Indicators of Disruption Potentials - *Analysis of the Blockchain Technology's Potential Impact*

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List of Abbreviations

APA	American Psychological Association
B2B	Business to Business
B2C	Business to Customer
C2C	Customer to Customer
CME	Chicago Mercantile Exchange
DLT	Distributed Ledger Technology
EHR	Electronic Health Records
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
IT	Information Technology
P2P	Peer-to-Peer
PBFT	Practical Byzantine Fault Tolerance
PoS	Proof of Stake
PoW	Proof of Work
PHR	Personal Health Records
R&D	Research and Development
SCPC	Survey of Consumers Payment Choice
WEF	World Economic Forum

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1 Introduction

"Disruption" might be the most overused and misused term in today's business jargon (Ignatius, 2015). Numerous innovators have been using the term to describe the impact of their products and services. The term originally goes back to Clayton Christensen's *The Innovator's Dilemma* from 1995. In this work, he defined how, in the process of disruption, initially insignificant and underestimated innovations threaten to displace industry leading incumbents (Christensen & Matzler, 2013).

The blockchain technology, too, is often referred to as a potential disruption (Tapscott & Tapscott, 2016). The technology uses mass collaboration and computer code to establish trust. It is an almost incorruptible distributed ledger technology (DLT) that can document transactions between several parties efficiently and in a verifiable, permanent, and decentralized manner (Iansiti & Lakhani, 2017). While the technology first became famous through its use in the underlying mechanics of the cryptocurrency Bitcoin starting in 2008, companies from many different industries have been investigating the benefits of the blockchain technology for their own uses.

This paper aims at connecting the frequent misuse of the term disruptive innovation and the common use of the term in reference to blockchain. By looking at the characteristics of a disruption process and by analyzing the impact the blockchain technology has had, and will continue to have, this work tries to answer the following research question:

Does the Blockchain Technology have the Potential to be truly Disruptive (especially in the Financial Industry)?

To answer this question, the emphasis has been placed on identifying potential indicators of disruption within different applications of the blockchain technology. The following figure presents the schematic structure of this thesis.

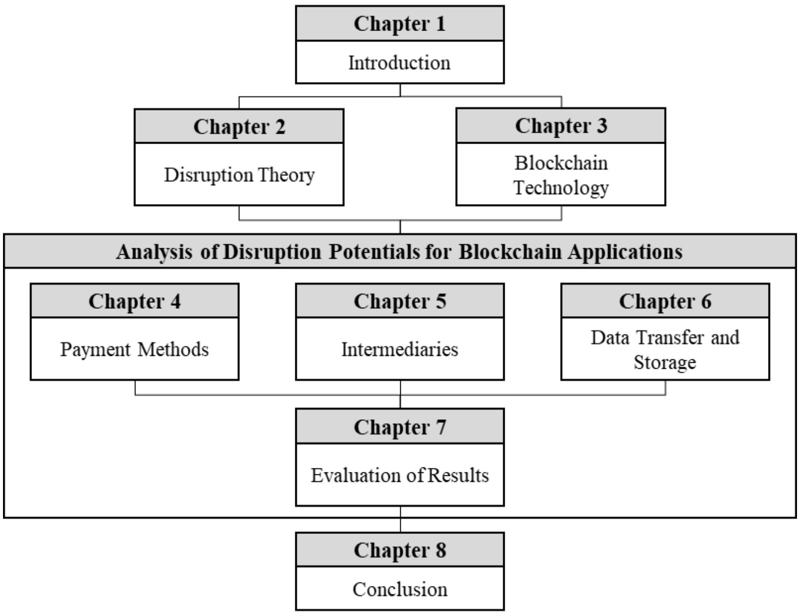

Figure 1. Schematic Structure of the Paper

The chapter succeeding this introduction presents Christensen's disruption theory. Besides an explanation of the concept, the chapter also introduces five features that characterize the process of disruption. The third chapter is dedicated to blockchain technology. In addition to its history and the mechanics of the technology, this section provides a literature overview about the potential impact of the technology and its applications. The main analysis is conducted in chapters four to seven. While chapters four, five, and six each deal with the disruptive impact of the DLT especially in the financial industry, chapter seven evaluates and interprets the results of the preceding chapters.

For chapters four to six, one example from each field of application is selected and tested for indicators of disruption. Therefore, the five characteristics of disruption serve as the underlying framework for the analysis. First, the potentially disruptive impact of blockchain-based cryptocurrencies on payment methods is tested. Second, blockchain's ability to displace intermediaries was analyzed by looking at the use of blockchain-based, intermediating platforms in microgrids. And thirdly, the implementation of blockchain solutions for health record management was considered to determine if the technology indicates disruption potentials for data transfer and storage. The results of each of the three applications are assessed in the seventh chapter with the aim of identifying common patterns and assessing the overall impact of the technology. Finally, the last chapter examines the value of the results, talks about limitations of this thesis, and makes suggestions for further research on the topic. Throughout the paper, the citation style of the American Psychological Association (APA) is used for referencing.

2 Definition and Characteristics of a Disruptive Innovation

In his book *The Innovator's Dilemma*, Clayton M. Christensen introduced the disruption theory (Christensen & Matzler, 2013). Analyzing the failure of industry leading companies, he defined the characteristics of a disruptive innovation and, thus, coined the term. While the theory is still commonly accepted in its original form, some critique has surfaced over time and the theory has been adjusted, accordingly (Denning, 2016).

2.1 Explanation of Key Terms

2.1.1 Value Networks

Since a disruptive innovation has its origins outside the *value networks* of established players in a market and causes new value networks to emerge, understanding the term is crucial (Christensen & Matzler, 2013). The initial idea of a value network is based on Dosi's definition of technological paradigms as a solution for selected technological problems (Dosi, 1982). However, with respect to disruption, the idea of value networks was coined by Christensen and Rosenbloom (1995) in the context of competition and the context of solving its customers' problems. Based on a company's past choices and its historic competitive strategies, its value network can be defined. Within the network, values derive from various actions such as the decisions of which markets to serve, how to respond to customers' needs, and how to react to competitors (Christensen & Matzler, 2013). Moreover, determining the firm's perception of economic value for new technologies, the value network, among other factors, indicates how successfully a company can innovate (Christensen & Rosenbloom, 1995). Based on the expected reward of investing in an innovation for a company's value network, the company will decide pro or con an innovation.

2.1.2 Incumbents

An incumbent is defined as a company which has a sizable share of a market ("Incumbent", n.d.). Under threat of being displaced in the mainstream market by the disruptive technology, incumbents play a key role in the respective theory and the process of disruption (Tellis, 2006). Having led their fields and industries for years, incumbents were role model companies that many other industry participants looked up to (Christensen & Matzler, 2013). Many incumbents became successful because of their innovative products and services. Thus, their strategies are copied and implemented by others. While a company's failure can often be attributed to poor management and investing, to arrogance, or to a lack of capabilities, a typical incumbent does not fail for such reasons. The reasons for the failure of incumbents are explored by Christensen's 1995 disruption theory.

2.1.3 Trajectory of Technological Improvement

Like the concept of the value network, the idea of technological trajectories goes back to Dosi (1982). Technological trajectories describe a path along which technological improvement and innovation takes place. They indicate the speed of technological improvement, like the development in microprocessors exemplifies: from 1979 to 1994, the speed of microprocessors improved by 20% annually, from 8MHz to 133MHz (Christensen & Matzler, 2013). For incumbents in particular, technological trajectories are of utmost importance. Their customers base their expectations on these trajectories of improvement, and consequently, it is the company's task to fulfill them. However, the focus on fulfilling their customer's expectations regarding existing technologies makes it likely that they miss out on new, disruptive technologies.

2.2 Characteristics of the Process of Disruption

2.2.1 Overview on Clayton Christensen´s Disruption Theory

In 1995, Christensen published his famous book *The Innovator's Dilemma* in which he presents his theory of disruptive innovation together with advice for managers how to deal with such situations (Christensen & Matzler, 2013). Since then, the theory has been established as a guideline for both small entrepreneurs who gather hope for their own business ideas, and for executives of leading incumbents who try to defend the market leading position of their companies against disruptive intruders (Christensen, Raynor, & McDonald, 2015).

In the process of disruption, an insignificant company with little resources manages to challenge and to displace the market leaders (Christensen et al., 2015). The underlying reason for the failure of established incumbents is their focus on improving existing products and services based on their most profitable customers' demands. Consequently, they tend to overemphasize the needs of some segments, while they miss out on the needs of others. These ignored segments are those targeted by entrants, which later turn out to be disruptive. They successfully manage to establish themselves in these segments by providing a more suitable functionality of their product or service. Generally, these products and services look financially unattractive for incumbents as their main customers will not demand these technologies yet because, at this point, the new technology does not fulfill the requirements of the mainstream market, which are based on technological trajectories (Bower & Christensen, 1995). However, the new entrants keep improving their performance until, at some point, they meet the requirements and demands of the mainstream market, too. At the same time, they manage to preserve the underlying advantages for their earlier success. In the process of disruption, usually, it is not until this point that the incumbents start exploring and investing in the new technologies. However, the technological advantage the new entrant has over the incumbents for the new technology is often too big, and the incumbents get displaced.

A very tangible, historic example of a disruptive technology is the steam boat (Christensen & Matzler, 2013). In 1783, the first functioning steam boat was built. However, at that point and for the following decades, it was not competitive against sailing boats in most aspects. The cost per mile was higher, the speed of travel was slower, and they were a lot more vulnerable. However, unlike sailing boats, steam boats can travel rivers up and downstream, even without wind. At that time, however, the main customers of the boat manufactures required boats that were able to cross oceans, which steam boats of the day were unable to do. Therefore, the manufacturers kept focusing on sailing boats and ignored the steam boat segment. However, the steam boats kept improving and at some point in the late 19th century, they were competitive in the mainstream market. By then, it was too late for the incumbent sailing boat manufactures to adapt to the disruptive technology, which is why they were displaced, at the end

2.2.2 General Pattern of the Process of Disruption

The so-called "technology mudslide hypothesis" has been a widely accepted explanation for the failure of companies (Christensen & Matzler, 2013). The hypothesis simply assumes that companies fail because they are not able to keep up with the technological progress. However, with his disruption theory, Christensen indicated that well-managed, renowned companies can fail even if they manage to keep up technologically with the pace and the complexity of innovations.

Indeed, it is crucial for the success of a business to listen to its customers and to fulfill their demands and expectations. Therefore, a company's value network, among other aspects, is shaped by the customers a company serves, by how it responds to customers' needs, and by how it reacts to its competitors. The customers expect products and services to improve along an existing technological trajectory, which could be a certain percentage of performance improvement in a given period. Therefore, incumbents focus on improving their services based on what their most profitable customers demand (Christensen et al., 2015). This innovation, along existing trajectories, is referred to as evolutionary innovation and, at first, seems to be what any incumbent should be doing in order to defend its market leading position (Christensen & Matzler, 2013). However, many incumbents have failed even though they followed trajectories and patterns that helped them to achieve the leading position they held in the past.

These companies have failed because of disruptive innovations, which are different to evolutionary innovations in that they create new technological trajectories. Disruptive innovations are commonly characterized by a different package of performance attributes (Bower & Christensen, 1995). These attributes are often of a technological nature and can result in a reduced price or might be valued by market segments other than the mainstream segments. In order for an innovation to be considered disruptive, its performance and capability ought not necessarily to meet the demands of the mainstream customers when the innovation is first released. As the new performance attributes of such innovations are, at the outset, not valued by incumbents' existing customers, disruptive technologies look financially unattractive to established companies and are therefore often ignored (Christensen & Matzler, 2013). Due to this, Christensen calls incumbents prisoners of their own customer.

One reason that makes the success of disruptive technologies possible is that products and services are innovated at a faster pace than the mainstream market demands (Christensen et al., 2015). Therefore, incumbents put efforts into improving attributes to a level that is not required. Disruptive technologies, too, improve at a faster pace than the demand of the mainstream market, which enables these technologies to eventually fulfill these expectations (Christensen & Matzler, 2013). At this point incumbents might still offer a higher performance than the new entrants, but since the mainstream market can be satisfied with the lower performance, the new entrant displaces the incumbent. Often, it takes too long for incumbents to realize the threat of the new entrant due to the different product or service attribute of the entrant. Some incumbents still try to adapt to the new technological trajectory, but very few succeed as the entrant's advantage in the new technology is usually too high.

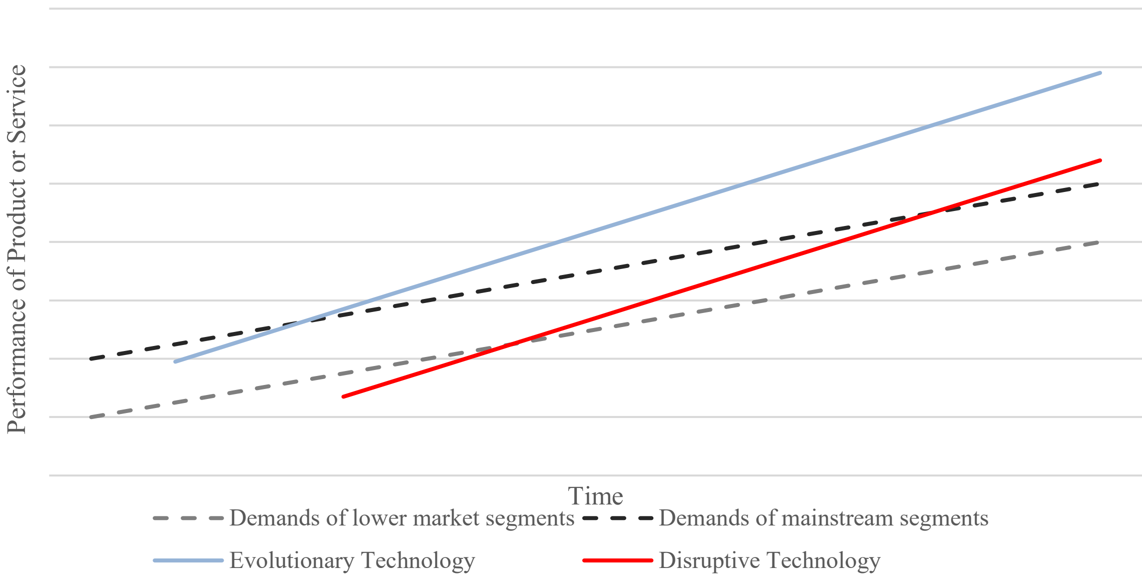

Figure 2. Schematic Display of Disruption Process (Christensen, & Matzler, 2013, p.7)

Figure 2 indicates how the performance of technology increases at a faster pace than demand in the respective market segments. While incumbents focus on evolutionary innovation in order to meet the most profitable customers' demands, the performance of the new entrant's disruptive technology is relatively weaker, and it targets less profitable market segments. However, the entrant's technology keeps improving and eventually it will meet the demands of the mainstream segments. Once this happens, the incumbents are displaced and the market has been disrupted.

2.2.3 Five Characteristics of a Disruptive Innovation

Christensen's initial version of *The Innovator's Dilemma* had quite an impact on the process of innovating and on reacting to innovations. However, while this initial version noticeably and in detail described the process of disruption, there is some ambiguity in its exact definitions (Tellis, 2006). For this reason, Tellis summarized Christensen's theory into five important characteristics that are displayed in Table 1. Christensen added these in later versions of his book (Christensen & Matzler, 2013).

Characteristic	Explanation
1. Initial Performance	*"A new disruptive technology initially underperforms the dominant one along the dimensions mainstream customers in major markets have historically valued."*
2. Product Feature	*"But the disruptive technology has other features a few fringe (and generally new) customers value. Products based on disruptive technologies are typically cheaper, simpler, smaller, or more convenient than those established on the dominant technology."*
3. Market Entry	*"The leading firms' most profitable customers generally do not want and indeed initially cannot use products based on disruptive technologies. So disruptive technologies are first commercialized in emerging or insignificant markets. Incumbents conclude that investing in disruptive technologies is not a rational financial decision for them."*
4. Performance Development	*"The new disruptive technology steadily improves in performance until it meets the standards of performance demanded by the mainstream market."*
5. Displacement of Dominant Incumbents	*"At that point, the new (disruptive) technology displaces the dominant one and the new entrant displaces the dominant incumbent(s) in the mainstream market."*

Table 1. Five Characteristics of Disruption (Tellis, 2006, p.34)

2.2.4 Different Types of Innovation

Unlike in the initial version of *The Innovator's Dilemma*, in his book *The Innovator's Solution*, Christensen differentiates between two types of disruptive innovations based on the target market of a product (Christensen, 2003). There are *Low Market Disruptions* on the one hand and *New Market Disruptions* on the other, which can be distinguished by the innovation's target customer group.[1] Besides these two types of disruptive innovations, Christensen discusses *Sustaining Innovations*, which focus on permanently improving products for an incumbent's most profitable customers (Denning, 2016).

2.3 Critique of the Theory

In 2015, Christensen wrote that his "disruption theory is in danger of becoming a victim of its own success" (Christensen et al., 2015, p.44). Being extremely popular, the initial for-

[1] Exhibit 1 in the appendix presents the differences between these two types in detail.

mulation of the theory often overshadows updates of it. Consequently, issues that have already been addressed are critiqued repeatedly. Ambiguity in the exact definition of disruption has been subject to much criticism, although Christensen added the five characteristics of disruptive innovation in a later version of his theory (Christensen & Matzler, 2013; Tellis, 2006).

Besides the lack of clarity in the initial definition of the theory, its usefulness to make ex-ante predictions has been questioned (Danneels, 2004). All the case studies Christensen used in his theory are successful examples of disruptive innovations which is why he has been accused of cherry-picking his examples. To be of use for managers, it is important for a framework to allow accurate decisions. However, very often, it is only possible afterwards to judge whether it was right or not to pursue or ignore an emerging technology (Doering & Parayre, 2000). Using Christensen's theory, mangers will have problems predicting the development of what customers will demand in the future, despite technological trajectories (Danneels, 2004).

As aforementioned, Christensen points out that one reason for the failure of incumbents is that they listen too carefully to their customers (Bower & Christensen, 1995). Therefore, his work has been referred to as an argument against customer orientation (Day, 1999). Slater and Narver (1998) opposed Christensen's claim that incumbents are prisoners of their own customers by stating that a truly customer-oriented firm understands its customers' needs, even if they do not specifically express these needs.[2]

Additionally, research suggests that innovations which ultimately transform an industry originate from incumbents most of the time (Cooper & Schendel, 1976). Moreover, there is evidence that, unlike Christensen claimed, there are also incumbents that succeed, despite disruptive innovations (King & Tucci, 2002). Contradicting Christensen's theory, King and Tucci found that incumbents are likely to enter niche segments of a market as well. As it seems that many, but not all, incumbents fail when a disruptive technology emerges, Christensen is critiqued for not answering the question: What ultimately determines if incumbents fail or succeed against disruptive innovations (Danneels, 2004)? Nevertheless, Chris-

[2] Christensen's response to this critique is outlined in Exhibit 2 in the appendix.

tensen's adjustments regarding the possibility of *Efficiency Innovations* and *Continuous Innovations* ensured the temporality of his theory, thus allowing it to serve as a basis for the subsequent analysis (Tellis, 2006).

3 Blockchain Technology: Underlying Technology, Potential Impact, and Application

3.1 Explanation of the Blockchain Technology

3.1.1 General Overview

In 1991, Haber and Stornetta first proposed the idea of cryptographic timestamps for securing digital data into a network of blocks (Haber & Stornetta, 1991). However, it was not until 2008 when this was initially implemented for setting up a blockchain for transactions of the cryptocurrency Bitcoin by its inventor, who worked under the pseudonym Satoshi Nakamoto (2008). While the Bitcoin itself hit the financial services industry several years ago, companies from many different industries have been focusing on the benefits of blockchain. Besides its use as the underlying technology of cryptocurrencies, blockchain provides great benefits if used as an intermediary or for data management. According to a prediction by the World Economic Forum (WEF), 10% of global gross domestic product (GDP) will be stored on blockchains by 2025, indicating how great the potential impact of the technology is (WEF, 2015).

In its most simplified form, blockchain uses mass collaboration and computer code to establish trust. Blockchain is an incorruptible DLT that can document transactions between several parties efficiently and in a verifiable, permanent, and decentralized way (Iansiti & Lakhani, 2017). These transactions can range from money and financial assets, such as stocks and bonds, to intellectual property or votes (FCCCO, 2018). The trust in the technology does not derive from banks, governments, or third-party intermediaries but from systematic network consensus, collaboration, and cryptography. Following the protocol of a blockchain for inter-node[3] communication and validation of new blocks, the blockchain is managed collectively by a Peer-to-Peer (P2P) network (Iansiti & Lakhani, 2017). In order to change data recorded in any given block, all subsequent blocks of the chain must be altered, which requires approval of the network majority. Due to the nature of its structure, blockchain is considered to be one of the safest ways to secure transactions (IBM, 2017).

[3] All participants in a Blockchain are referred to as nodes.

3.1.2 Mechanics of the Technology

Like a public ledger, blockchain can be regarded as a sequence of blocks, each of which contains a complete record of past transactions (Lee, 2015). The sequence keeps growing continuously every time a new block is added to it. Each block, which is basically a data package, can be subdivided into two parts, namely block header and block body. The block body comprises the information of all the blockchain's transactions (Nofer, Gomber, Hinz, & Schiereck, 2017). The block header includes the *Block Version*, the *Parent Block Hash*, the *Merkle Tree Root Hash*, a *Timestamp*, the *nBits,* and a *Nonce* (Zheng, Xie, Dai, Chen, & Wang, 2018). The table below provides explanations and functions of these terms:

Element of Block Header	Explanation
- *Block Version*	"Indicates which set of block validation rules to follow"
- *Parent Block Hash*	"A 256-bit hash value that points to the previous block"
- *Merkle Tree Root*	"The hash value of all the transactions in the block"
- *Timestamp*	"Current timestamp as seconds since 1970-01-01T00:00 UTC"
- *nBits*	"Current hashing target in a compact format"
- *Nonce*	"A 4-byte field, which usually starts with 0 and increases for every hash calculation"

Table 2. Elements of Block Header (Zheng et al., 2018, p.355)

According to Zheng et al. (2018) the structure of a block in the sequence can be illustrated in form of the figure below:

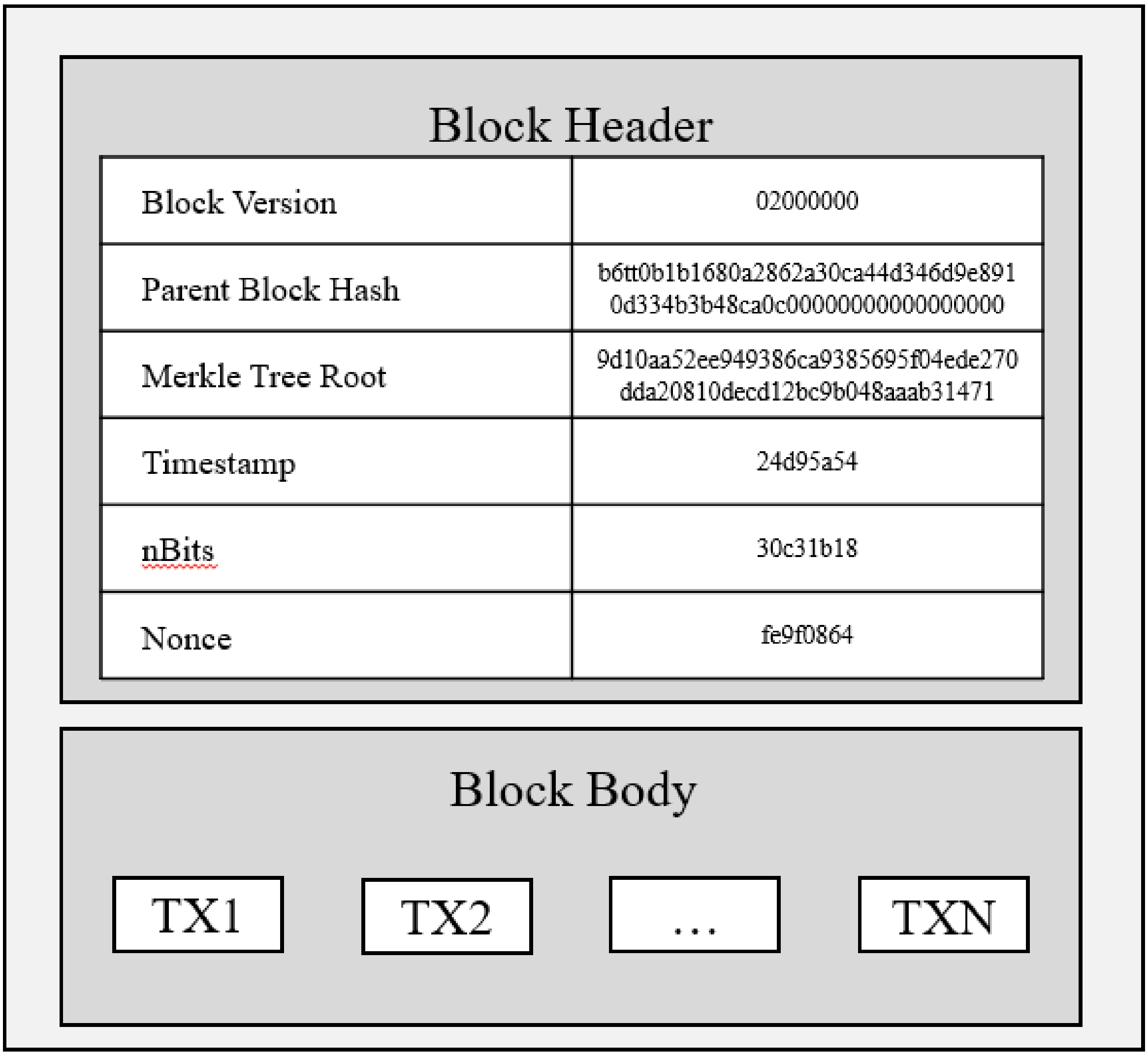

Figure 3. Block Structure (Zheng et al., 2018, p.356)

In the figure, the transactions of the blockchain in the block body are referred to as *TX1*, *TX2*, ..., *TXN*. These transactions can be subdivided into transactions and counter transactions. To validate the authentication of transactions, the DLT uses an asymmetric cryptography mechanism (Omohundro, 2014).

Both, the block size and the size of each transaction determine the maximum number of transactions a single block can contain (Zheng et al., 2018). A hash converts letters and numbers into an encrypted output of a predetermined length. The algorithms that are used to create hash values ensure the integrity of the blockchain (Nofer et al., 2017). Since the values are unique, changes of a block in the chain would immediately change the respective hash value. This way, the hash value effectively prevents fraud. To indicate the interconnectedness of blocks in a blockchain, the figure below outlines how the parent block hash always references to the previous block in the sequence (Zheng et al., 2018). Referred to as *Genesis Block*, the first block in the block chain is the only block without a parent block.

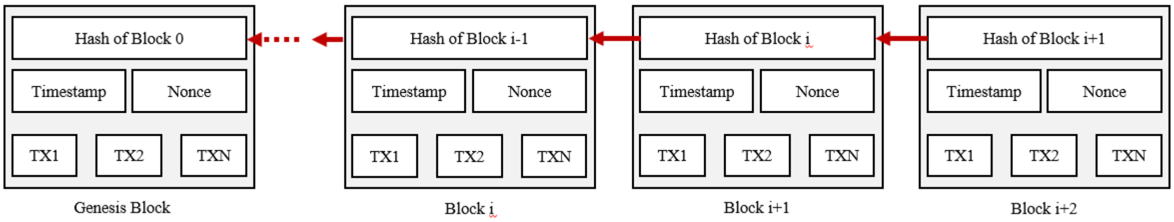

Figure 4. Illustration of a Blockchain (Zheng et al., 2018, p.355)

In order for a new block to be added to the chain, the majority of, if not all, nodes in the network need to agree by a consensus mechanism on the validity of the transactions in a block and on the validity of the block itself (Nofer et al., 2017). Consequently, new transactions are stored in a block for a certain time before being added to the distributed ledger due to the consensus process. The creation of blocks is usually carried out by so called miners who are rewarded for the validation with cryptocurrencies.

There are multiple approaches to consensus, such as *Proof of Work (PoW)*, *Proof of Stake (PoS)*, and *Practical byzantine fault tolerance (PBFT)*, all of which are varying in their nature of verifying blocks (Zheng et al., 2018). Exhibit 3 in the appendix further elaborates on these three consensus mechanisms. Once the information is verified and a block is added to the blockchain, the information can no longer be changed without the consensus of the nodes in the P2P network (Nofer et al., 2017).

Due to the nature of its technology, blockchain is characterized by four principles, which are Decentralization, Persistency, Anonymity, and Auditability (Zheng et al., 2018). Moreover, blockchain systems can be subdivided into three types, which are *Public Blockchain, Private Blockchain*, and *Consortium Blockchain* (Buterin, 2015). The principles and types are examined in Exhibit 4 and 5 in the appendix.

3.2 Potential Impact of the Blockchain Technology

As only ten years have passed since its implementation in 2008, it is difficult to tell whether blockchain will become a universal underlying technology behind a rejuvenated sharing economy, or whether it will just be beneficial for selected applications. There are voices conceding its potential to replace escrow services, but at the same time, other voices question if blockchain really is a cheaper, more secure, and easier solution than using a trusted third party (Comm, 2018).

However, most of the research provides a rather optimistic outlook. For example Tapscott and Tapscott (2016), who suggest that blockchain has the potential to disrupt any industry and to create a world in which people get to participate in the value that they create. The WEF suggests that 10% of the global GDP will be stored on blockchains by 2025 (WEF, 2015). The German consulting firm Roland Berger GmbH (2017), believes that companies who fail to implement blockchain in the future are at risk of losing tremendous amounts of market share within their industry. Indeed, blockchain represents a fundamentally new opportunity for businesses with its ability to cut out third parties. Especially the transaction-heavy financial services industry has the potential to be impacted tremendously by the DLT (Zheng et al., 2018).

Smart Contracts further increase the potential reach of blockchain. Based on a blockchain's transaction protocol, Smart Contracts are self-executing contracts (Voshmgir, 2016). Therefore, a transaction is only executed once all participants of a transaction meet pre-determined transaction rules. These rules are integrated in the program code of the Smart Contract. Transaction partners do not need a centralized third party any longer, since trust in the other participants is ensured by the Smart Contract.

Besides the aforementioned advantages, which derive from the technology's characteristics, blockchain will not lose its functionalities if some nodes in the network break down. This makes the technology extremely reliable, thus increasing its potential (Nofer et al., 2017). All of these benefits and the capability of Smart Contracts suggest an enormous potential for the technology, especially as underlying technology for cryptocurrencies or in its ability to store data and to function as an intermediary.

3.3 Application of the Blockchain Technology

In 2017 alone, more than $1 billion was invested into blockchain startups worldwide across many different industries (CB Insights, n.d.).[4][5] In addition to this, many established companies invested millions of dollars into research and development (R&D) of the technology (Tama et al., 2017). However, many startups working on blockchain applications have not implemented their solutions yet, which makes it harder to assess the impact and potential of the technology. Nonetheless, a substantial number of blockchain solutions and applications have already been implemented successfully.

The financial services industry is not just among the industries that are believed to be impacted most by blockchain (Tama et al., 2017). It is also an industry in which the technology has already been applied widely. Since blockchain was initially introduced as the underlying technology of Bitcoin, its most common application to this point has been in cryptocurrencies. Bitcoin's cumulative market capitalization was $66 billion in December 2018 (Blockchain, n.d.).

Besides its application for cryptocurrencies, the blockchain technology is already used in other areas as well. For example, blockchain and Smart Contracts are applied by Internet-of-Things (IoT)[6] platforms, such as Slock, a bicycle rental platform, that allows its customers to unlock a smart lock after both parties fulfilled the pre-determined terms of a Smart Contract (Rampton, 2018). In manufacturing, blockchain is used for numerous different purposes. Blockverify (2018), for example, provides a blockchain-based anti-counterfeit solution that identifies counterfeit products, diverted goods, stolen merchandise, and fraudulent transactions. Among the products for which this solution can be used are pharmaceuticals, luxury items, diamonds, and electronics. Transparency of the supply-chain is also the primary goal of numerous other blockchain-based approaches (Marr, 2018). Besides these and other applications in the presented fields, blockchain is applied in areas such as Cybersecurity, Healthcare, Government, Charity, Retail, Real Estate, as well as Transport and Tourism.

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[4] Exhibit 6 provides and overview over the industries blockchain could potentially disrupt.
[5] The development of investments in blockchain startups is presented in Exhibit 7 in the appendix.
[6] IoT applications are designed to create smart spaces between everyday objects that are interconnected and communicate via the internet (Mukhopadhyay, 2014).

4 Disruptive Impact of Blockchain as the Underlying Technology for Payment Methods

4.1 General Overview of Payment Methods

The volume of global online purchases has increased tremendously in recent years and is expected to reach $4 trillion in 2020 (eMarketer, n.d.). Electronic payment providers, such as PayPal, have become popular and threats to established incumbents such as Mastercard and Visa ("Impact of PayPal, Google, Amazon & Emerging Payment Providers on Visa, MasterCard & Payments Industry", 2010) are evident. Even Cryptocurrencies, such as Bitcoin, are already the preferred payment method for 2% of all online shoppers (CIGI, n.d.). The figure below indicates the preferred payment methods for online purchases worldwide as of March 2017.

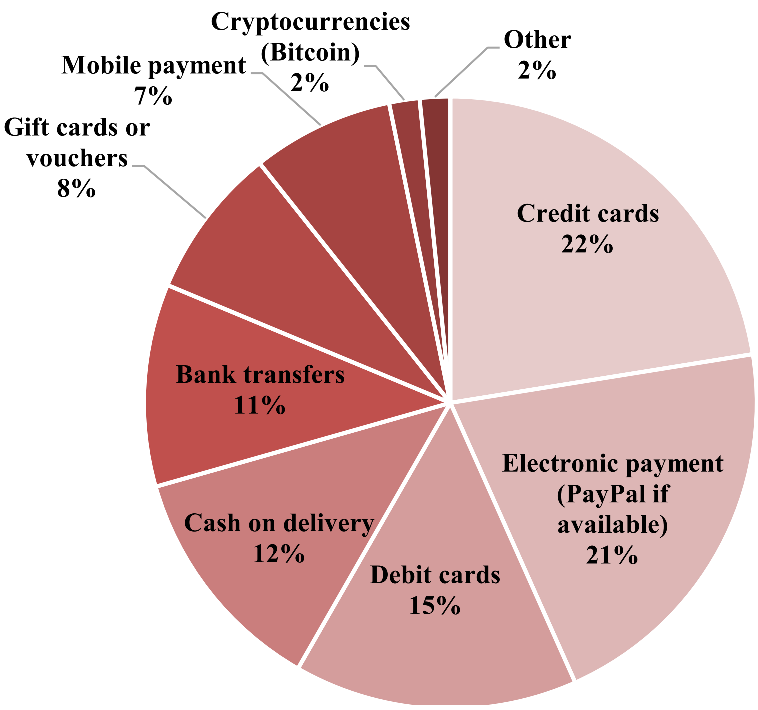

Figure 5. Preferred Payment Methods of Online Shoppers Worldwide as of March 2017 (CIGI, n.d.)

However, the preferred payment methods vary a lot between different geographical regions and cultures. Credit cards, for example, were used for only 11% of online purchases in Germany in 2017 (EHI Retail Institute, n.d.). In the US, they were used for 29% of online purchases in the same period (Wirecard, n.d.). Moreover, research indicates that the costs of different payment methods for retailers vary significantly, based on the amount owed by the customer (Grüschow, Kemper, & Brettel, 2016).

In order to analyze the potentially disruptive impact blockchain might have on payment methods, it is necessary to look at what characteristics customers value when it comes to selecting a payment option. The annual Survey of Consumers Payment Coice (SCPC) by the Federal Reserve Bank of Boston found that among other factors, the *security*, the *cost*, and the *convenience* of a payment method are the key dimensions for most customers (Greene & Stavins, 2018). Therefore, these factors will be considered in the analysis. The following table provides further details on each of the three dimensions:

Factor	**Explanation**
Security	Consumers are worried about data insecurity and fraud when paying online (Kwon & Lee, 2003). Research found that 66% of consumers are "extremely" or "very" concerned about their bankcard data being stolen or abused ("2018 UNISYS Security Index", 2018).
Cost	"The cost of payment instruments is one of the most important characteristics affecting payment choice" (Stavins, 2017, p.15). Among the costs that are significant for explaining consumers' choice of payment method are: opportunity cost, transaction cost, and handling cost (Klee, 2008).
Convenience	Besides the complexity of a payment method, its convenience is particularly influenced by its speed (Schuh & Stavins, 2015). However, at a certain level of convenience, the security might potentially be impacted.

Table 3. Factors Impacting Payment Selection

4.2 The Influence Blockchain has on Payment Methods

In the form of cryptocurrencies, the blockchain technology has started to impact consumers' payment choices in recent years. Due to its decentralized mechanics that make it almost impossible to change a transaction record, blockchain is one of the most attractive technologies for developing new payment methods (Brown, 2018). It is believed to improve the security, increase the speed, and reduce the cost of transactions. These benefits derive from the technology's ability to facilitate P2P and direct transactions as well as cross-border and cross-currency transactions (Yuan & Wang, 2018).

Additionally, there are numerous other applications of the blockchain technology that impact payment methods. Ripple, for example, has been using blockchain to make cash transfers more efficient ("One Frictionless Experiment to Send Money Globally", 2018). Using the DLT, they created a network, which connects banks and payment providers to enable its users to send and receive money.

While many people became aware of blockchain-based cryptocurrencies as alternative investments, few have yet been using it as a method to pay (CIGI, n.d.). It remains to be seen, to what extent the crash of Bitcoin in 2018 has had a negative impact on the reputation of cryptocurrencies. Thus, it is possible that customers might abstain from using cryptocurrencies for payments in the future, or that they first resort to other means of more conventional cashless payments. Nonetheless, it seems possible that the blockchain technology, in the form of cryptocurrencies, could turn out to be disruptive for payment methods.

4.3 Example of Application: Cryptocurrencies

To analyze whether the blockchain technology may have a disruptive impact on payment methods, we will analyze cryptocurrencies more in detail.[7] We will do so by assessing the extent of how cryptocurrencies, Bitcoin in particular, fulfill the previously introduced five characteristics of disruption by Tellis (2016).

4.3.1 Overview Cryptocurrencies

In early 2019, the cumulative market capitalization of cryptocurrencies was estimated to be $128,848,088,183 and the number of cryptocurrencies to be 2,082 ("Top 100 Cryptocurrencies by Market Capitalization", 2019). With its share of more than 51%, *Bitcoin* dominates the market. The initial cryptocurrency is followed by *Ethereum* and *XRP* with market shares of 12% and 11% respectively.[8] As aforementioned, the creation of cryptocurrencies goes back to Nakamoto (2008). On January 4, 2009, he created the genesis block of the cryptocurrency Bitcoin, and a week later he sent ten Bitcoins to another cryptographer, which is generally considered the first transaction with a cryptocurrency (Yuan & Wang, 2018). More than a year later, in May 2010, a programmer used 10,000 Bitcoin to buy two pizzas for $25, giving the Bitcoin its initial exchange rate. Since then, the value of the cryptocurrency has increased to almost $20,000 for one Bitcoin in late 2017. However, this rapid increase was succeeded by a drastic crash taking the price of one Bitcoin down to $3,790 as of January 4, 2019 from a maximum of $19,783.06 on December 17, 2017(Daxhammer & Facsar, 2018; "Top 100 Cryptocurrencies by Market Capitalization", 2019).

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[7] The scope of this paper does not allow for an analysis of every application with which blockchain could potentially disrupt currencies.
[8] Exhibit 8 in the appendix provides an overview over the leading cryptocurrencies.

Each cryptocurrency has slightly different mechanics but usually with the following components: a *public shared blockchain ledger*, a *distributed P2P networking system*, a *decentralized consensus algorithm*, a *well-designed economic incentive mechanism*, and *programmable Smart Contracts* (Yuan & Wang, 2018). Cryptocurrencies are generated in distributed systems and their issuance relies on a consensus process within a P2P network instead of a central authority. Bitcoin, for example, relies on PoW-based mining. Its miners in the P2P network compete to create new blocks in the chain, which include the latest transactions. The winning miner of the consensus competition gains the right to create this block and is rewarded with Bitcoin if it is approved by other nodes and included in the main chain.

This incentive also encourages other miners to contribute their computing power to the network. The approval by a certain number of nodes in the P2P networks and the use of cryptography with each transaction being hashed, ensure that the transactions are valid and that no alterations in the transactions can be made afterwards. The use of Smart Contracts allows the automatic circulation of cryptocurrencies.

4.3.2 Is Blockchain Potentially Disruptive for Payment Methods?

4.3.2.1 Initial Performance

According to Tellis' five characteristics of disruption (2006), a disruptive product or service is, among other factors, defined by its initial performance. When it is launched, it underperforms in at least one criterion that has been historically valued by mainstream customers compared to an incumbent's product or service. Therefore, three criteria that are valued by customers when it comes to selecting a payment method have been determined in section 4.1 based on a literature review. To recapitulate, these criteria are the *security*, the *cost*, and the *convenience* of a payment method (Greene & Stavins, 2018):

Security: When shopping online, the safest payment method is paying cash at delivery, as no bank account information is ever published on the internet. However, when it comes to paying online, the underlying DLT of most cryptocurrencies makes the actual payment safer than most other transaction methods (IBM, 2017). This is due to the replacement of third-party intermediaries by a systematic network consensus and cryptography. However, the security of cryptocurrencies and most other forms of online payment is threatened by increased computational power and advanced cryptanalysis (Giechaskiel, Cremers, & Rasmussen, 2018). The tremendous increase in value of many cryptocurrencies serves as a further incentive for people to attempt breaking the highly complex and secure blockchains behind cryptocurrencies. Another risk of paying with cryptocurrencies derives from its novelty. Unlike with credit or debit cards there are no laws and regulations in place that specify the rights and responsibilities of each party in the transaction (Quora, 2018). If credit card information is used fraudulently, for example, the owner's liability is limited by a legal framework. However, this is not the case with cryptocurrencies due to the absence of intermediaries and the fact that they were particularly designed to operate independently of any regulatory structure. Consequently, it could be argued that, despite its complexity and its cryptography, the initial performance of cryptocurrencies regarding their safety is weaker than the safety of dominant payment methods at this point.

Cost: Due to the necessity of third-party intermediaries, the customer faces additional costs when using dominant payment methods, such as credit cards. Especially in times of low interest rates, banks and other intermediaries tend to charge their customers even more in fees (Kashian & Drago, 2016). Due to the ability of cryptocurrencies to eliminate intermediaries, they reduce transaction costs. This leads to a great impact particularly on international money transactions, which are usually loaded with transaction fees (Beck, Avital, Rossi, & Thatcher, 2017). Consequently, the initial performance of cryptocurrencies regarding cost is at least as strong, if not stronger, than the currently dominating payment methods.

Convenience: The convenience of a payment method could potentially interfere with its security. The less data and information are needed for a payment, the more convenient it is, but the higher the chances of fraud become as well. Cryptocurrencies, especially when connected to Smart Contracts, could potentially contradict the above-mentioned correlation. As aforementioned, Smart Contracts are self-executing contracts, which allow a transaction to be executed automatically only if pre-determined transaction rules are met by all participants in a transaction (Voshmgir, 2016). If this can be accomplished, the performance of cryptocurrencies in terms of convenience could be considered at least as high as the convenience of other payment methods. However, the increased convenience for the user still results in a small transaction fee, to compensate the miner for the laborious PoW process.

Neither cost, nor convenience of cryptocurrencies fulfill the *Initial Performance* characteristic of a disruption process as the performance in these areas is not necessarily weaker than the performance of the currently dominating payment methods. In terms of security, however, it could be argued that cryptocurrencies underperform compared to the prevailing payment methods. This is not because of its underlying technology, but because of its lack of regulation and laws. Due to this underperformance, the *Initial Performance* characteristic could be considered fulfilled.

4.3.2.2 Product Feature

Second, disruptions are also characterized by a new *Product Feature* that only a few customers in niche segments value or consider beneficial (Tellis, 2006). As mentioned in the previous section, cryptocurrencies could be considered less secure compared to other payment methods due to their lack of regulations. Because of regulations and laws for dominant payment methods, the mainstream customers liability is limited even in cases of fraud.

However, the absence of official regulations for cryptocurrencies and the anonymity resulting from the decentralization of the underlying blockchain technology, are features that make them attractive for some people and certain types of payments (Quora, 2018). This, in addition to reduced transaction cost, is particularly useful for fast, worldwide, cross-border transactions (Chan, Chu, Nadarajah, & Osterrieder., 2017). With only 13% of online shopping in the US and only 18% in Europe being cross-border, international payments could be considered a niche (Tamturk, 2017). Therefore, the second of the five criteria for a disruptive innovation would be fulfilled.

4.3.2.3 Market Entry

Third, the *Market Entry* of an innovation needs to be looked at in order to determine whether cryptocurrencies are disruptive or not. According to Tellis (2006), an innovation can be considered disruptive if it enters the market through an emerging or insignificant market segment because it is not valued by the most profitable customers of incumbents. Therefore, these leading companies conclude that it is not worth investing in the innovation.

Whether cryptocurrencies match this criterion is difficult to determine, partly because the definition of the criterion is ambiguous. As outlined in the previous section, cryptocurrencies are currently more beneficial for niche markets, especially for cross-border transactions. This is also underlined by the fact that cryptocurrencies have been used by less than two percent of online shoppers (CIGI, n.d.). Therefore, the first part of the criterion's definition could be considered fulfilled. However, the second part of it, with the incumbents ignoring the innovation, is not fulfilled since leading companies have invested millions of dollars into R&D of the technology (Tama, Kweka, Park, & Rhee, 2017). Additionally, it is widely believed that the blockchain technology and cryptocurrencies will have a tremendous impact on the financial services industry, which is why the technology is far from being ignored or underestimated. Besides the high investments in the technology, the potential relevance of cryptocurrencies is also indicated by the fact that Bitcoin derivatives can be traded at the Chicago Mercantile Exchange (CME) since 2018.

Since the first part of the criterion is met, it could be argued that cryptocurrencies partially fulfill the *Market Entry* criterion. However, the R&D investments and the awareness of the impact cryptocurrencies could have rather suggest that they are not ignored by incumbents. Based on this, the third criterion of a disruptive innovation is not fulfilled.

4.3.2.4 Development of Performance

The fourth characteristic of a disruption process considers the *Product Performance* of an innovation. While it initially underperforms compared to the dominant products in some dimensions that have been of value for mainstream customers, it steadily improves its performance until the performance meets the demands in the mainstream market. By the beginning of 2019, it is not possible to tell whether this will be the case. Undoubtedly, the performance of cryptocurrencies has been improving and will do so in the future, especially with the use of Smart Contracts. However, it remains to be seen whether it will be enough to meet the demands of the mainstream customers. Therefore, it is not yet possible to determine if the fourth characteristic is fulfilled.

4.3.2.5 Displacement of Dominant Incumbents

Similarly to the fourth characteristic of disruptive innovation, the fifth, which is the *Displacement of Dominant Incumbents*, cannot be determined as fulfilled or unfulfilled at this point. Research shows that providers of dominant payment methods such as banks and credit card providers, including Mastercard and Visa, have been under pressure ("Impact of PayPal, Google, Amazon & Emerging Payment Providers on Visa, MasterCard & Payments Industry", 2010). However, this pressure mainly originates from other payment providers such as PayPal. Therefore, it remains to be seen whether cryptocurrencies will be able to displace dominant incumbents. Until then, it is not possible to tell if the fifth characteristic of disruptive innovation is fulfilled.

4.3.3 Conclusion

What has been criticized about Christensen's theory is that it is difficult to use for ex-ante predictions (Danneels, 2004). The analysis whether cryptocurrencies can be considered a disruptive innovation serves as an example for this. Although more than ten years have passed since the introduction of the cryptocurrency Bitcoin, it is not possible to tell if all the criteria that define a disruptive innovation are fulfilled. Especially for the *Performance Development* and the *Displacement of Dominant Incumbents* characteristics, it is only possible to speculate what will happen.

Even without considering the fourth and fifth criteria, cryptocurrencies may not be considered disruptive. While the *Initial Performance* and the *Product Feature* characteristics could be considered fulfilled, the *Market Entry* characteristic is not met. Unlike the criterion requires, cryptocurrencies are neither ignored nor underestimated by incumbents, which can be seen by the investments in the technology of such firms. However, just because cryptocurrencies may not be considered a disruptive innovation, their impact has been and will be immense. The reduced cost due the absence of intermediaries, the use of Smart Contracts, and the anonymity the technology provides will contribute to this. Additionally, on-going globalization would lead to an increase in cross-border transactions which promote the use of cryptocurrencies even further (Tamturk, 2017).

To conclude, it can be stated that the impact cryptocurrencies have will be enormous, but not disruptive as the table below indicates. However, more time is needed to determine the exact impact this application of the blockchain technology will have.

Characteristic	**Fulfillment**
1. Initial Performance	✓
2. Product Feature	✓
3. Market Entry	✗
4. Performance Development	?
5. Displacement of Dominant Incumbents	?

Table 4. Results of Analysis of Cryptocurrencies

5 Disruptive Impact of Blockchain as an Intermediary

5.1 General Overview on Intermediaries

The term *intermediary* has its origins in the 18^{th} century and derives from the French word “intermédiaire” (“Intermediary”, n.d.). It describes a person or organization that acts as a link, “third party”, between a minimum of two parties in order to bring about an agreement. The existence of intermediaries and their benefits are dealt with in an area referred to as intermediation theory. The key findings of this theory relate to asymmetric information and transaction cost (Allen & Santomero, 1997). According to Diamond (1984) intermediaries have the ability to overcome asymmetric information by acting as delegated monitors.

Intermediaries are used in any field or industry where transactions are of importance. They can include: intermediaries for C2C transactions, like AirBnB; intermediaries for B2C transactions, like electricity and energy providers; and B2B transactions, for example in the supply chain of manufacturers (Yoo, Choudhary, & Mukhopadhyay, 2002). Unfortunately, because of the enormous influence many intermediaries have gained, they have become an increasing part of bribery schemes which impacted the reliability of certain intermediaries (Foreign Corrupt Practices Act Clearinghouse, n.d.). However, reliability is a crucial characteristic for an intermediary, as many customers and businesses rely on their mediation in connecting activities.

For these reasons, *Transaction Cost*, *Asymmetric Information*, and *Reliability*, were selected as the three criteria valued by the mainstream market to be considered in the analysis. The table below provides an overview of the three dimensions:

Factor	Explanation
Transaction Cost	Initially, one of the main benefits of intermediaries was their ability to share fixed costs which reduced the overall transaction costs (Allen & Santomero, 1997). However, it is possible that using intermediaries is more expensive for customers due to the fees intermediaries charge (Diamond, 1984).

Asymmetric Information	Another great benefit of using intermediaries is their ability to overcome asymmetric information. Being a delegated monitor, they have a better knowledge of all participating parties in a transaction (Diamond, 1984).
Reliability	As the number of intermediaries increases, more and more customers and businesses depend on them (Edelman, 2014). Therefore, it is crucial for intermediaries to act as neutral, reliable, and trusted third parties.

Table 5. Factors Impacting Intermediaries

5.2 The Influence Blockchain has as an Intermediary

Due to the nature of the technology, blockchain has a great potential to replace many intermediaries (Tapscott & Tapscott, 2017). While intermediaries are generally considered to be useful third-party institutions, there are certain issues. To begin with, most of the criticism about intermediaries derives from their way of operating centrally. Because of this, the servers they use are vulnerable to hacks, fraud, and crashes. Moreover, this allows intermediaries to operate with little transparency and to collect customers data for their own uses. As aforementioned, intermediaries are useful to reduce transaction cost (Allen & Santomero, 1997). However, it is possible that due to charges, the use of intermediaries is still relatively expensive (Diamond, 1984).

With its ability to replace intermediaries, the blockchain technology could be the solution to some of these problems (Tapscott & Tapscott, 2017). As the DLT runs on computers provided by volunteers all over the world in the P2P network and uses encryption, it makes hacking and fraud almost impossible. Moreover, public blockchains are extremely transparent, which resolves another problem with intermediaries. Finally, with the verification through the P2P network instead of a central institution, transaction costs are further reduced as very few charges occur for the verification, which are usually paid for directly by the user who makes a transaction on the network. However, there is also literature that suggests intermediaries will not become obsolete because of blockchain, but rather that they will play a different role (Catalini & Gans, 2016). For Example, instead of having access to all transactions, an intermediary might only gain access to individual transactions if a problem occurs.

5.3 Example of Application: Microgrids

In order to analyze whether the blockchain technology poses a disruptive threat for intermediaries, the five characteristics of disruption serve as a framework again. This section uses microgrids in the energy market as an example. Consequently, the analysis does not allow general judgement about what impact blockchain might have when applied as an intermediary in the financial industry. Some similarities do exist, though.

5.3.1 Introduction

Microgrids are locally restricted energy networks that coordinate supply and demand of electricity (Lo Prete & Hobbs, 2016). They consist of multiple distributed generation units and loads which operate as a coordinated system. While a microgrid could sustain itself, in most cases, it is still connected to the main electricity grid. A microgrid could be a housing community or a neighborhood in which inhabitants use solar panels to generate renewable energy. Being part of the same microgrid, the inhabitants can trade electricity amongst each other. This way, so called prosumers - people that produce and consume a product, gain access to the electricity market (Green & Newman, 2017). Ideally, the peers trade energy directly with each other without intermediation by conventional energy suppliers (Zhang, Wu, Zhou, Cheng, & Long, 2018).

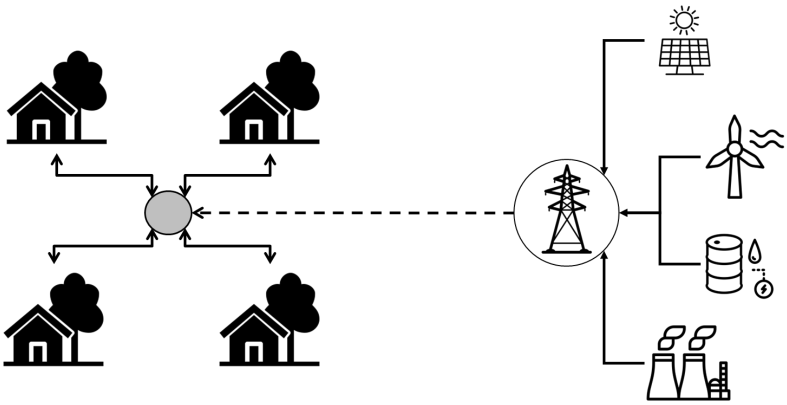

Figure 6. Schematic Display of Microgrid (Own Figure)

One benefit of a well-functioning microgrid is the reduction of energy cost and it additionally serves as an incentive for further investment in renewable energy sources (Coelho, Weiss Cohen, Coelho, Liu, & Gadelha Guimarães, 2017). Moreover, it leads to a decentralized infrastructure and it facilitates maintenance. All of these factors increase the microgrid's independence from the main electricity grid while it provides market access for prosumers at the same time.

If microgrids, and electricity grids in general, include operational and energy measures such as smart meters and smart appliances, the grid is referred to as a smart grid (Farhangi, 2010). It provides two-way communication, as consumers are empowered to interact with the energy management system. Moreover, information technology (IT) plays a crucial role in a smart grid, as it balances supply and demand while minimizing operational and maintenance costs.

With its decentralized consensus mechanism in a P2P network, the blockchain technology is believed to play a crucial role in microgrids, potentially making intermediation by conventional energy suppliers obsolete (Green & Newman, 2017). Some models suggest a P2P microgrid, which enables prosumers to trade energy locally with each other via a smart management system (Sabounchi & Wei, 2017). In these models, transactions are executed in a decentralized manner by leveraging blockchain technologies. Thus, Smart Contracts and verification in the P2P network are incorporated to build trust in the network and to enable prosumers in the microgrid to buy and sell energy in a real-time, auction-based manner. Depending on the desired degree of transparency by the peers, a public or a private blockchain solution can be employed (Pop et al., 2018; Aitzhan & Svetinovic, 2018).

Numerous startups and other initiatives have been working on blockchain solutions for microgrids, some of which have been implemented already (BDEW, 2017). For example, the US startup Lo3 Energy has created a permissioned data platform that creates localized energy marketplaces for transacting energy across existing grid infrastructure ("Reshaping the Energy Future", 2018). Using the blockchain technology, Lo3 Energy created the "Brooklyn Network", the first P2P energy trading solution for prosumers in history, by connecting neighboring residents. The success of this and many other projects, as well as the increasing necessity for renewable energy resources indicate the high potential of the blockchain technology being used as an intermediary in this area (BDEW, 2017). Therefore, the following section analyzes whether the tremendous impact of the technology could be disruptive.

5.3.2 Is Blockchain Potentially Disruptive for Electricity Grids?

5.3.2.1 Initial Performance

In order to be considered a disruptive innovation, the *Initial Performance* of a product or service must be weaker in a dimension that has been valued historically by the mainstream market (Tellis, 2006). In the previous sections, *Low Transaction Cost*, the overcoming of *Asymmetric Information*, and *Reliability* were identified as three dimensions which are considered crucial for intermediaries.

Low Transaction Cost: The use of blockchain in microgrids reduces transaction costs even further (Mylrea & Gourisetti, 2017). Instead of paying high charges to a central third-party intermediary for executing trades, the P2P validation by the network members does not create additional cost, other than a small charge directly associated with the validation. Moreover, the use of Smart Contracts increases the trust and allows the system to execute transactions automatically if the predetermined conditions in the contract are met. As the transaction costs with blockchain as an intermediary in microgrids are lower, the initial performance of the technology is stronger compared to third-party intermediaries.

Asymmetric Information: As aforementioned, the blockchain technology is extremely transparent. Even if a private instead of a public blockchain is used, the prosumers in a microgrid do not have to fear asymmetric information. Smart Contracts ensure that transaction partners fulfill all predetermined and relevant conditions. Therefore, the initial performance of a blockchain solution is at least as strong as the performance of third-party intermediaries. Moreover, it could even be argued that it is better, as blockchain is much more transparent.

Reliability: In terms of the initial performance regarding reliability, arguments for both a weaker as well as a stronger performance of blockchain solutions compared to third-party intermediaries can be found. When considering data security and protection from fraud, the blockchain solution outperforms third-party intermediaries due to its higher transparency. In terms of providing electricity, the decentral mode of operating via a blockchain microgrid is often considered an advantage (Coelho et al., 2017). However, at times it might be possible that the demand in a microgrid is higher than the supply. In these cases, a solution with intermediation by a conventional energy supplier outperforms the blockchain solution, as it can meet the demand by simply providing electricity from the main grid. Consequently, it could be argued either way regarding the reliability. However, the fact that most microgrids are still connected to the main grid, despite the local P2P trade, could be considered as an indicator that, in terms of reliability, blockchain solutions perform slightly weaker than solutions with conventional energy providers as an intermediary.

Neither the *Low Transaction Cost,* nor the *Asymmetric Information* criterion fulfill what the first characteristic of disruption demands. Regarding the *Reliability* criterion, it was hard to determine whether the initial performance is weaker or stronger. However, it is reasonable to assumed that blockchain solutions could be considered slightly less reliable since most microgrids are still connected to the main grid. Therefore, the first characteristic of a disruptive innovation is fulfilled.

5.3.2.2 Product Feature

To meet the second characteristic of a disruptive innovation, the product or service considered must provide a new *Product Feature*, which is not valued by the mainstream customers but only by a niche market (Tellis, 2006). Assuming the mainstream market in this case to be everyone who is supplied by the main electricity grid and everyone who is part of a microgrid with intermediation by a conventional energy supplier, it is difficult to find such a product feature. This derives from the fact that all product features the blockchain solution brings along, seem to be desired by the mainstream market and not just by a niche.[9] Therefore, the second of the five characteristics is not fulfilled.

5.3.2.3 Market Entry

A product or service fulfills the third characteristic of disruption, if it entered the market via an emerging or insignificant market. For blockchain solutions in a microgrid electricity market this applies, since the technology was first implemented in microgrids with prosumers. Intermediation by blockchain is most beneficial in a community where people generate their own electricity and trade it amongst each other. As less than 20% of all houseowners in Germany have installed solar panels and less than 7% of electricity in Germany is generated using solar panels, this can be considered an emerging market, especially since the number of prosumers tends to be even lower in other countries (AGEB, n.d.). Consequently, this characteristic is fulfilled.

5.3.2.4 Development of Performance

As indicated in previous sections, the only dimension that has been historically valued by mainstream customers and in which a blockchain solution underperforms was *Reliability*. Therefore, the *Performance Development* in this dimension must be regarded to analyze the fourth characteristic. Undoubtedly, the performance of blockchain solutions in a microgrid energy market will increase further. However, as the solution only aims at taking over intermediating tasks, it will never be able to provide electricity from the main grid in a way an intermediating conventional energy supplier can. Consequently, local blockchain

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[9] As it is impossible to prove for sure that something does not exist, it is possible that there is a product feature only desired by a niche the author is not aware of.

solutions will always be slightly less reliable in situations where a microgrid is not self-sustaining. Therefore, the characteristic is not fulfilled.

5.3.2.5 Displacement of Dominant Incumbents

As indicated in the previous section, it is very unlikely that incumbents will be completely displaced. Much more likely, and this is also what the literature suggests, their role will change, and their influence could decrease (Farhangi, 2010). Over time, the electricity grid could become increasingly decentralized because of the benefits blockchain provides as an intermediary in microgrids. Nevertheless, conventional energy suppliers will still play a significant role if the demand does not match the supply in microgrids. It is not yet possible to tell for sure whether incumbents will not be displaced, but as there are clear indicators that they will not, the fifth characteristic is not considered fulfilled.

5.3.3 Conclusion

With its decentralized consensus mechanism and its P2P validation, the blockchain technology is ideal for fulfilling intermediating tasks. Especially if the technology is connected to Smart Contracts, it serves and will serve as a useful intermediary in many fields and industries where transactions occur frequently. In microgrids too, blockchain-based intermediaries will have a big impact and will contribute to the decentralization of the electricity grid.

However, the impact the technology has as an intermediary will most likely not be disruptive. The literature agrees that as an intermediary, blockchain will most likely follow evolutionary trajectories instead of being the trigger for a drastic overhaul (Farhangi, 2010). In general, it is commonly believed that blockchain will not make intermediaries obsolete and displace them, but rather change their roles. This could derive from the fact that most of today's third-party intermediaries perform not only intermediating tasks but have a greater interest in the transactions themselves. In many microgrids, for example, conventional energy providers are executing the intermediating task between the prosumers, but they also supply the participants with electricity if the demand exceeds the supply. This is also part of the reason why the fourth and fifth characteristic are not fulfilled in the microgrid example. Neither was the second characteristic fulfilled, as there were no identified features valued by a niche and not the mainstream market. Regarding the initial performance, blockchain solutions fulfill this characteristic, as they are considered slightly less reliable than intermediating conventional energy suppliers. Additionally, the market entry characteristic is fulfilled, since prosumers of electricity are members of an emerging market. Overall, the potential of blockchain as an intermediary is immense. However, in the energy market, the technology will probably not be disruptive.

Characteristic	Fulfillment
1. Initial Performance	✓
2. Product Feature	✗
3. Market Entry	✓
4. Performance Development	✗
5. Displacement of Dominant Incumbents	✗

Table 6. Results of Analysis of Blockchain in Microgrids

6 Disruptive Impact of Blockchain on Data Transfer and Storage

6.1 General Overview on Data Transfer and Storage

In May 2017, the Economist claimed that "The world's most valuable resource is no longer oil, but data" (2017). While only 0.1 zettabytes of data were created worldwide in 2005, the amount has increased drastically since then and is expected to reach 47 zettabytes in 2020 and 163 zettabytes in 2025 (Kleiner Perkins Caufield & Byers, n.d.). Moreover, the importance of data is indicated by the impact the Big Data industry has had in recent years (SiliconANGLE, n.d.). However, industries have realized that by saving as much data as possible, they face storage restrictions sooner rather than later (Hashem et al., 2015). Therefore, capacity is a crucial factor to consider when analyzing solutions for storing and transferring data.

Another very important dimension, if not the most important, when storing and transferring data is protecting privacy (FCCCO, 2018). After severe breaches of data security in the past, companies have invested billions of dollars in protecting their clients' data (Kahn, Bodoni, & Nicola, 2018). Failure of this could be extremely costly for companies, as laws are in place now to punish security breaches in data management. According to the European Union's General Data Protection Regulation (GDPR), fines for companies can be as high as 4% of their annual revenue. Therefore, privacy protection is of tremendous importance for both providers and users of data management solutions.

Finally, accessibility is a third important dimension in data transfer and storage (Chen, Mao, & Lie, 2014). This includes, among other factors, user-friendliness and the speed of transactions. This is because the best protected and most capable data storage solution will be useless if the interface is poor or transaction speed is low because of laborious validation processes. Thus, the accessibility determines how fast data can be accessed and analyzed and is therefore of utmost importance.

For the abovementioned reasons, *Capacity*, *Privacy Protection*, and *Accessibility* were selected as three dimensions for the analysis:

Factor	Explanation
Capacity	This dimension considers the amount of data that can be stored or transferred by a solution. It has become increasingly important as storage restrictions limit the impact Big Data and Data Management can have (Hashem et al., 2015).
Privacy Protection	This dimension is not just crucial for the trust customers have in a company, it could also have a tremendous impact on a company's financial well-being as fines for data leaks are considerable (Kahn et al., 2018).
Accessibility	The third dimension is primarily concerned with transaction speed and user-friendliness as these factors determine the convenience of data analysis (Chen et al., 2014).

Table 7. Factors Impacting Data Transfer and Storage

6.2 The Influence Blockchain has on Data Transfer and Storage

As emphasized earlier in this paper, blockchain technology is of great use for transaction-based applications. Since data management largely depends on transactions, the impact blockchain will have is quite considerable. However, it is worth noting that the technology was originally not designed to store digital documents (Vo, Kundu, & Mohania, 2018). This derives from the relatively large size of digital documents and the fact that the size of a blockchain increases permanently as old transactions are saved while new ones are added. This results in several constraints of the blockchain for data management, such as storage size, bandwidth and transaction throughput. A possible solution to these constraints is to use blockchain-based platforms for data-verification and transactions but connect the platforms to offline storage where the data, including a digital hash, is stored.

As introduced third chapter, there are three different types of blockchains, depending on the writing and reading rights (Zheng et al.,2018). Due to the importance of privacy in data management, public blockchains are barely used. Instead private, and, even more, consortium blockchains provide many benefits for this sort of application (Vo et al., 2018). Using a platform that is based on consortium blockchains, every user can determine which other institutions or people gain access to the data (Zyskind & Nathan, 2015). This way, data management becomes much more decentralized but efficient at the same time, as only relevant people or institutions get access to the data. Because of these benefits, blockchain applications in data management are believed to be a possible solution for trusted computing problems in society.

Since data is becoming increasingly important in any industry and field, blockchain-based platform solutions have a tremendous potential (Katal, Wazid, & Goudar, 2013). The following section discusses whether the impact of blockchain on data transfer and storage is disruptive or not. Therefore, the data management of health records is regarded, as this field appears to be particularly impacted and some blockchain-based platforms have already been implemented (FCCCC, 2018).

6.3 Example: Medical Records

Using the five characteristics of disruption for assessing a blockchain-based health record management, this section aims to give a general recommendation on whether blockchain is potentially disruptive for data transfer and storage or not. So far, blockchain-based data transfer and storage systems have barely been implemented on a large scale in a field other than medical records which is why this particular field has been chosen for the analysis. However, due to certain similarities between the nature of the financial services industry and the healthcare industry, conclusions from the analysis of the technology in medical records might also be applicable for the financial services industry. Of the two industries, the healthcare industry was usually the one to learn from transformations in the financial services industry (Yamaguchi, 2016). With blockchain-based data storage and transfer, however, it might be just vice versa, given the progress that has been made in the implementation of such solutions for medical records.

6.3.1 Introduction of Application

Blockchain is widely believed to solve some of the biggest challenges in the field of healthcare (FCCCO, 2018). While the technology is likely to impact processes to accelerate R&D and to improve care delivery and management, it has had and will continue to have a tremendous impact on the management of health records. This has its origins in the fragility of many western health care systems, where electronic health records (EHR) are barely adopted (Tang, Ash, Bates, Overhage, & Sands, 2006). Instead, many institutions store their files with patient data locally, which results in slow processes and redundant examinations. Consequently, doctors, hospitals, and even governments have their own, independent solution for storing their patients' data. Additionally, and this also holds for some EHRs, the patients themselves have little to no influence on what happens with their data.

The establishment of blockchain-based platforms could permit all parties in the healthcare value chain to have access to patient information (FCCCO, 2018). The underlying DLT ensures the security and integrity of data and, by adjusting reading and writing rights of the chain, a patient could control who accesses their information. Estonia has been among the first countries to implement the blockchain technology in their healthcare system. With the project "e-estonia", the country has been able to digitize 95% of health data (e-Health Records, n.d.). Additionally, 100% of billing in healthcare is electronic and 99% of prescriptions are digital. This solution, provided by Guardtime, records patient data in an e-health record on a blockchain-based platform. There, it can be conveniently accessed and audited by different stakeholders, including the patients themselves. In an emergency, for example, doctors in hospitals can quickly access a patient's data, including image files, such as x-rays, from remote hospitals.

The interest in blockchain-based solutions in healthcare is immense, which is why it has gained the attention of numerous startups and initiatives and the impact of these solutions is considered revolutionary (FCCCO, 2018).

6.3.2 Is Blockchain Potentially Disruptive for Medical Records?

6.3.2.1 Initial Performance

The degree to which blockchain solutions under- or overperform conventional alternatives regarding *Capacity*, *Privacy Protection*, and *Accessibility* is evaluated in the following to find out whether blockchain-based health records qualify as disruptive:

Capacity: As outlined in section 6.2, the blockchain was not initially designed to store and transfer documents or files (Vo et al., 2018). Hence, the data might need to be stored outside the actual blockchain. Nevertheless, as the success of the Estonian health record system indicates, a blockchain-based platform can still outperform files stored offline by doctors and hospitals individually (Mettler, 2016). However, compared to other EHRs, which are becoming increasingly popular, the blockchain technology likely underperforms regarding the amount of data that can be stored or transferred (Tang et al., 2006; Vo et al., 2018).

Privacy Protection: It could be argued that by digitizing health records and by storing them on a device with internet access, the security is reduced (Grobauer, Walloschek, & Stocker, 2011). However, this does not imply that hardcopies or offline stored health records are necessarily safer. These files might not be as vulnerable to large scale fraud as files stored online, but abuse can still occur. At least, the blockchain technology increases the security of health records compared to other EHR solutions (FCCCO, 2018). Additionally, as blockchain-based platforms increase transparency by allowing the patient to partially adjust the reading and writing rights of the data, these platforms outperform conventional health records.

Accessibility: Blockchain-based health record platforms clearly outperform health records that every doctor or institution creates and stores individually, since these conventional health records are barely shared. Compared to other EHR solutions, the accessibility does not depend on the underlying technology as much as it does on the interface and user friendliness of the application, as well as on the degree of implementation. However, the success of the Estonian health record solution indicates that a blockchain-based solution can be at least as accessible as any other EHR solution (Mettler, 2016).

Blockchain-based platforms seem to outperform conventional alternatives in terms of *Privacy Protection* and *Accessibility* and therefore do not fulfill the first disruption characteristic. However, regarding *Capacity*, it can be argued that DLT solutions underperform conventional methods, as the mechanics of the blockchain technology are not ideal for storing and transferring documents and files. Consequently, the first characteristic of disruption is fulfilled.

6.3.2.2 Product Feature

While health records traditionally have had the purpose to inform doctors about the state of a patient and results from previous examinations, so called personal health records (PHR) are more patient centered (Archer, Fevrier-Thomas, Lokker, McKibbon, & Straus, 2011). These records aim at making health related information available to patients, thus assisting patients in health-self management. Blockchain-based health record platforms are ideal for PHRs, as they provide features that not only allow patients to view their records but also allow them to partially determine who else has access to these records. For example, it could be beneficial if a patient permits close relatives' access to his or her health record as well.

However, PHRs are not yet very common (Tang et al., 2006). Therefore, it can be argued that the product features of blockchain-based platforms, which enable patients or relatives to access their health records, are only useful for a few consumers. Hence, the second characteristic of disruption is also fulfilled.

6.3.2.3 Market Entry

It is rather difficult to determine whether the market entry characteristic is fulfilled or not due to the segmentation of the target market. Implementing a blockchain-based platform only increases efficiency and is beneficial if most people in a country participate and if the platform is used as the exclusive solution for storing and transferring a patient's health related data. Hence, the entire population of a country needs to be considered a market. However, this one market can barely be considered small or emerging like the disruption characteristic requires. Nevertheless, it may be argued that a blockchain-based platform was first implemented in Estonia, which is a relatively small market if the size of the population is considered. As equally strong arguments for and against the fulfillment of the third characteristic can be found, no ultimate decision can be made.

6.3.2.4 Development of Performance

To analyze the performance development characteristic, the performance of blockchain-based health records in the *Capacity* dimension needs to be considered. To fulfill the characteristic, the initial underperformance of blockchain platforms in this dimension needs to be overcome to meet the demands of mainstream customers. Since a lot of R&D is invested in this area, the amount of data blockchain is capable of storing or transferring is likely to increase. However, at this point, it is not possible to tell if the demands of the mainstream market can be met. While the success in the Estonian system suggests that these demands can be met on a small scale, it is not yet possible to consider this characteristic fulfilled.

6.3.2.5 Displacement of Dominant Incumbents

Since a successful EHR management system requires most people of a country to participate, all other alternatives could be displaced in that country. Therefore, if a country decides for a blockchain-based data management solution for its health records and, if the system succeeds, the fifth characteristic of disruption would be fulfilled. However, it is still a long way to go, which is why, at this point, it is not possible to determine if this characteristic will be met.

6.3.3 Conclusion

More and more people and institutions have become aware of the benefits of EHRs and even PHRs which is why they have become increasingly popular (Tang et al., 2006). With its DLT, blockchain seems to be almost ideal as the underlying technology for data management systems. Only its limited capacity for storing and transferring data and some remaining and justified skepticism concerning the security of storing data online could set a limit to the use of blockchain for data management.

The first characteristic of disruption is fulfilled by blockchain's limited capacity for storing and transferring data, as this is the reason for the underperformance of the technology in a dimension historically valued by the mainstream market. In the other two dimensions that were analyzed, namely *Privacy Protection* and *Accessibility,* the DLT provided at least the same level of performance as conventional health records. The second characteristic of disruption is fulfilled by the technology's ability to allow patients to view their records themselves and to partially control the reading and writing rights, as this feature seems to be particularly valued by a small segment of PHR users. Regarding the third characteristic, the *Market Entry*, it could be argued for or against indicators of disruption, depending on the segmentation of the market. If Estonia is considered a small segment of a market, the third characteristic is fulfilled. At this point, it is not possible to determine whether the *Performance Improvement* and the *Displacement of Incumbent*s criteria are fulfilled. However, there are indicators that these characteristics will be met in the future if blockchain-based platforms turn out to be the preferred solution for health record management. In that case, it will be possible to blockchain is a disruption for health record management.

Characteristic	**Fulfillment**
1. Initial Performance	✓
2. Product Feature	✓
3. Market Entry	✓ ✗
4. Performance Development	?
5. Displacement of Dominant Incumbents	?

Table 8. Results of Analysis of Blockchain for Health Records

7 General Evaluation of Results

Undoubtedly, the blockchain technology has had a significant influence on many industries, and most authors agree that this influence will increase even further in the future. Thus, the previous chapters assessed whether the increasing influence of the technology shows indicators elements of disruption. Therefore, we analyzed if the five characteristics of disruption are fulfilled by three major applications of the DLT.

First, the possible disruptive impact of cryptocurrencies on payment methods was tested. To analyze the fulfillment of the *Initial Performance* characteristic, security, cost, and convenience were used as the dimensions historically valued by mainstream customers. The analysis of cryptocurrencies indicated that the *Initial Performance* as well as the *Product Feature* criteria are fulfilled, while the *Market Entry* criterion is not. The latter derives from the fact that cryptocurrencies are not ignored by the industry's incumbents. Yet, it is not possible to determine whether the *Performance Development* and the *Displacement of Incumbents* characteristics will be fulfilled. Certainly, cryptocurrencies will have a tremendous impact on payment methods but based on the analysis, it is rather unlikely that this impact will be disruptive.

Second, the use of blockchain as an intermediary was analyzed. The dimensions that were used for the analysis are low transaction cost, asymmetric information, and reliability. It was revealed that only the *Initial Performance* and the *Market Entry* criteria were met, which is why there are not many indicators of a disruption process for this application. The example of microgrids indicates that one reason for this is that most intermediaries seem to have more functions than the actual intermediating. In most cases, this makes a replacement of incumbents unlikely.

And third, we analyzed if blockchain has the potential to disrupt data storage and data transfer. Of the three applications tested, this is the only one in which, according to the analysis, blockchain could be disruptive, indeed. The *Initial Performance* and the *Product Feature* characteristics are clearly met. For the former, capacity, privacy protection, and accessibility were used as the three dimensions historically valued. For the *Market Entry* characteristic, arguments can be found for and against the fulfillment. It is not yet possible to tell whether the *Performance Development* and the *Incumbent Displacement* characteristics will be met. However, this leaves a chance for blockchain to be disruptive for data storage and transfer in the future.

The table below presents an overview over the three applications of the blockchain technology and their fulfillment of the five characteristics of disruption. The table reveals how the *Initial Performance* is never the cause for blockchain not being disruptive, as the DLT underperforms in at least one of the dimensions which are valued by the mainstream market. Moreover, the table suggests that there does not seem to be a general pattern for the *Product Feature* and *Market Entry* characteristics for blockchain applications that indicate disruption. Regarding the fourth and fifth characteristics, the analysis supports one aspect that has been criticized about Christensen's theory. Although Christensen mentions in the beginning of his *The Innovator's Dilemma* how his work could be used by managers to recognize if their industry is disrupted, many authors claimed that the theory is not very useful for making ex-ante predictions. Especially the analysis for payment methods and data management indicates that it is almost impossible to tell, at this point, whether blockchain indicates disruption.

Characteristic	**Payment Methods**	**Intermediary**	**Data Management**
1. Initial Performance	✓	✓	✓
2. Product Feature	✓	✗	✓
3. Market Entry	✗	✓	✓✗
4. Performance Development	?	✗	?
5. Displacement of Dominant Incumbents	?	✗	?

Table 9. Results of Analysis

While this might be a problem for the academic theory, it is of little importance in the real-world. No matter whether an innovation is considered disruptive or not, if it has a significant impact on an industry, it requires immediate attention. Blockchain proves just that: Although it is unlikely to turn out to be disruptive for payment methods and as an intermediary, blockchain could play a key role in these fields. Therefore, the technology could be a potential risk for companies not taking it seriously, but it also creates many opportunities if it is given proper attention. However, coming back to the initial question, the analysis also indicates that blockchain also has the potential to become disruptive according to Christensen's theory. While it is not possible to ultimately predict that it will be disruptive, there are definitely indicators in the field of data management that it could be.

8 Conclusion

The goal of this paper was to answer the question whether blockchain has the potential to become a disruption according to Clayton Christensen's disruption theory. Therefore, the theory and the five characteristics that define the process of disruption were outlined in the first part of the paper. That and the following explanation of the blockchain technology served as the basis for the analysis and evaluation in chapters four to seven. For the analysis, three applications of the DLT, namely payment methods, intermediaries, as well as data storage and transfer, were considered. The fulfillment of the five characteristics of disruption was assessed using an example for each of the three applications.

While the results of the analysis provide a general idea about the indicators of disruption for three applications of blockchain, they are not fully representative. Hence, even if the example of microgrids suggests that blockchain will probably not be disruptive for intermediaries, there is a fair chance that it could be in fields other than electricity. Moreover, to answer the question concerning whether the DLT will be disruptive, only three major fields of application were considered. However, the technology also has other forms of application, which might or might not reveal indicators of disruption. Another possible source of error is the assumption that characteristics of disruption are not fulfilled, as it is not possible to ultimately prove that something does not exist. Moreover, there is a chance that some of the sources are biased towards or against blockchain.

Additionally, the paper might serve as a basis for future research on the topic, once the technology develops further, since it is generally hard to tell whether the fourth and fifth characteristics are fulfilled by blockchain at this point. Therefore, the results of the paper also back criticism of Christensen's theory regarding its usefulness for predictions.

This paper suggests that, in the financial services industry, too, the impact of blockchain will be significant. However, given the manifoldness of the services that are part of the industry, it cannot generally be concluded whether the DLT will disrupt the industry. For example, in services related to payment methods, blockchain is unlikely to follow disruptive pattern, despite the recent hype surrounding blockchain-based cryptocurrencies. However, regarding data storage and transfer, the technology might as well follow disruptive pattern in the financial services industry just as the application of blockchain solutions has been doing in the healthcare industry.

Overall, this paper indicates that blockchain shows indicators of disruption in some fields but is generally more likely to follow evolutionary trajectories. However, the technology needs to develop further before it can be determined what sort of innovation it is. Nevertheless, the impact blockchain has had and will have, is immense, and it will require incumbents' attention in many industries and fields.

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Appendix

Exhibit 1: Low Market Disruptions and New Market Disruptions

Low Market Disruptions are innovative products or services that target already existing customers (Christensen, 2003). However, these customers do not need the same level of performance that the high and mainstream end of the market requests. These so-called overshoot customers are overserved and, therefore, can usually be targeted with innovative technologies which allow a company to provide a product or service of a relatively lower quality, but at a lower price. As both the disruptive and the sustaining innovations in a market keep improving at a faster pace than the market demands, the number of overshoot customers increases (Christensen, 2013). Consequently, more and more of these customers can be satisfied with the quality the disruptive technology provides, which ultimately displaces the incumbents.

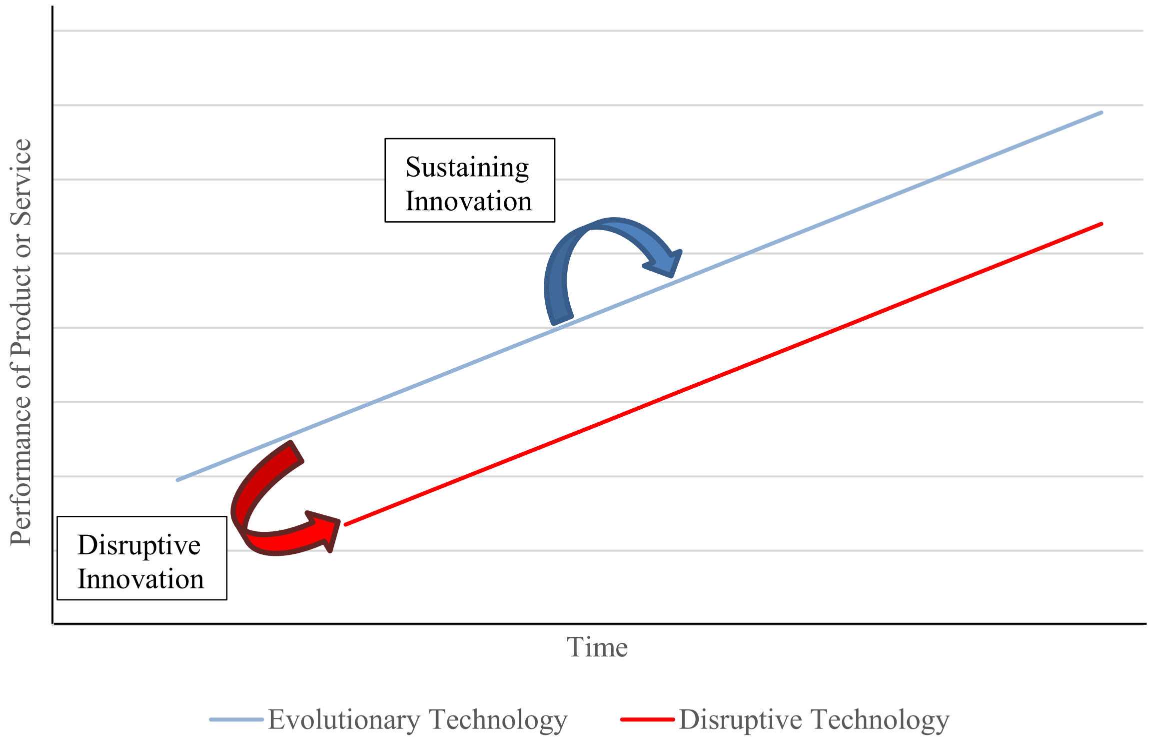

Figure 7. Low Market Disruption (Christensen, 2003, p.44)

Targeting non-customers of a product or service, New Market Disruptions do not compete for market shares with existing incumbents (Christensen, 2003). Therefore, the disruptive technology usually convinces these customers with a performance attribute that is not valued by the mainstream market. The costs of the disruptive technology might be higher compared to the evolutionary technology, although it performs weaker in the existing value network. However, New Market Disruptions create entirely new value networks, in which customers are willing to pay the potentially increased price because the new attribute is beneficial for the niche market in which they operate. Continuously improving its performance over time, the disruptive technology reaches a level at which it becomes attractive for the customers in the old mainstream market as well and displaces the incumbents (Christensen & Matzler, 2013). The previously mentioned steam boats serve as an example for this type of disruption.

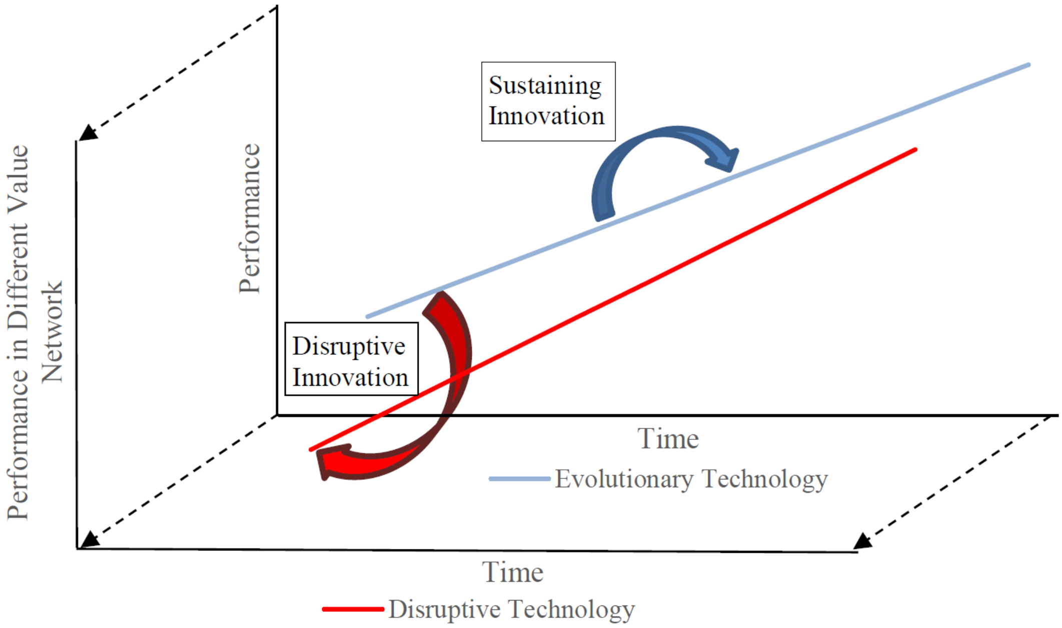

Figure 8. New Market Disruption (Christensen, 2003, p.44)

Exhibit 2: Adjustments to the Disruption Theory

As aforementioned, Christensen addressed some of the criticism of his initial theory in later versions of *The Innovator's Dilemma* and other papers about disruptive innovation. More recently, he admitted that his initial version did only mention sustaining and disruptive innovations but forgot about *Efficiency Innovations* (Tellis, 2006). Additionally, he pointed out the possibility of *Continuous Innovations*, addressing the critique that his initial theory considers customer orientation obsolete.

Efficiency Innovations

The idea of efficiency innovations is to do more with less (Tellis, 2006). These innovations follow the same disruptive pathway as other disruptive innovations and lead to the displacement of incumbents. Unlike New Market Disruptions, they follow the same trajectories as the mainstream dominance. However, they eliminate their competitors by innovations that allow them to do more with less. A product or service attribute for example allows them to reach the same, or better, relative result with fewer jobs or at lower costs. Examples for this are mini-mills in the steel industry or Walmart.

Continuous Innovations

By pointing out Continuous Innovations, Christensen aims at defending his theory against the accusation that it is an argument against customer orientation (Day, 1999). Instead, he writes that outstanding customer orientation is not just about listening to one's customers, but also about anticipating their needs (Tellis, 2006). This anticipation includes constantly experimenting and innovating. The underlying goal of this type of innovation is delighting the customer, while profit is just a result. Using this model, companies such as Apple, Amazon, and Zara have made experimentation and innovation an integral part of their business models. This way, they have managed to constantly disrupt their own businesses with innovation. Having made creating value for their customers a top priority, these firms focus on long term development and have succeeded for many years. According to Christensen, Continuous Innovations offer a way out of *The Innovator's Dilemma* and should be adopted to prevent a company from failing.

Exhibit 3: Approaches to Consensus in a Blockchain (Zheng et al., 2018)

Proof of Work (PoW)

In this approach to consensus, which is also referred to as mining, each node calculates a hash value of the permanently changing block header. To achieve consensus, the calculated hash value must be at least as small as a certain given value. Therefore, the nodes continuously calculate the hash value using different nonces until the target is reached. If one participant of the decentralized network obtains the required value, the other nodes must mutually confirm the correctness of the value. Once this step is completed, the transactions in the new block are validated in case of frauds. If they are validated, the collection of transactions is approved to be the authenticated result and then denoted by a new block in the blockchain.

Proof of Stake (PoS)

Compared to PoW, PoS is considered to be more energy saving. This derives from the fact that users are not required to find a nonce in an unlimited space but rather they are required to prove ownership of the amount of a currency. The underlying idea behind this is the belief that people with higher stakes are less likely to attack the network. As a result of this, the selection is based on account balance. However, this is why PoS if often considered to be unfair as the richest people are bound to be dominant in the network. Hence, there are several solutions that suggest a combination of PoS and PoW.

Practical Byzantine Fault Tolerance (PBFT)
This approach to consensus is based on an algorithm which tolerates byzantine faults. In fact, it is able to handle up to one third malicious byzantine replicas. For the creation of a blockchain, a new block is determined in every round. In the beginning of each round, a so-called primary is selected based on certain rules. The primary is then in charge of ordering the transactions. The PBFT process is divided in to three phases which are *pre-prepared, prepared* and *commit*. A node would only be able to enter the next of these stages if it received votes from at least two thirds of all nodes. Therefore, this consensus mechanism requires knowing every participant in a network.

Exhibit 4: Four Principles of the Blockchain Technology (Zheng et al., 2018)
Due to the nature of its technology, blockchain is characterized by the following four principles (Zheng et al., 2018):

Decentralization: Conventional transaction systems require a trusted central agency, which validates each of the transactions. This high level of centralization leads to performance bottlenecks at the central servers. However, blockchain allows the conduct of transactions on a P2P basis. The validation is not performed by a central agency but by the nodes. This decentralization results in a significant reduction of server cost and performance bottlenecks.

Persistency: The nature of a blockchain makes it extremely hard to tamper. This derives from the fact that each of the transactions is recorded in blocks distributed all over the network. As an immediate result of the decentralized P2P validation by the nodes, potential fraud becomes obvious quickly.

Anonymity: Deriving from the decentralization the blockchain technology provides, there is no longer a central party storing a user's private information. Within the blockchain network, users communicate and interact with a generated address. Moreover, the technology allows users to create several addresses to avoid identity exposure. Therefore, the technology guarantees a certain amount of privacy for the transactions.

Auditability: Using a timestamp for the validation of transaction, blockchain allows users to easily verify and trace the previous records by accessing a node in the distributed network. This guarantees traceability and transparency of the data stored. As previously mentioned, the type of a blockchain might restrict this transparency.

Exhibit 5: Different Types of Blockchain

Public Blockchains are fully decentralized. In this type of blockchain, anyone in the world can read the blockchain and can send transactions to it and can expect to see them included if they are valid (Buterin, 2015). Moreover, everyone can participate in the consensus process. Therefore, public blockchains are secured by cryptoeconomics which combines economic incentives and cryptographic verification using the aforementioned mechanisms.

Private Blockchains are blockchains where writing permissions are a privilege of a single organization. Depending on its application, reading permissions may be either public or restricted. Private blockchain applications may include database management within a single company. This type is considered to be the most centralized blockchain.

In a *Consortium Blockchain* only a pre-selected set of nodes participates in the consensus process. Buterin (2015) provides the example of a consortium of 15 financial institutions of which a minimum of ten must sign a block in order for it to be valid. Reading permission may be either public or restricted to the participants. This type of blockchain is partially decentralized.

The following table provides a general overview of the three types with regard to *Consensus Determination*, *Reading Permission*, *Centralization*, and *Consensus Process*[1]:

[1] Determines whether permission is required to join the consensus process.

Property	Public Blockchain	Consortium Blockchain	Private Blockchain
Consensus Determination	All miners	Selected Set of Nodes	One Organization
Reading Permission	Public	Public or Restricted	Public or Restricted
Centralization	No	Partial	Yes
Consensus Process	Permissionless	Permissioned	Permissioned

Table 10. Comparison of Blockchain Types (Zheng et al., 2018, p. 358)

Exhibit 6: Industries for Which Blockchain will be Crucial

Due to its mechanics, the blockchain technology is particularly useful when applied as an intermediary, used for storing and transferring data, and, as the last years have indicated, used as the underlying technology for cryptocurrencies (Käll, 2018; Patel, 2018). Hence, this thesis focuses on the disruptive impact of the blockchain technology on these three scopes. It is worth noting that these scopes coincide with each other for many real-world applications. Moreover, the scopes also indicate which industries are likely to be impacted most by the blockchain technology.

Due to the manifoldness of the technology, possible applications for blockchain can be found in almost any industry (Tapscott & Tapscott, 2016). If cryptocurrencies became a universally accepted payment method, members of every industry would have to consider adapting and accepting this form of payment. However, the extent of the technology’s impact varies in each industry. The transaction-heavy financial services industry, for example, will be impacted enormously as it benefits from all three of the aforementioned scopes of the technology (Zheng et al., 2018).

Among the industries that will be influenced by the data management scope of the technology are other data driven industries such as the insurance and healthcare industries, and fields such as governance and human resources (“Banking Is Only The Beginning: 42 Big Industries Blockchain Could Transform”, 2018). Additionally, industries in which copyright is crucial, like the film and music industry, are likely to be impacted by this scope of the technology. Industries with a high occurrence of trading will be particularly influenced by blockchain’s ability to replace intermediaries. Besides the abovementioned financial services industry, this group includes the electricity industry, the oil industry, and any other industries where purchasing is a crucial part of the supply chain (Perboli, Musso, & Rosano, 2018).

Exhibit 7: Level of Blockchain Startup Financing Worldwide 2012-2017

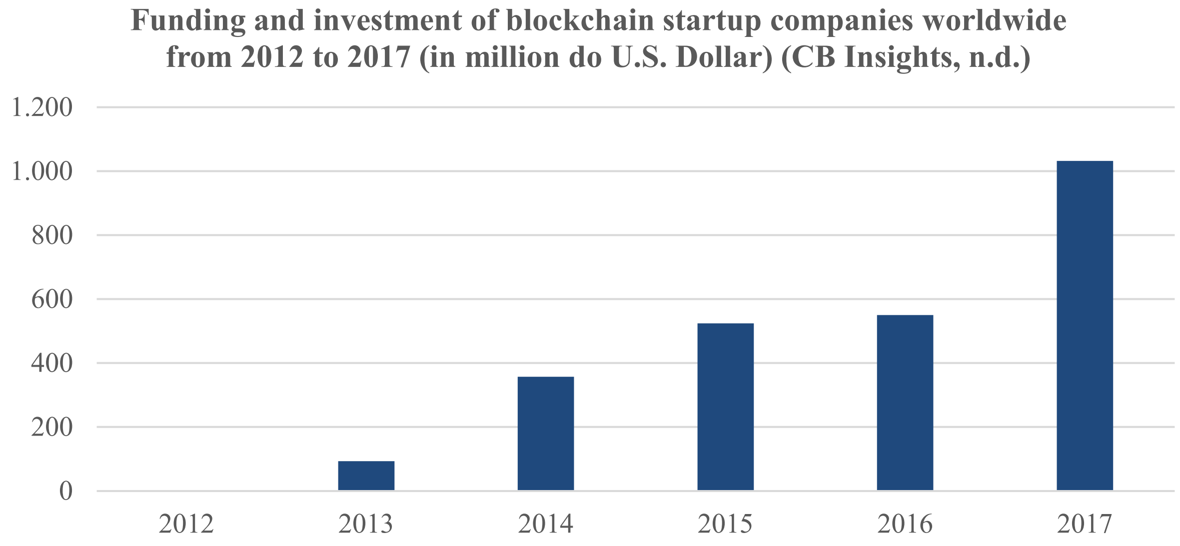

Exhibit 8: Overview on Leading Cryptocurrencies

#	Name	Market Cap. in USD (as of Jan 04, 2019)	Price in USD (as of Jan 04, 2019)
1	Bitcoin	$66.197.575.060	$3.790,85
2	Ethereum	$15.483.623.073	$148,61
3	XRP	$14.398.553.411	$0,352957
4	Bitcoin Cash	$2.749.025.075	$156,66
5	EOS	$2.401.918.600	$2,65
6	Stellar	$2.174.255.404	$0,113463
7	Tether	$1.902.512.916	$1,02
8	Litecoin	$1.886.596.372	$31,51
9	Bitcoin SV	$1.511.191.571	$86,12
10	TRON	$1.338.188.455	$0,020081
11	Cardano	$1.103.342.622	$0,042556
12	IOTA	$1.030.886.869	$0,370885
13	Monero	$825.583.599	$49,45
14	Binance Coin	$785.105.047	$6,00
15	Dash	$683.880.267	$79,99
16	NEM	$576.181.196	$0,064020
17	Ethereum Classic	$545.745.761	$5,09
18	NEO	$489.086.973	$7,52
19	Maker	$358.938.732	$492,89
20	Zcash	$318.585.144	$56,90

(Source: “Top 100 Cryptocurrencies by Market Capitalization”, 2019)

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