uncertainty (hard to manage)**

#### *Value proposition*

- VTH-1 Blockchain does not live up to its claim to being an enabler.
- VTH-2 It is difficult to realize transparency.

It will be a showstopper when the technology is hard to manage; the value proposition as it is defined in the reference business model is strongly related to the technology. When it is not able to meet the requirements that insurers put on their IT systems, the use of blockchain as an enabler is limited and it will be hard to realize transparency in the value chain.

#### *Technical requirements*

- TTH-1 Blockchain cannot meet the requirements (this is dictated by the description of this scenario).
- TTH-2 In this scenario, a selective, or consortium blockchain configuration (a hybrid blockchain) probably will be chosen.

The participants stated that this part of the heat map is dictated by the description of the stress factor and therefore did not lead to interesting insights. It is evident that in this case blockchain will not be able to meet the requirements that insurers put on their IT systems and that the possibilities to use it are very limited. Therefore, this showstopper will be ignored. This scenario could lead to the development of private (selective) or consortium (hybrid) blockchains, as these provide more options for control.

### *Activities*

- ATH-1 Alternatives, other than blockchain, for supporting processes could come into existence.
- ATH-2 Claim handling could be a use case in this scenario.

When blockchain is hard to manage, it might stimulate the development of alternative technologies that actually will be able to support insurance processes. In this scenario, claim handling could still be an interesting use case for blockchain.

#### *Resources & capabilities*

- RTH-1 No investments in blockchain are required, the status quo will be maintained.

When it is clear that blockchain is too hard to manage and is not able to meet the insurers' requirements, no investments in it have to be made and their dominant position on the market will be maintained.

## **Technological complexity and uncertainty (both)**

### *Technical requirements*

- TTB-1 Speed and storage are challenging.
- TTB-2 Data integrity is crucial.

Regardless of the manageability of blockchain, scalability, in terms of speed and storage is the most challenging problem that needs to be solved. Besides, every insurance application of blockchain, data integrity is crucial.

## **Technological complexity and uncertainty (manageable)**

### *Value proposition*

- VTM-1 The insurance process can be handled faster, more efficient and more transparent.
- VTM-2 Processes will be improved/sped up → costs will be reduced/controlled.

The value proposition as it is defined in the reference business model is strongly related to the technology. When it is able to meet the requirements that insurers put on their IT systems, the value proposition will be realized. Insurance processes will be handled faster, more efficient and more transparent.

### *Technical requirements*

- TTM-1 Risks can be managed by making sound agreements.

When the blockchain is manageable and meets the requirements that insurer put on their IT systems, agreements can be stored and enforced by it. When insurers are able to come to unambiguous agreements, they will be able to manage the risks of a blockchain implementation.

### *Activities*

- ATM-1 Blockchain could provide an alternative to a trusted third party.
- ATM-2 Blockchain lowers barriers of entry, but makes regulation more difficult.
- ATM-3 Barriers of entry could be created by the Dutch insurers. What will be the role of the authorities in this case?

Several services in the insurance landscape, such as fraud reporting and clearing house functions are outsourced to trusted third parties. Sometimes, these functions are fulfilled by commercial parties. Blockchain could enable insurers to keep this administration in-house, then they do not longer have to rely on the services of these third parties anymore.

When the technology is working and standardized, it will be easier for parties to join a blockchain platform. An increasing number of entrants on the insurance market will make regulation more difficult.

When the technology is manageable, it could be used by the 120 Dutch insurers to create a blockchain platform on which new entrants are not allowed. This will be a considerable barrier of entry that enables the insurers to lock-out new entrants. It is not clear how the authorities will react to this development.

### **Increasing regulatory complexity (moderate)**

#### *Value proposition*

- VIM-1 Blockchain provides opportunities for automating audits and compliance.

Implementation of blockchain will be less difficult, it could be used for automating audits and compliance. However, there might be less opportunities for blockchain to solve problems. There seems to be a trade-off between the viability of a blockchain implementation and the value that is created by it.

#### *Technical requirements*

- TIM-1 In this scenario, the use of a private blockchain configuration is more likely.

In this scenario, there will be less strict regulations on providing transparency, therefore the use of a private blockchain is more likely.

#### *Activities*

- AIM-1 The burden of proof is embedded in the system, this solves the trust problem.

In this scenario, there is more room for self-regulation, insurers have the freedom to develop a blockchain that enforces trust. However there seems to be a trade-off; it might be less likely that this will happen, as the necessity of such a blockchain will be lower when regulatory complexity moderately increases.

### **Increasing regulatory complexity (both)**

#### *Value proposition*

- VIB-1 The realisation of the value proposition requires strict monitoring and is difficult to automate.
- VIB-2 From a technical point of view, the realisation of the value proposition is not an issue.

From a technical point of view, it is possible for blockchain to realize the value proposition. However, even in the scenario of a moderately increasing regulatory complexity, it requires a large degree of monitoring and automation that is difficult to realize.

#### *Technical requirements*

- TIB-2 Smart contracts make the business transparent.

In both scenarios smart contracts are required to increase the transparency of the insurers.

### *Activities*

- AIB-1 Laws and regulations could be a limiting factor.
- AIB-2 The first use cases will probably be found in the following parts of the insurance value chain:
  - Underwriting & risk management;
  - Policy administration;
  - Claims management.
- AIB-3 Next, use cases will probably be found in investment management (blockchain could prove solvability).
- AIB-4 Next, use cases will probably be found in product development.
- AIB-5 The last use cases will probably be found in the following parts of the insurance value chain
  - Marketing;
  - Sales & distribution.

In both scenarios, laws and regulations dictate what is possible with blockchain, so they could limit the possibilities of insurers. Underwriting & risk management, policy administration and claims management will probably be the first parts of the value chain in which the first use cases will be found. Next, blockchain use cases will probably be found in investment management; it provides the possibility to register the insurers' assets on a blockchain, this can provide transparency in the solvability of the insurers. Besides it provides insight into the risks associated with their assets. Next, blockchain could be used for product development, it can be used to realize a finer granularity of insurance products; blockchain is able to process numerous parameters, for example behavior, into their service offering. Finally use cases will be found in marketing and sales & distribution.

### *Resources & capabilities*

- RIB-1 There is a lack of (legal) knowledge of smart contracts among consumers.
- RIB-2 There is a lack of (legal) knowledge of smart contracts among the authorities.

In both scenarios there is a severe lack of knowledge of blockchain technology and smart contracts. This especially holds for consumers and authorities.

### **Increasing regulatory complexity (strong)**

#### *Value proposition*

- VIS-1 This scenario provides more opportunities for blockchain (as an enabler).
- VIS-2 Blockchain could provide a solution to the decreasing trust in the self-driving car.

In this scenario there will be more opportunities for using blockchain, it could enable insurers to be compliant, as it could create transparency and might facilitate systems that store privacy-sensitive data locally at the customer. Implementation will be more difficult, but it could solve more problems; there seems to be a trade-off between the viability of a blockchain implementation and the value that is created by it.

The emergence of the self-driving car creates a trust problem regarding legal liability. For example, when a Tesla hits a tree, the only party that will be able to judge whether the human driver or the automatic pilot is to blame, is the firm that developed the auto pilot software. The latter therefore has an intrinsic motivation to use the explanation of the cause of the accident to their advantage. As



cases like this will become more widespread and have a considerable financial impact, morality risks will increase as a result. In a future with a widespread adoption of self-driving cars there will be a need for stricter regulations and therefore there are more opportunities for blockchain to provide added value.

#### *Technical requirements*

- TIS-1 It is necessary to keep all nodes within the borders of the European Union.
- TIS-2 There is no flexibility to adapt blockchains in such a way that data will be stored within the border of the European Union, instead of globally.
- TIS-3 Regulation in the insurance industry enables blockchain to contribute to transparency.
- TIS-4 Blockchain could provide a solution to the decreasing trust in the self-driving car.

In this scenario, there will be strict regulations on the geographical location of nodes, as data has to be kept within the borders of the European Union. However, there is no flexibility to adapt blockchains in order to have full control over this location. Therefore, it will be very difficult to be compliant in this scenario. As mentioned before when the value proposition was discussed, blockchain has the potential to increase the transparency in a strictly regulated insurance industry and to provide a solution to the decreasing trust in the self-driving car.

#### *Activities*

- AIS-1 Processes can be enforced by blockchain.

Blockchain can be used to enforce compliance in insurance processes.

#### *Resources & capabilities*

- RIS-1 IT-audit is essential.

When a blockchain implementation has to be compliant with regulations that are increasingly complex, IT-audit will be essential; the use of blockchain will probably increase in this scenario and the insurer will depend more heavily on it. Therefore, it is important to be sure that no errors are made.

### 4.2.5.1 Conclusion of workshop results group 2

#### *Cooperation*

When cooperation is weak, innovations might be less widely supported and the value proposition will not be fully realized, this has been identified as a showstopper. However, the existence of distrust makes the realization of a blockchain more valuable. Therefore, there seems to be a trade-off between the viability of the formulated value proposition on the one hand and the actual value of it on the other hand. When the cooperation is strong, transparency, reputation management and a finer segmentation will be provided by blockchain.

It is difficult to coordinate the development of standards when the cooperation is weak. When the cooperation is stronger, standards could be more widely supported, a sufficient degree of data exchange will be realized and a finer segmentation will be provided by blockchain. When the cooperation is weak, an "Identity of Things" would be required to ensure that data is coming from a specific "Internet of Things" device.

Typical use cases that could be realized when the cooperation is weak, would be peer-to-peer insurance, as customers will interact without the involvement of insurers or intermediaries once a platform has been developed by an insurer. When the cooperation is strong, blockchain enables insurers to share risks in use cases such as co-assurance and risk pooling.

#### *Technological complexity and uncertainty*

When the technology is hard to manage, the use of blockchain as an enabler is limited and transparency will not be realized. This has been identified as a showstopper. However, when the technology is manageable, the value proposition could be realized to a large extent. This seems quite evident since the value proposition is closely related to the technological characteristics of blockchain technology.

When the technology is hard to manage, a private or consortium blockchain configuration is more likely. In a scenario where the technology is manageable, using blockchain's potential for risk management requires insurers to come to unambiguous agreements. It is worth mentioning that group 2 unanimously agreed that blockchain technology will absolutely be manageable within 5 years, it is rapidly developing. All problems that currently exist for applications in insurance will be solved within 5 years. Besides group 2 mentioned that regardless of the manageability of the technology, speed and storage are the most challenging technical requirements and data integrity is crucial.

When the technology is hard to manage, claim handling could still be a use case for blockchain, or the development of alternative technologies for supporting insurance use cases could be stimulated. When it is manageable, it will be easier for parties to join a blockchain platform, but that could also make regulation more difficult. Advantages of this scenario are that it could provide an alternative to a trusted third party and enable insurers to keep administration in-house. Besides it could enable all Dutch insurers to jointly create a strong platform and lock-out new entrants.

When the technology is hard to manage, no investments in blockchain are required and the dominant position of insurers will be maintained.

#### *Increasing regulatory complexity*

When regulatory complexity increases, the realization of the value proposition requires strict monitoring and is difficult to automate (not from a technical point of view). When it moderately increases, the implementation of a blockchain that automates audits and compliance is less difficult, however, the value of blockchain as an enabler of compliance is limited. The value would be larger when the complexity strongly increases, therefore, this is a trade-off. An example of a use case in which blockchain could be used to handle strict future regulations and increase trust is the self-driving car.

When the complexity moderately increases, the use of blockchain will probably be limited to a private blockchain configuration as less transparency is required by regulation. In both scenarios of regulatory complexity, smart contracts are required to increase the transparency of the insurers. When complexity strongly increases, a showstopper has been identified: it will be hard to meet the requirements for data governance regarding the storage of data within the borders of the European Union.

In a scenario of moderate complexity, there is more room for self-regulation and the burden of proof can be embedded in a blockchain, this establishes trust. However, a trade-off has been identified, it might be less likely that this will happen, as the necessity of a blockchain that enforces processes will be higher when the complexity strongly increases. In both scenarios, laws and regulations could dictate in which value chain activities the first blockchain use cases will be found. The first uses cases will probably be found in underwriting and risk management, policy administration and claims management. Next, in investment management (for proving solvency), product development (finer granularity of insurance products) and finally in marketing and sales & distribution.

In both scenarios a showstopper regarding resources and capabilities has been identified, there is a lack of (legal) knowledge of smart contracts among both consumers and authorities. In the scenario of strongly increasing regulatory complexity, a related showstopper has been identified: when insurers increasingly depend on blockchain for being compliant in this scenario, a new IT-audit role is essential.

## 5 Conclusions, limitations and recommendations

The objective of this research was defined as follows in section 1.4:

*Help business decision makers to anticipate the impact of blockchain technology on their business models, by finding the most important parts of the business model that need to be addressed.*

In order to reach this objective, a literature review, semi-structured expert interviews and a business model stress test workshop have been conducted. This chapter first evaluates the key insights regarding the impact of blockchain technology on the insurance business model that resulted from this research. This will be done by first answering research sub-questions 1 to 8. Secondly, it will provide recommendations to business decision makers by answering research sub-question 9. Thirdly, it evaluates the academic contribution of the research to the field of business model stress testing. Next, the limitations of the research will be discussed and finally suggestions for future research will be made.

### 5.1 Conclusions

A main research question has been formulated in order to reach the research objective, it was defined as follows in section 1.4.1:

***RQ: How will blockchain technology impact the insurers' business models?***

The main research question has been broken down into nine research sub-questions in section 1.4.2. This section will provide an overview of these sub-questions and answer them.

***RSQ1: What are the main characteristics of blockchain technology relevant for application in the insurance industry?***

This question has been answered by conducting a literature review. Firstly, the literature review provided a definition of blockchain (Swan, 2015):

*“The blockchain is the decentralized transparent ledger with the transactions records – the database that is shared by all network nodes, updated by miners, monitored by everyone, and owned and controlled by no one. It is like a giant interactive spreadsheet that everyone has access to and updates and confirms that the digital transactions transferring funds are unique.”*

Secondly, it explained the working principles of blockchain technology and described three generations of blockchain that can be distinguished. Thirdly, the following selection criteria for high-potential use cases have been found (World Economic Forum, 2016):

- *Shared repository:* A shared repository of information is used by multiple parties.
- *Multiple writers:* More than one entity generates transactions that require modifications to the shared repository.
- *Minimal trust:* A certain degree of mistrust exists between entities that generate transactions.
- *Intermediaries:* One (or multiple) intermediary or a central gatekeeper is present to enforce trust.
- *Transaction dependencies:* Interaction or dependency between transactions is created by different entities.

Next, literature on the use of blockchain in the financial services industry was analyzed. The latter was combined with the description of the three generations of blockchain and the following value proposition of blockchain for the financial services industry was derived:

- The *need for a trusted third party* is eliminated, as the blockchain protocol describes how consensus on the validity of a transaction is reached. Transactions in a blockchain are unique and are authorized by linking a digital signature to an identity.
- *Controllability* of data is improved by linking transactions to each other and establishing an immutable “single source of truth”. This “single source of truth” is shared in a peer-to-peer network. Regulators could monitor this audit trail in near real-time, which could reduce the costs of regulatory compliance.
- It is *not necessary to (manually) combine data*, the risk of errors is reduced, transactions are settled quickly and do not require arbitrage, which makes risk management less difficult and improves liquidity.
- Blockchain offers *high resiliency*, as it does not depend on central infrastructure. It will continue to work in case of local system failures.
- Blockchain facilitates the use of so-called “*smart contracts*”, these contracts execute predefined lines of computer code when certain conditions are met.

However, blockchains are not always the preferred solution over centralized databases. Blockchains are more likely to be the preferred solution when disintermediation and robustness are more important, while centralized databases are more likely to be the preferred solution when confidentiality and performance are more important.

Guidance on the fundamental choice regarding a blockchain configurations has been provided by Table 3 on page 18, namely choosing between: public blockchains (permissionless), hybrid (consortium) blockchains (permissioned) and fully private blockchains (permissioned).

***RSQ2: Which business model ontology is suitable for describing the insurance reference business model?***

This question has been answered by conducting a literature review. In this literature review, three business model ontologies have been compared: the Business Model Canvas (Osterwalder & Pigneur, 2010), the VISOR model (El Sawy & Pereira, 2013) and the STOF Model (Bouwman et al., 2008). The Business Model Canvas has been developed as a representation of choices regarding strategy and marketing in which the individual firm is the unit of analysis (Bouwman et al., 2012). This focus on the individual firm makes it less suitable for the analysis of a service that is delivered by a network of business actors. Besides, the framework provides little insight into the technological aspects of service delivery in a networked environment. Therefore, it is not pre-eminently suitable for describing the reference business model and analysing the impact of blockchain technology on this model. The VISOR Model is suitable for describing service provision or product delivery in a so-called “networked digital industry” (El Sawy & Pereira, 2013) and provides more insight into the technological aspects of service delivery than the Business Model Canvas. Therefore, it is more suitable for describing the reference business model than the Business Model Canvas.

The STOF method is often used for the analysis of innovative technologies (Bouwman et al., 2017) and it is most suitable for exploring new service ideas. It has specifically been developed as a tooling-focussed design method for ICT-enabled services, where the service that is delivered by a value network is the unit of analysis (Bouwman et al., 2012). Besides, it includes the most detailed analysis of the technology architecture and technology design issues. Therefore, the STOF Model ontology is most suitable for describing the reference business model.

***RSQ3: Which uncertainties, against which the different components of the reference business model will be tested, are most relevant according to experts and literature?***

This question has been answered by both conducting a literature review and semi-structured expert interviews. The literature review provided an initial analysis on the most relevant uncertainties for this research. Blockchain technology is in an early stage of development, therefore, in the first part of this analysis, the most important technical uncertainties for blockchain in the financial services industry have been identified. It resulted in a list of technical requirements that the financial services industry puts on their IT systems and which are currently not met by blockchain technology. In the second part, the recent developments in the insurance industry have been analyzed. This resulted in additional technical uncertainties and an overview of uncertainties related to the market and regulations. Together, the two parts of the initial analysis resulted in an overview of the most relevant uncertainties related to the application of blockchain in the insurance industry. This overview can be found in Appendix B1 and was used to make an interview protocol for guiding the semi-structured expert interviews.

The transcripts of the semi-structured interviews have been analyzed with qualitative data analysis software (ATLAS.ti). From this analysis, a selection of the three most important contrasted uncertainties has been made. These uncertainties are the stress factors for the business model stress test workshop.

### *Stress factor 1: Cooperation*

The nature of blockchain technology stimulates parties in the insurance value chain to cooperate on the development and implementation of blockchain solutions. This cooperation determines the value of a blockchain implementation to a large degree.

- *Weak (stagnating cooperation):* The large number of parties involved in the cooperation initiative slows the innovation process down. In this situation, the envisaged cooperation will not be realized. The cooperation that actually has been realized is of low value and is stagnating, because the value proposition of blockchain can only be realized to a limited extent.
- *Strong (pre-competitive cooperation):* Parties in the value chain are able to cooperatively develop and implement blockchain solutions. Next to exchanging knowledge and experience, steps are made in order to improve standardization and compatibility. In this situation, the value proposition of blockchain can be realized to a large extent.

### *Stress factor 2: Technological complexity and uncertainty*

Blockchain technology is in an early stage of development, it does not meet the requirements that insurers put on their IT systems.

- *Blockchain technology is hard to manage:* The situation that is described above is not controllable within the next 5 years. Meeting the technical requirements requires very complex technical solutions. Blockchain will not be mature enough for large-scale implementation in the insurance industry and will get fragmented.
- *Blockchain technology is manageable:* The situation that is described above is controllable within the next 5 years, because several (large) parties cooperate with the insurance industry on blockchain implementations. Blockchain will be mature enough for large-scale implementation in the insurance industry and will not get fragmented.

### *Stress factor 3: Regulation*

There is a tension between the increasing cost of IT (updating legacy IT) caused by the pressure of rules imposed on insurers on the one hand and the need to innovate for gaining access to the market and reducing costs on the other hand. Therefore, the degree to which regulatory complexity increases, is expected to have a significant impact on the viability of blockchain in the insurance industry.

- *Moderately increasing regulatory complexity:* The level of complexity of laws and regulation is increasing, but compliance can be safeguarded by blockchain. Blockchain applications can be programmed in such a way that compliance is enforced by the code of the smart contracts. It will also be possible to increase the transparency of transactions that have been carried out.
- *Strongly increasing regulatory complexity:* The increasing level of complexity of laws and regulation makes it hard to develop blockchain implementations which are compliant with continuously changing laws and regulations like GDPR and Solvency II. Jurisprudence on the use of blockchain in the insurance industry is lacking. Depending on the type of blockchain, it can be hard to make changes afterwards, this creates the need for a careful evaluation of the code of an implementation.

**RSQ4: Which components of the reference business model are, according to experts and literature, most important for the assessment of the impact of the selected uncertainties?**

and

**RSQ5: What are core standard service processes that should be included in the business model description?**

Research sub-question 4 and 5 have been answered in section 4.2.2. in order to design a reference business model for the business model stress test workshop. The answers to these questions were based on both the interviews and a literature review. The strategy for reducing the complexity of the reference business model that is described in section 2.5.6.1 has been followed. This strategy consisted of aggregation and decomposition of the business model components. Besides, in the organizational domain, only the core standard service processes have been described. The result of following this strategy is represented by Table 21 on this page.

**TABLE 21: THE REFERENCE BUSINESS MODEL**

Service domain	Technology domain
<p><b>Customer and End-user</b></p> <ul style="list-style-type: none"> <li>• Consumer</li> </ul> <p><b>Value proposition</b></p> <ul style="list-style-type: none"> <li>• Blockchain increases the transparency of the insurance process and current value propositions for customers.</li> <li>• Extensive automation makes insurance processes cheaper and faster. This will result in lower premiums.</li> </ul>	<p><b>Technical requirements</b></p> <ul style="list-style-type: none"> <li>• Standardization and interoperability;</li> <li>• Identity- and access management with limited complexity;</li> <li>• Data governance (control over geographical storage location);</li> <li>• Compatibility with existing IT systems;</li> <li>• Long-term security and reliability;</li> <li>• Scalability;</li> <li>• User-friendly for consumers;</li> <li>• The ability to facilitate data-exchange, value transactions and smart contracts.</li> </ul>
Financial domain	Organization domain
<p>N/A</p>	<p><b>Activities</b></p> <ul style="list-style-type: none"> <li>• Product development;</li> <li>• Marketing;</li> <li>• Sales &amp; distribution;</li> <li>• Underwriting and risk management;</li> <li>• Policy administration;</li> <li>• Claims management;</li> <li>• Investment management.</li> </ul> <p><b>Use cases</b></p> <ul style="list-style-type: none"> <li>• Reinsurance;</li> <li>• Co-insurance;</li> <li>• Mutual insurance;</li> <li>• Asset provenance.</li> </ul> <p><b>Resources and capabilities</b></p> <ul style="list-style-type: none"> <li>• Customer data;</li> <li>• Knowledge on regulation and the insurance industry;</li> <li>• Brand recognition;</li> <li>• Expertise on blockchain platforms and smart contracts.</li> </ul>







**RSQ6: How do the selected stress factors relate to the different components of the business model?**

*and*

**RSQ7: What will the future impact of the stress factors on the different components of the reference business model be?**

These two questions have been answered in the business model stress test workshop. Workshop participants discussed on where to put sticky notes on the heat map templates. A place where a sticky note has been put, represents a relationship between an uncertainty outcome (a stress factor) and a business model component that has been established by the participants. The absence of a sticky note indicates that the uncertainty outcome is not expected to have a significant impact on the business model element. The color of the sticky note provides additional information on the expected impact, as is shown by the legend in Table 22 on this page.

**TABLE 22: THE LEGEND OF THE HEAT MAP, ADAPTED FROM (BOUWMAN ET AL., 2017)**

Legend of the heat map	
Red indicates a possible <b>showstopper; the business model will not be feasible.</b>	
Yellow indicates a <b>negative impact; action is required.</b>	
Green indicates that there is <b>no negative impact.</b>	
The absence of a sticky note indicates that the uncertainty has <b>no relevant impact.</b>	

The workshop resulted in two completed heat maps, one was made by the experts in group 1, the other was made by the experts in group 2. The heat maps provide a complete overview of the relationships between the different components and the stress factors. The colors of the cells of the heat map indicate which components are most important to address. The codes in the cells of heat maps refer to the labels and descriptions of each sticky note.

The heat maps of group 1 and 2 and their descriptions can be found in section 4.2.4 on page 88 and 4.2.5 on page 98 respectively.

**RSQ8: What are the weak points of the reference business model?**

This question has been answered by the construction and description of the two heat maps that resulted from the business model stress test workshop.

When the impact of the three stress factors on the business model components was assessed in the business model stress test workshop, nine showstoppers were identified. These components of the business model need to be addressed because they severely limit the feasibility of the business model. On the next page, these showstoppers are summarized for each stress-factor.

#### *Showstoppers for stress factor cooperation*

1. When the cooperation is weak, blockchain use cases might be less widely adopted and the intended transparency, cost reductions and automation will not be realized (group 1 and 2).
2. When the cooperation is strong and blockchain use cases are widely adopted, insurers will be required to make large IT modifications in order to solve compatibility problems (group 1).
3. When the cooperation is weak, the possibilities to share resources and capabilities and reach synergy in solving problems are rather limited. While in a scenario of strong cooperation, a blockchain platform that facilitates the modular development of applications could be realized (group 1).

#### *Showstoppers for stress factor technological complexity and uncertainty*

1. When the technology is hard to manage, the use of blockchain as an enabler is limited, transparency will not be realized and insurers' investments could be cancelled (group 1 and 2).
2. When the technology is hard to manage, insurers will be reluctant to share valuable customer data, because it will be hard for them to ensure compliance. This limits the potential for developing and providing new services (group 1).

#### *Showstoppers for stress factor increasing regulatory complexity*

1. When regulatory complexity strongly increases, it will be hard to meet the requirements for data governance regarding the storage of data within the borders of the European Union (group 2).
2. When regulatory complexity strongly increases, it will be hard for new entrants to be compliant. Therefore, there will be little new entrants and cross-fertilization between them and insurers will be limited (group 1).
3. Regardless of the degree in which regulatory complexity increases, there is a lack of (legal) knowledge of smart contracts among both consumers and authorities (group 2).
4. When regulatory complexity strongly increases, insurers increasingly depend on blockchain for being compliant, this requires a new IT-audit role (group 2).

Four trade-offs which should be addressed by the insurers have been identified in the workshop, these trade-offs are summarized below:

1. Especially when the cooperation is weak, trust is low and blockchain is pre-eminently suitable for enforcing trust and transparency, but it will be difficult to realize this value proposition. It will be less difficult to realize the value proposition when the cooperation is strong, but its value is rather limited (group 1 and 2).
2. It is difficult to coordinate the development of standards and prevent fragmentation when the cooperation is weak. When the cooperation is stronger, standards could be more widely supported (group 1 and 2). However, close cooperation, especially in large groups, could result in inertia, while competing standards could result in a rapid initial development (group 1).
3. When regulatory complexity moderately increases, the realization of a blockchain that automates audits and compliance is less difficult. However, the value of blockchain as an enabler of compliance is higher in a more complex regulatory scenario (group 1 and 2).

4. When the cooperation is weak, blockchain solutions might be less widely adopted and the intended transparency, cost reductions and automation will not be realized (group 1 and 2). However, when cooperation is strong and blockchain solutions are widely adopted, insurers will be required to make large IT modifications in order to solve compatibility problems (group 1).

#### *Blockchain implementation in the core standard service processes*

The groups identified very similar use cases of blockchain in the value chain that will be most likely be implemented in different scenarios. It can be concluded that when the technology is hard to manage and/or regulatory complexity strongly increases, the application of blockchain is likely to be limited to the following parts of the value chain: underwriting and risk management, policy administration and claims management. Only when the technology is more manageable and/or the regulatory complexity moderately increases, blockchain will be applied in investment management, product development, marketing and sales and distribution (group 1 and 2). Group 1 mentioned that a consequence of this development is that some parts of the value chain will have made the transition to a blockchain platform, while others will still be run on centralized IT systems. The fact that parts of the value chain do not simultaneously transition to blockchain platform might result in integration problems later on. In that case, it will take longer before a transition to an all-encompassing blockchain platform for the entire value chain will be realized.

#### *Blockchain configuration and contexts*

A constraint on the possible blockchain configurations and contexts has been identified in the workshop. This constraint is caused by a technological complexity and uncertainty that is hard to manage. When the technological complexity and uncertainty are hard to manage, mainly business-to-business applications will be developed (group 1) and a private (group 1 and 2) or consortium blockchain configuration will likely be preferred (group 2). The latter two provide more options for control. When the technological complexity and uncertainty are manageable, blockchain could also be used for business-to-consumer and consumer-to-consumer applications and it is more likely that a public blockchain will be the preferred configuration (group 1). Also, a constraint on contexts that is caused by a strongly increasing regulatory complexity has been found. In this scenario, blockchain applications will probably be limited to the business-to-business context. When the regulatory complexity moderately increases, blockchain could also be used for business-to-consumer and consumer-to-consumer applications. Besides, it is likely that regulators do not strictly enforce regulation and standards in this scenario, but insurers will be motivated to carefully consider the requirements they put on the use of blockchain in their business environment nonetheless. They would want to be sure that they will be able to safely implement blockchain (group 1). It can be concluded that in a future in which the regulatory and/or technological complexity increase, there is less freedom for insurers to choose a blockchain configuration and context.

#### *Resources and capabilities*

When the cooperation is strong, insurers will still be reluctant to exchange customer data, which limits the potential of a blockchain implementation; insurers have lots of customer data that is crucial for providing and developing new services. Besides, when cooperation is strong and a blockchain platform will be developed which is accessible to numerous parties, numerous parties will have more or less

the same possibilities for delivering services. Therefore, it will be harder for insurers to differentiate themselves from their competitors (group 1).

## 5.2 Practical implementation

***RSQ9: Which steps could be taken in order to improve the future robustness of the business model?***

Based on the insights that are gained from the literature research, expert interviews and business model stress test workshop, several recommendations to insurance industry business decision makers can be made.

Insurers are struggling financially because of several macro-environmental developments: the declining sales of life insurance policies, low interest rates and stricter solvency requirements. Besides they have to make considerable investments in their legacy IT systems in order to be compliant with regulation. Therefore, insurers are focussed on cost reductions and should carefully consider their investments in innovations. Currently, blockchain technology is not mature enough for the insurance industry. Enterprise-grade solutions that meet the requirements of the industry regarding governance, privacy, scalability, identity and access management, security and reliability are not available. A scattered field of solutions is under development and the configuration of these solutions requires low-level coding. In this situation, insurers are not willing to share data and the potential of blockchain, as a cooperative technology, is limited. Neither the interview, nor the workshop did provide a clear timeframe for enterprise-grade solutions. The blockchain innovation activities of insurers have been limited to experiments (both intra- and interorganisational) in sandboxes. As long as the technology does not meet the requirements of the insurance industry, it is recommended that they continue to do so with the goal of learning about the technology and providing feedback to the developers of enterprise-grade solutions. It should be noted that this way of working fits the risk appetite of the heavily regulated insurance industry, but postpones dealing with important challenges on the integration with existing IT systems. The insurance industry has been exploring blockchain for several years now, but in this research no concrete use cases that will reach maturity anytime soon and will actually realize benefits from the use of blockchain have been found. The use cases that have been described in this research are rather conceptual, they describe a promising future in which blockchain will be leveraged. Therefore, it is hard to justify investments that are specifically targeted at blockchain technology. However, there are two investments insurers should make that are not specifically targeted at blockchain technology, but will prepare insurers for technological innovation, whether blockchain will reach maturity in the near future or not. The competitive threat from FinTech firms seems to be low, as insurers have a large customer base, customer data, investment capital, strong brand recognition, knowledge on the industry, knowledge on regulation and insurance licenses. Therefore, insurers should mainly focus on competition from other insurers in their assessment of whether they can afford the following investment strategy.

The first and most important investment is related to standardization. The workshops led to the insight that the most crucial uncertainty outcome is the strength of cooperation, this was to be expected as it follows from the nature of blockchain technology; its value proposition, increased transparency, the establishment of trust, automation and cost reductions can best be realized when multiple parties are

cooperating. The standardization of data formats and field descriptions is a prerequisite for this cooperation. Insurers just started this standardization in order to facilitate data exchange with other insurers. Insurers should continue their standardization efforts, as it will facilitate data exchange in the insurance value chain and being compliant with GDPR, regardless whether blockchain will be implemented. Therefore, insurers should give greater priority to cooperating in standardization of data formats and field descriptions rather than cooperating in solving specific blockchain problems. Standardization will be challenging, as insurers still are internally struggling with it, while at the same time operational efficiency gains and regulation such as GDPR force them to cooperate with other parties in the value chain. Financial services consultancy firms could help insurers with the organization of their operational processes and coordinate the standardization process with other organizations in the insurance value chain. Besides their regulatory knowledge will ensure that the insurer will be compliant with the complex GDPR.

The second investment is related to rationalization. The rationalization of IT systems is in progress and will be completed within 5 to 20 years, this will enable insurers to respond more quickly to changes in IT and be compliant with regulation. Blockchain can be a driver for thinking about how systems can be developed to support decentralization, a division of roles and agility, however, the rationalization process should not be targeted to a specific blockchain platform, as it is hard to choose from the scattered field of blockchain platforms. A rationalized IT system should enable the insurer to quickly implement any new IT and convert data. The time that it will take insurers to complete this process (5 to 20 years) could be indicative for the time that it will take insurers to be ready for the implementation of new IT like blockchain. While the rationalization is in progress, it will become clearer which blockchain platforms, if any, might be implemented in the future. In case a blockchain platform will be implemented in the future, the low-code platforms which will enable insurers to translate required functionality to a blockchain platform of their choice, will be more mature as well. Financial services consultancy firms could provide insight in which operational processes that should be supported by the IT system. IT consultancy firms could actually realize rationalization of the IT system and use their knowledge on solutions that increase the agility of the system.

Next to the more concrete recommendations, the interviews and workshop also provided more general insights. The concept of smart contracts led to interesting insights regarding the role that insurers could fulfil in a blockchain-enabled service delivery. For example, smart contracts eliminate the need for collecting premiums, as reservations can be made on the balance sheet of insurees. This could impact the role that insurers will fulfil in the future; currently insurers are investors and risk bearers. When premium collection is no longer necessary, insurers could return to their original roles of risk assessors and claim handlers. However, it would also imply that a large part of the insurance organisation becomes obsolete (Interviewee 5, 2017). The role of insurers as claim handlers in a blockchain future is also recognized by Interviewee 1 and Interviewee 2 (2017); it is difficult to translate this role into business rules. Therefore, the experience and skills of insurance employees could still be valuable. The role of insurers as risk assessors in a blockchain future is also recognized by Interviewee 1 and Interviewee 2 (2017); they state that it is their core business. Insurers are able to assess risks based on a wealth of historical data. It is possible that insurers in a blockchain future will fulfil complex roles and provide advice, or maybe they will just facilitate the insurance process on a fee basis (Interviewee 1 & Interviewee 2, 2017). Interviewee 1 and Interviewee 2 (2017) also describe

that smart contracts eliminate the need for collecting claims, which reduces main income of insurers; interest on investments. It is interesting to see how thinking about a future technological concept triggers thinking on what the core business of insurers currently is and could become.

The research provides a practical method for evaluating the impact of blockchain technology on an organization. This study focused on the impact of blockchain in the insurance industry, however, the research method and the insights that can be gained from it are not limited to this industry. Insurers, as part of the financial services industry, have to deal with strict regulation. While the complexity that is introduced by regulatory compliance increases the value of blockchain as an enabler of automation, organizations outside the financial services industry have more freedom to experiment. Regulation and other insurance-specific developments played an important role in the business model stress test workshop. Apart from that, the two main challenges of blockchain implementation are probably quite similar for other industries. First of all, the very nature of blockchain is the reason that high potential use cases are to be found in situations in which numerous parties are working together, are exchanging data and have to share a single source of truth; these use cases call for standardization. Standardization is a process that typically requires organizations, which often are competitors, to work together. Second, the research provides insight into how blockchain stimulates organizations to consider whether their IT systems support decentralization, a division of roles and agility. This will improve the operational efficiency of an organization and gives it the ability to more quickly implement a new technology, not necessarily blockchain.

### 5.3 Academic contribution

#### **Interviews**

The interviews contributed to finding the most relevant future uncertainties against which the reference business model was tested in the business model stress test workshop. Besides, the interviews were helpful in gaining up-to-date expert knowledge of the application of a technology that is in an early stage of development; the experts provided market-specific in-depth knowledge that is relevant in the Dutch (and therefore partially in the European Union) market. Therefore, the interviews were a valuable addition to the rapidly evolving field of knowledge of blockchain technology in the insurance industry. The interviews also provided an opportunity to introduce the experts to the research project and increase their engagement in the workshop as the workshop design for a large part was based on their contributions. This approach increased both the support for and understanding of the relevant set of uncertainties against which the reference business model was tested in the workshop.

### **Business model stress test workshop**

The business model stress test workshop proved to be a practical way of evaluating the robustness of the reference business model components in different future scenarios. The structured visual presentation of the stress factors, the contrasting directions in which they could develop and the business model components facilitated fruitful discussions among participants. The explanation of the STOF business model ontology and the uncertainties that was given at the start of the workshop proved to be quite complex for the participants; the room for discussion that was left in the presentation proved to be necessary, this room was used to answer questions on the different components of the stress test. The value proposition that was described in the service domain of the reference business model was based on the most important advantages of blockchain technology for the insurance industry, rather than being based on a specific business model. This research showed the practicality of business model stress testing in a situation where a technology is in an early stage of development and concrete business model designs are not yet available. This application of the stress test provides an early insight into the and weaknesses of a reference business model.

### **5.4 Limitations of the research**

The replicability of the research is low, the results of the interviews and workshop heavily depend on the selection of interviewees and workshop participants. The qualitative analysis of the interviews and workshop also introduces subjectivity to the results. It is unlikely that a researcher who repeats this research with his or her selection of interviewees and workshop participants will arrive at the same results. The fact that only a small sample of eight people from seven organisations and three industries have been interviewed limits the generalizability of the results. However, it should be noted that this research aimed for providing guidance on making decisions regarding the impact of blockchain technology on insurers' business models. It was hard to validate the choice for the most relevant uncertainties, as the duration and unstructured character of the interviews limited the possibility to discuss the wide variety of developments that are mentioned in literature. This also limits the comparability of the different interviews.

It proved to be difficult to arrange a workshop that takes four hours (excluding travel time) and requires participants from different parts of the Netherlands to gather in one location. While the business model stress test quickly led to interesting insights in a rapidly evolving environment once it took place, it heavily depends on the availability of the participants. This practical limitation resulted in a difference in the composition of the group of interviewees and workshop participants, this limits the comparability of the results of the interviews and the workshop. Four workshop participants have not been interviewed, while they are experts in the field of the use of blockchain in insurance, it might have limited their acquaintance with the research project and the workshop design. In order to mitigate this, the interview protocol was sent to these four workshop participants well in advance of the workshop. Besides the workshop participants discussed and agreed upon the reference business model and selected uncertainties.

As the group of workshop participants was considered impractically large for the stress testing, the group was divided in two. Because the time that was available for the stress test was limited, the groups analysed the impact of the selected uncertainties in opposite directions. Both groups

completed their heat maps. As the business model stress test workshop is a rather organic process, the comparability of both heat maps is limited, but the division into two groups resulted in richer data.

The business model stress test workshop proved to be a practical way for gaining early insights into the impact of blockchain on the insurers' business models without the availability of concrete blockchain-enabled business model designs. However, the absence of a concrete business model design resulted in a rather conceptual reference business model. Besides, the reference business model might be oversimplified, it does not reflect the complexity of the insurance industry and was mainly based on the qualitative analysis of the interviews and a literature review. This introduced uncertainty to the results. Finally, in the STOF Model, there is an interdependency between the four core domains, the impact of the choice to omit the finance domain from the STOF Model that has been used to design the reference business model was hard to foresee.

### 5.5 Suggestions for future research

The limitations that have been discussed in the previous section provide suggestions for future research within the insurance industry.

Further research with a larger population of experts from different organizations would increase the generalizability of the results and would provide more insight into the relationship between the business model components and the selected uncertainties. When the blockchain-enabled business models in insurance evolve and become more concrete, a large number of structured interviews and workshops could increase the comparability of the results and could facilitate a quantitative analysis. This would even further improve the understanding of the relationship between the elements that have been discussed. This further research could follow an iterative process, in which the uncertainty of the results is reduced in each iteration.

Finally, the reference business models could be designed together with the workshop participants in order to make it more realistic and increase the participants' acquaintance with the workshop design. This more concrete model could also include the financial domain of the STOF Model to allow for a more complete analysis.



## References

- Afuah, A., & Tucci, C. L. (2000). *Internet business models and strategies: Text and cases*: McGraw-Hill Higher Education.
- Afuah, A., & Tucci, C. L. (2003). *Internet Business Models and Strategies* (2 ed.): McGraw-Hill, New York, NY.
- Al-Debei, M. M., & Avison, D. (2010). Developing a unified framework of the business model concept. *European journal of information systems*, 19(3), 359-376.
- Amit, R., & Zott, C. (2001). Value creation in e-business. *Strategic management journal*, 22(6-7), 493-520.
- Antonopoulos, A. M. (2014). *Mastering Bitcoin: unlocking digital cryptocurrencies*: " O'Reilly Media, Inc."
- Baden-Fuller, C., & Haefliger, S. (2013). Business models and technological innovation. *Long range planning*, 46(6), 419-426.
- Bain & Company. (2017). Digitalization in Insurance: The Multibillion Dollar Opportunity.
- Ballon, P. (2007). Business modelling revisited: the configuration of control and value. *info*, 9(5), 6-19.
- Bank, D. N. (2015). *DNB Guidance on the Anti-Money Laundering and Counter-Terrorist Financing Act and the Sanctions Act*. Retrieved from <http://www.toezicht.dnb.nl>
- Baran, P. (1962). On Distributed Communications Networks.
- Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of management*, 17(1), 99-120.
- Betlem, R. (2016). Aegon samen met andere verzekeraars in blockchain. *Het Financieele Dagblad*.
- Bouwman, H., De Reuver, M., Solaimani, S., Daas, D., Haaker, T., Janssen, W., . . . Walenkamp, B. (2012). *Business models: Tooling and a research agenda*. Paper presented at the 25th bled econference eDependability: Reliable and Trustworthy eStructures, eProcesses, eOperations and eServices for the future, 17-20 juni 2012, Bled, Slovenia.
- Bouwman, H., de Vos, H., & Haaker, T. (2008). *Mobile service innovation and business models*: Springer Science & Business Media.
- Bouwman, H., Faber, E., & Van der Spek, J. (2005). Connecting future scenarios to business models of insurance intermediaries. *BLD 2005 Proceedings*, 16.
- Bouwman, H., Heikkilä, J., Heikkilä, M., Leopold, C., & Haaker, T. (2017). Achieving agility using business model stress testing. *Electronic markets*, 1-14.
- Buterin, V. (2015). On Public and Private Blockchains. Retrieved from <https://blog.ethereum.org/2015/08/07/on-public-and-private-blockchains/>
- Casadesus-Masanell, R., & Ricart, J. E. (2010). From strategy to business models and onto tactics. *Long range planning*, 43(2), 195-215.
- Catlin, T., Hartman, R., Segev, I., & Tentis, R. (2015). *The making of a Digital Insurer - The Path to Enhanced Profitability, Lower Costs and Stronger Customer Loyalty*. Retrieved from
- Cavalcante, S. A. (2013). Understanding the impact of technology on firms' business models. *European Journal of Innovation Management*, 16(3), 285-300.
- Cavalcante, S. A., Kesting, P., & Ulhøi, J. (2011). Business model dynamics and innovation:(re) establishing the missing linkages. *Management Decision*, 49(8), 1327-1342.
- CB Insights. (2016). *The Pulse of Fintech Q2 2016*. Retrieved from <https://home.kpmg.com/xx/en/home/insights/2016/03/the-pulse-of-fintech-q1-2016.html>
- CGI Group Inc. (Producer). (2004, 16-09-2016). Public Key Encryption and Digital Signature: How do they work? Retrieved from [http://www.cgi.com/files/white-papers/cgi\\_whpr\\_35\\_pki\\_e.pdf](http://www.cgi.com/files/white-papers/cgi_whpr_35_pki_e.pdf)
- Chesbrough, H. W. (2010). Business model innovation: opportunities and barriers. *Long range planning*, 43(2), 354-363.
- Chesbrough, H. W., & Rosenbloom, R. S. (2002). The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. *Industrial and corporate change*, 11(3), 529-555.

- Christensen, C. (2013). *The innovator's dilemma: when new technologies cause great firms to fail*: Harvard Business Review Press.
- Credit Suisse. (2016). *Blockchain - The Trust Disrupter*. Retrieved from <https://www.finextra.com/finextra-downloads/newsdocs/document-1063851711.pdf>
- DaSilva, C. M., & Trkman, P. (2014). Business model: What it is and what it is not. *Long range planning*, 47(6), 379-389.
- Davenport, T. H. (2013). *Process innovation: reengineering work through information technology*: Harvard Business Press.
- De Filippi, P., & Hassan, S. (2016). Blockchain technology as a regulatory technology: From code is law to law is code. *First Monday*, 21(12).
- De Nederlandsche Bank. (2015). *State of Supervision 2015*. Retrieved from <https://www.dnb.nl/en/news/news-and-archive/nieuws-2016/dnb339573.jsp>
- De Nederlandsche Bank. (2016). *Technological innovation and the Dutch financial sector*. Retrieved from [https://www.dnb.nl/en/binaries/Themaonderzoek%20%20uk\\_tcm47-336322.PDF](https://www.dnb.nl/en/binaries/Themaonderzoek%20%20uk_tcm47-336322.PDF)
- De Reuver, M., Bouwman, H., & Haaker, T. (2013). Business model roadmapping: A practical approach to come from an existing to a desired business model. *International Journal of Innovation Management*, 17(01), 1340006.
- Demil, B., & Lecocq, X. (2010). Business model evolution: in search of dynamic consistency. *Long range planning*, 43(2), 227-246.
- El Sawy, O. A., & Pereira, F. (2013). VISOR: A Unified Framework for Business Modeling in the Evolving Digital Space. In *Business Modelling in the Dynamic Digital Space* (pp. 21-35): Springer.
- Euro Banking Association. (2015). *Cryptotechnologies, a major IT innovation and catalyst for change*. Retrieved from <https://www.abe-eba.eu/knowledge-and-research/>
- Gartner Inc. (2016). *Hype Cycle for Emerging Technologies, 2016*. Retrieved from <http://www.gartner.com/technology/research/hype-cycles/>
- Gordijn, J., Akkermans, H., & Van Vliet, H. (2000). *What's in an electronic business model?* Paper presented at the International Conference on Knowledge Engineering and Knowledge Management.
- Gordijn, J., Akkermans, H., & van Vliet, H. (2001). Designing and evaluating e-business models. *IEEE intelligent Systems*, 16(4), 11-17.
- Greenspan, G. (2015). Avoiding the pointless blockchain project. Retrieved from <http://www.multichain.com/blog/2015/11/avoiding-pointless-blockchain-project/>
- Greenspan, G. (2016). Blockchains vs centralized databases. Retrieved from <http://www.multichain.com/blog/2016/03/blockchains-vs-centralized-databases/>
- Hedman, J., & Kalling, T. (2003). The business model concept: theoretical underpinnings and empirical illustrations. *European journal of information systems*, 12(1), 49-59.
- Insurance Europe. (2012). *How insurance works*. Retrieved from <http://www.insuranceeurope.eu/search/type/Publication/year/2012>
- Interviewee 1, & Interviewee 2. (2017, 31 March) /Interviewer: L. Klomp.
- Interviewee 3. (2017, 13 March) /Interviewer: L. Klomp.
- Interviewee 4. (2017, 21 March) /Interviewer: L. Klomp.
- Interviewee 5. (2017, 21 March) /Interviewer: L. Klomp.
- Interviewee 6. (2017, 7 April) /Interviewer: L. Klomp.
- Interviewee 7. (2017, 20 March) /Interviewer: L. Klomp.
- Interviewee 8. (2017, 22 March) /Interviewer: L. Klomp.
- Johnson, M. W., Christensen, C. M., & Kagermann, H. (2008). Reinventing your business model. *Harvard business review*, 86(12), 57-68.
- King, S., & Nadal, S. (2012). Ppcoin: Peer-to-peer crypto-currency with proof-of-stake. *self-published paper*, August, 19.

- Lamport, L., Shostak, R., & Pease, M. (1982). The Byzantine generals problem. *ACM Transactions on Programming Languages and Systems (TOPLAS)*, 4(3), 382-401.
- Linder, J. C., & Cantrell, S. (2000). *Changing business models: surveying the landscape*.
- M. Mainelli, M. S. (2015). Sharing ledgers for sharing economies: an exploration of mutual distributed ledgers (aka blockchain technology). *The Journal of Financial Perspectives: FinTech*, 3(3), 38-58.
- Magretta, J. (2002). Why business models matter.
- Mahadevan, B. (2000). Business models for Internet-based e-commerce: An anatomy. *California management review*, 42(4), 55-69.
- Mainelli, M., & Manson, B. (2016). *Chain Reaction: How Blockchain Technology Might Transform Wholesale Insurance*. Retrieved from <http://www.zyen.com/publications.html>:
- McGrath, R. G. (2010). Business models: a discovery driven approach. *Long range planning*, 43(2), 247-261.
- McIvor, R. (2009). How the transaction cost and resource-based theories of the firm inform outsourcing evaluation. *Journal of Operations management*, 27(1), 45-63.
- Morris, M., Schindehutte, M., & Allen, J. (2005). The entrepreneur's business model: toward a unified perspective. *Journal of business research*, 58(6), 726-735.
- Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system.
- OECD. (2016). *OECD Science, Technology and Innovation Outlook 2016*. Retrieved from [http://dx.doi.org/10.1787/sti\\_in\\_outlook-2016-en](http://dx.doi.org/10.1787/sti_in_outlook-2016-en):
- Osterwalder, A. (2004). The business model ontology: A proposition in a design science approach.
- Osterwalder, A., & Pigneur, Y. (2002). An eBusiness model ontology for modeling eBusiness. *BLED 2002 Proceedings*, 2.
- Osterwalder, A., & Pigneur, Y. (2010). *Business model generation: a handbook for visionaries, game changers, and challengers*: John Wiley & Sons.
- Osterwalder, A., Pigneur, Y., & Tucci, C. L. (2005). Clarifying business models: Origins, present, and future of the concept. *Communications of the association for Information Systems*, 16(1), 1.
- Oxford Dictionaries. (2016). bitcoin - definition of bitcoin in English | Oxford Dictionaries.
- Pateli, A. G., & Giaglis, G. M. (2004). A research framework for analysing eBusiness models. *European journal of information systems*, 13(4), 302-314.
- Pateli, A. G., & Giaglis, G. M. (2005). Technology innovation-induced business model change: a contingency approach. *Journal of Organizational Change Management*, 18(2), 167-183.
- Pilkington, M. (2016). Blockchain technology: principles and applications. *Research Handbook on Digital Transformations*, edited by F. Xavier Olleros and Majlinda Zhegu. Edward Elgar.
- Porter, M. E. (2001). Strategy and the Internet. *Harvard business review*(March 2001), 1-20.
- Porter, M. E. (2008). The Five Competitive Forces That Shape Strategy. *Harvard business review*(January 2008).
- PwC. (2016a). Blockchain in financial services. Retrieved from <http://www.pwc.com/us/en/financial-services/research-institute/blockchain.html>
- PwC. (2016b). *Blurred lines: How FinTech is shaping the Financial Services*. Retrieved from [http://www.pwccn.com/home/eng/fs\\_fintech\\_mar2016.html](http://www.pwccn.com/home/eng/fs_fintech_mar2016.html)
- PwC. (2016c). *Blurred lines: How FinTtech is shaping Financial Services - Executive Summary for the Netherlands*. Retrieved from <http://www.pwc.nl/nl/publicaties/fintech-survey.html>
- PwC, States of Alderney, & Cardano foundation. (2016). *The Missing Links In The Chains - Mutual Distributed Ledger Standards*. Retrieved from <http://www.longfinance.net/publications.html?id=1051>
- Rappa, M. (2000). Business models on the meeb: managing the digital enterprise. *North Carolina State University, USA*. Retrieved from <http://digitalenterprise.org/models/models.html>
- Sarkar, P. (Producer). (2011, 16-09-2016). Hash Functions: A Gentle Introduction. Retrieved from <http://www.isical.ac.in/~palash/talks/hash-intro.pdf>

- Schumpeter, J. A. (1934). *The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle* (Vol. 55): Transaction publishers.
- Shafer, S. M., Smith, H. J., & Linder, J. C. (2005). The power of business models. *Business horizons*, 48(3), 199-207.
- Suichies, B. (2015). Why Blockchain must die in 2016. Retrieved from <https://medium.com/@bsuichies/>
- Swan, M. (2015). *Blockchain: Blueprint for a new economy*: " O'Reilly Media, Inc."
- SWIFT, & Accenture. (2016). Retrieved from <https://www.swift.com/node/22221>:
- Tapscott, D., & Tapscott, A. (2016). *Blockchain Revolution: How the Technology Behind Bitcoin is Changing Money, Business, and the World*: Penguin.
- Tata Consultancy Services. (2011). Vertical Snapshot: Mobility in Insurance.
- Teece, D. J. (2007). Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strategic management journal*, 28(13), 1319-1350.
- Teece, D. J. (2010). Business models, business strategy and innovation. *Long range planning*, 43(2), 172-194.
- Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic management journal*, 509-533.
- Timmers, P. (1998). Business models for electronic markets. *Electronic markets*, 8(2), 3-8.
- Van der Heijden, K. (1996). Scenarios: the art of strategic conversation.
- Verschuren, P., & Doorewaard, H. (2010). *Designing a research project* (Vol. 2): Eleven International Publishing The Hague.
- World Economic Forum. (2015). *The Future of Financial Services - How disruptive innovations are reshaping the way financial services are structured, provisioned and consumed*. Retrieved from [www3.weforum.org](http://www3.weforum.org):
- World Economic Forum. (2016). *The Future of Financial Infrastructure - An ambitious look on how blockchain can reshape financial services*. Retrieved from [www3.weforum.org](http://www3.weforum.org):
- Wright, A., & De Filippi, P. (2015). Decentralized blockchain technology and the rise of lex cryptographia. Available at SSRN 2580664.
- Yin, R. K. (2009). *Case study research: Design and methods 4th ed.* Paper presented at the United States: Library of Congress Cataloguing-in-Publication Data.
- Zott, C., Amit, R., & Massa, L. (2011). The business model: recent developments and future research. *Journal of management*, 37(4), 1019-1042.

## Appendix A – Glossary and acronyms

TABLE 23: TABLE OF TERMS

Term	Definition
<b>Bitcoin/cryptocurrency (Oxford Dictionaries, 2016)</b>	<i>“A type of digital currency in which encryption techniques are used to regulate the generation of units of currency and verify the transfer of funds, operating independently of a central bank.”</i>
<b>Blockchain (Swan, 2015, p. 1)</b>	<i>“The blockchain is the decentralized transparent ledger with the transactions records – the database that is shared by all network nodes, updated by miners, monitored by everyone, and owned and controlled by no one. It is like a giant interactive spreadsheet that everyone has access to and updates and confirms that the digital transactions transferring funds are unique.”</i>
<b>Byzantine Generals’ Problem (Lamport et al., 1982)</b>	A failure to agree on a collective course of action among components of a network that spread conflicting information around the network by communicating over an unreliable connection.
<b>Digital currency (Mainelli &amp; Manson, 2016, p. 55)</b>	<i>“A currency where the units of value exist only on a computer file.”</i>
<b>Distributed Ledger Technology (Gartner Inc., 2016; World Economic Forum, 2016)</b>	Blockchain technology
<b>Double spending (Nakamoto, 2008)</b>	An undesired situation in which a digital currency coin is spent more than once.
<b>Fork (Mainelli &amp; Manson, 2016, p. 55)</b>	<i>“A situation in which two rival versions of a blockchain exist simultaneously. A viable blockchain implementation must contain a mechanism to resolve forks in order to create a single agreed version.”</i>
<b>Hashing (Mainelli &amp; Manson, 2016, p. 55)</b>	<i>“A cryptographic function which provides a digital signature (a ‘hash’) for any computer file with the property that it is computationally impractical to find a second file with the same hash.”</i>
<b>Node (Mainelli &amp; Manson, 2016, p. 56)</b>	<i>“The computer of a user of a blockchain, holding a copy of the chain and performing operations on it. These operations maybe restricted to receiving updated versions and reading, but for at least some nodes must involve validating, updating, and broadcasting.”</i>
<b>Oracle (De Filippi &amp; Hassan, 2016)</b>	Interfaces or sensors through which smart contracts interact with the physical world.
<b>Permissioned blockchain (Mainelli &amp; Manson, 2016, p. 56)</b>	<i>“A blockchain which can be updated and validated only by users with explicit permission.”</i>
<b>Private blockchain (Mainelli &amp; Manson, 2016, p. 56)</b>	<i>“A blockchain only visible to authorised users.”</i>
<b>Proof-of-Work (Mainelli &amp; Manson, 2016, p. 56)</b>	<i>“A methodology for regulating update of an unpermissioned blockchain by giving preference to users devoting the most computing resources to the process. Bitcoin uses the methodology.”</i>

<b>Proof-of Stake (Mainelli &amp; Manson, 2016, p. 56)</b>	<i>“A suggested methodology for regulating update of the unpermissioned blockchain underlying a cryptocurrency using a voting system with votes pro rate to holdings of the cryptocurrency.”</i>
<b>Public blockchain (Mainelli &amp; Manson, 2016, p. 56)</b>	<i>“A blockchain broadcast freely to anyone.”</i>
<b>Smart contract (Mainelli &amp; Manson, 2016, p. 56)</b>	<i>“A contract embedded in a blockchain which executes automatically when its trigger conditions are met.”</i>
<b>Unpermissioned blockchain (Mainelli &amp; Manson, 2016, p. 56)</b>	<i>“A blockchain which can be updated and validated by any user.”</i>

TABLE 24: TABLE OF ACRONYMS

<b>Acronym</b>	<b>Explanation</b>
<b>AML</b>	Anti-Money Laundering
<b>CDD</b>	Customer Due Diligence
<b>DLT</b>	Distributed Ledger Technology
<b>DNB</b>	De Nederlandsche Bank (or the Dutch central bank in English)
<b>FinTech</b>	Financial Technology
<b>InsurTech</b>	Insurance Technology
<b>KYC</b>	Know Your Customer
<b>PKI</b>	Public Key Infrastructure
<b>PoW</b>	Proof-of-Work
<b>PoS</b>	Proof-of-Stake
<b>PSDII</b>	Payment Service Directive 2
<b>SHA-2</b>	Secure Hash Algorithm 2
<b>UBO</b>	Ultimate Beneficial Owner
<b>Wtt</b>	Wet toezicht trustkantoren (or Act on the Supervision of Trust Offices in English)
<b>Wwft</b>	Wet ter voorkoming van witwassen en financieren van terrorisme (or Anti-Money Laundering and Anti-Terrorist Financing Act in English)

# Appendix B1 – Interview protocol

## Introduction of the research

Innovation in financial technology (FinTech) is seen as one of the most important developments in the financial services. FinTech innovation is changing the competitive position of insurers, new entrants play an increasingly important role. This situation leads to an increased awareness of Dutch insurers of the impact of FinTech innovations on their business models.

Blockchain technology recently attracted attention the financial sector, in which the introduction of the cryptocurrency the Bitcoin in 2009 played an important role. The scale on which the Bitcoin is functioning, without requiring a trusted third party, in an environment where parties do not fully trust each other, shows organizations in the financial services industry the potential of blockchain and raises the question what it could mean to them.

Blockchain is able of establishing an immutable “single source of truth” for multiple parties that conduct transactions. As the insurance industry is characterized by numerous processes in which data and value are being exchanged, expectations of this technology are high. However, the complexity, uncertainty, transforming potential and barriers to implementation make it hard for insurers to assess the potential impact of blockchain on insurers.

## Research design and goal

This interview is part of a qualitative research on the impact of blockchain technology on the business models of insurers. The research consists of the following four parts:

- The selection of a business model ontology by using scientific literature.
- By combining data from research reports and this interview, developments in the insurance industry on a macro-environmental level and developments in the field of blockchain technology are mapped. The interviewees are working for multiple insurers, IT consultancy firms and PwC.
- Organizing a business model stress test workshop; in this workshop the researcher and the interviewees will assess the impact of blockchain on the different components of the business model in a structured way.
- Based on the findings of the workshop, recommendations will be made to the insurers, these will help them to anticipate on the development of blockchain.

## Goals of this interview

The goal of this interview is threefold:

- Mapping the developments in the insurance industry on a macro-environmental level that might influence the application of blockchain technology. This helps in putting the possible future development of blockchain in its context.
- Mapping the risks and uncertainties related to the application of blockchain in the insurance industry.
- Provide an initial analysis of the impact of blockchain on the business models of insurers.

The information mentioned above provides input for the business model stress test workshop, in which the researcher and the interviewees in an interactive way will analyze the impact of blockchain on the business models in more detail.

## Blockchain technology

### Value proposition of blockchain technology

The following characteristics of blockchain technology are often mentioned when the potential of blockchain for the financial services industry is assessed:

- The *need for a trusted third party* is eliminated, as the blockchain protocol describes how consensus on the validity of a transaction is reached. Transactions in a blockchain are unique and are authorized by linking a digital signature to an identity.
- *Controllability* of data is improved by linking transactions to each other and establishing an immutable “single source of truth”. This “single source of truth” is shared in a peer-to-peer network. Regulators could monitor this audit trail in near real-time, which could reduce the costs of regulatory compliance.
- It is *not necessary to (manually) combine data*, the risk of errors is reduced, transactions are settled quickly and do not require arbitrage, which makes risk management less difficult and improves liquidity.
- Blockchain offers *high resiliency*, as it does not depend on central infrastructure. It will continue to work in case of local system failures.
- Blockchain facilitates the use of so-called “*smart contracts*”, these contracts execute predefined lines of computer code when certain conditions are met.

### Characteristics of high-potential use cases

For the assessment of the impact of blockchain, it helps to derive characteristics of high-potential use cases from the characteristics of blockchain technology that have been mentioned above. This will help in the selection of business processes in which the characteristics of blockchain can be leveraged.

The following process characteristics can be identified:

- *Shared repository:* A shared repository of information is used by multiple parties.
- *Multiple writers:* More than one entity generates transactions that require modifications to the shared repository.
- *Minimal trust:* A certain degree of mistrust exists between entities that generate transactions.
- *Intermediaries:* One (or multiple) intermediary or a central gatekeeper is present to enforce trust.
- *Transaction dependencies:* Interaction or dependency between transactions is created by different entities.

This list should be seen as a tool for the identification of potential processes to which blockchain could bring improvements. A potential process does not necessarily meet all five characteristics that have been described. Besides, for a thorough analysis, it is important to take into consideration that blockchain not only offers possibilities for improvements in current service offerings, but it also could facilitate new insurance products.



## Topics of the interview

In this interview two main topics will be discussed, first the macro-environmental developments in the insurance industry, secondly the application of blockchain technology in the industry and its impact on the business model.

### Developments in the insurance industry

In this topic, the macro-environmental developments in the insurance industry will be discussed first, in order to gain insight into the context in which the development of blockchain technology takes place. Next, there will be a focus on specific uncertainties and/or risks related to the application of blockchain technology in the industry, in order to gain insight into the direction in which blockchain technology might develop. The following questions will guide the discussion.

- Which developments are taking place in the insurance industry?
- How could these developments relate to the application of blockchain in the industry?
- Which uncertainties and/or risks related to the application of blockchain in the insurance industry do you see? You could think of things related to:
  - Technology
    - Privacy;
    - Security;
    - Reliability;
    - Legacy IT systems;
    - Quantum computing;
    - Identity and access management;
    - Standardization and compatibility;
    - Scalability (storage capacity, transaction speed and energy consumption).
  - Regulation
    - Governance;
    - Immutability of public blockchains;
    - New laws and regulations such as GDPR and PSD2;
    - Being compliant with current laws and regulations such as Solvency II, Wft and Wwft.
  - Market
    - Consumer trust;
    - Closed-book portfolios;
    - Disintegration of the value chain;
    - Cooperation required for blockchain implementation.
- How do you expect blockchain technology to develop in the insurance industry?

## The impact of blockchain technology on insurers' business models

- Which blockchain use cases have the highest potential for the insurance industry and what would that mean for the industry's business models in particular?
  - Will blockchain impact the value proposition, backend (resources, capabilities, processes and partners) or the frontend (channels, customer relations and customer segments)?
  - In which processes or components of the business model do you expect the biggest impact of blockchain?
  - What would the nature of this potential be?
    - Cost reduction;
    - Differentiation;
    - Improved customer retention.

## Appendix B2 – Summary interview 1

### Developments in the insurance industry

#### **Exploring customer needs**

Insurers are exploring which customer needs need to be addressed, but in general, insurers seem to be satisfied with their current services and are looking for ways to improve their existing service offering. A smaller share of insurers goes further in exploring customer needs; they approach insurance as a personalized complement to other products and services.

#### **Exploring technological innovation**

In general, the view that the speed of technological innovation is low, makes insurers reluctant to explore technological innovation. Large Dutch insurer A considers technological innovation as crucial for firm growth, they are not only interested in FinTech, but also in other technologies like home appliances, as these technologies determine the future risks that have to be insured. The most important capabilities are in the risk domain.

#### **Influence of Chinese owner**

In China, mobile apps are the modus operandi in commerce, but they are moving away from apps towards chatbots for the ordering process. The Chinese are very interested in the way the European insurers deal with the heavily saturated European insurance market, as they expect this saturation to take place within 10 years in China.

#### **Multichannel/omnichannel**

In the near future, they should be able to deal with a multichannel/omnichannel offering.

### How large Dutch insurer A explores blockchain technology

#### **Working with blockchain technology and spreading knowledge**

In 2016, the IT department has made a proof of technology, the main goal of that project was increasing the understanding of blockchain technology. They consider working with the technology by building applications is the best way to do that. They were guided by an external firm and were able to, after six weeks, to validate, design and build blockchain applications. Each time they share their knowledge in the organization, led to new insights from fruitful discussions. Currently, the IT department receives new ideas on a weekly basis that have to be validated, this results in the active distribution of knowledge in the organization. They do not want to be part of bureaucracy, it is important that they facilitate spontaneous and creative discussions by motivated people. Even if something does not have to be solved with blockchain, the people with ideas can be helped by the evaluation of their ideas.

#### **Keeping knowledge up to date**

It is very important for large Dutch insurer A to keep their blockchain knowledge up to date, as blockchain innovations take place in an increasing speed. More and more ready to use blockchain solutions become available, it takes a lot of effort to stay up to date, but it is worth it, because a lot of solutions are provided by an open-source market that is relatively new for them.

## Technological risks/uncertainties

### **Privacy**

They are not worried about privacy, as solutions for maintaining privacy are continuously being developed and realized.

### **Quantum computing**

When quantum computers are available, encryption might be broken, however, the power of quantum computers is not yet realized. While quantum computing is under development, cryptographic solutions will be found, because the stakes are high and the market will demand them.

### **Legacy IT systems**

Legacy systems are currently being replaced rapidly and the easiness of replacement will only increase when microservices will become the norm. Besides, artificial intelligence will automate the interpretation of data. As there is a demand for easily replacing legacy IT systems, solutions are offered.

### **Emerging platforms**

Changes are low that insurers will be able to choose a platform that will meet their needs on the long term. Therefore, it is important that insurers do not make large investments in platform, they should realize a quick return on investment and be able to easily migrate to another platform. Insurers have to trust on the creativity, flexibility and the skills of employees to quickly master new technologies, instead of investing in the platform that they (wrongly) assume to be dominant in the future.

Besides low-code platforms are already able to translate desired functionalities into an underlying platform such as .NET or Java. The low-code platforms keep the platforms that they can translate to and the engines they use up to date; it might be possible that in the future low-code platforms are able to translate desired functionalities of a service to different blockchain platforms, such as the Bitcoin or Ethereum blockchains. The insurers model of the service does not have to change, only the translation to the blockchain platform has to be made. It is expected that large suppliers of low-code platform will be able to port to different blockchains within two years. This development reduces that lock-in that software vendors of underlying platforms can create.

### **Speed of development of technological solutions**

In general, as large organizations are actively working on solutions that are required by enterprises, the speed of development of blockchain technology is so high, that technological factors are not considered to be a limiting factor in the development of blockchain solutions. Technology adopts to the needs of organizations, humans and their norms, values, laws and regulations are the limiting factor, but also in that regard the speed of change is increasing.

## Regulation

### **Compliance driven internal application of blockchain**

Large Dutch insurer A is looking for the internal application of blockchain for audit processes; blockchain might eliminate the need for internal audit processes, as data is locked within the blockchain. Compliance might be provided by technology and audit shifts to IT-audit.

### **Governance and GDPR**

Currently, in a public blockchain data is stored on multiple locations over which no central authority has control. In a private blockchain however, it is possible to determine where data is stored. But probably the number possibilities for controlling where data is stored will increase, even for public blockchains as large organizations, such as IBM (Hyperledger), Microsoft (Ethereum) and Intel (Ethereum) have founded consortia. From their experience in enterprise environments, these consortia are actively looking for enterprise grade solutions to problems like this. The hybrid blockchains offered by these large organizations are already able to control for the geographic location where data is stored. Regulations are temporarily hampering innovation, regulation will be changed when there is the need to do so.

## Cooperation

It is important to work with external parties on different aspects, the first one being technology; the insurer should have access to the frontrunners in blockchain technology, in order to acquire knowledge. The insurer can help those technology parties with validating their experiments. The second one is business to business; in order for a business to business blockchain solution to succeed, there has to be a case that has to be developed cooperatively and where a trust problem exists. It is also possible to deliver services in an ecosystem in which the cooperating parties deliver complementary services in which complex processes of drafting contracts and settlement are required. Blockchain could be a platform on which different services could be linked together.

## Use cases

### **Short-term insurance**

InsurEth is a good example of a short-term insurance that shows how easy it is for a smart contract to autonomously earn money by offering insurance on a blockchain. However, it is hard to create a revenue model for something that exists on an open-source blockchain. This case shows that a service like this can work and that a company on a blockchain is able to offer services.

### **Blockchain in reinsurance and co-insurance**

Several parties can cooperate on the basis of the same data, this is the case where large risks are shared by multiple parties, like in for co-insurance, or reinsurance. B3i aims to solve in the reinsurance market on the backend of insurers. Here the focus is on automation, increasing speed and provide insight into complex processes which currently are manually done by multiple parties that do not trust each other. Besides a lot of paperwork still is involved. Besides, contractual agreements and claims can be registered on a blockchain.

### **Fraud prevention**

Blockchain on itself will probably not be a solution against fraud, the combination with the “Internet of Things” and artificial intelligence will lead to services that will be provided by multiple parties. Blockchain could add trust to this service provisioning and an important aspect therein lies in the shared infrastructure that no central authority controls. The trusted third parties that are founded to reduce fraud, like CIS, are costly. The blockchain could provide a cheaper solution than those trusted third parties, however, it should be noted that these parties sometimes offer complementary services. These use of the services of these parties often requires the local installation of IT systems. Blockchain might eliminate the need for this additional infrastructure and the overhead that is added by these systems.

### **Mutual insurance**

The mutual insurance blockchain use case is great, in that case there are payments that can be automated with blockchain. All claims can be processed automatically as well; when you are able to put all processes in smart contracts, you automatically stored the claims than someone can make upfront. It is impossible to deviate from those claims. This case is linked to operational excellence, de running costs are very low. Besides the reliability of this blockchain-enabled insurance is high.

### **Role of insurers in mutual insurance**

Some roles are very difficult to record in business rules; for example, claim handling is a process in which multiple parties are involved, like several loss adjusters, in that process an employee could still fulfil a role. An insurer could be able to add value by offering their claims handling knowledge as a service, this would still be done by employees. Risk assessment is a core business of insurers, this assessment is based on vast amounts of historical data, insurers could offer risk assessment as a service in blockchain-enabled insurances. The insurer could provide complex functionality, advise or facilitation of blockchain-enabled insurances, but they will probably become less important.

### **Investment of premiums**

Currently, investing premium is an important source of income for insurers. Beside mutual insurances are less suitable for insuring large risks like liability insurance, in these instances an insurer might still be needed to ensure that these risks can be shared by a larger pool of insured. A nice side effect of this kind of blockchain use cases is that people are forced to think about the core business of insurers, the added value and how processes are working.

### **Animal insurance and asset provenance**

Insurers want to know which animal they are insuring, for example the parentage is relevant to the insurer. This knowledge should be available on a location that is accessible for several parties like veterinarians, owners and animal breeders. This could be a blockchain use case, however the benefits in this niche case is rather limited. Besides, the data could be centrally stored, this kind of considerations are being made in validating blockchain use cases. This case is similar to Everledger, a firm that provides asset provenance for diamonds.

### Impact on business model

The new functionalities that are provided by blockchain provide new ways for creating value, but also new ways of process optimization, for example in existing process where trust is an issue. These processes can be speeded up, which results in cost reduction. It is impossible to predict where blockchain can be used, because the addition of smart contracts added the model of business rules. Blockchain functionalities are continuously added which creates new possibilities for both offering new possibilities and improving efficiency of existing processes.

## Appendix B3 – Summary interview 2

### Developments in the insurance industry

#### Distribution of insurance premiums

- ~75 Billion euros of premiums is written for the insurance industry.
  - ~40 Billion euros is written for health insurance.
    - 4% of this premium is used for covering costs of the insurer
    - 96% of this premium is used for paying for healthcare
  - ~25 Billion euros is written for life insurance, non-life insurance and pensions.

There is a lot of discussion about health insurance, but the government determines the coverage of health insurance and some additional coverage is provided. Therefore, there is not a lot to be gained in health insurance, maybe the 4% of costs of the insurer could be reduced. But there is more to be gained from reducing the claims ratio by smart healthcare tenders.

#### Individual life insurance

Individual life insurance was very popular in the 1970s and 1980s, because it was possible to receive tax-free pay-outs and they were used to cover mortgages. In 1991 the taxation reliefs were reduced, besides laws made it less interesting to not pay off a mortgage and pay it off with a life insurance instead.

#### *Low trust*

The fact that unit-linked insurances were mis-sold to around 7 million customers led to a breach of trust. The general public often accuses banks and insurers of being greedy.

#### *Closed-book portfolio*

In the 1970s and 1980s, a lot of life insurance policies have been sold, so insurers have large portfolios of those policies, the contracts of these policies have a duration of 30 years. The value of this portfolio is declining with an annual rate of 10% and production is practically non-existent. The systems and administration for this portfolio has to be maintained, while the value of the portfolio is rapidly declining, therefore, there focus is on cost reduction.

#### Decreasing premiums received in non-life insurance

About 50% of the premiums received from non-life insurance is coming from car insurance. Premiums received in the non-life insurance market are decreasing because of the following reasons:

- Traditional risks are reduced by the use of sensors. Sensors are able to prevent accidents (for example in the case of traffic accidents) or reduce the severity of damages by facilitating quick intervention (for example quickly detecting and solving water leakage in houses).
- Disintegration of the value chain is taking place; for example, car manufacturers like Tesla increasingly use sensors and are increasingly interested in offering insurance and energy providers offer a free household insurance.



## Regulation

### **Solvency II**

Solvency II requires insurers to be able to bear the financial consequences of risks that might happen once in 200 years; insurers that have high concentration risk should have more financial means to survive those risks. Determining how large financial reserves have to be requires a lot of calculations. Insurers have to report on how they meet the Solvency II requirements, currently most Dutch insurers exceed the required solvency ratio 130% by a large margin.

### **GDPR (General Data Protection Regulation)**

Being compliant with GDPR regulation will be a difficult task, as insurers possess a large variety of information on their customers; for example, when customers buy policies online, information on their internet connection and surfing behaviour might be stored. Besides information on payment behaviour might be bought from external parties. These are examples of information that qualify as personal information under the GDPR. When a customer requests the removal of his or her data, the insurer has to be sure that they are allowed to do so, where information is stored. Meeting the last requirement is very hard, as data travels through the organisation, external organisations and data might be stored in an inconsistent way (the labels of the data or the data itself might be different on different storage locations). GDPR also requires insurers to facilitate the transportation of customer data to other parties, this requires numerous parties to agree on a certain data format in order to be able to absorb data into their IT systems. Many insurers just took the first steps towards GDPR compliance, this is problematic, considering they have been spreading customer data to insurance agents, insurance brokers, banks and direct channels for years. When they are not able to meet GDPR, fines up to 20 million euros or 4% of annual revenue could be levied by regulators.

### **PSDII (Payment Services Directive II)**

PSDII requires financial services providers to give third parties access to bank account information of their customers. Insurers could offer additional services based on this information. A lot is about to happen in the field of personal data.

### **Blockchain applications in insurance versus banking**

Generally speaking, the number of transactions in banking are larger than in insurance, so it is less clear what is to be gained from blockchain applications. In banking, at the end of the day all transactions have to be settled. In insurance, premiums already have been received and if a claim is made, settlement does not necessarily have to take place faster than it currently does (within a few days).

## Technological risks/uncertainties

### **Privacy and governance**

On a blockchain, data is stored on multiple locations and often blockchains are used to increase transparency. Improving privacy by using key management solutions adds complexity and reduces performance. Besides, European regulations prohibit insurers from saving customer data outside the European Union, therefore, a global blockchain is not allowed. Companies that are offering blockchain-as-a-service, like Microsoft, already have to deal with this; they have to guarantee that data is not saved outside the European Union.

### **Identity and access management**

This aspect relates to GDPR; management of customer data requires high quality identity and access management solutions. However, it is not clear what blockchains have to offer in this aspect, while other solutions already exist.

### **Performance and scalability**

Scalability (in terms of storage capacity, transaction capacity and energy consumption) is a very important aspect of blockchain that has to be addressed. Considering the vast amount of data that insurers store in their ERP systems, storing each transaction multiple times on a blockchain might be problematic.

### **Legacy IT**

Insurers are using old IT systems that are linked together, these systems have to be rationalized in order to be more agile. They are already working on rationalization, within 5 to 10 years that process will be completed. The insurance industry is changing rapidly, the number of insurers has been reduced to 250 insurers and 150 pension providers, in 10 years from now, those numbers may even be reduced to 25%. Considerable scaling up of IT is taking place.

### **Standardization and compatibility**

Standardization is required in order to be able to realize cost reductions by the implementation a blockchain solution, because it will increase the number of organisations that will join the implementation.

## **Cooperation**

### **Keeping up with blockchain developments**

Insurers should be involved in exploring blockchain technology, because they should understand the technology in case of rapid adoption by the industry. Insurers who decide they would like to join blockchain-related collaborations on a later moment in time may be locked out. So beyond keeping up with the technology, it might also be strategically relevant to be a frontrunner and join a collaborative initiative. This potential lock out might have the greatest impact on the insurance industry.

## **Use cases**

### **Fraud prevention**

The decreasing premiums received, combined with fierce market competition result in lower insurance premiums. In the Netherlands, FISH and CIS record insurance data regarding cars and customers, there is not a problem in trust that blockchain could solve in this situation and cost reduction could more likely be realized by putting data on a cloud. Of course, fraud is taking place, but data analytics is more suitable for fraud prevention, that is why the recorded data is shared by parties in the insurance value chain.

The most expensive cases of fraud have to do with fraudulent claiming behaviour of people, data analytics solutions that are able to recognize this fraudulent behaviour are under development. Blockchain does not provide the best solutions for preventing this fraud from happening, as it is suitable for ensuring payments are done right, but is not still possible to fraud when information from the physical world has to be transferred to a blockchain. Fraudulent claims are already centrally recorded in the FISH database, which functions quite well, blockchain does not provide clear advantages to that solution.

### **Mutual insurance**

Mutual insurance could be facilitated by blockchain technology, but mutual insurance is not interesting for the car insurance market, as liability insurance should provide a coverage of 2,5 million euros, which is problematic in small mutual insurance groups. Besides, when smart contracts facilitate this type of insurance, the information on which the smart contract relies for deciding on whether a claim will be paid out, still has to be verified. In that case, blockchain provides self-execution of the contract, but it does not solve this issue of trust.

### **Disintegration of the value chain**

Disintegration of the value chain is increasingly taking place, insurers increasingly outsource parts of the value chain. However, De Nederlandsche Bank (DNB) still holds them responsible for the compliance of the complete value chain. Financial crime regulation requires insurers to know the ultimate beneficial owners (UBO) of their partners, if a certain partner is blacklisted, it would be very valuable if the insurer is able to roll forward to a new partner. A roll forward is only possible when data quality and processes are closely monitored; every step in the processes between the insurer and the partner could be recorded in an audit trail on a blockchain. This could facilitate the activation of a contract with a backup partner. Besides it would increase transparency and the likelihood that fraudulent activity of a partner will be detected.

## Appendix B4 – Summary interview 3

### Developments in the insurance industry

#### Revenue model of insurers

- Risk assessment;
- Calculating premiums;
- Invest on the basis of premiums received and reservations.

Large Dutch insurer B is looking for alternative revenue models; one of the alternatives is a fee-based revenue model in which the insurer receives a fee based on the delivery of service such as helping customers with taking preventive measures.

#### Decreasing premiums received

The number of insurable objects is decreasing on the long term, especially in the non-life insurance. Objects are becoming smarter which:

- Results in less damage;
- Makes them traceable, which will reduce theft;
- Facilitates the rise of the sharing economy and increasing sustainability, which will reduce the number of objects that customers own;
- 3D printing reduces the need for insurance, as (spare parts of) objects are cheap to replace.

In summary, the insurability of objects will decrease, because both the number objects and the severity of damages will decrease. This will result in lower premiums received. For example, the self-driving car will cause less damage than conventional cars; car manufacturers will bear the risk of their cars and put them on their own balance sheet. Besides, manufacturers like Apple offer insurance as a supplementary service. These developments reduce the insurability of objects.

#### New entrants and experimenting with blockchain

A number of parties will experiment at the edge of the insurance organisations. These parties could be new entrants from the Netherlands or foreign countries. It may seem like there are numerous new entrants on the Dutch market, however, often they are (backed up by) insurance firms. There hardly are any new entrants which are financed by parties outside of the insurance industry, as these new entrants are likely to be “too small to comply” with strict regulations. The actual new entrants will likely be looking for a construction like a joint venture, but this is not part of the core business of insurers. These experiments will primarily be about fraud detection, customer service (customer support in next best actions), Large Dutch insurer B is also experimenting in these fields. Fraud detection and prevention is suitable for experimentation, as it is not controversial. Experimenting with the acceptance process is more controversial, as it requires detailed risk profiles, which undermines the solidarity of insurance. A certain tension exists between individualisation of society and the solidarity of insurance.

## **Interest in blockchain**

Large Dutch insurer B is mainly interested in the impact of blockchain on the business model of the insurer. There is a lot of fuzz around blockchain and they try to determine which information is most valuable to the organization and use it to assess what it will mean for our organization, which is quite hard.

## **Organization arrangement for exploring new technologies**

Recently, large Dutch insurer B. formed a separate new department to explore new technologies. This department cooperates with other departments like life insurance, non-life insurance and ICT. This new department is separated from the other departments and is placed directly under the board of directors. New technologies are explored by three departments; the ICT department handles the IT part, the new department looks at how a technology facilitates new business- and revenue models and the third department is the department that is responsible for a specific type of insurance that will be impacted by the technology. This cooperation focusses on innovations that lead to new business models.

## **Technical risks/uncertainties**

### **Technical limitations vs. societal acceptance**

Advanced applications, like the insurance of object that is registered in a blockchain by a manufacturer, in which smart algorithms continuously determines the right type of insurance and links it to a smart contract, are not unthinkable. However, they make high demands on societal acceptance of the technology. Therefore, technical limitations in terms of performance etcetera are not yet relevant at all for insurers. Insurers will not look into advanced applications before technical limitations like scalability and efficiency are solved. The current state of the technology offers ample opportunities for experimentation; technical limitations will not be problematic before the scale and complexity of applications significantly increase.

### **Identity and access management**

Identity is crucial in the exchange of value. Data is stored in multiple locations in a blockchain, so access management should facilitate the authorisation of access to data in this distributed situation.

### **Interoperability, data integrity and standardization**

In order for blockchain to be successfully applied in the insurance industry, interoperability should be realized and both the quality and integrity of data should be ensured. This might be the largest hurdles that have to be taken, as they already pose a problem in the internal organisation; the internal organisation already uses a multitude of applications and more than ten policy administration systems. Within these applications and systems, data is differently labelled and defined. It is not hard to see that this problem will be harder to solve in a setting in which multiple organizations manage and share their data. Standardization is challenging as well in the internal organization, but also will be harder in a multi-organizational setting; all definitions regarding smart contracts and the associated data have to be defined uniformly, which is challenging. These factors are all prerequisites for conducting economic transaction on a blockchain, they are crucial for realizing advanced blockchain-based insurance services.

## Regulation

### **Balancing room for experimentation and customer protection.**

Regulators, for the insurers these are the Nederlandsche Bank (DNB), Dutch Authority for the Financial Markets (AFM) and Dutch Data Protection Authority (DPA), among others, are aware of recent developments. For example, they notice the digitalization in the insurance industry and since the last few years they adapt their supervisory frameworks to allow for experimentation. However, new regulations are putting strict requirements on the use of new technologies. In general, regulators provide more room for experimentation, while on the other hand they look for ways for protecting customers. Just like insurers, regulators do not know how the future will develop, how consumers will react and what will technically be possible. They have to find the right balance between experimentation and customer protection. In non-life insurance, developments are more concrete and easier to comprehend, besides the discussions are ethically less controversial, when compared to discussions on life insurance.

### **New regulation such as GDPR**

GDPR for example regulates the right to know which personal data an organisation uses, the permission to use personal data and the right to be forgotten. But it also requires organisations to be able to reconstruct how a certain advice was produced, which will be very complex when algorithms like artificial intelligence are used.

## Cooperation

### **Balancing organizational complexity and adoption**

Applications like fraud prevention and efficient data exchange will be developed as a pilot, an experiment of a limited number of parties. In these experiments they will look at how the blockchain applications works, how it behaves, what the effect is on a specific part of the value chain. As blockchain applications will start to commoditize, other parties will adopt the blockchain application. This adoption depends on how locally-focussed the application is and how much it will take to bring it to the next phase were more parties are involved. In this process a certain balance has to be found between the complexity of the experiment and the degree of readiness of the application to evolve into a multi-party setting. For example, when insurers, regulators, the Ministry of Finance, the Fiscal Information and Investigation Service, tax authorities and employers are involved, it is likely that a successful experiment will lead to wider adoption of an application. However, involving parties like the tax authorities and the Fiscal Information and Investigation Service increases the complexity of the experiment and might actually hamper the adoption of a blockchain application. This balance between the number, diversity and complexity of parties that are involved on one hand and the likelihood of adoption by a larger number of parties in a value chain has to continuously be found. It is important to involve a sufficient number of relevant parties in order to create a valuable blockchain application; this will also help to attract other relevant parties that eventually have to be involved to take the next step in adoption, however, the involvement of too many parties will lead to a degree of complexity that stifles the development.

### Impact on business model

Cryptocurrencies are not interesting to insurers. Regulation regarding cryptocurrencies is under development, large Dutch insurer B does not actively participate in that development, they wait and see.

### Fraud prevention

Large Dutch insurer B mainly is interested in smart contracts and the underlying technology, the blockchain. Several aspects, like the resiliency that is realized by the distributed nature of blockchains. The fact that blockchains are secured by cryptography and provide transparency makes them interesting for fraud prevention.

### Data exchange

Large Dutch insurer B exchanges large amounts of data within multiple business processes. Blockchain in combination with smart contracts could be used to increase the efficiency of processes that require consensus; it could be used for sharing data in which blockchain ensures the validity of the data and is able to manage data permissions. Managing data permissions is very important in the insurance industry, blockchain could be an efficient solution which provides transparency for parties like regulators and auditors. This could be a typical application that is suitable for experimentation where the current limitations of blockchain will not immediately be problematic.

## Appendix B5 – Summary interview 4

### Developments in the insurance industry

The following developments are taking place in the insurance industry:

1. *Distribution:* All insurers are becoming multi-channel organization who sell through intermediaries, directly and banks.
2. *Multi-label branding:* Insurers use different labels for different customer segments.
3. *Policy administration:* Policy administration is increasingly being automated and centralized. Regardless of the type and brand of a product that is offered by a single insurer, it is likely to be administered by a single system. In the past, different types and brands of products were administered by different organizations.

The first development means that the front end opens up; portals are used to attract customers. The multi-label branding is about developing a finer segmentation and personalization. It should be noted that the personalization of insurance often undermines solidity. The actuarial processes are improved; the calculation of risks and premiums facilitates this development. The last development refers to the development of a shared platform between the finely segmented labels with the goal of cost reduction. These developments are driven by the tough market conditions requires insurers to gain access to the market and reduce costs.

### Tough market conditions

1. The financial crisis weakened the financial position of the insurers.
2. European regulation puts strict requirements on the solvency of insurers (Solvency II), which puts a lot of pressure on cost reduction.
3. The life insurance market almost ceased to exist because of unit-linked mis-selling, which was an important money maker for the insurers as they took a share of the investment return.

### Revenue model

The revenue model of insurers is based on the following three elements:

1. The operating profit; the mortality margin of life insurance and the combined ratio of non-life insurance.
2. Return on investment; are the returns on investment higher than you accounted for and used in your actuarial models for the calculation of premiums.
3. Costs are allocated to products, these costs can turn out to be lower or higher than they anticipated.

One of the most important money makers for insurance, the return on investment, is decreasing because of decreasing interest rates and the limited number of new life insurance customers. Besides, European regulation (Solvency II) requires insurers to put aside adequate financial resources. Insurers try to solve this revenue problem by offering personalized products through multiple channels and labels.



### **Compliance-related IT costs versus innovation**

Adapting IT systems to be compliant with new regulation is very costly, because legacy IT systems of insurers are very diverse, while there is a lot of duplication in their functionality. This results in a focus on cost reduction and limited resource availability for innovation. Insurers are aware of the fact that they have to invest in new technologies like predictive analysis and big data. Besides they are interested in cognitive systems, chatbots, to optimize their customer service and customer journey. These innovations are important as they have the potential for cost reduction, but at the same time the strict regulations force insurers to reduce costs; this is a difficult situation in which the future revenue model is not clear and a balance between cost reduction and innovation should be found.

### **Decreasing premiums received**

Two important reasons for decreasing premiums received are:

1. The life insurance market shrunk.
2. Car manufacturers increasingly take responsibility for their smart cars, they insure the malfunctioning of the self-driving systems.

These developments show that the future of revenue models is uncertain.

### **Reasons for stricter regulation**

Regulations mainly have become stricter because consumer trust has been neglected and decreasing; the mis-selling of unit-linked insurance and provision-based sales have been important reasons for the introduction of several regulations like Solvency II.

### **Innovation in the insurance industry**

The Dutch insurance market is saturated, money makers are decreasing, regulations are becoming stricter and some insurance needed government support in recent years. This all leads to a reduction of innovative activities by the insurers.

The main problem in innovation in insurance is that innovating for current customers, as innovation always is about offering a proposition at lower costs. Old product portfolios therefore are more profitable and offering new propositions to current customers reduces profitability. Customers are price sensitive (and are using comparison websites), insurances are substitutable, and no one likes insurance.

### **Disintegration of the value chain**

Disintegration of the value chain poses a threat to insurers; the unbundling of insurance services changes their role in the value chain. The functionality that is covered by the total value chain does not change, but parts of the value chain, like claim handling, are fulfilled by other parties. These parties are often able to realize economies of scale and are working with a network of selected partners.

## Technical risks/uncertainties

### **Current state of development of blockchain**

At the moment, experiments are taking place in the field of databases; validated and verified documents, or hashes of documents are being stored. This might not be the most exciting blockchain use case, however it provides an opportunity for exploring and learning about what blockchain might eventually evolve into. Learning by experimenting without having high expectations is the only thing that organisations can do now.

### **Governance**

Currently, more than 700 cryptocurrencies exist, so there is no clear winner yet, it is bleeding-edge technology with a lack of governance.

### **Safety and security**

Blockchain is not yet safe and secure, it is not advisable to exchange value on a public blockchain, other than the Bitcoin blockchain. However, that blockchain does not support the use of smart contracts.

### **Privacy**

Usually, when value is exchanged, parties have to know the identity of their counterparties. Blockchains are designed in such a way that recording and publishing transactions results in transparency of the network, parties do not have to know the identity of their counterparties for the blockchain to function. Sometimes transparency on identities on a blockchains is preferred, sometimes it is not. This aspect relates to transactions, not to blockchains per se.

### **Security and reliability**

Considering the fact that the Bitcoin blockchain has not been hacked and the computing power in the Bitcoin network, the Bitcoin blockchain seems to be safe for the exchange of value. The Bitcoin blockchain is suitable for experimenting which is limited to the use of hashes. The centralization in Bitcoin mining pools poses a risk; powerful groups could potentially have the power to influence or attack the pools. This could result in a severe depreciation of value of the Bitcoin. There has been a situation in which a pool approached 50% of mining power, which resulted in the depreciation of the Bitcoin. The pool reacted by splitting, after which the value of the Bitcoin appreciated. However, the members of the pool could still work according to agreements. The system is funded by people and organisations with a stake in maintaining or destructing it. The forces that are at play are not well understood.

### **Scalability**

The Bitcoin blockchain is about 125GB in size, it can be stored on a regular computer and small nodes.

### **Legacy IT**

Legacy IT is very problematic in the insurance industry; however, only small investments are made in replacing them step-by-step. When applications have the same functionality, one is chosen, which is called rationalisation. The legacy IT will be replaced within 20 years, it is just a temporary problem.

### **Quantum computing**

At the moment, it is hard to say something sensible about quantum computing.

## Identity

It is about which transaction you would like to do, whether you use a blockchain as a source of identity, or something else, does not matter. It is more about the source of the identity and how a consumer transports identity attributes. It is possible to use a blockchain for that, but it is not necessary. There is a lot of interest in using a blockchain for identity and access management; for example, TNO and the Dutch Digital Delta are looking into this. However, numerous organisations already worked at another solution called iDin that uses bank cards for authorisation and identification purposes. Organisations have invested in iDin, it will be widely used and it does not require the use of a blockchain. A blockchain does not provide additional benefits, is less known and probably more complex. The banks are able to transfer identity attributes for just 22 eurocents with iDin. Blockchains do not solve anything if parties have access to reliable registers.

## Impact on business model

It is unclear what the impact of blockchain on the insurance industry will be. Besides blockchain should be assessed together with other technological innovations such as artificial intelligence and the “internet of things”. The standalone value of blockchain, in which pseudonymous identities, rather than anonymous identities are used, is limited. In the current state of development, blockchain can be used for the verification and validation of data by saving hashes and referring to them. This mainly is interesting for databases, in which blockchain also adds transparency.

The real innovation will be in the following areas:

1. *Supply chains:* In supply chains, where interoperability between a large number of parties is needed and where parties need to have access to the same information, blockchain could provide distributed workflow management. In this solution, parties ideally should be able publicly share information on a blockchain, but also should be able to make confidential agreements on this blockchain, or another blockchain.
2. *Smart contracts:* Blockchains that are limited to timestamped value transactions are not interesting in the Netherlands, as the payment system seems to function well. However, blockchains become interesting when they enable you to attach value to contracts, what smart contracts basically do. They even become more interesting when they are self-executing by using oracles. They even could be linked to artificial intelligence and the “Internet of Things”, but it is hard to see which self-regulating organisms will emerge based on that; this will take several years, in which a lot of (disappointing) experiments will take place.

## Use cases in insurance

### *Mutual insurance*

Small Dutch blockchain consultancy firm A built the a blockchain lottery, it facilitates risk sharing with value transactions between man and machine. Digital identities are able to exchange risks and value by putting agreements into smart contracts. A customer chooses a lottery number and how many times he or she wants to “play”. The winning number of an existing Dutch lottery is the oracle for determining the winner in the blockchain lottery. The customer chooses the amount of Ethers that is attached to the chosen lottery number in the smart contract. When there is a winner, the smart contracts transfer the right amount of Ether to the winner. In the case there is no winner, the Ethers are returned to the players, except for a platform fee. This model imitates a mutual insurance. Because no interest is paid in cryptocurrencies, there is no incentive for collecting premiums, besides full transparency is provided; one can show that the Ether are still attached to the smart contract and everyone can verify who was the winner. This use case is used do demonstrate what could be done with blockchain and smart contracts in the insurance industry and to learn about blockchain. In this use case, the insurer will no longer be an institutional investor, they will be an independent party that only fulfils their traditional roles in which they do not collect premiums:

- damage assessor (determines the level and extent of a damage);
- risk assessor/underwriter (determines what it would cost to insure this risk and what the premium would be);
- claim adjuster (determines how a claim will be handled by the parties that are involved in the insurance process).

When they only fulfil these roles, there is no incentive in minimizing claim pay-outs. Insurers started collecting money, because it turned out that customers were not able to pay for losses that other customers incurred. In the case of a smart contract, that is not needed, as the required funds are attached to the smart contract (as a reservation). In case of a mutual insurance, the insurers could pay for the blockchain platform and traditional services that an insurer provides on that platform. Besides, for insuring larger risks, a reinsurance might be needed. The costs for these services will be made more explicit. When an insurance policy is taken out, a payment is made to the reinsurer and the platform owners, the remainder of the premium is attached to a smart contract. When a certain damage exceeds the reservation in the smart contract, the reinsurer provides additional coverage.

### *Value chain infrastructure*

Blockchain is interesting in the insurance value chain, as every party fulfils a different role and unbundling results in an increase in the number of parties that fulfil a particular role in that chain. This blockchain should support the whole process from underwriting to claims management. Blockchain could facilitate a complete infrastructure for the insurance industry in which the roles of all parties are defined. This definition should include read and write permissions of the parties, based on these permissions, interactions can take place in which risks are shared. In this case, a blockchain can be seen as a solution for risk-sharing in the complete value chain.

## *GDPR*

From May 2018, GDPR requires every organisation should be able to:

- provide every customer with the data they have on that customer;
- delete this data on request;
- transfer this data in a format that can be electronically sent.

This is very complex for insurers, as they outsource numerous processes. Blockchain could help by gathering data, keeping data secure and transferring data in processes that a customer has to go through in applying for financial services. In order for this to work, customers should internally be identified by a unique number in order to gather data and all parties in the value chain should be able to identify customers the same way. This solution requires standardisation of datasets; currently, the data model of the Dutch insurance standardization institute consists of 27,000 data elements.

### **Result of blockchain implementation**

In the end, the customer will benefit from blockchain implementations as costs will decrease and transparency will increase. This transparency works both ways; when customers are fraudulent, the blockchain is suitable for reputation management, it will be recorded in the blockchain, which means the customer is going to pay more in the future.

## Appendix B6 – Summary interview 5

### Dealing with the advent of blockchain technology

Organizations are struggling with the advent of blockchain technology; expectations are high, but often they do not understand it. They have to decide on when to start exploring, whether they will develop a single “killer use case”, multiple use cases, or even a blockchain development platform. Will they develop a use case that impacts the core business, or is it safer to start with a more trivial use case for the sake of learning? The fact that blockchain is developing rapidly makes it hard to keep up with it. Besides, blockchain is bleeding-edge technology and many blockchain-related initiatives fail. The most important question is what the revenue model of a blockchain use case will be. Multiple blockchains have been developed and it is not clear what a blockchain is and what it can do; different blockchains are being tailored to fit different business needs. Eventually, there might be a very large number of blockchains, each with their strengths (e.g. speed, security, low costs, storage capacity, easy connection to existing IT systems, etc.). It is a difficult task for developers to choose from the wide variety of blockchains and subsequently configure them; it is not yet clear how much low-level knowledge a developer needs for this task. Assembling blockchain applications will become easier, which will help developers to draw up a smart contract, these contracts will eventually be translated to a blockchain or virtual machine. This will take time, but this is probably a requisite for building high-quality applications; currently blockchain programming takes place on a low level, which is error-prone.

### Technology

#### Privacy

There seems to be a lot of confusion around the topic of privacy; many people seem to associate blockchains with privacy and anonymity, however, when a link is made between an account and identity, blockchain is perfectly suitable for tracking activity. A lack of knowledge creates false expectations; if data should be kept private, it should not be stored on a blockchain. An alternative could be storing data elsewhere and storing a hash of the data on a blockchain to prove data ownership. No of-the-shelf products for guaranteeing privacy on blockchains currently exist, but multiple parties are experimenting with it. It is hard for anyone to build security applications, as it is likely that errors will be made in cryptographic implementations. Of course, someone should develop a privacy solution, but with a low market demand, that may take some time.

#### Security

Blockchain software is immature, it may contain bugs that may result in stability problems or a susceptibility to surface attacks. Especially public networks are slowed down by constantly being under attack of, for example, DDos attacks or attacks of miners that try to find loopholes. Blockchain software in itself may not be unsecure, but the visibility and accessibility are large, so the impact of a successful attack is much larger when compared to a closed system that is used for a single application. When there is a problem with a blockchain platform like the Ethereum, the impact will be felt by many users.

## **Reliability**

In insurance, reliability is mainly concerned with the lifespan; to which degree can a blockchain application be trusted at the moment and in the long run? For several insurance products a lifespan of over 10 years is required, while blockchain technology has not even been in existence for 10 years. There are numerous insurance applications where that will not be an issue, for example in negotiation processes or claim handling, as these processes are settled in a limited amount of time.

## **Legacy IT systems**

Security and predictability are important for insurers, their IT systems are outdated and different software programs are used to offer the same functionality, besides data labelling is not used consistently. These factors make it difficult for insurers to keep up with IT innovation. It is too early to connect blockchain applications to their IT systems, because privacy and security cannot be guaranteed. However, it is very important to solve the issue of connecting blockchain applications to their IT systems (data, login systems, key management, etc.). Experiments are often done in a so-called sandbox, while this offers more room for experimentation, it does not provide a full insight in the implementation challenges that lie ahead.

Blockchain can be seen as a driver for making IT systems more agile by separating certain roles and preparing systems for decentralization. For current systems adapters will probably be developed, these adapters prepare data for use on a blockchain. Existing IT security will be impacted, especially when a public blockchain is used, it is unlikely that the relatively low level of control over blockchains will be accepted by firm management. IT systems are rapidly being rationalized, it is important to be able to quickly move to a different platform and convert data. Currently, there already are solutions for moving to another platform without lots of programming or data conversion, these will probably be developed for blockchain platforms as well.

## **Quantum computing**

Some encryption protocols are less resistant to quantum computing, but most asymmetric protocols (elliptic curve cryptography) that are currently in use have a higher resistance than earlier implementations. Quantum computing will be there some day, but it will happen gradually. Cryptographic principles are continuously being optimized as they are continuously under attack. It comes down to having the possibility to upgrade. Aspects like scalability and implementation security are more important.

## **Scalability**

If you would like to do something concrete in for example throughout the Netherlands, that would be impossible. The greatest challenge is to get a grip on the maturity and scalability of the technology. The scalability of, for example, the Bitcoin blockchain is very limited and it consumes a lot of electrical energy. However, multiple parties are working on solutions for improving scalability. It is more important to know in which case a certain blockchain can be used and what its limitations are. When a new insurance product on a blockchain will be launched, it is unlikely that scalability will be problematic anytime soon. Solutions will be driven by an increasing number of parties that reach the limits of blockchain scalability.

### **Identity and access management**

There is a lot to be done in the areas of access, user-friendliness and reliability. For example, consumers will not be able to take care of their security keys. Everyone is waiting for a convenient solution for identity and access management, as it is a very important facilitator of financial applications, especially in consumer applications (this is less important for the professional users of backend applications).

### **Standardization and compatibility**

Standardization is lacking, but is an important facilitator, as the potential of blockchain application is high when multiple parties make transactions. It might be too early for standardization, as no concrete use cases have been developed. A standard that is developed too soon in absence of concrete use cases will probably be weak and need updates very soon. There is a scattered field of blockchain solutions, each with their own specific applications.

### **Decentralized infrastructure of blockchain**

Next to the advantages of blockchain that have been mentioned in the information that the interviewer sent before this interview, blockchain offers an additional advantage; a decentralized, largely open-source infrastructure already has been realized. This infrastructure with its libraries and peer-to-peer network could provide resiliency, as it removes the dependency of a central infrastructure and proprietary software. Blockchain platforms are able to host multiple applications and new applications can be developed quickly, as they can be linked together as building blocks on the same platform.

## **Market**

### **Disintegration of the value chain**

It is important that insurers are aware of their strengths and weaknesses and the role that they would like to fulfil in the future. Blockchain might provide an opportunity for offering a platform to which other parties can connect. It is important that insurers start thinking about what their role could be in such a platform, even though it might seem that insurers will give up some of their current activities.

### **Competing with FinTech firms**

Compared to FinTech firms which are new to the insurance market, insurers have a strong position in the market as they:

- Have a high level of brand awareness;
- Are considered to be trustworthy;
- Have a large customer base;
- Possess valuable customer data, for example on claim behaviour;
- Are experienced in the insurance industry;
- Have regulatory advantages.

For new entrants, it will be difficult to comply with laws and regulations (they are “too small to comply”), therefore insurers should think about launching products that cannot be launched by new entrants in a scalable, realistic way.



Instead of using their resources and capabilities for offering full insurance products, they could offer their knowledge, a platform and data to facilitate other parties in offering those products. In that case, insurers facilitate a part of the insurance value chain. It is important to think about which advantages this approach could bring, whether it will increase profitability or reduce costs. Besides it could bring other advantages like improving public relations or attracting talent. Insurers have to determine in which areas they would like to excel and which activities could be outsourced. Activities like payment processing could be outsourced, as they do offer limited possibilities for distinguishing an insurer from the competition. When this approach is successfully implemented, insurers will be able to focus on distinguishing activities. The small Dutch emerging IT consultancy firm notices that insurers tend to think that reducing the number of activities they engage in, or moving to other activities, will disqualify them as insurers. Insurers should think about their added value in certain insurance-related activities, instead of insurance as a full service.

### Regulation

Blockchain applications are currently being developed on a low level of coding, this increases the risks for bugs and security issues. Errors in a blockchain have financial consequences, it can be hard to recover from an error in a smart contract. Maybe a new role for IT-auditors will arise at the intersection of software, laws and regulation. These auditors will check upfront whether the smart contract will execute as they are intended to do.

### Cooperation

The very nature of blockchain technology is the reason that there is a huge potential when multiple parties are cooperating, lots of data is exchanged between parties and parties have to share a “single source of truth”. Internal use cases can be used for learning more about the technology, but very little will be learned about good business models and no trust issue will be solved.

Customers of the small Dutch emerging IT consultancy firm are often struggling with selecting partners for exploring blockchain technology. They are worried about sharing sensitive data and selecting partners that are (at least) equally experienced. When too many parties are working together in this exploration, progress might be slowed down.

### Use cases

Many existing use cases are copies of existing products and business models, just like in the early days of the Internet. That is a phase that the technology has to go through, as the technology and knowledge have not yet developed to the extent that they will be able to facilitate other, stronger use cases. This requires more experimentation. It is expected that these use cases will significantly differ from existing business models, products and organizations. They might be developed by new entrants, such as FinTech firms or an energy supplier.

There is a large mismatch between a top-down push to explore concrete use cases and their business models and the availability of technical expertise and solutions on a component level (in terms of functionality that is fulfilled by existing IT systems). These components will be developed as the demand for them rises.

For comparing use cases, the small Dutch emerging IT consultancy firm uses a framework with two axes: the degree of decentralization of the product and the degree of decentralization of settlement. In

essence, use case are compared based on whether parties own production assets and control contractual and financial settlement or not. This framework can help organisations to come up with new use cases, for which they have to consider the revenue model, value proposition, (additional) services that could be delivered, platform maintenance and the value of data that will be generated. This will be rather time-consuming. Often transaction fees are mentioned as a revenue model, however that model could be copied very easily.

### **Mutual insurance**

This can be seen as basic use case that can help to explain how blockchain works by using it for facilitating an insurance product they are familiar with. It is important to gain domain knowledge, experience and a shared language by learning by doing. Specific (backend) blockchain use cases are only comprehensible for few domain experts. A mutual insurance is not complex and therefore it is easy understand how it could be facilitated by blockchain. The small Dutch emerging IT consultancy firm has developed an interactive proof of concept, which offered the possibility to show the underlying business rules and how it works from different perspectives. This use case is very concrete and suitable for introducing blockchain to insurance professionals in a workshop. The commercial interest in this use case is rather low, it might be too radical or the revenue model might be unclear for insurers.

### **Business-to-business**

In the near future, business-to-business uses cases probably are more interesting than business-to-consumer applications. Barriers of identity, privacy, scalability, accessibility, user-friendliness are too high for consumer applications. Using blockchain might be interesting for backend processes in reinsurance and communication between insurers. Blockchain could be used to speed up settlement processes and manage the large number of contracts that insurers have to deal with.

### **Regulation**

When changes in regulation put strict requirements on audibility transparency, provenance, public availability of data, blockchain could offer a solution that is both cheaper and easier than building an infrastructure that requires the establishment of trust.

### **Impact on the insurers' business models**

- *Cost reduction:* In all use cases, before cost reductions will be realized, insurers will have to invest in tooling and education. The first significant cost reduction has not been realized yet.
- *Differentiation:* Blockchains offers possibilities for differentiation in a disintegration value chain; activities can be disposed, activities can be linked to each other and network effects can be realized on a platform. On this platform, activities or data can be offered to other parties, but it might be hard to make a profit out of it.

*Customer retention:* It is unlikely that blockchain will improve customer intention in the consumer market, consumers are not especially interested in blockchain, they are mainly interested in cheap and user-friendly services. This cannot yet be offered by blockchain technology. However, in the business-to-business market blockchain might improve data sharing between business partners.

## Appendix B7 – Summary interview 6

### Dealing with the proliferation of blockchain technology

#### **Innovation in large firms**

Innovation that goes beyond incremental innovation requires freedom and resources. Resources should be allocated without being restricted by internal rules and the current business model of the firm. Firms that are meeting requirements of their customer base will have difficulties with bringing revolutionary innovations to the market; customers often ask for incremental innovation. This increases the risk of being disrupted by a new entrant

#### **Speed of development**

Blockchain has existed for 9 years now, it has taken several years before applications other than exchanging value appeared. Most parties are completely in the dark about the development of blockchain technology. It does not make sense to predict the development of blockchain, as its development just started and no historical data is available. Blockchain is often seen as a fundamental technology on which a wide range of applications can be built. The physical networks and (mobile) devices that will facilitate blockchains are already in place. Therefore, that development of blockchain will probably go faster than the development of the internet. Besides, blockchain seems to attract many bright people, which increases the likelihood that problems will be solved and use cases will be developed quite soon.

#### **Cooperation**

Blockchain is a “collaborative technology”, which implies that in general, cooperation between multiple parties is needed for developing a strong value proposition. Cooperation should go beyond talking and gathering, instead, parties should invest in actually building applications; this development should receive sufficient funds and ideally take place on a single location. However, when the number of cooperating parties is too high, progress will be slowed down.

Instead of starting off in a cooperation, it might be more effective for a single firm to develop an idea into something substantial before it approaches other firms. This makes it more attractive for other firms to join. Valuable applications are more likely to be found by experimenting, rather than talking; it is unlikely that firms will be able to develop a so-called “killer use case” without failing multiple times.

#### **Technology**

Firms that are not investing in blockchain because of technological uncertainties are taking a risk, because it is developing very rapidly. Firms should experiment to learn more about the possibilities, what blockchain could mean for the organization and the challenges that lie ahead.

#### **Security**

It is hard to say something sensible about security risks before proof of concepts or minimal viable products are made. Possible security risks should not be a reason not to invest, problems will be solved when enough resources are put into it

## **Scalability**

There always have been complaints about the scalability of blockchain, but also this will be solved. For example, BigchainDB developed a database with blockchain characteristics that is very scalable and has a low latency. The capacity and speed of this database actually increases with every node that is added. BigchainDB uses a consensus mechanism in which consensus is reached between a number of nodes that is sufficient for a desired level of security, instead of between all nodes. Besides, BigchainDB is able to store terabytes of data. To summarize, technological problems can be solved when firms start experimenting, it should not discourage them. Currently, there are hardly any cases that are at a stage of development where scalability already is problematic and resources are required to solve them

## **Market**

### **Disintegration of the value chain**

Blockchain applications will have a very strong focus, just like Everledger has. Parallels can be drawn between the development of blockchain and the applications and business models that have been developed on the internet. Within 5 years from now, it is likely that strongly focused, cheap and disruptive insurance products will be offered. These products might be offered by the insurer's employees that see the potential of blockchain, but are frustrated by the slow progress that the insurers are making.

## **Regulation**

Firms have a tendency to innovate within the borders of regulation, however, that approach is only suitable for incremental innovation. It is better to start the other way around; first start experimenting and discover the possibilities of a technology and worry about regulatory compliance afterwards.

## **Use cases**

Firms are mainly interested in concrete blockchain business cases; a clear business case will attract larger investments. When firms experiment with use cases that require new business models, the business case will be less clear. Investing in clear use cases that solve a concrete problem makes sense, but exploring a wider range of use cases and assessing their impact on the business model could also be interesting. A balance has to be found between exploration and exploitation. Customers often ask small Dutch blockchain consultancy firm B to explore use cases that are focused on concrete incremental improvements that could be realized by using blockchain. Small Dutch blockchain consultancy firm B would like to challenge firms to explore new business models that benefit the customer, because that would lead to valuable insights into a possible radically different future in which the current firm might not play a role.

### **Disability insurance**

Small Dutch blockchain consultancy firm B is developing a blockchain-enabled diversification plan for disability insurance. This product allows self-employed persons to combine multiple disability insurances in a convenient way. The self-employed workers are part of a collective and are free to determine the percentage of their income that they would like to pay to their insurance each month. This allows them the flexibility that suits their fluctuating incomes. The diversification plan can be changed at any moment. Premium payments go from the insuree to the insurer through an exchange, this exchange is a smart contract that distributes payments to the insurers according to the

diversification plan. At the same time, the collected premiums are shared with other self-employed persons. Decentralization and consensus are important, the blockchain ensures that all parties comply with the agreements that have been made in the network, including the payments that should have been made. The platform matches supply and demand, in which more security and insight are offered to the customer. Besides it challenges insurers to come up with a new business model.

### **Individualization**

Blockchain could advance automation when it is used in combination with other technologies like artificial intelligence. Artificial intelligence is able to interpret customer data and offer highly personalized products. When the step from the physical world to a blockchain has to be made (for example in case of a damage claim), there still is a need for trust. Blockchain could be used to facilitate a reputation management system on which the history of actions of an insuree or other data sources is stored and can be shared with the insurer. In that way a certain degree of trust could be established.

### **The impact of blockchain technology on insurers' business models**

#### **Frontend vs. backend**

Reputation will become more important and lots of checks and balances will be taken over by blockchain. Firms and persons will build up a reputation; their reputation is very important and blockchain will be able to facilitate a decentralized, immutable and transparent reputation management system. It is hard to distinguish between frontend and backend impact. The backend facilitates the frontend and every proper application needs a frontend.

#### **Smart contracts**

In general, smart contracts will require parties to work out contracts more upfront than they do now, because processes will automatically be run the smart contracts. Parties will have to agree on the business rules, for example on performance standards, record keeping and data that is needed for executing the smart contract. This data could come from sensors or (big) data analysis. When firms challenge themselves to think these contracts through, the quality of the contracts will be higher.

## Appendix B8 – Summary interview 7

### Developments in the insurance industry

#### **Conventional revenue model**

In the conventional revenue model, insurers sell policies which generates a stream of premiums, these premiums are invested and (ideally) this generates a positive return on investment. However, the investment climate currently is unfavourable and government bond yields are considerably lower than they have been in the past. This means that insurers have to make changes in their revenue models.

#### **Centralization of policy administrations**

Insurers increasingly centralize the policy administration and development of different products. When these different products are sold, the organisation increasingly acts as a whole. This development is not typical for insurers, in the financial services in general, it can be seen that operations and centralization takes place and operations are run from head offices.

#### **Disintegration of the value chain**

Disintegration of the value chain has been taking place since the late 1990s/early 2000s, more and more operations are outsourced. There are some new entrants, however it is hard to determine whether they pose a threat or an opportunity. An important change in the insurance business model is that in the past intermediaries sold insurance policies and handled claims. Nowadays, customers often buy insurance policies through comparison websites. That poses a huge risk, as insurers lose control over agents; in the past insurers it was easier to control agents by offering them commissions. On the other hand, it provides a great opportunity, as every insurer was able to control agents, while now insurance information is publicly available; comparison websites create a level playing field where the product itself and its price are more decisive for generating sales. Therefore, insurers are able to focus on improving the value proposition of their products. Besides, these commissions are quite expensive, they raise the costs of a product without realizing a competitive advantage.

#### **Consumer trust**

It is said that the mis-sale of unit-linked insurances has damaged consumer trust. These products did not necessarily protect consumers against certain risks, which is the essence of insurance, in fact they were investment products. However, it did not damage consumer trust to a degree that led to a significant reduction of insurance sales.

## Technology

### **Standardization and compatibility**

Standardization is a big issue, existing standards are not being used; a core standard exists, it has been discussed for as long as 15 years and even a book has been written. Some parts of this core standard are used, for example data labels that simplify data exchange. The limited use of standards a very big obstacle that insurers are encountering in the insurance blockchain consortium.

It is not inconceivable that the translation of all contracts into smart contracts, in an international insurance setting will never be realized. However, there is a lot of low hanging fruit in which there is a lot to be gained in the short term.

### **Immaturity and privacy considerations**

Blockchain technology is immature, several parties are developing privacy-preserving solutions, but to date no concrete solutions have been developed beyond proof of concepts. The technology is under development and parties have to learn a lot. There are no standard tools that are guaranteed to work. The development of the technology lags behind the development of ideas. It is important to determine for how long data should be stored and how privacy of all parties is safeguarded, while managing data access, without increasing complexity too much. Different platforms put these issues on their roadmap and large organizations will follow this year.

### **Multiple platforms**

Currently, there are several competing blockchain platforms, for example Ethereum, Monax, Hyperledger Fabric or Corda, insurers are experimenting with multiple platforms. Using multiple platforms is not necessarily problematic, just like using multiple data platforms currently is not problematic for insurers. Insurers experiment in order to discover the strengths and weaknesses of the different platforms in specific use cases.

## Regulation

### **Lack of jurisprudence and regulation**

The consortium in which large Dutch insurer C participates did not yet encountered problems related to regulation, but this will only be a matter of time. Jurisprudence on the use of blockchain in the insurance industry is lacking. Because of the complexity of the business-to-business insurance, judges will tell parties to try to reach settlement outside the court. It will take several years before these cases will be taken to court. Regulators like the AFM (Autoriteit Financiële Markten or the Dutch authority for the Financial Markets in English), DNB (De Nederlandsche Bank or the Dutch central bank in English) and other (foreign) regulators do not yet have a clear policy for blockchain. The consortium does not yet have a concrete blockchain application that can be examined by regulators.

### **GDPR (General Data Protection Regulation)**

Safeguarding the “right to be forgotten” that is part of GDPR on a blockchain could be problematic; data could be encrypted and the encryption key could be deleted, but it is not clear whether that will be sufficient. A solution will be developed, but it is hard to predict when this will happen.

## Cooperation

### **Main goal of the consortium in which large Dutch insurer C participates**

The global consortium consists of organizations from the insurance industry. The main goal of the consortium is exchanging blockchain experience, especially related to developing standards which could benefit insurers and reinsurers. However ultimately, the policyholders will benefit the most from it, because their premium is spent on claim handling, buildings and many administrative processes. In the insurance industry, insurers often transfer risks to a second, third, fourth or even a fifth insurer, this process is called reinsurance. This is not done for insured objects such as cars or phones, but for larger objects such as life insurances. This process takes place in a business-to-business chain in which everyone operates in the same market and performs the same activities in a different way. In this chain, everyone should be able to communicate with each other. The consortium took blockchain as a solution and looked for a problem that matched the criteria of high-potential use cases that have been described by the information that was sent prior to this interview. The reinsurance case matches these criteria very well. The consortium was not interested in developing a random blockchain application for the sake of doing it, instead it looked for an application where blockchain actually solves a problem and adds value. This application can be presented to the management of the insurer, it is not hard to explain what has been done and how it benefits the firm and ultimately the firm's customers.

The consortium mainly consists of insurers, some of them might not have a reinsurance business unit, however nearly all insurers will have such a business unit, this creates a level playing field. The consortium is founded by 5 parties, this attracted other parties and resulted in the support of the CEO and CTO of the firms they are working for. The first project that is undertaken by the consortium focusses on reinsurance applications. However, the objective of the consortium is broad: exploring areas where blockchain could be of practical value, right now, on the short-term, for the insurance industry. The consortium is looking for short-term applications of blockchain applications which will bring process improvements or to provide customers with better service in another way; these applications do not necessarily have to improve efficiency and reduce costs. Most potential can be realized in applications that are being shared by multiple parties.

When an insurer is looking for a competitive advantage, it would not make sense to involve as much insurers as possible; as long as a collaborative effort for realizing a blockchain application can be clearly communicated to the customer, there is a benefit in cooperating.

## Impact on the insurers' business model

### **Low-hanging fruit**

The strongest use cases are to be found in settings where parties are equal, business-to-business or consumer-to-consumer that is. In these settings, it is more likely that a sufficient level Byzantine fault tolerance will be realized. But probably a solution will be developed in which a sufficient level of Byzantine fault tolerance could be realized in a business-to-consumer setting.



## **Frontend vs. backend**

The frontend and backend are linked to each other, but most work needs to be done in the backend. Actually realizing a blockchain application in the backend will result in changes in the frontend, for example ease of use, increased speed, or cost reductions. That is where most is to be gained. This is comparable to the benefits that were realized by moving from paper ledgers to computer systems; the customer still bought the same product, but the price of that product could be lowered, while at the same time the speed of claim handling could be increased. It will be the next step in the automation revolution, a new layer on top of the internet or internal processes. For example, instead of having auditors check internal administration, information could be shared directly on a blockchain, which would save a considerable amount of time.

## **Main benefits**

The main benefit of using blockchain in insurance will be faster settlement as it lowers the need for financial reservations for counterparty risk. These reservations are strained capital, which is a major issue that the consortium aims to solve. The reservations that can be freed up can yield a positive return on investment. It should be noted that cost reduction and quality gains can be realized simultaneously; better services can be delivered at the same price, the same services can be delivered at a lower price or it could even be possible to deliver better services at a lower prices. That is where a lot could be gained from in reinsurance.

## **Use cases**

### **Smart contracts in reinsurance**

The reinsurance use case of the consortium is developed by organizations who are in close geographical proximity of each other. In reinsurance, risks are transferred to a second, third, fourth or even a fifth reinsurer. The insuree receives a rather straightforward policy from the first insurer, but the insurers agree on bespoke mutual contracts. The contract is a piece of paper that describes the insured risk, liabilities and the claim handling process. This contract changes every year. This piece of paper has to be translated in order to store it in the administration system of the insurers. In this step, where legal language is translated into computational language, assumptions on the meaning of the legal language have to be made. Most of the time, different parties will make the same assumptions, but when they do not, it can take a while before it will surface and even longer before they reach settlement (up to several years). It gets more complicated and time-consuming when more reinsurers are involved. The reinsurance use case of the consortium aims to solve this problem by using smart contracts on a blockchain; in a smart contract ambiguity is eliminated, as the contract consists of computable rules. When changes regarding the smart contract are made, the smart contract calculates what the consequences of those changes are, this result is reported to the parties that are involved in the insurance policy. It is crucial that this data is not shared with other parties, however, on current blockchain platforms, that cannot yet be guaranteed. The parties that are involved can verify the reported result as they: possess the data that went into the calculation, are able to calculate the result on their own smart contract on their own node and can verify that their result of the calculation is similar to the result of other parties. Of course (programming) errors can still be made in drawing up the smart contract, but the fact that all parties possess the same data, makes it is easier to find an error. With the addition of more reinsurers, the gains that can be made increase exponentially, so this use case is especially interesting when risks are reinsured numerous times, or when a risk is shared by numerous insurers. To summarize, smart contracts can solve a trust issue that is caused by the error-prone reinsurance processes, the trust issue is not related to bad intentions.

**Co-insurance**

Co-insurance is a type of insurance in which large risks are covered by multiple insurers, these insurances are bespoke and complex. In this type of insurance, parties have to work together, while they do not fully trust each other. Again, this lack of trust is not the result of bad intentions, but errors will be made in a complex chain in which every party has its own regulators, risk-, compliance- and legal departments. In these chains a lot of duplicate work is done, parties have to check each other. Errors are often found in contracts; the contracts are bespoke and data often has to be reconciled manually.

**Asset provenance**

Tokenization of assets can make tracking ownership redundant. If someone puts that information on a blockchain and it is accessible, without sending paperwork to another identity, the insurance processes can be sped up.

## Appendix C – Workshop time schedule

TABLE 25: TIME SCHEDULE OF THE BUSINESS MODEL STRESS TEST WORKSHOP

Activity	Time	Supporting activities
Pick up keys to room and prepare the computer and beamer.	08:15 - 8:45	Arrange a large room with a beamer and enough tables and seats.
Welcome participants and offer them a drink.	08:45 - 09:00	Arrange catering
Introduction <ul style="list-style-type: none"> <li>• Round of introductions;</li> <li>• Present the business model stress testing methodology;</li> <li>• Present the STOF business model ontology.</li> </ul>	09:00 - 09:20	<ul style="list-style-type: none"> <li>• Provide participants with pen and paper for making notes;</li> <li>• Ask permission for recording parts of the workshop.</li> </ul>
Present the reference business model.	09:20 - 09:35	<ul style="list-style-type: none"> <li>• Put two A1 posters of the reference business model on the wall;</li> <li>• Discuss and agree on the reference business model.</li> </ul>
Present the three selected stress factors.	09:35 - 09:45	<ul style="list-style-type: none"> <li>• Provide participants with the handouts of the stress factors;</li> <li>• Discuss and agree on the three selected stress factors.</li> </ul>
Stress testing part I <ul style="list-style-type: none"> <li>• Estimate the future impact of the stress factors on the business model components, in order to construct a heat map.</li> </ul>	09:45 - 10:45	<ul style="list-style-type: none"> <li>• Put A1 posters of the heat map template on the wall. One heat map for each stress factor for each group (a total of six heat map posters);</li> <li>• Put two A4 posters of the legend of the sticky note colours on the wall.</li> </ul>
Break	10:45 – 11:00	
Stress testing part II <ul style="list-style-type: none"> <li>• Estimate the future impact of the stress factors on the business model components, in order to construct a heat map.</li> </ul>	11:00 - 11:40	<ul style="list-style-type: none"> <li>• Provide the participants with markers and sticky notes. They can write their contributions on the sticky notes and stick them on the posters;</li> <li>• Arrange catering.</li> </ul>
Groups present their findings	11:40 – 12:00	Set up a camera and start recording
Lunch	12:00 – 13:00	Arrange catering

## Appendix D – Business model definitions

TABLE 26: BUSINESS MODEL DEFINITIONS FOUND IN LITERATURE

Author(s)	Definition
(Bouwman et al., 2008, p. 33)	<i>“A business model is a blueprint for a service to be delivered, describing the service definition and the intended value for the target group, the sources of revenue, and providing an architecture for the service delivery, including a description of the resources required, and the organizational and financial arrangements between the involved business actors, including a description of their roles and the division of costs and revenues over the business actors.”</i>
(Timmers, 1998, p. 2)	<i>“A business model is an architecture for the product, service and information flows, including a description of the various business actors and their roles; and a description of the potential benefits for the various business actors; and a description of the sources of revenues.”</i>
(Amit & Zott, 2001, p. 511)	<i>“we propose the business model construct as a unifying unit of analysis that captures the value creation arising from multiple sources . . . A business model depicts content, structure, and governance of transactions designed so as to create value through the exploitation of business opportunities.”</i>
(Osterwalder et al., 2005)	<i>“A business model is a conceptual tool that contains a set of elements and their relationships and allows expressing the business logic of a specific firm. It is a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, and delivering this value and relationship capital, to generate profitable and sustainable revenue streams.”</i>
(Osterwalder & Pigneur, 2010, p. 14)	<i>“A business model describes the rationale of how an organization creates, delivers, and captures value”</i>
(Chesbrough & Rosenbloom, 2002, p. 532)	<i>“The business model provides a coherent framework that takes technological characteristics and potentials as inputs, and converts them through customers and markets into economic outputs. The business model is thus conceived as a focusing device that mediates between technology development and economic value creation.”</i>
(Magretta, 2002, p. 87)	<i>“Business models . . . are stories that explain how enterprises work. A good business model answers Peter Drucker’s age-old questions: Who is the customer? And what does the customer value? It also answers the fundamental questions every manager must ask: How do we make money in this business. What is the underlying economic logic that explains how we can deliver value to customers at an appropriate cost?”</i>
(Shafer et al., 2005, p. 202)	<i>“. . . a representation of a firm’s underlying core logic and strategic choices for creating and capturing value within a value network”</i> The four components of the business model are: Strategic Choices, Value Network, Capture Value, Create Value.
(Afuah & Tucci, 2000, p. 4)	<i>“A business model can be conceptualized as a system that is made up of components, linkages between the components, and dynamics.”</i>
(Linder & Cantrell, 2000, pp. 1, 2)	<i>“A business model . . . is the organization’s core logic for creating value. The business model of a profit-oriented enterprise explains how it makes money”</i>
(Morris et al., 2005, p. 727)	<i>“A business model is a concise representation of how an interrelated set of decision variables in the areas of venture strategy, architecture, and economics are addressed to create sustainable competitive advantage in defined markets . . . “</i> The six components are: the value proposition, the customer, internal processes and

	competencies, external positioning, the economic model, and personal/investor factors.
<b>(Teece, 2010, p. 173)</b>	<i>“A business model articulates the logic and provides data and other evidence that demonstrates how a business creates and delivers value to customers. It also outlines the architecture of revenues, costs, and profits associated with the business enterprise delivering that value.”</i>
<b>(Casadesus-Masanell &amp; Ricart, 2010, p. 197)</b>	<i>“a reflection of the firm’s realized strategy”</i>
<b>(Johnson, Christensen, &amp; Kagermann, 2008, pp. 60, 61)</b>	<i>“A business model . . . consists of four interlocking elements that, taken together, create and deliver value.”</i> These elements are: customer value proposition, profit formula, key resources, and key processes.
<b>(DaSilva &amp; Trkman, 2014, p. 382)</b>	<i>“Business models represent a specific combination of resources which through transactions generate value for both customers and the organization”</i>
<b>(Morris et al., 2005, p. 727)</b>	<i>“A business model is a concise representation of how an interrelated set of decision variables in the areas of venture strategy, architecture, and economics are addressed to create sustainable competitive advantage in defined markets.”</i>