DEGREE PROJECT
REAL ESTATE AND CONSTRUCTION MANAGEMENT
BUILDING AND REAL ESTATE ECONOMICS
MASTER OF SCIENCE, 30 CREDITS, SECOND LEVEL
STOCKHOLM, SWEDEN 2017

BLOCKCHAIN

A NEW TECHNOLOGY THAT WILL TRANSFORM THE REAL ESTATE MARKET

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MASTER OF SCIENCE THESIS

Title:	Blockchain – A new technology that will transform the real estate market
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Department:	Real Estate & Construction Management
Master Thesis Number:	TRITA-FOB-ByF-MASTER-2017:10
Archive Number:	468
Supervisor:	Sviatlana Engerstam
Keywords:	Blockchain, Real Estate, Inefficient Market, Implementation.

ABSTRACT

The overall market is in front of a new technological change, where blockchain is the most probable technology that will be implemented. There are several markets that need a technology that bring more efficiency, safety and transparency into the market, for instance the real estate market. The real estate market is highly important to the overall economy due to its size and devastating consequences if it collapses. A real estate crisis often affect and creates financial crises which in turn could lead to economic meltdowns both on a micro- but also on a macrolevel. There are inefficiencies within the real estate market that might cause the crises, such as problems with transparency and illiquidity, high transaction costs, personal biases and slow transaction processes.

This master thesis examines the potential of an implementation of blockchain technology on the real estate market and how it might affect the inefficiencies within the market. Blockchain is a new and emerging information technology with several markets and areas suitable for an implementation. Earlier researches on the topic are generally focusing on the technology itself or its implication impacts in the financial sector. This master thesis aims to examine the implications to implement blockchain technology on the real estate market and how an implementation would impact the market.

To be able to answer the research questions formulated in the thesis, an extensive literature study has been conducted, and additionally, semi-structured interviews as well as a questionnaire have been performed. The research is primarily contributing with an improved knowledge about blockchain technology and its potentials and challenges on the real estate market. One conclusion from the study is that the technology is most likely capable in changing the real estate market fundamentally, which is why the topic needs to be investigated deeper and to develop the technology further for a successful implementation.

ACKNOWLEDGEMENTS

This thesis has been written as the final thesis of the Master's program in Real Estate & Construction Management with specialization in Real Estate Economics at the Royal Institute of Technology in Stockholm, Sweden.

Without the support, patience and guidance of our supervisor Sviatlana Engerstam, this thesis would not have been possible. The dedication and thoughtfulness of Sviatlana is extraordinary, so thank you!

We would like to give many thanks to all the interviewees for agreeing to participate in the interviews and give their opinions about the subject and share their knowledge with us. Without these people, it would not have been possible to do the thesis.

Thank you all who participated in the questionnaire conducted, it truly helped us to get a better understanding of the thought of the general public.

We would also like to thank our parents, siblings and friends for supporting us during the project. Without your love and support, it would be much tougher to keep the focus on the important things in life and the importance of finishing the master thesis on time and receive the diploma.

Denis would also like to give many thanks to the co-writer of this thesis, Ulrika Lindh. Your personality, your dedication and your cooperation skills has truly made this project fun to do and I have been blessed with having you as the co-writer of this thesis.

Likewise, Ulrika is thanking Denis for his wide knowledge and discussion capacity, which have helped us to progress effectively and work with different approaches. I could not have found a better co-worker for my master thesis.

Denis Corluka & Ulrika Lindh

Stockholm 16 May 2017

Examensarbete - Masternivå

Titel:	Blockchain – En ny teknologi som kommer förändra fastighetsmarknaden
Författare:	Denis Corluka
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Institution:	Real Estate & Construction Management
Examensarbete Master nivå:	TRITA-FOB-ByF-MASTER-2017:10
Arkiv nummer:	468
Handledare:	Sviatlana Engerstam
Nyckelord:	Blockchain, Real Estate, Inefficient Market, Implementation.

SAMMANFATTNING

Dagens marknad står inför en ny teknologisk förändring, där blockchain är den mest sannolika teknologin som kommer implementeras. Det finns flera marknader som behöver en teknik som tillför mer effektivitet, säkerhet och transparens till marknaden, en av dessa marknader är fastighetsmarknaden.

Fastighetsmarknaden är mycket viktig för den totala ekonomin på grund av dess storlek och förödande konsekvenser om den kollapsar. En fastighetskris påverkar ofta och skapar i många fall finansiella kriser som i sin tur kan leda till svåra ekonomiska konsekvenser, både på en mikro- men även på en makronivå. Det finns ineffektivitet på fastighetsmarknaden som kan orsaka kriserna, till exempel problem med transparens, marknaden är inte likvid, höga transaktionskostnader, personliga ”biases” och långsamma transaktionsprocesser.

Detta examensarbete undersöker möjligheterna av en implementering av blockkedjeteknik på fastighetsmarknaden, de medförda utmaningarna och hur det kan påverka ineffektiviteten inom marknaden. Blockchain är en ny och framväxande informationsteknik med flera marknader och områden som är lämpliga för en implementering. Tidigare undersökningar om detta ämne fokuserar främst på själva tekniken eller dess konsekvenser i finanssektorn. Detta examensarbete syftar till att undersöka konsekvenserna för att implementera blockchain-teknik på fastighetsmarknaden och hur en implementering skulle påverka marknaden.

För att kunna svara på de forskningsfrågor som formulerats i uppsatsen har en omfattande litteraturstudie, semi-strukturerade intervjuer samt en enkätundersökning genomförts. Forskningen bidrar främst till förbättrad kunskap om blockchain-teknik och dess potential och utmaningar på fastighetsmarknaden. En slutsats från studien är att tekniken sannolikt är kapabel att förändra fastighetsmarknaden fundamentalt. Ämnet måste dock undersökas djupare och tekniken måste vidareutvecklas för en framgångsrik implementering.

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1 INTRODUCTION

This chapter describes the background in brief and gives the reader an overview of the problem and a better understanding of what blockchain technology is and why it is needed. It also describes the purpose and aim of the thesis and delimitations of it.

1.1 Background

The overall market is in front of a new technological change, where several markets need a technology that can speed up the different processes and bring more safety and transparency into the market (Tapscott, 2016). One of these markets is the real estate market and this market is highly important for the overall well-being of a country. Zhao and Michales (2006) argues that a real estate crisis often affect and creates financial crises which in turn could lead to economic meltdowns both on a micro- but also on a macro level. The real estate crises are in many cases linked to inefficiencies within the market, inefficiencies such as illiquid market, not transparent enough, high transaction costs, personal biases and slow transaction processes (Shiller, 2005).

It takes on average 114 days from the time the property is listed to the day the official transfer-day occurs for small houses in Sweden (Flink, 2017). This process is time-consuming and inefficient. Crowston and Wigand (2010) argue that a real estate transaction usually occurs in five steps; listing, searching, evaluating, negotiation and execution, which in turn includes approximately 33 steps according to Lantmäteriet et al. (2016) (see figure 1).

Figure 1: The transaction process today involving approximately 33 steps.

According to Shimizu et al. (2016) the usual transaction process starts with the property owner deciding to sell and in most cases contacts a real estate broker. The broker values the property and decides with the seller an optimal asking price (reservation price). The reservation price is in most cases not modified, but in a situation where the houses are unsold and still on the market, the price can be modified (Mcgreal et al., 2009). When the reservation price is set, then the broker starts marketing the property and search for a potential buyer. When a potential buyer is found, evaluation and negotiation are initiated. If the buyer and the seller agree upon a price, they usually write a contract and a transaction occurs. The broker reports the transaction price to a specific realtor database and the buyer usually needs to report the transaction price to a government-agency.

Lantmäteriet et al. (2016) argues that the system is slow due to several reasons; the major one is due to the repeated process of validating information. Many of the documents are signed on paper and need to be send through the postal service. The validation of the documents needs to be done through manual processes. Due to the amount of signed papers, mistakes occur and needs to be corrected. All these combined, makes the process slow and inefficient. Due to the time-consuming process, higher transaction costs occur.

With blockchain technology, many of these inefficient activities could be reduced or excluded from the process (see figure 2).

Figure 2: The transaction processes based on blockchain technology.

Lantmäteriet et al. (2016) argues further that blockchain technology is a much more secure technology to use compare with todays. In this new technology fraud and lost documents cannot occur or are minimized and the whole transaction process could be significantly reduced.

Blockchain is a new and emerging technology on the market. It is an information technology with multiple classes of application i.e. any form of asset registry, exchange or inventory (Swan, 2015). Blockchain is a decentralized transaction technology first developed for Bitcoin cryptocurrency (Yli-Huumo et al., 2016), but every area of economics, finance and money could be included in the technology. The technology uses ledgers (a distributed database architecture) to register any kind of information (Pinna and Ruttenberg, 2016) and has the potential to shorten the transaction time in any kind of transaction and make systems more transparent and reliable.

Saint-Paul (2008) states that the outcome of implementing new technologies, such as blockchain technology, is not always clear and could affect far more areas than imagined. The real estate market is highly important for the overall economy and should not be exposed to unnecessary risk when trying to implement new technologies. It is highly regulated as well and new technologies should not interfere with current regulations.

1.2 Purpose

Given the background above, many problems could be identified. There are transparency problems, problems with slow and inefficient systems, high transaction costs and implementation problems. The aim of this thesis is to examine the implications of implementation of the blockchain technology within the real estate sector and its possible consequences. The research questions below are formulated to provide an overview of the impact of blockchain in the real estate market and its challenges and/or potential it has according to leading experts within the market.

Research sub-questions:

- What implications exists to implement blockchain into the real estate sector?
- How will blockchain affect the transparency on the real estate market?
- Can the market become more efficient by blockchain technology?
- Should the market implement blockchain technology?

1.3 Method in brief

To gather information for this thesis, a literature study, interviews and a questionnaire have been performed. The literature study contains information about blockchain, the history of it, what it is and how it works. It also contains information about the real estate market and different aspects of it. The literature study aims to gather information about blockchain and the real estate market. This is necessary knowledge for the reader and the authors of this thesis in order to better understand the underlying theories of the subject.

The interview study is the result of the six interviews, were the participants are all related to blockchain or the real estate market. The interview study aims to gather more insight and broader knowledge about the possibilities and challenges of blockchain on the real estate market. The questionnaire is the result of answers from 23 participants where the aim is to get a broader picture about how house owners in Sweden think about digitalisation and different actors within the real estate market. Read more about the methods chosen in the method chapter.

1.4 Limitations

The focus of this thesis is to get a broad picture of the possibilities and challenges for blockchain on the real estate market in Sweden. Regulatory and legal perspectives are not examined, but they are as important as any and should be examined.

Since blockchain is an emerging technology, there are not many peer-reviewed research papers on the subject. Research papers from well-known journals are used at first hand, but white-papers, reports, well known blogs and newspapers are necessary to use as well to get all the information needed. The information received by these sources can have some amount of bias and vested interests. To minimize the bias, only reliable and well-known sources are used when information could not be received by peer-reviewed research papers.

Due to the limited time of the thesis, six interviews are being conducted and a questionnaire with lower degree of participants.

There are plenty of markets suitable for an implementation of blockchain technology. However, the focus in this thesis is only on the real estate market in Sweden and especially toward small houses.

1.5 Explanation of technical terms

Bitcoin: Bitcoin is a digital currency that runs on blockchain technology.

Blockchain: Blockchain is a distributed database operating (in most cases) on a peer-to-peer network (P2P). Blockchain maintains a continuously growing list of records (transfers) and is secured from revision and tampering.

Consensus Protocol: A consensus protocol in computer science is when a distributed network has a general agreement among its peers.

Cryptography: Is the practice of securing information between two parties when a third party is present, a so-called adversary.

Data mining: Data mining, or mining, is the process where a computer discovers patterns in large data sets. The goal with the process of data mining is to extract information from a large data set and transform it to understandable structure.

Decentralized: A process of distributing data, information, power etc. across a network and away from an authority or from a central location.

Hash function: A hash function is any function that maps data from arbitrary length to data of fixed length. The value generated from a hash function are called hash number or hash value.

Ledger: A computer File or principle book that records economic transfers.

Peer-to-Peer Network: A Peer-to-Peer Network (P2P) is a distributed network where the partitions tasks are distributed across the network.

1.6 Disposition of thesis

Chapter 1 – Introduction

The first chapter in the thesis starts with an introduction to the subject and the problems within it. This is followed by the purpose of the thesis, the research questions, a brief summary of the methods chosen and ending with the limitations of the thesis.

Chapter 2 – Methods

The second chapter explains the chosen methods, the theory behind why they were chosen and how they are used. The chapter starts by explaining the purpose of the literature study, followed by an explanation of the interviews and the interviewees. This is followed by an explanation of the questionnaire conducted and the chosen participants, followed by a description about how data is analysed and ending with the validity and reliability of the thesis.

Chapter 3 – Theory

The theory chapter begins with an introduction to blockchain technology, the history of it and a more technical overview of the technology. This is followed by a sub-chapter about the real

estate market, where different inefficiencies, the transaction theory and process and smart contracts are being explained. The chapter ends by an explanation about strategic innovation and the cycle of technologies.

Chapter 4 – Results

The result chapter will give the readers all results from the interviews and from the questionnaire. The chapter ends with a summary of all results gained.

Chapter 5 – Discussion

The fifth chapter discusses and analyses the result of the thesis, combined with the literature study conducted. The chapter begins with discussing digitalization, followed by a discussion about transparency. The chapter ends by discussing efficiency within the real estate market, how it could be improved with blockchain technologies and the challenges with a successful implementation.

Chapter 6 – The authors vision of blockchain

This chapter gives the authors vision of a use of blockchain technology within the real estate market.

Chapter 7 – Conclusion and further research

The conclusion chapter gives a summary of the thesis and the results and conclusions are presented. The chapter ends with suggestions about further research.

2 METHODS

In this chapter, an overview of the chosen methods will be given. The chapter begins with a short presentation about the research strategy, followed by an explanation about the chosen methods and the reliability of the thesis.

Saunders et al. (2009) states that an inductive research approach is used when theories are developed from the explored data and subsequently related to the literature study. The inductive research approach is a good approach to use when the subject is new and little literature has been written on the subject. They further argue that no predetermined theories or conceptual frameworks are needed. An inductive research approach has been applied in this thesis since the subject is new and there is not much research regarding it. The parts of the theory are developed from empirical data observed from actors and experts on the real estate market. Bogdan and Biklen (2006) argue that triangulation facilitates validation of data through cross verification from two sources or more. In this thesis, the triangulation is based upon a literature study and qualitative- and quantitative approaches. A qualitative method is preferred in this type of research, due to the limited amount of earlier research and available data. Qualitative data collected by semi-structured interviews is a useful way of triangulating data collected quantitatively, such as surveys (Saunders et al., 2009).

A questionnaire for house owners was performed. This in a combination with a literature review and the interviews, have shaped the foundation for this thesis to be able to, in an explorative way, investigate and present the implications of implementations of blockchain technology in real estate.

2.1 Literature Study

Secondary data in form of an extensive literature review are being collected during the whole master thesis process. The literature study is a complement to the collection of primary data described above and is gathering existing research related to the field of study (Saunders et al, 2009). It is mainly focused on blockchain, the real estate market, implementations of innovations and finance to create a foundation for the following research to build upon. Since blockchain is a relatively new phenomenon, not many peer-reviewed research papers have been written. This is one limitation and that is why interviews and a questionnaire are being conducted. The literature study, interviews and the questionnaire have together created the foundation for further analysis.

2.2 Interviews

As mentioned in the previous section, a qualitative approach has been used for in-depth interviews. A qualitative method is suitable to use when there does not exist much information about the subject and/or if the purpose of the research is to investigate the future opportunities within the subject (Robson, 2002). Data collection has been gathered through interviews with different actors within the fields of banking, real estate and IT. The interview questions have been semi-structured with low degree of structure. Patel and Davidson (2011) argue that a lower degree of standardised question gives room for a more adjustable interview process. The lower degree of structured questions, gives more space to the respondents for their own ideas and thoughts (Stukát, 2011).

Alvehus (2013) argue that an important way of deepening the knowledge about a subject is to gather information about the participants' attitude towards the subject. Saunders et al. (2009) argue that if several participants are interviewed and have similar answers or opinions, then it is possible to generalise from these cases and come up with a possible finding. However, in this thesis, different actors are chosen with different professions and knowledge. Some know and work with blockchain while some do not know what blockchain is or the potential of it. The argument why these participants are chosen is that this thesis aims to get a wide perspective about the subject from different areas of application.

Six participants are chosen and interviewed:

- Lantmäteriet, the Swedish Cadastral Authority, maps Sweden, demarcate boundaries and maintains and guarantees secure ownership of Sweden's real property. They are actively working with blockchain and are in cooperation with other companies currently exploring the opportunities with the technology. Mats Snäll, the Land Registry Development and Digital Director is one of the interview participants. Mats Snäll is chosen since he leads the pilot project for implementation of blockchain at Lantmäteriet and thus one area of the real estate market.
- Deloitte is a multinational revision and consultancy company. They are one of the "big four", together with PwC, EY and KPMG. Deloitte are currently working actively with developing blockchain platforms in Ireland. Ester Sundström, the Senior Manager at Deloitte is another participant. She has great knowledge about digitalization, the financial market and IT-related question.
- Swedbank is a bank that operates in the Nordic and Baltic countries. Swedbank has the most number of customers in Sweden compared to other Swedish banks. They are not actively working with blockchain technologies and do not support any such projects. To get a broad picture about the challenges with the overall real estate market in Sweden, two leading employees at Swedbank agreed to be interviewed. Göran Råckle, the Head of Real Estate Analysis and Sören Jonsson, a Real Estate Analyst specialised toward cash-flow analysis.
- Stronghold develops, owns and invests in real estate services and companies. They focus on digitalization and modern technology. Stronghold are however not working with blockchain technology at this time. Daniel Kraft, the Head of Investment Realtech at Stronghold is one interview participant. Daniel Kraft has great knowledge about investing in new technologies and about the real estate market from an appraisal point of view.
- Hans Lind is a professor at KTH (Royal institute of technology in Stockholm, Sweden). He is a professor in Real Estate Economics and Dr. in National Economics. He has great knowledge about the social aspects about economy and his arguments are usually based upon research.
- Rickard Engström is currently a Ph.D. and lecturer at KTH, specialized towards real estate agent studies. He has worked 13 years as a real estate agent. Rickard Engström has great knowledge about how the real estate market works from a broker point of view and what house buyers usually want and need.

Trost (2010) divides the interview process into three steps. The first step is to collect data from the participants. The second step is to analyse the data received and the third step is to interpret the data through the theoretical background. These steps have been followed in this thesis and the interviews were held in Swedish and were audio-recorded. Due to the different knowledge of the participants, different questions have been asked (see appendix B for the interview questions). The questions are based on the theoretical framework and how blockchain might affect specific markets within real estate. All interviews were held face-to-face except of the interview with Hans Lind where Skype was used.

2.3 Questionnaire

A questionnaire is frequently used in exploratory research and is selected as a strategy in this thesis since it allows the gathering of a large amount of data from a substantial amount of actors in an economical way (Saunders et al., 2009). The questionnaire collected quantitative data from the actors within the sector, which further on is analysed quantitatively by statistics. This is done to get a better understanding of the real estate market.

To get a better understanding of how house owners think about digitalization and different actors within the Swedish real estate market, a questionnaire has been sent out (see appendix C). Andersson (2016) argues that there are advantages with the usage of questionnaires. She points out that the questionnaires are less time-consuming compared with interviews, they are relatively cheap and the data collected is easy to process. Byström and Byström (2011) points out some disadvantages with using questionnaires compared to interviews. They argue that there cannot be a follow-up on how the respondents perceived the questions due to anonymity and the questions are standardised and cannot be personally fitted.

The questionnaire was designed and administrated using a web based platform called Survey Monkey. To be able to reach out to a broader audience in a fast way, web based platforms are a good tool to use. The questionnaire was produced using the different tools and design options provided by the platform. The participants of the questionnaire are people above 18 years old that have privately bought and own a house. The respondents are kept anonymous and they are divided into different age-groups and education. This is done to see if there are any correlation between age, education and the willingness to adapt to new technologies or whether the participants trust the different actors within the real estate market or not. Gender is not investigated since it is not relevant to the questions that are being asked.

The questionnaire participants are chosen using the snowball sampling technique where the questionnaire first was sent to close friends and family who have bought a house and then they are asked to send it further to their friends. Snowball sampling is used in sociology and statistical research and is a non-probability sampling technique (Goodman, 1961). One of the advantages with this kind of technique is that people of specific population (in this case house owners) can be located. One disadvantage is that the sampling population size is unknown. Another disadvantage is that there could exist community biases, where the first participants have strong impact on the results obtained since that first person chooses the first group of participants. One way of minimizing this bias is to choose multiple first persons, with different backgrounds, ages, education and geographical locations. Due to the unknown sampling population size, no valid respond-rate can be shown. This is however no issue for this thesis due to the purpose and goal of the questionnaire.

This questionnaire-study is a pilot-study, meaning that the results of the questionnaire are only used to get a wider perspective of the real estate market and the attitudes within it. The findings obtained by the interviews, connected to the literature study, are the main findings and the only purpose with the questionnaire is to increase the validity and reliability of the research.

2.4 Data Analysis

Data from the interviews have been analysed using the "general analytical procedure". This approach is not limited to a qualitative or quantitative collection methods, instead both could be used if needed. In this research paper, both qualitative- and quantitative research data have been analysed. General analytical procedure helps the researchers to analyse the data in a more systematic way. The researchers reduced the amount of data by only selecting relevant and interesting data from the interviews and chooses to analyse these further. A diagram have been created from the data, which allows conclusions to be drawn (Collins and Hussey, 2013).

2.5 Validity and reliability

To make sure that the research is not manipulated or fiddled with, two particular emphases are paid attention to in the research design, the validity and the reliability of the research (Saunders et al., 2009). This is a way of reducing the possibility of getting the answer wrong. Andersson (2016) argues that validity and reliability are the measures of how good a measurement or a measurement-tool is. Validity measures whether the concept, conclusion or measurement is corresponding to the real world (Brains, 2011). Reliability measures how consistent the measurement is, how reliable the measurement is and whether the measurement can be received by an independent measure (Andersson, 2016).

The master thesis is written under limited time and high time-pressure. Due to this, only limited time can be spent on literature review, the interviews and the questionnaire. The sampling of the interviews and surveys are being affected by this time-limit and restrictions are necessary to make. This could lead to somewhat misleading results. To increase the reliability of this thesis some actions are taken;

- The questionnaire is being conducted with clear and easy-to-answer questions where all the questions are being interpreted in the same way by all the participants.
- The participants of the questionnaire have different age, education and geographical location.
- One common thing all participant has is that they own a house, are over 18 years old and that the house is privately owned.
- The interviews are conducted with leading people, with plenty of experience and knowledge about the real estate and surrounding markets.
- The interview questions are semi-structured, meaning that the participant can express whatever he/she feels like expressing.
- Five of the six interviews were face-to-face, meaning the interviewer could observe the facial and body language of the participant.

Despite the actions taken, there are still some validity and reliability issues. The sample size of the questionnaire is small which could lead to misleading and not representative results to

some degree. As mentioned earlier, the results from the questionnaire are of a supporting character and the findings in the interviews are the main results setting the foundation for this thesis.

The participants in the interviews are not anonymous and this could result in vague answers to some degree and therefor decrease the reliability. The companies could have company-secrets and the individual participant could have hidden agendas behind the answers.

3 THEORY

This chapter will give the reader the knowledge needed to better understand blockchain technology, the inefficiencies within the real estate market that might get affected by an implementation of blockchain and the theory of innovation.

3.1 Blockchain

This sub-chapter will explain what blockchain is and the history of it.

The blockchain is a new system of decentralized trustless transactions of data that does not require a third party to perform the task of validating the transaction. One may consider blockchain to be a chronological database of transactions recorded by a network of computers, a so-called distributed ledger[1] (Peters & Efstathios, 2016). Blockchain is a decentralized peer-to-peer technology at its origin and can be seen as a ledger of facts. Decentralized means that data is not stored in only one network with a common processor, instead it is distributed across several networks of interconnected computers. The decentralized database uses blocks where records of information are stored and it is a continuously growing list of ordered records. The blocks are linked to previous blocks and each block contains a time-stamp (nonce) and a hash-number. The system is inherently resistant to modification of data due to the linking-system, time-stamp and hash-number in all the single blocks and the data in a blockchain can therefore not be easily altered. Members of the network are anonymous individuals called nodes. Some nodes, sometimes referred to as miners, participate in the process of adding new information, linking blocks to existing blockchains and securing the system by hashing the blocks. To add a new block into an already existing blockchain, the block needs to go through a consensus protocol. Different designs can be used for the consensus protocol depending on the purpose and goal of the block (Backlund, 2016). To protect the blockchain against unauthorised individuals, the technology relies on public key cryptography (Peters & Efstathios, 2016). The nodes that participates in the process of adding new information to the blockchain gets a reward, in most cases a reward in a cryptocurrency.

Blockchain technology can be used both as a public or private ledger. In a public ledger, cryptoeconomics[2] are used as consensus protocol while in a private ledger, no consensus protocol is generally needed. Blockchain was first introduced as the technology behind the bitcoin. Blockchain makes is possible to transfer bitcoins between users in a safe way (to see the transaction process of a Bitcoin (see appendix A). Blockchain technology is not only used for securing transactions, it is so much more. With services, such as Etherum which are built on blockchain technology, fully turning-complete smart-contracts can be used. Nasdaq has developed a service called Linq that is built upon blockchain technology (Backlund, 2016). Linq keeps formal records of shareholders within a private company. Both Bitcoin and Etherum uses public ledgers while Linq uses a private ledger.

[1] A distributed ledger is a consensus of replicated, shared and synchronized digital data. The data is spread geographically across multiple sites, countries or institutions (UK Government, 2016). There is no central data storage or central administrator.

[2] Cryptoeconomics refers to the combination of game theory, computer networks and cryptography to provide secure systems. Cryptoeconomics uses some set of economic incentives (Buterin, 2015).

3.1.1 History of payment systems and blockchain

In 1980s, David Chaum (1983) introduced for the first time in history the idea of digital payments and digital currencies. Some institutions attempted to use the idea of Chaum, and make a commercialized cryptocurrency, E-gold and E-money were introduced (Miró, 2016). Although all the efforts, the commercialization of cryptocurrencies failed for several reasons; the lack of centralized network structure, the lack of centric based networks and the lack of regulatory benchmark compliance (Frisby, 2014). A more secure, decentralized and transparent system was needed.

Blockchain was introduced for the first time in 2008 when bitcoin was introduced by Satoshi Nakamoto (Nakamoto, 2008). Nakamoto proposed fully digitalized currencies that run on a decentralised system which solved the double-spending problem[3] without using a trusted third party. Although the early introduction this millennium, not much happened with the technology but in recent years (especially 2015 and forward) blockchain became a hot topic. Like in the 1980s, a more secure, decentralized and transparent system is needed for the use of digital payments, contracts etc. Banks such as Goldmans Sachs, Barclays, JP Morgan, Royal Bank of Scotland, Credit Suisse and a couple of other banks have joined forces with a financial technology firm, R3, in 2015. The sole purpose is to create a framework for using the blockchain technology within the financial market (Crosby et al., 2015).

[3] The double-spending problem is a concern within digital currencies. There is a possibility for the user to spend the same money twice (Nakamoto 2008). The problem can be solved by using a trusted third-party, e.g. a central bank that controls the money-market. In a blockchain system, Nakamoto proposed a system where the double-spending problem for digital currencies were solved without using a trusted third-party. It is based on a trust-less network of peers where the peers processes transactions and updates a common ledger.

3.2 A technical overview of blockchain

This sub-chapter will provide the reader with knowledge needed to get a better understanding about blockchain and how it works. It will also explain cryptography and give a highly technical overview of blockchain.

3.2.1 Cryptography

Franco (2015) argues that the sole purpose of cryptography is to provide secure and confidential communication channels. If cryptography did not exist, intruders or adversaries could listen in and even control the communication channel. With cryptography one user can send information to another user without having someone unknown taking part of the information send. Cryptography is not just used to prevent intruders and adversaries from taking part of the information sent, it is also used to ensure that the information is not modified and that the information is sent from the right user (Delfs & Knebl, 2015).

Singh (2000) argues that classical cryptography, called symmetric cryptography, was used by Caesar to communicate with the other generals when they were at war. To prevent the enemies to get access to the information, Caeser used ciphertext to convert the message sent. The recipient of the message knew how to translate the message, but to the enemies the ciphertext appered like nonsense. Caesar used a cipher called substitution cipher, where letters were substituted by another letter. The receiver of the message needs to know how the substitution cipher works to be able to encrypt the message. Franco (2015) argues that there is a great disadvantage with symmetric encryption: key distribution. The sender and the receiver must interchange the keys before they can use the symmetric encryption system. To ensure no intruders are taking part of the information, a secure channel must be used when exchanging the key. Franco further argues that there many situations where a secure channel cannot be used, e.g. in e-commerce.

Kerckhoffs Principle says that it is fairly easy to make an encryption algorithm that cannot be broken by its creator, but someone in the world is smarter and will eventually break the encryption algorithm. Cryptographers recommend that only the encryption key is kept secret and the encryption algorithm is made public, this will make it harder for intruders and adversaries to access the information (Franco, 2015). Public key cryptography follows the principles of Keckhoffs and uses most often a public encryption algorithm and a private encryption key.

There are multiple cryptographic tools and bitcoin originally uses three of them (Franco, 2015):

- Public key cryptography is used to handle bitcoin transactions.
- Hash functions are used to secure the information in the blockchain.
- Symmetric key cryptography is used to protect the private keys in a user´s wallet.

3.2.2 Public key cryptography

Buchmann et al. (2013) argues that cryptography is highly needed in today's internet-world due to its highly security-sensitive services such as online banking and online trading. Internet is not a secure channel and to solve the key distribution problem that symmetric encryption faces, public key encryption was developed (Franco, 2015). Public key cryptography is probably the most needed cryptographic tool for securing sensitive services (Bachmann et al., 2013). The key distribution problem is avoided by using a pair of keys. In the analogy of a safe, a pair of keys are used where one key (the public key) only locks the safe while the other key (the private key) only unlocks the safe (Franco, 2015). The public key is perfectly safe to publish in public while the private key must be kept secret. The private key can only be used to decrypt a message while the public key can only be used to encrypt the message (Buchmann, 2013)

Bitcoin protocol uses digital signatures, a second application of public key cryptography. Digital signature is used to ensure that the signer generated the message and that the message was not tampered with. It is utterly important for the digital signature to be non-repudiable. Digital signatures are used as the private key, where e.g. a bank account number is a public key and to access the account digital signatures are used as the private key.

When a sender wants to send an encrypted message, a public key encrypt is used and published. Everyone in the channel can access the message but it is shown as a ciphertext and is impossible to interpret. Only the receiver with the right digital signature (the private key) can decrypt the message and read it (Segendorf, 2014). To see a visualization of the process, see figure 3.

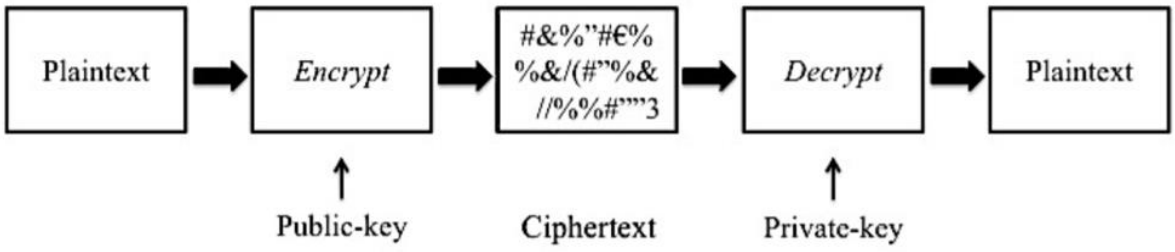


Figure 3: Encryption process (source: Lundström (2016)).

3.2.3 Hashing

Franco (2015) argues that the hash value is a bit-string of fixed length that is received through a hash function. The hash function uses an algorithm that takes data of arbitrary length as an input and outputs a hash value. He further argues that the hash function will always produce the same hash value for the same input data. The hash value is a random number, with a nonce in the block header for variability. If the data is changed, then the hash value is significantly changed as well. It is very hard and time-consuming to decrypt the data from the hash value. In the analogy of a meat grinder, it is impossible to revert from the hamburger to the original piece of meat. The cryptographic hash function work in the similar way as the meat grinder (Franco, 2015).

To perform consensus protocol, bitcoin uses cryptographic hash functions (Franco, 2015). The NSA (National Security Agency) designed a cryptographic hash function called SHA256, which

gives a 256-bit long output. SHA256 meets the preimage resistance requirement, meaning that is infeasible to recover the data from a given hash value. In practice, this means that given the hash value a brute-force algorithm cannot break the hash function without taking impractical amount of time. Bitcoin uses SHA256^2 cryptographic hash function to avoid length-extension attacks. SHA256^2 is the original SHA256 cryptographic hash function used twice (Franco, 2015).

Backlund (2016) argues that the hash value in a blockchain works as a unique identifier of the blocks data. Each block has a unique hash value and a unique time-stamp. A time-stamp confirms when in time the hash occurred. When linking blocks to each other, each single block uses its parent blocks unique hash value. All blocks that are linked together form a chain of links that goes back to the first block in the blockchain, often referred to as the genesis block. Due to the linking to the parent blocks hash, any change in the data stored in a specific block within the blockchain will change the hash and thus all descending blocks hash values. This means if data is changed within a block stored within a blockchain but the descending blocks are not recalculated, then the blockchain is considered invalid. For the blockchain to be valid, all descending blocks needs to get recalculated if any data is changed with a block.

3.2.3 Merkle Tree

Franco (2015) states that to verify any kind of data stored, handled and transferred in and between computers, Merkle trees are used. A Merkle tree is a binary tree data structure where each leaf node is a hash of a block of data. Each non-leaf node is a hash of its children. Figure 4 represents a four-leaf Merkel tree where the leafs nodes are concenated par-wise. The leafs are hashed using a cryptographic hash function, in bitcoin SHA256^2 is used. This is done through-out the whole tree and eventually only one node is left, the top hash (Franco, 2015).

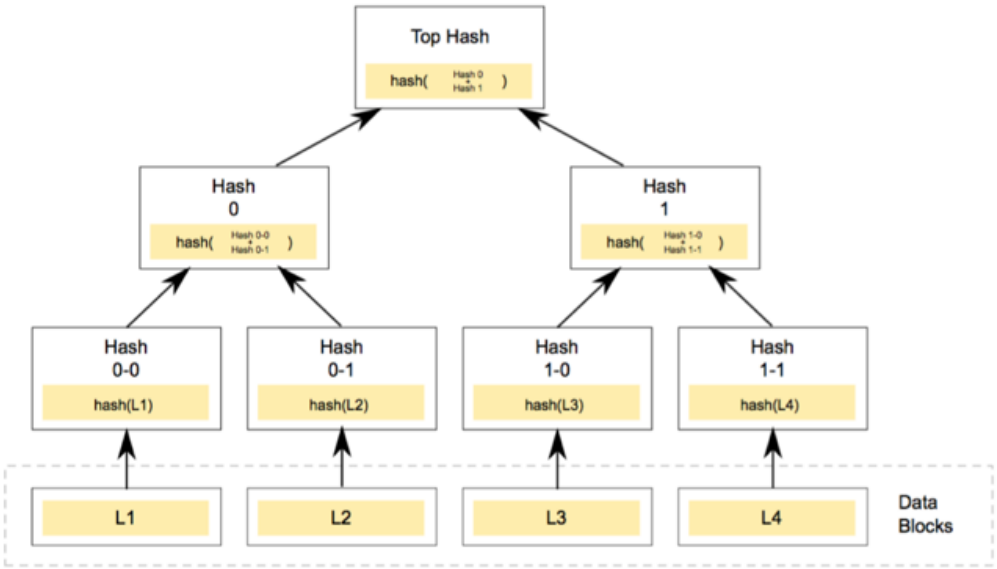


Figure 4: A Merkle tree with four blocks of data hashed into a top hash (source: Backlund (2016)).

The key function of Merkle trees in blockchain technology is to make sure that data received from other peers in a peer-to-peer network are unaltered and undamaged. At the top of the Merkle tree, there is a top hash that is directly concatenating with all the previous leaf nodes. This makes sure that peers cannot lie and use fake blocks or use false information. The top

hash has the ability to be used to determine in an efficient way if two data-sets are equal (Merkle, 1987).

3.2.4 Public and Private Ledgers

Buterin (2014) argues that there are three categories of blockchain-like database application. A *fully* open *public ledger* has no constraints on the reading- and writing permissions. Anyone connected to the network can get access to information and has the possibility to add information. Anyone connected has the right to participate in the consensus protocol, where cryptoeconomics (e.g. proof-of-work or proof-of-stake) are used to make sure that the added information is correct and does not contradict with previous blocks in the chain. The consensus protocol is forced to be based on cryptoeconomics due to the open nature of the system and because no trust can be assumed between nodes. It is a system that operates without the requirement of trust between users. Such a system is considered to be fully decentralised.

Instead of having a fully open uncontrollable network, a *private ledger* could be used. A private ledger has constraints on the reading- and writing permissions and is more tightly controlled. The right to modify, add or read information is restricted and kept centralised to one organisation. A consensus protocol is in most cases not needed due to its trusted nature. Private ledger blockchains have been a primary focus of interests from financial institutions in recent years. This is due to private ledgers ability to fast access information, makes transactions cheaper and to the possibility to control the level of privacy. There is a hybrid between public- and private ledgers, a *consortium ledger*. In the consortium ledger, the consensus protocol is usually predetermined and controlled by a couple of institutions (Buterin, 2014). A consortium ledger could e.g. have 20 institutions controlling one node, and every newly added block must be signed by at least 15 institutions to be considered valid. This type of system is considered to be partially decentralised. The reading permissions could be open to the public or it could be restricted to participants. There is a hybrid solution to this as well, where parts of the information are public and other parts are not.

Buterin (2014) further argues that there exist advantages and disadvantaged with the different kind of ledgers, depending on the circumstances. A public ledger is a trustless system and requires no trust from among the users and it is not controlled by a single entity. This reduces the risk of misuse by the controlling part. The ledger cannot be single-handedly controlled and thus, there is no efficient way to alter balances, revert transactions or change the rules of the system. This is a crucial aspect for cryptocurrencies. However, many institutions today cannot have systems where users can change information. In the case of e.g. national land registries, it is utterly crucial to keep writing permissions central to the government, and the system private. This kind of system avoids the 51%-attack-problem where one user with plenty of computing power could change the register and quickly make it unrecognizable for the government itself. In a private ledger it is easy to change information and transitions are usually cheaper to make due to fewer nodes of conformation. The private ledger could also provide a great level of privacy due to its ability to restrict reading- and writing abilities3.2.5 Peer-to-peer network

The peer-to-peer (P2P) network is a computational system consisting of peers (also referred to as nodes) connected to each other. The network is powered by the computing power of each peer and the Internet typically connects them. Shen et al. (2010) argues that a

decentralized network architecture could be called a P2P network if the peers share their computing power within the network. The peers are connected through links in the network and together perform mutual tasks. Aberer (2011) argue that due to the decentralized nature of P2P networks, no peer has any special authority and all peers are equivalent. A P2P network is in most cases used to share and provide access to resources such as media, documents or data.

Pacitti et al. (2011) argues that in a P2P network, each peer is both a client and a server at the same time. In a more traditional network, each peer is either the client or a server (see figure 5).

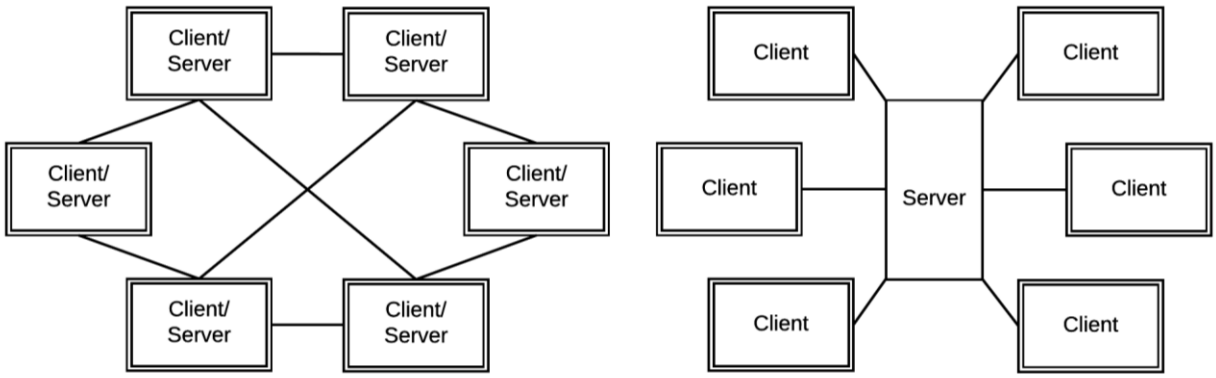


Figure 5: A peer-to-peer network is illustrated to the left and a client server network to the right (inspired by Lundström (2016)).

The advantage of using a P2P network over the traditional client-server network is that P2P is cheaper to build and maintain and no full-time system administrator is needed (every peer in the network acts like a system administrator).

3.2.5 Consensus Protocol

A major difficulty with blockchain technology with public ledgers is to ensure that the consensus protocol is reached by the entire peer-to-peer network participants (Kraft, 2016). A consensus protocol is used to make sure that the participants in the network follow the networks rules and to make sure the transactions are validated in the right order. It is also used to make sure that the information within a block is correct, that the nodes (miners) get a fair compensation, to avoid issues like the double-spending problem. Probably the most used consensus protocol is the proof-of-work protocol which is used by the Bitcoin network. There are other options as well, such as proof-of-stake, which is used by another cryptocurrency called BlackCoin. All consensus protocols cannot ensure to maintain the right order of transactions within the blockchain network. They are threatened by arbitrary concurrent failure (a type of Byzantine fault) of multiple network nodes. To reduce this problem a Practical Byzantine Fault Tolerance (PBFT) consensus protocol can be used.

3.2.5.1 Proof-of-Work

Backlund (2016) argues that one way of ensuring authenticity is to let each user within the network get one vote and let all users vote which transaction should be included in the next block. The number of votes decides which set of transactions should be included. This kind of consensus-process is vulnerable to Sybil attacks, where one user could create multiple

accounts and get a higher influence within the network. Nakamoto, the creator of Bitcoin, solved this issue of influence by adding a cost to the vote. Each users amount of influence is based on the computing power of that user. The more computing power, the higher energy- and hardware costs. This is the concept of proof-of-work consensus protocol.

In the case of bitcoins (which uses a proof-of-work consensus protocol) the network collects all the transactions made during a set period into a block. The nodes task is to confirm those transactions and write them into a blockchain. They hash the information as well, to protect it from intruders. The nodes get economic incentives to keep mining and hashing, the more blocks created, the more bitcoins received. Carlsson and Huang (2016) argues that when a node creates a block, it gets distributed to neighbouring nodes. The neighbouring nodes independently verify that the information is correct within the block and that the rules have been followed. In a bitcoin network, it is recommended to wait at least six blocks to make sure that the transaction is final.

Nodes compete against each other to be the first one to produce a block and a couple of nodes could be working on the same transaction simultaneously, a blockchain fork is than created. The block that is created first, with the longest blockchain behind it wins and that node gets rewarded. The node is required to have plenty of hardware-power and brute force its way to "victory". This competition is hardware and energy intensive. The bitcoin-networks constant power draw is just under 215 MW of energy and one transaction equal to approximately 1.57 American household's daily consumption of energy (Malmo, 2015). Despite the high energy costs, proof-of-work has been empirically proven to be both safe and robust (Backlund, 2016). Buterin (2014) argues that there are some downturns with a proof-of-work consensus protocol, e.g. the risk of a 51% attack and there are high energy costs of producing one block. Courtious (2014) further argue that the proof-of-work protocol is leaning towards self-destruction. The mining community is getting smaller and more specialized, where big companies with great resources could outwork the individual miner. This specialization of mining is making the system more centralized to a few big companies and the risk of a 51% attack increases.

3.2.5.2 Proof-of-Stake

To reduce the risk of a 51% attack and to reduce energy consumption, a new consensus protocol was introduced within the blockchain community, called proof-of-stake. Instead of proving that a node solved a computational hard task, like one does in the proof-of-work protocol, the node could instead proof it has a certain amount of coins (Vasin, 2014). In the case of proof-of-stake it takes coins to create a new block, not computational power and the node with the most coins, gets the most influence (Buterin, 2014b).

The bitcoin community and Manning (2016) argue that a proof-of-stake protocol will reduce the risk of a 51% attack. He argues that the likelihood of a 51% attack is reduced due to the coins invested by the miner within the network. If someone has 51% of the computational power within a proof-of-stake protocol, one needs to own 51% of the total bitcoins as well. According to game theory, it is thus in the interest of the majority owner to have a stable and secure network, and will therefore not attack it. If there is an attack, it will only destabilize the digital currency and decrease its value. One issue with the proof-of-stake protocol is the issue of forking. When one node starts mining on a transaction, another node could start mining on it simultaneously, without the cost of computational power. Backlund (2016) argues that the

risk of villainous nodes that fork the blockchain is increased compared with a proof-of-work protocol. This increases the risk of double-spending attacks and greedy behaviour, where the nodes start to mine on all forks to not miss out on block rewards. This issue can be solved by using check-point blocks, where blocks before a check-point cannot be revised and the issue of double-spending attacks are solved.

There still remains a risk of a 51% attack in a proof-of-stake protocol and Houy (2014) argues that the points made by the bitcoin community and Manning is not valid. He argues that it will cost nothing for a miner to buy 50% of a proof-of-work cryptocurrency monetary base and thus take over the platform.

3.3 Real Estate Market

This sub-chapter will provide an overview of different theories related to the real estate market, to recognise the possible impact of an implementation of blockchain technology. Efficient market theory, institutional theory, transaction process theory, smart contracts and transparency will be further explained and analysed.

The real estate market is an utterly important market for the whole economy. The real estate market is larger in valuation than the entire stock market according to Shiller (2013). Zhao and Michaels (2016) research suggest that a financial crisis often emerges from a real estate crisis if the financial system is weak and too closely linked to the countries real estate sector. They further argue that when there is a real estate crisis it often creates a financial crisis which in turn creates a macroeconomic crisis. Hence, it is important for a country to have a well-functioning real estate market.

3.3.1 The efficient market hypothesis and behavioural economics

Eugene Fama (1970) proposed the asset market is efficient and, thus, the efficient market hypothesis was born. This hypothesis suggested that an assets price always trades at their fair value, making it impossible for investors to find arbitrage opportunities. The assets price fully reflects all available information and all investors have access to the same information and are making rational decisions when investing. Most of the academic world assumes that investors act in accordance with rationality when purchasing real estate, which leads to an efficient market despite the illiquidity of real estate (Salzman & Zwinkels, 2013). However, many researchers dispute the efficient market hypothesis, both empirically and theoretically.

Case and Shiller (1989) found that important determinants in predicting housing prices, such as real interest rates, do not incorporate into the pricing and they found positive serial correlation in single family homes. They further found that the market is inefficient mainly due to the high transaction costs within the housing market. Quigley (1999) argues that simple models of economic fundamentals only explain between 10-40 percent of changes in the property prices. He further argues that economic fundamentals are important but a big share of the price is still unexplained. This argument is confirmed by Farlow (2004a) who argues that the last decade's most plausible explanation for the price increases cannot be found in supply and demand fundamentals. The price volatility is not explained by market fundamentals and therefor a large extent is determined by behaviour of consumers and financial institutions. Salzman and Zwinkels (2013) argues that arbitrage opportunities are an obvious reaction to market inefficiencies, where someone could take advantage of pricing inefficiencies without any exposure to risk.

Due to the emerging belief that the market is inefficient, researchers started to look at the behaviours of both corporate investors as well as private investors. Behavioural economics revolution begun in the 1980s, where researchers brought psychology and other social sciences into economics (Shiller, 2014). Behavioural economics studies the effects of psychological, emotional, cognitive and social economic decisions of institutions and individuals and the consequences of such irrational behaviour on market prices and returns (Lin, 2012). These irrational behaviours, or biases, comes from different places. Biased behaviour amongst corporate investors can be found when evaluating an investment project. Berkham and Geltner (1994) argue that property indices are prone to smoothing and lagging.

The true volatility of property returns is understated in indices since most indices are based on valuations which are lagged. This in return results in biased investment policy and decision making. Geltner et al. (2003) argues that due to a lack of trades or confidentiality, there is no optimal use of past and current information. They further argue that performance measurements are smoothed, and therefore market tracking as well. Brown and Matysiak (2000) argues that risk cannot be managed optimally and they suggest the usage of high frequency indices not to reflect the market trend, it should rather reflect a more general trend. Farlow (2004b) argues that the most important psychological bias in real estate markets is over-optimism, where the investor is overly optimistic about the future returns. Households believe that the house prices will on average increase with 11% and they don't believe buying a house involves a great deal of risk. Farlow (2004b) further argues that media has a big role in bubbles, where they tend to be more optimistic than pessimistic when reporting about the housing market. This could lead to misinformed ordinary investors and could possibly have harmful consequences. Shiller (2005) acknowledges that behaviour in the real estate markets are significantly determined by overconfidence. When an investor is overconfident that person usually underestimates the risks with the investment (Salzman & Zwinkels, 2013). Behavioural biases like the momentum effect and herd behaviour has a crucial role as well. Case et al. (2003) investigated the momentum effect and could confirm that on average 80 percent of the respondents bought a house because they got stimulated by the price increases. These findings confirm that people has a certain ignorance towards market fundamentals. Shiller (2005) argues that herd behaviour plays a crucial role for people when making decisions. Due to social pressure, independent judgments are not always exercised by people and they tend to follow others. They rationalise this kind of behaviour by thinking that not everybody can be wrong. Shiller (2005) further argues and shows that herd behaviour is a source of mispricing and a reason for speculative bubbles within the real estate market.

3.3.2 Real Estate Bubbles, Booms and Busts

Bubbles are a well discussed topic within the real estate sector but a clear definition is not yet defined. Stiglitz (1990) defined bubbles as following:

"If the reason that the price is high today is only because investors believe that the selling price will be high tomorrow—when "fundamental" factors do not seem to justify such a price—then a bubble exists."

Lind (2009) however, means that this definition is too vague to be a "true" definition of what a bubble is. Linds' criticism mainly highlights two flaws in Stiglitz definition of a bubble. The first flaw is that the article does not refer to a bubble episode as a whole; it merely mentions the increase (and not the decrease in price). Secondly, Stiglitz definition can explain the price increase, but not in two identical ways. Lind (2009) argues that Stiglitz definition of a bubble focuses, firstly, on the fact that prices will be high today since investors think that it also will be high tomorrow, while the second part focuses on price not being justified by fundamentals. Lind (2009) defines a bubble as following:

"There is a bubble if the (real) price of an asset first increases dramatically over a period of several months or years and then almost immediately falls dramatically."

A similar definition to the term housing bubble, which many academic articles discuss, is the terms booms and busts. According to Agnello and Schuknecht (2011), a boom can be defined as:

"A price rice of major duration and amplitude that deviate significantly from long term trends. These might (ultimately) turn into the reverse phenomenon, i.e. busts."

A difference between the two different concepts is however, that a boom and bust may be driven by fundamental factors, but it can also be driven by speculative actions (i.e. non-fundamental factors). Further on, they also state that a housing bubble may have certain features of non-fundamentals such as speculation (Agnello & Schuknecht, 2011).

Even though, Lind (2009) criticize the definition of fundamentals as being vague and imprecise, certain fundamentals seem to play a vital role in modeling a "normal" housing market (i.e. one without a housing bubble or a boom and bust). These factors can be summarized as: income growth, interest rate, credit-supply, growth of the working-age population, industrial production and the employment rate (Agnello & Schuknecht, 2011; Bracke, 2013). The most obvious reason why fundamentals are important in explaining a housing bubble can be exemplified with the findings of Agnello and Schuknecht (2011) who mean that a higher growth of personal income may be positively associated with a higher probability of a housing boom, while diminishing growth might lead to a probability of a bust.

However, there are also fundamental variables which increase the risk/chance of a booming market. A common variable used to explain the development of house prices is income or GDP. The logic by using this variable, is that an increased income enhances our possibilities to spend more money on our living. Various studies have also found that the price elasticity between housing prices and income is approximately one. Thus, if wages increase by 1%, housing price also tends to increase by 1 % (if supply is held constant) (Englund, 2011).

The short-term interest rate is negatively correlated with housing prices. A decrease in the short-term interest rate, will thus have a positive effect on housing prices. The effect of the interest rate will be similar to income. Decreasing the interest rate, will also decrease the user cost of living in housing, which in turn means that people can spend more on housing (Agnello & Schuknecht; 2011).

International liquidity also plays a vital role in affecting housing prices, where it increases the probability of a housing boom. According to Agnello and Schuknecht (2011) international liquidity is one of the major drivers of housing busts.

3.3.3 Real Estate Transparency

A transparent real estate market is open and organized and operates with available information in a reliable manner between actors (Farzanegan & Fereidouni, 2014). Despite the term transparency is frequently used, it is not well-defined in the real estate literature. Tough transparency in economic science is seen as information shared equivalent of the participants on the market, the opposite of transparency can be interpreted as information asymmetry. According to Yun and Chau (2013), information should, in a transparent real estate market, be accessible and spread in the property and construction market, as well as in the rental market, investment market and capital market.

To achieve a successful investment in real estate, a certain level of transparency on the market is essential (Schulte et al., 2005). There is an ongoing change towards an improved transparency, which has occurred during the last decade in several countries. Actors such as brokers, consultants, academic institutions and banks etc., have all affected the increased number of high quality brokers reports and real estate databases with a potential to measure

the amount of transactions and performance. Due to the increased globalization, and the resulting spread of transactions and movement of corporations, the request for market information have increased sufficiently (Farzanegan & Fereidouni, 2014). Since real estate transparency have the possibility to reduce speculations on the property market, which in turn entails e.g. property bubbles or other negative effect for national economies, the improvement in transparency should be evaluated by decision-makers.

There are, however, studies presenting that the association between the real estate transparency and the amount of foreign real estate investors are less extensive than previously known, hence a rising number of investors investing in countries with less transparent markets have been shown (Farzanegan & Fereidouni, 2014). It is further argued that the relationship between real estate transactions cross-border and the transparency-level on the real estate market is less strong than earlier expected. It follows that fundamentals on the property market are the motivating force for transactions cross-border, rather than the markets transparency improvement.

3.3.4 Transaction Costs Theory

Transaction cost theory and agency theory are examples of contractual theories that stems from the same background as property right theory (Kim & Mahoney, 2005). Transaction cost theory has been usefully applied in several areas of social and political science, likewise in finance, economics and marketing but also in organization theory and strategic management. In a situation where more than two contracting actors are involved, the owner of the resources perform a transaction of the control of some attributes to another transacting actor. The definition of a transaction is described as this displace of control or rights. Hence, the transaction costs theory describes the appropriate structural form for a transaction with certain transaction characteristics.

Transaction costs consists of a combination of factors that hinder, prevents or makes a transaction between actors more expensive (Skogh & Lane, 2000). The term *cost* in this manner comprises not only monetary costs, but costs that occurs as a result of time delay or other difficulties in a transaction. These costs can be divided into three categories; costs that occur before, during or after a transaction. To implement a contract, the transaction costs related to the contract can be categorized as ex ante and ex post (Williamson, 1981). Ex ante transaction costs occur in connection to the creation of the contract and information asymmetry characterizes the cost. Whilst ex post transaction costs occur after the establishment of the contract when both parties are verified to have completed their agreed part of the contract. On a perfect market, with complete information access and trust, the ex post costs would be eliminated (Skogh & Lane, 2000). That is not the case on today's market.

In contrast to agency theory, transaction costs theory assumes the contractual regulations to be incomplete which leads to a theory that instead focuses on ex post transaction costs (Kim and Mahoney, 2005). Further on, in transaction costs theory, it is not certain for an optimal unitization contract when initially formulating the economic incentives correctly and the choice of governance is a choice between accessible collections of monitoring and decision-making mechanisms rather than an optimal combination of these mechanisms. By this, the transaction costs theory has a more holistic perspective of the governance choice than in e.g. agency theory.

3.3.5 Transaction Process Theory

However, when talking about transactions, it is in most cases meant the transfer of ownership of goods or services between an individual (or a firm) to someone else (Milgrom & Roberts, 1992). When there occurs a transfer of ownership from a seller to a buyer within the real estate sector, one does not talk only about a transaction, instead it is a whole process – a real estate transaction process. Transactions are divided into different dimension to easier understand them. Williamson (1991) divides transactions into three dimensions: *asset specificity, frequency and uncertainty*. Williamson further discusses two assumptions that are directly linked to these three dimensions*, bounded rationality* and *opportunism*. These assumptions are based on the nature of human behaviour.

Bounded rationality refers to the limited mental capacity of humans where the mind cannot foresee all possible outcomes or behave in the optimal way in every situation (Milgrom & Roberts, 1992). Opportunistic behaviour in a transaction is a way of achieving personal gains by not being completely honest about one's intentions (Williamson, 1991). Milgrom and Roberts (1992) argue that an investment can be both asset-specific or non-asset-specific, where an asset-specific investment could e.g. be airplane wings to a specific airplane model. For a transaction to occur in this case, the developer of the airplane wings has a specific customer in mind when developing the product. Small house transactions are said to be non-asset-specific, where the parties involved are not forced to have the customer in mind when developing the product or service. They further argue that frequency depends on how often a specific transaction occurs. Hence, a small house transactions is seen as a one-time-transaction. When writing a contract, it is impossible to specify everything and that is one of the reasons there exists uncertainties in transactions. In a small house transaction, the market price might change during the process and is therefore hard to specify in the early stages of the process. The price can go up or down and is set at the last moment before the contract is written and despite this, you still don't know if you have gotten the true market value.

3.3.6 Transaction Process in Sweden

In a real estate transaction, there are two main parties involved – a seller and a buyer. In some countries, there are regulations on the involvement of third parties that must be involved as well, such as an attorney, clerks, property inspectors etc. In Sweden however, there are no regulations on third parties and the buyer and the seller could carry out the transaction on their own (Lindqvist, 2006). There are though, regulations on the contract of sale. The most common way of doing a real estate transaction in Sweden is by contacting a real estate agent. The agent helps both parties in the process for a fee that the seller usually pays for the services provided.

Lindqvist (2006) describes the real estate process, where a real estate agent is hired, for small houses in Sweden in six steps (see figure 6).

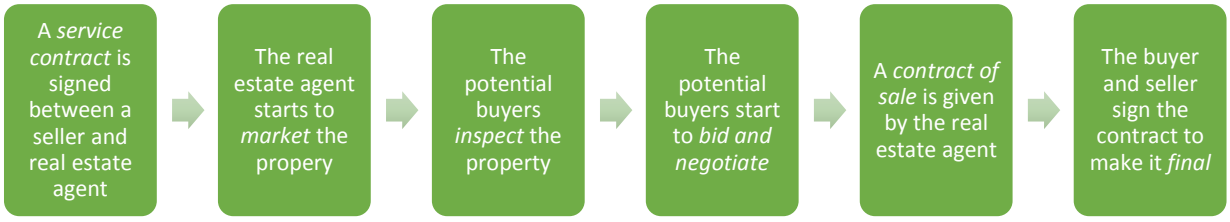


Figure 6: The real estate transaction process in 6 steps.

In the first step, a seller contacts a real estate agent and a *service contract* is signed. There are no regulations in Sweden on whether the real estate agents get exclusive selling rights or not, they are determined in the service contract. Right after the service contract has been signed, the real estate agent starts to *market* the property and try to localise potential buyers. When the potential buyers are located, they usually *inspect* the property. The duty of inspection is regulated in Sweden and must be performed by the buyer, even if the buyer has hired a professional property inspector. After the inspection one or a couple of potential buyers start to *bid and negotiate* on the property. The bidding process is usually time-regulated and in most cases, the highest bid get to sign the contract. However, it is important to understand that the highest bid is not the final transaction price, the final price is when the contract is signed. The *contract of sale* is in most cases a standardized document given by the real estate agent. The buyer and seller are forced to sign the contract to make it *final*. The real estate agent makes sure that the buyer has a loan commitment from a financial institution when finalizing the contract. The contract is legally bounded first when both the buyer and seller has signed it. The title deed must be reported by the buyer within a period of three months to "Inskrivningsmyndigheten" (a land survey authority).

3.3.7 Smart Contracts

Blockchain technology has the potential to, in a revolutionary way, influence the contract law and the contract process with less human intermediation (Peters & Panayi, 2015). The technology means faster transaction process due to lack of reliable intermediates, which, in a combination with the use of cryptography, generates smart contracts which in turn integrates for distributed and automatic processes (Christidis & Devetsikiotis, 2016). Smart contracts were already proposed in 1993, but the economic market were not ready for an implementation of the technology (Omohundro, 2014). Smart contracts are today defined as scripts stored on the blockchain and it generates automated multi-step processes (Christidis & Devetsikiotis, 2016). A transaction gets, consequently, addressed to the smart contract. Hence, it executes automatically in a set and specific way in the network. An input in a smart contract will always provide the same output, since a smart contract is deterministic. Smart contracts can hold an extensive amount of virtual money and the platforms, such as Ethereum, uses an open network to attract actors (Luu et al., 2016).

Primarily, smart contracts enable the transaction entities to inspect the cryptograph and decides whether to sign the contract or not. Secondly, the fact that the code is stored on the blockchain, provides a high certainty of the execution. Lastly, it provides a verifiability of the procedure due to the digitally interactions, that causes that the final result of the verifiable process cannot be disagreed upon by the participating actors.

One of the most established systems is Ethereums' smart contract system, which uses a blockchain technology similar to Bitcoin, and makes complex contracts possible and automatically executed (Omohundro, 2014). They enable for instance a detailed definition and execution of different kinds of transactions, such as financial exchange, derivatives or insurance contract. Applications for information and interactions of records of "smart property" ownership in both real estate and vehicles, as well as insurance for earthquakes or weather and automatic property rental is proposed to be extended in smart contracts. If the contracts are automated, then it is possible for "Distributed Autonomous Organizations", DAO, also referred to as "Decentralizing", which enables selling processes, decisions and managing employments without human management. It is also suggested that many of the

current governmental processes could be applied more reliable and less costly by managing smart contracts. Many are predicting that transactions will involve cryptocurrencies and smart contracts, which in turn will interact with any kind of area to make the process more efficient.

3.3.8 Institutional Theory

Most organisations in the industrialized world are influenced, both political and economical, by the market economy (Dillard et al., 2004). One of the most common and rational objectives is striving for economic efficiency that will create organizational legitimacy and homogeneity. Based on institutional framework, organizations adapt a structure that benefits the legitimacy. Institutional theory is focusing on the structure of formal organizations and the nature of social processes these structures stems from and is applicable in a wide range of areas. Institutional frameworks were initially assumed to only be applicable to organizations that have been institutionalized but it has been found that the theory is valid concerning all kinds of organizations. In a varying degree, all organizations are institutionalized organizations since the governance structure control all organizations both locally and generally and due to the fact that all organizations are established socially and affected by institutional development. Institutional theory comprises organizations interfering in institutional environments and their actions and behaviour that is based on the quest for legitimacy and social rules and constraints. Economic efficiency is fundamentally the strive for organizations and to create an interaction between hierarchies and actions within the organization. Despite, the intension and strive for efficiency for a highly institutionalized organization, may appear in conflict with the necessity to adapt to institutional constraints and rules.

Institutions, according to Douglass North (1991) are formal and informal constraints that affects interactions in an economic, political and social manner. Formal constraints consist of structures and rules that are restricted by law and property rights, while informal constraints include social restraints such as codes of conduct, taboos and traditions or customs and sanctions. An economys' development regarding growth/progress, stagnation or decline is affected by the evolved structure and constraints provided by institutions. A more recent work presented by Acemoglu et al. (2005), identifies institutional theory as the essential reason of economic growth in the long-run perspective. The early institutional theory and development aims to explain how different constraints and rules affects the expansion of different markets and its actions for generating economic growth (Fernández & Tamayo, 2017). The linkage between institutions and economic growth is complex and compounded by several dimensions. However, the connection between institutions and financial development is long known, and a declining financial market is considered as a market with costly transactions and information which is a fundamental cause of institutions. Financial development affects in turn the economic growth due to financial limitations, more extensive risk-sharing and generating suitable liquidity with entails an improved resource distribution as well as increased rates of the accumulation of capital. Claude and Shirley (2011) argue that the core of the theory of new institutional economy, transformed by Douglass North among others, consists of transaction costs, property rights likewise financial contract, which make the theory more distinctive and focusing on the specific organization. The new direction of the theory influence organizations to strive to achieve stability.

Effective institutions have the possibility to reduce both transaction and construction costs by using cooperative advantages (North, 1991). Transaction costs take a substantial part of the resources and institutions, in a combination with the efficiency of enforcement, regulate the

extent of the cost. Financial transactions involve for instance property right institutions which provides a legal framework that aim to reduce information asymmetry as well as unequal bargaining power (Fernández & Tamayo, 2017). The process of financial development also gets influence of financial contracting, thus there are institutions which intends to generate the implementation of contracts, hence they consist of an independent system of law and justice. A financial development likewise affects the macroeconomic environment, why institutions handling fiscal and monetary policies exists to provide a moderate expansion pace. This is done primarily through budget processes by the government but it also gets influenced by the central banks' and other essential financial actors' independence as well as liability. Lastly there are informal institutions involving social norms and restraints that aim to influence individuals to take on riskier investments and decisions with high interests.

By controlling the costs for monitoring, screening and administering transactions, there is a potential to resolve or reduce the problems with the emerging information asymmetries and executive problems as well as transaction costs between the actors in the financial markets due to institutions protecting property rights, the judicial system in financial contracting and informal institutions affecting for instance social restraints (Fernández & Tamayo, 2017). Institutions affecting macroeconomic aspects contributes with a level of financial instability and concentration that impairs problems such as adverse selection and moral hazard.

A complex agreement, such as financial contracts, tend to include several types of limitations, restrictions and contingencies. Hence, institutions protect actors at disadvantage by enforcing property rights and other decided contractual conditions. Too extended judicial formalism in the implementation of the contract may result in high application costs but can be accounted for during the application, however at substantial impact on the efficiency (Acemoglu et al., 2005). Glaeser et al. (2001) argues that ex post confirmation of the implementation of contracts and ex ante changes due to property rights complements each other rather than replace each other in the institutional process.

There can be several reasons for an institutional change or formation of new institutions. Newly established institutions can, however, change structural trends among actors and existing institutions holding opposing intentions and interests (Fernández & Tamayo, 2017). In response to changes on the market, institutions change less rapidly since many essential factors prefer the existing institutions to stay preserving. A change or transformation of aims and strategies within existing institutions occur due to exogenous differences. This transformation will, in particular concerning a transformation of trust, be opposed by actors which benefits the current order of institutions and their intentions.

3.4 Strategic Innovation and the cycle of technologies

This sub-chapter will provide knowledge about innovation and strategic innovation. Additionally, it will provide information about the hype cycle of emerging technologies, such as blockchain technology.

3.4.1 What is strategic innovation and why should it be used?

To stay competitive, many companies rely on efficiency improvements and cost retrenchment (Nadler & Spencer, 2009). The academic world has warned companies about this dependency and argues that this is not enough (Normann, 2001). They suggest that companies should re-focus, from efficiency improvements to revenue growth. This will improve their performance and stay competitive (Berman et al. 2010). Govindarajan and Trimble (2005) suggests that one way of staying competitive, profitable and sustaining growth when competitive advantage erodes quickly is to use strategic innovation. Strategic innovation is described as different business actions and management processes where the company redefines its customers, the value offered and the delivery methods (Tse, 2013). Schlegelmilch et al. (2003) defines strategic innovation as the fundamental reconceptualization of the business model. Strategic innovation reshapes the existing markets by changing the nature of competition and breaking the rules. They argue further that companies use strategic innovation to achieve a dramatic value improvement for customers and to gain high growth. This definition contains three broad components; reconceptualising the business model, finding new market spaces and to provide significant improvements in customer value (Schlegelmilch et al., 2003).

There are several ways of achieving strategic innovation. Kim and Mauborgne (1997) argue that the managers need to question the fundamentals and assumptions underpinning their industries. They need as well challenge their firms strategic focus and the way the firm is approaching different tasks and problems. Schlegelmilch et al. (2003) suggests another method, they argue that strategic innovation can be reached if the firm foster a certain way of thinking. There are four internal drivers that needs to be fostered: process, culture, people and resources. In the process the firm could foster more creative exploration. In the firm's culture, a more questioning attitude could be established. The people within the firm should hold a more open-minded perspective on things and within dialogues. By creating strong relationships with networks of partners, more recourses are added to the firm. There are other ways of achieving strategic innovation, where the firms redesign its organisational architecture. Govindarajan and Trimble (2004) suggest a firm with a "dual-purpose", in which spin-offs are created. The advantage by this is that the spin-off has permission and the freedom to seek profit by developing new activities and it has the option of copy some of the characteristics of the core business.

3.4.2 Difference between innovation and strategic innovation

One of the 20th century's greatest economist, Joseph Alois Schumpeter (1939), argued that until profit margins are wiped out, no market can passively lean toward equilibrium. To reach a higher standard of living, entrepreneurial innovation and experimentation needs to be used. He further argued that innovation and experimentation constantly destroy the old and introduce new equilibriums. There is a difference between innovation and strategic innovation. When innovation is used within a firm, it is the process that is discussed. The process helps the firm to bring new ideas and products and to reach the firms goals.

Kaplan (2012) argues that innovation first become strategic when it is an intentional, repeatable process, which in turn leads to an institutional change. This process creates great difference within the organization. Innovation often time uses simple brainstorming-facilitated ideas and the linear principles of strategic planning where focus is on extrapolating the past (Gebauer et al., 2012). Kaplan (2012) further argues that strategic innovation is more future-oriented and a framework to identify growth opportunities and accelerate business decisions. To get a competitive advantage a long-term vision is created combined with short-term impact. Companies that apply strategic innovation have bigger business impact.

3.4.3 Gartner Hype Cycle for emerging technologies

Blockchain technology is still in the early stages and companies are exploring the opportunities within the technology. Gartner (2016) places blockchain technology close to the peak of inflated expectations on the Gartner hype cycle for emerging technologies 2016 (see figure 7).

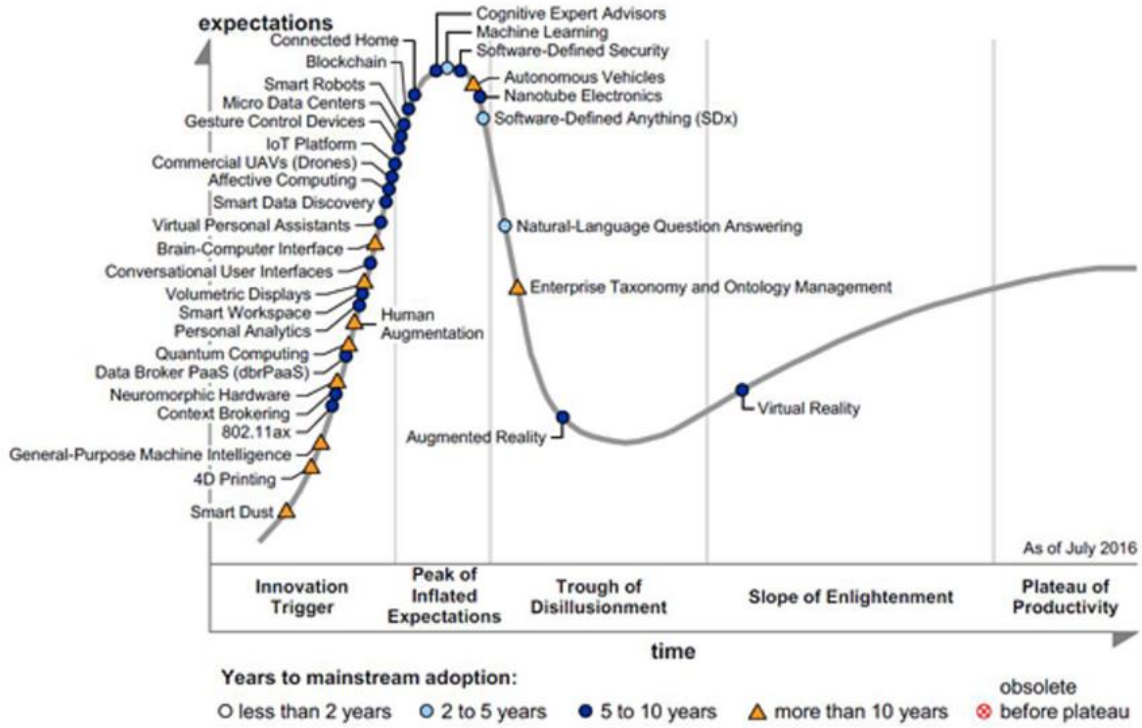


Figure 7: Gartner Hype Cycle 2016 (source: Gartner (2016)).

The Gartner Hype Cycle has five key phases of a technologies life cycle. In the Innovation Trigger, the technologies breakthrough happens and media interests are triggered. In this early phase, there usually does not exist any usable products. In the Peak of Inflated Expectations phase, there are many success stories of what the technology can do there is usually a lot of hype surrounding the technology. When the hype is at its peak, companies and institutions experiment and tries to implement the technology. In many cases, the experiments and implementations fail and interest wanes. Investments will only continue if the surviving providers improve their products and satisfy the early adapters. In the Slope of Enlightenment phase, more instances are found of how the technology can benefit the company. More enterprises start with pilot-programs and tries to explore the technology. Conservative companies usually remain cautious. When the enterprises start to find ways of using the technology and start to implement it, mainstream adaptors start to take off.

Gartner (2016) argues that to maximize value through reduction of operating costs and to overcome legal and regulatory hurdles, businesses needs to discover emerging technologies that will enable competitive advantage and transform their business models. The concept of how platforms are defined and used are being revolutionized by emerging technologies such as blockchain. Gartner (2016) further argues that blockchain, among other technologies, are shifting the traditional technical infrastructure to an ecosystem-enabling platform. This shift is laying the foundations for entirely new business models and are forming the bridge between technology and humans.

4 RESULTS

This chapter will provide the output and result from the performed interviews and questionnaire and includes a summary of the overall results at the end of the chapter.

4.1 Interviews

The following sections are providing a summary of the six interviews conducted with important actors in the field of study. The interview questions for every participant can be found in appendix B.

4.1.1 Mats Snäll, Registry Development and Digital Director at Lantmäteriet

Lantmäteriet is the Swedish cadastral authority, they map Sweden and maintain and guarantee secure ownership of Sweden's real property. Mats Snäll is the Land Registry Development Director at Lantmäteriet as well as the Digital Director and he also leads the digital development. Lantmäteriet are currently evaluating the potential of blockchain technology in cooperation with other actors such as Cromaway, Kairos Future, Telia, SBAB and Landshypotek. The project is restricted to the private real estate market in Sweden.

To ensure safety within systems and on the real estate market in general, Lantmäteriet needs digitalization and that is the reason why they have started to evaluate and work with blockchain, according to Mats Snäll. He further argues that blockchain technology can provide guarantees that the quality of the information is good and true. There are plenty of other technologies that can make systems faster or more secure, but no one like blockchain. There is no other technology that can provide both digital contracts and digital currencies in a safe and secure way, and that is what makes blockchain unique. He further argues that blockchain technology provides transparency in an easier way and that the technology is more open and does the process better, at least for a governmental institution as Lantmäteriet.

For a governmental institution, it is utterly important that the systems are open and transparent. This is to show the public that no one fiddles with the system and that the institutions are corruption-free. He further argues that as a government institution they want to be completely transparent. But he also says that there are some restraints when they need to divide privacy-questions and what transparency around information is. Today the institutions need to prove that they are not fiddling with the system and they do this by trying to be as transparent as possible. Mats Snäll means that the one reason why the Swedish system works is because we do not have any cataclysms and because we live in a democracy and trust the system. With blockchain technology, trust is no longer needed if the technology works as expected. Mats Snäll argues that blockchain is a "trust-machine".

There are plenty of challenges and threats to new technologies. One of the biggest threats to blockchain is if someone manages to hack the system and distort material, says Mats Snäll. This could lead to less trust in the system itself from the general public and then there is impossible for digital contracts and digital currencies to exist. It is utterly important to have a "bulletproof" system that people trust. Mats Snäll argues that the biggest advantage for blockchain, compared with other technologies, is the possibility of making public documents and systems impossible to corrupt. Blockchain is a huge short-cut for new democracies when they want to establish trust and transparency for the system. He further argues that new democracies that are considering implementing blockchain technology will reach an

unattainable level of transparency, compared with today's systems. Mats Snäll also mentions that blockchain deserves all the hype it has got so for, due to the endless possibilities of the technology.

There are major costs of developing and implementing new technologies and this could delay or even cancel the progress of technologies. Mats Snäll argues that it is expensive to change systems. This is not something new for companies and every system needs to have some sort of lifecycle management on their supporting technologies. Lantmäteriet are currently changing some of the major systems to newer ones (not blockchain based) and it usually cost a couple of hundred million SEK over a five-year period. Lantmäteriet is thinking to change smaller stand-alone system to blockchain based. Their budget for developing and implementing is around 60 million SEK. Mats Snäll further argues that they are not in a position to accurately calculate the cost for a blockchain based system but he does not think it will be much more expensive to change to that type of a system compared to more traditional ones.

4.1.2 Göran Råckle, Head of Real Estate Valuation and Sören Jonsson, Real Estate Analyst at Swedbank

Swedbank is one of Sweden's largest banks and operates in the Nordic and Baltic countries. They are heavily weighted towards real estate and have therefor a real estate analysis department. Göran Råckle is the head of real estate analysis and Sören Jonsson is a real estate analyst specialised towards cash-flow analysis.

There are many different threats to the real estate market in Sweden. Göran Råckle thinks the biggest threat is when long-term interest rates and inflation starts to grow, then the yield-gap will grow as well which will lead to lowered values on properties. Sören Jonsson thinks that one of the biggest threats to the market is the increased capital requirements on banks. Banks will be more careful when lending money which will force capital-seeking companies and persons to look somewhere else. Sören Jonsson further explains that Swedbank and other Swedish banks does not want to be so heavy weighted towards real property and therefor tries to reallocate to other markets, e.g. obligations and certificates. They do this to spread their risks in a better way.

Göran Råckle explains that there are other threats to the market, e.g. herd-behaviour and the psychology behind rational thinking. The actors think they act rational but they only follow other people's opinions. He further explains that this is a big issue for the market due to the increased risks and the increased volatility. One way of decreasing the volatility on the real estate market is to have a more transparent market, says Göran Råckle.

The financial crises in recent years have been smaller and smaller due to more transparency on the market. Göran Råckle argues that the bank want a as transparent market as possible but says that in a less transparent market there are bigger arbitrage opportunities. To benefit the market overall however, it is better to try to optimize the operating net income instead of having the opportunity of buying something due to information advantage. Göran Råckle argues that a more transparent market will benefit the market overall and unnecessary risks are taken out from the market.

To decrease the risks when lending money, Göran Råckle argues that it is important to know your customer. The banks usually want to know how their customer think about risk and they need to understand the business idea. He further argues that this kind of information is

expensive and that digital systems have so far helped a lot in this process. However, there are still a lot to do and much information is added manually today.

To make sure that the companies are innovative they need to hire younger people who thinks digitalization, says Sören Jonsson. He further argues that Swedbank does not just hire bankers, instead they hire people from all sorts of fields. One issue with staying innovative and digitalized is the high costs of developing and implementing new technologies, says Göran Råckle. He further argues that the Baltic branch of Swedbank is more digitalized compared to the Nordic. This has to do with the high costs when changing system from an old one to a new one. The Baltic countries had a different starting point and have surpassed the Nordic banks when looking at digitalization in the banking sector.

Both Göran Råckle and Sören Jonsson are positive toward blockchain technology, despite not being experts on the subject. They both mentions that the know-your-customer process needs to be improved.

4.1.3 Ester Sundström, Senior Manager at Deloitte

Deloitte is a revision and consultancy company operating worldwide. Ester Sundström is a Senior Manager at Deloitte and are currently working with IT-revision, IT related risk questions, and with consulting related to IT-questions.

To make sure that a company is one step ahead of their competitors, they need to consider new technologies according to Ester Sundström. She further explains that Deloitte wants to be at the forefront in the market and to ensure that, they need to make sure they are working with the latest technologies. Deloitte are currently developing blockchain technologies in Dublin and they are monitoring the technology here in Sweden. Ester Sundström says that everything that has a slow process or insecure contracts would benefit from blockchain. She mentions that smart-contracts and an integration between blockchain and internet-of-things (IoT) would be truly interesting. Ester Sundström says that the greatest application for smart-contracts are that terms and condition could come into force. She explains that today we have cars that will not start if the lease on the car is not payed. The problems with smart-contracts, according to Ester Sundström, could be if the terms and condition are set to sharp and if there are no flexibility within the contracts.

Ester Sundström argues that the real estate market is a market suited for blockchain. In the real estate market, there is plenty of documentation on paper and it is a very intensive market. The financial market has plenty of work right now with regulations and does not have the time to start implementing whole new systems. According to Ester Sundström is the real estate market in a much better position compared with the financial market and could therefor focus more on implementation and development of new systems.

One of the reasons why blockchain is not bigger today than it is, is because of the regulations in the financial market, says Ester Sundström. The financial market has huge challenges with regulations and especially regulations about money laundering. There is a huge gap between what the technology can do and what the regulations says is legal, and no one knows what consequences new technology might bring. Additionally, Ester Sundström believes that making the system “bulletproof” is extremely important, and that is a challenge as well. Companies will not implement blockchain technology if these systems are not proven to be safe and secure. Companies and institutions will not invest in technologies if there are insecurities about the technology. The market wants to see proof that the technology works

and that takes time. It is only in the recent year's companies have considered and investigated the potential of blockchain and they are now trying to explore different areas of application. She further argues that it would be a revolution within the financial market if securities could be transferred in a way similar as money is being transferred today using the application Swish, but in a more global perspective.

The driving forces behind new technologies are more efficiency in the systems and to save money. Ester Sundström argues that the driving forces behind the revolution of blockchain are the same. Efficiency and cost savings are the factors that are going to determine if companies are prepared to invest in a new technology or not. With blockchain, there is an opportunity for companies to be more transparent towards their customers. Ester Sundström argues that transparency is something that benefits everyone in the market, especially the customers. She further argues that it is time for a more transparent system in a connected world as today and companies needs to adapt their business models to this.

Many new technologies are hyped when they are new and there are plenty of enthusiasm around the technologies. Ester Sundström says that she does not know if blockchain is overhyped or not. She says that if the technology works as everyone says, then there are endless application areas and then it is a revolution. But she also says that "the truth is in the pudding", it is all about making sure the technology works as said and if it is reliable enough to get the general public and companies to start implementing this technology. She further argues that the technology has great potential but different stakeholders could delay or even cancel developments of blockchain technology. She believes that the stakeholders will probably delay the progress and not cancel developments and that the majority of the market will probably adapt some kind of blockchain based system within 10-15 years.

The market today seems to be open to new technologies and large sums of money are invested in developments and implementations of these. However, many companies are recumbent and many would rather wait for someone else to take the initiative to invest in new revolutionary technologies, says Ester Sundstrlm. She argues that it has to do with the willingness to invest and many companies within the fin-tech sector has seen start-ups grow and "run past" established companies due to more digitalized systems. The established companies do not want to lose profit and to prevent this they need to adapt and develop new technologies.

4.1.4 Hans Lind, Dr. National Economics and Professor at KTH

Hans Lind is a former Professor at KTH and is now retired since the past one year. His field of knowledge is economics and additional real estate economics. Hans Lind has been active in all different fields of the real estate market during his 25 years at KTH, where the latter ones were primarily focusing on the housing market. He is starting the interview by explaining similarities on the property market during the crisis in the beginning of 1990s' and todays problems on the market regarding for instance price bubbles and its driving factors. He is further on explaining that the economy and the property cycles is caused by chance, and he is referring to the situation in 2003-2004 where the property prices were record high where the property prices continued to rise even after the following financial crisis. In the beginning of the 90s' the behaviour to property cycles was seen as a sociological question, where people that have been experienced a property crisis acted more carefully on the market the following

30 years whilst the next generation had forgotten about the effect of the crisis. Hans Lind believes that if there were a way of avoiding crises, we would already know about it.

One of our first question to Hans Lind is regarding the problems on today's property market and the transaction process where Hans is mentioning the qualities of the properties in both the public and private sector. He is pinpointing the fact that every property is unique and has its own technical system and potential faults. Hans Lind is believing that it is time to create a system that, in a reliable way, secures the information and qualities connected to a specific property over time. Hans Lind continues to clarify that it is a challenge to get that reliable information secured to achieve a well-functioning market.

Historically, one have thought that more transparency on the property market is connected to less volatility but, according to Hans Lind, there is no concrete evidence for that linking to be true. Hans believes instead that a transparent market is a contradiction and that everyone aims to direct the information stream to their own benefit. He means that if a market is completely transparent, everyone will get the same market information and by using the same theories and analyses one will draw the same conclusions. Hans Lind is of the opinion that the information stream of the qualities of the properties is however something that could become more transparent. All actors on the market are of interest that the information is available. The question Hans Lind is rising is if the number of people that want the information is enough and sufficiently willing compared to the number of people that does not want the information. He continues to explain that some people make money from having different information.

Additionally, Hans Lind is stating that the goal of blockchain is not focusing on the transaction costs, but that the transaction information is available for everybody and to achieve a more efficient market. Using blockchain technology in the transaction process can make it possible to remove a central trusted third party since every actor creates trustworthiness trough blockchain. He visualizes the situation as property owners have the possibility to join the system and insert the property's qualities in a quality assured system that attracts customer that value the reliable information when the property is up for sale. He means that blockchain have the possibility to create an assured information system without a controller or another intermediator, which in turn will save plenty of money, both in a socio-economic manner and private.

Further on in the interview Hans Lind discusses whether or not the property market is ready for such a fundamental change that an implementation of blockchain technology could generate. According to Hans Lind, the political system in Sweden is weak at the moment where the current discussed problems in the debate have been discussed during the last 15 years, which has resulted in fairly little action. He believes however that blockchain would not have an increased influence of the "moving chain" but there are other factors that have more fundamental effect on the moving pattern, such as how people want to live, if they want to live mixed or segregated and so on. He continues to state that processes and cycles cannot be affected easily.

4.1.5 Rickard Engström, Ph.D. and lecturer at KTH

Rickard Engström is a former real estate agent for 13 years in a suburb to Stockholm, and is currently a Ph.D. and lecturer at KTH focusing on real estate agencies, brokerage process, fairness and consumer protection etc. Rickard Engström is beginning the interview by explaining his opinion of the problems of the property market. He points out that the

secondary market must get started in Sweden and some locking effects must be sorted out. He means that several people stay in their big villas since it is too expensive to move due to capital gains taxes and that there is no well-functioning rental market in Sweden. Rickard Engström additionally points out that the transaction process and the transparency on the market can get improved to achieve a more functioning market.

With today's regulations on the rental market it is problematic and expensive to find a rental apartment in Stockholm which leads to problems with a black market. According to Rickard Engström, there would be a solution to create a central registry over all rental apartments. It would be possible to demand that each possible tenant must go through the central registry. He believes that there is a lot that must be done to achieve more transparency in the rental housing market. Rickard Engström continues to state that real estate agents are positive to transparency on the market and that the Real Estate Brokerage Law regulates the broker, also regarding transparency. The law changed during 2011, which now requires the broker for a record which in turn increase the transparency. Rickard Engström further on states that transparency is important to build trust between the broker and the seller, and does not believe that the number of brokers will decrease in the future but that the profession is refined instead. He believes that a potential buyer of an apartment or house would prefer to buy from a broker instead through a standardized contract produced by blockchain technology. He continues to explain that the Swedish brokers have a relatively low level of commission compared to other countries and believes that a system based on blockchain technology possibly would endure better in a country with a high level of commission.

Rickard Engström is continuing the interview by explaining that apartments "time on market" have declined and that several sales objects are sold in advance. Furthermore, he adds that the transaction process in Sweden is relatively smooth compared to other countries and that efficient brokers contributes to a low time on market for sales objects. He means that there are several buyers that argues that the buyer is in a worse position due to the fact that the process is going too fast. Rickard Engström claims that from his experience in the brokerage industry half of the customers think that the process is too fast mean while the other half of the customers think it is going too slow.

He ends the interview by stating that if blockchain technology, or any other technology, will increase the transparency, also on the rental market, it is preferable. He adds that he believes that there will be higher demand and requirements on the broker to inform and convey knowledge, and that the focusing of the profession possible will change to become an advisor in a greater extent.

4.1.6 Daniel Kraft, Head of Investments Realtech at Stronghold

Stronghold is a holding company that invests, owns and develops real estate companies in Northern Europe. Their key investments contain companies such as Newsec, Datscha, Tessin and Niam. Stronghold have a substantial focus on innovation and digitalization as well as the use of modern technology. Daniel Kraft, the interviewee, is the Head of Investments Realtech. He has a financial background and is a former management consultant. He has previous worked with business development, acquisition, process development and cost-efficiency. At Stronghold, he is responsible for Realtech Ventures which is focusing on the investments in tech companies, start-up or mature, with a connection to real estate.

The property market is, according to Daniel Kraft, 15-20 year behind other markets, such as the security industry or healthcare, concerning the technical way of working. This is the reason why the current investments in realtech are so extensive on the property market. Daniel Kraft continues to explain that if blockchain can accomplish what is said it can do, then it will affect all markets enormously. He believes that the property market and the financial market, two markets with transactions and great values, are the markets that are the most suitable to a solution based on blockchain technology. Daniel Kraft means that it is costly to just ensure the security and reliability of the transaction process.

Further on in the interview, Daniel Kraft explains that by using blockchain in the transaction process one hope to accomplish a combination of a more secure and faster process. He believes these factors are linked and affect each other. According to Daniel Kraft, an implementation of blockchain technology on the real estate market will primarily affect title deeds and registries of ownerships in the transaction process in both commercial and private transfers. He adds that the process in Sweden is relatively smooth compared to e.g. the process in England, but it is still expensive to transfer title deeds etc.

Stronghold is currently not working with blockchain, but they are involved in several realtech investments such as a development of an information standard on the property market. They run approximately 80 digital initiatives within the Group, according to Daniel Kraft. He believes that these kinds of investments have an effect that spill over to the rest of the Group.

Daniel Kraft reasons that it is a possibility that the idea of bockchain technology is overhyped and compare it to other systems such as Artificial Intelligence and VR. He means that it is most likely a lot of hype in the belief of all new technologies. Daniel Kraft continues to mention the most comprehensive advantage of blockchain, is a reduction of intermediates and other actors that ensures the transaction process. He also believes that blockchain has the possibility to make the property market more transparent, but reiterates the fact that the real estate market is technically far behind other markets and much can be improved without the implementation of blockchain. The fact that the market will be more transparent by using blockchain technology can be a problem, according to Daniel Kraft, since it will distinguish between very well performing actors and not so well performing actors. This will in turn create a clearer competition in the market.

Daniel Kraft's opinion is that a more transparent and secure market due to the use of blockchain, is not necessarily connected to less volatility on the market but to a higher quality on the market. He also believes that that situation is in a far distance from today and is not sure if it will be the financial sector or the real estate sector which will initiate the implementation.

4.2 The Questionnaire

The following section is providing a summary of the performed questionnaire with house owners. The questionnaire questions can be found in appendix C.

To get a better understanding of the attitude and reliability from small house buyers regarding today's transaction process as well as the attitude to new technology connected to this process, a questionnaire is being used. The questionnaire in this thesis is created and administrated through the platform Survey Monkey, and is sent out electronically to different fairly new (maximum 5 years) house owners. Due to the snowball sampling technique, it is difficult to know the amount of sent questionnaires which in turn makes it difficult to estimate the response rate of the questionnaire.

Hence, the answers from the questionnaire is well distributed regarding age, education level, etc., the results from the questionnaire can be seen as a proxy for the whole population despite its low number of responders. The chart below, table 1, gives an overview of the responders' distribution.

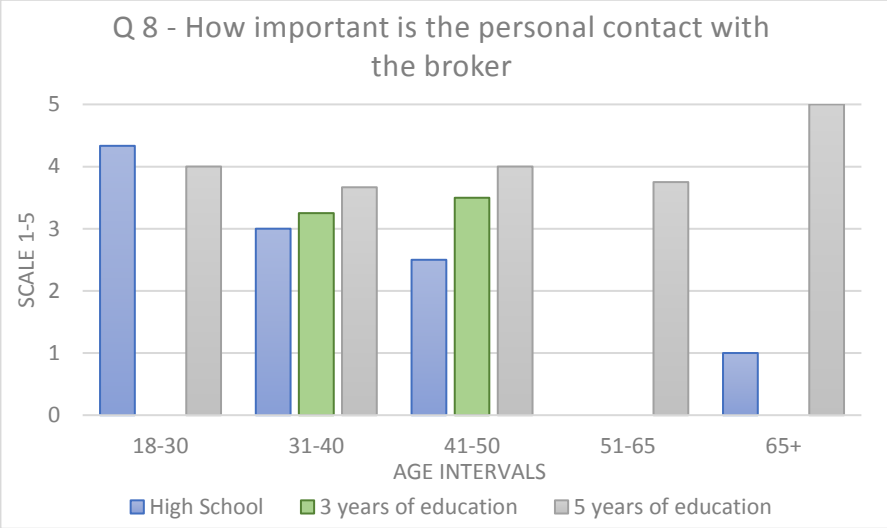
Table 1: Distribution of responders

	Amount
Total responders	23
People between the age 18-30 years	4
People between the age 31-40 years	8
People between the age 41-50 years	5
People between the age 51-65 years	4
People above 65 years	2
People with high school education	7
People with 3 years of education	6
People with 5 years of education	10
First-time buyer	14

One can see in table 1 that the distribution is slightly overrepresented by the age interval 31-40 years and by people with 5 years of education, which in turn possibly can explain the large amount of first-time house buyers.

The responders' average opinion regarding trust and reliability to the broker, the seller and the todays' system as a whole is somewhat mediocre. From analysing the answers one can see that the reliability to the broker compared to the seller is slightly higher or the same in almost all age- and education categories. Further on, the answers show that as good as everyone experience an information advantage by the seller or the broker during the transaction process, where the groups with 3 or 5 years of education is experiencing the information advantage a slightly bit more than the ones with a high school degree. There can also be seen a vague connection between age and level of experience of information differences, whereas higher age is resulting in higher degree of believed information advantage. Additionally, the fact that the real estate registry is centralized to one authority (Lantmäteriet) does not seem to a be such a vital factor for the mediocre confidence to the system. Although, the persons with high school degrees (compared to the other education categories) are generally feeling most uncomfortable due to the increased vulnerability as a result of the centralized system.

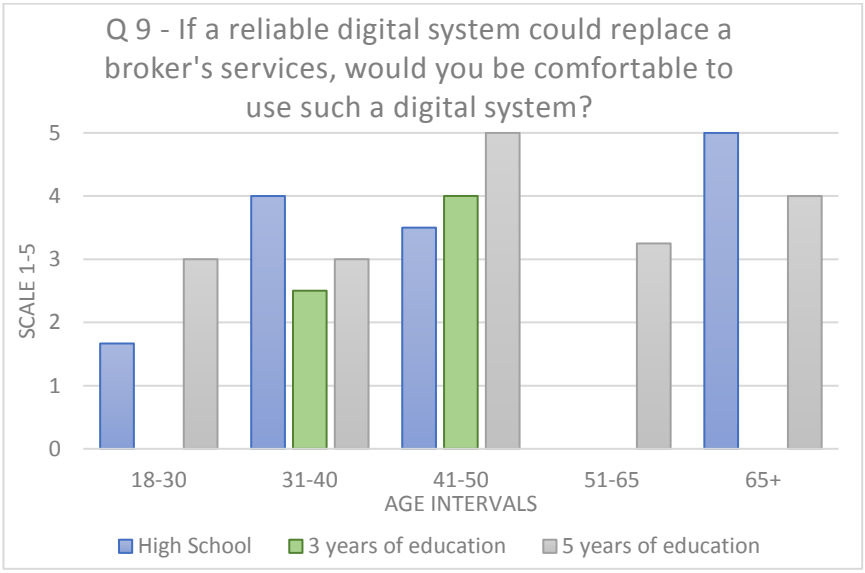
The last questions on the questionnaire covered the importance of the personal contact to a broker and the buyers' open mindedness to technically innovative way of signing contracts or conduct a real estate transaction. One can, by the responders' answers, see that personal contact to the broker in the sales process is by far most important to the group of people with 5 years of education, see graph 1. The graph below show the proportion between the different education categories and the age intervals regarding the importance of personal contact to the broker.



Graph 1: The relationship between age, education level and importance of personal contact with a broker. 5=very important and 1=not important.

One can additionally see in the graph above that the importance of personal contact to the broker is decreasing by age within the group of people with a high school degree meanwhile it is close to be an opposite relationship within the groups with 3 and 5 years of education. Overall, the average is 3,52 in a scale from 1-5, whereas 5 equals very important and 1 equals not important regarding the personal contact to the broker.

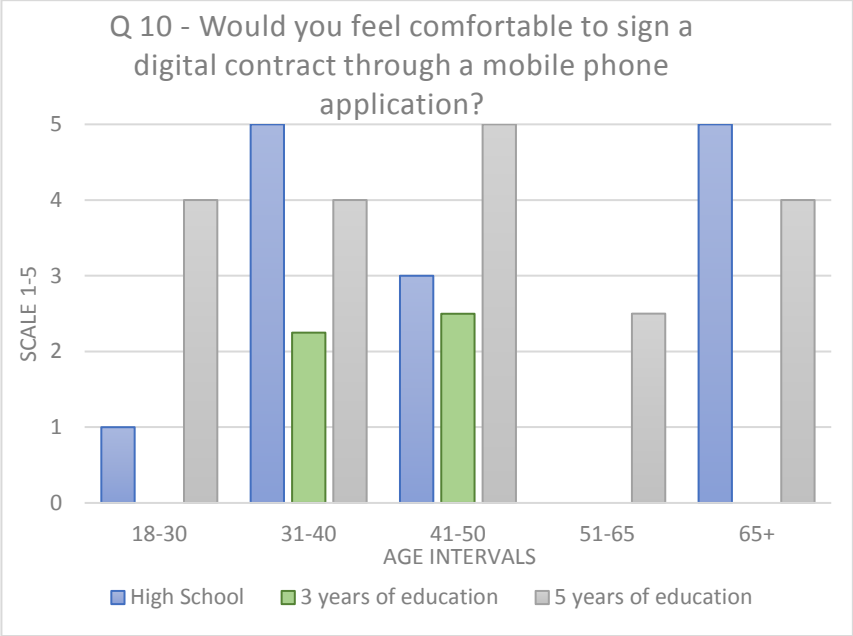
Furthermore, the questionnaire examines the attitude to replace a broker's services by a reliable digital system, where the result is presented in graph 2.



Graph 2: The relationship between age, education level and the open mindedness to a replacement of a broker's services by a reliable digital system. 5 = very comfortable and 1 = not comfortable.

The graph is showing that the openness to a digital system in this matter is increasing by age with an exception in the group of people within the age interval 51-65. The spread between the different education groups is relatively constant and the overall average is 3,17 in a scale from 1-5, whereas 5 equals very open minded to a replacement and 1 equals not comfortable with a replacement of the brokers services.

Lastly, the questionnaire examines the responders attitude to sign a digital contract through a phone application, where the result of the asked question is shown in graph 3.



Graph 3: The relationship between age, education and the attitude towards signing digital contracts through a mobile phone application. 5 equals very comfortable and 1 equals not comfortable.

In the graph, one can see that the groups that are least comfortable with signing a contract through a mobile phone application are the people with 3 years of education, but also the peoples within the age intervals 18-30 years and 51-65 years. The overall attitude to such an application can be stated by a calculated average, which is 2,96, in a scale from 1-5 whereas 5 equals very comfortable and 1 equals not comfortable to sign a digital contract through a phone application.

4.3 Summary of the results

Table 2 represents a summary of the different participants' opinions regarding the discussed subject in the interviews. As seen in the table below, all the interview participants have a positive attitude towards digitalization and many of the actors believe it is necessary. Some of the participants are working actively with blockchain and some are not. There are different opinions regarding the biggest obstacles towards blockchain. Lantmäteriet, as an authority, needs to establish trust and transparency towards the system and they thus believe that building a unhackable and reliable system is probably the biggest obstacle. Deloitte however, believes that the regulations in the financial sector is one major issue and Hans Lind argues that information added into the system needs to be secure and reliable, which is a major difficulty to accomplish.

Table 2: A summary of the interviewees opinions regarding the discussed subject.

Interview summary	Governmental authority	Financial institution	Companies		Academic world	
	Lantmäteriet	Swedbank	Deloitte	Stronghold	Hans Lind	Rickard Engström
General attitude towards digitalization	Positive	Positive	Positive	Positive	Positive	Positive
Develops blockchain based platforms	Yes, in cooperation	No	Yes	No	No	No
Biggest obsticles towards Blockchain	Building a unhackable and reliable system	Development and implementation costs	Regulations in the financial sector	The real estate market is 15-20 behind other markets	Secure reliable information	People's preference to a brokers contact
Attitude towards transparancey	It is utterly important for a governmental insitution to have transparent systems	As transparent as possible, but bigger arbitrage opportunities in a less transparent market	Transparency benefits everyone in the market	Increased transparency will create more competition in the market	A transparent market is a contradiction, but efficient in some matters	Transparanecy is just positive
Most interesting benefit from blockchain	"Trust-machine"	Improved know-your-customer process	Transparent to its customers	More secure and faster transaction processs	Transaction information will be available for everyone to achive a more efficient market	Transparanecy on the rental market

The different actors are mainly positive towards more transparency on the market. Hans Lind however, argues that a transparent market is a contradiction. If the market is completely transparent, all the actors have the same information and will draw the same conclusions, which could harm the market. Stronghold argues that increased transparency will create more competition on the market but it will also make less-serious actors leave the market after a while due to the increased competition. Lantmäteriet argues that transparency is utterly important for a governmental institution, this is to ensure the public that the system is reliable and not fiddled with. Lantmäteriet further argues that the most interesting benefit with blockchain is that no trust is needed in that kind of a system. Blockchain is a trustless system, a "trust-machine". Swedbank believes the most interesting benefit is the improved know-your-customer process and Rickard Engström believes it is the increased transparency on the rental market.

The questionnaire show that the participants have higher reliability towards the broker compared to the seller. The house buyers responded that they experienced information asymmetry in the transaction process, where the seller and/or the broker had more information compared to the buyers. The respondents believed that a centralized real estate registry is not a vital issue and they had mediocre confidence to the system. They further believed that the personal contact with the broker is important and whether to replace the

broker or not with a digital system increased by age. Signing a contract with an application on a device seemed to be somewhat of a concern for the participants. They answered below average and the group most critical towards signing contracts with an application where participants in the age of 18-30 with no higher education than high school.

5 DISCUSSION

In this chapter, the literature study and the results from the interviews and the questionnaire are being analysed and discussed.

5.1 The inefficient market and a fundamental change

Eugene Fama (1979) believed the capital market is efficient due to access to the same information and all the different actors would make the same rational decisions. This would be true in a totally transparent market, but not in a market as today, where information is not shared to everyone. Robert Shiller however argued that the market is inefficient, the actors operating with the market does not have the same information and there exist arbitrage opportunities. The same thoughts could be applied to the real estate market, where Shiller argues that the real estate market is inefficient today due to personal biases, transparency problems, high transaction costs and slow transaction process. The capital market, and especially the stock market, is fairly efficient due to repeated sales, however, this is not the case with the real estate market. Properties are not sold very often and it is therefore hard to know the true market value, the value buyers are willing to buy for and seller are willing to sell for.

Case and Shiller (1989) found that high transaction costs are one contributing factor to market inefficiencies. There are plenty of actors involved in a transaction of a property which makes it expensive. Due to the high costs, not as many transactions are made and the properties are held for a longer period of time. With blockchain technology some of these actors could be cut out and some intermediates are no longer needed, which could lead to lower transaction costs and more sales.

To make the real estate market more efficient and less volatile, emotions and personal biases needs to be addressed. Today, people are emotionally attached in a broad sense to their homes and they tend to overvalue their property. This might be a problem, since, if there exist emotions and personal biases, then the market can never be fully efficient and we will probably still have real estate cycles with booms and busts. One way of decreasing these biases is by educating people. Hans Lind argued that people whom have lived through recessions are more careful and restricted compared to the younger generations that have not been through major economic downturns. It is hard to measure which of these two groups that would have the most amount of bias, but one thing one could argue about is that biases are in many cases taught. The older generation teaches the younger generation about risks and different biases and the younger generation develop their own opinions about it. This could lead to younger generations which are overoptimistic and have overconfidence biases which Shiller (2005) acknowledged. Shiller (2005) also argued that herd behaviour is one major bias. This bias effect all generations, some are more pessimistic and some are more optimistic. Göran Råckle, at Swedbank, argued that herd behaviour and other biases are not good for the market because they bring unnecessary risks to the market. To reduce all the different personal biases, more education about how the market works and what factors drives the prices should be taught at a young age. However, even if this is taught, it will still exist some biases within the market due to the nature of the human behaviour, but it could be reduced and stabilized.

There is a belief that cycles could be smaller if there is more transparency within the market and the volatility would decrease. Göran Råckle believes that this will happen due to increased transparency and it would be of great benefit to the overall market due to less risk. Schulte et al. (2005) argued that to achieve a successful investment in real estate, a certain level of transparency on the market is essential. One could argue that the market today is lacking transparency and many of the properties bought today are not based on rational decisions, but rather on illusions and on herd behaviours. People need to access the necessary information to be able to make a rational decision. If the general public have more information about the property and the current and future trends of the market, they will most likely make more rational decisions compared to today. This could lead to less volatility and fewer busts.

Blockchain is one technology that can help the real estate market with these inefficiencies. If we have all properties in a blockchain, where the different attributes and their qualities are included (as Hans Lind proposed), we would create a system with more reliable data, and consequently, more rational decisions can be made. If the real estate market in collaboration with the financial market are fully operating on a blockchain based systems, then busts in the market could be avoided and plenty of money could be saved and the overall market risks will decrease

To make the market more efficient, a fundamental change needs to occur within the real estate market, where personal biases among others are addressed. Blockchain technology can reduce many of the existing problems within the real estate market, e.g. it could reduce the high transaction costs and bring more transparency into the market. Figure 8 illustrates a possible progress of fundamental changes within the real estate market.

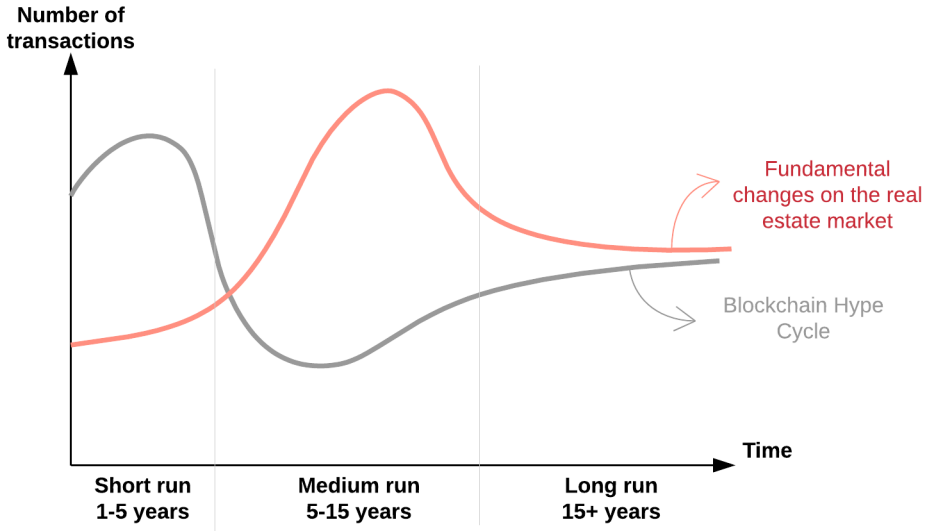


Figure 8: The expectations of fundamental changes combined with the hype of blockchain.

The vertical axis represents the expectations of a fundamental change and the expectations of blockchain. The horizontal axis represents time. There exists a possibility of increased fundamental changes towards a more efficient market when the hype of blockchain is reduced and one knows how to use the technology. In the short run, not much will happen due to inefficiencies within the market and the same biases as today. In the medium run, there are high expectations of how the market could change in a fundamental way. This is, however, only expectations and speculations. In the medium run, blockchain system has proven its potential and companies are starting to implement systems based on blockchain technology. This will make the expectation about a fundamental change to highly increase. In the long

run, where a new generation has got more knowledge about biases and market trends combined with a blockchain-based system that reduces inefficiencies, radical changes are going to happen. The blockchain is no longer hyped, instead its implemented and is well proved to work. The fundamental changes within the market has gone from expectations to reality, where the market is now more efficient and liquid and personal biases are addressed to some degree. There will always be some degree of inefficiencies within the market and this is due to the nature of the human behaviour, where one does not always take rational decision even if they have all the necessary information.

5.2 Digitalization

There are several theories of how companies stay competitive and how they survive through different crises. In a world that is rapidly changing, adaption and innovation are the key skills a company need to have to survive. Companies cannot rely on their reputation and act in the same way they always have done. Consumers and the demand is changing, and if the companies are not adapting to the changed demand, then they will most likely not survive. Various companies today are relying on efficiency improvements and cost retrenchments, and this is not enough according to Normann (2001). To stay competitive in a fast-changing world, companies need to refocus from efficiency improvements to revenue growth using strategic innovation. The customers, the product, the value offered and the delivery methods, all needs to be redefined to be able to survive. Revenue growth can be achieved using many different methods, e.g. efficiency improvements and cost retrenchments, but these are only a short-run solution. To be able to have a long-run revenue growth, one need to fundamentally adapt and change. One way of achieving this is by developing and implementing new technologies. Ester Sundström, at Deloitte, argued that companies need to adapt to new technologies to be able to be at the forefront and to be able to stay competitive. We have seen small start-ups come and run past big established companies and this is not a coincidence. The big established companies, in many cases, overestimate their ability to survive due to their size and importance to the market. If companies do not implement new technologies, they will eventually fall, it does not matter how big they are.

Companies today are in a tough situation. The world is changing at a rapid pace due to digitalization and the world is connected as never before. The competition has never been higher and it is difficult to make good profits. As seen in the Gartner Hype Cycle, there are many new emerging technologies and there is much hype behind them. Companies that try to be at the forefront and stay competitive, need to see through all the hype and explore what the potential of the technology truly is. This could be an issue. Ester Sundström means that companies are today, in many cases, waiting for the technology to prove its hype and what it can do, before the companies makes an investment. This is one of the reasons why there is a delay of the digital revolution and many promising technologies are not being used. The companies are only going to invest if they see great potential of the technology.

Daniel Kraft, at Stronghold, believes that the real estate market is approximately 15-20 years behind the healthcare and security market with digitalized systems. He means that it must be an increase of digitalization in the real estate market. The authors of this thesis agree upon this view. The real estate market is very conservative and it needs to change. However, as Ester Sundström believes, the companies are not going to invest until the technologies has proven to work. This is an issue and somewhat contra productive, one needs new digitalized

systems to increase the efficiency, but are not willing to invest in new technologies until they have proven its worth.

Within the financial sector, there has been huge investments in digitalized systems. There is a collaboration between many of the world's biggest banks where they work together to create a standardization of a blockchain based system and, for instance, Nasdaq has a blockchain based system already running. The financial sector need these new systems to stay competitive because the market is changing fast and many new players are constantly entering it.

The real estate market is not changing as fast as the financial market and the market has not changed much in the recent decades. Properties are usually sold through a broker, contracts are signed using paper and pen and there is not as extensive transparency within the real estate market as within the financial market. However, real estate companies have started to adapt more digitalized systems in recent years and there is a shift within the market. Göran Råckle explained that the digital system Datscha is one example of a digital service where the actors within the market can get more information about commercial properties. Lantmäteriet are currently working on a pilot-project where they strive to build a blockchain based platform for the whole land registry, in a much more secure way compared to today's system. These are innovation that are going to be of great benefit if the projects succeed.

One issue with digitalization is the costs of developing and implementing new systems. Göran Råckle means that the greatest obstacle towards blockchain is the cost of developing and implementing it. There is a huge investment to go from old system to new ones and several companies are unfortunately not prepared to make such big investments. Mats Snäll, at Lantmäteriet, argues however, that the cost of implementing new systems are more or less the same, it does not matter if it is blockchain-based or not and if companies are not making such investments, they will not survive. This is accurate in a fast-changing market, like the financial market, where the companies are forced to adapt and therefore invest in digitalised system to survive. This is not necessarily the case within the real estate market though. Companies could still run on old systems and still make a great profit due to the inefficiencies within the market.

One major challenge blockchain is facing is to earn the trust of the general public to be able to truly expand and change the market in a fundamental way, argues Mats Snäll. This is probably one of the biggest obstacles of blockchain in a combination with the unwillingness of companies to invest more in it. One could argue that people are somewhat afraid of new emerging technologies because no one knows the outcome of it. Additionally, digital systems have replaced human labours in some sectors and this could be an issue in earning the trust of the general public. People will not support technologies if they could lose their jobs when the technology is implemented. Ester Sundström argues that people and companies need to accept and not be afraid of this kind of change. The change is coming, whether you want or not.

5.3 Transparency

A transparent market is frequently mentioned in both literature and studies as a goal for achieving a more efficient market. The term itself is rarely well-defined in the real estate literature but the general pursuit is to share the market information equally between the participants. One can see several advantages and disadvantages by more transparency on the real estate market. Some literature mean that some level of transparency on the real estate market is essential for achieving successful investments, why the market is moving toward more and more transparency. Other studies states that an increased transparency on the real estate market can result in less speculations which in turn affects property cycles. However, Hans Lind argues that the connection between transparency and property cycles is not evident. Instead, Hans Lind means that the term "transparent market" in fact is a contradiction. If all information on the real estate market would be accessible to all participants it would imply that everybody could draw the same conclusions about investments or changes on the market. This in turn would be destructive to the market. Hans means, additionally, that some level of transparency at some specific areas on the real estate market is satisfactory. Daniel Kraft, at Stronghold, on the other hand, believes that increased transparency on the market would affect the competition between actors on the market. Increased competition on the real estate market would most likely appear due to increased knowledge the actors on the market and their intentions, which can be advantageously for the real estate market and its customers. This would result in less amount of bad performing actors on the market and increased amount of good performing actors. If the market is not completely transparent, which would be highly unlikely, there would exist information asymmetry on the market which in turn is harmful for the transparency on the market. Thus, it is crucial for the well performing actors to use methods as signalling to ensure their reliability.

One central question that was discussed during the six performed interviews was regarding the interviewees opinions about the ideal level of transparency on the real estate market. From the results one can see slightly differences of their beliefs, but the overall impression is that transparency is positive. Mats Snäll, at Lantmäteriet, which is the only interviewed authority, is the only interviewee that finds transparency as a complete necessity due to their role as a governmental institution. Hence, the level of transparency on the market must most likely be different complete in different areas. Blockchain is a technique that indeed can have a large impact on the transparency on the real estate market, and as Hans Lind argues, one possible market area that could be attractive for increased transparency due to an implementation of blockchain is the valuation of properties qualities. If the real estate market were more transparent it would, hence, affect the valuation and the valuation methods of the properties. Blockchain could affect an implementation of a new valuation system with less intermediates, such as brokers and real estate appraisals, where the valuation of the property is done through the blockchain technology. Thus, it would have major impact on these intermediates and their work tasks. Rickard Engström at KTH believes that a brokers tasks will change and that the profession will me more refined. Most likely, the work tasks will focus on the convey between the actors instead of the actual property valuation in a transaction process.

One aspect that contradicts the change of appraisals and brokers work tasks is, for instance, the importance of personal contact for a buyer during a transaction process that can be seen in the results of the performed questionnaire. Most likely, buyers tend to believe more in a

broker than in e.g. a mobile phone application of another digital platform. This can also be validated by Rickard Engströms professional experience as a broker.

Since blockchain technology have a possibility in making the transaction process secure without intermediates it can, as Mats Snäll states it, be seen as a “trust-machine”. Blockchain will possibly contribute with a trust-transformation, where the trust between actors on the market is less important and where the actual supply on the market is more in focus. Once again, information asymmetry can be discussed but is less of a problem due to the increased transparency of the actor’s qualities, abilities and intentions on the market. The fact that less intermediates are used due to a secured blockchain system, there are huge costs to save although the system itself is expensive to implement on the market as mentioned above.

5.4 Efficiency

There are plenty of markets that would benefit of an blockchain based system. Blockchain could, for instance, revolutionize the methods used when voting in election, it could make the political system much more transparent and trustworthy. It could help new democracies to reach a new level of trust in the system, a level that have never before been reached by any democracy. But to be able to do this, the general public and the companies need to be convinced that the technology is worth investing in, as discussed in the digitalization part.

Mats Snäll argues that trust is taken out of the equation with a blockchain based system and blockchain is a “trust-machine”. The democratic systems in the west is only working due to trust to these systems. Everything is built on trust. But one important thing to remember is that most of the elected politicians have their own interests and agendas, and this could deviate from the general publics. Blockchain cannot fix everything in a political system, but one major advantage with a blockchain-based system is that they are difficult to corrupt and fraud with. If a democratically elected president leans towards a dictator, it might harm the whole system. However, if the system is based on blockchain technology, no one can change the stored information in the chain and fiddle with the data. This is a huge advantage and maybe the biggest with blockchain. There are other ways of reaching higher levels of trust, but the essential part is that one need to trust other people. This is not always optimal and a trust-less system would be of great benefit to all societies.

Mats Snäll, through Lantmäteriet, are currently helping a country in eastern part of Europe to develop and implement a blockchain based system for their cadastral register. This country is a new democracy with plenty of promise but they are constantly under the threat of an invasion from a neighbouring country. It is therefore utterly important to protect their systems and ownership rights. If the neighbouring country decides to invade this new democracy, they cannot fiddle or claim true ownership of some property if the property is registered in a blockchain-based system. Within the chain, there is clear proofs who the rightful owner of the property is and this is well-known facts across the world.

Blockchain has great promise and could reduce the many problems within the real estate market, problems such as long transaction processes, high transaction costs and booms and busts within the market. The transaction process takes on average 114 days in Sweden for small houses and this increases the transaction costs. There are plenty of paper-work and a lot of information that needs to get validated several times. With blockchain technology, as Lantmäteriet wrote in their report, many shortcuts can be taken and several steps are no longer needed. If a system is created where all necessary information about the property and

where all the necessary information about the seller and the buyer is within a blockchain, combined with smart contracts, then the transaction process time and transaction costs could be drastically decreased.

When a blockchain system is successfully implemented and the transaction costs are reduced, one could expect an increase in transactions (see figure 9).

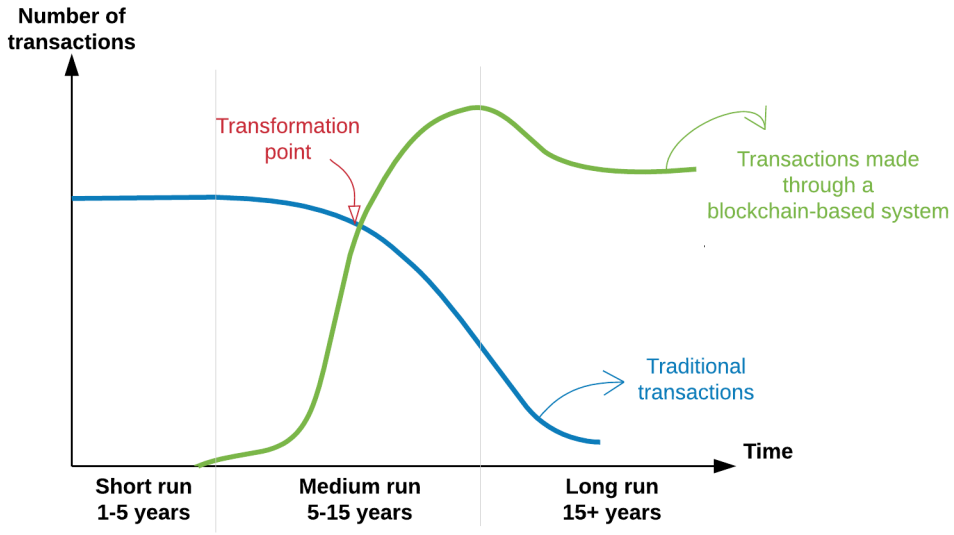


Figure 9: Number of traditional ownership transactions vs. number of blockchain ownership transactions made during a period of time.

The vertical axis represents the number of transactions made and the horizontal axis represents time. Traditional transactions, as they are today, are going to reduce when blockchain starts to get implemented. One could expect ownership transactions through a blockchain-based system to occur in four years and the popularity will increase drastically in approximately 8-10 years. Within 15 years there would probably be a peak in the number of ownership transactions due to the new way of doing transactions, but it will decrease in the long run and get a new normal. The new normal will be higher compared to todays and more transactions will occur. There are several reasons why one could expect such a development. When people have more information about the market, and the transactions costs decreases and when the transactions process is not as complicated as today, then an increase in sales will occur.

One big question is whether this would really happen and if this is something the market truly need. Transactions costs are a big deal and would benefit most parts in the process but it will also reduce the number of actors on the market. The transaction time will probably not change much from what it is today, but blockchain will bring the possibility of instant ownership transfers and transaction costs will most likely be reduced. It is therefore likely that we will see a new normal with increased number of transactions and an increased liquidity within the real estate market.

With a more liquid and efficient market, arbitrage opportunities are few or non-existent. Göran Råckle argued that the market would benefit from less arbitrage opportunities but he also believed that arbitrage opportunities should exist in a market. Without any arbitrage opportunities, not as many good deals could be made as today, where information is one major aspect to make a good deal. In a system without arbitrage opportunities, signalling is the key. If a company with a trustworthy CEO requests money, he or she will probably get it.

This would lead to a market where signalling, as discussed earlier, is the most important aspect when doing businesses. This, in turn, could lead to more trust within the market, but it could also lead to less competition. Daniel Kraft means that with more transparency there will be less actors within the market, since the less transparent companies that do not adapt to the changes will go bankrupt. Less competition is in many cases associated with more market power, and thus higher power, which could lead to even more corruption compared to today.

There is no clear evidence that blockchain will bring transparency, and therefore more efficiency to the real estate market. Companies could, and probably will, use private ledgers instead of public. This will make most of the information secret to the general public and could lead to devastating outcomes. Market leading companies will probably start collaborating and develop a private blockchain-based system they share. These companies will most likely give the general public the transparency they need, only to satisfy them and to maintain their market positions. Companies with not as much market power cannot compete and will accordingly go bankrupt. This could lead to an oligopoly, where a small number of companies have the majority of the market shares. It is therefore of great importance for regulators to regulate the market and always make sure the regulations are valid up to date.

6 The authors vision of blockchain

There are many application areas of blockchain but one area where blockchain can make a large difference, is within real estate transactions. The authors of this thesis have combined all the knowledge and information from this thesis and created a vision of how the blockchain could be used in this area (see figure 10).

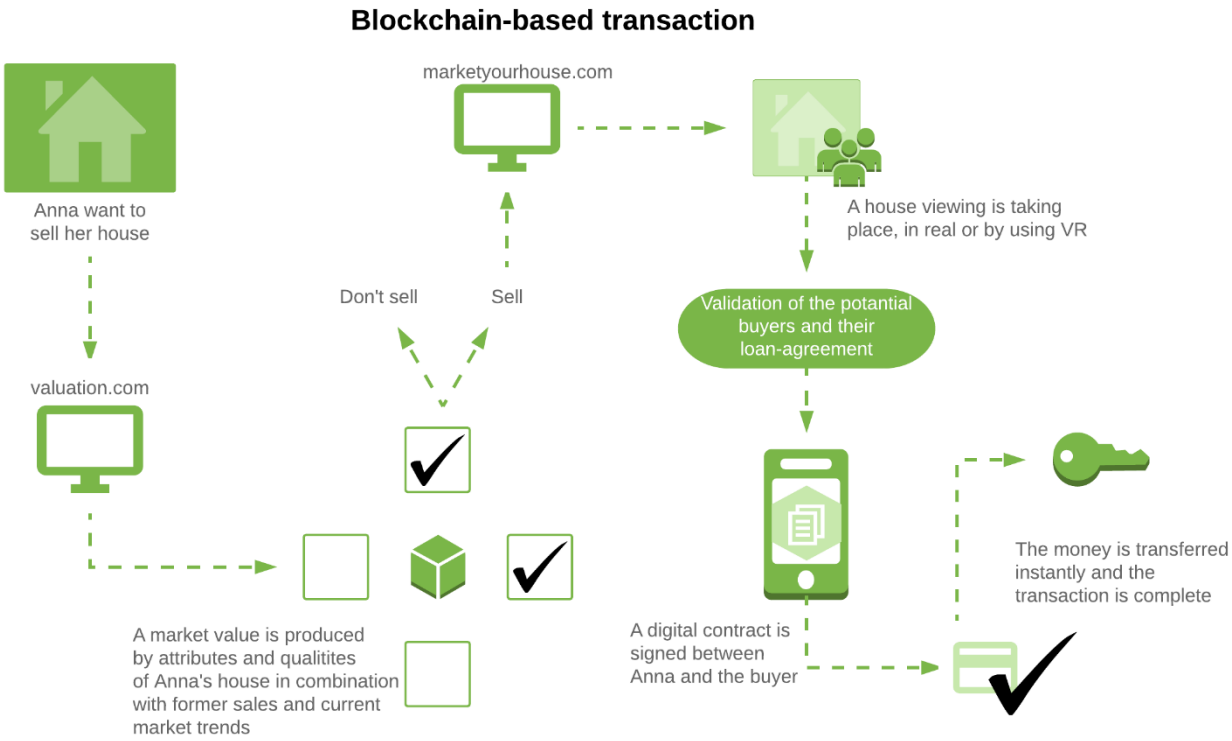


Figure 10: The possible transaction process in the future using a blockchain-based system.

Figure 10 represents a real estate transaction, where the underlying technology working in the background is blockchain-based. In the first step, we have a person called Anna. Anna request to sell her house and she have stored all the different attributes of the house in a blockchain. The attributes are, for instance, square meter size of the house, when it was last refurbished and by whom, how energy-efficient the house is and what the monthly maintaining costs have been so far. She then uses a web-based service called valuation.com which is connected to the blockchain with all the attributes of Anna's house. This blockchain is connected to all the houses in Sweden and different areas are considered. Valuation.com uses a smart algorithm that will produce the most probable market value of Anna's house. This valuation is independent of human biases but is based on former sales and on current market trends. When Anna has received the most probable market value, she will decide whether to sell or not. If she chooses to sell, she could decide to publish and market the house for a fee on marketyourhouse.com. Marketyourhouse.com matches the house with buyers who have similar requests as those whom the house can provide. These requests could be e.g. location, price, size, energy-efficiency, architectural drawn or module house etc.

When the buyers are identified, they are contacted by marketyourhouse.com and a house viewing is scheduled. The house viewing could be in real life, but it could also be done using VR (virtual reality). The buyers that are still interested in the house are now bidding on the house. To make sure that the buyers are serious potential house buyers and not only with the

intention to increase or decrease the price of the house, a screening is conducted. Marketyourhouse.com makes sure that the buyers have the money to buy the house or a loan-agreement from the bank. This screening is conducted by a blockchain-based system, and not by a human.

When Anna is satisfied with a bid, she agrees to that bid and the buyer who won the bidding process can choose to inspect the property one more time. If both Anna and the buyer has agreed upon the price and the condition of the house has been confirmed, a contract can be signed. Marketyourhouse.com offers digital contracts in their mobile phone application, where both Anna and the buyer are already registered. The contract is signed using digital signatures and the money is transferred instantly between the buyer and Anna. The ownership transfer is now complete and registered in the blockchain.

The price the buyer payed to receive the ownership rights does not need to correspond to the market value received by valuation.com. However, both the valuation made by valuation.com and the value the buyer payed are registered within the blockchain. This is to reduce the risk of misleading market values.

In this vision, there is no need for a broker. The blockchain-based system manages everything from valuation, finding the buyers to ownership and money transfers. However, there will still exist the possibility to use a broker. The broker will though have different work tasks compared to today. In a system like this, there are little or non experts needed to make a transfer. Some people want and rely more on humans than on a digital system. Therefore, there will still exist brokers who support the buyer and the seller throughout the process. They will, for instance, decorate the house to affect the attraction, or deal with different questions from the seller and/or buyer and they will validate the process is conducted in the right way (even though there is no need for that due to the blockchain-based system).

6.1 Comments on "the authors vision of blockchain"

From a market perspective, a system like the one described above would be of great benefit. There will be less biases and more efficiency within the market. However, one could argue that this will decrease the trust to other humans and make the society emotionless. Many biases today are due to human emotions and this is causing many problems. But emotions are essential to us and that is what makes us human in a sense. If we reduce emotions and irrationalities, what is left then? A world that is working well from a market perspective, but is emotionless and dull. This could cause far more social problems compared to today's problems caused by an inefficient market.

If we behave in a more rational way, where we have plenty of reliable data supporting our thoughts, than there could be a reduction in optimism about the future. The highly optimistic people will decrease which will lead to an even lower normal level of optimism. This could cause great harm to the society, when optimism about the future is reduced.

One could argue that if the general public does not have to think and worry about booms and busts, market trends, arbitrage opportunities etc. there will be more time to be more creative and artistic. The society will maybe be even more colourful and more emotions will be expressed, due to less stress and worry about the economic outlook.

The discussion above is an extreme case and will probably not happen in many years or ever. But it is important to discuss the consequences of a totally transparent and reliable market

where emotions are reduced. It is also important do discuss who would benefit from such a society, will the people living in it benefit the most or will the companies who survived the radical change? One could argue that all parts will benefit but to some degree. It cannot go to the extremes where people stop relaying on each other and only base their judgements on data. This is not a society that is built for humans.

7 CONCLUSION

This thesis has examined the possible consequences by an implementation of a blockchain-based system within the real estate sector. The study is contributing with an improved knowledge about blockchain technology and its potential and challenge within the real estate market.

The thesis has discussed the importance of adapting to the fast changes regarding increased digitalization to stay competitive in the market. The change toward systems based on blockchain technology is most likely one of these changes that has to be done, in both the financial and real estate market, to keep the actors positions on the market in the long-run. One can argue that the focus should be reconstructed from efficiency improvements to revenue growth based on strategic innovation. It is known that the real estate market is fairly conservative and inflexible, that is one of the reasons why the market must reconsider a fundamental change and adapt to blockchain-based systems to be comparable with other markets. By the performed interviews one can draw a conclusion that all the different actors seemed positive toward a blockchain-based system and due to that, a more secure and transparent system. The key issue, however, is that the actors are unwilling to invest until its fully potential are proven, despite all actors' positive attitude towards blockchain. Since the technology is in a very early development stage, and the fact that it has the potential to make the market significantly more transparent, it is a natural consequence the actors are carefully positive to the implementation. Additionally, the costs to implement new technology is extensive which can affect the implementation speed. Daniel Kraft argues that the real estate market is many years behind the technological trends compared to other markets, a digital renewal will happen, even though it will not happen overnight. The cost of developing and implementing a new digital system is costly either if it is blockchain or anything else, that is why the developing costs is not a strong enough reason not to implement.

From the results of the achieved questionnaire, one can draw a conclusion that the house buyers are slightly pessimistic to the change toward more digitalization if it affects the personal contact to the broker. Historically, one is used to sign a paper and pen contract through a traditional and personal contact, which has strong physiological influence. This behaviour and the stronger trust in a person than in a digital system is not easy to change, and it must be a fundamental change of how people view and value properties to make this happen. To earn peoples trust in the system is most likely one of the biggest challenges for a smooth implementation of a blockchain-based system. If that fundamental change is applied, many intermediates will have changed work tasks due to a shortened transaction process with less steps through intermediates. This is an adaption that should be considered, both to save costs in the transaction process, but also to make the process more efficient and smooth-going. These intermediates, for instance brokers, will most likely have different work tasks and it is highly possible that the valuation-part will be replaced by a blockchain-based system, while the brokers profession regarding conveying will be refined, where a personal contact might be more important.

Due to the fact that blockchain has the potential to create more transparency on the market, one can argue if the investments will be more successful due to the increased transparency or if there might be less speculations on the real estate market. A market with too much emotions and biases is not fully efficient. Less speculations would in turn have an impact on the property cycles and decreased bubble effects in the property market due to more

information about trends which results in more rational decisions. However, as Hans Lind discussed, a completely transparent market is a contradiction and not a desired goal for the general market. But, some transparency on the market is a necessity and there are some market areas where an increased transparency is more efficient and suitable, for instance valuation of properties.

There is, of course, plenty of markets that will benefit from an implementation of blockchain technology, not only the real estate market. One of the biggest advantages with the system is its high level of security and unhackability, where it is difficult to corrupt and fraud the system. In the real estate market, there would be possible, and worth striving for, to create a blockchain-based system with all the necessary information regarding the property, its qualities and information about the seller and the buyers and their loan commitments, and where a transaction is signed by a digital smart contract. This would result in less transaction time and costs, likewise greater security.

Finally, a summary of the conclusion of this research and the contribution of the results is stated below.

- A fundamental change towards more digitalization is most likely one change that must be done in the real estate market, where blockchain-based systems is one solution. This is necessary to maintain the actors' positions on the market in the long-run perspective.
- Blockchain could change the real estate market fundamentally, with less inefficiencies. Inefficiencies such as personal biases could be addressed and improved and a more liquid market could be reached due to reduced transaction costs.
- Real estate cycles and volatility within the market could decrease with more transparency.
- One of the biggest challenges for a smooth implementation of a blockchain-based system, is probably a fundamental change of how people value properties and their opinion regarding trust toward a digital system.
- Another big challenge for blockchain technology is to convince the companies and institutions that the technology is reliable and worth investing in.
- Intermediates, such as brokers, will have changed work tasks due to a shorter transaction processes. This can save money in the transaction process, and also make the process more efficient and smooth-going.
- Some level of transparency on the market is necessary and valuation of properties is a suitable area for more transparency.
- One of the biggest advantages with the system is its high level of security and unhackability, where it is difficult to corrupt and fraud the system.
- Worth striving for is a blockchain-based system with all the necessary information regarding the property, its qualities and information about the seller and the buyers and their loan commitments, and where a transaction is signed digitally by a smart contract.

The implementation of blockchain could, as mentioned above, contribute to more transparency and openness within the system, but it will result in some costs for the general public. The companies will most likely adjust their business models, but they will still manage to get great profit. Companies will start to take charge for their increased transparency in some way which could eventually lead to less competition and thus higher prices and more market power. This could in turn lead to more corruption and a less stable democracy.

From this research, one could draw a final conclusion that blockchain is a promising technology with great ability to fundamentally change not only the real estate market, but the market overall. Table 3 and 4 below shows a comprehensive view of possible impacts due to this implementation. The authors of this thesis are finally recommending the companies and overall market to invest more money and time in the development and implementation of blockchain technologies.

Table 3: The benefits to the society, the individuals and the market itself by an implementation of blockchain-based system on the real estate market.

Benefits		
Society	**Individual**	**Real Estate**
Less market inefficiency	Safety	Less cycles, more stable market
More relible democracy	Easier to trust the system	Higher transaction frequency

Table 4: The threats to the society, the individuals and the market itself by an implementation of blockchain-based system on the real estate market.

Threats		
Society	**Individual**	**Real Estate**
Oligopol	Changes in work tasks	Less arbitrage opportunities
Emotionless system, everything is based on rationality	Less human contact	Problems with adjustments to the increased requirements

7.1 Further research

This master thesis focuses on the implications of implementation of blockchain technology into the real estate market, the consequences of it and if the implementation should occur or not. There are plenty of fields that are suited for blockchain within the real estate market and this thesis has only scratched the surface of the potential of the technology. A future valuation of what blockchain brought to the market would be an interesting research topic in the next decade, what the advantages are and how it should further be improve.

One interesting topic within the real estate market is valuation. Blockchain has great potential to affect the valuation market, where appraisal might no longer be needed. This is a topic well suited for further research. Another interesting topic is how to make the rental-market more efficient and how blockchain technology could affect the way we are renting out our homes and how the rental market might get affected. A general framework for a blockchain based platform should as well be investigated and analysed.

Blockchain is not only suited for the real estate market, it is suited for all market that has ownership and transfers occurring. The financial market is a hot field but the car industry,

payment solutions and security fields are as interesting. To see how these markets would be affected by a big technical change, an investigation needs to be conducted.

Regulations is a hot topic and the regulators are not up to speed with the advances of technology. This is a problem for the different markets, especially the financial market. An interesting research topic would be how regulators adapt to the fast-changing world and if there exist any regulatory obstacles with the implementation of blockchain.

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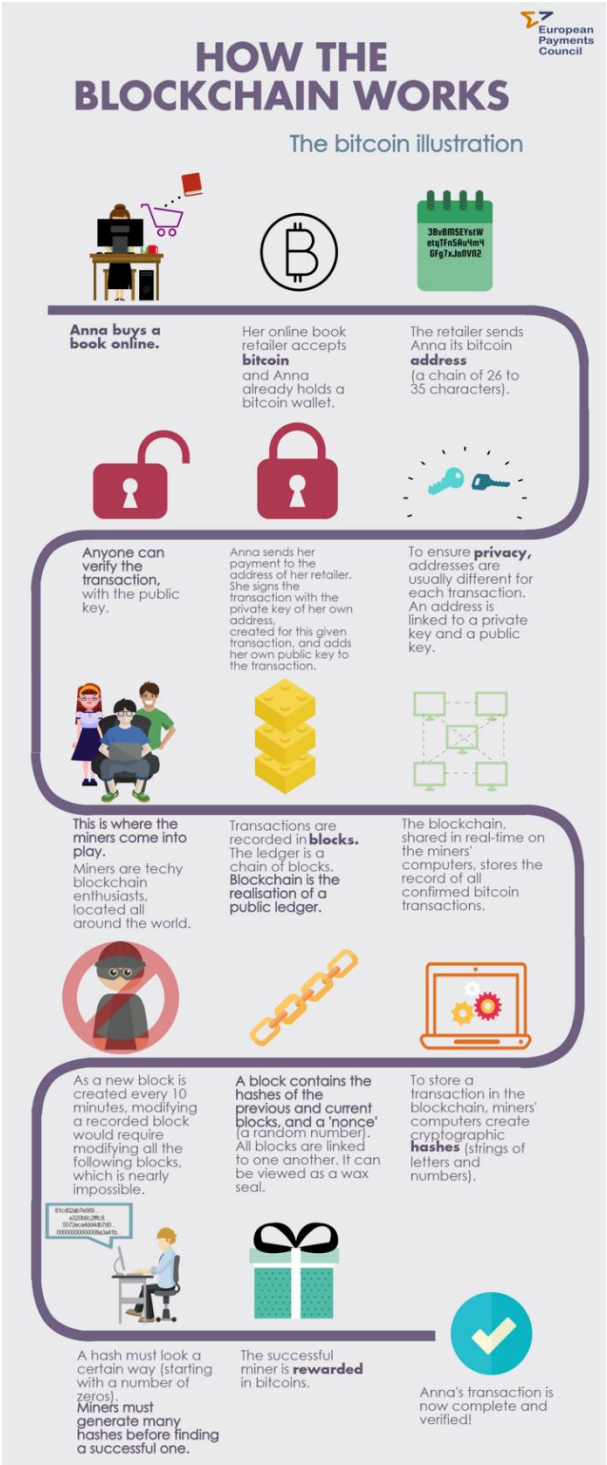
9 APPENDIX

Appendix A – How the blockchain works



Source:
http://www.europeanpaymentscouncil.eu/index.cfm/newsletter/article/?articles_uuid=F9B5D02B-5056-B741-DB2A2784926CB3F8

Appendix B – Interview questions

Mats Snäll, Registry Development and Digital Director at Lantmäteriet:

- Could you please describe who you are and what your role is at Lantmäteriet is?
- In what phase is the blockchain pilot-program? Which role does Lantmäteriet have in the project?
- How could an implementation of blockchain market affect the real estate market in a short-run and a long-run perspective? What are the opportunities for Blockchain?
- What future challenges exists for blockchain within the real estate market? Are there any obvious risks with the implementation?
- How will the implementation of blockchain go about at Lantmäteriet? Are there any necessary collaborations between any actors to make the implementation work?
- What is your opinion about market transparency? How transparent should the market be?
- What are the biggest advantages with smart contracts? What problems could you identify with it?
- Why do you think the market is ready for blockchain right now? How will the technology spread to different institutions?
- What is the biggest advantage with blockchain? What is the biggest obstacle?

Göran Råckle, Head of Real Estate Analysis and Sören Jonsson, Real Estate Analyst specialized toward cash-flow analysis at Swedbank.

- Could you please describe who you are and what your role is at Swedbank?
- What is the biggest challenges for the real estate market now and in the future?
- What needs to change to get a more functioning real estate market?
- What affects the real estate cycles?
- Would a more transparent and secure market make the real estate market less volatile?
- What affects bubbles? How can one avoid bubbles?
- What are the biggest challenge for the banking sector today?
- How does Swedbank work with innovation? How does Swedbank work with increasing its digitalization?
- What is the biggest advantage with blockchain? What is the biggest obstacle?

Hans Lind, Dr. National Economics and Professor at KTH.

- Could you please describe who you are and what your role was at KTH?
- What is the biggest challenges for the real estate market now and in the future?
- What trends do you see in the real estate market today?
- Would decreased transaction cost affect the “moving-chain”?
- What affects the real estate cycles?
- Would a more transparent and secure market make the real estate market less volatile?
- What affects bubbles? How can one avoid bubbles?
- How will more transparency affect the real estate market?
- Is it necessary to have a more transparent market? Do the people or the different actors want a more transparent market and why?

- Is the market ready for a fundamental change?
- What is the biggest advantage with blockchain? What is the biggest obstacle?

Rickard Engström, Ph.D. and lecturer at KTH, former real estate agent.

- Could you please describe who you are and what your role is at KTH?
- What trends do you see in the real estate market today (related to valuation and transaction prices)?
- Are there any problems with todays valuation methods? What are the primary problems?
- How are the transaction prices affected by the problems associated with valuation?
- Is there a need to change these problems and why?
- How are the market value of properties affected by “bait-and-switch” prices?
- What is your definition of a market value of a property?
- How would more market transparency affect valuations?
- Is there a need for a more transparent market and why?
- If there is a technology that makes the transaction process shorter and faster, how would that affect the margin of error within valuations?
- What should the appraisers do to get a value of a property closer to the true market value?
- How does the future real estate broker profession look like?
- Are there any problems with the selling process of a property today?
- How does commissions affect the way a broker acts?
- What is the biggest advantage with blockchain? What is the biggest obstacle?

Ester Sundström, Senior Manager at Deloitte.

- Could you please describe who you are and what your role is at Deloitte?
- Are you current developing and/or implementing blockchain-based systems?
- What is the main purpose with blockchain?
- What is the biggest obstacle for blockchain today and in the future?
- What markets are most suitable for blockchain?
- What is your opinion about an blockchain implementation on the real estate market? What could blockchain accomplish on the real estate market?
- Are there any clear risks involved with the implementation?
- What is your opinion about transparency and how transparent market should we have?
- What are the biggest advantages with smart contracts? What kind of problems could you identify with these?
- Why do you think the market is ready for blockchain right now? How will the technology spread to different institutions?
- Is blockchain overhyped?
- What is the biggest advantage with blockchain? What is the biggest obstacle?

Daniel Kraft, Head of Investment Realtech at Stronghold.

- Could you please describe who you are and what your role is at Stronghold?
- How does Stronghold work with innovation and digitalization?
- Why are the realtech investments so big today and what is the market trying to accomplish?
- How would an implementation of blockchain affect the real estate market in the short-run and long-run perspective?
- What are the opportunities of blockchain within the real estate sector?
- Are there any collaborations between different actors to make a standardization within realtech? Is it necessary to have a market standard and why?
- Is blockchain overhyped? Are the expectations overhyped about what blockchain can accomplish?
- What is the biggest challenge for the real estate and financial markets today and in the future?
- What needs to be changed to get a more functioning real estate and financial market?
- What affects real estate cycles?
- Would a more transparent and more secure market make the market less volatile?
- What is the biggest advantage with blockchain? What is the biggest obstacle?

Appendix C – Questionnaire

Q1. What is your age?

Q2. What is your education?

Q3. Are you a first-time house buyer?

Q4. How reliable do you think the broker is?

Q5. How reliable do you think the seller is?

Q6. Do you think any party (eg. a broker or seller) has an information advantage compared to you in the sales process?

Q7. Today's real estate register is centralized to one authority which can make the system more vulnerable. Is that something you feel uncomfortable with?

Q8. How important is personal contact with the broker?

Q9. If a reliable digital system (such as an AI) could replace a broker's services, would you be comfortable to use such a digital system?

Q10. Would you feel comfortable to sign a digital contract through a phone app?