BLOCKCHAIN: TOWARDS DISRUPTION IN THE REAL ESTATE SECTOR

An exploration on the impact of blockchain technology in the real estate management process.

P5 REPORT

Martijn Dijkstra
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PREFACE

Before you lies my master thesis, this thesis marks the end of one of the most memorable times during my study, completing the master track Management in the Built Environment at the Technical University of Delft. Within this document, you will find insights in two of my personal fascinations; real estate and technological innovation. The aim of this study was getting to the bottom of one of the most recent technological innovations, blockchain technology, and projecting this on the current real estate management process.

Personally I embrace the different trends which currently occur in the Real Estate Sector relating to the internet of things and big data. Blockchain even goes beyond current developments. I believe the blockchain has the potential to disrupt the real estate industry, which makes it a very interesting and relevant topic to study.

Currently there is hardly any scientific knowledge about the relation between blockchain and real estate. This gives me the opportunity to explore on a topic which I find very interesting, consequently it gives me the chance to be one of the first students exploring this interesting topic. With this research I want to contribute to the creation of knowledge on a topic only a few people are familiar with. Due to the explorative nature of this study it might raise more questions than it answers. Nevertheless, my goal is contributing to the current discussion and motivate fellow students to continue studying ways the current real estate sector can be innovated.

The support, time and cooperation given by many enabled me to finish this thesis according to my planning. Through this way, I would like to take the opportunity to thank everyone who has supported me throughout the whole process. In particular I want to thank all those who wanted to participated in the interviews, your input was very helpful in obtaining the right data for completing this thesis. In addition, I would like to thank my mentors Peter Boelhouwer and Alexander Koutamanis for giving their support and guidance on a topic which is not very common within the faculty. I would also like to express special gratitude to Jo Bronckers for the nice discussions we had and helping me in arranging the interviews through his personal network.

Last, but definitely not least, I would like to thank my parents for their unprecedented support throughout my study. Great thanks for giving me the opportunity to attend university, one of the biggest changes in my life. Special thanks to my girlfriend for her patience and support. My apologies for the boring weekends I had to spend time behind my desk.

Enjoy reading!

Martijn Dijkstra
Rotterdam, 2017
MANAGEMENT SUMMARY

Introduction

Real estate is a unique and complex asset class. Real estate differs from other asset classes by having high transaction costs, land use regulations and other barriers to entry, long-lasting improvements, and a relatively slow reaction of supply to changes in demand. These characteristics have implications for the overall efficiency of the market. This inefficiency implies that more or better market knowledge and experience may have a payoff (Brent & Lusht, 2008). The two primary characteristics of real estate assets are their heterogeneity and immobility. Because of these two factors, the market for buying, selling, and leasing real estate tends to be illiquid, localized and highly segmented, with privately negotiated transactions and high transaction costs due to the involvement of a vast amount of trusted third parties (Ling & Archer, 2013).

In response to greater demand for transparency, technology advancements and the disintermediation by startups are gradually making some of the information public. As a result, property-related information is increasingly available in digital and paper form. However, a significant portion of the digitized information is hosted on disparate systems, which results in a lack of transparency and efficiency, and a higher incidence of inaccuracies that creates a greater potential for fraud. Blockchain technology could enable the commercial real estate industry to address these inefficiencies and inaccuracies (Deloitte, 2017).

Simply said, blockchain is a digital peer-to-peer platform that allows transactions between two parties without the need for a central institution. Blockchain can be seen as a global distributed ledger, which facilitates the movement of assets across the world in seconds, with only a minimal transaction fee. These assets can be any type of value, as long as they can represented digitally (Froystad & Holm, 2015). Blockchain technology holds many promises for real estate, allowing for optimized processes and accelerating disintermediation in an industry that has been “plagued” by middlemen (Ngo, 2016).

Opinions and statements of several experts indicates that blockchain technology can replace middlemen with peer-to-peer transactional tools. It can provide a comprehensive platform for the lifecycle of a property. Title insurance, escrow companies, county recorder’s offices, brokers, lawyers, home owner associations, and various support staff can be replaced with a combination of digital tokens, multi-sig escrow, smart contracts, time stamped encrypted data, and crypto currency (Lifthrasir, 2016). Among the benefits of using this technology, Bitcoin and other public blockchains can reduce costs, stamp out fraud, speed up transactions, increase financial privacy, internationalize markets, and make real estate a liquid asset (Ngo, 2016).

These findings lead to the problem statement of this study. Blockchain has the potential to interfere at the basic principles of existing real estate processes. In a sector plagued by middlemen and characterized by inefficient processes, this technology might be able to restructure the process of managing real estate and transferring digital assets.

Therefore, the main research question to be answered in this research is:

What are the different opportunities and constraints for the implementation of blockchain technology in order to improve the current real estate management process?

This research will focus on exploring the different possibilities for integrating blockchain technology in the real estate management process. By analyzing the current real estate management process and gaining knowledge about the implementation of blockchain technology, the objective of this research...
is exploring in which phases of the real estate management process the process can benefit from the use of blockchain technology.

The research findings contribute to the knowledge of opportunities for broad implementation of blockchain technology in the real estate management process by providing a scientific based research document. It provides a broad overview of different opportunities and constraints for using blockchain technology in the process. It increases awareness for the disruption this technology might bring. This research provides scientific arguments for possibilities of implementing blockchain technology in the real estate management process and will function as a trigger for continuation of research into this topic.

**Methodology**

Due to the explorative character of this study, the research strategy is of qualitative nature. This research will encourage the connection between a literature study, developments of the blockchain and practitioners. It seeks to bring theory and practice together in the pursuit of developing practical solutions for parties involved in the real estate management process concerning blockchain technology. Gathering empirical results is based on two types of research methods, literature study and interviews. The literature study covers the concept of blockchain technology and real estate management, whereas the interview focusses on the implementation of blockchain in real estate. These methods are captured in the research model as shown in figure 1.

*Figure 1 – Research model. Source: Own figure*
Theoretical Framework – Blockchain Technology

The concept
Literature is clear about defining blockchain technology (Antonopoulos, 2014; Swan, 2015; Morrison, 2015; Goldman Sachs Global Investment Research, 2016; Spielman, 2016). In essence the blockchain is a transparent, immutable and distributed digital ledger of economic transactions that can be programmed to record digital transactions of everything which represents value. Simply said, blockchain is a database of transactions between two or more parties, with copies of the database replicated across multiple locations or nodes. The copies of the database are constantly update automatically, so all the participants share the same immutable database.

The database is split into blocks with each block containing details of the transactions (such as the seller, buyer, price and contract terms), a block header, a time stamp, a hash with the previous block, a merkle root which represents the merkle tree of transactions and a nonce which shows the digest of value that allows to verify the value has not changed. The blocks are validated by the entire network of nodes via encryption by combining the common transaction details with the unique signatures of two or more parties. The transaction is valid if the result of the encoding is the same for all nodes. Finally the block is added to the chain of prior transactions (Antonopoulos, 2014; Swan, 2015; Morrison, 2015; Goldman Sachs Global Investment Research, 2016; Spielman, 2016).

Although the blockchain is originally build for a decentralized network, a blockchain can be either public or private, also known as permissioned or permissionless. A permissionless ledger is defined as a blockchain protocol where a client may operate a full node without prior approval. Everyone can access the network. The biggest advantage of permissionless blockchains, as it gains adoption, it becomes highly decentralized and redundant, becoming very difficult to shut down (ENISA, 2016). The downside of a public ledger is that everyone has universal access to the information in the blockchain (Spielman, 2016). Private, or permissioned ledgers are a form of distributed ledger that operate as a “members’ club” (ENISA, 2016). A permissioned blockchain operates the same as a public or permissionless blockchain. The main difference is that for a permissionless blockchain the identities of the user which want to participate in the blockchain, need to be validated against a list of authorized “members”. The advantage of a permissionless blockchain over a permissioned blockchain is the ability to hold control over the users which participate and maintaining control over private transactional data.

Applications
One of world’s most well-known application of blockchain technology is Bitcoin. Bitcoin is a digital currency, created and held electronically without the control of anyone (decentralized). Next to Bitcoin some several other digital currencies emerge. However, using blockchain for digital currency is not the only application one can think of. World wide start-ups in different sectors are emerging and exploring the possibilities of blockchain technology for other use cases instead of digital currency. Different studies and books (Antonopoulos, 2014; Williams-Grut, 2015; Schatsky & Muraskin, 2015; Swan, 2015; Tapscott & Tapscott, 2016;) noticed some interesting potential use cases for blockchain technology. Everis (2016) and CBinsights (2017) looked at a vast amount of startups which are currently working on those uses cases (Everis Next, 2016). It becomes clear that among others blockchain can be used for the exchange of value, internet of things, collaborative transport, decentralized markets, energy distribution, digitization of documents, data and contracts, supply chain management and governmental services.

Real estate opportunities
Based on the analyses of different articles and reports five opportunities for the implementation of blockchain technology can be pointed out which are (1) Digital records of real estate assets, (2) Re-

- **Digital records of real estate assets** – In real estate the whole lifecycle of a property can be digitalized and transferred on a blockchain. Blockchain has the ability to create a system where every property has its own digital passport with all the information about this specific asset, such as title registration with recent owners, sales prices, transaction dates, lease contracts, loans, maintenance contracts, and even the origin of the building materials and their condition recorded digitally.

- **Re-design of real estate processes** – If real estate assets are stored digitally on the blockchain, transactions could be handled on a blockchain in a similar way to how payments between parties are handled using digital currencies as stated by the literature study. With a fully-secure, verifiable system, two parties could conduct a transaction immediately, without the need for a trusted third party to verify the transaction. Because the history is easily audited, all parties have confidence in the data being shared, and the time needed to close a transaction could be much shorter.

- **Transparant markets** – By creating a public ledger of transactions the real estate market becomes more transparent and new platforms may arise as well as reducing falls listing or other fraudulent activities. Due to blockchain, transparency may also arises in the form of immutable results of the performance of actors in the process. If the performance results of stakeholders are stored via an blockchain, this can create an immutable track record of performance and a possible new rating system. An increase of transparency will also allow regulators and rating agencies to get a better understanding of the risks affiliated with real estate. If more information about the risks of real estate is known, the risk aversion against real estate as an investment class may change resulting in higher demands for real estate investments.

- **Payment system** – Another point which is argued by literature is using cryptocurrencies in for instance lease payments or as deposits for rental agreements. The power of software is its programmability. The power of cryptocurrency is you can program it to escrow and distribute itself. Nevertheless, digital currencies are currently fluctuating a lot in their price. It is therefore arguable if digital currencies should be used in the ecosystem.

- **Smart contracts** – Smart contracts are inherent to the development of blockchain based applications. Smart contracts enables self-executing contracts which can automatize several processes in real estate.

**Challenges & Limitations**

Blockchain technology is still in its early stage of development. In order to gain world wide adoption, this nascent technology needs to overcome some challenges and limitations of the current system both internal and external, including technical challenges, standardization, public perception, government regulation and mainstream adoption of technology.

Special-purpose blockchains will need to be created for a wide variety of applications. In order to gain broad adoption, technical standards must be produced and agreed upon to assure compatibility across industries (Spielman, 2016). Major threats for broad adoption are fragmentation of platforms and institutional and social inertia to transition to a specific platform (Credit Suisse, 2016). Another challenge, both functional and technical, is related to business models. Failure to reach a consensus among counterparties as to business processes or to resolve commercial conflicts could significantly hinder blockchain’s adoption (Swan, 2015; Spielman, 2016; Deloitte UK, 2016; Credit Suisse, 2016). Another significant technical challenge and requirement is that a full ecosystem of plug-and-play solutions needs to be developed to provide the entire value chain of service delivery (Swan, 2015).
Furthermore, blockchain will also need to overcome challenges for the tradeoff between Security versus Costs and Efficiency versus Cost (Credit Suisse, 2016). Not only the security of the blockchain comes with high costs, hence the speed and effectiveness with which blockchain networks can execute peer-to-peer transactions comes at a high aggregate cost. This inefficiency arises because each node performs the same tasks as every other node on its own copy of the data in an attempt to be the first to find a solution. This means that blockchain applications must harness network effects to deliver value to consumers or to sectors at large (Deloitte UK, 2016).

How government regulation unfolds could be one of the most significant factors and risks in whether the blockchain industry will flourish into a mature industry. Some argue that in the modern era of big data, governments are increasingly unable to keep up with their record-keeping duties of recording and archiving information and making data easily accessible (Swan, 2015).

**Theoretical Framework – Real Estate Management**

The different stages of the current real estate management process where we see trusted third parties involved in exchanging deeds of value and trust are defined according to the management triangle designed by Van Driel & Van Zuijlen (2016) and in the latter used by several other authors.

![Management Triangle](image)

*Figure 2 – The real estate management process and management triangle. Source: (Van Driel & Van Zuijlen, 2016) edited by author.*

As can be witnessed from the schedule, the operating phases consist of three different levels. The different levels are portfolio management, asset management, and property management. Since, portfolio management is quite often an internal process among institutional investors, the involvement of trusted third parties in exchanging deeds of value or trust mostly occurs during asset management and property management. This research therefore focusses only on those two management levels.

Within the real estate management process a vast number of stakeholders is involved. The major stakeholders are among others; investors, occupiers, funders, brokers, governmental departments, contractors, designers and other advisors. Each stakeholder has its own roles and responsibilities within the different stages.
Transacting real estate

Transacting real estate is the acquisition for buyer and disposition for seller, those phases are comparable taking into account a different perspective and interest. Generally, based on the studies of McNamara (1998), Crosby and McAllister (2004), and Hordijk and Teuben (2008), real estate transactions are characterized by four different stages; preparation period, marketing period, due diligence period, and exchange to completion. In the first stage, all the information of a property needs to be collected. During the marketing period buyer and seller try to find each other and set up a head of terms. During the due diligence period, buyer will research all the information and specifications of the property, the findings will be reported. Finally during exchange of completion, all the legal work will be settled and all the property information will be transferred. The real estate transaction process including the exchange of information and the stakeholders the process is visualized in figure 3.

Operating commercial real estate

The operating phase of the property is according to Van Driel & Van Zuijlen (2016) characterized by four management levels, those are commercial management, technical management, administrative management, and promotional management. Commercial management consist of advising on and coordination of the operating tasks, including contact with the asset manager and tenants, hence also maintaining and attracting tenants. During technical management the property manager tries to maintain the desired quality level of the property via inspections, maintaining the budget and give order to contractors. Administrative management is the process of registering, classifying, and processing the information of the property. This also includes reporting to the asset manager. Finally, promotional management are all the activities aimed for improving the market position of the property (Van Driel & Van Zuijlen, 2016). The information exchanged among the stakeholders within the operating phase is visualized in figure 4.

Figure 3 – Flowchart of the real estate transactions process. Source: Own figure

Figure 4 – Information exchange during property management. Source: Own figure
Exchange of information
The exchange of assets occurs in both the transaction phase and the operational phase. It is obvious that during real estate transactions all the information about a property is exchanged and transferred to the new owner. Whereas the title of ownership is one of the most important. All the information which is exchanged consist of: marketing material, legal title & searches, management information, design & construction, utilities, physical & environmental condition, rates / outgoing, tax / financial (IPF, 2012).

The critical information exchange in commercial management is the contractual relation between tenants, both new and existing, and the owner of the property in the form of a lease contract. In the Netherlands, lease contracts for commercial properties are standardized and based on the ROZ (Raad voor Onroerende Zaken) model. Another notable part of the exchange of information in the commercial management process is tenant services. In exchange for a small payment additional tenant services can be provided. Services such as; facility management, hospitality management, meeting rooms, coffee/lunch etc. Via separate contracts (or included upfront) these services can be used.

During technical management the most notable exchange of information, is the relation between the property manager and contractors in order to fulfill maintenance tasks. During administrative management all the businesses related to the property needs to be registered. The two most important processes are tenant administration and owner / service charges administration.

Within tenant administration all the agreements which could potentially have a financial impact between tenant and owner needs to be administrated. Also an exchange of assets occur with the lease payments. Despite the rent payments, tenants pay an annual rent and an advance payment for the service charges adjusted subsequently on the basis of actual costs. The property manager needs to make an estimate once a year to which operational costs belong to the owner and which costs to the tenant, based on the agreed terms from the lease contract.

The hypothetical blockchain based process
By analyzing the characteristics of blockchain and the characteristics of the real estate management process five hypothetical opportunities derive. These are:

- **Hypothesis #1 – Digitalizing real estate**: Creating a digital representation of a property on a blockchain with all the relevant information stored digitally (IPF, 2012; Mizrahi, 2016; Spielman, 2016);
- **Hypothesis #2 – Alternative financing tools**: New business models for financing real estate via blockchain could potentially make it easier for parties to gather their investment (Marchand, 2016; Gout, 2017);
- **Hypothesis #3 – Exchange of ownership**: If the real estate world achieves to store assets digitally on a blockchain, real estate transactions could be handled on a blockchain in a similar way to how payments between parties are handled using digital currencies (Lifthrasir, 2016);
- **Hypothesis #4 – Digital lease contracts**: Blockchain can support in lease transactions by pre-lease due diligence by using smart identities, creating lease agreements based on smart contracts, automated payments and cash flow management using the smart contract, and real-time immutable data analysis (Deloitte, 2017);
- **Hypothesis #5 – Digital building performance & maintenance**: Blockchain could be used to trace the full lifecycle of building materials, as well as registering the performance of buildings.
Empirical Findings

Conducting the document analysis and interviews offered a large amount of in-depth data. This chapter addressed the findings of the interviews with different stakeholders within the real estate management process and provides data and clarification of the current process and the attitude towards a blockchain based process.

By looking to the current real estate management process, the interviews did not provide any contrary results compared to the theoretical framework. All the respondents seems satisfied with the different steps in the current real estate transaction process. Nevertheless, the findings indicated a demand for more structured information up front, which is well maintained and documented during the operation phase. A lack of well registered and updated documents is experienced as most disturbing factor in the process.

The data retrieved from the interviews illustrates some interesting initiatives, or products which are currently being employed in order to innovate the current process. It seems that all participants are aware of the major trends and developments currently occur. Client focus and data efficiency are the main drivers for innovation.

The basic knowledge about blockchain technology is present among the different stakeholders. Subsequently, the perception towards blockchain based solution that may innovate or disrupt the current process is positive. Some companies are already experimenting with blockchain pilots in real estate. However, there is need for a certain kind of standardization and simplification of the current processes in order continue building blockchain application.

By looking to the proposed blockchain based transaction process, all interviewees showed a positive attitude. Nevertheless, findings indicate that blockchain technology by itself is not enough, since blockchain is just a ledger of transactions. Other innovations should be incorporated in order to create a renewed blockchain based environment, such as machine learning and artificial intelligence.

All interviewees were clear about the starting point for blockchain in real estate, digitalizing assets. This is also seen as the biggest challenge. Via conceptual thinking the possibilities seems endless, however, in practice this is much more complex.

In order to create a blockchain environment in real estate, all stakeholders need to cooperate. Market parties will be the push behind this movement. Consequently, the government needs to formulate clear guidelines, regulations, and standardization. Otherwise, the situation may occur that all stakeholders are building their own product, without the possibility to interact with each other.

Blockchain based Real Estate Management

Opportunities

By aligning the hypothetic opportunities with the findings of literature five opportunities for implementing blockchain in real estate are identified:

1. Creating a building passport of commercial real estate represented by a smart token on the blockchain;
2. Developing alternative financing tools;
3. Transacting commercial real estate via blockchain;
4. Digitally sign lease contracts and monitoring of all the obligations deriving from the agreement;
5. Measuring building performance & maintenance via the blockchain.
The key for using blockchain technology in real estate management is creating a digital representation of a property in the blockchain as revealed by this study. The property can be represented by a smart token which consists of or is linked to four different field of information which are general information, commercial information, technical information and financial information. The biggest added value of the use of blockchain is that all stakeholders can rely on the same data, and they do not have to check the data over and over again. Another great added value of using this token system is that this will streamline real estate transactions and due diligence becomes more efficient, since in the current situation often important documents of a property are lacking or missing. Blockchain based transaction may potentially save time and therefore money. On the long term also the influence of the notary will be questionable. This will reduce the transaction costs.

Also in the operational phase of the property blockchain can add value compared to the current system. Within commercial management the process of creating and signing lease agreements will be much more efficient via the earlier mentioned smart contracts. All these contracts and the monitoring of the obligations deriving from the contract will become automatic. During technical management all the technical information, invoices, warrantee certificates, etc. could be up to date during the complete lifecycle of the property by the use of blockchain.

Another added value of the use of blockchain, the owner does not have to care about administrative procedures anymore and can trust on the data, since the blockchain maintains this administration automatically. Besides the time and cost savings, the owner can focus on improving their product and create new business models. This can add value to the client experience of buildings. Blockchain can make real estate markets transparent. This adds value to the research departments of the broker firms who need to check all transaction data manual on quarterly basis. Transparent markets allow also for new rating systems of companies based on the registered performances in the blockchain.

The design of the new blockchain based real estate management process is best shown in the flowchart models as shown in figure 5 and 6. The first model visualizes the components of a digital buildings passport, whereas the second model represents a blockchain based transaction process.

Figure 5 – Representation of elements of digital real estate coin. Source: Own illustration.
Challenges & Limitations

Complete disruption of the current real estate management process by using blockchain technology is questionable. The real estate sector needs to overcome a couple of challenges in order to implement blockchain properly.

In order to gain broad adoption, technical standards must be produced and agreed upon to assure compatibility across industries. All stakeholders need to cooperate on a global scale in order to create a uniform framework both legal and technical for digital assets on the blockchain. This widespread adoption is essential for the positive network effect of blockchain to be truly harnessed. The major threats to achieve this critical mass are fragmentation of platforms and institutional and social inertia.
to transition to a specific platform. As a starting point, the biggest industry stakeholders should collaborate on EU level. The European Union has created common standards to facilitate the exchange of information and data between the local, regional, national and European or international levels via their initiative INSPIRE. A certain platform is extremely suitable for further development of blockchain standardization.

Another challenge is a change in the current processes to support high quality data input. Considering a blockchain database is only as good as the data and the business processes that underlie it. Failure to reach a consensus among counterparties as to business processes or to resolve commercial conflicts could significantly hinder blockchain’s adoption. Especially for the Dutch environment this might be a challenge. All stakeholders have a positive attitude towards the current system. The change of current business processes might be an immense challenge. Every country has its own regulation and systems. It is practically impossible to change all the processes throughout the world into one uniform blockchain based system. Transacting real estate on the blockchain in the same way bitcoin is transacted, decentralized, on a global scale, seems infeasible.

Since the several processes within real estate management are complex and involve a variety of stakeholders, further development of blockchain solutions need to be explored on sub-parts of the real estate management process. More extensive research about these sub-processes is needed for creating better understanding of the impact of blockchain technology. Blockchain by itself will not achieve this proposition. Other data-driven innovations such as artificial intelligence and machine learning algorithms needed to be incorporated as well.

It is important to note that as blockchain is becoming more mature, they can gain purpose and deliver their promises to the greater public. The technology by itself is still in its early stages. It has proven itself for digital currencies, despite the potential for blockchain technology, there are not many proof of concepts built on the blockchain for other industries yet. In order for blockchain technology to become mature it is important that companies are keep working on creating proof of concepts for blockchain applications. Try and error seems to be the best method.

**Conclusion**

Blockchain has the potential to interfere at the basic principles of existing real estate processes. In a sector plagued by middlemen and characterized by inefficient processes, this technology is able to restructure the process of managing real estate and transferring digital assets. In order to improve the current real estate management processes, blockchain can add value due to:

1. Creating a building passport of commercial real estate represented by a smart token on the blockchain;
2. Developing alternative financing tools;
3. Transacting commercial real estate via blockchain;
4. Digitally sign lease contracts and monitoring of all the obligations deriving from the agreement;
5. Measuring building performance & maintenance via the blockchain.

Although the opportunities are promising research shows that blockchain is still in its early stage of development and therefore needs to overcome some limitations and challenges of the current system both internal and external, including technical challenges, standardization, public perception, government regulation and mainstream adoption of technology. In order for this technology to become mature special-purpose blockchains will need to be created for a wide variety of applications. Special challenges for the real estate industry are producing technical standards and a framework both legal and technical, forcing a change in current business processes, further development of solutions
for sub-parts of the process and involving other innovations such as artificial intelligence, or machine learning.

The empirical results of this thesis contribute to the existing body of knowledge for possible applications of this technology in real estate. The outcomes of this study make sure one can fully understand the potential of blockchain and its implications in real estate. This research contributes in creating this understanding, in order to define a starting point for companies active in the field of real estate to further build on blockchain applications. The findings and outcomes of this study are supposed to trigger fellow students and interested companies to conduct further research in this field.

This study is of explorative nature and focused solely on identifying possible opportunities and constraints for the implementation of blockchain technology, therefore there is much that cannot be explained by this study. Despite the extensive literature study and the various interviews, this study might have raised even more questions than it provided answers to. Further research is needed in order to identify and research specific business process use cases and reinvent business models. Other interesting field for further research might be creating technical standards or a juridical framework, finding relations with other innovations, or measuring the impact of improved liquidity of real estate assets.
# TABLE OF CONTENTS

Preface .......................................................................................................................... 4  
Management summary ................................................................................................... 5  

**Part I – Introduction chapter** ................................................................................... 20  
1  Introduction ............................................................................................................. 20  
   1.1  Research Objective ......................................................................................... 20  
   1.2  Problem Analysis ......................................................................................... 21  
   1.3  Problem Statement & Research Output ......................................................... 24  
   1.4  Research Questions ...................................................................................... 24  
   1.5  Scientific Relevance ..................................................................................... 25  
   1.6  Practical Relevance ....................................................................................... 25  

**Part II – Research Methods** .................................................................................... 27  
2  Research Methodology ............................................................................................ 27  
   2.1  Research Approach ...................................................................................... 27  
   2.2  Research Design ............................................................................................ 27  
   2.3  Research Scope .............................................................................................. 30  

**Part III – Theoretical Framework** .......................................................................... 32  
3  Theoretical Framework – Blockchain Technology .................................................. 32  
   3.1  Introduction .................................................................................................... 32  
   3.2  How does it work .......................................................................................... 33  
   3.3  Public versus Private Blockchain .................................................................. 35  
   3.4  Current Blockchain Applications and Use Cases ......................................... 36  
   3.5  Smart Contracts ............................................................................................ 39  
   3.6  Opportunities for Real Estate ........................................................................ 39  
   3.7  Challenges and Limitations .......................................................................... 43  
   3.8  Conclusion ..................................................................................................... 45  

4  Theoretical Framework – Real estate Management Process .................................... 46  
   4.1  Commercial Real Estate ............................................................................... 46  
   4.2  Managing Real Estate ................................................................................... 46  
   4.3  The stakeholders involved .......................................................................... 49  
   4.4  Transacting real estate ............................................................................... 50  
   4.5  Operating in the real estate life cycle ............................................................ 56  
   4.6  Conclusion ..................................................................................................... 61  

**Part IV – Empirical Findings** .................................................................................. 63  
5  The blockchain based real estate management process ......................................... 63  
   5.1  Identifying possible opportunities in the process .......................................... 63  

17
Part I

INTRODUCTION CHAPTER
INTRODUCTION

This chapter illustrates the starting point of the study and provides an introduction of the concept blockchain. First it will elaborate upon the research objective of this study, followed by a problem analysis into the concept of blockchain. Section 1.3 covers the problem statement of this research, followed by the research questions in Section 1.4. This chapter will conclude with the scientific and practical relevance.

1.1 Research Objective

While the Bitcoin hype cycle has gone quiet, Silicon Valley and Wall Street are betting that the underlying technology behind it, the Blockchain, can change... well everything (Williams-Grut, 2015). The internet made it possible for individuals to transfer information, quickly, cheaply and paperlessly without obtrusive intermediaries. Similarly, blockchain technology offers the same advantages for transferring value and enabling trust. You use the internet to transfer words and pictures. You use blockchain platforms to transfer money and assets.

Currently some notable changes in the real estate industry can be witnessed, not just regarding blockchain, but regarding the acceptance and use of digital platforms and technology in general. Initiatives, such as Redex and SBR’s ‘vastgoedtaxonomie’ are trying to improve standardization in order to support better exchange and use of real-estate data. Blockchain technology holds many promises for real estate, allowing for optimized processes and accelerating disintermediation in an industry that has been “plagued” by middlemen (Ngo, 2016).

The potential of the Blockchain seems endless and companies are investing millions in this technology. An analyst of Goldman Sachs (Williams-Grut, 2015) argues that blockchain has the potential to redefine transactions and the back office of a multitude of different industries. From banking and payments to notaries to voting systems to vehicle registrations to wire fees to gun checks to academic records to trade settlement to cataloguing ownership of works of art, a distributed shared ledger has the potential to make interactions quicker, less-expensive and safer.

The founder of the International Blockchain Real Estate Association (IBREA) Mr. Lifthrasir says “Blockchain technology can replace middlemen with peer-to-peer transactional tools. It can provide a comprehensive platform for the life cycle of a property. Title insurance, escrow companies, county recorder’s offices, brokers, lawyers, home owner associations, and various support staff can be replaced with a combination of digital tokens, multi-sig escrow, smart contracts, time stamped encrypted data, and crypto currency.” Among the benefits of using this technology, Bitcoin and other public blockchains can reduce costs, stamp out fraud, speed up transactions, increase financial privacy, internationalize markets, and make real estate a liquid asset (Ngo, 2016). Simply said, blockchain is a digital peer-to-peer platform that allows transactions between two parties without the need for a central institution. Today visions of decentralized peer-to-peer platforms, contract management systems, clearing and settlement of securities transactions without the need for a trusted third party, and trust-free transaction systems announce disruptive changes in market structures (Nothelson et al., 2017).

Real estate is a unique and complex asset class. Real estate differs from other asset classes by having high transaction costs, land use regulations and other barriers to entry, long-lasting improvements, and a relatively slow reaction of supply to changes in demand. These characteristics have implications for the overall efficiency of the market. This inefficiency implies that more or better market knowledge
and experience may have a payoff (Brent & Lusht, 2008). The two primary characteristics of real estate assets are their heterogeneity and immobility. Because of these two factors, the market for buying, selling, and leasing real estate tends to be illiquid, localized and highly segmented, with privately negotiated transactions and high transaction costs due to the involvement of a vast amount of trusted third parties (Ling & Archer, 2013).

As can be witnessed from the above mentioned literature, the possibilities for blockchain applications seems endlessly and game changing. The hype is exaggerating and more and more people are showing their mutual interest in this topic. Due to the characteristics and inefficiencies in real estate processes, blockchain technology might improve the current real estate processes. This research tries to grab onto this hype by projecting blockchain technology on real estate management, by taking into account the following objective:

This research will focus on exploring the different possibilities for integrating blockchain technology in the real estate management process. By analyzing the current real estate management process and gaining knowledge about the implementation of Blockchain technology, the objective of this research is exploring in which phases of the real estate management process the process can benefit from the use of blockchain technology.

The research findings contribute to the knowledge of opportunities for broad implementation of blockchain technology in the real estate management process by providing a scientific based research document. It provides a broad overview of different opportunities and constraints for using blockchain technology in the process. It increases awareness for the disruption this technology might bring. This research provides scientific arguments for possibilities of implementing blockchain technology in the real estate management process and will function as a trigger for continuation of research into this topic.

1.2 Problem Analysis

The Blockchain Revolution

Back in 2008, when the world was still recovering from a huge financial crisis, it was the anonymous Satoshi Nakamoto who launched a whitepaper which was going to shake the foundation of the whole financial sector. In his paper “Bitcoin: A Peer-to-Peer Electronic Cash System”, Nakamoto argues that while the financial system works well enough for most transactions, it still suffers from the inherent weaknesses of the trust based model. Completely non-reversible transactions are not really possible, since financial institutions cannot avoid mediating disputes. The cost of mediation increases transaction costs, limiting the minimum practical transaction size and cutting of the possibility for small casual transactions, besides it fives the chance for double spending problem (Nakamoto, 2008). Nakamoto describes a new electronic payment system based on cryptographic proof instead of trust, allowing any two willing parties to transact directly with each other without the need for a trusted third party. Transactions that are computationally impractical to reverse. This new digital currency is called the Bitcoin.

Bitcoin is digital cash that is transacted via the Internet in a decentralized trustless system using a public ledger called the blockchain. The terminology can be confusing because the words Bitcoin and blockchain may be used to refer to any three parts of the concept: the underlying blockchain technology, the protocol and client through which transactions are effected, and the actual cryptocurrency (money) (Swan, 2015). Nevertheless, this research is not focusing on the Bitcoin as a digital currency. It is the underlying technology which is of interest for this research, the Blockchain.
Imagine, for a moment, a global, online ledger, or network of ledgers, listing every single transaction in the world. It’s verified immediately by other people using the system, which protects people’s privacy, but is transparent enough to allow for oversight from anyone. No one group regulates it, so it’s neutral and accessible to anyone with a computer. That is the world that visionaries of the blockchain foresee (Lachance, 2016).

But how does the Blockchain work? Deloitte published an article devoted to the blockchain and describe the blockchain as a new solution to a more challenging version of Byzantine General Problem that includes the ability to add participants over time. A blockchain is a digital, distributed ledger, with identical copies maintained on multiple computer systems controlled by different entities (Schatsky & Muraskin, 2015).

Melanie Swan, founder of the institute for blockchain studies defines blockchain in her book (Swan, 2015) as a decentralized transparent ledger with the transaction records, a database that is shared by all network nodes, updated by miners, monitored by everyone, and owned and controlled by no one. It is like a giant interactive spreadsheet that everyone has access to and updates and confirms that the digital transactions transferring funds are unique (Swan, 2015). The blockchain is built upon different blocks. According to Swan the block is a group of transactions posted sequentially to the ledger – that is, added to the chain. Blockchain ledgers can be inspected publically with block explorers, internet sites where you can see a transaction stream by entering a blockchain address (Swan, 2015).

The research paper of EVRY (Froystad & Holm, 2015) gives the definition a broader proposition by seeing the blockchain as a global distributed ledger, which facilitates the movement of assets across the world in seconds, with only a minimal transaction fee. These assets can be any type of value, as long as they can represented digitally (Froystad & Holm, 2015).

From the above mentioned literature it becomes clear what blockchain in principle is capable of. However, how does it really work? The following scheme, as shown in figure 1, created by the Credit Suisse Research gives a visualization on how the blockchain works for the bitcoin protocol.

Figure 7 – Visualization of the bitcoin blockchain. Source: (Credit Suisse, 2016)
From Internet of Information to Internet of Value
Due to blockchain one of the most notable changes since the start of the internet may happen. According to Don Tapscot (Maciver, 2016) the underlying technology of blockchains might actually represent a second era of the internet. For the last 40 years we’ve had the internet of information; now, with blockchains, we are getting the internet of value.

The article of Maciver (2016) mentioned that the information-centric medium of the web was never designed to handle the exchange of actual value. When information is send, it is not actually the real information, but it is just a copy. For instance, when sending money online, the actual value is not moved directly. Instead an instruction is send to an intermediary (Bank, a credit card company, PayPal) to pass on the value. The peer-to-peer exchange facilitated by blockchains has its basis in some pretty complex but powerful IT architecture. In essence, blockchains are cloud databases distributed over large numbers of devices that maintain a global distributed ledger of transactions (encapsulated in blocks), whose integrity, permanence and non-reputability is assured by the running of regular comparisons across chains of those interconnected blocks. The underlying technology is open source, leaving companies free to innovate; and it maintains security through the use of heavy-duty encryption. For the first time, value can actually be transferred peer-to-peer (Maciver, 2016).

Blockchain in Real Estate
The commercial real estate industry is well known for its information intransparency to create a possible competitive advantage. In response to greater demand for transparency, technology advancements and the disintermediation by startups are gradually making some of this information public. As a result, property-related information is increasingly available in digital and paper form. However, a significant portion of the digitized information is hosted on disparate systems, which results in a lack of transparency and efficiency, and a higher incidence of inaccuracies that creates a greater potential for fraud. Blockchain technology could enable the commercial real estate industry to address these inefficiencies and inaccuracies (Deloitte, 2017).

Several companies see the potential of blockchain technology and are trying to find solutions via this technology. Online, different articles are devoted to the impact of blockchain in real estate. Ragnar Lifthrasir discusses in his article (Lifthrasir, 2016) that the Blockchain will transform real estate in four ways:

1. Disintermediation, taking out the third party
2. Fraud prevention
3. Money 2.0, replacing escrows
4. Smart Contracts

Deloitte presented an article more recently about their vision on the way blockchain may affect real estate. Deloitte spotted three advantages of blockchain for the real estate industry (Donkers & Santing, 2016):

1. Total transparency
2. Removing the risk of fraud
3. Speeding up the process associated with buying or selling a property

All the above mentioned advantages and implementations are just rough ideas. There are hardly any proof of concepts of blockchain in real estate. The first proof of concepts starts to emerge though. Among others, in Rotterdam CIC is working together with Deloitte to digitize rental agreements based on blockchain technology. Also ABN AMRO recently launched an experiment together with IBM to use blockchain technology in real estate transactions. There are more examples of experiments of Blockchain in Real Estate, this topic will be further elaborated on later in this study.
1.3 Problem Statement & Research Output

As can be witnessed from the above mentioned articles and which is confirmed by different authors there are different opportunities for the implementation of blockchain in real estate. The real estate sector is characterized by intransparent markets, inefficient processes, and a lack of technological developments. Blockchain technology might benefit the sector by solving this issues with its capability of transferring real assets via the digital world without the need for a trusted third party. This technology seems possible to not only disrupt the sector, but giving it a new foundation. This leads to the following problem statement:

Blockchain has the potential to interfere at the basic principles of existing real estate processes. In a sector plagued by middlemen and characterized by inefficient processes, this technology might be able to restructure the process of managing real estate and transferring digital assets.

This research will elaborate on how blockchain technology can be used to restructure real estate management processes more efficient. Due to the lack of scientific knowledge, the different opportunities for blockchain in real estate management still need to be explored. The output of this research provides scientific evidence on the opportunities and constraints for implementing blockchain technology in current real estate processes and develops a framework for key fields of further research.

1.4 Research Questions

Main Research Question
Based on the problem statement and the objectives of this research the following main research question has emerged:

What are the different opportunities and constraints for the implementation of blockchain technology in order to improve the current real estate management process?

Sub Questions
To be able to answer the main research question properly, several sub-questions need to be answered. The sub-questions are divided into the two main fields of this research: Real estate management and Blockchain. From the main research the following sub-questions have been derived:

Real estate management
1. What are the different phases of the current real estate management process where we see ‘trusted third parties involved’ in exchanging deeds of ‘value’ or ‘trust’?
2. Who are the stakeholders involved in the different phases of the real estate management process and what is their added value to the entire process?
3. What are the process-flows and cost-structures in these real estate management processes?
4. Which assets are exchanged and transferred during the real estate management process?

Blockchain
5. What is blockchain technology and how does it work?
6. How is blockchain technology currently applied worldwide?
7. What are the potential opportunities of blockchain to enhance in the real estate management process?
8. Where in the real estate management process can blockchain lead to significant added value compared to the present situation?
9. How can the new real estate management process be structured by the use of blockchain technology?
10. What are the challenges for implementing blockchain in the real estate management process?

1.5 Scientific Relevance

As stated earlier, the way we are transferring and exchanging assets can be changed radically. The scientific body of knowledge on blockchain is extensive; a vast amount of articles, books and papers have been published on the concept of blockchain. Yli-Huumo et al. (2016) studied the current field of scientific research on blockchain technology. Their research showed that in over 80% of the studies the focus was on Bitcoin systems (digital payments) and less than 20% deals with other blockchain applications. The majority of current research in the field of Blockchain is focusing on revealing and improving limitations of Blockchain from privacy and security perspectives, but many of the proposed solutions lack concrete evaluation on their effectiveness (Yli-Huumo et al., 2016). From the 20% of research dealing with other blockchain applications, there is hardly any scientific research about the possibilities for the applications in real estate. With the growing interest in blockchain technology, this lack of scientific knowledge shows the need for research on the possibilities for blockchain applications in the field of real estate. This research focuses on this knowledge gap and makes an attempt to fill this gap.

1.6 Practical Relevance

It is clear that more and more companies, researchers, and governmental entities are looking at the potential impact of blockchain technology on businesses and daily life. Some researchers even say that blockchain represents the next generation of the Internet. If the Internet was the first native digital format for information, then blockchain is the first native digital format for value – a new medium for money. It acts as ledger of accounts, database, notary, sentry and clearing house, all by consensus. And it holds the potential to make markets radically more efficient, secure, inclusive and transparent (Tapscott, 2016).

With a technique which is so powerful to completely change the foundations of an industry, it seems obvious that this topic is worth researching. If blockchain has indeed the potential to reshape the real estate management process, it can change the way involved companies do their business. This will affect a wide range of stakeholders in the field of real estate.

However, the first step to taking advantage of this new technology is making sure one can fully understand its potential and its implications. This research contributes in creating this understanding, in order to define a starting point for companies active in the field of real estate to further build on blockchain applications.
Part II

Research Methods
PART II – RESEARCH METHODS

2 RESEARCH METHODOLOGY

This chapter discusses the research methodology. Section 2.1 will explain the research approach most suitable for this research. Section 2.2 clarifies the research design and model used for this study as well as the different methods needed for answering the research questions. Finally, section 2.3 covers the research scope.

2.1 Research Approach

Due to the explorative character of this study, the research strategy is of qualitative nature. This is in line with the explorative character of qualitative research, since this study is concerned with finding answers to generate a theoretical explanation of a certain phenomenon rather than testing a predefined theory (Bryman, 2012). A qualitative approach is also considered more as a relatively unstructured approach to the research process, which is preferable for a topic where hardly any research is done for in the past (Bryman, 2012). Therefore, the qualitative approach is most appropriate for this study.

This research will encourage the connection between a literature study, developments of the blockchain and practitioners. It seeks to bring theory and practice together in the pursuit of developing practical solutions for parties involved in the real estate management process concerning blockchain technology. This study can therefore be classified as action research. There is no single type of action research, and hardly any short definition. However, the terms refers to approaches that are concerned with producing practical outcomes. The research emphasizes the production of practical knowledge and new forms of structuring the asset management process (Reason & Bradbury, 2001).

2.2 Research Design

The study is based on different methods. The different steps below describe the different phases of the research project. Figure 2 shows the research model. After creating a proper problem statement and research question the theoretical framework will be built in Step 1. The theoretical framework defines the real estate management process and the concept of blockchain. After step 1 the operational part of the research begins. The identification as mentioned in step 2 will be conducted via semi-structured interviews with involved parties. Step 2 and 3 operate as a cycle. After step 2 the results will be analyzed. If needed, additional interviews will be conducted in order to create theoretical saturation. The last step is writing down the findings, and point out opportunities for further research.

- Step 1a – Exploration on the phenomenon of the blockchain (why blockchain, how does it work, advantages and bottlenecks, current applications);
- Step 1b – Draw up an inventory of the current real estate management process and how it is organized (stakeholders, data structures);
- Step 2 – Identifying which technologies for the storage and transferring of information and assets are used during the real estate management process and how blockchain technology can contribute;
- Step 3 – Analyzing the results of step 2 and identify opportunities for the implementation of blockchain technology;
- Step 4 – Writing down the different results and discuss for which topics further research is relevant.
Desk Research
To acquaint yourself with the available body of knowledge in the research field and to gather more understanding of the theoretical background, concepts and theories that needs to be applied, a literature study is necessary (Kumar, 2011) (Bryman, 2012). Kumar (2011) notices that a well-executed literature review can bring clarity and focus to the research problem, improve the research methodology, broaden the knowledge base, and contextualize the findings.

Within this study desk research functions as an important pillar throughout the whole research. The literature study aims to clarify the two major concepts of this study: real estate management and blockchain technology. The empirical findings together with the findings from the desk research will be used to formulate an answer on the main research question. The aim of the literature study and the main literature sources used to clarify the two concepts will be discussed below.

Blockchain Technology
The literature study into the concept of blockchain technology aims to clarify this concept in an easy way. It will focus primarily on how this technology works in order to identify the opportunities this technology might bring for the real estate management process. Due to the scope of this research the literature study will not go into detail about the way a blockchain needs to be programmed.

As stated earlier by Yli-Huumo et al. (2016) the current scientific research in the field of Blockchain focuses mainly on the bitcoin application (digital currency). The literature on the applications of blockchain technology for other fields is limited. The study will combine the findings and definitions of different studies to develop a clear and comprehensive framework which can be used complementary to the interviews.
Real Estate Management
Within the context of this study the desk research into the concept of real estate management aims to reveal the different phases from acquiring a real estate asset, operating the asset, and finally the disposition of the asset. Within each phase the literature study focusses on the different tasks and deliverables needed to accomplish the stage. In addition, the literature study will also cover the main stakeholders involved and the data streams and process flows which occur during the process.

Research done in the field of real estate management is extensive and a variety of literature sources is available. The literature covers both the different phases and stages in the real estate management process as well as more detailed studies for each stage separately. For this research the real estate management process is mainly based on the concept of Van Driel (2016) as described in chapter 3.2. Within each phase, additional literature will be used.

Interviews
During the first phase of this research project, several exploratory expert interviews were conducted in order to support shaping the problem statement and the research questions. These interviews were of unstructured nature, since this offers the broadest approach and therefore creating a diverse range of information. In the early stage of the research broad data input was desired. The interviewees were professionals from different areas of expertise: a consultancy firm, a real estate advisor, a bank and a tech-firm. Respectively known as Deloitte, JLL, Rabobank and Eneco.

In the second phase of this research several semi-structured interviews will be conducted with experts working at the major stakeholders involved in the real estate management process as well as blockchain experts. The reason for choosing semi-structured interviews is the allowance of adjusting the emphases in the research as a result of significant issues that emerge in the course of interviews (Bryman, 2012). Due to the explorative nature of this research this flexibility is needed during the interviews.

The main aim of the interviews is two-folded. On the one hand it will validate the real estate management process as formulated in the theoretical framework by the input of practical data. On the other hand it aims to reveal the perception of the interviewees towards blockchain technology. The semi-structured interviews will be conducted with experts and stakeholders in the real estate management process: asset managers, property managers, real estate broker, bank, notary, maintenance company. Appendix I provides the interview protocol which will be used during the interviews.

The semi-structured interviews will provide qualitative data which can be further analyzed. One of the main difficulties with qualitative data is the failure to give the data wider significance for science. So the researcher must guard against being captivated by the richness of the data collected (Bryman, 2012). All the interviews will be transcribed and coded to make sure the data allows for analysis. The empirical findings of the interviews together with the results from the literature study will be used to answer the main research question.
### Table 1 – Relationship between research questions and research methods (Own illustration).

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Literature study</th>
<th>Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What are the different phases of the current real estate management process where we see ‘trusted third parties involved’ in exchanging deeds of ‘value’ or ‘trust’</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>2. Who are the stakeholders involved in the different phases of the real estate management process? And what is their added value to the entire process?</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>3. What are the process-flows and cost-structures in these real estate management processes?</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>4. Which assets are exchanged and transferred during the real estate management process?</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

### Research Scope

Regarding the real estate management process this research focusses only on the real estate management process in the Netherlands. It takes into account the different phases from buying an asset, the operation phase, till eventually selling the asset. Within the real estate management process the study zooms in on the data streams for each stakeholder. The study explicitly addresses the process in general, it will not focus on specific problems which occur in the process.

Regarding blockchain technology the focus of this study is on blockchain as a theoretical concept based on literature studies and expert reviews. It does not take into account the underlying programmable codes to create a block, since this does not fit within the universities program and is therefore beyond reasonable time and available resources. Subsequently, this study will create a concept with suggestions for further research instead of a proof of concept.
PART III – THEORETICAL FRAMEWORK

3 THEORETICAL FRAMEWORK – BLOCKCHAIN TECHNOLOGY

This chapter is the second part of the theoretical framework and focusses on the concept of blockchain. This chapter will describe the definition of the concept blockchain and how this technology works. It will also consider the distinction between a public and a private blockchain. Within this chapter an analysis is made of the current applications of the blockchain technology and will elaborate on the concept smart contracts. This chapter concludes with describing the opportunities and the limitations of blockchain technology.

3.1 Introduction

Chapter 1 of this thesis already gave a first definition of the concept blockchain. This section will give more insight in the phenomenon blockchain. Blockchain technology is in other words a distributed ledger technology. From the viewpoint of Swan (2015) blockchain is defined as a decentralized transparent ledger with the transaction records, a database that is shared by all network nodes, updated by miners, monitored by everyone, and owned and controlled by no one. It is like a giant interactive spreadsheet that everyone has access to and updates and confirms that the digital transactions transferring funds are unique (Swan, 2015).

Since the blockchain is a distributed database holding a public ledger of all transactions, in the most basic explanation, blockchain technology is a tool for the management of information, with a focus on managing the records of transactions. The part that makes the blockchain a transformative innovation is that every node on the network has a complete or partial copy of the blockchain and all historical transactions. Via the placement of a timestamp on each transaction in the blockchain, the transactions are immutable and can always be trusted. This eliminates the need for a central database and ensures that a single user is unable to fraudulently manipulate the data (Spielman, 2016).

Goldman Sachs Global Investment Research (2016) addresses the essence of blockchain technology with defining blockchain as a shared, distributed database of transactions among parties that is designed to increase transparency, security, and efficiency. The anatomy of the blockchain can be described by the following process:

“Blockchain is:
A database (with copies of the database replicated across multiple locations or nodes)
of transactions (between two or more parties)
split into blocks (with each block containing details of the transaction such as the seller, the buyer, the price, the contract terms, and other relevant details)
which are validated by the entire network via encryption by combining the common transaction details with the unique signatures of two or more parties. The transaction is valid if the result of the encoding is the same for all nodes.
and added to the chain of prior transactions (as long as the block is validated). If the block is invalid, a “consensus” of nodes will correct the result in the non-conforming node” (Goldman Sachs Global Investment Research, 2016).

Another viewpoint to look to blockchain technology is introduced by Anand et al (2016) with a rather more technical definition. Simply put, the blockchain is an economic layer for the internet. It provides a protocol for tokens of value to be transferred on a peer-to-peer (P2P) basis without central actors being necessary. Not only can these tokens be used as a form of currency and a payment system but tokens can represent other forms of value such as stocks, bonds, votes, and even property.
If the layers of the internet are divided the Transmission Control Protocol (TCP)/ Internet Protocol (IP) layer of the internet was designed to transfer packets of information from one computing device on a network to another. The Hypertext Transfer Protocol (HTTP) layer was designed to allow the information to be organized and many layers and applications were built on top spawning the internet as it exists today. The blockchain can be then thought of as the value transfer protocol or the financial internet (Anand, 2016). On top of the HTTP layer a lot of applications are build which are nowadays used on a day-to-day basis. With the introduction of blockchain a new layer was build which enables a lot of parties and individuals to build new innovative applications on top of the blockchain.

Important to notice is that there is not one single type of blockchain. There are many different blockchains all serving for similar or different purposes, such as the Bitcoin-, Ethereum-, Dash-, Lisk-, Steem-, and Ripple blockchain. Each blockchain features different characteristics. Nevertheless they share the same principle of peer-to-peer transactions and decentralized applications.

### 3.2 How does it work

A blockchain is a distributed tamper proof public database which stores its transaction data in containers called “blocks” (Antonopoulos, 2014). Blocks are files where data pertaining to the network is permanently recorded. A block records some or all of the most recent transactions that have not yet entered any prior blocks. Thus a block is like a page of a ledger or record book. Each time a block is ‘completed’, it gives way to the next block in the blockchain. A block is thus a permanent store of records which, once written, cannot be altered or removed (Investopedia, 2017).

Each block created is linked to the parent block through digital fingerprints called hashes. A hash is a unique identifier and shortcut that’s created when actual transaction data is passed through a cryptographic tool in order to keep transaction data secret (Morrison, 2015). These hashes are publically timestamped in a header at the top of each block of information. This history of transactions stored on the blocks can be linked back to the initial “parent” or “genesis” block. A parent block is referred to as the previous block in the chain, whereas the genesis block is the first block ever created in the chain.

The information stored in blocks is resilient against tampering and corruption even by those who store and process the information. This is made possible by independent nodes that come to a decentralized consensus for all transactions which have occurred (Antonopoulos, 2014).

**Miner**

In the blockchain network miners are the ones who are validating the transactions added to the blockchain. A miner is a participant in a blockchain that participates in securing the network and validating new transactions. The mining and validating process happens via either competitive, voting, or luck-based methods depending on the consensus protocol chosen. Miners are incentivized to participate in a blockchain either because they receive mining rewards in the form of cryptocurrency (eg. Bitcoin) or because they have a vested interest in accessing and exchanging data on the network. Think of businesses that chooses to participate in an industry or market-specific blockchain to gather a data advantage from their competitors (ENISA, 2016).

**Consensus Protocol**

The core difference between a distributed ledger and a traditional database is the way in which datasets evolve over time. The system allows multiple participants to submit new inputs to a distributed ledger. Consensus is then used to determine over time which state of the database is considered as valid. This is in contrast to a traditional database, where multiple participants submit new inputs and one counterparty is relied on to provide the valid state of the database. Consensus
protocols are the mechanisms by which all users within a distributed ledger agree on the validity of the underlying data (ENISA, 2016).

One of the key aspects of a distributed ledger is that the data held within it, is considered valid because all parties agree to a single “true” version. In the event that existing participants in a blockchain decide to include data in a non-compliant manner with established protocols, an event named a fork occurs. Forks result in a split of the ledger and the consequent creation of two groups, each validating their own version of the ledger. In order for the participants to be able to continue to interact with each other they are required to follow the same fork of the ledger (ENISA, 2016).

Research of the European Union Agency for Network and Information Security (ENISA, 2016) distinguished four main consensus protocols in use which are shown in the following table:

<table>
<thead>
<tr>
<th>Consensus Protocol</th>
<th>Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proof of Work</td>
<td>Uses computational power to validate new blocks of data. To participate in this scheme, participants are required to collate transactions within a single block and then apply a hash function with the use of some additional metadata.</td>
</tr>
<tr>
<td>Proof of Stake</td>
<td>Validators (special nodes) voting on valid blocks whilst posting collateral in order to be able to participate in the validation process. Unlike Proof of Work, Proof of Stake relies on proving the user is invested in the underlying token of value of the network being mined rather than being the owner of a large amount of computing power.</td>
</tr>
<tr>
<td>Ripple Protocol</td>
<td>In order to validate new transactions, servers amalgamate outstanding transactions into a “candidate list.” All participants then vote on valid transactions to be included in the ledger. Transactions that meet the 80% threshold of “yes” votes are included within the following last closed ledger state.</td>
</tr>
<tr>
<td>Proof of Elapsed Time</td>
<td>As part of its Inteldledger proposal, Intel has devised a means of establishing a validation lottery that takes advantage of the capability of its CPUs to produce a timestamp cryptographically signed by the hardware. Whoever in the chain has the next soonest timestamp will be the one to decide which transactions will be a part of the next block in the chain. This consensus method is extremely energy efficient compared to Proof of Work and therefore more adapted to IoT devices.</td>
</tr>
</tbody>
</table>

Table 2 – Overview of different consensus protocols. Source: (ENISA, 2016)

Cryptography

To verify the validity of the blocks in the blockchain heavy cryptography is used. In the first part of this chapter the concept of hashes is described. In the blockchain hash pointers are used to connect the blocks. Each block has data as well as a pointer to the previous block in the list. So each block not only tells were the value of the previous block is, but it also contains a digest of value that allows to verify the value has not changed. Another important aspect of the blockchain system is the keys of ownership and the ability to transfer the units of account or digital tokens to other users.

Distributed ledger technology relies on the use of asymmetric cryptography to sign messages (digital signatures) and encrypt data through the use of private/public key pairs (Spielman, 2016; ENISA, 2016). The public key creates a publicly shareable address for the user represented by a unique string of numbers and letters. The private key is the information used to sign the public key and to create a unique digital signature. This signature, once submitted, is used to create a transaction on the network (Spielman, 2016).

The private keys, which allow a given entity to transact with the assets or virtual currency allocated to it in the Blockchain are typically stored in what is called a digital wallet. In a given wallet multiple keys could be stored (ENISA, 2016).
Merkle Trees
To reduce the space of the blockchain and to make it possible to show it on the smallest devices a merkle tree is used. A merkle tree, also known as a binary hash tree, is a data structure used for efficiently summarizing and verifying the integrity of large sets of data. Merkle trees are binary trees containing cryptographic hashes. Merkle trees are used to summarize all the transactions in a block, producing an overall digital fingerprint of the entire set of transactions, providing a very efficient process to verify whether a transaction is included in a block.

Visualizing the blockchain
Credit Suisse (2016) did an extensive research on how the blockchain works and came up with the visualization as shown in Figure 3 of 40 minutes of the bitcoin blockchain in early June 2016. Each block contains a block header, a time stamp, an hash with the previous block, a merkle root which represents the merkle tree of transactions and a nonce which shows the digest of value that allows to verify the value has not changed.

![Figure 9 – Visualization of 40 minutes of the bitcoin blockchain. Source: (Credit Suisse, 2016).](image)

3.3 Public versus Private Blockchain
Although the blockchain is originally build for a decentralized network, a blockchain can be either public or private, also known as permissioned or permissionless. A permissionless ledger is defined as a blockchain protocol where a client may operate a full node without prior approval. Everyone can access the network and download for instance a copy of the database and act as a validator for future transactions. The advantage of a permissionless ledger is that, as it gains adoption, it becomes highly decentralized and redundant, becoming very difficult to shut down (ENISA, 2016). Furthermore applications that are built on a permissionless ledger will be able to interact with other applications on the same ledger. If two applications are on separate ledgers, then a communication channel
becomes required (ENISA, 2016). The downside of a public ledger is that everyone has universal access to the information in the blockchain. For many high-volume commercial transactions, where transactional privacy is important, a private blockchain can be utilized among participants where trust has already been established (Spielman, 2016).

Private, or permissioned ledgers are a form of distributed ledger that operate as a “members’ club”. In this environment, the underlying consensus protocol is freely chosen by the group that initiates the protocol (ENISA, 2016). A permissioned blockchain operates the same as a public or permissionless blockchain. The main difference is that for a permissionless blockchain the identities of the user which want to participate in the blockchain, need to be validated against a list of authorized “members”. The advantage of a permissionless blockchain over a permissioned blockchain is the ability to hold control over the users which participate and maintaining control over private transactional data.

3.4 Current Blockchain Applications and Use Cases

Throughout the world a wide variety of startups is finding new ways for using blockchain technology to develop new products or make processes more efficient. One of world’s most well-known application is Bitcoin. Bitcoin is a digital currency, created and held electronically without the control of anyone (decentralized). Next to Bitcoin some several other digital currencies emerge. However, using blockchain for digital currency is not the only application one can think of. Different studies and books (Antonopoulos, 2014; Williams-Grut, 2015; Schatsky & Muraskin, 2015; Swan, 2015; Tapscott & Tapscott, 2016;) noticed some interesting potential use cases for blockchain technology. Everis (2016) and CBinsights (2017) looked at a vast amount of startups which are currently working on those uses cases and came to the following list of applications which are being build or which are already operational (Everis Next, 2016):

- Peer-to-Peer Payments and Lending;
- Internet of Things (IoT);
- Voting Systems;
- Currency Exchange and Remittance;
- Collaborative Transport;
- Decentralized Markets;
- Proof of Authorship and Ownership;
- Energy Distribution;
- Trustworthy Endorsements and Proof of Identity;
- Data Storage;
- Custodian Services;
- Smart Contracts;
- Prediction Platforms & Online Gaming;
- Digitization of documents and contracts;
- Digital Security Trading;
- Supply Chain Management;
- Governmental Services.

Exchange of value

One of the major disruptions for blockchain technology is the peer-to-peer exchange of value (a.o.: Swan, 2015; Tapscott & Tapscott 2016; Everis, 2016). Start-ups such as Abra, BTC Jam, Bitbond, Coinffeine, Circle, Plutus are working on peer-to-peer services and platforms to facilitate peer-to-peer payments. By eliminating the intermediaries, the blockchain can enable cheaper cross-border remittances and therefore enhance the spending power of recipients (Everis, 2016). In a global financial system where trillions of dollars are moved daily the sector is still relying on outdated systems (Tapscott & Tapscott, 2016). Multiple issues such as high transfer cost, limited money distribution methods, limited brand options, limited ways to deal with money, etc. hold potential for innovation in financial services (Everis, 2016). Almost 50 of the world largest bank and financial services providers are collaborating on improving their business models with blockchain technology in the so called R3 Blockchain cooperation. Start-ups such as Coinbase, Ripple, Chain.com and Stellar are working on different initiatives that facilitate exchanges between digital and normal currencies, financial technologies and building blockchain networks that can exchange any type of asset in any market.
Internet of Things (IoT)
As the number of connected devices grows from billions to hundreds of billions, and as governments and corporations race to take control of devices and data, the IoT needs to be restructured. Adopting peer-to-peer computing to process the hundreds of billions of IoT transactions can significantly reduce cost associated with installing and maintaining large centralized data centers (IBM Global Business Services, 2014). As stated in the book of Tapscott & Tapscott (2016); “The internet of things needs a ledger of things”. Companies such as Chimera-inc and Filament are working on ways blockchain technology can record a ledger of data exchanges between individual and other devices, web services, and human users. Examples include electronic couriers to securely transfer sensitive information, escrow services to transfer ownership rights, or even auto-installation services to verify and push updates to the software governing other Digital-to-analog converters (DACs) (Everis, 2016). IBM and Samsung have been working on a concept known as ADEPT, which uses blockchain-type technology to form the backbone of a decentralized network of IoT devices. This blockchain would serve as a public ledger for a vast amount of devices, which no longer need a central hub to mediate communication between them (CBinsights, 2017).

Collaborative Transport
Another interesting user case can be found in the world of smart transportation. Smart transportation is about maximizing already-existing infrastructure and resources rather than adding new ones. Better use of existing resources creates affordable transportation without the need for more roads or vehicles. Real-time ridesharing is the key, enabling people with private cars to share their journey with others traveling in the same direction. What blockchain adds on top of this is the possibility to put together users without any middlemen thanks to decentralized platforms. Platforms such as La’Zooz and Arcade City are creating Ubers’ worst nightmare; platforms for decentralized ride sharing services owned by the participants without sharing a fee with the middlemen (Everis, 2016).

Decentralized Markets
Currently, trust in the retail system is mainly linked to trust in the marketplace where that purchase is being made on for instance Amazon or eBay (CBInsights, 2017). Decentralized markets can make it possible for any two people in the planet to trade with one another without depending on any institution. It can even bring ecommerce to countries that still have not experienced what these traditional marketplaces have brought to industrialized nations. Open Bazaar and Slock.it are start-ups which are currently buildings those platforms (Everis, 2016).

Energy Distribution
Energy management is another industry that has historically been highly centralized. When one does to transact in energy it have to go through a trusted power holding company, a national grid, or deal with a re-seller that buys from big electricity companies (CBInsights, 2017). Start-ups like Transactive Grid, LO3 Energy, Brooklyn Microgrid, and Solar Change offers technologies that enables customers to transact in decentralized energy generation schemes, and effectively allows people to generate, buy, and sell energy to their neighbors (Everis, 2016; CBInsights, 2017).

Digitization of documents & contracts and Data Storage
With the dramatic increase in types of data and respective formats, the need to integrate and share data across systems has become vital. For most organizations, this involves delicate balancing of the processes that move data between systems. Blockchain plays an important role in a holistic innovation and risk management strategy, including concepts of cyber liability, big data and telematics. Start-up Colu is creating, storing and managing digital assets using blockchain technology, a record-keeping tool for online identity and the Internet of Things (Everis, 2016).
Supply chain management
One of the most universally applicable aspects of blockchain technology is that it enables more secure and transparent monitoring of transactions. Supply chains are basically a series of transaction nodes that link to move products from point A to the point-of-sale or final deployment. With blockchain, as products change hands across a supply chain from manufacture to sale, the transactions can be documented in a permanent decentralized record — reducing time delays, added costs, and human errors. Several blockchain startups are jumping into this sector: Provenance is building a traceability system for materials and products, Fluent offers an alternative platform for lending into global supply chains, and Skuchain builds blockchain-based products for the business-to-business trade and supply-chain finance market (CBInsights, 2017).

The afterlife of goods can be dramatically changed through the existence of a full lifecycle record and supply chain tracking, now possible thanks to blockchain technology. Although luxury objects such as gold, diamonds (which is recently launched by Everledger) and watches are interesting examples, the disruptive use of this technology within identification and authentication lies in the health industry. According to Interpol, more than 200,000 people die worldwide annually from counterfeit anti-allergy drugs alone. Blockchain helps anti-counterfeit in very meaningful ways (Everis, 2016). Decentralized markets can not only play a role in retail or medical goods, but also in for instance the music industry where PeerTracks is developing a platform which aims to offer a music streaming platform that lets users listen to music and use the blockchain to directly pay the artists without an intermediary (Swan, 2015; Tapscott & Tapscott, 2016; Everis, 2016; CBInsights, 2017).

Governmental Services
In the field of public governance blockchain can enable different kind of innovations. Within the governmental boundaries every participant has a proof of existence which is registered somewhere. True identification should be readily available to all those who need it. Identity is who you are and what others think of you. Therefore several start-ups suchs as ShoCard, UniqulD, Traity and Onename are start-ups which are providing alternative platforms for proving you identity based on blockchain technologies (Everis, 2016).

It is not only the true identity of people which could be an issue. Proof of existence can be authorized for any kind of document. Hence it can also be applied for devices. In combination with blockchain technology, this can enable the evolution from ‘Internet of Things’ towards an ‘Economy of Things’. Time stamping data in an unalterable state while maintaining confidentiality is perfect for many fields, especially legal and artistic applications. Start-ups such as Proofofexistence, Blocktech, Clipperz, Stampery, Bitproof, and Blockai are working on tools and platforms to manage store and certify the proof of ownership of different type of documents (Everis, 2016).

The last interesting application for governmental use is that of electronic voting. Elections require authentication of voters’ identity, secure record keeping to track votes, and trusted tallies to determine the winner. Blockchains can serve as the medium for casting, tracking and counting votes so that there is never a question of voter-fraud, lost records, or fowl-play. By casting votes as transactions within the blockchain, voters can agree on the final count because they can count the votes themselves, and because of the blockchain audit trail, they can verify that no votes were changed or removed, and no illegitimate votes were added. Follow my Vote is currently in a Kickstarter campaign and aims to change the way we vote (CBInsights, 2017).
3.5 Smart Contracts

One of the latest game-changing innovations with the introduction of blockchain technology is the possibility to execute smart contracts on a blockchain. Nick Szabo, a legal scholar, cryptographer and computer scientist was the first one back in 1993 which introduced the term smart contract. In 1995 Nick Szabo wrote an article about this topic and defined a contract as being a set of promises agreed to in a meeting of the minds which is the traditional way to formalize a relationship (Szabo, 1997). Contractual obligations features three characteristics as outlined by Szabo (1997) and described in the paper of ENISA (2016):

• Observability: The ability of the principals (parties to the contract) to observe each other’s performance of the contract, or to prove their performance to other principals;
• Verifiability: The ability of a participant in a contractual agreement to prove to an arbitrator that a contract has been performed or breached, or the ability of the adjudicator to find this out by other means;
• Privity: The principle that knowledge and control over the contents and performance of a contract should be distributed among parties only as much as is necessary for the performance of that contract. A generalization of the common law principle of contract privity, which states that third parties should have no say in the enforcement of a contract.

According to Swan (2015) a contract in the traditional sense is an agreement between two or more parties to do or not do something in exchange for something else. Each party must trust the other party to fulfill its side of the obligation. Smart contracts feature the same kind of agreement to act or not act, but they remove the need for one type of trust between parties. This is because a smart contract is both defined by the code and executed (or enforced) by the code, automatically without discretion (Swan, 2015).

Ethereum, the world largest smart contract platform, states on their website that smart contracts enable the exchange of money, property, shares, or anything of value in a transparent, conflict-free way, while avoiding the need for a third party to clear the transaction. More importantly smart contracts are autonomous; once a contract is specified and running, no additional human action is ever needed, the platform automatically enforces the terms of the contract. Smart contracts are decentralized thanks to the blockchain and are therefore no longer stored on one central database, thus providing the security benefits of such shared infrastructure. As a result, this technology eliminates the counterparty risk and therefore dramatically diminishes transaction costs by getting rid of middlemen (Ethereum, 2016). This is a direct application of Szabo’s principles.

3.6 Opportunities for Real Estate

A vast amount of companies is getting a better understanding of blockchain technology, as a result new ideas and applications are emerging. In the financial industry blockchain is already a major issue on the agenda, R3 leads a consortium of more than 40 financial institutions including BBVA, Bank of America, JP Morgan, UBS, ABN Amro, and others. In the real estate industry more and more companies are seeing the potential of blockchain technology and experiments are rising. Different firms and several experts are addressing the opportunities blockchain technology has to offer (Ray, 2015; Swan, 2015; ABN AMRO, 2016; Barrington, 2016; Bhargava, 2016; Deloitte, 2016; Donkers & Santing, 2016; Kaplan, 2016; Lifthrasisr, 2016; Spielman, 2016; Tapscott & Tapscott, 2016; Cushman & Wakefield, 2017; Hoefsmit, 2017).

By analyzing the different opportunities from the authors mentioned above, a distinction can be made between five major opportunities for blockchain technology in real estate. Those are:
- Digital records of real estate assets;
- Re-design real estate processes;
- Transparent markets;
- Payment systems;
- Smart contracts.

**Digital records of real estate assets**

The blockchain can be used for any form of asset registration (Swan, 2015). For instance colored coins build a network on top of the bitcoin blockchain for transferring any kind of assets. In real estate the whole lifecycle of an property can be digitalized and transferred on a blockchain. Imagine an system where every property has its own digital passport with all the information about this specific asset, such as title registration with recent owners, sales prices, transaction dates, lease contracts, loans, maintenance contracts, and even the origin of the building materials and their condition recorded digitally. These ideas could be reality with blockchain technology.

Spielman (2016) wrote a thesis about the possibilities for recording property titles on a blockchain for Davidson County in the U.S.. In the Netherlands there is already an advanced digital systems which is called Kadaster. Compared with other countries this is a properly working system. However, recently “Financieel Dagblad” published an article about the major safety risks and data leaks Kadaster is suffering with. According to Spielman (2016) a blockchain title recording system is the future of title record keeping and would provide immediate benefits over the current title recording system, with additional benefits accruing in the future as blockchain technology grows in acceptance (Spielman, 2016).

In addition to the thesis of Spielman, Ragnar Lifthrasir, chairman of the International Blockchain Real Estate Association founded velox.RE and created a comprehensive real estate transaction platform built upon the bitcoin blockchain. Velox.RE conducted a pilot project in consultation with the Cook County Recorder of Deeds (CCRD) in Illinois for the records of deeds on the blockchain. The pilot project concluded, though blockchain can make transacting real estate simpler, safer, more accurate and easier to understand, there are challenges facing its adoption. Yarborough (2017) found that one of the biggest challenges may be resisting the urge to remake the nation’s real estate system to fit the blockchain. However, CCRD sees the potential of blockchain and is conducting more research to see if blockchain should replace their current system.

The next step in digitalizing real estate assets on a blockchain is creating a token of a property in which all the information of a property is stored. A pilot project from ABN AMRO called “Torch” is trying to do so. Although Torch is operating on a permissioned blockchain, this blockchain pilot gives commercial real estate clients the opportunity to enter their lease contracts for properties financed by ABN AMRO in the Torch app. The client’s relationship manager at the bank can validate this. If the property needs to be valued, the bank employee uses Torch to send the necessary details directly to an appraiser. When the valuation report is finished, the appraiser shares it with the bank and the client. Torch also unlocks additional information from the Land Registry Office and the Chamber of Commerce. The regulator (in this case the Dutch Central Bank, which is responsible for monitoring how banks value and finance commercial real estate) also has access to Torch and to all this information (ABN AMRO, 2016).

Despite the different challenges and the early phases of the pilot projects, blockchain has the potential to enable every property, everywhere, to have a corresponding digital address that contains occupancy, finance, legal, building performance, and physical attributes that conveys perpetually and maintains all historical transactions. Additionally, the data will be immediately available online and correlatable across all properties (Ray, 2015).
Re-design real estate transaction processes
If the real estate world achieves to store assets digitally on the blockchain, transactions could be handled on a blockchain in a similar way to how payments between parties are handled using digital currencies. With a fully-secure, verifiable system, two parties could conduct a transaction immediately, without the need for a trusted third party to verify the transaction. Because the history is easily audited, all parties have confidence in the data being shared, and the time needed to close a transaction could be much shorter (Donkers & Santing, 2016) (Cushman & Wakefield, 2017).

Transaction real estate is not only time consuming, it is also expensive. As discussed earlier for instance the due diligence process suffers with high costs. Cost from hundred thousand euros up into millions are common for the complete professional due diligence of an investment. The main cause of the high cost is due to middlemen such as; brokers, government property databases; title companies; escrow companies; inspectors and appraisers; notary publics. Currently, these middlemen exist because they hold information which is not public accessible or one does not have the skills and licenses that are needed to operate the information (Lifthrasir, 2016). If all the information is easily accessible and updated automatically when an event occurs, this can potentially saves a lot of time and costs during the due diligence phase.

Transparent markets
Due to digital assets and an automatically updating system information asymmetry belongs to the past with blockchain and a level playing field is created. All data necessary for a transaction is stored in the database and is easily accessible for the buyer and seller of real estate. Relevant information about prices of comparable objects is available for everyone and not only for a few person or at a high price. The entire transaction history of the property could then be followed through the blockchain. Consequence is that the need of a middlemen or due diligence will disappear when this technology is adopted within the marketplace (Donkers & Santing, 2016).

If markets become more transparent the risk of fraud will be reduced. For instance, banks are already using funds to research how blockchain could change the way they transfer funds. Creating a certifiable digital ID allows for funds to be fully tracked. In real estate, the use of a proof of funds document or a bank letter is often used to show purchasing capabilities. These documents can often be forged or outdated. Often these documents are saved as simple .pdf files and can even be emailed and forwarded on without consent. Blockchain provides a certifiable and instant way to verify ownership of funds. Picture an instance where you have verifiable proof of funds and a digital transfer of a deed. The Blockchain could allow two parties to exchange large assets instantly, securely and even anonymously (Kaplan, 2016).

By offering a 100 percent incorruptible resource, whereby the sender and recipient of funds was logged, and where “digital ownership certificates” for properties are saved, the blockchain would effectively make forged ownership documents and false listings a thing of the past. The unique “digital ownership certificates” would be almost impossible to replicate, and would be directly linked to one property in the system, making selling or buying properties easier, safer and faster (Oparah, 2016).

Due to blockchain, transparency may also arises in the form of immutable results of the performance of actors in the process. If the performance results of stakeholders are stored via an blockchain, this can create an immutable track record of performance and a possible new rating system. Via a blockchain based reputation system each stakeholder is rated based on his performances. This may change the way how companies in the real estate supply chain are selected.

An increase of transparency will also allow regulators and rating agencies to get a better understanding of the risks affiliated with real estate. If more information about the risks of real estate
is known, the risk aversion against real estate as an investment class may change. This may result into higher demands for real estate investments. Higher demands with slow development of new assets leads to a shortage with positively impacts the price movement.

Payment systems

Bitcoin is a digital currency. Ethereum has its “Ether” token. Unlike the Dollar or Euro, blockchain currencies aren’t paper that are later represented by software, but are 100% software from birth. The power of software is its programmability. The power of cryptocurrency is you can program it to escrow and distribute itself. With fiat (Non-crypto) money, you need humans and banks (Lifthrasir, 2016).

When someone rents an apartment or office, the landlord takes a security deposit in case the tenant damages the property. The landlord is supposed to keep the funds in a separate escrow account and not spend it. Once the lease ends, the tenant has to rely on the good faith of the landlord to return the deposit (Lifthrasir, 2016).

Bitcoin has a function called multi-signature. In bitcoin, you use your private key to approve the sending of the digital currency to another person. With “multisig,” you can create a transaction with three private keys, where at least two are required for spending. Bitcoin can be used to create a programmable escrow. Instead of sending the landlord dollars to a bank account, the tenant and landlord create a multi-signature transaction. The tenant and landlord each has one private key, and a third one is given to neutral third party (Arbitrator). For the security deposit to be spent, two out of the three people will need to use their private key. The funds are locked in crypto-escrow for the duration of the lease. When the lease ends, if the tenant didn’t damage the property, the landlord uses his private key to release that bitcoin deposit. If the tenant damaged the property, then the landlord will send evidence to the arbitrator. The tenant can respond. After the arbitrator hears both sides, she will use her private key to send the deposit to the winning party (Lifthrasir, 2016).

Nevertheless, digital currencies are currently fluctuating a lot in their price. It is therefore arguable if bitcoin or ether is the right currency to use. For the long-term prices may rises which could be interesting for speculators. However there is also a downward decline risk which should be covered by the landlord.

Smart contracts

Blockchain technology not only represents a new way to exchange funds and track payments, it also has the potential make contracts smarter. The goal of smart contract is to reduce the need for humans to process and verify an agreement (Lifthrasir, 2016). The Blockchain’s distributed ledger can track a series of events in chronological order with 100% accuracy. The blockchain cryptography ledger can record events and create digital IDs for a multitude of scenarios. Some usage examples of this type of ledger could be for mortgage payments, escrow, or deed transfers. To make things simple, they allow for if-then statements in contracts to be made, then demanded fulfillment. Imagine if you finished paying a mortgage or completed escrow on a new home or building. The moment those funds and conditions were met the digital contract would instantly transfer that deed ownership (Kaplan, 2016). One can also think of a digital lease which automatically withdrew rent payments and service charges with nu human error and a full audit trail (Cushman & Wakefield, 2017).

Smart contracts can also be used to aggregate inputs from various “oracles” and serve as a progress monitor for a real estate transaction. An oracle is a third party that is trusted by the participants in the blockchain. It can be something like a known API or another blockchain. An oracle could track the progress of the assembly of the various executed documents necessary to create a legally enforceable real estate transaction (Barrington, 2016).
In the Netherlands, the city of Rotterdam, CIC and Deloitte are developing an blockchain application to record lease agreements. The concept comprises the digital recording of the lease agreements of the CIC on blockchain. This enables startups in the CIC-network to conclude contracts faster and easier. According to Deloitte, recording legally binding contracts on blockchain is a first step towards a more efficient and transparent management of real estate. The next step will be monitoring the rental payments. By implementing additional block chain applications in the real estate industry transaction times and costs can be reduced further. Furthermore it enables decision makers to use data analysis for making future investment decisions on selling, buying and constructing real estate (Deloitte, 2016).

3.7 Challenges and Limitations

Blockchain technology is still in its early stage of development. In order to gain world wide adoption, this nascent technology needs to overcome some challenges and limitations of the current system both internal and external, including technical challenges, standardization, public perception, government regulation and mainstream adoption of technology.

Special-purpose blockchains will need to be created for a wide variety of applications. In order to gain broad adoption, technical standards must be produced and agreed upon to assure compatibility across industries – particularly in cases where multiple blockchains will need seamless interoperability (Spielman, 2016). This widespread adoption is essential for the positive network effect of blockchain to be truly harnessed. The major threats to achieve this critical mass are fragmentation of platforms and institutional and social inertia to transition to a specific platform. To achieve critical mass, firstly a single opensource platform would need be built upon by all developers. Secondly industry consortia would need to unanimously agree on chain projects (Credit Suisse, 2016).

Another challenge, both functional and technical, is related to business models. Considering a blockchain database is only as good as the data and the business processes that underlie it. Failure to reach a consensus among counterparties as to business processes or to resolve commercial conflicts could significantly hinder blockchain’s adoption. A blockchain represents a total shift away from the traditional ways of doing things – even for industries that have already seen significant transformation from digital technologies. It places trust and authority in a decentralized network rather than in a powerful central institution. And for most, this loss of control can be deeply unsettling. It has been estimated that a blockchain is about 80 per cent business process change and 20 per cent technology implementation (Swan, 2015; Spielman, 2016; Deloitte UK, 2016; Credit Suisse, 2016).

Another significant technical challenge and requirement is that a full ecosystem of plug-and-play solutions be developed to provide the entire value chain of service delivery. For example, linked to the blockchain there needs to be secure decentralized storage (MaidSafe, Storj), messaging, transport, communications protocols, name- space and address management, network administration, and archival. Ideally, the blockchain industry would develop similarly to the cloud-computing model, for which standard infrastructure components—like cloud servers and transport systems—were defined and implemented very quickly at the beginning to allow the industry to focus on the higher level of developing value-added services instead of the core infrastructure. This is particularly important in the blockchain economy due to the sensitive and complicated cryptographic engineering aspects of decentralized networks (Swan, 2015)

Blockchain will also need to overcome challenges for the tradeoff between Security versus Costs and Efficiency versus Cost. Unpermissioned public blockchains like that which underlie the bitcoin system can be seen as the 'purest' form of blockchain. Full distribution and permissionless participation mean authority is fully devolved; it is in theory infeasibly costly for any one entity to gain even a semblance of control. This truly trustless architecture means high security, but as we see with bitcoin, such
security comes at a price not dissimilar from the transaction costs we see in legacy systems. On the other hand, permissioned ledgers can be much cheaper as the consensus mechanism doesn’t require participants to engage in resource intensive proof of work type activities to prove their trustworthiness; instead only trustworthy actors are permissioned to be involved in determining consensus and adding to the chain. However, as we increase our trust in permissioned authors, we lose the distribution which ensures high levels of ledger integrity (Credit Suisse, 2016).

Not only the security of the blockchain comes with high costs, hence the speed and effectiveness with which blockchain networks can execute peer-to-peer transactions comes at a high aggregate cost, which is greater for some types of blockchain than others. This inefficiency arises because each node performs the same tasks as every other node on its own copy of the data in an attempt to be the first to find a solution. Blockchains are something of a productivity paradox, therefore. At the scale of the entire network the process is significantly productivity enhancing, but requires a certain ‘critical mass’ of nodes. Yet, even so, individual nodes can work extremely hard and may not contribute very much to the network overall. The returns to individual processing nodes – either individuals in a public blockchain or organizations in a sector-wide blockchain – may diminish as the network grows in size. This means that blockchain applications must harness network effects to deliver value to consumers or to sectors at large (Deloitte UK, 2016).

Another important challenge for distributed blockchains is the scalability. Recently Bitcoin has seen a slowdown in transaction processing times, indicating that the bitcoin version of blockchain may not be suitable for public markets. The average time it takes for a bitcoin transaction to be verified is now 43 minutes, and some transactions remain unverified forever. To put this in context, Visa says its payment system processes 2,000 transactions per second on average and can handle up to 56,000 transactions per second if needed (Gilbert, 2016). A recent study of researchers concerning this problem suggests that bitcoin would need a complete redesign to support a much larger network of users and transactions (Croman, et al., 2016). Besides the scalability of the blockchain some other technical issues which needs to be solved include increasing the block size, addressing blockchain bloat, countering vulnerability to 51 percent mining attacks, and implementing hard forks to the code (which occurs with the DOA case).

Security and privacy is also a challenge which needs to be addressed. While cryptocurrencies like Bitcoin offer pseudonymity (Bitcoin transactions are tied to ‘wallets’ rather than to individuals), many potential applications of the blockchain require smart transactions and contracts to be indisputably linked to known identities, and thus raise important questions about privacy and the security of the data stored and accessible on the shared ledger. Some argue that while no technology is completely secure, no one has yet managed to break the encryption and decentralized architecture of a blockchain. Identities created within a blockchain would be unique and offer a higher level of assurance that the party was who they claim to be. But these claims do not take away from the need for every organization adopting the technology to consider how privacy and security can inform the design. In particular, driving public acceptance of blockchain applications will likely mean proactively framing the discussion of privacy around concepts of value, security and trust (Deloitte UK, 2016).

How government regulation unfolds could be one of the most significant factors and risks in whether the blockchain industry will flourish into a mature industry. The deliberations and early rulings of worldwide governments on Bitcoin raise some interesting questions. One issue is the potential practical impossibility of carrying out taxation with current methods. A potential shift from an income tax–based system to a consumption tax–based system could be a significant change for societies. A second issue that blockchain technology raises with regard to government regulation is the value proposition offered by governments and their business model. Some argue that in the modern era of big data, governments are increasingly unable to keep up with their record-keeping duties of recording
and archiving information and making data easily accessible. On this view, governments could become obsolete because they cannot fund themselves the traditional way—by raising taxes (Swan, 2015).

In order to successfully implement blockchain applications it is important to temper the hyped expectations on where, how and when blockchain will add value. Blockchain is a technology which can improve current processes, however blockchain is not a golden key that magically solves everything. For a blockchain to be relevant you must: (1) require a database, (2) need shared write access, (3) have unknown writers whose interests are not unified, and (4) not trust a third party to maintain the integrity of the data (Credit Suisse, 2016).

3.8 Conclusion

This conclusion summarizes the chapter and describes the key features of blockchain which will be used in further elaboration on the renewed and disrupted real estate management process.

Blockchain is a database of transactions between two or more parties, with copies of the database replicated across multiple locations or nodes. The database is split into blocks with each block containing details of the transactions (such as the seller, buyer, price and contract terms), a block header, a time stamp, a hash with the previous block, a merkle root which represents the merkle tree of transactions and a nonce which shows the digest of value that allows to verify the value has not changed. The blocks are validated by the entire network of nodes via encryption by combining the common transaction details with the unique signatures of two or more parties. The transaction is valid if the result of the encoding is the same for all nodes. Finally the block is added to the chain of prior transactions. Blockchains can be either public or private, depending on the user’s preferences.

World wide start-ups in different sectors are emerging and exploring the possibilities of blockchain technology. Blockchain can be used among others for the exchange of value, internet of things, collaborative transport, decentralized markets, energy distribution, digitization of documents, data and contracts, supply chain management and governmental services.

Based on the analyses of different articles and reports five opportunities for the implementation of blockchain technology can be pointed out which are (1) Digital records of real estate assets, (2) Re-design of real estate processes, (3) transparent markets, (4) payment systems, (5) smart contracts.

Blockchain is still in its early stage of development and therefore needs to overcome some limitations and challenges of the current system both internal and external, including technical challenges, standardization, public perception, government regulation and mainstream adoption of technology. In order for this technology to become mature special-purpose blockchains will need to be created for a wide variety of applications. In order to gain broad adoption, technical standards must be produced and agreed upon to assure compatibility across industries – particularly in cases where multiple blockchains will need seamless interoperability.

Blockchain is a technology which can improve current processes, however it is important to bear in mind that this technology can only be useful when: (1) the process requires a database; (2) the participants in the process need shared (write) access; (3) the process has writers whose interests are not unified; (4) the participants do not want, or do not want to trust a third party to maintain the integrity of the data. When these requirements are met and blockchain technology is applicable, the process may benefit from; disintermediation & trustless exchange, empowered users, high quality data, process integrity, transparency and immutability, ecosystem simplification, faster transactions, lower transaction costs.
4 THEORETICAL FRAMEWORK – REAL ESTATE MANAGEMENT PROCESS

This chapter will be the first part of the Theoretical Framework which will be used in order to answer the main research question and to support the interviews. The first section will give a short definition of commercial real estate. The second section will introduce the topic of managing real estate. The section afterwards will each cover a part of the process. The last section will schematically give an overview of the process, activities and stakeholders.

4.1 Commercial Real Estate

When you ask someone, What is commercial real estate?, the answer you will receive will clearly depends on the profession of the person. However, the mostly heard definition for commercial real estate is property that is used solely for business purposes. In the literature, this definition is clearly explained by Geltner and Miller (2001), in their book “Commercial Real Estate, Analysis and Investments, using market concepts. According to Geltner and Miller (2001) the commercial real estate market consists of two major market components that are relevant for analyzing real estate: the space market and the asset market. The space market is the market which is more fundamental to real estate, in the sense that the space market is the market for the usage of (or right to use) real property (land or built space). Whereas the asset market is related to the ownership of real estate assets. In which the real estate asset consists of land parcels and the buildings on them.

The real estate market of space and the real estate market of assets are highly inter-related. The needs of tenants and the type and quality of buildings available determine the rent for real estate space in the space market. At the same time, buildings may be bought, sold, or exchanged between investors. These transactions occur in the asset or capital market and determine the asset price of space. The space market is the most fundamental, since the rent for real estate space create the underlying cashflow needed for determining the value of a property. Nevertheless, those markets are of equally importance (Geltner & Norman, 2001) (DiPasquale & Wheaton, 1992).

Within the market of space three primary types of real estate can be distinguished, namely: commercial real estate, residential real estate, and industrial real estate. Commercial real estate are properties used for commerce, such as: office buildings, restaurants, shopping malls, leisure facilities, and so on. Residential real estate are the properties used for living. Industrial real estate are the properties used for the manufacturing and production of goods.

4.2 Managing Real Estate

Whenever real estate is called an asset class, the term management inevitably follows. Whether it is property management, facility management, asset management or portfolio management, there are different terms which are being used under this concept. Despite several definitions, the term real estate management is best described in the books of Van Driel & Van Zuijlen (2016) and Bosak et al. (2007):

Real estate management is the discipline to realize pre-defined investment objectives and systematically optimizing the returns of entrusted real estate assets by strategically managing and transact them in their total life cycle and value chain (Van Driel & Van Zuijlen, 2016) (Bosak et al, 2007).

According to Van Driel & Van Zuijlen (2006) and in the latter used by several studies, a distinction can be made between a strategic, tactical and operational part of the process. On the following page, figure 4 shows the different steps of the real estate management process.
The process starts with the acquisition phase in which the investor or asset manager chooses the right product for their portfolio and buys the particular property. Once acquired the operating phase starts, this is where the real management begins. As can be witnessed from the above mentioned schedule, the operating phases consist of three different levels. The different levels are portfolio management, asset management, and property management (Van Driel & Van Zuijlen, 2016). The division of the real estate management process in three different levels is not new. Back in 1996, Miles et al (2007) introduced the management triad and gave their vision on the responsibilities for each stakeholder involved, which they reviewed over time, hence never deviating from the three levels.

**Portfolio management**

On the strategic level of the process there is a distinction between investment management and portfolio management. The investment management is obliged with the task to make an investment strategy a finding the right investment opportunities based on the investors profile. The portfolio management is functioning as an extension of the investment manager and is primarily obliged to realize the goals and objectives of the investor (Van Driel & Van Zuijlen, 2016).

The main responsibilities of the portfolio manager are: communicating with investors and setting portfolio goals and investment criteria; defining and implementing the portfolio investment strategy; overseeing acquisitions, dispositions, asset management and reinvestment decisions. The portfolio manager is accountable for portfolio performance and therefore needs to report its clients and manage the cash flows (Miles et al, 2007).

**Asset management**

The main objective of the asset manager is optimizing the direct returns of the asset in the operating phase and maximizing the asset value during the lifecycle of the asset. The choices and strategy of the asset manager are based on the input and guidelines from the portfolio manager. The asset manager is involved in all the three stages of the process (acquisition, operating, disposition). The asset manager can either be an internal person or department or an external asset management company who is responsible for a particular fund (Van Driel & Van Zuijlen, 2016).
The main responsibilities for the asset manager are: the development of property strategic plans; choosing the right asset to acquire by the use of hold/sale analysis; reviewing opportunities to reposition properties and to provide justification for major expenditures; monitoring property performance; managing and evaluating the property manager by comparing property performance to peer properties in the particular submarket; assisting in tenant relations (Miles et al, 2007).

Property management
For the operational management of the property the property manager will be appointed. The main tasks of the property manager are supporting the asset manager with the day-to-day activities. During the acquisition and disposition the tasks are primarily operational, like the supporting with due diligence, handing over the keys, etc. In the operating phase of the property lifecycle the responsibilities of the property manager are rising. He has to make sure that commercial, technical, administrative and promotional activities are in order (Van Driel & Van Zuijlen, 2016).

Summarized the main responsibilities of the property manager are: tenant relations and retention; rent collection; control of operating expenses; financial reporting and record keeping; maintenance of property; planning capital expenditures; crisis management; security issues; public relations (Miles et al, 2007).

Process overview
The following scheme of Van Driel & Van Zuijlen (2016) provides an overview of the different tasks which needs to be managed in each management level during the process.

Table 3 – Overview of the tasks for different management levels (source: Van Driel & Van Zuijlen, 2016) edited by author.
4.3 The stakeholders involved

The commercial real estate industry is a highly fragmented industry with different stakeholders involved in the value chain. Concerning a commercial property several stakeholders are involved in operating the property. Each stakeholder has its own expertise and value to add to the chain. This section will discuss eight of the most important stakeholders during the operation phase of a commercial building, namely:

- Investors
- Occupiers
- Funders
- Brokers
- Government
- Contractors
- Designers
- Advisors

Investors
The Investors are the owner of a property. Investors can be split into two groups, namely institutional investors and private investors. The owner is responsible for successfully managing the property during its lifecycle on all the three management levels. Investors are buying and selling real estate as an investment in return for an annual cash flow from tenants and for a potential increase of value of the property. On a strategic and sometimes tactical level, large institutional investors have in-house capabilities for investment and asset management. Property management is usually outsourced.

Occupiers
Occupiers are the users of a building and is the most important stakeholder during the operational phase of a property. Occupiers can be split into owner-occupiers and tenants. Owner-occupiers are the owner of a building for their own business purpose. Tenants are using the building of an investor without owning it. In return, tenants pay an annual rent to the investor/owner of the building. The rental income obtained from tenants is the input for the cash flow of the investor.

Funders
In order to obtain enough funds for acquiring properties, investors can involve a funder into the process. A funder is able to finance a part of the project via a loan. The investor needs to pay an interest rate for making use of the loan. If the investor is not able to meet its financial obligations towards the funder, the underlying real estate asset is functioning as a security.

Brokers
The main task of a broker is bringing demand and supply together, both in the market of space and in the market of assets. Brokers are involved in the acquisition and disposition of a property by supporting the buyer or seller of a property. During the operational phase brokers are responsible for successfully acquiring new tenants and renegotiating contracts with existing tenants in the building.

During the years the profile of brokers changed towards an full service organization and are now functioning as a one stop shop real estate advisor. Larger broker firms can offer a wide range of services such as, property & asset management, research & consultancy, valuations, and more services related to corporate users.

Government
The government is an important stakeholder when it comes to regulation. Regarding fiscal, private & public law, the owner of the property will face some challenges, both in the form of regulation and for taxes. The government is also responsible for maintaining and organizing land title registrations of properties. In the Netherlands there is an sufficient system which is called “Kadaster”. Kadaster allows for online checking the property ownership structure.
Designers & Contractors

The designers and contractor are responsible for the physical realization of a property or project. During the lifecycle of a property the designer and contractor can change or improve the existing building. The designer and contractor knows exactly which materials and designs are used in the property and can add this knowledge of the building to the value chain.

Advisors

During the different stages of the real estate management process several advisors are involved. Mostly the advisors are helping the several stakeholders with specific knowledge, for instance on commercial, juridical, financial or technical issues. However, during the process advisors are also appointed for trust issues, to check and verify if specific documents or transactions are legal and honest. For instance, a notary during the sale of a property, or legal firms during the due diligence.

4.4 Transacting real estate

4.4.1 Theoretical Background

The first step in the real estate management process is the acquisition of the right property, which can be called the acquisition process. The acquisition for the buyer encourages the disposition for the seller. The process of acquiring real estate is much slower than in for instance centralized financial asset markets. The real estate market is often characterized by a heterogeneous product, infrequent market transactions, and high information and transaction costs. This makes real estate an illiquid asset.

McNamara (1998) was one of the first to explore the acquisition and sale process. His research focused on the UK commercial real estate market through a survey of investment principals and agents directly involved in transacting commercial real estate on behalf of institutional investors. He noted three key points in the transaction process – heads of terms/price agreement, exchange and completion – and used these to define three stages in that process: either search (buyer) or marketing (seller), due diligence and settlement. He then reported indicative times for these stages. A seller was judged to need four to six weeks to find a buyer for high street retail, six to eight weeks for offices and seven to nine weeks for shopping centers. Due diligence ranged from four to six weeks for high street retail through to twelve weeks for shopping centers. On the buy side, similar patterns were reported, though with longer times to allow for search and selection of appropriate assets (McNamara, 1998).

Crosby and McAllister (2004) also studied the transaction process of commercial real estate and came to comparable key stages as McNamara, hence they described the process in more detail an added the pre-marketing period as a separate stage. Pre-marketing is the period between the decision to sell a particular asset and the assembly of all necessary information on the asset for the sale by the investor. Also in their research long transaction times were noticed. Working from the first record of sale the mean transaction time was found to be more than nine months and the median time to be more than six months in length (Devaney & Scofield, 2015).

Hordijk and Teuben (2008) conducted a more recent study to the transaction process in the Dutch market for institutional investors. Their research was based on the above mentioned studies plus interviews with several experts. They divided the transaction process in six stages. Starting with a real estate portfolio decision to sell particular sector or sub-sector. The next stage is making a decision to sell a particular asset. The third and fourth stage are respectively pre-marketing and marketing period. Those stages are followed by a due diligence period and finally exchange to completion. Hordijk and Teuben (2008) noticed an average mean transaction time of 25 weeks (approx. six months) with a median of twenty weeks (approx. five months).
Based on the studies by McNamara (1998), Crosby and McAllister (2004), and Hordijk and Teuben (2008), the assumption can be made that the average transaction time of a real estate asset varies from six to nine months. Despite the transaction time, each transaction follows a comparable process which can be divided in six different stages. The first two stages – real estate portfolio decision to sell particular sector or sub-sector and decision to sell a particular asset – are the stages prior to knowing which particular asset is going to be sold. Those stages are more common for institutional investors and can be considered as preparation stages prior to the search (buyer) or marketing (seller) stage as mentioned in the research of McNamara (1998). Based on the above mentioned literature, the transaction process can be divided into four stages:

1. Preparation period
2. Marketing period
3. Due diligence period
4. Exchange to completion

**Preparation period**

The preparation period are the stages prior to the actual transaction process. This period is most often an internal process. Within this stage the real estate manager / owner makes the decision to reduce the size of a total real estate portfolio. These decisions will mainly be based on asset liability studies or on the choices made by investors in a fund. After this choice, a decision has to be made on which property is going to be sold. This decision will most likely be made based on hold/sell analyses (Hordijk & Teuben, 2008). When the decision is made for selling a particular asset, all data on that particular asset will be assembled to provide a complete overview of the product being sold. In some literature this is called pre-marketing. Nevertheless, the more information is collected within this phase, the more advantage will be gained in the due diligence period. In the preparation period a broker needs to be selected as well, which is going to assist in the upcoming stages (Hordijk & Teuben, 2008). The last part of the preparation period involves also an instruction to agents to prepare an assessment of value and marketability. Often, but not always, solicitors are simultaneously instructed to identify any potential legal obstacle to sale. This can take one to two weeks (Crosby & McAllister, 2004).

**Marketing period**

After the preparation phase the formal marketing of the asset occurs. In the marketing period the agent produces and distributes brochures, advertisements, etc. to potential buyers (Crosby & McAllister, 2004). The marketing period may follow a formal process in which specific bids needs to be collected within a specific time frame following different bidding rounds, or unstructured where the bids are just collected and adjusted via an intransparent process. The marketing period and its duration depends on a lot of economic factors though.! It is a challenge of supply and demand. If the property is going to be sold in positive market circumstances (the demand is higher than supply) this phase is easier and takes less time. The location, type of real estate, the size of the asset, and the length of the lease contracts are also depending variables (Hordijk & Teuben, 2008). At the end of the marketing period best bids are invited from interested purchases. The bids received are assessed and Heads of Terms agreed with the selected bidder. At this point solicitors are instructed to proceed towards exchange of contract and go through the next phase, the due diligence period.

**Due diligence period**

Due diligence is the process to check all the relevant available information before the purchase is actually be made. It means taking caution, performing calculations, reviewing documents, procuring insurance, walking the property, etc. The “chapters” of a real estate due diligence consists of real estate issues, legal issues, tax and accounting issues, and technical issues (Bosak et al., 2007). The due diligence process suffers with high costs. Cost from hundred thousand euros up into millions are
common for the complete professional due diligence of an investment (Bosak et al., 2007). Parallel to the due diligence, the buyer will arrange his financing needed for the investment.

Due diligence can take another three to four weeks. However, Crosby and McAllister (2004) suggests it was at this stage that transactions are most likely to be delayed due to previously unknown or ignored inherent problems, changes in the asset e.g. tenant default, change in market conditions, or changes in the circumstances of the purchaser.

Each part of the due diligence should lead to a report with a clear summary and a clear proposal to the buyer, recommending what to do with the findings. This should consist of a short description of the issue, a risk valuation, and a solution or recommendation to cancel the deal (Bosak et al., 2007). Exchange of contracts takes place at the end of this period. This is the point at which the sale becomes certain. For properties sold at auction, price agreement and exchange of contract occur ‘when the hammers falls’ (Crosby & McAllister, 2004).

**Exchange to completion**

Legal completion is the final act in the process. This is the date on which ownership rights are transferred to the purchaser and cash is transferred to the vendor. Anecdotal evidence suggests that simultaneous exchange of contract and completion has become more common. However, the norm is for a gap of two to four weeks between exchange of contracts and completion (Crosby & McAllister, 2004).

Usually the purchase contract has to ensure both seller and buyer that payment and transfer of ownership rights are realized on a secured basis. The best way is to set up an escrow account system, where a law firm or bank acts as a trustee to collect the money and transfer the assets. Although the transfer of cash from one account to the other seems quick and easy, parties spent hours and days waiting for the bank’s written confirmation that the money has been irrevocably sent and booked to the other account (Bosak et al., 2007).

### 4.4.2 Process Flow

The above mentioned phases of the acquisition process are carried out behind each other. Whenever a certain phase is finished a new phase will start. Before putting the property on the market, the preparation period is needed for the seller to consider a complete documentation of the building. A list of materials and information is discussed in section 3.4.3. Whenever the preparation period is ready and the property is successfully market a head of terms will be signed with the potential buyer. The head of terms gives the potential buyer exclusivity for further negotiations, and is the starting point for the buyer to start his due diligence. Based on the findings of the due diligence parties will start negotiating on the contract. Whenever both parties agree on the contract, contracts will be exchanged and parties are both committed to the deal. In the exchange to completion phase all the documents will be ready for completion. IPF (2012) conducted an extensive research into streamlining the commercial property transaction process and came up with a clear flowchart of the exclusive process between seller and buyer from the head of terms till completion. Based on the research of IPF and the defined stages of the transaction process by McNamara (1998), Crosby and McAllister (2004), and Hordijk and Teuben (2008) the flowchart shown on the next page in figure 5, gives an overview of the process.
Figure 11 – Overview of the real estate transaction process. Source: (IPF, 2012), edited by author.
4.4.3 Information exchange

The most effective way of streamlining real estate transactions (and therefore minimising delays and potential abortive transactions and wasted costs and expenses), is for the intending seller and its advisors to have familiarized themselves thoroughly with the property and its title before putting it on the market. Sellers should also consider their financing arrangements (e.g. any debt, early repayment sums and swap break costs which might influence their decision to sell). In this way the seller can formulate its negotiating strategy from a position of knowledge, and can offer the prospective buyer a full package of legal documentation and management information from the outset (IPF, 2012). The exchange of information during the acquisition and disposition of a property is primarily between seller and buyer. Advisors and other parties will be appointed to deliver and evaluate the information of the property. IPF (2012) came up with a complete list of information which needs to be collected and exchanged, the following list is applicable for Dutch properties:

1. Marketing material
   1.1 Brochure or particulars
   1.2 Site plan
   1.3 Floor plans (and independent measured areas)
   1.4 Verified tenancy schedule

2. Legal title and searches
   2.1 Land Registry (Cadastral Data)
   2.2 Relevant title documents
   2.3 Lease agreements, including tenant information (BAG-data, CoC-data, Credit Ratings)
   2.4 Third party consents
   2.5 Defective title insurance policies
   2.6 Searches
   2.7 Any consents/authorities needed for transaction

3. Management information
   3.1 Managing agents’ contact details
   3.2 Copies of most recent rent and service charge demands
   3.3 Payment history and confirmation of status where consistent late payment
   3.4 Arrears schedule and confirmation of status of all arrears
   3.5 Service charge:
      3.5.1 Current year’s budget
      3.5.2 Current year’s apportionment (showing percentage and areas)
      3.5.3 Full details of caps and fixed service charge, RPI uplift calculations
      3.5.4 Last 3 years’ service charge accounts
      3.5.5 ‘Reserve Fund’ statement – and confirmation if it is allocated
      3.5.6 Expenditure to date
      3.5.7 Service charge collected to date
      3.5.8 Details of major service charge expenditure in the last 3 years and any anticipated expenditure
   3.6 Insurance certificates
   3.7 Last insurance valuation
   3.8 Insurance claims history and details of any outstanding claims
   3.9 Details of any disputes
   3.10 Ongoing management transactions
   3.11 Schedule of maintenance/service contracts (including notice periods)

4. Design and construction
   4.1 Building contract and all appendices/specifications
   4.2 Consultant details and professional appointments
   4.3 Warranties/guarantees/bonds
   4.4 Status of contractor/consultants
   4.5 Details of consultants’ professional indemnity insurance
   4.6 Practical completion/making good defects certificates
   4.7 Health and safety file
   4.8 Operation and maintenance manuals
   4.9 BIM information
   4.10 Payments (retention) outstanding

5. Utilities
   5.1 Supply contracts
   5.2 Energy certificates / EPC calculations

6. Planning/statutory agreements/infrastructure
   6.1 Copies of:
      6.1.1 planning applications
      6.1.2 planning permissions
      6.1.3 approval of reserved matters/conditions
      6.1.4 satisfaction of planning conditions
   6.2 Confirmation of established use and certificate where relevant
   6.3 Any planning agreements

7. Physical condition/environmental
   7.1 Asbestos survey/assessment
   7.2 Measured/structural/mechanical and electrical surveys
   7.3 Environmental report
   7.4 Environmental licences/notice
   7.5 Energy Performance Certificate

8. Rates/outgoings
   8.1 Rating assessments and valuation report
   8.2 Any correspondence/appeals

9. Tax/financial
   9.1 Any capital allowance elections
   9.2 VAT details
   9.3 Copy of option to tax and acknowledgement
   9.4 WOZ-value
   9.5 Any security and arrangements for discharge
4.4.4 Process Flow & Stakeholders

By combining the theoretical background with the process flow, exchange of information and the stakeholders a theoretical process can be described as shown in figure 6. In the preparation phase the owner prepares all the information needed for the property transfer. Input is given from external stakeholders. During the marketing phase, the broker sets up a data-room. Interest buyers can get access to a selected part of the data room in order to provide a formal bid to the owner. Owner evaluates the bids and will form a head of terms with one selected buyer. During due diligence, buyer (supported by several advisors) will go through all the information and validates if the property information is correct and there are no hidden problems. Finally, after agreeing and formalizing the contract, the exchange of the property occurs. The notary checks if both parties met the agreed terms and will approve the deal. After approval of the notary, the deal is official and buyer is the new owner of the property.

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**Figure 12 – Real estate transactions process flow and stakeholders. Source: own illustration.**
4.5 Operating in the real estate life cycle

4.5.1 Theoretical background

Once the property is acquired the operation of the property starts. During the operation phase of a property, the asset manager will formulate, in accordance with the portfolio manager, a property strategy. During the operating phase the asset manager will manage the property by analyzing the performance of a property. Based on the performance and analysis the asset manager will adjust the strategy of the property during the operating phase (Van Driel & Van Zuijlen, 2016).

The day-to-day management of a property is the responsibility of the property manager who is operating in the operational management level. One of the characteristics for this management level is the lack of strategic responsibilities (Van Welsens, 2012). In the contemporary property management, value is customer driven in the sense that real estate in itself does not generate any turnover, it is the customer who pays the rent that generates turnover (Palm, 2016). During the acquisition and disposition of the property, the property manager can be involved as well to make sure the property that needs to be acquired is manageable in the operating phase. For the disposition of the property the property manager makes sure all the documents are ready for the due diligence and for the final transport of the property.

During the operating phase a distinction can be made between for main responsibilities of the property manager, namely; Commercial management, Administrative management, Technical management and Promotional management (Van Driel & Van Zuijlen, 2016).

Commercial Management

Commercial management is the core business of the property manager and represents the goals the property manager has. Namely, advising on and coordination of the operating tasks in order to maximize the returns of the property. The most important tasks of the property manager during the commercial management are: internal contact with the asset manager about the strategy for the property; day-to-day contact with the tenants and other external parties; coordinating all daily operating tasks, and the letting of (vacant) space (Van Welsens, 2012). In order to fulfill the tasks in the best possible way, it is important to feature specific knowledge of the property and arrange a highly professional governance (Van Driel & Van Zuijlen, 2016).

During the commercial management the property manager has according to Van Driel & Van Zuijlen (2016) among others four main responsibilities. The property manager is in control of maintaining all contractual affairs. This consists of maintaining all the contracts with the existing tenants, and arrange the contracts with potential new tenants. For the acquisition of new tenants, the property manager will be assisted by brokers. The second major task is account management. This should be both done with tenants, the asset manager and other third parties. Those other third parties are for instance; governments, brokers, technical advisors, maintenance- and service companies, and so on. The third aspect of the commercial management is knowing all juridical and fiscal affairs. This is mainly in assistance to the asset manager. The last responsibility is tenant services. This in particular done to optimize the relationship with the current tenants by offering them additional services in order to get their commitment for the long term (Van Driel & Van Zuijlen, 2016).

Technical Management

The main objective of technical management is maintaining the desired quality level of the property, as well as – based on the instructions of the asset manager – improving the quality level of the property (Van Driel & Van Zuijlen, 2016). Technical management is obliged with six major responsibilities. The first responsibility is the planned technical maintenance of the property, by doing inspections, maintaining the budget, give orders to contractors to do the maintenance. Secondly, the technical
manager is responsible for the commercial management. Commercial management consist of maintaining the commercial competitive position on the market of space. It makes sure the building is attractive for tenant while taking into account the continuously changing market demand. The third responsibility is maintaining complaints with respect to technical issues tenants face. Fourthly, the technical manager is responsible for the delivery of planned and improvement maintenance. The technical manager has to make sure that improvements match the desired level of delivery. If the situation occurs that there is vacancy in the building, as a fifth responsibility, the technical manager has to make sure he adopts his strategy accordingly. The last responsibility of the technical manager is energy policy. On the one hand the energy policy consists of buying energy for attractive prices, on the other hand it consists of reducing energy consumption (Van Driel & Van Zuijlen, 2016).

Administrative Management
Administrative management is mainly about registering, classifying, and processing the information with respect to all the incoming and outgoing cash flows of the property. This also includes reporting on the financial numbers directly to the asset manager. The main tasks for administrative management are: rent administration, collection of payments, calculations of the service charges, archiving the information, providing services to tenants and providing management with information and reports (Van Driel & Van Zuijlen, 2016). It is an important task of property management, hence the people working for the administrative management are required to have good financial, economical skills. As well as good communicative skills, since they are constantly in contact with tenants, the asset manager, and other disciplines within property management (Van Welsens, 2012).

Promotional Management
Promotional management are all the activities aimed for improving the market position of the particular asset or supporting the position of the owner against different interest groups. The main responsibilities of the promotional manager are; supporting marketing with implementing their vision (marketing is the responsibility of the asset manager) into the property. Another important responsibility is hospitality management. Hospitality management is upcoming and not widely applied yet. It is about the service regarding the people who will use the building on daily bases. It is all about experience, based on the same philosophy hotels are doing their business (Van Driel & Van Zuijlen, 2016).

Process Overview
The following scheme gives an overview of all the activities involved in property management.

<table>
<thead>
<tr>
<th>Property Management</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Property intake</strong></td>
</tr>
<tr>
<td>• Due diligence</td>
</tr>
<tr>
<td>• Project management</td>
</tr>
<tr>
<td>• Completion</td>
</tr>
<tr>
<td>• Transfer</td>
</tr>
<tr>
<td>• Aftercare</td>
</tr>
<tr>
<td><strong>Administrative Management</strong></td>
</tr>
<tr>
<td>• Tenant administration</td>
</tr>
<tr>
<td>• Collection of rents</td>
</tr>
<tr>
<td>• Service charges</td>
</tr>
<tr>
<td>• Archiving and database</td>
</tr>
<tr>
<td>• Management information and reports</td>
</tr>
</tbody>
</table>

*Table 4 – Overview of all activities involved in property management. Source (Van Driel & Van Zuijlen, 2016), edited by author.*
4.5.2 Information exchange & stakeholders

During the operation phase a vast amount of data and information is exchanged and registered. If we align the operation phase with the process of transferring real estate, we can assume that data which needs to be exchanged is collected during the operating phase. Therefore, by zooming in on the different information sources needed in order to transact real estate by IPF (2012), as discussed in chapter 4.4.3, and relation can be made between the information needed for transacting real estate and the collection and exchange of the information during the operating phase. Based on the list of IPF (2012) and the activities defined by Van Driel & Van Zuijlen (2016), each management phase has its information exchanges.

Commercial Management

The critical information exchange in commercial management is the contractual relation between tenants, both new and existing, and the owner of the property in the form of a lease contract. In the Netherlands, lease contracts for commercial properties are standardized and based on the ROZ (Raad voor Onroerende Zaken) model. At least the following information and stakeholders are needed in order to create a contract:

<table>
<thead>
<tr>
<th>Information</th>
<th>Stakeholders</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lease Conditions</td>
<td>Owner</td>
<td>Needs to sign to agree on conditions</td>
</tr>
<tr>
<td></td>
<td>Tenant</td>
<td>Needs to sign to agree on conditions</td>
</tr>
<tr>
<td></td>
<td>Advisor - Broker</td>
<td>Creating and negotiating on the lease conditions</td>
</tr>
<tr>
<td></td>
<td>Advisor - Lawyer</td>
<td>Validates the legal terms</td>
</tr>
<tr>
<td>Landlord information</td>
<td>Kadaster</td>
<td>Provides administrative and spatial data on property and the rights involved</td>
</tr>
<tr>
<td></td>
<td>Chamber of Commerce (CoC)</td>
<td>Provides business information of the owner</td>
</tr>
<tr>
<td>Tenant information</td>
<td>Chamber of Commerce (CoC)</td>
<td>Provides business information of the tenant</td>
</tr>
<tr>
<td></td>
<td>Government</td>
<td>Identity check of the legal signing person</td>
</tr>
<tr>
<td></td>
<td>Banks</td>
<td>Credit Rating</td>
</tr>
</tbody>
</table>

Table 5 – Roles and stakeholders commercial management. Source: own table

Another notable part of the exchange of information in the commercial management process is tenant services. In exchange for a small payment additional tenant services can be provided. Services such as; facility management, hospitality management, meeting rooms, coffee/lunch etc. Via separate contracts (or included upfront) these services can be used.

Technical Management

Technical management is mainly about maintaining the desired quality level of the building (Van Driel & Van Zuijlen, 2016). During the process, the most notable exchange of information, is the relation between the property manager and contractors in order to fulfill maintenance tasks. The following information and stakeholders are needed during this process:

<table>
<thead>
<tr>
<th>Information</th>
<th>Stakeholders</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building information</td>
<td>Contractor</td>
<td>Has the original building contract with all appendices and Warranties as well as operations and maintenance manuals. If possible, the original builder of the building set up an BIM Model.</td>
</tr>
<tr>
<td>Physical Condition</td>
<td>Property Manager</td>
<td>Contains all the documents about the physical state, such as: Asbestos surveys, environmental reports, measured/structural /mechanical and electrical surveys.</td>
</tr>
</tbody>
</table>
Maintenance Schedule

Property Manager
Provides a schedule of all the maintenance and service expenditures.

Maintenance & Service Contracts

Property Manager
Initiate and set up the contracts

Contractor
Provides his services based on the contract

Owner + Advisor
Signs the contract

Advisor – Legal
Validates the legal terms of the contract.

Table 6 – Roles and stakeholders technical management. Source: own table

Administrative Management

During administrative management all the businesses related to the property needs to be administered. The two most important processes are tenant administration and owner / service charges administration (Van Driel & Van Zuijlen, 2016).

Tenant administration

All the agreements which could potentially have a financial impact between tenant and owner needs to be administrated. Both the investor and the tenant needs to rely on the property manager that this information is accurate and correct. Also the annual payments of the tenant are involved (Van Driel & Van Zuijlen, 2016). For tenant administration the following stakeholders are involved.

<table>
<thead>
<tr>
<th>Information</th>
<th>Stakeholders</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lease Contract</td>
<td>Owner</td>
<td>Agreed on the lease terms</td>
</tr>
<tr>
<td></td>
<td>Tenant</td>
<td>Agreed on the lease term</td>
</tr>
<tr>
<td></td>
<td>Property Manager</td>
<td>Needs to make sure that all the obligations deriving from the lease contract are properly administrate and fulfilled.</td>
</tr>
<tr>
<td>Payments</td>
<td>Tenant</td>
<td>Obliged to pay rent and service charges</td>
</tr>
<tr>
<td></td>
<td>Bank</td>
<td>Handles the payment</td>
</tr>
<tr>
<td></td>
<td>Owner / investor</td>
<td>Receives the payment, directly from tenant or via property manager</td>
</tr>
<tr>
<td></td>
<td>Property manager</td>
<td>Administration of payments (Reports to asset manager about status and possible late payments)</td>
</tr>
</tbody>
</table>

Table 7 – Roles and stakeholders tenant administration. Source: own table

Owner charges & service charges

Tenants pay an annual rent and an advance payment for the service charges adjusted subsequently on the basis of actual costs. The property manager needs to make an estimate once a year to which operational costs belong to the owner and which costs to the tenant, based on the agreed terms from the lease contract (Van Driel & Van Zuijlen, 2016). The following stakeholders are involved:

<table>
<thead>
<tr>
<th>Information</th>
<th>Stakeholders</th>
<th>Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service Charges</td>
<td>Owner</td>
<td>Needs to pay a part of the charges</td>
</tr>
<tr>
<td></td>
<td>Tenant</td>
<td>Needs to pay a part of the charges according to the agreed term stated in the lease contract</td>
</tr>
<tr>
<td></td>
<td>Property Manager</td>
<td>Calculates which costs belongs to who</td>
</tr>
<tr>
<td></td>
<td>Contractor</td>
<td>Will be paid for the services delivered</td>
</tr>
<tr>
<td></td>
<td>Other parties (such as electrical and water companies)</td>
<td>Will be paid for the services delivered</td>
</tr>
</tbody>
</table>

Table 8 – Roles and stakeholders owner & service charges. Source: own table
Promotional Management
During promotional management, hospitality management and park & area management are important tasks for the property manager. Hospitality management is upcoming as part of property management. The main objective is the delivery of additional services for tenants in order to achieve the level of hotels. Additional service comes with additional administration. The involved exchanges of information and stakeholders are covered in commercial management.

4.5.3 Overview stakeholders & information exchanges
By combining the several tasks and stakeholders of the operational process, figure 7 gives an clear overview of the information exchanges.

Figure 13 – Real estate management process flow and stakeholders. Source: Own illustration.
4.6 Conclusion

This conclusion summarizes the chapter and describes the different stages of the real estate management process, the stakeholders, and the information exchanges during the process.

The real estate management process can be divided into three major phases. Those are acquisition of a property, operating the property, and disposition. Within the operating phase, the theory of Van Driel & Van Zuijlen (2016), suggest that management needs to be conducted on three different levels; portfolio management, asset management & property management.

Within the real estate management process a vast number of stakeholders is involved. The major stakeholders are among others; investors, occupiers, funders, brokers, governmental departments, contractors, designers and other advisors.

Transacting real estate is the acquisition for buyer and disposition for seller, those phases are comparable taking into account a different perspective and interest. Generally, based on the evaluated literature, the transaction of real estate uses four different stages; preparation period, marketing period, due diligence period, and exchange to completion. In the first stage, all the information of a property needs to be collected. This is mainly an internal process, information is requested from several stakeholders. During the marketing period buyer and seller try to find each other and set up a head of terms. During the due diligence period, buyer will research all the information and specifications of the property, the findings will be reported. This may influence the price. Finally during exchange of completion, all the legal work will be settled and all the property information will be transferred.

The operating phase of the property is characterized by four management levels, those are Commercial management, technical management, administrative management, and promotional management. Commercial management consist of advising on and coordination of the operating tasks, including contact with the asset manager and tenants, hence also maintaining and attracting tenants. During technical management the property manager tries to maintain the desired quality level of the property via inspections, maintaining the budget and give order to contractors. Administrative management is the process of registering, classifying, and processing the information of the property. This also includes reporting to the asset manager. Finally, promotional management are all the activities aimed for improving the market position of the property.
Part IV

Empirical Findings
PART IV – EMPIRICAL FINDINGS

5 THE BLOCKCHAIN BASED REAL ESTATE MANAGEMENT PROCESS

After introducing the theoretical framework it’s essential to combine the findings of the real estate management process and blockchain technology. The first part of this chapter discusses the findings of the theoretical framework and gives a first glimpse in the blockchain based real estate management process. This is followed by a chapter on the empirical findings collected through interviews. These interviews enlighten the vision and view of stakeholders in the real estate management process on the implementation of blockchain technology.

5.1 Identifying possible opportunities in the process

In the previous chapters the concept of blockchain and the real estate management process were researched separately. This section aims to align blockchain technology to the real estate management process in order to indicate possible opportunities. Those opportunities will form the assumptions for designing a blockchain based real estate management process.

As stated earlier, in chapter 3.7, for a blockchain to be relevant the process must (1) require a database, (2) need shared write access, (3) have unknown writers whose interest are not unified, and (4) not trust a third party to maintain the integrity of the data. Based on these 4 characteristics the theoretically defined real estate process is analyzed. The real estate management process focusses on the acquisition, operation, and disposition phase of an asset, described from an asset- and property management level. This chapter addresses five hypothesis for opportunities within this process.

5.1.1 Transacting real estate

The real estate transaction process consists of four major stages; preparation, marketing, due diligence and exchange to completion. Based on the analysis of the theoretical framework and bearing in mind the four characteristics for blockchain relevancy, there are three hypothetical opportunities in the real estate transaction process for exploring the possibilities for a blockchain based solution.

**Hypothesis #1 – Digitalizing real estate**

According to research of IPF (2012), the most effective way for streamlining real estate transactions is for the intending seller and its advisors to have familiarized themselves thoroughly with all the property information in the preparation stage. The more information is known upfront, the more efficient the process will be. As can be witnessed in the process flow of commercial real estate transactions, the box of information collected upfront (indicated in the blue circle), needs to be validated and checked throughout the whole process. This large box of information is a database in which different stakeholders are involved (with different interests). During the marketing and due diligence phase, parties will check and validate if all the information presented in the box via a data room is correct and true, since they do not or will not trust each other or a third party (in this case a broker) completely. Eventually it is that large box of information which is exchanged between seller and buyer. The characteristics of this large box of information meet the four requirements for a blockchain to be relevant. Therefore, a blockchain based solution for
combining, validating, and transacting all the information from different stakeholders upfront at any time, with hardly any administrative actions, seems to be an opportunity in the transaction process.

First thoughts on how to store real estate assets on a blockchain are starting, In the white paper of Alex Mizrahi (2016) the concept of a blockchain-based property ownership recording system is explored. On for instance the bitcoin blockchain the recording of property ownership is possible via colored coins, or smart property. Smart property is property whose ownership is controlled via the Bitcoin blockchain, using contracts. Examples could include physical property such as cars, phones or houses. Smart property also includes non physical property like shares in a company or access rights to a remote computer. Making property smart allows it to be traded with radically less trust (Mizrahi, 2016).

Colored coins enable a user to determine and attribute value of an asset into a token (or many tokens) for exchange or distribution. For example, a token can be colored to represent ownership of a single property, or many tokens can be colored to signify shared ownership in a building. Regarding for instance land administration, property title can be attributed to a token – which can include public registry details such as size, GPS coordinates, year built, etc. – and the exchange of the token can be tracked every time it changes hands through a series of transaction outputs (Spielman, 2016).

Hypothesis #2 – Alternative financing tool
When all the information is assessed and both parties agreed on the conditions for the deal. Buyer will arrange his finances for the transaction. Financing commercial real estate is usually done via a bank. There is a large variety in debt, hybrid and equity securities to finance real estate, ranging from mortgages to preferred equity and everything in between. Crowdfunding real estate however might be the next major innovative investment structure (Marchand, 2016).

Banks are trying to increase their solvability by limiting credit loans. Making things worse, solving this lack of available capital is hampered by the recent introduction of Basel III (which is supposed to decrease bank leverage and increase bank liquidity). In other words, banks are increasingly obliged to lower their provision of capital. As a result, obtaining credit is subject to higher financing costs and additional regulations. There are only three large banks in the Dutch real estate finance industry: Rabobank Real Estate Finance, ING Real Estate Finance and ABN Amro Real Estate Finance. Together they add up to 88% of all real estate development finance structures. These factors show the oppressive dominance of just three banks forcing investors and developers to rethink their financing strategies (Marchand, 2016).

Due to competition in the mortgage market, technological advancements, and changing client demand as well as ever stricter regulation the traditional role of banks in the mortgage domain is under pressure. For the bank to stay relevant new business models must be researched. Gout (2017) conducted a study into a blockchain inspired business model for a mortgage funding marketplace. His study showed that alternative funding by the use of blockchain could be the second opportunity in the transaction process. These new business models for financing real estate could potentially make it easier for parties to gather their investment.

Hypothesis #3 – Exchange of ownership
The last step in transacting real estate is the actual legal exchange of information and ownership rights. Nowadays a notary is involved to make sure all the documents and legal acts are transferred properly. The buyer fulfills his payment obligation in order to receive the legal rights of the property, and all the information of that particular property accordingly. After this transaction is done, the notary will make sure all the administrative changes for the government will be carried out.
If the real estate world achieves to store assets digitally on a blockchain, real estate transactions could be handled on a blockchain in a similar way to how payments between parties are handled using digital currencies. Meaning, with the use of blockchain, real estate can be transacted peer to peer with less interference of a notary or other trusted third party. This could save time and costs.

5.1.2 Operating real estate
During the operational phase of a property, literature divided the process on a property management level in four quadrants, namely; commercial management, technical management, administrative management, and promotional management. Within the operational phase the flowchart shows the relation between the four quadrants. During commercial- and technical management, information is collected and agreements are done. In the administrative management phase, all those information is gathered and administrated. By taking into account the characteristics of blockchain technology, three opportunities can be identified in the process.

Hypothesis #4 – Digital lease contracts
A first opportunity is noticeable during commercial management. As found during the literature study (chapter 4.5.2) the critical information exchange in commercial management is the contractual relation between tenants and the owner of the property via a lease contract. In order to make and validate a lease contract several stakeholders are involved each for their own interest. The process of making and validating the lease contract is still traditional. Information from the chamber of commerce, kadaster, government, banks, tenant and owner of the property is needed. After tenant and owner agreed on the terms, the contract needs to be signed hard-copy. For deals were one of the parties is at the other side of the world, this may take a while. When the contract is signed, all the information will be administrated by the property manager and both parties needs to fulfill their obligations coming from the lease agreement.

Digitalizing lease contracts seems to be an interesting opportunity, especially in relation to the administration of those lease contracts, and automatizing the financial obligation resulting from the agreement. Deloitte is already exploring this subject, and, together with the municipality of Rotterdam and Cambridge Innovation Center (CIC), building an actual working application. In earlier reports they mention that blockchain can support in lease transactions by pre-lease due diligence by using smart identities, creating lease agreements based on smart contracts, automated payments and cash flow management using the smart contract, and real-time immutable data analysis (Deloitte, 2017). With the use of blockchain, the process of blockchain based lease contracts can look like this:

1. Both parties digitally sign the smart contract (agreement), which includes details such as rental value, payment frequency, and tenant and property details.
2. Based on the terms of the contract, the smart contract periodically initiates the lease payments from the tenant to the landlord and the contractors.
3. On termination of the lease, the contract triggers the payment or security deposit back to the tenant after adjusting for any damage repair charges.

Figure 14 – Lease contracts via blockchain. Source: (Deloitte, 2017)
Hypothesis #5 – Digital building performance & maintenance

The second opportunity during the operational phase of the property can be found in the technical management phase and relates to all the material and technical use of the property. The primarily ambition of technical management is maintaining/improving the desired quality level of the building. In order to fulfill maintenance tasks the property manager and the contractors needs to know from which materials the building is built of and how those materials needs to be maintained. With trends, such as circular economy and energy efficiency the awareness and interest for the use of sustainable materials is rising. With the use of Building Information Modelling (BIM) buildings are becoming smarter and easier to adjust. However, it is often not clear how the complete supply chain of used materials look liked. Blockchain could be able to trace the lifecycle of all materials.

During technical management, the opportunity is two-folded. On the one hand, a full supply chain of the building materials can be enrolled, enabling circular economy to further integrate in the real estate economy. As an example, the Everledger project can be used, in which the full supply chain of diamonds is traced. Everledger knows who owns which diamond and where it is. It can even trace the movement of diamonds on platforms such as eBay and Amazon as they are bought and sold.

On the other hand, when data is more accurate and the performance of a building more insightful, the service charges and owner charges can be connected, via smart contracts, to the lease contract. This enables automated calculation of service & owner charges, and connects them to payments. No middle men are needed anymore.

5.2 Digitalizing the real estate management process

The results of analyzing the real estate management process shows that all the information needed for the transaction process is gathered during the operational phase. It is assumable that the same data is used in both phases, however the databases are not completely aligned to each other. Based on this assumption and based on the indicated possibilities, as described in the previous section, a hypothetical process for blockchain based real estate management can be designed.

In the digital real estate management process, every asset is represented via a smart token. The smart token consists or is linked to several types of information, such as: marketing material, legal title & searches, management information, design & construction, utilities, physical & environmental condition, rates / outgoing, tax / financial. Due to the blockchain this information is live update and timestamped. Different stakeholders, according to their interest, may have access to certain types of data. The owner of a property is the one who decides which party may see which data.

Within the hypothetical transaction process there will not be any preparation phase. In every moment in time the information is accessible and up to date. All the information needed for the transaction process is constantly available. During the marketing phase of the property, brokers will still do their best to find the right buyer for the property, aligning supply and demand. No notable changes will occur during the marketing phase.

Within the due diligence phase however, the role and aim of a due diligence will change. Instead of going manually through all the documents, smart programs will go through all the information collected in the digital token via algorithms. Subsequently, the technical due diligence can be a lot more accurate if the internet of things is combined and used with the digital token. Since all the installations will tell us when they need to be repaired. Vendor due diligence for interested buyers but also for other stakeholders in the supply chain could become easier by introducing a blockchain based rating system. This system makes a rating system for companies based on the immutable ledger of performance results.
In the last phase during the exchange to completion, all the agreements made will be put together in a smart contract. Brokers need to change their activities and need to set up those smart contracts (assisted by lawyers). If both parties agree the smart contracts make sure the property will only be transferred to the seller when he met the obligations coming from the contract. Therefore, seller will arrange his financing via a different token. This token consists of private equity of the owner and another part of equity which is financed by a bank (or via the crowd).

Once the smart contract is ready and seller has his financing arranged. The tokens will be exchanged peer-to-peer. Buyer will receive the token which represents the property (and all the data related) and seller will receive his money.

If the property is acquired the operation phase of the property start. During the operation phase the property still needs to be managed according to four main activities as mentioned by Van Driel & Van Zuylen (2016), those are commercial-, technical-, administrative-, and promotional management. However, the process will be much more efficient. Specially during administrative management.

Within commercial management, if a (new) tenant wants to rent space, he will sign a digital smart contract. Due to blockchain the identity of the tenant will be digital as well, so the building owner knows exactly who the tenant is. In this smart contract, all the obligations and agreements are saved. If both parties digitally sign the smart contract, payments will start automatically. The contracts are linked to the digital token which represents the property. This enables that all the contracts are automatically connected to the property. Therefore, no further administrative management procedures are needed.

During technical management, the blockchain process relies on the intelligence of the building. If a building is smart, all the installations are connected via the internet of things to the blockchain. The building knows exactly when maintenance needs to be done. It automatically manages which costs belong to the tenant and which costs belong to the building owner. This is also linked to the smart contract and to the payment system. Again, no further administrative management processes are needed during the operational process.

Via an app or computer program, the building owner can manage the performance of his property easily, and can focus on generating more cash flow from his buildings. For instance, the owner can facilitate pay-per-use constructions via blockchain. It is comparable to flexible working concepts. The owner can grant the public access to the ground floor of the building via a card system. From the moment somebody wants to work, he pays only the number of hours he is in the building. If he needs to use a meeting-room or a printer, additional costs will be charges. All the activities are collected via a blockchain and will be paid per month automatically. This may save huge administrative processes, and can therefore make this concept feasible.

The flowchart on the next page visualizes the preliminary flowchart, of the new real estate management process.
Figure 15 – Preliminary flowchart of blockchain based real estate transactions. Source: Own illustration
6 BLOCKCHAIN IN REAL ESTATE EXPLORATIONS

Further research in the real estate management process and the possible impact of blockchain technology is conducted by various semi-structured interviews. This chapter discusses the results distilled from the interviews with stakeholders within the real estate management process. The first part will elaborate on the interviewees and the interview questions. The second part addresses the results of the interviews.

6.1 Interviewees

The selection of appropriate interviewees is vital for conducting qualitative research through interviews. All the approached and selected interviewees are key stakeholders in the real estate management process which are influenced by blockchain, as well as stakeholders who started with the first blockchain initiatives in the Netherlands. Basic knowledge of blockchain technology is preferred, however this is not a necessity. To ensure correct and qualitative data, interviewees have been selected based on their role in the real estate management process and company. In general, all interviews have been conducted with directors or managers of the related department.

In total nine interviews are conducted with several stakeholders, respectively; Real estate owner / investor (2x), Broker (2x), Advisor (1x), Bank (1x), Cadaster (1x), Contractor (1x), Notary (1x). The transcripts of each interview are attached in appendix II.

6.2 Categories and Questions

Based on explorative interviews and desk research into both real estate management and blockchain technology, a flowchart of the conceptual blockchain based real estate management process is made and discussed in chapter 5. The flowchart is used as an impression of the new process and assist in guiding the interview. Based on the desk research and the conceptual blockchain based real estate management process an interview protocol was made to use during the interviews. This protocol can be found in appendix I. A short version with the different categories and questions for the interviews is shown in table 9. Important to mention, all interviews conducted were semi-structured, therefore offering flexibility in follow-up questions and reactions which occur during the interview. The interview, as a result, offers primarily qualitative data.

<table>
<thead>
<tr>
<th>Category</th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>• What is the role of your company in the real estate management process?</td>
</tr>
<tr>
<td></td>
<td>• What kind of services does your company offer within this process?</td>
</tr>
<tr>
<td></td>
<td>• Who are stakeholders needed to realize the services?</td>
</tr>
<tr>
<td>Current process</td>
<td>• How are the processes to realize those services structured and organized?</td>
</tr>
<tr>
<td></td>
<td>• What kind of information and assets need to be stored, monitored and</td>
</tr>
<tr>
<td></td>
<td>transferred?</td>
</tr>
<tr>
<td></td>
<td>• Which technologies are used to do so?</td>
</tr>
<tr>
<td>Blockchain technology</td>
<td>• Do you know blockchain technology? If not, blockchain is explained.</td>
</tr>
<tr>
<td></td>
<td>• What do you think of blockchain technology as an improvement for your</td>
</tr>
<tr>
<td></td>
<td>processes?</td>
</tr>
<tr>
<td>New process</td>
<td>• What do you think of the suggested new process via blockchain technology?</td>
</tr>
<tr>
<td></td>
<td>• Which stakeholders do we need to create this blockchain based process?</td>
</tr>
<tr>
<td></td>
<td>• From your perspective, what are the biggest hurdles to overcome?</td>
</tr>
<tr>
<td></td>
<td>• Do you see other opportunities that might benefit from blockchain</td>
</tr>
<tr>
<td></td>
<td>technology?</td>
</tr>
</tbody>
</table>

Table 9 – Interview categories and questions. Source: Own table.
6.3 Coding scheme

Completeness and reliability of the data needs to get attention before analyzing the data. A coding scheme can be used to code all the data which belong to an item in a sufficient and structured way (Bryman, 2012). The coding scheme as shown in table 10 addresses the different categories which are covered during the interviews. The coding scheme checks and verifies which coding categories are covered during the interviews and which parts of the interviews are relevant for further analysis. The analyses of the data retrieved from the interviews will be based on the different coding categories. Fortunately, all the interviews covered almost all the defined categories. The interviews are therefore extremely useful for further analyses.

<table>
<thead>
<tr>
<th>Coding Category</th>
<th>Subcategory</th>
<th>Interviewee A</th>
<th>Interviewee B</th>
<th>Interviewee C</th>
<th>Interviewee D</th>
<th>Interviewee E</th>
<th>Interviewee F</th>
<th>Interviewee G</th>
<th>Interviewee H</th>
<th>Interviewee I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stakeholder clarification</td>
<td>Role</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Responsibilities</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Real estate management process</td>
<td>Transaction process</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Partly</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Operational process</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Partly</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Process innovations</td>
<td>Partly</td>
<td>Partly</td>
<td>Partly</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Perception of blockchain</td>
<td>General knowledge</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Initiatives</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Blockchain in real estate management</td>
<td>Opportunities &amp; constrains during transaction process</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Partly</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Opportunities &amp; constrains during operational process</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Partly</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>The roadmap</td>
<td>Stakeholders needed</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Partly</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Hurdles to overcome</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Partly</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 10 – Interview coding scheme. Source: Own table.

6.4 Interview results

The interviews are analyzed based on the two concepts discussed in the theoretical framework, respectively real estate management and blockchain technology. The relevant flowcharts for the current transaction and operational process, as well as the conceptual blockchain based process framework functioned as guidelines during the interviews. The results of the interviews have been coded categorized based on the coding categories and subcategories.

There were several goals for conducting the interviews. Firstly, the interviews identified if the arguments addressed in the theoretical framework are supported by the practical experience of the stakeholders. Secondly, the findings of the interviews needed to validate if the hypothetical process is indeed an improvement, and which limitations occurred for creating this process. Lastly, the interviews with stakeholders who started blockchain initiatives aimed to identify the opportunities and bottlenecks for further development of those concepts. This section will discuss the results accordingly.

6.4.1 Stakeholder clarification

The theoretical framework introduces several stakeholders which are involved during the real estate management process. The theoretical framework describes the main tasks and responsibilities for each stakeholder. There might be a mismatch between theory and practice. Therefore, this subject note whether in practice stakeholders share the description of their roles and responsibilities as stated in the theoretical framework.
Interviewee B and G represents the Investors and are indeed the owner of a property. The interviewed investors can be categorized as institutional investors. Their main responsibility was executing the asset management of a property. Both interviewees noted that it quite common to outsource technical/property management. The responsibilities of the investor as an asset manager are in line with the theory. Their main responsibility is keeping track of the lifecycle and acquisition/sale of a property from a strategic perspective. They acknowledge the fact that their mainly focused on creating a business plan and strategy for a property. Their responsibility is well executing the strategy.

Interviewee A represented one of the three large real estate finance institutions in the Netherlands. The interviewee sees the rol of the funder as: “A large back of money”. The added value of a bank is of course giving a loan for a property. However, emphasis lies on reputation. Specially for banks it is of vital importance to have a good reputation and integer employees. However, the banks are also looking for ways to share their knowledge with other stakeholders in real estate.

Literature states that during the years the profile of brokers changed towards a full-service organization with a wide range of services such as, property & asset management, research & consultancy, valuations, and services related to corporate users. Interviewees C and E represented two of the larger broker firms in the Netherlands. They indeed confirmed their current role contains delivery of far more services than before.

The government is among others responsible for maintaining and organizing land title registrations of properties. In the Netherlands, there is an sufficient system which is called “Kadaster”. An interview with Kadaster (Interviewee F) gave interesting insights in their business. Kadaster is responsible for the registration of real estate. They facilitate notaries with guidelines for filing of the deed. Kadaster is checking and validating among others if the notary was correct.

The contractor interviewed in this study is a large holding company (Interviewee I). The contractor can facilitate all aspects within the construction industry, ranging from apartments to large infrastructural projects. During the lifecycle of a property the contractor is mainly obliged with the task of maintenance which is confirmed by the interviewee.

The notary interviewed (Interviewee H) was part of one of the largest law firm in The Netherlands. The notary would describe himself more as a juridical advisor. The advisor is mainly involved in the transaction process. They add value due to advising property owners in an early stage. Specially during due diligence and negotiations.

The advisor interviewed was Deloitte (Interviewee D). The objective of this interview was gathering more insight into their pilot project with CIC and the municipality of Rotterdam for digitalizing commercial lease contracts into the blockchain. Stakeholder clarification was not relevant for this interview.

The category stakeholder clarification consisted of some introduction questions to the interviewee in order to position their role within the process. The literature study gave a clear explanation about the roles and objectives of the stakeholders. The results of the interviews were in line with earlier findings.

## 6.4.2 Real estate management process
As discussed in the theoretical framework the real estate management process can be divided into two process flows, the transaction process and the operational process. In each process flow relevant data is transferred and certain technologies are used. Literature showed several information exchanges within this process. However, the importance of these information exchanges, and the inefficiencies were not pointed out by literature. This sections aims to support the existing literature with practical insights.
Transaction process flows and inefficiencies

Interviewee B and G explicitly mention that real estate transactions are initiated by the investors, this argument is supported by the other interviewees who indeed see the investor as the initiator. The data shows a similarity between all the interviewees about the involvement in the process. All interviewees indicate they can add the most value when they are involved in the early stage of the transaction process. The more information is made available upfront, the easier the transaction goes. It becomes clear from the findings that in general, real estate owners have their data not structured properly. Quite often, documents are missing or lost.

Findings indicate that there are certain documents which are essential for a building. Interviewee H addresses the public registries, Kadaster, and zoning plans as documents which are easy to obtain. This is supported by interviewee E and G. However, these interviewees argue that the lease dossier and the technical dossier are the most difficult to maintain. Nevertheless, these are the most important documents in a transaction according to the interviewees. The lease dossier contains all the information about the tenants, expiration dates, rental income, advanced service charges payments, information about the next indexation, allonge’s on the lease agreement etc. All these documents should be well registered. The technical dossier is more complex, since this contains all the invoices of delivered work plus the warranty certificates, invoices, and so on. It becomes clear from the interviews that the lack of these documents delays the due diligence process notably. The most time consuming part of the due diligence is therefore, the Q&A session regarding the content of documents or documents which are missing.

An interesting observation of the interview data is that almost all interviewees mention the lack of legislation and standardization for the way data and documents are stored and digitalized. All interviewees have their own system in structuring the data. However, in the process of selling a property, if the buyer works with a completely different system, all the information must be transferred to the structure of the new owner. This diversity and the lack of standardization makes it difficult to digitalize assets into the blockchain. This could be a major constraint.

After the due diligence and finalizing the negotiations the execution of the transfer of deed find place. In the Netherlands, the notary is responsible for this exchange. He needs to submit the necessary files by Kadaster, this organization will check the validity. According to interviewee F and H the system in the Netherlands is functioning very well, interviewee F clarified this statement as follows:

“In the most countries, it will take 6 months for the owner to be able to request his deed of ownership. In Germany, this process cost 2 weeks. In the Netherlands, depending on the system used, this may take several seconds”.

With the system used, interviewee F means the way a deed is submitted. It is possible in the Netherlands to do this hard copy. However, this is more time consuming and therefore more expensive in comparison with digital registration. According to interviewee F almost 40% of all Deeds is submitted electronically.

Concluding, all the respondents seems satisfied with the different steps in the current real estate transaction process. Nevertheless, there is a demand from all interviewees for more structured information up front, which is well maintained and documented during the operation phase. The interviewees experience the lack of well registered and updated documents as most disturbing factor in the process.

Operational process flow and inefficiencies

Once a property is acquired and transacted to the new owner, the operational process starts. Within the operational process, literature shows four different process flows, namely commercial-,
, administrative- and promotional management. The respondents explain that during the operational process the asset manager is responsible for the strategic management of the property, whereas property management is usually outsourced. This is in line with the findings from the literature study.

During the operational phase the commercial management of a property is well structured in general. Since property managers need to deliver performance reports with a rent roll on monthly or quarterly basis, documentation of these performances is therefore one of the most well-structured process. In contrast is the process flow of technical management. Registration of all the maintenance works, registration of all invoices, administrating all the receipts of the executed works and documentation of service charges are processes which are often not structured properly.

One of the interviewees was mainly focused on executing maintenance during the operation phase. He mentioned an interesting change in the way maintenance is done. Maintenance is focusing more on achieving a certain level of comfort instead of just making sure the installations are working properly. Users demand a guarantee that they can use their space for a certain timespan with the right performance level. A shift is noticeable from traditional maintenance towards performance based maintenance.

A shift towards a more client based approach was also identified in an interview with one of the investors, interviewee B in particular. Interviewee B provided a clear statement that currently the real estate market is not focusing on their clients:

“On the real estate side, the concept of customer does not exist. In my opinion it is a miracle that people are still using our products. Newly built dwellings are all looking the same. All the shopping streets we have look the same, and for offices, I don’t know one company who knows five years in advance how many employees he thinks he needs. But they say they know pretty well how many square meters they need, and once they moved in, those square meters will be delivered empty. Well, I never see anyone sitting on the floor, so why do they not deliver the square meters with furniture.”

Despite the negative image about the current products delivered in the current real estate market, interviewee B, G and H were positive about the future. They are working on creating new products which are more suitable for the current demands and wishes of the users. Pay for what you use, pay-per-use constructions is an example.

In conclusion, within the operational process, findings indicate that responsibilities of the stakeholders are in line with the defined responsibilities in the literature study. The interviewees agree that there is a need for better structuring data, and the traditional process flows are changing towards new models.

Process innovations
Observing the gathered data suggests that all the interviewees see possible innovations for their business, some of the interviewees are currently working on those innovations. Others are seeing the possibilities, hence they are focusing on their daily business. These possible innovations shows market demand for improving current processes, as well as solutions which might be feasible due to blockchain.

In line with the earlier mentioned client approach, interviewee C explains that when it comes to innovations there must be a client focus. This is also the approach of Interviewee B, who focusses on developing new business models for their client instead of optimizing their back office. Another statement made by interviewee C and which is observed in other interviews as well, is ‘learning by doing’; “We just need to get started with exploring projects. Do not think in limitations, just try and see
if it works”. This vision is shared by other interviewees who came up with the same motives for initiating innovative pilot projects.

The most general observation concerning innovation indicates that all innovations currently explored by the interviewees are mainly data-driven and built around the use of big-data in combination with machine-learning. The approach towards the way initiatives are started defers. Most interviewees pointed out that they have internal project groups which are focusing on new business models and innovations. The exception is interviewee B, who despite the internal efforts of creating new products, is also incorporating start-ups and facilitate them as an incubator.

The need for a better structured data-room for real estate transactions is observed and discussed earlier. In line with these observations, Interviewee G is currently exploring a new system to solve the issue of the lack of documentation during transactions. The focus in this experiment lies on creating a uniform database throughout all their offices in the world, which is set-up in the acquisition phase of the building. During the lifecycle, all the information concerning the building goes directly into the system on the right place. However, this process is executed manually, so it is still possible to lose documents. The biggest advantage is that throughout the various offices of interviewee G around the world, everybody knows exactly on which place certain information is found. When one decide to sell the building, the owner has easy access to all the information and already a prepared dataroom. This allows for a better streamlined sales process.

Another notable innovation was addressed by interviewee F. They are currently working with a system which makes it available for notaries to submit the registration of deeds digitally. In accordance with the KNB they developed a standard deed which can be filled in with the use of a style sheet. The documents are exported into an XML file. This allows interviewee F to easily import them in their own system with some additional manual checks.

The data retrieved from the interviews illustrates some interesting approaches towards innovating the process. It seems that all participants are aware of the major trends and developments currently occur. Client focus and data efficiency are the main drivers for innovation. The responses gave a clear perception of the positive attitude towards innovation in the current market.

6.4.3 Perception of blockchain

The theoretical framework introduces the concept of blockchain and addressed several use cases for the implementation of blockchain in real estate. The second part of the interviews focused on this technology in relation to the real estate management process. By addressing the concept of blockchain technology, it is interesting to see whether the respondents have already general knowledge about this topic and whether they are carrying out pilot projects already. The aim of this interview section is identifying the mood towards blockchain as well as explaining current initiatives.

Most of the participants of the study were familiar with blockchain technology. Three interviewees had heard of blockchain technology, hence did not quit understand the principles of the technology. Respondents B, F and I are working on a blockchain pilots but did not come up with a proof of concept yet. Interviewee A and D actually build a blockchain based application which is discussed in the following chapters.

By analyzing the data of Interviewee D, it gives an impression of the designed blockchain based product. The aim of this system is digitalizing lease agreements via a blockchain structure, which is already mentioned in chapter 5. Users of the system should be able to easily create lease agreements, based on the ROZ-model, and connect them to the right building. Subsequently, the lease agreement is shared between Landlord and tenant, and can be signed digitally. Creating digital lease agreements and connecting them to the right building is not new, and to do so, blockchain does not seems
necessary. However, the true value of blockchain for this system is the ability to digital sign the agreement and creating a shared immutable ledger of the history of signed agreements. The system is built on the Bitcoin blockchain, users are able to identify themselves with their own unique bitcoin address. Linking the bitcoin address to the building allows for validating if the user is authorized to sign. Using two bitcoin transactions ((1)Landlord agrees to tenant →(2)Tenant agrees to landlord) both parties agree on the lease agreement and the document is valid. The hash of the original lease agreement together with the two bitcoin transactions is added to the network, creating an immutable record. Interviewee D mentioned that currently research is done in order to expand the possibilities with tracing of the financial obligations resulting from the agreement.

The interview results of interviewee A explain their project Torch properly and it becomes clear that this is in line with the findings in the literature study. In relation to the earlier mentioned client focus. This project originally focused on improving the internal processes of interviewee A. However, with the use of blockchain a new infrastructure is created. This enables interviewee A to develop new propositions for their clients. The observations of interviewee A indicate that in contrast to the project of Interviewee D, their project uses the Hyperledger fabric blockchain protocol in cooperation with IBM. The main difference between the Bitcoin protocol and Hyperledger fabric protocol is the difference in accessibility (Bitcoin is public, Hyperledger is permissioned) and the difference in consensus (Bitcoin uses proof of work whereas Hyperledger uses practical byzantine fault-tolerance consensus). The blockchain used for this project can therefore be seen as a distributed network instead of a decentralized network. The advantage of a certain system is that it allows for controlling which parties are running a node in the network. The disadvantage is that all the data is still stored on one local server, which is a contradiction of the philosophy of blockchain.

Interviewee I is also conducting a pilot project in cooperation with PWC and Microsoft, by using Microsoft’s Blockchain as a service platform. This project aims on digitalizing performance agreements on the blockchain. All the variables within a performance agreement are measured, and each measurement is seen as a unique transaction which is registered in the Blockchain. This allows stakeholders to have real time insights in the performances and cost of their building. Currently this project is explored on dwellings, however the observations show that this can be expanded to commercial real estate as well. These findings are supported by interviewee B, who specifically mentioned they are working on a pilot project for commercial real estate to change the model for service charges. The aim of this project is giving tenants of a building real time insights in service charges in order to force tenants to operate the building more sustainable.

When observing the different pilot projects, all interviewees indicated the need for a certain kind of standardization and simplification of the current processes in order to innovate them. Currently there is a lack of regulation and standardization, therefore all interviewees are pointing to each other, however nobody is taking the responsibility to take this roll. Due to the lack of standardization all innovations are explored sideways to each other, hence these projects are not integrated to each other. Everybody is re-inventing the wheel by themselves. Interviewee B strengthened this argument by stating; “A lot of start-ups are exploring interesting initiatives for different fields, however, there is nobody who is integrating all these aspects”. In relation to blockchain, this statement is a clear sign for the need of a common approach towards innovation.

6.4.4 Blockchain in real estate management

In chapter 5.2 a conceptual real estate transaction process based on blockchain technology is designed. This section introduces the results from the interviewees on their vision and thoughts about this process, as well as the feasibility of this process.
All interviewees were positive about the proposed blockchain based process, each with their own area of concern. Based on the results it seems a blockchain based real estate process is possible. Consensus between the interviewees was found in the starting point of the transaction, creating a digital token of a building which is a building passport, with the possibility to gain real time insights in all the information about a property. This digital building passport is indicated by all respondents as the biggest added value in the process, it can provide a solution for the lack of well-structured data of a property.

The buildings passport functions as the starting point of a transaction. However, all the information related to this digital representation of a building is collected during the operational phase of the property. The respondents mentioned identity of owner, commercial information, and technical information as main components for the passport. The added value of this passport both in the transaction process and in the operational process is pointed out by all interviewees. Interviewee E provided perhaps the most evident statement:

“What I find particularly interesting is how the coin is filled upfront. That is actually something we are missing at this moment. If you can create a building passport that keeps all the information automatically up-to-date and you can rely on the correctness of that information, I think it provides a huge added value to the process”.

Findings indicate that creating a solid, trustworthy and reliable digital identification of a building is inevitable for the further transaction process. If this information is correct and up to date, the whole due diligence process may change according to the interviewees. The digital token of a building and all the transaction which occurred during the operational phase may also change business models. Interviewee C identified a possible change for their valuation advisory department. Since all transaction history and information of properties is available, valuations can become automatic. It may also change the way the research departments operate within big real estate firms. Currently, transaction data of commercial transactions is collected by RealNext, an independent platform. However, participants need to pay to receive all the transaction data since Realnext is a third party. If all the brokers create a blockchain based network which documents all real estate transaction, data becomes more transparent and research departments can rely on the data and do not have to validate and check all the data manually.

Within the due diligence process, the respondents see possibilities for more efficient and faster processes. Interviewee E gives perhaps the most notable statement for this argument; “Due diligence will shift towards a more conformation due diligence. Perhaps, by the use of smart algorithms, this process can be digitized. The algorithms can check for instance if all documents are available and if the content of these documents is correct”. Interviewee G mentioned that part of these processes are already used. For instance, it is easy to share a (part of the) dataroom with an interested or selected buyer. Blockchain will not add value for this process. However, interviewee G agrees that the added value of blockchain in due diligence is the verification and validation of the availability and correctness of the documents available.

The observations on the last part of the proposed process, the actual transaction, vary among the respondents. Interviewee B, E and G say on the long term the notary can easily be replaced for checking the validity of transferring deeds in transactions. Nevertheless, the respondents mention the complexity of real estate transactions and therefore have some doubts over the feasibility of a blockchain transaction without interference of a notary.

The complexity of the transfer of deeds for commercial real estate is best expressed by interviewee F via an example for only stating the name of the owner in a deed:
Interviewee F: “The notice of a party in a deed is called a ‘comparitie’, which can consist of 1 person, 2 persons, but also 1000 people. Often this is just a repetition of the same steps, hence it becomes difficult if all the people have different roles. Then there also constructions were several companies collectively buy a property via a partnership with all kind of management constructions and arrangements in between. It is very hard to program all those exceptions.”

The example of interviewee F is only about putting the right name of the owner in the deed. Subsequently one have to deal with insurability of the property, or how to deal with bankruptcy after the deed is transferred. Interviewee H acknowledge this complexity and adds the problem of the transfer of money, “Do I need to pay first before I receive the ownership of the property, or do I receive the ownership first and afterwards the payment”. Currently, the notary is appointed as an arbitrator to arrange this process properly. The same applies for the proposed digital escrow. In order for the bank to provide a loan on a property he first needs to receive a mortgage right on the property. The buyer can only provide a mortgage right on the property if he is the actual owner, so who goes first.

Despite all the issues addressed by the interviewees relating to the transfer of ownership part of it is just a formality which blockchain could digitalize. Nevertheless, all respondents agree that also if the whole process changes into a blockchain based transaction process, there is still need for a neutral person who controls the transaction. Interviewee H illustrated this statement clearly by using the following example: “Please note that the transaction has been completed without the buyer placing a knife on the throat of the seller. The blockchain is not able to check this”.

In conclusions, all interviewees showed a positive attitude towards the proposed blockchain based transaction process. Nevertheless, findings indicate that blockchain technology by itself is not enough, since blockchain is just a ledger of transactions. Interviewee B, E and I agree that other innovations are needed in order to create a renewed blockchain based environment. Innovations which were mentioned are machine learning and artificial intelligence. Within this systems, blockchain functions as the ledger, whereas machine learning or artificial intelligence may automatize the input and output to the ledger. Chapter 7 will further elaborate on the renewed blockchain based real estate management process.

6.4.5 The roadmap
As discussed in the theoretical framework a significant technical challenge and requirement of blockchain is that a full ecosystem of plug-and-play solutions needs to be developed to provide the entire value chain of service delivery. In order to make blockchain a success, multiple stakeholders need to be involved in the development of an eco-system. Therefore, the last part of the interviews focused on the roadmap with steps to take and stakeholders that need to be involved for the integration of blockchain in real estate.

Most of the interviewees mentioned digitalization of assets as a starting point for blockchain. By representation of an asset via a token in the blockchain network, one can think of several features which could be further build. Despite the clear starting point, full digitalization of assets is also seen as the biggest challenge. Currently all property files are stored on several computers, or exist as hard copy files. It will therefore be time consuming and expensive to digitalize all relevant documents of a property. In addition, all the input for the properties must be correct, since it will otherwise be an immutable error and a negative influence on the output. A frequently heart term was ‘Rubbish in is rubbish out’. Interviewee E added the statement that once a digital token of a building is created, it should operate as an active system, which is constantly updating itself.

According to results, most of the interviewees agree that the real estate system will not be disrupted at once. Small blockchain projects need to be started for sub-processes. This is also the way interviewee A is developing their project type. First the fundamentals of the project needs to be solid
and well working. The next step is to add several other features. Despite the consensus on this topic among the respondents, interviewee B, C and E addressed a major technical challenge for this approach. If all the stakeholders are building their own blockchain network by themselves, how does one make sure all the networks are able to communicate with each other. Further research is needed to identify if this is possible.

The observations of the results from Interviewee F and H show an interesting juridical challenge for the Dutch system. Currently, the Netherlands uses a form of a negative legal system. Meaning, there is not one single version of the truth, the actual and legal situation needs to grow together over the long term. It is therefore possible to acquire the ownership of a property by prescription. In for instance Germany a positive legal system is used. They have no time limit on the ownership of a property. The Cadaster in Germany is therefore always right. There is just one single version of the truth. With blockchain technology, there should be only one single version of the truth as well. Therefore, the Dutch legal system needs to be changed into a positive system to deal with blockchain accordingly.

Regarding the stakeholders needed for further development of blockchain based applications, most of the interviewees mentioned the government as an important stakeholder. If the government creates new guidelines or regulations for blockchain, market parties are forced to reconsider a blockchain alternative. Nevertheless, all parties agree that market parties have to come up with the biggest push for a blockchain based system. In addition, observations show that the respondents indicate that all stakeholders in the process are needed for full implementation.

The results illustrate the willingness and the possibilities for blockchain technology as well as a clear starting point. Nevertheless, it is obvious that certain hurdles need to be taken in order to implement blockchain technology within real estate management. Digitalizing all assets may be time consuming, and its arguable if the added value of blockchain succeeds the effort and work that needs to be done. Interviewee F raised perhaps the most evident question to support this argument: “Well, than the first question arises, is there a problem in the current situation, and if so do the benefits outweigh the costs?”. Without experimenting and initiating pilot projects, this question may be unanswered after all.

6.5 Summary of the findings

This chapter addressed the findings of the interviews with different stakeholders within the real estate management process and provides data and clarification of the current process and the attitude towards a blockchain based process.

By looking to the current real estate management process, the interviews did not provide any contrary results compared to the theoretical framework. All the respondents seems satisfied with the different steps in the current real estate transaction process. Nevertheless, the findings indicated a demand for more structured information up front, which is well maintained and documented during the operation phase. A lack of well registered and updated documents is experienced as most disturbing factor in the process.

The data retrieved from the interviews illustrates some interesting initiatives, or products which are currently be employed in order to innovate the current process. It seems that all participants are aware of the major trends and developments currently occur. Client focus and data efficiency are the main drivers for innovation.
The basic knowledge about blockchain technology is present among the different stakeholders. Subsequently, the perception towards blockchain based solution that may innovate or disrupt the current process is positive. Some companies are already experimenting with blockchain pilots in real estate. However, there is need for a certain kind of standardization and simplification of the current processes in order continue building blockchain application.

By looking to the proposed blockchain based transaction process, all interviewees showed a positive attitude. Nevertheless, findings indicate that blockchain technology by itself is not enough, since blockchain is just a ledger of transactions. Other innovations should be incorporated in order to create a renewed blockchain based environment, such as machine learning and artificial intelligence.

All interviewees were clear about the starting point for blockchain in real estate, digitalizing assets. This is also seen as the biggest challenge. Via conceptual thinking the possibilities seems endless, however, in practice this is much more complex.

In order to create a blockchain environment in real estate, all stakeholders need to cooperate. Market parties will be the push behind this movement. Consequently, the government needs to formulate clear guidelines, regulations, and standardization. Otherwise, the situation may occur that all stakeholders are building their own product, without the possibility to interact with each other.
Part V

Analyzing the results
PART V – ANALYZING THE RESULTS

7 INTERPRETING THE EMPirical RESULTS ON BLOCKCHAIN BASED REAL ESTATE MANAGEMENT

The previous parts outlined both the results from desk research and the interviews. This part will continue with comparing the findings from these chapters. Data from desk research will be compared with the interviews in order to identify where in the process blockchain can add value and designing of a blockchain based real estate management process. The first part of this chapter aligns the opportunities for blockchain in real estate derived from the literature study with the findings from the interviews. The second part provides a design framework for blockchain based real estate and addresses the added value compared to the current process. The last part of this chapter provides a roadmap with the challenges we need to overcome to achieve the designed process.

7.1 Desk research on blockchain in real estate versus the interpretation of the interviews

By studying the opportunities for blockchain in real estate five notable opportunities arose from literature. Those are: digital records of real estate assets, re-design real estate processes, transparent markets, payment systems, smart contracts. Aligning these findings with research on the real estate management process resulted in five hypothetical opportunities as addressed in chapter 5.1. This first section compares the findings of the interviews with the hypothetical blockchain based solution. The solutions are analyzed by using the following three main criteria:

1. Feasibility of the solution;
2. Requirements needed for development of the solution;
3. Constraints for implementation;

7.1.1 Hypothesis #1 – Digitalizing real estate

Blockchain has the potential to enable every property, everywhere, to have a corresponding digital address that contains occupancy, finance, legal, building performance, and physical attributes that conveys perpetually and maintains all historical transactions. Additionally, the data will be immediately available online for all properties according to the literature study. The interview results confirm the need for a digital address as addressed in desk research. Based on the results of both the interviews and the desk research it seems that creating a digital representation of real estate on a blockchain is possible. Creating a solid, trustworthy and reliable digital identification of a building is inevitable for a blockchain based transaction process. If this information is correct and up to date, the whole due diligence process may change according to the interviewees. Due diligence will shift towards a more confirmative due diligence. Perhaps, by the use of smart algorithms, this process can be digitized. The algorithms can check for instance if all documents are available and if the content of these documents is correct. Nevertheless, findings indicate that blockchain by itself is not capable of doing so. Alternative innovations should be embraced in order to create a digital building passport. This digital building passport is indicated by all respondents as the biggest added value in the process, it can provide a solution for the lack of well-structured data of a property.

Throughout the several interviews it became clear that the most important components for creating a buildings passport are general building information, identity of owner, commercial information, and technical information. Currently, the registration and documentation of these elements is a mess in the current processes. However, all the information related to this digital representation of a building is collected during the operational phase of the property. Another important requirement derived
from the interviews is how the building passport is filled upfront. This digital building passport will only contribute to the process if the data input is correct and refreshed automatically. All the information needs to be up-to-date during the lifecycle of a property and all the stakeholders need to rely on the correctness of all the information. If so, blockchain functions as the trustworthy registration of all the documents.

Although the concept seems perfectly suitable, the observations show some issues with the practical implementation of a digital address. For instance, title registration of properties in the current system with all kind of exceptions. In case of the implementation of a blockchain-based Land Registry system, one should not underestimate the complexity of the legal system, the meaning of the rights in rem (numerus clausus or not), the complexity and variety of different transactions and the proceedings of the legal professionals in the chain of conveying immovable property. Without standardizing (parts and elements of) this process, the complexity may be the threshold to success (Vos et al., 2017).

Currently both literature and research argue that blockchain technology is not mature yet. However, it acknowledges that blockchain features the right elements for future application. A statement which is supported by the interviewees.

Another constraint is the lack of industry standards concerning registration of real estate assets on the blockchain. The situation might occur that all stakeholders developed their own blockchain environment without the possibility to communicate with other systems. All stakeholders need to cooperate on global scale in order to create a uniform framework for digital assets on the blockchain. How government regulation unfolds could be one of the most significant factors and risks in whether the blockchain industry will flourish into a mature industry.

### 7.1.2 Hypothesis #2 — Alternative financing tools

Although literature argued the possibility for blockchain for real estate financing tools. Within real estate transactions, and also during the operation phase of a property the digital currencies built on blockchain can be used for various purposes in relation to real estate. Both the results of the theoretical framework and the interviews show possible applications for creating a digital escrow during transactions, or for automatizing rent & service charges payments.

Although the theoretical framework is quite positive about the use of digital currencies, the interviewees argue the need for those currencies. The process for fulfilling payments emerging from the lease agreement is already a digital and automatic process. The true added value for blockchain in this matter is identified by the interviewees as the possibilities to track and trace all those payments. Real estate owners can look through the history of their tenants and see exactly which tenants pay their rent on time, and which tenants face an arrear of rent.

The limited data retrieved from the interviewees on this topic could be due to the set-up of the interviews or the limited expertise of the interviewees on this particular subject. Only one financial institution was interviewed for this study. From his opinion blockchain based financing tools could enable participation in real estate investments from a broader audience. Further research is needed to verify this statement and identify the opportunity and limitations.

### 7.1.3 Hypothesis #3 – Exchange of ownership

Blockchain technology has the potential to handle real estate transactions in a similar way to how payments between parties are handled using digital currencies according to literature. Based on these assumptions the preliminary blockchain based real estate transaction process was designed and evaluated among the interviewees. The results of the evaluation were partly in line with the findings of the literature review. Blockchain has in theory indeed the potential to handle real estate transactions.
The study showed some requirements for transacting real estate via the blockchain. Firstly, all the important elements of a building needs to be digitalized and represented in the blockchain via a token, which is discussed in section 7.1.1. Within the real blockchain transaction there are certain similarities with the current process steps, hence blockchain will make these steps more efficient. This is particularly the case during due diligence. Both findings from the interviews as well as the theoretical framework identify a new meaning of real estate due diligence. Blockchain can be used for the registration and verification of documents, whereas smart algorithms automatically analyze all the relevant property information. In order to transact real estate, an blockchain based escrow is needed to place the funds needed for the transaction in a neutral environment. Finally, the sales contract needs to be digitalized via a smart contract. This allows for the exchange of ownership and funds.

Although the interviewees were clear about the conceptual feasibility, the results indicated a couple of important hurdles for the transfer of ownership of real estate via the blockchain. Clearly, all respondents seems satisfied with the current process and the role of the notary and Kadaster. In the current Dutch system transferring a deed can be processed completely automatically, without the interference of any human, in tenths of a second. Placing these findings in broader perspective shows that different countries all have their own unique system. Creating one universal blockchain where real estate assets can be transacted on a world wide scale seems practically impossible, due to the diversity of systems, regulation and customs.

7.1.4 Hypothesis #4 – Digital lease contracts
In order to create self executing tasks on the blockchain, smart contracts are essential and need to be used for various application. Among the interviewees there was some confusion about the term smart contracts. The interviewees who were currently working on pilot projects were familiar with the term and addressed the need for those contract in order to facilitate the applications on blockchain. Within the proposed blockchain based transaction process, smart contracts are essential. Both the interviews and the findings of the theoretical framework support this argument. The pilot project of Deloitte together with the municipality of Rotterdam and CIC showed that digitalizing lease contracts on the blockchain is feasible.

The system of Deloitte is built on top of the Bitcoin blockchain. Each user is able to login to his account via their own unique Bitcoin address. This address allows for verification on the authenticity of the signature. The hash of the lease transaction is added on the blockchain and linked to the original contract. The original contracts can be stored on an independent server. This reduces the size and subsequently the speed of the blockchain. The tenant and landlord come to an agreement via two Bitcoin transactions. The hashes of the transaction are visible on the blockchain network, hence they are not readable. The encrypted reference to the original lease contract can only be decoded by the two parties who signed the agreement.

The challenges with creating digital lease contracts on the blockchain faced by Deloitte were creating a digital identity of owner and tenant, and how to coop with an exchange of ownership. In their proof of concept several assumptions were made for these particular topics. Further research and development of their proof of concept is needed to fully integrated all the aspects relating to a lease agreement.

7.1.5 Hypothesis #5 – Digital building performance & maintenance
Measuring the performance & maintenance of real estate on the blockchain is way more complex then described in the literature. The interviewees agreed that the biggest added value of blockchain in this process is having all the technical information, invoices, warrantee certificates, etc. up to date during the complete lifecycle of the property. Literature addressed that a full supply chain of the building materials can be enrolled, enabling circular economy to further integrate in the real estate
economy. In addition, when data is more accurate and the performance of a building more insightful, the service charges and owner charges can be connected, via smart contracts, to the lease contract. This enables automated calculation of service & owner charges, and connects them to payments.

The interviewees agree that for a digital building passport to operate these information is vital for making this passport useful. A pilot project of one of the interviewees showed that it is possible to digitalize performance agreements on the blockchain and measure all the related obligations to give real time insights in the building performance. Unfortunately, this project is only tested on dwellings yet. There is no evidence in literature or in the conducted interviews which shows the feasibility of this concept for commercial real estate. Further research is needed to identify how this process can be built on the blockchain and which constraints may occur.

7.2 The design of blockchain based real estate management

7.2.1 Managing real estate with blockchain

The key for using blockchain technology in real estate management is creating a digital representation of a property in the blockchain. The property can be represented by a smart token which consists of or is linked to four different field of information. These are:

1. **General information** – Contains the digital registration of an object and all the rights involved, as well as all the information about the ownership of the property with all the rights involved, and finally public information concerning the property, such as zoning plans;
2. **Commercial information** – Consist all the information about the tenants and the related lease contracts with all the appendices and allonges, as well as the monitoring of the payments and other issues deriving from the lease contract. This information should also include the details for service charges from a tenant perspective;
3. **Technical information** – Represents all the technical documents and information of a property, as well as information about the physical condition of the building by monitoring all issues concerning maintenance and the outgoings. Within technical information also the performance agreements and certificates of the building should be incorporated.
4. **Financial information** – Lastly, the token should contain a financial component in which the rating assessments and valuation reports are incorporated, as well as the WOZ-value and VAT registration details for tax purposes.

![Figure 16 – Representation of elements of digital coin. Source: Own illustration.](image-url)
The blockchain allows for real time up to date data and trust for this information. Different stakeholders may grant access to parts of the coin based on their interest. For instance, banks may have access to the commercial information to check if the property is in line with the given loan, or the government may have access to the financial part for handling their taxes. The biggest added value is that all stakeholders can rely on the data, and it does not have to be checked repeatedly. Another great added value of using this token system is that this will streamline real estate transactions and due diligence becomes more efficient.

More benefits of this digital token system can be found in the operational phase of the property. Within commercial management the process of creating and signing lease agreements will be much more efficient via the earlier mentioned smart contracts. All these contracts and the monitoring of the obligations deriving from the contract will become automatic.

During technical management, the biggest added value of blockchain is having all the technical information, invoices, warrantee certificates, etc. up to date during the complete lifecycle of the property. In the current system this information is lacking, which results in time consuming and therefore costly preparation phases once the property needs to be transacted. By going even step further, with the rise of smart buildings, all the installations can be connected via the internet of things to the blockchain. If that is possible, maintenance will shift even further into performance maintenance and all the stakeholders can rely on the building performance information registered in the blockchain.

Another added value of the use of blockchain, the owner does not have to care about administrative procedures anymore, hence can focus on generating more cash flow from his building and makes their product even better. One example is the pay-per-use construction as discussed earlier, which are currently difficult to employ due to the administrative procedures.

7.2.2 Transacting real estate on the blockchain
Blockchain has the potential to enable a change in the way real estate is transacted. By combining all the findings from both desk research and interviews, the earlier designed preliminary flowchart of a blockchain based real estate transaction process is adjusted resulting in the following final model as shown on the next page.
Figure 17 – Blockchain based real estate transaction flowchart. Source: Own illustration.
The smart token as discussed earlier in this section functions as the input for the blockchain-based real estate transaction. In comparison with the current system, this will save real estate owner tremendous time in the preparation phase, since all the information is already present and does not have to be searched everywhere.

In the early stages of a transaction several advisors are selected, such as the broker and legal advisors. With a new blockchain based rating systems also smaller real estate advisory companies can prove their track record. Since the track record is immutable and company performances are more transparent, parties are benefited from good ratings. Both bigger and smaller firms can join the real estate business if they build a sufficient track record.

Marketing of the property will not change due to blockchain. No added value of blockchain technology is noticed. The current data rooms used allow the owner to grant access to stakeholders for a specific part of the data. Blockchain will not add any additional value. Within the due diligence phase however, the role and aim of a due diligence will change. Instead of going manually through all the documents, smart programs will go through all the information collected and registered via blockchain in the digital token via algorithms. This identifies the dependence on other technologies in order for blockchain to add value. By combining blockchain with machine learning algorithms, value is added in the due diligence phase for easier automatically due diligences, which both saves time and costs.

The last part of the process addresses the possibility for using a smart contract to execute the transaction without the interference of a notary. In order to do so, a digital escrow is needed to make the financing for a property available. Although in concept this is indeed the way real estate can be transferred, the added value of blockchain is questioned for the Dutch system, since this is one of the best working systems around the globe. Nevertheless, blockchain may add value for system which face long transaction times for real estate transactions.

Finally, the transaction is registered in the blockchain. This registration, together with the registration of lease contracts, can allow for a way more accurate research system among brokers. Currently all the transaction data is checked manually. In potential, this will save a large amount of time and money. So, the added value of registration real estate transactions is creating mutual trust and reliable public data of all the transactions.

Creating a blockchain based management process will transits the way the current stakeholders operate. Within the transaction process, the role of the notary can be argued. On the short term, all interviewees agree that their role still exists, hence it will shift towards an arbitrator role within the process. For the long term, the findings are aligned to the findings from the theoretical framework which states the role of a notary in the process may disappear. The role for advisors who are conducting due diligence will change notably in a blockchain based process. They can still add value in providing smart algorithms who automatically can check all the property information, this will save costs for the seller and buyer.

Within the operational phase, the role of the property manager may change sufficiently. A lot of the process will be executed automatically. The new tasks of the property manager will be monitoring the performance of a property by using smart tools. All the administrative processes can be cut out.
7.3 Steps to take – The roadmap

Complete disruption of the current real estate management process with the use of blockchain technology is questionable as argued by the respondents. For creating a blockchain environment in real estate, several steps need to be taken. This section provides an approach towards the steps that need to be taken, not taken into account the technical improvements of blockchain technology to become mature.

First of all, both desk research and the interviews show there is a need for a standardized framework with rules and guidelines for digitalizing real estate in the blockchain. In order to gain broad adoption, technical standards must be produced and agreed upon to assure compatibility across industries and interoperability between technologies. Currently different projects are experimenting with blockchain in real estate, however, all on their own network according to their own rules. The situation might occur that all stakeholders developed their own blockchain environment without the possibility to communicate with other systems. This is in contrast with the philosophy of blockchain. All stakeholders need to cooperate on global scale in order to create a uniform framework for digital assets on the blockchain. How government regulation unfolds could be one of the most significant factors and risks in whether the blockchain industry will flourish into a mature industry. The feasibility is arguable since this collaboration should occur on world wide scale in order to achieve full implementation. As a starting point, this collaboration needs to take place via EU-regulations. Through INSPIRE, the European Union has created common standards to facilitate the exchange of information and data between the local, regional, national and European or international levels and thus support integrated policy decision-making at all levels of government. INSPIRE is a set of EU and national legal acts and their coordinated implementation. A certain platform is extremely suitable for further development of blockchain standardization.

This widespread adoption is essential for the positive network effect of blockchain to be truly harnessed. The major threats to achieve this critical mass are fragmentation of platforms and institutional and social inertia to transition to a specific platform. To achieve critical mass, firstly a single opensource platform would need be built upon by all developers. Secondly industry consortia would need to unanimously agree on chain projects. Whenever all stakeholders agree on a standardized framework for digital assets on the blockchain, a digital representation of real estate needs to be developed. Currently, several projects are trying to develop a building passport with all kind of elements of the property represented digitally with good efforts. Incorporating several stakeholders in further building those applications may strengthen the developments. It is important to focus on the quality of the data input and the business processes supporting this input. Considering a blockchain database is only as good as the data and the business processes that underlie it. According to the theoretical framework, failure to reach a consensus among counterparties as to business processes or to resolve commercial conflicts could significantly hinder blockchains adoption. It has been estimated that a blockchain is about 80 per cent business process change and 20 per cent technology implementation.

If the guidelines are set and an institutional framework is created the development of blockchain applications will continue by exploring solutions for sub-parts of the whole process. Both the interviews and the literature study show that a full ecosystem of plug-and-play solutions needs to be developed to provide the entire value chain of service delivery. Blockchain by itself will not achieve this proposition. Other data-driven innovations such as artificial intelligence and machine learning algorithms needed to be incorporated as well. Finding uses-cases for this type of technologies exceeds the scope of this study and is therefore not elaborated on.
In order to find-out if the several use-cases for blockchain technology really work, further research needs to be done for each sub process. Although the results of the literature study and the interviews were positive about the possibilities, complete disruption of the sector will not happen at once. Processes within commercial real estate are very complex. Development of blockchain based solutions needs to be explored step by step. Each creating solutions for a small piece of the pie.

For instance, the process of transacting properties via the blockchain. Payments via the blockchain with all related persons and roles involved in the transaction is not the biggest challenge. However, checking that the consensus between parties is intended by both parties without forcing one or another is difficult. In the current system, the notary welcomes both the buyer and seller face to face and notices that both parties are indeed intended to transfer the property. But also, if a buyer tries to mislead the seller and will acquire the property for a price which is way less than the actual market value. Kadaster and the notary are the bodies who are controlling these kinds of exceptions currently. This system works properly and has a proven track record throughout history. This example is only about validating the willingness and intentions of two parties for selling a property. There may also arise problems with the actual transfer of deeds and money. In these kinds of transactions there is always a trusted third party involved who extract the money from the bank and the title of ownership from the seller so that he can check if both parties met all the right conditions for sale. Bankruptcy at the moment of transferring can be for instance a major issue, therefore a 24hour gap between the exchange of ownership of a property and the exchange of money is built in. It could be the case that blockchain can replace this role. However, the technology needs to prove his capacities further.

Finally, it is important to note that as blockchain is becoming more mature, they can gain purpose and deliver their promises to the greater public. The technology by itself is still in its early stages. It has proven itself for digital currencies, despite the potential for blockchain technology, there are not many proof of concepts built on the blockchain. In order for blockchain technology to become mature it is important that companies are keep working on creating proof of concepts for blockchain applications. It will be the early adaptors of this technology who will benefit in the long-term.
8 CONCLUSIONS & RECOMMENDATIONS

8.1 Conclusions

Contracts, transactions, and the records of them are fundamental for the commercial real estate industry. However, the management of those assets have not kept up with the economy’s digital transformation. In the new digital world, the way we regulate and maintain administrative control has to change. This researched focus on a technology which has the potential to exchange value digitally, blockchain technology. Blockchain has the potential to interfere at the basic principles of existing real estate processes. In a sector plagued by middlemen and characterized by inefficient processes, this technology is able to restructure the process of managing real estate and transferring digital assets.

This aim of this research was exploring the different possibilities for integrating blockchain technology in the real estate management process. By analyzing the current real estate management process and gaining knowledge about the implementation of Blockchain technology, this research explored in which phases of the real estate management process the process can be optimized and contribute from blockchain technology. The output of this research as summarized in this conclusion provides scientific evidence on the opportunities and constraints for implementing blockchain technology in current real estate processes as well as recommendations for further research.

This chapter is concerned with providing an answer for the main research question: “What are the different opportunities and constraints for the implementation of blockchain technology in the real estate management process?”

Blockchain can be defined as a transparent, immutable and distributed digital ledger of economic transactions that can be programmed to record digital transactions of everything which represents value. Simply said, blockchain is a database of transactions between two or more parties, with copies of the database replicated across multiple locations or nodes. The copies of the database are constantly update automatically, so all the participants share the same immutable database.

Research shows that blockchain is still in its early stage of development and therefore needs to overcome some limitations and challenges of the current system both internal and external, including technical challenges, standardization, public perception, government regulation and mainstream adoption of technology. In order for this technology to become mature special-purpose blockchains will need to be created for a wide variety of applications. In order to gain broad adoption, technical standards must be produced and agreed upon to assure compatibility across industries – particularly in cases where multiple blockchains will need seamless interoperability.

The empirical results of this study indicate five different opportunities for the implementation of blockchain technology in the real estate management process. These opportunities were identified by verifying the hypothetical blockchain based solution as discussed in the theoretical framework with the results of the interviews. This leads to the following opportunities:

1. Creating a building passport of commercial real estate represented by a smart token on the blockchain;
2. Developing alternative financing tools;
3. Transacting commercial real estate via blockchain;
4. Digitally sign lease contracts and monitoring of all the obligations deriving from the agreement;
5. Measuring building performance & maintenance via the blockchain.
The key for using blockchain technology in real estate management is creating a digital representation of a property in the blockchain as revealed by this study. The property can be represented by a smart token which consists of or is linked to four different fields of information which are general information, commercial information, technical information and financial information. The biggest added value of the use of blockchain is that all stakeholders can rely on the same data, and they do not have to check the data over and over again. Another great added value of using this token system is that this will streamline real estate transactions and due diligence becomes more efficient, since in the current situation often important documents of a property are lacking or missing. Blockchain based transaction may potentially save time and therefore money. On the long term also the influence of the notary will be questionable. This will reduce the transaction costs.

Also in the operational phase of the property blockchain can add value compared to the current system. Within commercial management the process of creating and signing lease agreements will be much more efficient via the earlier mentioned smart contracts. All these contracts and the monitoring of the obligations deriving from the contract will become automatic.

During technical management the biggest added value of blockchain is having all the technical information, invoices, warrantee certificates, etc. up to date during the complete lifecycle of the property. In the current system this information is lacking, which results in time consuming and therefore costly preparation phases once the property needs to be transacted. By going even step further, with the rise of smart buildings, all the installations can be connected via the internet of things to the blockchain. If that is possible, maintenance will shift even further into performance maintenance and all the stakeholders can rely on the building performance information registered in the blockchain. Although these statements sound promising, there is no evidence these opportunities are feasible. Further research is needed to prove blockchain can really add value in these processes.

Another added value of the use of blockchain, the owner does not have to care about administrative procedures anymore and can trust on the data, since the blockchain maintains this administration automatically. Besides the time and cost savings, the owner can focus on improving their product and create new business models. This can add value to the client experience of buildings.

Blockchain can also make real estate markets more transparent. This adds value to the research departments of the broker firms who need to check all transaction data manual on quarterly basis. Transparent markets might also allow for new rating systems of companies based on the registered performances in the blockchain.

The combination of transparent markets, more efficient processes and reducing transaction costs could result in real estate markets becoming more liquid. This study did not address the validation & verification of the effect on liquidity. However, this could be an argument for further research. Furthermore, the added value of blockchain technology in the current real estate management is based on theory. Further research is essential to examine the impact of this technology for specific use cases.

The result of the study indicates that complete disruption of the current real estate management process with the use of blockchain technology is questionable. The real estate sector need to overcome a couple of challenges in order to implement blockchain properly.

In order to gain broad adoption, technical standards must be produced and agreed upon to assure compatibility across industries. All stakeholders need to cooperate on global scale in order to create a uniform framework both legal and technical for digital assets on the blockchain. This widespread adoption is essential for the positive network effect of blockchain to be truly harnessed. The major threats to achieve this critical mass are fragmentation of platforms and institutional and social inertia
to transition to a specific platform. As a starting point, the biggest industry stakeholders should collaborate on EU level. The European Union has created common standards to facilitate the exchange of information and data between the local, regional, national and European or international levels via their initiative INSPIRE. A certain platform is extremely suitable for further development of blockchain standardization.

Another challenge is a change in the current processes to support high quality data input. Considering a blockchain database is only as good as the data and the business processes that underlie it. Failure to reach a consensus among counterparties as to business processes or to resolve commercial conflicts could significantly hinder blockchain’s adoption. Especially for the Dutch environment this might be a challenge. All stakeholders have a positive attitude towards the current system. The change of current business processes might be an immense challenge. Every country has its own regulation and systems. It is practically impossible to change all the processes throughout the world into one uniform blockchain based system. Transacting real estate on the blockchain in the same way bitcoin is transacted, decentralized, on a global scale, seems infeasible.

Since the several processes within real estate management are complex and involve a variety of stakeholders, further development of blockchain solutions need to be explored on sub-parts of the real estate management process. More extensive research about these sub-processes is needed for creating better understanding of the impact of blockchain technology. Blockchain by itself will not achieve this proposition. Other data-driven innovations such as artificial intelligence and machine learning algorithms needed to be incorporated as well.

It is important to note that as blockchain is becoming more mature, they can gain purpose and deliver their promises to the greater public. The technology by itself is still in its early stages. It has proven itself for digital currencies, despite the potential for blockchain technology, there are not many proof of concepts built on the blockchain for other industries yet. In order for blockchain technology to become mature it is important that companies are keep working on creating proof of concepts for blockchain applications. Try and error seems to be the best method.

8.2 Recommendations for further research

This study is of explorative nature and focused solely on identifying possible opportunities and constraints for the implementation of blockchain technology, therefore there is much that cannot be explained by this study. Despite the extensive literature study and the various interviews, this study might have raised even more questions than it provided answers to. Nevertheless, this study provided a basis for further research.

Business process use cases
The study focused primarily on indicating different potential fields for blockchain solution to occur within the real estate management process. However, this research did not dive into the requirements and practical implementations of the solutions. Due to the complexity, each opportunity introduced can be a study by itself. Providing a comprehensive study into the development of a blockchain based building passport seems to be an interesting case for further research. Also, the process of actual transacting real estate peer-to-peer via a blockchain comes with a lot of boundaries and limitations. This could be an interesting problem field for further research as well.

Technical standards
It became clear that there is a need for technical standards in order to assure compatibility across different stakeholders and industries. In particular for real estate, this kind of standardization is
lacking. Stakeholders are all using their own systems and infrastructure. Studying this particular topic can contribute to create the technical and practical standards as desired among the stakeholders.

Juridical framework
Within this study, the juridical boundaries of the current system are not considered. As mentioned by one of the interviewees, one single version of the truth, one of the features of blockchain, does only work in a legal positive system. Currently the legal system in the Netherlands is more or less a hybrid form. Research into this topic and other legal issues concerning implementation will benefit further developments of blockchain based application and adds more body to the general knowledge about implementing this technology in real estate. In addition, creating blockchain based transactions allows for investors throughout the whole world to participate in acquiring real estate, this raises questions on (intern)national jurisdiction.

Enhancing innovation
Blockchain technology is an interesting technological innovation which enables exchange of value through the internet. Nevertheless, blockchain is just a ledger of transactions. This study addressed that several other innovations, such as machine learning algorithms, or artificial intelligence are needed to successfully create the proposed blockchain based environment. By diving into specific use cases, the enhancement of these kind of technologies should be researched as well.

Re-inventing business models
Although the philosophy of blockchain is disintermediation of trusted third parties, these parties may also use blockchain technology as an opportunity. As the adage is saying: If you cannot beat them, join them. Both practical and scientific research can be conduct to identify the impact of this technology on the different stakeholders. This could contribute to the general acceptance of blockchain.

Market liquidity
By transacting real estate via blockchain, the market becomes more transparent and the transaction become faster and less expensive. The study mentioned that an increase of transparency will allow regulators and rating agencies to get a better understanding of the risks affiliated with real estate. If more information about the risks of real estate is known, the risk aversion against real estate as an investment class may change. This may result into higher demands for real estate investments, especially when transaction real estate becomes much more easier and the market becomes more liquid. An increase of market liquidity, and a better understanding of the risk associated with real estate may result in higher demands for real estate investments. Due to the limited production of new assets this may results into a shortage of investment products with positively impacts the price movement.

Extending the real estate value chain
Besides opportunities within the real estate management process, there might be more interesting opportunities for blockchain technology in the real estate environment. For instance, the connection with circular economy. Studying opportunities for the use of blockchain technology in other aspects of real estate might be an interesting field of research.

International exploration
One of the interviewees showed some interesting insights in the differences between the governmental registration of property among several countries. Probably there are more differences for real estate management processes within countries. Since blockchain strives for creating a global systems without the dependency on local authorities, further research is needed in order to find out if all the processes can be aligned on a global scale.
8.3 Practical recommendations

Adoption of blockchain technology among the market parties in the Dutch real estate management process is lacking. This study gave insights in possibilities for the implementation of blockchain technology within this progress and pointed out some interesting use cases for market parties. Based on the study, several recommendations for practice are formulated.

Standardization of business processes

According to the study, the current real estate management process are complex and a lot of exceptions are applicable within this process. A blockchain represents a total shift away from the traditional ways of doing things. It places trust and authority in a decentralized network rather than in a powerful central institution. And for most, this loss of control can be deeply unsettling. Considering a blockchain database is only as good as the data and the business processes that underlie it. Each stakeholder should be critical against their own business processes and see which aspect of those processes can be standardized. Standardization of business processes is needed to develop a blockchain based environment.

Governmental embracement

The coordination of blockchain innovation by the government is still lacking behind. The results showed that the way how government regulation unfolds could be one of the most significant factors and risks in whether the blockchain industry will flourish into a mature industry. The guidelines must be set by the government to change the system. This is not only the task of the government, market players and other actors have to set aside their personal interests and should support the developments of regulation and coordination based on shared values.

Collaboration

In order to gain broad adoption, technical standards must be produced and agreed upon to assure compatibility across industries. Currently different projects are experimenting with blockchain in real estate, however, all on their own network according to their own rules. The situation might occur that all stakeholders developed their own blockchain environment without the possibility to communicate with other systems. This is in contrast with the philosophy of blockchain. All stakeholders need to cooperate on global scale in order to create a uniform framework for digital assets on the blockchain.

8.4 Reflecting on the results

This last section reflects upon the gathered research results and the view of the author on the possible implementations.

The final results as presented in the thesis provided an extensive answer on the main research question. It can be argued that the results may lack in-depth clarification for how these opportunities can actually be integrated in the real estate management process. From my perspective, it was clear from the beginning of this research that the findings should indicate several opportunities, which is done by this study. The next step is diving into the different opportunities to identify what needs to be done to fully integrated these opportunities. This allows for more in-depth knowledge about a particular topic.

The research indicated five opportunities for the implementation of blockchain into the real estate management process. I strongly believe that blockchain will change current process and introduces new business models. Nevertheless, blockchain by itself is not a goal, it is a means. Currently blockchain is way overhyped. A lot of companies are trying to look for opportunities to implement blockchain in their business models. This is a positive development, since companies are rethinking
their strategy. However, it may result in blockchain not needed for their purposes, hence other innovations are better suitable.

Further research is needed to prove if the proposed outcomes are indeed visible and of added value for the current process. The outcomes mostly rely on findings from a limited number of stakeholders interviewed. Due to the variety of stakeholders and the timeframe of the thesis, it is not possible to interview multiple stakeholders within each category. I strongly recommend that fellow students are enhancing this topic and dive deeper into this interesting subject. More evidence is needed to validate the proposed opportunities.
RESEARCH LIMITATIONS

Blockchain technology is a relatively new innovation with a limited amount of scientific research in the field of blockchain in real estate. The aim of this study therefore was providing a scientific starting point for further research based. An explorative approach was chosen in order to come up with a first theory. Conducting explorative research comes with some research limitations, those are discussed in this section. The limitations are a result of the wide scope chosen and the limited amount of research conducted in the field of blockchain technology.

Blockchain hype
Blockchain technology is on the top of the hype cycle, and is currently being overhyped. Although all the attention for this technology is positive, it is rather difficult to distinct facts from fiction. There is a large variety of papers and publications which are all describing the possibilities for this technology. Nevertheless, most of them seemed biased, and are not grounded with solid scientific arguments. Gathering relevant scientific data on this topic was therefore difficult.

Research depth
The scope of this research was limited to real estate management in the Netherlands and the theoretical concept of blockchain technology. Nevertheless, this was a very broad scope and therefore this study has limited depth. Although the opportunities for blockchain can be pointed out by this study, addressing complete blockchain based solutions is way too complex for a broad theoretical framework and a limited number of interviews.

Practical use cases
Blockchain technology has not proven itself yet in the real estate market. Although some pilot projects emerging, the results did not prove the full potential of blockchain. This increases the difficulty in gathering data, hence it forces this study to come up with a lot of assumptions. It becomes clear that further research is needed in order to support the arguments addressed in this study properly.

Governmental regulation & Legal issues
Although governmental regulation and legal issues concerning blockchain seems vital for this technology to really flourish, these aspects have not been assed in this research. Governmental regulation and legal issues have had added a complete new dimension to this study. In addition, governmental regulation & legal issues concerning blockchain is one of the biggest questions add this moment. Due to the limited experience of the author with these topics, it is not feasible to incorporate them.

Process inefficiencies
This study projected blockchain technology on the current real estate management process to indicate possibilities. The technology was the driver for this study, not the process. Therefore the question, is there really a need for a change in current processes, as addressed by one of the interviewees, was not taken into account. In addition, blockchain is not the answer to all the questions, other technologies might be better suitable within the process, this study did not provide any alternatives.
REFERENCES


Part VI

APPENDICES
PART VI – APPENDICES

Appendix I – Protocol for semi-structured interviews

Interview length: 45-60 minutes

Preparation
\begin{itemize}
\item Print contact summary sheet
\item Print copies for questions (interviewer and interviewee)
\item Pen and paper
\item Recording device
\end{itemize}

Contact summary sheet

Name of interviewee: 					Date:
Age:					Time:
Company:
Telephone no.:
E-mail address:
Job title:
Name of interviewer:

Introduction to the interviewee

I would first like to thank you for your time to help me with this research. This study explores in which phases of the real estate management process the process can be optimized by the use of blockchain technology. Because of your experience in the real estate management process we would appreciate your participation. With this research I try to answer the following main research question:

“What are the different opportunities and constraints for the implementation of blockchain technology in the real estate management process?”

The set-up of this interview consists of two main concepts. The real estate management process and blockchain technology. Each concept will be covered separately as you will see in the interview. We will have an open conversation and care about your opinion on these topics. I would like to emphasize that there are no right or wrong answers to the questions. Therefore feel free to answer them in any way you like and bring up additional information whenever you feel like it’s needed.

The interview starts with a couple of introducing questions. As the interview continues there might be questions that require a moment to think. Therefore I shall not rush through them but give you enough time to answer as honest as possible.

The information obtained from you will only be used for the purpose of this research. All answers you provide will be kept in strict confidentiality.

After this introduction I will start with the interview. Are there any questions before we start?

Introductions to topics and questions

The real estate sector is typically a sector which is plagued by middle men, and has got a lot of different stakeholders involved. It is often said that the real estate sector is a slow moving sector with a lack of innovation. Currently the financial markets are reconsidering their business processes and business models since the rise of Blockchain technology. It was in 2008 when this technology became famous for the first time due to the Bitcoin protocol. From 2008 this development is exaggerating and the
possibilities of this new technology seems endless. A lot of experts are saying that this new technology can change the whole fundamentals of a complete sector.

Also in the field of real estate companies are starting to search opportunities for development of blockchain applications. This new era is still in the very early stage. Nevertheless, this research aims to analyze the current real estate management process and point out opportunities for restructuring the real estate management process by the use of blockchain technology.

This interview is called a semi-structured interview. This allows you to answer briefly on each question and to elaborate on the giving answers. Feel free to answer whatever you think is relevant.

Do you have any questions or do you need further elaborations?

Ok, then we will start the interview.

Real Estate Management Process
Question 1: What is the role of your company in the real estate management process?
Question 2: What kind of services does your company offer within this process?
Question 3: Who are the stakeholders needed to realize the services?
Question 4: How are the processes to realize those services structured and organized?
Question 5: What kind of information and assets needs to be stored, monitored and transferred, and which technologies are used to do so?

Blockchain Technology
Question 6: Do you know blockchain technology? What do you think of blockchain technology as an improvement for your processes? (If no on the first question, explain technology and continue.)

*show flowchart of new process*
Question 7: What do you think of the suggested new process via blockchain technology?
Question 8: Which stakeholders do we need to create this blockchain based process?
Question 9: From your perspective, what are the biggest hurdles to overcome?
Question 10: Do you see other opportunities that might benefit from blockchain technology?

Closure
Once again thank you for taking part in the interview. We have covered a great amount of data, however, do you think that there is anything we might missed? Or do you have any comments about the interview as a whole? Do you wish to receive a transcript of the whole interview? I am willing to provide you with a summary of the research findings and, should you wish, we can also send you a copy of the final report of our research. Thank you once again for your participation.
Confidential

For the full version of the Appendix, please contact the author.