UNIVERSITEIT TWENTE.

Master Thesis

The Future Of Contracts In A Digital Economy:

„The Impact Of Smart Contracts On Transaction Costs In Financial Markets"

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Abstract

Blockchain technology is regarded as one of the most important digital innovations of the last decade. Its increasing popularity has made applicability beyond cryptocurrencies a growing topic of interest. Smart contracts, based on blockchain technology, have created much excitement in the financial community, but their potential to significantly impact the way businesses and individuals trade with each other has yet to be examined. Building on case study research and a review of recent literature on the topic, this thesis evaluates their ability to decrease transaction costs in financial markets. Results suggest that smart contracts reduce moral hazard and adverse selection problems by automating trading processes, lowering information asymmetries and enhancing market transparency. Successful implementation of blockchain technology is likely to occur first in the clearing and settlement of financial securities, therefore challenging the traditional service portfolio of many financial intermediaries. Based on the findings, implications for market structure are discussed and a number of practical recommendations for financial institutions are given.

Table Of Contents

List Of Figures

List Of Tables

1. Introduction

1.1 Innovation In Financial Markets And Blockchain Technology

Over the last few years, the financial industry has seen a growing number of new financial technology, or "fintech", startups emerge and challenge traditional banking institutions. In their quarterly venture capital report, KPMG and CB Insights (2016) state that global investments in fintech companies reached 19.1 billion US Dollars in 2015, its highest ever. Compared to 2014, venture capital investments in fintech doubled, reaching 13.8 billion US Dollars total. Furthermore, KPMG and CB Insights list a record of nineteen fintech *unicorns* (startups valued over 1 billion US Dollars) with fourteen positioned in the payments and lending sectors. Amidst this innovative disruption, blockchain technology is considered one of the most promising opportunities with related annual startup investments now exceeding 500 Million US Dollars[1].

The potential of blockchain technology was first brought to the attention of the wider masses through the introduction of *Bitcoin* in 2008. Now the world's most popular virtual currency, it is based on peer-to-peer transactions which take place between users directly, without the need for intermediaries. Built on the idea of a gradually growing list of ordered records called blocks, blockchain technology is inherently resistant to data modification. Once added to a blockchain database, a new block cannot be manipulated retroactively, since each segment is made up of a timestamp as well as a link to a previous block. Per definition, a blockchain consists of a network of duplicated databases, synchronized via the Internet and is observable to anyone within the network. It is this distributed and public ledger, which keeps records of digital transactions across a network that makes blockchain technology unique. As new blocks of validated transactions are interconnected to older blocks, the entire chain is continually updated, giving each network member the ability to verify who owns what at any given time. In addition, the lack of centralized points of vulnerability or failure makes it virtually impossible to exploit such a database.

[1] See CB Insights. (2017, June 29). Ledger Fever: 95 Bitcoin & Blockchain Startups In One Market

1.2 Problem Statement And Research Question

Due to the high information asymmetries found in financial markets, there have traditionally been a great number of regulations aimed at lowering the risk for both borrowers and lenders. However, as shown by the 2008 financial crisis set off by the sudden insolvency of investment bank Lehman Brothers, there still exist certain costs and dangers to using financial markets. Economic literature assumes that such *transaction costs* are the result of an unpredictable and complex world, where humans do not have the capacity to design contracts that plan for all possible contingencies. Among other problems, this can lead to hold-up situations where uncertain and relationship-specific investments create unequal bargaining power between seller and buyer or capital provider and capital receiver. Here, even though both parties would benefit from transacting, they refrain from doing so because of their lack of trust in one another. While the most prominent solutions of problems related to transaction costs are based on either vertical integration (Williamson 1979, Klein et. al. 1978) or a clear definition of property rights (Grossman and Hart, 1986), the emergence of blockchain technology has created a third possible option for overcoming or at least reducing transaction costs.

An inherent characteristic of the blockchain technology is its ability to trigger transactions automatically. This feature has greatly increased the possibility of computer programs that are capable of facilitating, executing, and enforcing the performance of an agreement. While the idea of such *smart contracts* dates back to the late 1990s (Szabo 1997), gradual implementation has only recently begun. The potential impact smart contracts can have on our increasingly digital economy is of immense significance and should not be underestimated. The ability to enforce contracts at virtually no cost drastically reduces the need for supervision while allowing an increasing number of businesses and people to trade more frequently and more efficiently. By eliminating various types of intermediaries smart contracts will likely disrupt numerous sectors of the financial industry as well as our economy as a whole. The possible scope of this change has already been addressed in the literature and is often listed as a potential fifth "Disruptive Computing Paradigm" - after the *mainframe* (1970s), the *PC* (1980s), the *Internet* (1990s) and *social*- and *mobile* *applications* (2000s) (Swan 2015a). Whereas the Internet has revolutionized the exchange of information and data, smart contract technology can fundamentally alter the exchange of assets and valuables. While there exist a number of whitepapers and articles on the technology itself, we still lack a thorough understanding of how this change will take place and to what extent different intermediaries and sectors of the financial industry will be affected. By identifying the underlying technological and economic processes involved in smart contracts this thesis aims to close the aforementioned research gap and contribute to the current scientific discussion. In order to adequately analyze the impending developments it makes use of transaction cost theory, drawing on both established and contemporary literature. The following research question summarizes this:

„What impact will smart contracts have on transaction costs in financial markets?"

To facilitate analysis, the research question has been divided into three sub-questions:

1. What types of transaction costs are most frequent in financial markets? (Chapter 3)
2. What are the most probable uses of smart contracts in the financial industry in the near future? (Chapter 6)
3. How will smart contracts affect market structure in the financial industry? (Chapter 7)

1.3 Structure Of The Thesis

In order to answer these questions, this thesis presents a thorough overview of transaction cost theory, which is done in Chapter 2. This framework is then applied to financial markets in Chapter 3 to identify the most frequent transaction costs in the industry. Chapter 4 familiarizes the reader with the general functionality of the blockchain as well as its different categories and advantages over traditional databases. This is done to gain the necessary understanding of the underlying technology that enables smart contracts, which are discussed in detail in Chapter 5. Here, a framework of potential benefits and efficiency gains is provided while also examining outstanding issues and challenges. Based on recent scientific literature and empirical evidence, Chapter 6 focuses on the possible uses of smart contracts in the financial industry. Next to the general process of securities trading, the exchange and handling of futures and leveraged loans will be looked at and evaluated. Chapter 7 uses the proposed framework as well as the processes outlined in Chapter 6 to assess implications for market structure. The roles of three major market participants will be reviewed - banks, investment funds and clients. It is further outlined what impact smart contracts will have on their business models. Finally, the most important findings are summarized in a conclusion and complemented by an outlook in Chapter 8.

2. Transaction Cost Theory

2.1 Theory Choice

Given the above research goal, the author is faced with a difficult question: Which theoretical framework should form the basis of the analysis? In order to adequately investigate changes in markets and institutions, a theory is needed that is able to describe both individual behavior of market agents as well as collective behavior of businesses or intermediaries. To achieve this the thesis makes use of transaction cost theory (also known as social cost theory), drawing on both established and contemporary literature. Transaction costs form the foundation of our understanding of the exchange of assets as well as their underlying contracts and are a fundamental part of marketplaces. Interestingly, the framework allows us not only to identify the overall impact of the new technology on (financial) markets - after all, any technological change implies an increase in efficiency and therefore a reduction of costs – it can also address questions of when, how and to what extend this change will take place. Transaction costs vary greatly between industries and certain transaction costs are more directly affected by automation and efficiency gains than others. Only by identifying these different cost elements can one determine specific changes in market structure and organizational design beyond a general trend.

2.2 Neoclassical Framework

In order to correctly understand the implications of smart contracts for transaction cost in any type of firm, it is necessary to study the evolution of economic thought on the theory of the firm in general and the transaction cost approach in particular. What is usually referred to as the "neoclassical" theory of the firm arose in the 1920s and 30s in the works of Pigou (1928), Viner (1931), and Robinson (1933; 1934) as a way of formalizing consumer theory (Hicks and Allen 1934; Loasby 1976). In short, economists sought to theorize the firm's effort to maximize profit subject to a given production function and input prices, just like consumers maximize utility subject to a budget constraint. It can be argued that the underlying aim of Pigou, Viner, and Robinson's work was to construct a precise Marshallian price-theoretic apparatus applicable to the firm. In the following the basic assumptions of the neoclassical theory of the firm along with their implications will be analyzed. This is done to the give the reader an understanding of how traditional theorists neglected transactions costs and to what extent this approach was limited in its application to practical problems – something that would directly lead to the establishment of Transaction Cost Theory by Coase (1937) and Williamson (1975).

The three fundamental assumptions of neoclassical economics can be outlined as follows:

I. Rationality Principle: Individuals - in this case the firm owner - have rational preferences between outcomes that can be identified and associated with values.
II. Profit Maximization Principle: The firm's single goal and sole purpose is that of profit maximization
III: Perfect Information Principle: Complete knowledge is assumed about the past performance, the present circumstances and the future changes in the market place as well as the firm.

The neoclassical theory of the firm introduces two additional assumptions:

IV. Single Owner-Entrepreneur Principle: There is no separation between ownership and management.
V. Marginalist Principle: The firm's goal is attained by equating marginal costs (MC) with marginal revenue (MR).

Let us examine these assumptions in some detail.

I. Rationality Principle
Given the rationality principle the individual bases its decisions on a consideration of its own personal utility function. This *Homo economicus* model has been criticized by both economists and sociologists. Most notably, Keynes (1936) argued that real

people have limited time to process information and thus not always make ideal choices. Von Mises (1942) and the Austrian school of economics completely reject the distinction between rational and irrational behavior, as this requires an objective standard of rationality that does not exist in the real world. Empirical studies such as the one by Tversky (1995) have shown that investors tend to make risk-averse choices in gains and risk-seeking choices in losses. In his experiment, test subjects appeared risk-averse for small losses but unconcerned with small chances of large losses, a behavior that defies economic rationality as typically understood. Further research on this issue, demonstrating other deviations from traditionally defined economic rationality, is being done in the emergent field of experimental and behavioral economics. Some of the more general subjects involved in this criticism are studied in decision theory, which also includes rational choice theory as a subset.

II. Profit Maximization Principle

The Profit Maximization Principle assumes that firms seek to maximize profit. In fact, any firm's single goal and sole purpose are that of profit maximization, which is achieved by increasing revenue while at the same time decreasing costs. Therefore, a firm needs to assess changes in costs and revenue and for every additional unit sold. If the subsequent increase in revenue is greater than the increase in costs, producing more can always raise total profit. This will not change until marginal revenue (MR) equals marginal cost (MC) (Menger, 1871; Jevons 1863). Therefore, a firm seeking to maximize profit will produce until MR = MC.

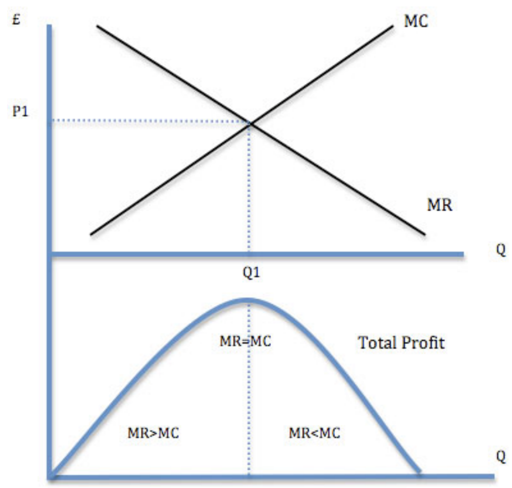

Figure 1. Optimal output under the Profit Maximization Principle. Adapted from Pettinger, T. (2015). Economics – profit and revenue. Retrieved June 29, 2017, from http://www.economicshelp.org/microessays/costs/profit-revenue/

Figure 1 illustrates how, if the firm produces less than Quantity 1 (Q1), MR is greater than MC. Consequently, for any extra output, the firm is increasing revenue greater than it is increasing its costs. Thus, total revenue will increase. The closer a firm gets to Q1, the smaller the difference between MR and MC, and the lesser the increase in profit. Once Q1 is passed, MC becomes greater than MR leading to a fall in profit.

The profit maximization theory has been severely criticized by economists on different grounds. Becker (1962) notes that it assumes that firms are certain about the levels of their maximum profits, though profits are most uncertain as they most often accrue from the difference between future revenues as well as future costs. It is, therefore, extremely difficult for firms to maximize their profits under conditions of uncertainty. Hayek (1945) adds that the profit maximization hypothesis is based on the assumption that all firms have perfect knowledge not only about their own revenues and costs but also of all competing firms. However, in reality, firms seldom possess accurate and sufficient knowledge about the circumstances under which they operate. Furthermore, most real-world firms simply do not know their marginal revenue and marginal cost and never bother to find out. Empirical evidence (Hall & Hitch 1939) confirms this, showing that most businessmen have not heard of marginal cost and marginal revenue. Lastly, as neoclassical theory of the firm is static in nature, it is unable to tell the duration of either the short period or the long period. All decisions are considered as temporally independent, which weakens the applicability of the profit maximization principle (Alchian 1950). In actuality, decisions are always temporally interdependent, where present decisions are affected by past decisions and will, in turn, influence future decisions of a firm.

III. Perfect Information Principle

The Perfect Information Principle is a feature of perfect competition, which assumes that all consumers and producers have perfect knowledge of price, quality, utility, and production procedures of products. In other words, perfect information implies the knowledge of all economic aspects of the past, present and future that have effects on the activity of market participants. For the Perfect Information Principle to become valid, it has to be assumed that uncertainty is eliminated. However, as Mises (1966) states: “The uncertainty of the future is already implied in the very notion of action (...) if man knew the future he would not have to choose and would not act” (p. 105). Therefore, the elimination of uncertainty results in a rejection of the nature of human action.

IV. Single Owner-Entrepreneur Principle

The Single Owner-Entrepreneur Principle assumes no separation between ownership and management. This owner-entrepreneur takes all the decisions, with unlimited time and unlimited information at his disposal. Such behavior is described by hypothesizing that the entrepreneur acts with global rationality in pursuing the definite goal of profit maximization. Clearly, these assumptions do not hold true for the modern business, where organizations are characterized by the separation of ownership and management. Here, the relationship between owners and management are characterized by information asymmetries as described in the *principal-agent problem*. Furthermore, management cannot act within a framework of global rationality or unlimited time and has to evaluate all potential strategies based on those restrictions.

V. Marginalist Principle

The Marginalist Principle assumes that all decision-making is characterized by a maximization of profits by setting its output and price at the level described by the intersection of the MR and MC curves. Since decisions are assumed to be temporally independent, such short-run profit maximization always implies long-run profit maximization. This assumption has been criticized on several grounds. As noted by Hall & Hitch (1939), in a world without perfect information and with complete rationality, it is unclear how managers are supposed to identify marginal costs and marginal revenues, let alone calculate with such values. Furthermore, even if the goal of a firm is long-term profit maximization under these conditions, this can very well mean that businesses violate them in the short run to benefit in the long run.

2.3 Economic Theory And Transaction Costs

Transaction costs as an influencing factor on the individual's action do not exist in traditional neoclassical economics. As shown above, most of the main assumptions do not hold true when applied to real life situations. Despite the obvious restrictions of the neoclassical theory of the firm, it remained the most accepted economic framework throughout much of the beginning of the twentieth century. Interestingly, the efficient market hypothesis also implied that those who are able to provide a particular good or service most cheaply are already doing so. This, in turn, meant it should always be cheaper to contract out than to hire, which raised the question of why firms exist in the first place. Given that any form of production could theoretically be carried on without formal organization, why doesn't the market consist of only independent, self-employed people who contract with one another? Why is it that people instead choose to form large firms?

2.3.1 Ronald Coase – The Nature Of The Firm (1937)

According to Ronald Coase (1937), the reason for such behavior is certain costs to *using* the market. These "transaction costs" raise the cost of obtaining a good or service above the actual market price of said good and can include examples such as costs involved in gathering information, negotiating, policing and enforcing contracts. These hidden costs have to be included in any economic calculation and drastically change the environment in which entrepreneurs act. When evaluating whether to start a firm, they are essentially predicting to direct resources within the firm with sufficient efficiency so as to produce at a lower cost than the market price, while accounting for transaction costs. That is, an entrepreneur is expecting to economize on transaction costs. This, Coase (1937, 5) concludes, is the raison d'être of a firm. He argues that if production were solely based on market exchanges and through negotiated and renegotiated contracts between individuals and self-employed producers, then cultural transmission, as well as inter-organizational learning, would exist to a far lesser degree. Organized firms tend to foster and intensify relationships between individuals and the relative robustness and permanence of firms facilitate the diffusion of information and the generation of practical knowledge. In many instances, this practical knowledge exists only in the body of an organized group and would not endure in a world of contracting and re-contracting between individuals. As a result, a "contractual world" without firms, would see less productive growth and self-producers would be driven out of business as soon as single entity firms emerge. As such, the existence of firms is not only a result of transaction costs but of the more efficient collective learning processes within the firm (when compared to the marketplace). Intra-organizational learning increases knowledge diffusion and growth while reducing transaction costs relative to an exchange-based mode of cooperation.

Given the fact that firms are able to eliminate certain transaction costs and thus reduce the cost of production, why are there any market transactions at all? Would it not be more efficient to carry out all production by one big firm? Obviously, there must be some underlying factor that keeps firms from growing and "insourcing" indefinitely. Coase (1937) argues that the boundaries of the firm are set according to the principle of marginalism, meaning that any firm will grow to the point where, at the margin, the net benefits of the firm are identical to an exchange-based coordination (p. 404). Consequently, a firm will increase in size until the costs of organizing an additional transaction inside the firm are equal to the costs of conducting said transaction in the market or in a different form of organization (Coase 1937; 1988). Therefore, the reason why one firm cannot carry on all production is due to the fact that as activity within a firm increases, so do the costs of organizing the additional transactions. Not only does this decrease returns, it also hinders the firm from positioning the means of production to their highest efficiency use. As such, the size of a firm (measured by the number of "internal" relations compared to the number of "external" relations) will depend on identifying an optimal balance between the conflicting tendencies of the costs as described above. Generally, an increase in firm size will initially prove advantageous, however, as returns decrease in the process so will the incentive to continue insourcing, inhibiting the firm from growing indefinitely (1937, 394 - 97).

Ceteris paribus, a firm will tend to be larger:

- the smaller the general costs of organization and the smaller the marginal cost of organization for each new transaction that is organized.
- the smaller the general likelihood of the entrepreneur to make mistakes and the smaller the marginal likelihood of making mistakes for each new transaction that is organized.
- the greater the decrease (or the smaller the increase) in the supply price of factors of production to firms of larger size.

The first two factors will surge with an increase in geographic distribution of the transactions as well as the divergence of the transactions. This is often cited as the reason for firms to be either in different geographic locations or to specialize in different functions.

2.3.2 Changes In The Market Environment And Their Effect On Firm Size

The three factors outlined above tend to vary over time as the general market environment is transformed by technological and social changes. According to Coase (1937), the essential nature of the firm and its source of advantage over the product of markets lie in its flexibility to react to change, varying circumstances and uncertainty. This advantage over the market can be increased or decreased by changes in the environment. In the case of taxation as a popular government intervention, Coase (1937) states:

"If we consider the operation of sales tax, it is clear that it is a tax on market transactions and not on the same transactions organized within the firm. Now since these are alternative methods of "organization" - by the price mechanism or by the entrepreneur - such a regulation would bring into existence firms which otherwise would have no reason to enter" (p. 393).

Additionally, similar changes may occur in the presence of technology changes. Assuming a positive technological change, which mitigates the cost of organizing transactions across space, this will likely cause firms to grow in size. The introduction of cheap air travel and the invention of the telephone have facilitated the establishment of global corporations spanning the globe. Similarly, the rise of the Internet and comparable modern communication and information technologies has led to the existence of so-called virtual organizations.

2.4.1 Theory Of Incomplete Contracts

The theory of incomplete contracts builds on Coase's (1937) and Williamson's (1979) work as discussed above. While there is no commonly recognized definition of incomplete contracts, contracts are generally considered incomplete if they are unable to contract for all relevant information and leave certain decisions to be agreed upon at a later time. Hermalin, Katz & Craswell (2007) identify five causes of contractual incompleteness:

i. Bounded rationality

As discussed above, bounded rationality implies imperfect foresight of future events. It should be noted that failure to foresee certain eventualities does not lead to incomplete contracts unless all parties also fail to foresee that they might fail to predict certain eventualities. In theory, if all parties recognize their limited foresight, then they can design contracts as to include a residual ("none-of-the-above") clause. Naturally, the possibility to design any contract with a none-of-the-above clause does not mean that the involved parties would wish to do so. It might very well be the case that they fear that the optimal response to different unforeseen eventualities varies with those eventualities. Per definition, a none-of-the-above clause implies a one-size-fits-all solution. Therefore, the parties may request more flexibility should unforeseen eventualities occur.

ii. Description costs

Even if we were to assume that all the relevant states could be described (and thus ignored the restrictions created by bounded rationality), there are still costs to the description process itself. These costs can sometimes be so large as to render detailed descriptions uneconomical and impractical. Such costs increase with the number of contingencies that are included in the contract, while the marginal gain from more details approaches zero. As Hermalin and Katz (1991) and Maskin and Tirole (1999) have shown, even abstract descriptions can be enough for the parties to do as well as they could be were it realistic to write very detailed contracts.

iii. Complex environments

As suggested by Segal (1999a), incomplete contracts can arise when the contracting environment is complicated. Following his model, as the number of potential contingencies rises, the ideal second-best contract does increasingly worse. In the limit, the ideal second-best contract performs no better than a simple incomplete contract (or no contract at all). The reason for this is that, as the number of contingencies increases, the number of incentive constraints rises as well. Assuming that writing complex contracts is expensive, there is a cutoff point at which the environment is so complex that the simpler, less expensive contract is superior to the complex contract.

iv. Asymmetric information

Information asymmetry occurs in transactions where one party has more or better information than the other. While this primarily creates a difference of power in the transaction and can lead to problems such as adverse selection, moral hazard, and information monopoly, Spier (1992) suggests that another consequence of this is contractual incompleteness.

v. Verification costs

In traditional economic literature, it is assumed that, if information is verifiable, it can be verified instantly and at no cost. Under real world conditions, however, information can only be verified at a cost (e.g. auditing, surveillance monitoring, record keeping) and if such costs are high relative to the benefits of a complete contract, the parties will most likely avoid them. The result will be incomplete contracts.

2.4.2 Practical Implications Of Incomplete Contracts

As complete contracting is not a feasible option when negotiating the terms of an agreement, other solutions to the problems discussed above have to be found. In circumstances where it is difficult to design and enforce complete contracts, there can still be certain benefits to selling or assigning "control rights" (or "property rights"). The key assumption in Incomplete Contract Theory is that many potential contingencies are purposely left out of the original contract and as they occur, the contract will be altered and adapted in future renegotiations. In this case, instead of requiring a complete list of future actions to be taken and payoffs to be realized for numerous contingencies, contracts need to "only" consider how to assign control rights over decisions that will have to be made as the future unfolds. As such, one party could decide to sell control rights over difficult-to-anticipate contingencies to another party to accelerate the future decision-making process. Nonetheless, this option is not always ideal and complications may still arise prior or during the transaction.

Within the series of possible complications, the best documented case is the *hold-up problem*. Hold-ups occur due to eventualities not explicitly described by a contract and, in turn, destroy incentives to enter the transaction ex ante, leading to deadweight losses (Williamson, 1975, and Klein, Crawford, and Alchian, 1978). As it is most likely impossible and certainly uneconomical to specify the course of action in every future contingency, potential renegotiations can take an opportunistic form. That is, one of the parties uses their stronger bargaining position to extract rents at the cost of the other parties. A common example of this is a buyer-supplier relationship that involves a (non-contractible) asset/relationship-specific investment. Because such investments constitute sunk costs, the bargaining position of the investing party, in this case the supplier, depreciates after the investment is completed and the possibility for opportunistic behavior during renegotiations by the buyer arises. In the context of financial contracts, a borrower may threaten to participate in an unanticipated high risk project after a contract already agreed upon and leverage this threat to extract concessions from lenders (Dewatripont and Maskin, 1995). Similarly, an entrepreneur may worry about being held up by creditors who threaten to withdraw a loan or to not extend further credit before a project is completed (Sharpe, 1990, and Rajan, 1992). While it is not easy to resolve these conflicts, economic literature has proposed a number of solutions to solve or to alleviate hold-up problems. Vertical integration, e.g. a merger after which all parts of the product are produced internally rather than externally, is generally seen as one possibility of overcoming hold-up situations (Williamson 1975). It transfers the proprietorship of the administrative asset to the firm and thus generates more flexibility. Thereby, the transaction costs related to hold-up situations provoked by contracting could be avoided and so could the costs connected to the sum of contracts written as well as enforced. If vertical integration is chosen varies with the size of the specific investment and the capacity to design long-term contracts, adaptable enough to prevent a future hold-up. Nevertheless, the capacity to design adaptable long-term contracts greatly depends on the external environment uncertainty along with the firm's reputation. Furthermore, the magnitude to which vertical integration can ease the hold-up problem similarly depends on the type of information available. Whereas the traditional models of incomplete contracting and vertical integration such as Grossman and Hart (1986) often rely on symmetric information, asymmetric information frequently occurs under real world conditions. While Schmitz (2006) has designed a theoretical solution to account for asymmetric information within the incomplete contracting framework, this thesis discusses the idea of *smart contracts* as a practical solution for the reduction of transaction costs and the alleviation of the hold-up problem in financial contracts.

3. Transaction Costs In Financial Markets

In this section, current transactions costs that exist in financial markets will be analyzed. Furthermore, traditional strategies of mitigation – such as the establishment of financial intermediaries – will be looked at and evaluated.

As described above, neoclassic economic theory assumes symmetric information among all market players (Nagel 1963). For instance, someone buying shares or bonds from a company is assumed to have the same information as the company's managers. This would also mean that either party is able to make informed decisions and evaluate the same options. In actuality, however, market players have private information that they may or may not disclose with contracting parties (Arrow 1984). A company issuing shares might know of a coming lawsuit or other negative circumstances, but the buyer of those shares might be unaware. Here, information asymmetries occur, where one transacting party has better information than the other (Arrow 1984). The occurance of such information asymmetries makes it costly for both borrowers and savers to conduct transactions (Williamson 1975). Cecchetti et al. (2006) identify two main costs arising from asymmetric information in financial markets. Both will be discussed in more detail below:

Adverse selection: The difficulty of distinguishing good-risk applicants from the bad-risk applicants before making an investment from the perspective of the lender.

Moral hazard: A lender's confirmation that borrower(s) are using all funds as intended.

3.1 Adverse Selection

3.1.1 Adverse Selection In Financial Markets

Adverse selection makes lending in financial markets more costly, affecting both the bond and stock markets' ability to efficiently allocate capital from savers to borrowers (Cecchetti et al. 2006, 229). An example shall illustrate this. *Startup A* is developing *Product X* and requires outside capital for mass production. If *Startup A* issues new shares of stock, it can develop *Product X*. If it doesn't, the opportunity will be lost. At the same time, *Startup B* is seeking funds to pursue *Product Y,* which is similar to *Product X,* but, unknown to the market, inferior in quality. Since investors cannot examine the quality of the startups' productive capabilities and scientific expertise, they will assign *Startup A's* stock the same value as to *Startup B's* stock, therefore undervaluing *Startup A.* In a more practical sense, this means that *Startup A's* cost of capital is greater than it could be if possible shareholders had the same information *Startup A* possessed. The consequences of adverse selection are present in bond markets as well (Bolton & Freixas 2000). Suppose that *Startup A* and *Startup B* are better informed about the risk of their developments than average investors in the bond market. Now, if the interest rate on treasury bonds (assumed to be risk free) were to increase, this makes them a more appealing investment than either of the startups' bonds. Lenders will then raise the interest rate they demand to hold *Startup A* and *Startup B* bonds. In turn, as lenders gradually increase their necessary returns on bonds, adverse selection takes place (Mishkin 1995). In the context of high interest rates, only high-risk borrowers, such as *Startup B*, will be likely to borrow capital. Should their projects be successful, both lenders and borrowers benefit, of course. In case of failure, however, all lenders suffer. Financiers are aware of this issue and will likely limit the obtainability of loans instead of raising rates to the point at which supply and demand of funds are equal. This effect is known as "credit rationing" and leads to higher costs of capital for unknown firms - both good and bad (Cecchetti et al. 2006, 230). The negative effects of adverse selection further slow economic growth (Akerlof 1970). When competent firms have problems signaling their capability to the financial market, their cost of external financing rise and will be forced to grow primarily through savings or other internal funds (Cecchetti et al. 2006, 230). As the companies that are most harmed are generally in emerging, dynamic industries, opportunities for accumulation of physical capital tend to be restricted (Hellmann & Stiglitz 2000).

3.1.2 Common Strategies Of Reducing Adverse Selection

Adverse selection makes it tough for good borrowers to acquire capital and decreases the returns achieved by savers. It is therefore in the interest of all participants to find ways of communicating information more efficiently in the marketplace. A number of strategies, both formal and informal, are generally applied to reduce information costs – often through the use of financial intermediaries (Pilbeam 2010, 41ff). One of the most common strategies is the direct disclosure of information (Cecchetti et al. 2006, 231). In many regions of the world, government agencies have outlined regulations for the release of information of firms that wish to sell securities in the financial market. In the United States, the Securities and Exchange Commission requires any publicly traded firm to disclose its performance in yearly financial publications in accordance with standard accounting methods[2]. Such statements reduce the negative impact of adverse selection, but cannot eliminate them completely. One reason is that many unknown firms are simply too young to offer enough information for possible investors (Graham et al. 2005). Furthermore, bad firms will likely seek to present the required information in a way so that investors will overvalue their assets and undervalue their liabilities (Cecchetti et al. 2006, 231).

There have also been private efforts to reduce the costs of adverse selection, oftentimes through the use of intermediaries specialized in information-gathering and subsequent sales of this information to investors and savers. So long as the costs of buying such information are less than the cost of adverse selection, those purchasing the information will benefit from the intermediaries and lending efficiency will improve (Bolton & Freixas 2000). Examples of companies specialized in the collection of information include Standard & Poor's Corporation, Moody's Investor Service and Dun and Bradstreet, which generally offer subscriptions to paying clients in the form of businesses' balance sheets, income statements and investment decisions. Even though only subscribers are meant to receive the information collected, outsiders can benefit without paying for it. If uninformed outsiders are able to identify decisions made by informed market players, they can simply emulate their behavior and share in their profits. As a result, subscribers are less willing to pay for information and intermediaries, deprived of the additional revenue, are not able to collect as much information to sell to subscribers. This *free-rider problem* damages their incentive and effectiveness to reduce adverse selection (Diamond 1984).

Should direct disclosure of information fail to reduce the likelihood of adverse selection, lenders can decrease information costs by restructuring financial contracts

[2] See SEC U.S. Securities and Exchange Commission. What We Do". Retrieved June 27, 2017, from https://www.sec.gov/Article/whatwedo.html

and concentrating on borrowers' net worth and collateral (Cecchetti et al. 2006, 232). In this case, collateral will act as a deterrent towards the borrower to default on bonds. The higher the value of the collateral the more costly it is for borrowers to take advantage of their asymmetric information. Net worth**,** the difference between liabilities and assets, serves the same purpose, as lenders might place claims against net worth if a borrower defaults on a loan. The higher a firm's (or individual's) net worth, the lower its chance of default. Consequently, costs associated with adverse selection are less probable in lending to borrowers with a higher net worth (Bolton & Freixas 2000).

3.2 Moral Hazard In Financial Markets

A moral hazard situation describes one in which the borrower has the incentive to withhold information or perform in such a way that would not represent the lender's interests (Brealey et al. 1977). Similar to adverse selection, moral hazard arises due to information asymmetries: A borrower is better informed than the lender about how the borrowed funds will be used, increasing the lender's risk. In the case of stocks, for example, the company has an incentive to underestimate profits to reduce dividend payments. In order to mitigate these risks, the lender will make efforts of monitoring the behavior of the borrower, which in turn reduces the lender's profit from interest and simultaneously raises the borrower's cost of acquiring capital (Cecchetti et al. 2006, 234).

To reduce the chance of fraud, many government agencies regulate reporting by requiring firms to adhere to certain accounting standards when reporting their income and overall financial situation. While such standards can assist investors in evaluating a firm's financial condition, further problems arise when incentives between owner (principal) and manager (agent) are not aligned. This *principal-agent problem* is likely to arise when managers are not (or not sufficiently) invested in the firm with their own capital and therefore do not have an equal incentive to maximize firm value as the owner does (Grossman & Hart 1983, 7). Improvements in profitability of a firm will accrue to owners and not to managers who are usually paid a fixed salary (although stock bonuses are sometimes handed out to decrease this effect). Some form of principal-agent problem persists in most equity agreements. While some uses of corporate capital by managers are visible to investors (e.g. large investment projects), others are hidden from them (e.g. research and maintenance expenses). Additionally, managers often seek to maximize their own utility, which can involve accruing power and prestige (Grossman & Hart 1983, 8). Determining whether corporate funds are used efficiently requires costly monitoring and audits, which no individual investor has an incentive to pay. Even if a group of shareholders was to do so, others could just as well take advantage of their efforts. As a result, most small shareholders lack both the motivation and ability to assess managers.

One possible option to decrease the negative effects of moral hazard is to use debt rather than equity financing (Bolton & Freixas 2000). As interest rates are generally agreed upon before a loan is given, debt promises a fixed payment without the need to audit the borrower unless interest and principal payments are not met. This translates to lower monitoring costs and can make debt more appealing than equity in some cases (Bolton & Freixas 2000). However, this advantage is somewhat nullified by the fact that debt contracts allow the borrower to hold on to any profits exceeding the set amount of the debt payment. Hence, borrowers are motivated to accept greater risks than would be in the interest of the lender to earn such profits. The most typical restrictive covenant used to address this problem is a limit on the borrower's risk taking (Cecchetti et al. 2006, 235). For instance, a restriction may be included in the debt contract that prohibits the borrower from buying particular goods or taking over other businesses. Another type of restrictive covenant demands that the borrower uphold a specific amount of net worth, especially in liquid assets, to lower incentives to assume too much risk. Lastly, a third type of restrictive covenant requires borrowers to maintain the value of any collateral presented to a lender (Cecchetti et al. 2006, 236). This is common in consumer lending, for example when taking out a loan to purchase a new car. Here, one might have to take on a certain amount of insurance against collision and theft and cannot sell the car unless the loan has been paid off.

Although such restrictive covenants can help to reduce moral hazard, they obscure debt contracts and lower their value in secondary markets. The more restrictive a contract, the higher its monitoring costs which further hampers liquidity and marketability (Pilbeam 2010). Finally, such measures cannot shield a lender against every potentially hazardous activity in which a borrower could be involved.

3.3 Financial Intermediaries

3.3.1 Information Costs And Financial Intermediaries

As stated before, transactions costs decrease the expected returns to lenders and increase the cost of capital borrowers have to pay. In financial markets two issues related to transactions costs are most common; adverse selection and moral hazard, to which market participants and governmental agencies have responded with a series of regulations and guidelines. Likewise, a number of financial intermediaries have specialized in reducing these market imperfections for their clients. They play key roles in most industrial economies and will be looked at in this subsection.

In the United States, Germany and Japan most external funds needed are not raised through financing from financial markets for stocks and bonds, but through financial intermediaries such as banks (Schmidt 2001). Table 1 highlights this.

Table 1.
Sources of Finance for Business Firms

Sources of Finance for Business Firms
Business firms rely more heavily on financial markets to raise external funds.

	Financial Markets	Financial Intermediaries
United States	45%	55%
Germany	12%	88%
Japan	14%	86%

Note. Reprinted from Cecchetti, S. G., Schoenholtz, K. L., & Fackler, J. (2006). *Money, banking, and financial markets* (Vol. 4). McGraw-Hill/Irwin.

3.3.2 Financial Intermediaries and Adverse Selection

Financial intermediaries, predominantly banks, have specialized in collecting information about the default risk of interested borrowers. They channel the supply and demand of capital by raising funds from depositors and lending them to low-risk borrowers (Allen & Santomero 2001). As banks are usually better informed than individual savers about the risks of potential borrowers, they can earn a profit by demanding higher rates from borrowers than they pay to depositors. Additionally, banks are able to avoid the free-rider problem by mainly holding loans that are not traded publicly in financial markets (Diamond 1984). Potential free riders thus cannot observe their activity and profit by mimicking them. The information advantage of banks in reducing adverse selection is one of the main reasons for their important role in providing external financing (Cecchetti et al. 2006). Whereas, multinational corporations have access to bond and stock markets, small and medium-sized businesses often depend on loans given to them by banks.

3.3.3 Financial Intermediaries And Moral Hazard

Larger investors are usually more successful than small investors in both gathering the necessary information about the behavior of corporate managers and reducing the free-rider problem that arises with it (Diamond 1984). When large investors, such as financial intermediaries, hold big blocks of shares, they are motivated to screen closely how agents spend their capital. Many venture capital firms, which often invest in young and growing business ventures, take advantage of this method (Bergemann & Hege 1998). They usually acquire high equity stakes and place their own employee on the company's board of directors to monitor management's actions. Also, when equity is acquired those shares are held by the venture capital firm and not marketable to other investors, thus avoiding the free-rider problem (Cecchetti et al. 2006). Outside investors are then kept from taking advantage of their efforts of monitoring. In the case of a successful investment, the venture capital firm will then make a profit while simultaneously lowering information costs as well as aiding in the efficient distribution of capital from savers to borrowers.

3.4 Further Remarks

Transaction and information costs restrict the efficiency of financial markets in a number of ways, most notably through two problems of asymmetric information: adverse selection— the difficulty of distinguishing good-risk applicants from the bad-risk applicants before the transaction—and moral hazard—the necessity to monitor the borrower's use of capital after the transaction. Both reduce returns for investors and increase the cost of funds for borrowers. Empirical evidence (Healy & Palepu 2001; Michaelas et al. 1999) suggests that small savers, as well as small businesses, are more negatively affected by these problems than larger investment funds and corporations. This creates a competitive disadvantage and hinders economic growth. A number of strategies have been developed to reduce transaction costs in financial markets, most notably the direct disclosure of information or the use of collateral and net worth requirements in financial contracts. However, such provisions often come with further monitoring and legal costs, which limit their applicability. Financial intermediaries try to lower monitoring expenses through the use of economies-of-scale and earn a profit from channeling funds from savers to borrowers. While this reduces the cost of adverse selection and moral hazard, it also creates certain dependencies on intermediaries for smaller businesses and individual savers that oftentimes cannot opt for alternative means of investment or funding such as the bond or stock market. The following chapters will therefore assess how transaction costs in financial markets can be reduced without the need of intermediaries through the use of smart contracts. Though still in development, this technology promises to drastically change the landscape of financial markets by automating many of the activities currently carried out by intermediaries. First, the technology itself will be presented and explained using the distributed ledger model. Second, the functionality of smart contracts, their distinction from traditional contracts, as well as current contingencies will be discussed. Lastly, possible uses of smart contracts will be assessed and analyzed in their ability to reduce transaction costs. Argumentation will be based on recent scientific literature and empirical evidence, in the form of case studies and white papers.

4. Blockchain Technology

4.1 Blockchain Functionality

Smart contracts are based on the concepts of *blockchain technology* and the *distributed ledger.* Despite the growing relevance of the subject and their increasing presence in both the scientific and media discourse, there is still no generally accepted definition of either of the two terms. While often used synonymously, there are certain differences that the reader should be made aware of. Thus, the overall framework, as well as their important characteristics, will be explained in the following.

A “distributed ledger" is a digital record or databank that is consensually synchronized and shared across a network of various sites, institutions or geographies (Pinna & Ruttenberg 2016, 6). Most importantly, the distribution of the ledger is entirely decentralized and constructed in a similar fashion as a peer-to-peer network. Blockchain is the best-known practical application of the Distributed Ledger framework and can be described as a constantly updating database, in which all transactions are recorded and stored in a decentralized manner (Pinna & Ruttenberg 2016, 15). Transactions that occur between different nodes within the network are reviewed, aggregated into new data blocks, validated and executed by a network-wide consensus mechanism. Therefore, the blockchain represents the chronological and consecutive chaining of all previously created transaction blocks, going back to the very first block. The first initial model of a functioning blockchain was designed by Japanese computer scientist Satoshi Nakamoto (2008) and implemented as an essential component of the digital currency *Bitcoin*, in which it acts as the public ledger for all transactions. What set his software apart from other digital currencies was the fact that each newly created block, in addition to the bundled transactions and other relevant data, contained the unique cryptographic image of the previous block - the so-called hash. It is this ever-growing chain of the blocks through the hash that protects it against manipulation and subsequent changes. Figure 2 illustrates the structure of the blockchain in a simplified model.

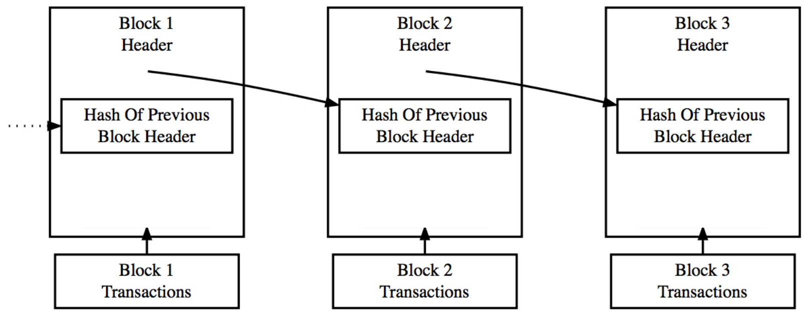

Figure 2. Simplified Blockchain Model. Adapted from Bitcoin Foundation. (2016, October, 24). Bitcoin Developer Guide. Retrieved June 29, 2017, from https://bitcoin.org/en/developer-guide#block-chain-overview

Most importantly, the hash technology creates a protection against "double spending" (Karame et al. 2015). Unlike physical objects, digital goods can be reproduced indefinitely and are classified as non-rival goods. This makes it possible to use them without limiting their availability to others. A functioning contract or currency system, however, is dependent on exclusive rights of use that need to be assigned to specific owners. Furthermore, the iterative nature of the blockchain ensures that individual blocks cannot be manipulated without compromising the integrity of the entire chain (Pinna & Ruttenberg 2016, 12). Once validated, new blocks that are attached to the chain cannot be modified or deleted afterward. As stated by Plansky et al. (2016), the result is what programmers call a "single source of truth", which guarantees that there exists only one transaction record for all parties involved. This is accomplished without relying on a central authority but by enabling a distributed consensus, that creates a record of events, past and present, in the digital world. Since all nodes (in this case all participants) of this peer-to-peer network regularly receive a complete copy of the latest version of the blockchain, the network as a whole acts as the authority. Figure 3 illustrates this concept further.

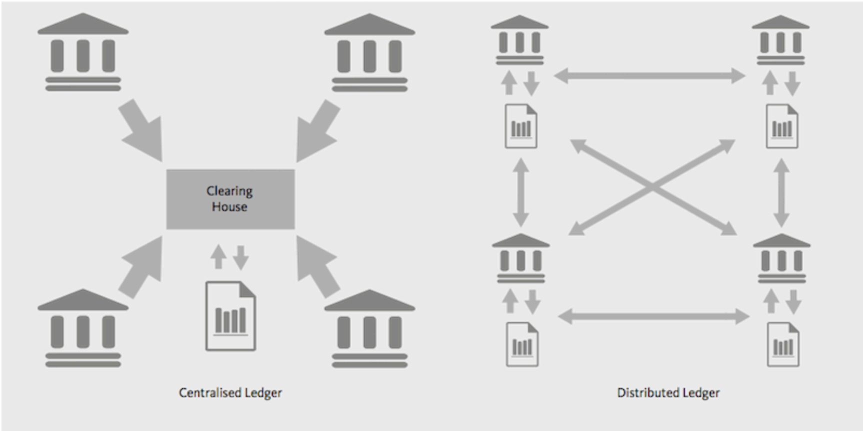

Figure 3. Traditional centralized ledger compared to distributed ledger. Reprinted from Santander InnoVentures, Oliver Wyman & Anthemis Group (Publisher.) (2015). The Fintech 2.0 Paper: rebooting financial services

The left-hand side of Figure 3 illustrates the traditional ledger model where a financial intermediary, such as a bank, functions as a central authority and oversees both the database and its records. All transactions of the participating parties are managed by this authority and kept in a single "central ledger" (Santander InnoVentures 2015, 14). Participants will receive only one copy of their individual activities (e.g. a bank account statement). While a central ledger does ensure direct accountability of the database holder it also centralizes risks of manipulation and exploitation (Ali et al. 2014). Thus, to successfully fulfill its role as database holder the authority must maintain the trust of its participants at all times. The right-hand side of Figure 3 illustrates the distributed ledger model where a central authority is no longer required and the decentralized network itself assumes the role of the database holder (Santander InnoVentures 2015, 14). This minimizes the risks described above while also eliminating a "single point of failure" (see Ernst & Young 2016). Instead, each participant can interact directly with the other participants and conduct transactions bilaterally, since all participants hold the same complete copy of the ledger. This results in higher data security as well as increased transparency.

4.2 Advantages Of Blockchain Over Traditional Databases

As mentioned before, the blockchain differs greatly from traditional ledgers and databases. The consequences of this difference are that blockchain is superior in a number of ways when compared to traditional databases. According to Greenspan (2016), the most notable include disintermediation, recordability and transparency.

Disintermediation

Disintermediation describes the elimination of intermediaries in a transaction. The core value of a blockchain consists of enabling databases to be directly shared between participants of a network without the need to verify and monitor each participant by a central administrator. As explained above, this is achieved by ensuring a “single source of truth” across the network. Transactions will automatically be processed and verified by different nodes, with the blockchain working as a consensus tool. In this case, the economic value of disintermediation lies in a reduction of risk for participants (Mattila 2016). Traditional databases can be changed and manipulated by anyone with access to them. As a result, participants who entrust their data to a regular database, also become dependent on the organizing authority, which oversees the database (Greenspan 2016). While many institutions, such as governments or banks, are generally regarded as trustworthy, their protection against outside manipulation requires a great amount of financial as well as human resources. Blockchain offers a way to replace these organizations with a shared database secured by the network itself. Here, verification services are automated and transactions can be conducted within a matter of seconds, without an intermediary functioning as a bottleneck or the risk of outside manipulation.

Recordability

Most regular databases store information that is up-to-date at a particular moment. Their records more or less reflect a certain moment in time and are more of a “snapshot” of the status quo than a representation of the database itself (Greenspan 2016). Once digital storage space has run out, old and unnecessary data has to be overwritten by new data. Blockchain databases are able to keep all the information that processed in the past while also adding relevant new data. As each hash includes all past transactions the database grows similar to an ever-expanding physical archive (Nakamoto 2008). As the code of the blockchain cannot be changed without compromising the integrity of the network some computer scientists have called the blockchain database immutable.

Transparency

The publicly accessible historical record of all transactions further enables effective monitoring and auditing by any network participants (Ernst & Young 2016). This not only lowers the need for trust in a transaction, as any network participant can theoretically review the past actions of all other network participants, it also facilitates the supervision of transactions by regulators (Mattila 2016). In the case of smart contracts, which will be looked at in more detail in Chapter 5, the transacting parties are also informed beforehand about the conditions of the contract and have to agree to it through their digital signature.

4.3 Different Types Of Blockchains

Blockchains can be classified on the basis of two higher-level categories (Peters & Panayi 2015, 5). On the one hand, they are based on the access rights to the blockchain data itself, with regards to their "reading rights" (e.g. for the review of the transaction history) and "writing rights" (e.g. to carry out transactions). This category includes two types of blockchains: public and private (Garzik 2015). Public blockchains describe any type of blockchain that allows its participants to view, track, and even independently perform transactions on the network at any time. In private blockchains, however, reading- and writing rights are granted to only a certain group of users.

As a second category, blockchains can be distinguished according to whether or not permission is required to verify any incoming transactions entering the peer-to-peer network (Garzik 2015). Here one has to distinguish between permissioned and permissionless blockchains. Permissioned blockchains require authorization and therefore only a preselected, well-known group of participants can validate transactions and create new blocks. Permissionless blockchains do not require authorization and here any participant in the network can validate transactions and thus create new blocks. In these types of blockchains the number of participants is unrestricted (Pinna & Ruttenberg 2016). Since permissionless blockchains, by definition, always provides public access, this leads to a total of three possible combinations of blockchain types, which are illustrated in Figure 4 and will be explained in the following.

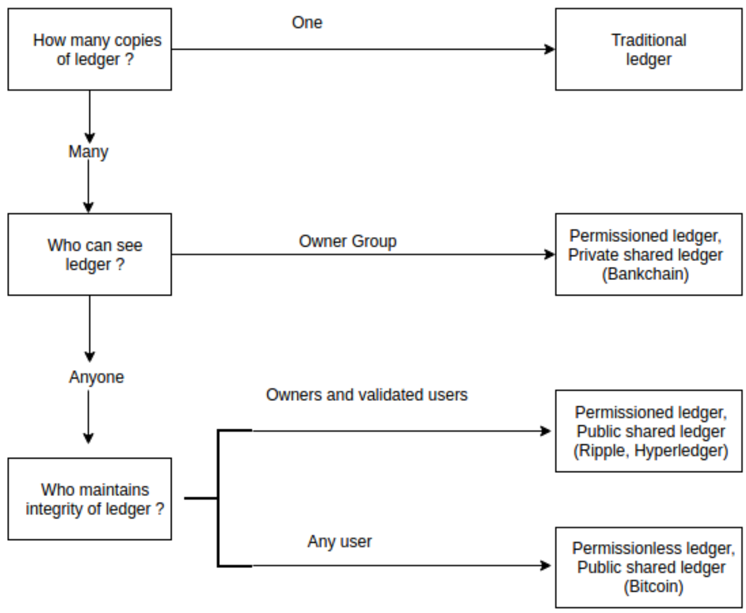

Figure 4. The three types of blockchains compared to a traditional ledger. Adapted from Github. (2016). Retrieved June 29, 2017, from https://mastanbtc.github.io/blockchainnotes/blockchaintypes/

1. Permissionless-Public Blockchains

The permissionless-public blockchain is the most common type of blockchain. It is built on a completely decentralized structure, which is freely accessible to anyone who wishes to participate in the network (Mainelli & Smith 2015, 24). The integrity of the ledger is maintained, as shown in Figure V, through a common consensus. Bitcoin and Ethereum are currently the most well-known variations of this type.

2. Permissioned-Public Blockchains

Like permissionless-public blockchain, permissioned-public blockchains are freely accessible to anyone wanting to participate in the network (Lamarque 2016, 20). However, a group of network participants is appointed and given authority to provide the validation of blocks of transactions. Interestingly, this somewhat counteracts the original basic concept of the blockchain, since a form of centralization takes place (Walport 2016, 41ff). The advantage of a permissioned blockchain is the fact that the consensus mechanism, e.g. the computer-intensive proof of work, is not needed. This makes permissioned blockchains more cost-effective as less hardware and energy is consumed, which also leads to faster transactions[3].

3. Permissioned-Private Blockchains

Permissioned-private blockchains are similar to permissioned-public blockchains, however only selected network participants are granted reading- and writing rights (Walport 2016, 35). This type is especially interesting for financial institutions as it allows them to retain a certain degree of influence over the network (Hewlett Packard Enterprise 2016, 4).

Concluding, it can be said that the more decentralized a blockchain, the less trust is needed within the network (Walport 2016). In completely decentralized blockchains, the validity of each transaction is checked by all network participants. Therefore, a permissionless-public blockchain offers the highest level of security. However, this level of security comes at a tremendous cost in computing power and hardware. Furthermore, permissionless blockchain networks are public spaces and as such share the same concerns of public goods governance in regards to network evolution and updates (Mainelli & Smith 2015). As a consequence, these networks will most likely adopt innovation slower than their permissioned counterparts. Permissioned blockchains, on the other hand, require verification by fewer participants and thus allow for faster adoption of changes and evolution of the network. This also reduces computing cost though this lessens the level of security of the blockchain as a whole.

[3] see Buterin, V. (2015, August 07). On Public and Private Blockchains. Retrieved June 29, 2017, from https://blog.ethereum.org/2015/08/07/on-public-and-private-blockchains/

5. Smart Contracts

5.1 General Overview

Smart contracts are self-executing computer programs based on blockchain technology that automatically perform functions after a triggering event has taken place (Szabo 1994; Swan 2015a; Mattila 2016). Such contracts exist only in digital form and can include two or more participating parties. As the blockchain framework allows no alteration of its properties once the code has been programmed, neither do smart contracts. This means that the terms of any such contract are linear and will be carried out automatically once agreed upon (Swan 2015a, 16). For example, if a smart contract is set up between a German buyer and an American seller, which includes the payment of 20% of the funds, once the goods have been cleared by customs, the contract would automatically release the funds after confirmation has been entered into the blockchain that the customs office has cleared the goods. There is no need – nor possibility – for participants or intermediaries to verify the payment or alter the conditions of the agreement (Christidis & Devetsikiotis 2016). The theoretical framework of smart contracts can be attributed to American computer and legal scientist Nick Szabo. He first mentioned the term in a white paper in 1994 that describes it as follows:

"A smart contract is a computerized transaction protocol that executes the terms of a contract. The general objectives of smart contract design are to satisfy common contractual conditions (such as payment terms, liens, confidentiality, and even enforcement), minimize exceptions both malicious and accidental, and minimize the need for trusted intermediaries."

According to Szabo (1994; 1997), such transactions can include simple buy/sell transactions or may also have more extensive instructions embedded into them. Similar to contracts in the traditional sense, smart contracts involve an agreement between different parties to do or not do something in exchange for something else (Swan 2015a, 17). While traditional contracts require each party to trust the other party to meet its obligations, smart contracts eliminate the need for this type of trust between participants (Capgemini Consulting 2016). This is due to the fact that any smart contract will execute its program code automatically and without discretion. All smart contracts are essentially based on the principle of "if-this-then-that conditions", which means that *if* certain criteria are met *then* an automatic response is triggered by the program (Mattila 2016, 16). Their technology depends on intelligible, unambiguous logic, as well as complete and accurate information for complete operability. This leaves no room for interpretation as the program is always executed exactly as it was programmed in advance. Since smart contracts are stored - and ultimately processed - in the blockchain, human intervention is no longer necessary and even impossible after the programming phase (Swan 2015a, 17).

Another common example used to demonstrate this is a simple vending machine (Szabo 1997). Similar to a program code, a vending machine behaves algorithmically, meaning the same set of instructions will be followed every time in every case. As soon as someone deposits money into the machine and makes a selection, the item is delivered. So far as the machine is working properly, it has neither the ability nor the possibility to not comply with the contractual conditions. Similarly, a smart contract is bound by its binary design to execute the prespecified code. Therefore, the program's code defines the rights and obligations arising from the contract instead of contemporary legislation. How this might affect current legal system will be discussed in more detail under section 5.7.

5.2 Asset Management Through Smart Contracts

Another important characteristic of modern smart contracts is their ability to send, receive and transfer assets to other parties participating in the contract (Christidis & Devetsikiotis 2016). This means that smart contracts have the capacity to receive not only information but also assets as part of transactions and further to keep and manage the respective assets in the sense of a trustee according to the terms of the contract and its predefined conditions. In this context, Swan (2015a) identifies three distinctive elements of smart contracts: autonomy, self-sufficiency, and decentralization. *Autonomy* describes the lack of necessity to monitor the contract after it has been agreed upon and launched. Participating agents need not manually take action themselves. Any asset that can be digitalized or represented in digital form (e.g. through a certificate of ownership) will be transferred automatically.

Moreover, smart contracts are *self-sufficient* in their ability to manage resources. This includes, for example, raising capital by issuing equity and spending said capital on required resources, such as storage or processing power. Lastly, smart contracts are *decentralized* in that they are based on blockchain technology and do not necessitate an intermediary for the transaction.

5.3 Limitations Of Traditional Contracts

Most legal systems define a contract as an agreement between at least two parties that creates mutual obligations enforceable by law. For example, both the *Uniform Commercial Code*[4] as well as the German *Bürgerliche Gesetzbuch*[5] (BGB) require the two basic elements of "offer and acceptance" for a contract to be legally enforceable and valid. This guarantees mutual assent and provides a basis for voluntary transactions (compared to forced transactions such as a bank robbery). Unless federal law requires a certain form, contracts can thus be verbal and/or written so long as the framework of "offer and acceptance" is not violated. As explained in Chapters 2 and 3, a common problem with traditional contracts is the high degree of trust needed between the participants with regard to the fulfillment of the agreements (Strahorn et al. 2015). In the case of non-fulfillment of promised obligations, legal action is often required to assert and enforce one's own rights. The process of enforcement comes at a price and depending on the contract, legal system and financial capital of the contracting parties, it may raise transaction costs above a point where potential expenses are higher than potential benefits (Williamson 1975). In this case, no transaction will take place even though it would have been beneficial to both parties. The result is a loss in net welfare (Coase 1937, Williamson 1975). This problem is particularly evident in the financial service industry. The following sections will describe the functionality of smart contracts and evaluate if and how they can overcome these problems and minimize transaction costs in the process of contracting.

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[4] See UCC § 2-205

[5] See BGB § 145 ff.

5.4 Functionality Of Smart Contracts

This subsection will explain the detailed process of setting up and enforcing a smart contract using a 5-step model that includes the following: Step 1: Identifying the agreement; Step 2: Setting conditions; Step 3: Coding the contract; Step 4: Contract execution & processing; Step 5: Network updates. The explanation is based upon research reports published by BBVA Research[6] (2015) and Capgemini Consulting[7] (2016).

Step 1: Before setting up the actual contract, the parties involved must define the content and terms of the contract. This includes identifying a cooperative opportunity as well as the desired outcomes. Potential agreements can include business processes, transferal of rights, asset swaps, and more.

Step 2: As smart contracts rely on if-this-then-that conditions to be executed, the participants must agree on so-called “trigger events” that initiate the contract. Such events can be conditions like changes in financial market indices, a certain GPS location or a natural disaster. Temporal conditions are also possible, which would trigger a contract: for instance, on birthdays, holidays or religious events.

Step 3: Now, a computer code has to be programmed that will automatically execute the conditions of the contract once the conditional parameters are met. This requires all participants to transform verbal language into binary code. Once the contract has been designed as coded, it is digitally signed by the parties and integrated into the blockchain.

Step 4: After the contract has been signed and successfully authenticated by the blockchain network, it will execute itself by recognizing any (external) predefined trigger events as mentioned under Step 2. The external events described here are directly related to so-called "Oracles", which will be discussed in more detail in the next subsection. The execution of the contract is followed by a value transfer of

[6] BBVA (2015) *Smart contracts: the ultimate automation of trust*?
[7] Capgemini (2016) *Smart Contracts in Financial Services: Getting from Hype to Reality*

ownership and assets. This transfer can take on two different forms (Peters & Panayi 2015). In the case of digital assets that are available on the blockchain ("on-chain" assets), ownership as well as the asset itself will be transferred directly, whereas in the case of non-digital assets ("off-chain" assets) only ownership will be transferred and the asset itself will have to be transacted outside the blockchain.

Step 5: Once the smart contract has been fully executed, all systems in the network will update their ledgers in order to reflect the new state. This also means that after the new record is verified and added to the blockchain, it cannot be modified and will be read-only.

5.5 Connecting Smart Contracts With External Data

Even though the technology is still in development, smart contracts can theoretically be implemented in countless everyday situations. Applications in gambling, ridesharing and financial contracts (which will be looked at in later sections) have already been proposed (as outlined by Buterin 2014; Pilkington 2015; Luu et al. 2016). However, many of these uses still remain hypothetical as smart contracts can only read information on the blockchain, but require a way to exchange information with the outside world to be truly operational (Zhang et al. 2016, 1).
One possible solution for this problem are middleware programs, so called “oracles”, which can be programmed to transmit data from outside of the blockchain, allowing smart contracts to be truly practical. For instance, a smart contract for salary payments in Bitcoins would use a price oracle to define the exact amount to be paid while taking into account potential market fluctuations. The integration of an oracle as a single data provider is, however, fundamentally opposed to the idea of risk minimization through a peer-to-peer network. The oracle would essentially act as a gatekeeper, filtering information and transferring only what is deemed significant enough to trigger an even in the contract (Shadab 2014). According to Deloitte University Press (2016), the authenticity and transparency of such oracles are therefore of the highest importance for the success of smart contracts. Several solutions to this problem have been proposed with the most prominent including the use of not just one but several oracles (Swan 2015b). In this case, the respective

oracles would first have to come to a majority agreement before the smart contract can receive the requested data and information. Similar to the blockchain, a common consensus would ensure authenticity and trust. Still there exists the problem of finding a consensus on an inter-oracle communication protocol (Hess et al. 2017, 5). Identifying parties willing to join a network is even more difficult since a suitable incentive process needs to be in place while also deciding on how exactly the oracles interact with each other. Additionally, a major limitation will most likely be the data-source(s) providing the oracles with information (Hess et al. 2017, 8). Will there be one single data source? Or can different oracles use different sources? At this point, the question of how to handle different data from multiple oracles is still to be answered.

5.6 Potential Benefits Of Smart Contracts

While the everyday use of distributed ledger-based smart contracts is still limited, its theoretical framework, as well as a number of case studies (Hewlett Packard Enterprise 2016; McKinsey 2016; Capgemini 2016), show that smart contracts have the potential to drastically reduce transaction costs in a number of ways. This subsection will analyze how the negative effects of the two most prominent forms of transaction costs in financial markets – adverse selection and moral hazard (as described in Chapter 3) – can be minimized. Furthermore, potential efficiency gains and innovation capabilities will be evaluated. Assessment is based on to Yin's (2009) proposed core attributes of case study research "precision, process, and practicality". Cases are selected with regards to their representability of common trends in blockchain innovation. Theory development in the following chapters aims to answer the formulated research questions by using both data from the cases and analytical generalization to allow for an application of the same theory to "similar situations where analogous events also might occur" (Yin 2010, 21).

5.6.1 Smart Contracts' Ability To Reduce Adverse Selection

Adverse selection problems occur *ex-ante* any transaction. This means that information asymmetries during the search and negotiation phases of an agreement create risks and reduce possible profits for all participants even before the transaction has taken place (Cecchetti 2006). The introduction of smart contracts into the marketplace can reduce these risks by ensuring unambiguousness due to their iterative design and reliance on logical equations (Mattila 2016). As previously mentioned, any blockchain network member has access to the complete record of previous transactions. This allows agents to analyze and review past behavior of potential trading partners without having to rely on reputation or recommendations of others (Walport 2016). Young business relationships that do not benefit from prior interaction now enjoy a higher amount of trust regarding the fulfillment of contractual provisions.

Any risk involved in the transaction will be further reduced by the fact that the contract also functions as an escrow (Patel 2016). An escrow is a designated third-party trusted to hold assets until certain conditions are met. In traditional contracts, this task is generally assumed by either a custodian or a governmental agency to ensure objectivity towards the contracting parties. However, their service comes at a cost that directly correlates with the length of the deposit[8]. Smart contracts remove this cost factor, as they are able to store information and digital assets directly on the blockchain. Any deposited asset will not be available to either party until it is released directly by the program. This also eliminates any privacy concerns as the smart contract can act as an anonymous channel between the parties (Heilman et al. 2016).

5.6.2 Smart Contracts' Ability To Reduce Moral Hazard

Problems related to moral hazard occur *ex-post* any transaction. It constitutes a lack of ability to observe potential counterparties' actions after the transaction has taken place (Cecchetti et al. 2006). Oftentimes this arises from a situation where the agent has an incentive to withhold information or act in a way that does not reflect the principal's interests. In traditional agreements, the costs of verifying and monitoring that agents behave as contracted are generally high. Smart contracts, however, allow

[8] Traditional custodians charge fees based on the characteristics of the deposit and how long it is to be safekept.

the verification of certain actions at certain times through the use of proofs of existence and oracles, both of which have been discussed in earlier sections. Should further verification be needed any addition of oracles will further increase the security of the confirmation (Swan 2015b). The likelihood of moral hazards is therefore directly reduced or even removed entirely. When correctly designed, smart contracts enable simplified surveillance of transaction performance and greatly reduce the costs of agency for the principal (Tabarrok & Cowen 2015). As a direct consequence of this much of the intermediation currently done by banks, lawyers or notaries would become redundant. Any remaining agency costs would persist only for transactions that involve technical expertise and where verification takes place off-chain[9] (IBM 2016). Through the implementation of proofs of existence and oracles, Smart Contract technology lets principals execute and verify governance protocols and complex agreements that are currently hard to verify or simply impractical.

Further reductions of the negative impact of moral hazard can be expected from the unambiguousness that is inherent in the binary design of the blockchain technology. Unlike traditional a non-digital contract, which is designed according to contemporary (legal) language and often open for interpretation, the code of a smart contract has no such limitations. Linguistic ambiguities, as well as differences in the understanding of individual sections of a contract, can thus be eliminated directly by the smart contract's code (Wright & De Filippi 2015, 24). This will likely prevent potential legal disputes between contracting parties that are forced to reach a satisfactory agreement before signing the contract. From that point on, the contract, or rather the code, is executed by the blockchain exactly as it was agreed upon in advance, preventing subsequent manipulations or non-fulfillment. Smart contracts, therefore, ensure the greatest possible certainty with regard to the execution and the fulfillment of contractual provisions (Mattila 2016, 21). This eliminates the need for trust and/or dependence towards other contracting parties.

5.6.3 Efficiency Gains Through Automation

[9] Meaning outside the blockchain

A commonly cited improvement of smart contracts over traditional contracts is their use of digital computing power, which allows for increases in both performance and implementation efficiency through automation. They can be an especially valuable option if a large number of similar transactions are taking place between participants within a network and if the respective transactions are carried out through manual or duplicating activities (Deloitte University Press 2016, 2). Given the fact, that smart contracts are able to automate these activities and scale them virtually infinitely, they have the potential to increase the speed of numerous business processes and thus enable process and transaction execution to be carried out almost in real time (Wright & De Filippi 2015, 25). As we will see in a later chapter, this is particularly beneficial to the financial sector, where multiple transactions are made within a matter of seconds.

5.6.4 Internet Of Things

Further potential to decrease transaction costs lies in the application of smart contracts to physical products connected to the web (commonly known as the *Internet of Things*). Especially interesting is the fast, safe and transparent transfer of property ownership as mentioned before in the last section (known as *smart property*) (Institute of International Finance 2016, 5). Smart contracts eliminate the need for intermediaries to handle such transfers and property ownership can theoretically be allocated to any person anywhere in the world. Such innovation will likely have a substantial impact on the global economy, as the Internet of Things already comprises billions of nodes sharing data through the web. According to American IT advisory firm *Gartner*, 8.4 billion[10] physical devices will be connected to the Internet in 2017 and this number is estimated to reach 20.8 billion[11] by 2020.
One of the most prominent companies seeking to connect the Internet of Things with smart contracts is IBM. Using its Watson IoT Platform, IBM is planning to design radio-frequency identification (RFID) chips, barcode scanners, and similar devices to

[10] Gartner Press Release (2017, February 7): 8.4 billion connected things will be in use 2017. Retrieved June 27, 2017, from http://www.gartner.com/newsroom/id/3598917
[11] Gartner Press Release (2015, November 10): 6.4 Billion Connected "Things" Will Be in Use in 2016, Up 30 Percent From 2015. Retrieved June 27, 2017, from http://www.gartner.com/newsroom/id/3165317

transmit data to distributed ledgers to verify and update smart contracts (Institute of International Finance 2016, 7). In a corporate press release[12] from February 2016, the company provided an example of how this process would work: “As an IoT-connected package moves along multiple distribution points, the package location and temperature information could be updated on a blockchain. This allows all parties to share information and status of the package as it moves among multiple parties to ensure the terms of a contract are met.”

5.6.5 Simplified Compliance

The further development of blockchain technology and smart contracts might also allow more efficient compliance and regulatory efforts. Such efforts fall under the category of “RegTech” where innovative technology is used to address regulatory challenges in the financial services sector (Larsen & Gilani 2017). Smart contracts would be coded to initiate automatic compliance with specific regulations or even intra-organizational compliance rules (Institute of International Finance 2016, 5). Furthermore, because contracts are kept on the distributed ledger, an everlasting financial audit trail would exist for anyone interested, such as supervisors and regulators. While there is still a number of obstacles to RegTech use cases, first and foremost the willingness of regulators to authorize them, such applications would be a large step towards reducing regulatory and compliance costs (Lootsma 2017). This is especially true for the financial industry. Deloitte (2014) estimates that complying with new regulations cost the European insurance industry between 5.7 and 6.6 billion US Dollars in 2012 (p. 3). In 2014, compliance costs for Deutsche Bank amounted to €1.3 billion and $946 million for UBS (Institute of International Finance 2016, 5). However, not only established financial institutions will see a decrease in spending. Lower compliance costs will directly benefit smaller banks and financial startups that face the same regulatory scrutiny as larger firms, yet they often only have a fraction of the large disposable capital of well-known banks. Therefore, a reduction in transaction costs in the form of lower compliance costs will directly lead

[12] See IBM Press Release (2016, February 16). New IBM Cloud Services Put Blockchain to Work. Retrieved June 29, 2017, from https://www-03.ibm.com/press/us/en/pressrelease/49029.wss#release

to more competition in the financial sector through the entrance of smaller businesses (Fenwick et al. 2017).

5.6.6 Socioeconomic Changes

While, at first sight, the benefits outlined above might seem to primarily affect the financial industry and its particular (transaction) cost structure, they also suggest fundamental changes in the way humans interact with each other and how society operates. A global blockchain also includes a change in how trust is established – not through traditional institutions and intermediaries like governments, multinationals and banks, but through mass collaboration and computer code. Whereas the Internet allowed for the worldwide exchange of information, blockchain opens the door for an exchange of anything of value – be it money, assets or intellectual property. This has far reaching implications and is possible only due to the reduction of moral hazard risks (as identified in section 5.6.2.). The interaction between companies and consumers will change as reputation systems will now be based on social capital and operated by individuals instead of intermediaries.

Interestingly, as such technology will decrease information procurement costs it would most likely decentralize much of the modern sharing economy (Tapscott & Tapscott 2016a). Intermediaries such as Airbnb and Uber would no longer be necessary for two (or more) individuals to contract with each other, as securities and background checks are no longer needed. For instance, a person could loan out his car to a stranger given the possibility to program into a smart contract the spontaneous deactivation of the car key if loan payments are missed by the borrower. This creates the possibility of trustless transactions, where multiple parties do not have to know nor trust each other to transact.

5.7 Outstanding Issues And Challenges Of Smart Contracts

As stated in previous chapters, much of the smart contracts technology is still under development and similar to other cutting-edge innovations, certain questions and concerns abound. These include issues surrounding technical feasibility, legality, the likeliness of fostering criminal activity, as well as consequences for financial stability - all of which will be analyzed in the following.

5.7.1 Technical Difficulties

There are a number of technical problems surrounding smart contracts that could obstruct its implementation in the real world. One of the most commonly named is irrevocability (Institute of International Finance 2016, 8). Even though one of the major benefits of blockchain-based contracts is the automatic enactment of obligations, the strictness that comes with any program built on binary code can lead to inflexibility (Deloitte University Press 2016, 6). Contemporary contract law allows for the discharge of contracts based on impossibility (e.g. due to the death of one of the parties or destruction of property) or illegality (e.g. if certain terms of a contract violate the civil rights of a party involved). Flexibility is an important part of contract law to avoid the need for participants to foresee and negotiate every possible outcome. Smart contracts, however, become irrevocable the second a coded agreement is signed and stored on the distributed ledger. If not addressed this problem of rigidity can hinder the development of smart contracts (Capgemini 2016, 8). In order to truly compete with traditional contracts, they must have the capacity to be revised when generally desired, or when considered necessary from a regulatory or legal standpoint. Ari Juels, co-director of the Initiative for Cryptocurrencies & Contracts (IC3) at Cornell Tech, stated that the apparent lack of flexibility in smart contracts might be addressed by adding an “escape hatch” into the code of the contract thus allowing someone with a specific cryptographic key to intervene and change the agreement if necessary[13].

[13] See Castillo, M. D. (2016, December 03). Blockchain Pros Debate 'Looming Challenges' for Smart Contracts. Retrieved June 27, 2017, from http://www.coindesk.com/blockchain-smart-contracts-looming-challenges/

Another technical concern revolves around the ability to incorporate external data sources, as described in section 5.5. Because blockchain represents a consensus-based technology, each node in the network has to agree on new (external) data prompting a smart contract event. As stated before, oracles can be a way of verifying data and embedding it in the chain, however, this means that the oracle now acts as an intermediary, undermining the core ideal of a distributed ledger (Shadab 2014).

The last major technical challenge facing widespread smart contract adoption is the limited use of similar technology based on distributed ledgers today. Since replicated and shared ledgers are required for the operation of smart contracts, the widespread adoption and standardization of blockchain technology are paramount to the success of digital agreements (Institute of International Finance 2016, 8). In view of the knowledge required to deploy and develop smart contract systems, only very few people can make use of it in 2017. More user-friendly programs based on everyday language will have to enter the market for network effects and commercial adoption to take place.

5.7.2 Legal Difficulties

Besides the technical challenges presented above, there are substantial legal issues regarding smart contracts. For instance, smart contracts present concerns of jurisdiction (Institute of International Finance 2016, 9). It is still undecided which type of national or international courts could litigate disputes and which laws would apply to decide on the legality of a contract (Raskin 2016, 321ff). Furthermore, how would the blockchain itself be viewed in the eyes of the law? Does it count as a business record or is categorized as hearsay? How could parties show acceptance of contractual terms in a way that aligns with established law?

Since few lawyers have the ability to draft and code their own smart contracts, computer programmers would take up an even more important role in the process, thus creating new concerns of liability when it comes to faulty algorithms or even ethical questions regarding the practice of law by amateurs (Raskin 2016, 328). As stated in the last section, smart contracts will likely reduce legal cost around contract execution and surveillance. Yet, the possibility exists that these costs would shift from execution to the drafting phase (Institute of International Finance 2016, 9).

Houman Shadab[14], professor at New York Law School, added that "by requiring parties to strictly commit, at the outset, to decisions of a smart contract, the need for transactional attorneys and others to structure smart contractual relationships may increase. Parties would most likely want to specify a more detailed range of contingencies and outcomes ahead of time before committing themselves to abide by the decisions of a software-driven contract." Furthermore, public and permissionless smart contracts could violate consumer privacy laws and will have to abide by anti-money laundering (AML) and know your customer (KYC) procedures.

5.7.3 Smart Contracts And Criminal Activity

"Investigating the Future of Criminal Smart Contracts", a pre-publication paper published by the Initiative for Cryptocurrencies & Contracts (IC3) at Cornell Tech in New York City outlines several risks that may arise with smart contract technology on specific types of decentralized shared ledgers such as Ethereum. Possible cases include the disclosure of confidential information, sharing of cryptographic keys, and a number of real-world criminalities such as arson, murder and terrorism (Juels et al. 2016, 4ff). Due to the fact that smart contracts allow mutually distrustful parties to anonymously and confidently trade with one another, this could create new black markets whereby anyone could hire thieves, assassins and hackers to carry out criminal services (Juels et al. 2016, 12). The online black market site *The Silkroad*[15], where millions of dollars worth of drugs and illegal firearms were traded until its ban in 2014 was a prominent example of online criminal activity facilitated through the use of blockchain technology.

According to the IMF report "Virtual Currencies and Beyond: Initial Considerations" released in 2016, financial stability and consumer protection are further areas of concern. The authors state that the "widespread use of smart contracts could increase risks to financial stability by automatically propagating adverse events through the financial system, with self-reinforcing feedback loops (similar to the risks posed by

[14] See Shadab, H. (2014, December 15). What are Smart Contracts, and What Can We do with Them? Retrieved June 29, 2017, from https://coincenter.org/entry/what-are-smart-contracts-and-what-can-we-do-with-them

[15] See Delamarter, A. (2016, December 09). The Darknet: A Quick Introduction for Business Leaders. Retrieved June 29, 2017, from https://hbr.org/2016/12/the-darknet-a-quick-introduction-for-business-leaders

automated high-speed trading)” (Habermeier et al. 2016, 23). Additionally, the difficulty of smart contracts may also make it problematic for consumers to recognize what they are agreeing to. These concerns, combined with the aforementioned various risks, will likely challenge policymakers, lawyers and computer scientists for years to come (Habermeier et al. 2016, 35).

6. Possible Uses Of Smart Contracts In The Financial Industry

Contracts form the basis for any economic transaction. According to transaction cost economics, the more efficient and less costly the process of designing a contract is, the more transactions will occur in the marketplace (Coase 1937; Williamson 1975; Hart & Moore 1988). Smart contracts are said to directly increase this efficiency and therefore directly improve underlying conditions of business negotiations. The possible applications show a great diversity, some of which have been outlined in the previous section. However, in view of the selected topic, this chapter analyzes only those uses, which can be attributed to the financial sector. In this context, different forms of securities and securities processing will be looked at. Much attention will be given to futures and leveraged loans. Current literature suggests that many of the responsibilities assumed by intermediaries today will be handled by automated contracts in the future (Swan 2015a; Peters & Panayi 2015; Tapscott & Tapscott 2016a). With this in mind, the second part of this chapter will look at how intermediaries, such as banks and investment funds, can use this, most likely inevitable, technological change to their advantage. Lastly, it must be pointed out that Smart Contracts are only at a very early stage of development and that potential approaches can only be indicated.

6.1 Financial Securities

6.1.1 General Securities Trading

The term security refers to any fungible, negotiable financial instrument that represents some type of monetary value[16]. It is generally characterized by some form of ownership in a publicly-traded business (through stock), a creditor relationship with a business or governmental body (through bonds), or rights to ownership (through options) (Gitman et al. 2015, 20). Exchanging and trading financial securities is an integral part of any financial market, however, due to legacy infrastructure, the time necessary to transfer them can be extensive. For instance, in

[16] See Investopedia. (2017, May 18). Security. Retrieved June 29, 2017, from http://www.investopedia.com/terms/s/security.asp

the U.S., securities exchanges often take up to several days, with loan settlements regularly extending to 20 days or more (Institute of International Finance 2016, 3). Such considerable time lag increases the risk between contracting parties and constitutes grave regulatory consequences. Following the 2008 financial crisis, both American and European regulators have mandated financial institutions to hold larger amounts of capital to protect themselves against the risk of default of counterparties when trading securities (Institute of International Finance 2016, 3). According to Blythe Masters[17], CEO of Digital Asset Holdings, smart contracts using distributed ledger technology could decrease settlement times from several days to seconds for many financial products, mitigating risks and freeing up capital in the process.

6.1.2 General Process Of Securities Trading

Figure 5. The general process of securities trading. Adapted from Oliver Wyman (Publisher) (2016). Blockchain in capital markets: The prize and the journey. *euroclear, February*.

Figure 5 illustrates the general process of securities trading, which consists of four main steps: pre-trade, trade, post-trade and securities servicing (Oliver Wyman 2016, 12). Each of the steps bears significant potential for increased efficiency through the use of smart contracts.

Pre-Trade:

As explained in more detail in Chapter 5, an introduction of smart contracts will greatly reduce the risk involved in the negotiation phase leading up to a trade. Trading parties will benefit from an increased transparency due to open accessibility of the distributed ledger as well as a direct verification of holdings (Mattila 2016). According to Oliver Wyman Businesses Consultants (2016), this will also lead to

[17] See Robinson, E., & Leising, M. (2015, August 31). Blythe Masters Tells Banks the Blockchain Changes Everything. Retrieved June 29, 2017, from https://www.bloomberg.com/news/features/2015-09-01/blythe-masters-tells-banks-the-blockchain-changes-everything

reduced credit exposure on the side of loaners, who are now more easily able to mutualize their statistic data with other loaners.

Trade:

The pre-trade phase is followed by the actual trade (also referred to as *clearing*). In this case, mutual claims and liabilities from corresponding securities transactions are established and trading positions are reconciled. This function is assumed by a clearing house which fulfills the legal role of a central counterparty (CCP). CCPs are used to reduce credit risk by mutualizing it between their members and to facilitate the clearing process (Rehlon & Nixon 2013, 148). According to Oliver Wyman (2015, 7), clearing processes could be automated by the incorporation of smart contracts after the conclusion of the trading or closing of the transaction. Due to the fact that all participants would use the same underlying infrastructure for trade-related processes, the blockchain reduces the potential for disputes, data errors and reconciliation lags, accelerating the end-to-end process.

Post-Trade:

Following the trade, post-trade (also referred to as *settlement*) describes the handling and processing of the transaction. Smart contracts will not only allow for secure transactions but also enable the transfer of securities with minimal time lag (Oliver Wyman 2015, 12). From a purely technological viewpoint, this may appear to be a surprising assumption. The implementation of a consensus-based shared database should, in theory, be a slower process than the conventional centralized database due to the fact that it entails several nodes to form a consensus instead of relying on updates to be verified by a single database supervisor. However, this neglects the fact that in most international trades, post-trade settlement already proceeds according to a sort of consensus resolution (EBA 2016, 10 – 12). As accounts and information are interchanged between different banks and custodians, settlement demands reconciliation and execution between each layer of the custody chain. A consensus-based settlement system built on smart contracts could reduce inefficiencies related to this process since information only has to be recorded in one shared database that is accessible to all participants, rather than in each individual database layer throughout the custody chain (EBA 2016, 11). As shared ledgers require no central clearing for security transactions, they can be traded in what is essentially real-time. Smaller time lags also lead to lower collateral requirements on the side of borrowers, since the risk of default decreases (Capgemini 2016, 10). More specifically the blockchain will permit the automatic process of “Delivery versus Payment” on a cash ledger, where all necessary documents for the transfer of securities are delivered simultaneously in exchange for a receipt of the payment amount (Euroclear 2016, 12). This receipt along with further information of the contracting parties will be stored on the ledger, facilitating the automatic report of the transaction to market authorities and governmental agencies (Tyson et al. 2017, 11ff). As noted by Oliver Wyman (2016, 12), such practices will also increase anti-money laundering standards and increase security in financial markets.

Custody & Securities Servicing:
After the transaction has been processed, securities need to be stored and kept safe to protect their owners against theft and/or manipulation. However, even if this does not occur, investors are still exposed to *custody risk*, which describes (i) the risk that a custodian in the custody chain fails or (ii) the risk of errors in the settlement of securities at any point throughout the custody chain (Euroclear 2016, 6). Smart contracts using the distributed ledger technology remove the need for reconciliation and obviate database redundancies. They could therefore significantly reduce the magnitude of these risks. In today’s multi-tier holding system, investors typically have access only to the account held by the intermediary nearest to them in the chain. The potential of the distributed ledger technology is to merge these points of information into a single master record (Micheler & von der Heyde 2016). Such a record, for example, could be made completely transparent to the issuer, and only partially transparent to intermediaries and relevant regulators. This would also offer investors a direct link to the issuer of a security, possibly facilitating the direct exercise of investor rights and interaction with that party.

After evaluating possible efficiency gains from smart contracts in the general process of securities trading, two specific types of securities will now be analyzed: futures and leveraged loans.

6.2 Futures

In a futures contract, a market actor agrees to buy or sell an underlying asset or a cash-equivalent at a predetermined price at a pre-specified time in the future[18]. Someone betting on a price decrease of Bitcoins would take the "short" position in a futures contract and decide to sell a certain number of Bitcoins, at a future date and for a specific price. For example, on January 1st *Person A* may agree to sell 1 Bitcoin to *Person B* on February 1st for 3000 US Dollars, expecting the market price to fall under this level within the next 30 days. If this is the case, *Person A* will be able to buy the Bitcoin from the market and subsequently sell it to *Person B* at a profit. On the other hand, if Bitcoins were to increase in price after January 1st, the futures contract would still require *Person A* to sell to *Person B* at what would be below-market prices.

In the United States, the trade of futures is controlled by the Commodity Exchange Act (CEA) and may be allowed only on regulated exchanges[19]. The CEA defines regulated futures exchanges as a designated market for contracts required to conform to certain "core principles[20]." These principles essentially command exchanges to protect customers, prevent manipulation and fraud, keep records, and maintain fair and organized markets by, for example, enforcing trading limits (Shadab 2014, 4 - 5).

Because futures agreements are highly standardized contracts, they are likely to be among the first types of blockchain empowered smart contracts to be implemented for common use in financial markets (Shadab 2014, 14). Interestingly, smart contracts would allow the trade, clearing and settlement of futures without a direct exchange partner. These activities, along with the related decision-making, would be programmed into the code that makes up the digital agreement. Figure 6 illustrates how traders would interact with smart futures based on blockchain instead of a central exchange platform:

[18] Futures contract, CFTC Glossary, U.S. Commodity Futures Trading Commission

[19] CEA § 6(a); 7 U.S.C. § 6.

[20] CEA § 5(b-x), 7 USC § 7(d).

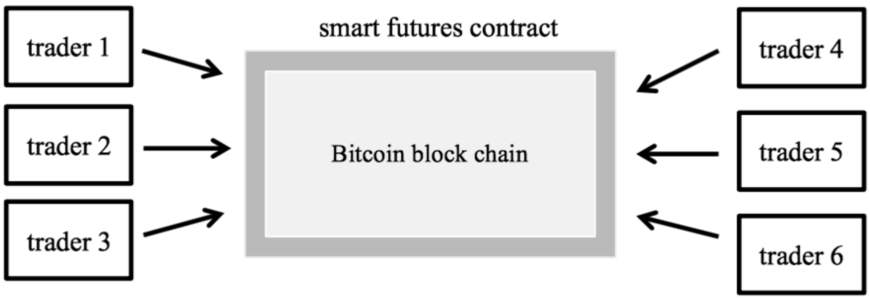

Figure 6. Futures contract built around the blockchain. Adapted from Shadab, H. B. (2014). Regulating Bitcoin and block chain derivatives.

In the most likely scenario, smart futures would have the specific quality, quantity, and date of delivery programmed into the code. The price for each contract, however, would be decided by an algorithm that receives market data through an oracle (Shadab 2014, 15). Additionally, the core principles mandated by the CEA could be included as part of each futures contract. For example, the smart future could be programmed to block excessive orders and large positions meant to disrupt or manipulate markets. Regarding risk management, once an investor opens an account and deposits Bitcoins in the electronic wallet, the futures contract could automatically make changes to the wallet and settle the agreement upon expiration.

Futures markets based on smart contracts have several advantages over traditional exchange-based markets. First, as trades may be processed faster and with no intermediaries, settlement costs would be mostly eliminated (Capgemini 2016, 7). Second, a blockchain futures market will likely be less vulnerable to manipulation because there would be no incumbent firms benefiting from profits generated by bad actors (Shadab 2014, 15). In theory, the concept could also allow for the creation of a single, international futures market that is not broken down by customers, products, or separate national regulations. Further innovation may be possible by connecting futures markets to other digital markets. This could include, for instance, commodity markets which automatically open a futures contract on behalf of an agricultural manufacturer if expected crop prices drop below a certain level[21].

[21] This possibility was suggested by Adam Luwin (2014, October 11) in his blog post Bitcoin's Killer Apps. Retrieved June 29, from http://www.coindesk.com/bitcoins-killer-apps-look-future/

6.3 Leveraged Loans

Leveraged loans are extended to businesses that already have substantial amounts of debt. They, therefore, carry a higher risk of default, and as a result, leveraged loans are generally more costly to the borrower (Antczak et al. 2009, 42). As of 2017, the leveraged loan market faces serious settlement problems. The average settlement period for a leveraged loan often extends close to 20 days, compared to high-yield bonds, which are usually settled within three days (Capgemini 2016, 10). This extremely long settlement period not only creates greater risks and liquidity problems for actors within the market, it also reduces its growth and attractiveness to outside investors. In fact, the market has seen negative growth since the 2008 recession, while the high-yield bond market grew by 16% (Capgemini 2016, 10). Smart contracts, with the help of a shared ledger, could significantly reduce the duration of processes such as documentation, clearance and post-trade services. Capgemini Consulting (2016) estimates that the settlement period for leveraged loans could be reduced to anywhere from six to ten days, making the leveraged loan market more attractive and liquid than it is currently. It is further estimated that a reduction in settlement times, when coupled with a five to six percent growth, would amount to an additional 149 billion US Dollars of global loan demand (Capgemini 2016, 10). Additionally, with the shortening of the settlement cycle, operational costs, costs associated with delayed payments and regulatory capital requirements will be reduced.

While some of these changes will likely require a few years to be implemented, there are several firms who have already developed ways for smart contracts to be integrated into the bond market. Most notably, *Symbiont*, a New York City-based financial startup has developed a patented smart securities technology built and designed for financial markets. The technology enables syndicated loans to be modeled in an “easy to understand programming language and fully digitized onto a distributed ledger” (Institute of International Finance 2016, 3). First successful applications of this technology were already made as early as 2015. In a press release[22] from March 2016, the company announced to partner with software provider *Ipreo* to develop programs that will allow fully-automated loan settlement and maintenance, leading to millions of dollars in annual savings for potential clients.

Another promising test project, commonly referred to as "BondCoin", was initiated by the Swiss bank UBS in its innovation lab in London in 2015 (UBS 2016, 1). Here, a smart bond was executed within the Ethereum blockchain to replicate issuance, interest calculations and coupon payments of the underlying security. The test showed that information and cash flows between the issuer and investor could be completely automated and thus eliminated the need for intermediaries in the transaction (UBS 2016, 1). UBS later stated that its initial assumptions regarding the usability of smart contracts and virtual currencies were confirmed which could result in faster, more efficient and transparent clearing and settlement processes, while at the same time reducing the risk of fulfillment and operating costs[23].

[22] See Ipreo (2016, March 3). Ipreo and Symbiont team on blockchain for syndicated loans. Retrieved June 28, 2017, from https://www.finextra.com/pressarticle/63423/ipreo-and-symbiont-team-on-blockchain-for-syndicated-loans/execution

[23] See Lisco (2016). Cutting through the blockchain hype

7. Implications For Market Structure

Smart contracts likely fit the description of a disruptive technology (Swan 2015a). The automation of numerous transactions is expected to bring on large changes to the financial sector as a whole as well as to individual participants within the industry. While most economists agree that, on a large scale, finance will benefit from the innovation, many segments are predicted to undergo drastic transformations (Tapscott & Tapscott 2016b; Fanning & Centers 2016). This chapter reviews the role of three major market participants – banks, investment funds and clients - and outlines what impact smart contracts will have on their business models.

7.1 Banks

Today banks function as important intermediaries in most financial transactions. Not only do they handle direct monetary transfers from one individual (or business) to another, they also give out loans, collect savings and offer trading and brokerage services to clients. Most banking institutions have traditionally enjoyed high annual profits[24] with relatively stable growth rates. During the 2008 crisis a number of major banks were even denoted as "systemically important financial institutions" by American and European governments and subsequently saved from bankruptcy through public funds. However, it is possible that their preeminence will decline with the widespread adoption of smart contracts and blockchain technology. Axel Sarnitz, partner at *zeb*, a German financial services consultancy, notes that "with smart contracts, retail customers will be able to agree on financing directly with the seller when buying a car or home and forcing banks into the role of the passive onlooker[25]." Lower operating costs and increased compliance will likely reduce contract disputes and through the use of the shared ledgers, all contract participants will have identical data simultaneously. This eliminates the need for third-party clearing services and intermediaries. This development can be summarized under the term *disintermediation,* as discussed in Chapter 4.

[24] Osborne et al. (2009) estimate the long-term average ROE of U.S. commercial banks to be between 7.5% and 12.5%

[25] See Sarnitz (2017). Blockchain in retail banking.

The Spanish BBVA even concludes in a 2015 research paper[26]: “The main purpose of smart contracts is to enable people to do business with strangers, usually over the Internet, without the need for a trusted intermediary. The idea is that software can automate much of the process, allowing the enforcement of contractual promises without human involvement” (p.6).

As mentioned in Chapter 6, the two early use cases for smart contracts will likely be trade clearing and settlement. In late 2016, the Deloitte CFO Program issued a primer, which stated that “smart contracts offer the ability to automate approval workflows and clearing calculations, which otherwise are prone to lag and error” (Deloitte 2016, 2). Banks and other intermediaries that are highly invested in these processes will be forced to adapt quicker than those with less focus on trade clearing and settlement. One example is *Citibank*, which acts as one of the largest registrar, transfer- and exchange agents of treasury notes in the world. Together with other clearing systems such as *DTC* in the United States and *Euroclear* or *Clearstream* in Europe, it handles the settlement of millions of treasury notes every year[27]. Starting with the wider adoption of smart contracts in the financial industry, which Capgemini Consulting (2016, 15) estimates to begin around the year 2020, these institutions will possibly be the first to see a decrease in their revenue through settlement and handling fees.

However, even then the technology will still be in its early days and observers have suggested ways in which banks could benefit from smart contracts or employ them on their own. Armen Kherlopian[28], CSO for analytics and research at *Genpact*, believes banks should monitor and actively invest in the development of smart contracts, mainly those that will develop in the transfer of physical assets, supply chain and commercial lending. Even though long-term smart contract networks will likely become the dominant player in finance, banks can still offer value on the basis of superior service, especially by presenting a bridge between the technology and the end customer.

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[26] BBVA (2015) Smart contracts: the ultimate automation of trust?

[27] See World Bank Treasury (2016) Clearance and Settlement. Retrieved June 27, 2017, from http://treasury.worldbank.org/cmd/htm/documents/ClearanceandSettlement.pdf

[28] Ginovsky, J. (2017, 15 June). Beware smart contracts' dark side (for banks). Retrieved June 28, 2017, from http://www.bankingexchange.com/news-feed/item/6896-beware-smart-contracts-dark-side-for-banks?Itemid=259

7.2 Investment Funds

Alongside banks, investment funds are among the most common intermediaries in the financial sector. Managers of investment funds pool capital coming from numerous investors to collectively purchase securities. In the process, each participant maintains control and ownership of his own shares. Benefits for the individual investor include a wider selection of investment opportunities, third-party administration as well as lower investment fees than one might be able to attain on their own. Recent developments show that smart contracts offer unique innovation opportunities for this industry (Swan 2015a, 22). A number of private investment funds have decided to benefit from the latest growth of the technology by directly trading Bitcoin and other cryptocurrencies or by investing in companies that develop product and services related to blockchain. Examples[29] of funds that include the technology in their portfolio include the *Northern Trust* in cooperation with *IBM*, *Polychain Capital*, *Intellisys Capital LLC* and *Numerai*.

Others have gone even further by trying to set up a fully automated hedge fund built and secured by smart contracts (Allen & Overy 2016, 2ff). The most noteworthy example here is *The DAO* (abbreviation for Decentralized Autonomous Organization), a decentralized and automated smart fund, created by German brothers Christoph and Simon Jentzsch and their British business partner Stephan Tual. In May 2016, The DAO raised around 160 million US Dollars through their crowdfunding campaign where the digital currency Ether was exchanged for "DAO tokens", which constituted ownership shares of the fund. The collected capital was to be matched by means of electronically submitted proposals, through which the investors could vote for promising projects. Thus, The DAO essentially replaced individual fund managers and handed investment decisions over to the majority of investors, which could vote for any project that had been approved by the fund curators. The Jentzsch brothers were able to create an organization in which participating investors could directly contribute their funds and manage them in real-time and where underlying control and management functions were completely automated and recorded solely on the blockchain. The project failed, however, when

[29] See Kaal, W. A. (2017, April 25). Blockchain innovation for private investment funds. Retrieved June 28, 2017, from http://www.caymanfinancialreview.com/2017/04/26/blockchain-innovation-for-private-investment-funds/

on June 17, 2016, an unknown investor took advantage of an explicit function of the program and transferred the equivalent of 50 million US Dollars to his account[30]. Since the "theft" was carried out in accordance with the original conditions of the program, it was highly controversial whether this constituted an actual hacker attack or whether the attacker had only discovered a weakness in the program code and used it to his advantage[31]. Following this dispute, The DAO had to be closed and all funds were returned to their original owners.

While the failure of The DAO revealed current inadequacies of Smart Contracts, especially with regard to the technical difficulties (as described in Chapter 5), it ultimately revealed the possibility to fully automate even complex (hedge) funds and replace expensive administration cost. Once smart investment funds will be programmed with sufficient security measures to be used alongside traditional investment funds, this will lead to more competition in the market place and likely lower fees for their clients (Capgemini 2016, 7). Users of *Lending Robot*, a partly automated investment fund, already enjoy some of these benefits. They can cash out on a weekly basis at no additional cost and the company only charges a 1% management fee with a maximum of 0.59% fund expense fee each year[32]. As the example shows, automated business models can create greater efficiencies by removing much of the overhead costs, investment advisers and legal fees associated with each investor agreement.

7.3 Consumers and Clients

In all likelihood, clients and consumers of financial services will be the largest beneficiaries of the introduction of smart contracts. According to the aforementioned study published by Oliver Wyman and Euroclear (2016), the greatest expected benefit will come from “the reduction in costs of capital markets dealing and securities servicing” (p. 12). The direct access to a variety of new financial services will lead to

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[30] See Kohn, A. (2016, October 26). The Failure of The DAO: Should We Regulate Cryptocurrency? Retrieved June 28, 2017, from https://futurism.com/the-failure-of-the-dao-should-we-regulate-cryptocurrency/

[31] See Siegel, D. (2016, June 27). Understanding The DAO Attack. Retrieved June 28, 2017, from http://www.coindesk.com/understanding-dao-hack-journalists/

[32] Compared to an average total fee of 2% - 4% for actively managed funds according to Edelen et al. (2013)

more self-organization and direct contact between contracting parties. As outlined in Chapter 6, loan settlements would no longer necessitate banks as intermediaries and a reduction in the risk of default will lower expense for both loaner and borrower. Furthermore, the transfer of assets via the blockchain can encourage international trade and eliminate the various forms of mediators currently needed.

As many of these innovations will take time, however, many intermediaries will still play an important role in the market in the foreseeable future. By taking principal risk where liquidity is thin and sourcing liquidity for assets, they can guarantee future profits (Oliver Wyman 2016, 12). Much of their importance will be centered on advising customers on complicated transactions and execution management, rather than providing market access. With this change, consumers can expect direct benefits within the next few years. Capgemini Consulting[33] estimates that the average customer could save more than 500 US Dollars in insurance and banking fees thanks to the emergence of smart contracts over the next few years. Their report *Smart Contracts in Financial Services: Getting from Hype to Reality* draws on initial trials with industry professionals and researchers from the financial services sector. It is projected that retail banks in the US and EU alone would be able to reduce their processing costs by between 3 and 11 billion US Dollars yearly (Capgemini 2016, 2). Additional savings will likely come from insurance companies, primarily in the motor, health and travel sector, where smart contracts will accelerate claims and require fewer forms to be filled out by the clients. By bringing together everyone involved in the insurance value chain – insurers, consumers, third-party vendors and claim agents – under one domain, the result will be faster claim processing because of reduced documentation, and less need for manual checks. Such gains in efficiency are estimated to result in almost 21 billion US Dollars in annual cost savings for insurers globally (Capgemini 2016, 2). Were they to forward even half of the reduction in expenses on to their customers this could lead to a median saving of $45 annually on premiums. Concluding, Amol Khadikar, lead blockchain researcher at Capgemini's Digital Transformation Institute, said[34]: "Contracts have largely escaped the

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[33] [33] See Capgemini Press release. (2016, October 11). Consumers set to save up to sixteen billion dollars on banking and insurance fees thanks to blockchain-based smart contracts. Retrieved June 28, 2017, from https://www.capgemini.com/news/consumers-set-to-save-up-to-sixteen-billion-dollars-on-banking-and-insurance-fees-thanks-to

digitization of financial services, leading consumers to bear the financial brunt of manual, antiquated processes. We're at a point where distributed ledger technology can, and will, drive a revolution in contracts. This will hugely benefit the industry to reduce risks, cut costs and enhance operational efficiencies. Consumers would benefit, not just financially, but also from processes that are simpler and free of many of the hassles of today's customer experience."

8. Conclusion

8.1 Findings

The introduction assumed smart contract technology to have the potential to significantly disrupt financial markets. This can be confirmed in the sense that by providing a secure and automated way to execute, monitor and record transactions, the distributed ledger technology can deliver substantial cost and efficiency benefits while lowering risks. This thesis' objective was to describe and – to a lesser degree quantify – the impact of smart contracts on transaction costs in financial markets. This also includes the outlining of possible use cases as well as an analysis of changes in market structure. In regards to direct benefits, it was shown that within private equity markets, which are traditionally plagued by high information asymmetries and excessive risks of moral hazard and adverse selection, the technology will likely lead to greater accountability and transparency. Lower transactions costs in the supply of capital also translate to lower interest rates, which particularly benefit small and medium sized enterprises dependent on bank loans. Furthermore, smart contracts could prove to be valuable tools in eliminating abusive practices in public equity markets and restore consumer trust in the system. Lastly, the distributed nature of the blockchain network changes the financial market's infrastructure, by eliminating a central point of failure and substituting it with a peer-to-peer ledger. Vigna and Casey (2015) take this idea one step further by arguing that "the public ledgers used by cryptocurrencies can bring into the open the inner workings of an economic-political system that was previously hidden within impenetrable, centralized institutions" (p.6).

However, despite its apparent possibilities blockchain technology still faces certain limitations and challenges that need to be overcome to enable widespread adoption. These include not only technical uncertainties but also a complete adjustment of the regulatory and legal framework. Questions of how smart contracts can be aligned with existing law or how criminal activity should be monitored are still unanswered. Since finding solutions to these problems require time, current systems will coexist with the new technology at least in the short term. Here, existing players, intermediaries and central authorities will still play an essential role in financial markets. In fact, the cooperation between current institutions and young technology firms might be a key factor for the smart contract technology to have a concrete and meaningful impact. Whether such cooperations take the form of interconnected joint ventures, simple investments or something else entirely, will depend on individual circumstances, of course.

Where and how smart contract technology will be applied first was examined in Chapter 6. While possible use cases in financial markets are numerous, securities trading and handling is often thought to be the easiest to automate. By reducing current lags and processing times risks could be mitigated and capital freed up. Much of these efficiency gains will be made in the post trade (a.k.a. settlement) phase.

Instead of transmitting accounts and information between different banks and across continents, a consensus-based settlement system built on smart contracts could reduce such process inefficiencies. Information would only have to be recorded in one shared database that is accessible to all participants, rather than in each individual database layer throughout the custody chain. One type of security especially suited for this process is a futures contract, which already is a highly standardized document. Here, the specific quality, quantity, and date of delivery would be programmed into the code while the price for each contract would be based on market data provided by an oracle. Loans, especially leveraged loans comprise another type of security suited for early blockchain adoption. Current settlement periods for a leveraged loan often extends close to 20 days and smart contracts could significantly reduce the duration of documentation, clearance and post-trade services to a total of to anywhere from six to ten days.

The subject of how such changes affect market structure made up the last part of the overall research question. This was discussed in Chapter 7. While short term changes in market structure might allow for the continuous existence of most financial institutions, in the medium- and long term, certain businesses will see a decline in market share as well as customer base. The automation of numerous transactions is expected to bring on large changes to the financial sector as a whole as well as to individual participants within the industry. However, the impact of smart contracts will likely affect some industry sectors more than others. Clearing and settlement houses are expected to be among those institutions most at risk of becoming obsolete. Nonetheless, other back-office services designed to reconcile and record information might also suffer from the ongoing digitalization and automation. Even traditional financial intermediaries such as large banks will have to adapt their model to the technological changes in order to ensure long-term profits. The ability for customers to directly transact and finance with sellers not only eliminates their traditional role as intermediaries of capital, but also the possibility to charge fees and interest – both are among the most important streams of income in banking.

Alongside banks, another form of financial intermediary was looked at – investment funds. While providing costumers with a wider selection of investment opportunities, they usually have to contribute not only their personal investment but also pay administration fees and management salaries. Decentralized and automated smart funds can reduce these costs to a minimum while providing much of the same benefits. Even though the most prominent example, The DAO, ultimately failed, its framework survived and is expected to be used in similar fashion in the future. Automated low-cost investment funds will lead to increased competition and force actively managed funds to adapt their strategies and prices. This is good news for consumers of financial products. They can expect a wider variety of new services and lower fees. The ability to transact directly without the need for intermediaries not only lowers the risk for both parties but also allows international transfer of assets through the blockchain. This will most certainly also be the case in insurance markets, where smart contracts will speed up claims and bring together different parties in the insurance value chain – consumers, insurers, third-party vendors and claim agents, creating less dependence on manual checks and intermediaries.

8.2 Theoretical Contributions

The current discourse on blockchain largely acknowledges the efficiency gains and automation possibilities offered by the technology. However, questions of how different actors and orgnaizations will be affected and to what extend remained unknown. Using the framework of transaction cost theory, it was shown that the interaction between intermediaries and consumer will drastically change over the coming years. While the obvious reductions in market imperfections can be characterized as a trigger for these developments, a more important underlying phenomenon emerged during theory development. As the technology replaces "trust" with reliability and security during the process of exchanging valuables, the need for many intermediaries is greatly reduced, if not eliminated. This explains how potential trade partners need no longer rely on outside help to do business. The data presented in Chapters 6 and 7 suggest that the implementation of blockchain includes a fundamental shift in the nature of how humans interact and our society functions. In a traditional economy, intermediaries are the key to trust management and therefore successful transactions. Under blockchain potential contractors no longer rely on outside help to do business, sign agreements or exchange valuables. This puts them in a position of both privilege and responsibility. Privilege because of the countless new possibilities of doing business; responsibility because of the necessary attention to the contract's code. Industry wide standards and surveillance mechanisms will have to address this ambiguity. Otherwise, new information asymmetries could arise about the content of a smart contract, thus reducing the innovation's practicality. Current market structure as analyzed in Chapter 7, suggests that during this transition period consumers will still seek the help of professionals, which, unlike traditional intermediaries, do not act as an access point to the market, but rather as a type of consultant for complicated transactions and execution management. Organizational leadership will undergo similar changes and in order to adapt will have to shift from a position of surveillance to a position of proactive support. Therefore, smart contracts bring together different parties in the value chain – not only buyers and sellers, but also third-party vendors and counselors - while creating less dependence on manual checks and intermediaries.

8.3 Outlook And Practical Implications

Based on the previous findings, a general outlook on the technology can be provided. Furthermore, a number of practical recommendations for financial institutions will be given. Given the potential impact of smart contracts, it is clear that certain parts of the banking industry's traditional service portfolio are being actively challenged by the technology. However, as stated before, blockchain technology can also be regarded as an opportunity to restructure current systems and practices in a more efficient way. Most fintech startups are desperately looking for outside investors and willing to provide their partners with technical know-how and expertise. The view that collaboration instead of competition yields greater benefits for all parties is shared by Santander InnoVentures (2015), emphasizing that banks can aid fintech startups to scale and achieve critical mass, while at the same time profiting from their technological expertise. In other words: “To realise the opportunity of fintech 2.0, banks and fintechs will need to collaborate, each providing the other with what it now lacks, be that data, brand, distribution or technical and regulatory expertise” (Santander InnoVentures 2015, 14). Interestingly, American banks seem to estimate this “window of opportunity” to be much narrower than their European counterparts. Of all patent applications filed in relations to blockchain-based products only one was filed by a European bank – Zürich located UBS[35]. As of 2017, American banks like JPMorgan, Wells Fargo, Goldman Sachs and Bank of America also offer significantly more venture capital towards blockchain related startups. Of course, it is still unclear whether these early investments will pay off in the future, as an adoption of the technology by the existing financial system will take time. Therefore, the current focus of financial institutions should be to design realistic applications in small parts of their business, in order to test the technology in a controlled environment. Over the next five to seven years, large-scale applications should then be implemented and industry standards agreed upon. Since many existing blockchain technologies suffer from regulatory burdens and compliance requirements, speedy implementation will also require assistance public authorities and legal experts. Getting such institutions to act in accordance with the innovation can be difficult but first advances have already been made. For example, Nasdaq the second-largest exchange in the world has recently announced Linq, a blockchain ledger to successfully complete and record private securities transactions. Adjusting operational structures to the new technology will be increasingly important since it is estimated that 80% of the work for blockchain implementation needs to be done on business processes, and only 20% on the technology side[36].

[35] Reuters. (2016, October 19). European banks risk lagging Wall Street in blockchain race. Retrieved August 08, 2017, from http://www.reuters.com/article/us-banks-tech-blockchain-idUSKCN12J22L

[36] Mougayar, W. (2015, December 22). Blockchain 2015: Analyzing the Blockchain in Financial Services. Retrieved August 08, 2017, from https://de.slideshare.net/wmougayar/blockchain-2015-analyzing-the-blockchain-in-financial-services

All in all, however, the future looks bright for blockchain. Development of related products is at an all-time high and will probably grow further in the coming years. The technology conveys big promises and one can only be excited about the future.

8.4 Limitations And Further Research

The development of blockchain is still at a very early stage, so its environment is constantly changing and evolving. While the scope of the study allows for a profound answer to the research question, it does not outline the entire impact of blockchain on our economy. Data from case study research is always specific and can only be generalized under certain conditions (Yin 2010). Even though the theory development presented above can be adapted to other sectors, this should not be done without a prior assessment of the market structure. This is especially true when analyzing specific (transaction) costs, which can differ widely from one industry to another. Therefore, future research, both qualitative and quantitative, is needed to overcome these limitations. Of special interest are also the socioeconomic consequences of the elimination of intermediaries. How do customers handle the need for more responsibility and how do highly integrated industries like the retail sector react to such disruptive innovations? The study of the widespread adoption of blockchain is still in its infancy and more research is needed to examine future developments.

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