

Blockchain and Real Estate Industry

Master thesis

International Master of Science in Construction and Real Estate Management
Joint Study Programme of Metropolia UAS and HTW Berlin

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Alireza Khalafi

S0557526

First supervisor: M.Sc. Sunil Suwal

Second supervisor: Dr. Sc. Giw Zanganeh

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¹ Influenced by Rami Mlek's speech on Feb 24, 2019

Proposed conceptual formulation



International Master of Science in Construction and Real Estate Management Joint Study Programme of Metropolia Helsinki and HTW Berlin

Date 21.08.2018

Conceptual Formulation
Master Thesis for **Mr.Alireza Khalafi**
Student number **S0557526**

Topic: Blockchain and Real Estate Industry

EXECUTIVE SUMMARY:

This research firstly introduces blockchain technology with a focus on the economics. Secondly investigates different aspects of the real estate industry to highlight trades that either is already benefiting from the blockchain economy or have a higher potential for migrating to this economy. Finally, after introducing the blockchain economy and highlighting the trades, research will look for obstacles in implementing the blockchain economy and will try to offer solutions.

BACKGROUND:

Since the very first release of Autodesk's flag product for windows at 1986, the Real Estate Industry (REI) managed to seize the opportunity of implementing computing in various aspects of the industry. This implementation gifted the industry with more feasible communication between the different assets of projects. DWG files become a standard file format for drawings that could be viewed, edited, and sent by almost all the professionals working in the REI.

Building Information Modelling (BIM) has taken the established communication to another level by benefiting from the cloud technology. Industry Foundation Classes (IFC) files are the new standard data exchange file format for BIM applications. Unlike DWG files, IFC files can carry more information than just drawings but more importantly, can be exported and imported by several new applications such as Tekla and Trimble Connect.

International standards such as Eurocodes has facilitated the new era of communication with international standards. Neglecting the national annexes to international standards and codes, professionals in the industry are no longer bounded by the national boundaries and can trade their expertise with foreign colleagues and corporations.

However, with the all mentioned above breakthroughs in the road to globalization, economic barriers are yet to overcome. It is most common that various participants of a project, either freelancers or corporations, have to decide on a specific source of legalization and economy. This centralization limits projects as local banks, as financial assets of any given project, are overruled by local government. The governments' approach with financials may fluctuate based on their business-friendly political consensus. In case of dramatic political redirections, due to huge changes on financial platforms, the success of many projects can be jeopardized. For instance, the European Union (EU) referendum in the United Kingdom (UK) resulting of the UK's walkout from the EU and/or the sanctions against Russia and Iran has forced many projects to be on held for long or even considered cancelled or failed. In yet to be developed countries that the state itself is not in a very stable position and their currency fluctuation is rather harsh, international collaborations tend to get cold feet. In more stable situations that the whole status of a project is not jeopardized due to a centralized economy, replacing bank, which acts as a middleman, with a decentralized financial platform is the highest goal of this research.

The research will firstly, introduce smart contracts and blockchain economy from a real estate point of view. Then, secondly, using different key performance indicators such as level of BIM implementation, the research will try to investigate different trades of real estate industry that are more likely to benefit from the smart contracts and blockchain economy. Finally, the obstacles to this implementation will be mentioned and some solutions will be offered.



OBJECTIVES:

1. Introduce blockchain, smart contracts, and blockchain economy
2. Investigate current status of smart contracts and blockchain economy in real estate and other industries.
3. Highlight trades from the real estate Industry that can benefit the most from smart contracts and blockchain economy due to their nature and current status of BIM implementation.
4. Point out obstacles within the implementation of smart contracts and a blockchain economy in the real estate Industry and offer solutions to overcome them.

RESEARCH QUESTIONS:

1. What is blockchain?
2. What is cryptocurrency and what is its current status in the market?
3. What are smart contracts and how do they work?
4. What assets and trades of the real estate industry have the highest potential for migrating to a blockchain economy?
5. What are the obstacles to the implementation of smart contracts and the blockchain economy in the real estate industry and how they can be tackled?

METHODOLOGY:

Primarily, using the reference resources for blockchain, the smart contracts and the blockchain technology will be explained. Finding the most suitable aspects of the industry for implementation of smart contracts and the blockchain economy will take place mostly using research papers and experts interviews. Highlighting obstacles and solutions to overcome them will happen mostly to the knowledge accumulated through the research as well as consultations with supervisors and professionals.

TIME FRAME:

The master's thesis will commence on September 1st, 2018 and will last for 20 weeks.

- 3 weeks: Study the key contents and create an outline
- 3 weeks: Forming a table of content and road map
- 3 weeks: Drafting economical chapters
- 2 weeks: Interviewing and surveying professionals.
- 2 weeks: Drafting real estate chapters
- 1 week: Outlining assets and obstacles
- 1 week: Getting feedback assets and obstacle's output
- 2 weeks: Preparation of the first draft
- 3 weeks: Research conclusion, Final draft, Hardcopy handover

Mr. Sunil Suwal
M.Sc. HTW Berlin/Metropolia Helsinki

Dr. Sc. Giw Zanganeh
ETH Zurich

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REQUEST TO CHANGE THE TITLE OF THE FINAL THESIS

Family Name:	Khalafi	First Name:	Alireza
Telephone:	+358442301546	Email:	alirezakhalafi86@gmail.com
Street address:	Aristotelessteig 10	Postal Code/City:	10318 Berlin
1st Supervisor:	Sunil Suwal	2nd Supervisor:	Giw Zanganeh

I wish to request for the following change to the title of my thesis.

Previous title:

Implementation of Token Economy in Real Estate Industry

New title to be confirmed:

Blockchain and Real Estate Industry

Please note that changing the title of the final thesis does not constitute a rejection of the topic as defined by § 21, no. 2 of HTW's Examination Framework Regulations!

Agreement of the 1st examiner:

Agreement of the 2nd examiner:

Agreement of the examination board:

Berlin, 20.12.18

Signature of the candidate

Abstract

The underlying layer of Bitcoin, blockchain technology, is the disruptive technology after the internet. This thesis studies the real estate industry and blockchain technology to highlight the needs for a fusion, along with the current technological and economic developments as the facilitators of adaptation between the industry and technology. Conducting a survey, this study proofs that public perceptions, interest, knowledge, and legal awareness for cryptocurrencies and smart contracts are low for both real estate and other industries. After reviewing the current applications of blockchain technology in the real estate, this thesis offers other use cases of the technology within the industry.

Table of Contents

Acknowledgment	ii
Abstract	vii
Table of Contents	viii
Table of Figures.....	xii
List of Tabulations	xiii
List of abbreviations.....	xiv
List of Symbols	xv
List of equations	xv
1. Introduction	1
1.1. Subject	1
1.2. Motive	3
1.3. Objective	4
1.4. Structure.....	4
1.5. Scope	5
1.6. Methodology.....	6
1.7. Importance of the study	7
1.8. Assumptions	9
2. Real estate industry	10
2.1. Introduction.....	10
2.2. Technology developments.....	11
2.2.1. Building Information Modeling	11
2.2.1.1. BIM in development and construction phases.....	12
2.2.1.2. BIM in the utilization phase	15
2.2.2. Internet of Thing	17
2.2.3. Green and smart environments	20
2.3. Globalization and Internationalization.....	23
2.4. Share economy and Gig economy	24
2.5. Challenges	27

2.5.1. Inefficiencies	27
2.5.1.1. Development	28
2.5.1.2. Title Transaction	29
2.5.2. Fraud	31
2.5.3. Transparency	32
2.5.4. Corruption	34
2.6. Summary	35
3. Blockchain.....	37
3.1. Introduction.....	37
3.2. Blockchain basics.....	38
3.2.1. Definition.....	38
3.2.2. Block.....	42
3.2.3. Distributed Ledgers.....	42
3.2.4. Cryptography	43
3.2.5. Public key cryptography	44
3.2.6. Hashing and chaining the blocks	45
3.2.7. Merkle Tree.....	46
3.2.8. Consensus Protocol.....	47
3.2.8.1. Mining and Proof-of-Work.....	47
3.2.8.2. Proof-of-Stake	49
3.3. Blockchain 1.0 Currency.....	50
3.3.1. Currency	50
3.3.1.1. Concept of currency	50
3.3.1.2. Representative currency.....	50
3.3.1.3. Fiat currency.....	51
3.3.1.4. Euro: An international currency	52
3.3.1.5. Drawbacks of fiat currencies	52
3.3.1.6. The market crash of 2008.....	54
3.3.1.7. Comparison of Cryptocurrency and Fiat currency	56
3.3.1.8. Summary	56
3.3.2. Cryptocurrency.....	57
3.3.2.1. Bitcoin.....	57
3.3.2.1.1. Lightning network	57
3.3.2.2. Other Cryptocurrencies	58
3.3.2.3. Colored Coins.....	58

3.3.2.4. Wallets.....	59
3.3.2.5. Drawbacks of cryptocurrencies	59
3.3.3. Cryptocurrencies and real estate industry.....	60
3.3.4. Summary.....	61
3.4. Blockchain 2.0: Smart Contracts	62
3.4.1. Ethereum	63
3.4.2. Crowdfunding.....	64
3.4.3. Artificial intelligence	65
3.4.4. Internet of things	66
3.4.5. Limitations and Drawbacks	67
3.4.6. Smart contracts and real estate industry.....	68
3.4.7. Summary.....	69
3.5. Blockchain 3.0: Beyond Currency, Economics, and Markets	69
3.5.1. Blockchain for organizing activity model	70
3.5.2. Extensibility of Blockchain concepts	70
3.5.3. Digital Identity	71
3.5.4. Hashing and timestamping.....	72
3.5.5. Proof of existence, location, and ownership of physical and digital assets	
72	
3.5.6. Decentralized autonomous organizations	73
3.5.7. Blockchain Government.....	73
3.5.8. Decentralized Governance Services.....	74
3.5.9. Liquid Democracy and Random-Sample Elections	75
3.5.10. Blockchain 3.0 and real estate industry	76
3.6. Limitations, Drawbacks, and Challenge.....	77
3.6.1. Technical.....	78
3.6.2. Public Perception	78
3.6.3. Legal, Governmental and Political	79
3.6.4. Scalability.....	83
3.6.5. Sustainability.....	83
3.7. Conclusion: Blockchain, The internet of value	84
4. Current applications of blockchain in the real estate industry	86
4.1. Introduction.....	86
4.2. Alt.Estate: Real estate asset tokenization, Investment, and trade	87

4.3. Propy: Land title registry and transaction platform.....	88
4.4. Rentberry: Decentralized renting platform	90
4.5. Bitrent: Developers and investors' collaboration platform.....	90
4.6. Travala: Short term accommodation platform on the blockchain.....	90
4.7. Unitalent: Freelancing platform on the blockchain.....	91
5 Survey.....	93
5.1 Conduction and purpose	93
5.2 Key findings	94
5.3 Results	94
5.4 Scoring and analysis	100
5.5 Summary	106
6 Use Cases	107
6.1 Introduction.....	107
6.2 Project management on the blockchain.....	107
6.3 Blockchain empowered artificial intelligence as a decision-making tool in real estate investments	112
6.3.1 Introduction	112
6.3.2 Real estate and Artificial intelligence	112
6.3.3 Available data and AI training mindset.....	114
6.3.4 Code architecture for a self-training AI.....	116
6.3.5 Interpretation of trained AI output and conclusion	119
6.4 Facility cost management on the blockchain	120
6.5 Local energy markets on blockchain	122
7 Conclusion	124
8 Declaration of Authorship.....	126
9 Appendixes	127
9.1 A: Real estate transactions today according to Swedish to real estate division 127	
9.2 B: Survey Results.....	129
10 Publication bibliography	145

Table of Figures

Figure 1: Publication year of blockchain related academic papers	7
Figure 2: Industries seen as leaders in the blockchain	8
Figure 3: Areas of the real estate industry most likely to adopt blockchain technology	10
Figure 4: Project team and the collective organization boundaries.....	12
Figure 5: The Vico Office Suite overview.....	13
Figure 6: Data flow within the Vico Office	14
Figure 7: Overview of applied BIM in FM.....	16
Figure 8:BIM maturity towards digital sustainability	17
Figure 9:The Top 10 IoT Segments in 2018 – based on 1,600 real IoT projects	18
Figure 10: Amazon Go guideline	19
Figure 11: Bright green buildings.....	20
Figure 12: A schematic overview of a smart city.....	22
Figure 13: the World of Real Estate Transparency	34
Figure 14: Two Yap islanders standing next to their ancient currency, a Rai	39
Figure 15: Yapi's trading concept using Rai currency.....	40
Figure 16: The Merkle Tree of transactions A, B, C & D.....	46
Figure 17: A schematic overview of the transaction process on a blockchain	49
Figure 18: Iran's annual inflation rate, official compared with its actual	53
Figure 19: The purchasing power of the consumer dollar (1920-2019)	54
Figure 20: Deviation from Trend of GDP per Working-Age Person since 2007	55
Figure 21: Results for survey question, "Do you own some cryptocurrency?"	62
Figure 22: The first American house deed using a smart contract	68
Figure 23: Growth of crypto assets (2014-17) in comparison with the growth of websites (1991-95)	77
Figure 24: The biggest barriers to blockchain adoption	79
Figure 25: Bitcoin and Ethereum ATMs shut down after a new regulation in China	80
Figure 26: Responses for: What is the legal status of cryptocurrencies at your region?	81
Figure 27: Global legal status of cryptocurrencies	82
Figure 28: Blockchain projects' status	87
Figure 29: Interaction of transaction participants via the blockchain.....	88
Figure 30: Peer-to-Peer Transactions in the Propy decentralized application	89
Figure 31: Token ecosystem of unitalent.....	92
Figure 32 : Age and Region overview.....	95
Figure 33: Real estate professionals' participantship ratio and involved phase.....	96
Figure 34: Employment status and sector	96
Figure 35: Tenancy and education status.....	97
Figure 36: Source of knowledge on Bitcoin/blockchain and smart contracts	97
Figure 37: Highest and lowest tendencies to utilize the blockchain applications	98
Figure 38: Ownership, knowledge, and utilization of cryptocurrencies	98
Figure 39: first time using the internet and online payments	99
Figure 40: Scoring logic for Yes/No and rating questions	100
Figure 41: Scoring logic for the question "How many cryptocurrencies do you own?"	101

Figure 42: Score comparison between real estate and other industries	102
Figure 43: Score comparison between different age groups	102
Figure 44: Comparison of scores based on the first time of using the internet	103
Figure 45: Comparison of scores based on point of view on internationalization ...	103
Figure 46: Comparison of scores among real estate professionals based on the phase of involvement.....	104
Figure 47: Comparison of scores based on region	104
Figure 48: Comparison of scores based on using gig economy as customer.....	105
Figure 49: Comparison of scores based on using share economy as customer....	105
Figure 50: Comparison of scores based on coding skills.....	106
Figure 51: Project management on blockchain.....	108
Figure 52: blockchain-enabled crane leasing	109
Figure 53: Funds release procedure for a rental tower crane	110
Figure 54: the three states of data	114
Figure 55: AI training mindset.....	115
Figure 56: Overview of a self-training code architecture.....	118
Figure 57: Comparison between P and housing market index	119
Figure 58: Procurement delivery on smart contract	120
Figure 59: Task management system on IoT	121
Figure 60: Blockchain based architecture for decentralized management of energy grids.....	122

List of Tabulations

Table 1 Real Estate cryptocurrencies by market capitalization size in million dollars	61
Table 2 Energy consumption of Bitcoin compared to existing methods.....	84

List of abbreviations

AI.....	Artificial Intelligence
ATM.....	Automated Teller Machine
BTC.....	Bitcoin (Currency abbreviation)
BIM	Building Information Modeling
CIM	City Information Modeling
CPU	Central Processing Unit
DAR	Data at Rest
DAO.....	Decentralized Autonomous Organizations
FM	Facility Management
IoT	Internet of Things
IP	Internet Protocol
KPI	Key Performance Indicator
PC.....	Personal Computer
QR.....	Quick Response
RFID.....	Radio frequency identification
RTLS.....	Real Time Locationing Solutions
SPV	Simplified Payment Verification
SWIFT	Society for Worldwide Interbank Financial Telecommunication
WSN	Wireless Sensor Networks

List of Symbols

T_i : Time of study

K'_1 : Extracted price for areas near the studied pixel

W_1 : Key Performance Indicators' influence on the studied pixel (Wight)

K_1 : Estimated price for the studied pixel

K_2 : Study pixel's actual price received from human feedback or a trade certificate

P : Ratio between estimated price and the actual price

List of equations

$P = K_1 / K_2$: Ratio between estimated price and the actual price

$\lim_{i \rightarrow \infty} P = 1$: Training object

1. Introduction

1.1. Subject

Ten years after publication of Satoshi Nakamoto's whitepaper "Bitcoin: A Peer-to-Peer Electronic Cash System" (Nakamoto 2008), the technology behind this electronic cash that removes the need for participation of a third trusted party, known as blockchain, has been expanded to be the next disruptive technology after the internet (Swan 2015).

Nakamoto's paper created the world's very first cryptocurrency known as Bitcoin which by February 23rd, 2019 has a disposal value of over four thousand dollars with a market capitalization of over 67 billion dollars (Saint Bitts LLC. 2019) . This value, no matter its fluctuations, indicates the global trust in blockchain technology. However, cryptocurrencies' value itself is not in this thesis's concern, but, it demonstrates the functionality of the blockchain technology at its first class, known as Blockchain 1.0. This research is to explain the blockchain technology and its current classifications, current blockchain projects within the real estate industry and finally how it can affect the industry.

Blockchain technology is so vast and new that even choosing the right name for this technology has its difficulties. As the most of the blockchain related resources reviewed in the literature review keep their aim mostly around the problems that can be solved using the blockchain technology, it can be understood that the technology is in the infrastructure development phase. Meaning that many possible functions of this cutting-edge technology are yet to be unveiled. To explain more, comparing blockchain with its previous disruptive technology, the Internet, can be convenient. Taking blockchain technology just as a payment method is the same as assuming the internet as a fancy telephone (Antonopoulos 2016, p. 8).

The real estate industry as one of the oldest industries has implemented different technologies in various ways. Building Information Modeling BIM can be named the latest implementation of digitalization and the first implementation of practical use of clouds and instant communications. The creation of BIM was to tackle the tremendous amount of inefficiency in all three major phases of a real estate property's lifecycle.

The authors of strategic guide for implementation of BIM believe that the real estate industry is facing a looming crisis of inefficiency both at energy and raw material consumption that can lead to catastrophes like global warming and climate change (Tardif Michael and Smith Dana K 2009).

The importance of BIM as an infrastructure for implementation of blockchain technology, however important, is not binding. For example, foreign labors sending money to their families that are part of the world's two billion unbanked population (Hodgson 2017), may be the first adopters of blockchain 1.0 in practice within the industry. This example illustrates why participants, both professionals, and clients' needs and tendencies can be vital in the adoption of the technology. On the other hand, real estate industry trades, that use BIM can adopt different functions of blockchain technology to solve many issues such as trust, transparency, and machine to machine transaction in smart environments.

As there are needs for functions that blockchain technology has to offer for real estate industry such as authentication and ownership, this thesis aims to demonstrate the potentials of this adaptation.

The author believes that blockchain can disrupt the real estate industry from various aspects by removing uncertainties about assets and participants. Blockchain has proved its ability to deliver a distributed and tamper-resistant transaction framework for the Internet. For example, in many procedures in real estate industry, it is not so uncommon for any legally binding document or agreement to be typed, printed and signed, scanned and sent, followed by handing over the hard copies. In these types of procedures, the internet is being used to send a message that mostly has no value without the existence of the original hard copy. These inefficiencies can be traced in deeper layers of the real estate industry too. By extracting value from its mediums like paper, blockchain's ability to reform the real estate industry is to discuss in this thesis.

1.2. Motive

Born during wartime and raised during the sanction era, I believe blockchain technology can embrace peace and help humans to overcome the imaginary borders that divide the people. Beyond that, by disrupting the current concept of trust, this revolutionary medium of value, aids financial democracy in the same way that the internet enhances knowledge democracy. Thanks to the internet, this thesis, written, supervised, and coordinated by participants from four different nationalities living in three different countries. I believe blockchain can be the platform where a property can be developed and managed on a global scale where its participants are not limited by the current boundaries that are mostly due to the consistent need of a higher authority to legitimize any valuable transaction. Furthermore, using the blockchain technology, these participants do not necessarily need to trust, or even know each other.

The motive is to explain the blockchain's potential as an infrastructure for a real estate industry in which, a piece of land could be bought, permitted, built, sold or rented, and utilized more efficiently than today. For instance, According to Lantmäteriet (2016), the Swedish mapping, cadastre, and land registration authority: the average property title transaction has 33 steps and takes 124 days to complete². In a blockchain friendly environment, that could be with few clicks. It is to review this machine of trust and deliver the understandings through this thesis to arouse enthusiasm for further studies because it is what blockchain needs today.

The quest of this thesis is to understand how blockchain, as a tool, that can change the real estate industry to a more efficient, sustainable, transparent, and global industry that benefits its end users and professionals instead of the one percent who have deeply rooted at the top its current hierarchical system.

With lower influence from higher-level society, it is to find out how blockchain can bring power to the people. This transition of power is possible with the blockchain technology that offers a practical infrastructure for micro-investing, voting, and value transacting through the internet without any interaction of any dominative third party. Author has the motive to highlight the role of blockchain technology as a new tool that has the potential to make this blue planet a better place to live by embracing democracy.

² See Appendix A for details

1.3. Objective

How blockchain technology will affect the industry is the primary concern of this research. Because this technology is less than a decade old, there are limited resources that cover both the real estate industry and blockchain simultaneously. Most of the available resources covering blockchain and real estate industry's interaction are limited to online publications and few master thesis' reports. This research firstly will aim to deliver a conceptual understanding of blockchain technology and its classifications. Second, by breaking down the real estate industry to its current technological developments and challenges, highlighting the potential and need for adopting the technology. The final step will be investigating the impact of the blockchain technology using break down of blockchain classifications mashed with trades and participants of the real estate industry.

Technical understandings about blockchain are minimized to keep the main objective clear. However, essential technical knowledge about the fundamentals of each class of blockchain discussed in brief.

1.4. Structure

This thesis is conducted in seven chapters. After introducing the study in the first chapter, the second chapter studies through the real estate industry aiming to highlight developments and challenges. The third chapter introduces blockchain technology within its different classification with a sample of implementation within the industry for each classification. The fourth chapter will create an overview of current applications of blockchain technology within the real estate industry from various categories. In the fifth chapter, the author reports, and analyses the results of a survey conducted by this study. In the sixth chapter, using the accumulated knowledge during the study, in order to illustrate that how different participants in different trades of the real estate Industry can adopt the blockchain technology and benefit from it, the author offers four different use cases as case studies. The conclusion puts the findings in a nutshell.

1.5. Scope

As this master thesis is in Construction and Real Estate Management, which is a joint study programme between the Metropolia UAS, and HTW Berlin School of Technic and Economic, the scope of the study is to remain in managerial level with economic perspectives. Having said that, as “joint programmes” are conducted through the European Union to facilitate internationalization (European Commission 2018), this study tends to overview the general effects of blockchain technology on the real estate industry with a global perspective.

The quest of this thesis is to highlight the potentials of blockchain technology to facilitate transactions within the real estate industry. The author finds it crucial to emphasize that transactions are not limited payments. The blockchain is known as the internet of values and values are not limited only within the financial sector, for example, selling a property is a transaction that transfers the ownership title of a real estate property between two parties. Taking this one-time transaction to the global scale, even investors with U.S administrative privileges and influences have problems handling their international real estate investments and trades (Gup 2017, p. 213). The purpose is to demonstrate an overview of a technology that solves such problems. With solutions offered by the blockchain technology through applications such as the Alt. Estate that offers international investments as small as one square meter. There eswanst far valuable and complex transactions within the real estate industry that this thesis aims to cover and discuss.

The scope is to deliver collected knowledge through this thesis by highlighting current solutions to such barriers. Though the technical aspects are only demonstrated to explain the concepts better and how exactly these functions will be executed and what are the specific legal and technical limitations are beyond the scope of this study. However, both mention barriers studied and reported in brief.

The scope of is study is to be useful for real estate participants who are enthusiastic about blockchain implementations and blockchain experts who tend to lean through the real estate industry. This is a conceptual, informative thesis with a broad but shallow coverage over the real estate industry, its pain points, blockchain technology, facts and ideas about blockchain empowered solution for the mentioned pain points.

1.6. Methodology

The paper is of explorative and conceptual. The author reviews related literature of real estate and blockchain, same with literature and applications overlapping both industries and finally, by running a survey and overviewing current applications of blockchain technology within the industry, the study offers some use cases of blockchain technology within the real estate industry.

The raised topics within real estate are to highlight technological development, modern formats of the economy and finally the pain points of the industry. A survey with 201 participants from both the real estate industry and other industries illustrates the current public's perception about the technology. The sample selection was from sharing the survey request within the author's' social media networks such as LinkedIn that got shared in different groups such as Metropolia UAS,' and Commercial Real Estate Executives' groups (Linkedin 2019a, 2019b). Two hundred printed handouts mantled on HTW and TU Berlin's boards as well as some community working offices in Berlin such as WeWork and Silicon Allee.

In real estate, a selection of developments within the industry mostly influenced by different courses studied during construction and real estates management master programme such as applied product modeling, sustainable development, facility management, intercultural working and cooperation, and international site management (HTW Berlin 2019). The challenges within the industry are mostly the pain points raised by the International Blockchain Real Estate Association's conferences and articles (IBREA 2018).

The blockchain literature review based on a framework offered by Swan's (2015) book on blockchain technology with some modifications for delivering the required knowledge about blockchain in order to understand the use cases. For the illustration of high potentials of the blockchain technology in the real estate industry, selected use case with relevance to pain points of the real estate industry studied. The importance of conceptual style of the paper is necessary due to the general lack of knowledge about this technology.

1.7. Importance of the study

The importance of this study is adding to limited academic researches on the overlapping area between the real estate industry and blockchain technology. There are limited academic resources on the blockchain, claimed Yli-Huumo et al. (2016) and offered Figure 1 that shows there are less than 25 papers that study blockchain each year until 2015.

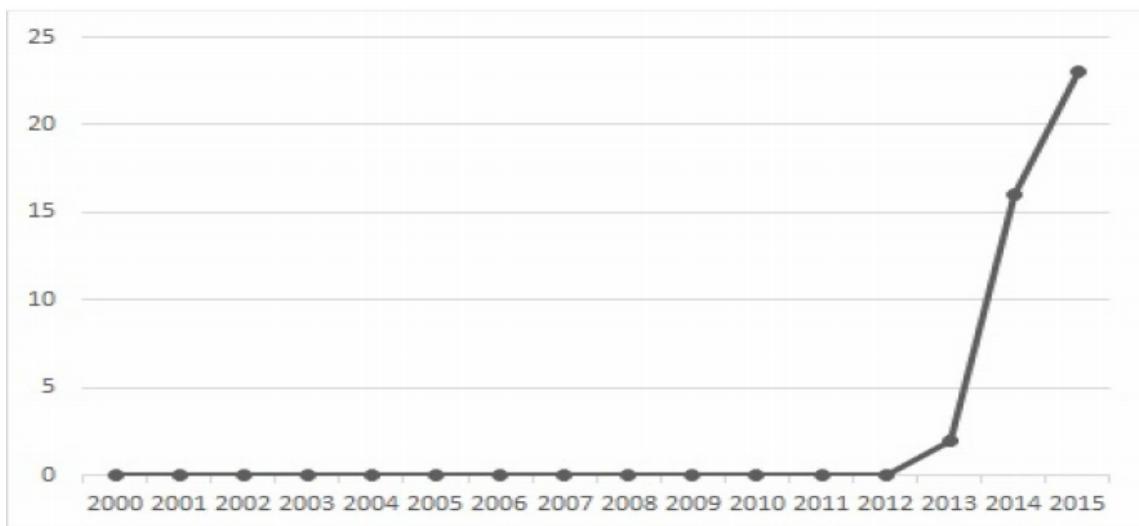


Figure 1: Publication year of blockchain related academic papers³

However, the number of studies are rising, and by November 2017, number of academic publications were 154 papers (Blockchain Library 2018). The other importance of this study is that, as shown in Figure 2 on the next page, the real estate industry has less than one percent share from the blockchain market (PwC 2018). The importance of this study is to arise information and enthusiasm within the real estate industry for more adoption and collaboration with the blockchain industry. As Antonopoulos (2016) mentioned that growth in blockchain is exponential so the first studies can create an environment that experiences exponential growth in the number of studies. More important than that, there would be more studies that result in practical

³ Yli-Huumo et al. 2016.

business plans which can step into really in a collaboration of blockchain experts and real estate professionals.

Figure 2 illustrates existing industries within the blockchain environment, whereas the real estate industry's participant is less than one percent and not even mentioned.

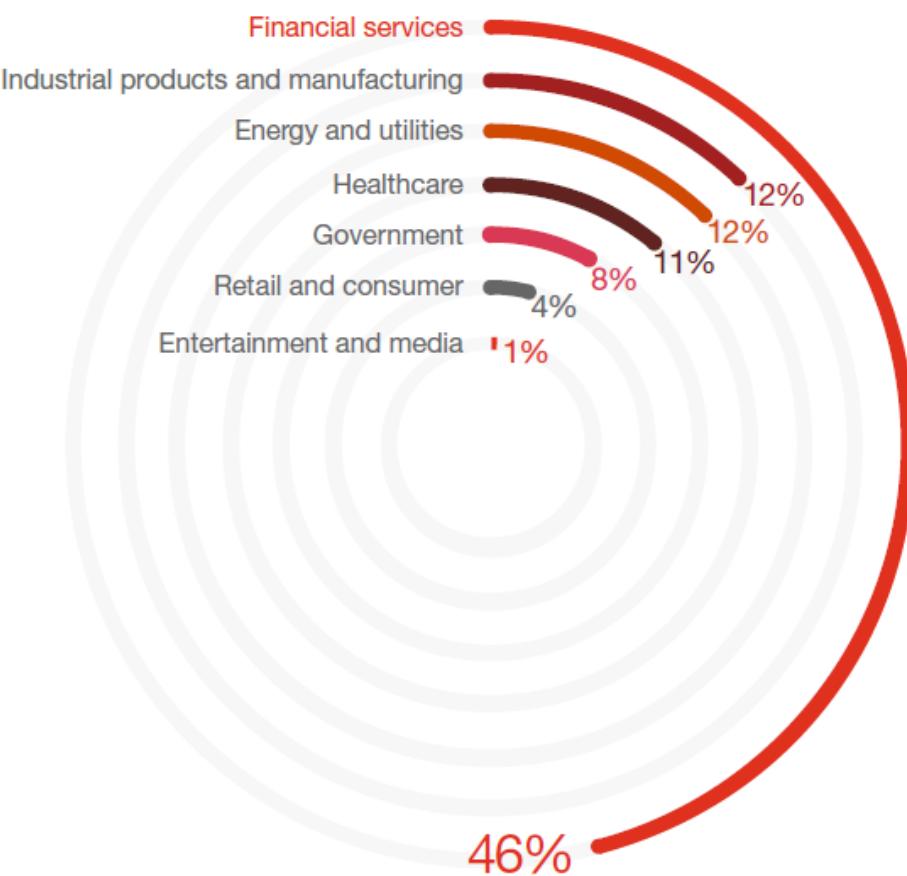


Figure 2: Industries seen as leaders in the blockchain⁴

⁴ Source: PwC 2018.

1.8. Assumptions

The phrase “Real Estate Industry” refers to the whole industry as a business that covers producing, buying and selling of real estate properties and not only the procedure of final trades.

The Blockchain mainly refers to the technology that is empowering Bitcoin, which is fully decentralized. Different approaches to the different applications about private and public chains are possible. Differences between public blockchain and private blockchains can relate to differences between the internet and intranet. However the true merits lie within the publicity, private blockchains have their functions too. As a closed network, or as a tool to apply some centralization within the decentralized network, the phrase “blockchain technology” refers to this technology from its general aspect and does not specify what kind of blockchain or which specific chain.

The legality of transactions, as the nature of transactions, are not a concern in use cases as this paper takes cyberlibertarianism approach to the internet.

To respect all underrated ladies around the world, all thirds persons addressed as she.

2. Real estate industry

2.1. Introduction

By accumulating more than 280 trillion dollars, global real estate is the biggest store of wealth. By eight percent growth of value during 2017, real estate stands at the third place of growing value after equities and gold (Savills 2018). However, there are mutual interests in global real estate; blockades have been standing still against the professional's way to establish global integrated communication (CBRE 2017).

On their study, PwC and the Urban Land Institute (2018), they estimate that blockchain technology is twenty years away from implementation within the real estate industry and offer the most likely areas of implementation as illustrated in Figure 3.

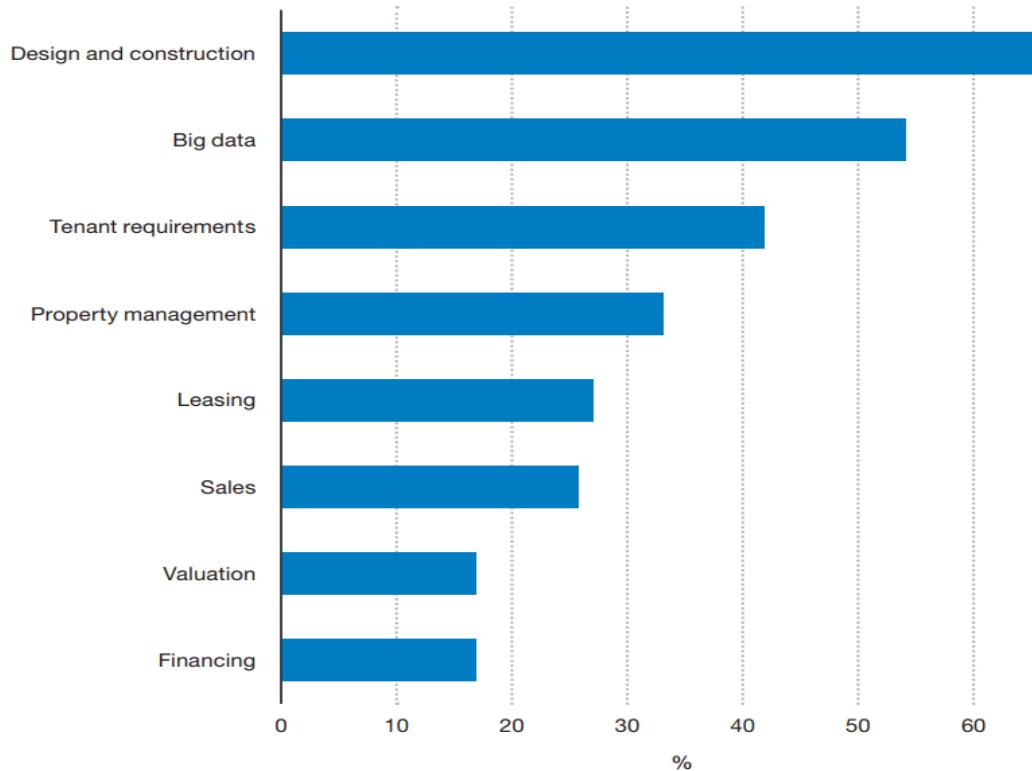


Figure 3: Areas of the real estate industry most likely to adopt blockchain technology⁵

⁵ PwC and the Urban Land Institute 2018

This chapter gives an overview of the real estate industry from three different perspectives:

- Developments that can facilitate implementation of the blockchain
- Concepts that can use blockchain to facilitate their implementation
- Challenges that can use blockchain as a solution

Firstly, real estate technology developments as an infrastructure that can support the implementation of blockchain technology are discussed. Secondly, the author investigates two new global concepts that are affecting the real estate industry and can use blockchain as a transaction platform: internationalizing and globalization, share and gig economy. The final sub-chapter states challenges within the industry that can use blockchain as a solution.

2.2. Technology developments

Technological developments, both as tools for implementation of the blockchain technology and trends that can benefit from this implementation, are discussed in this subchapter.

2.2.1. Building Information Modeling

The American National Building Information Modeling Standards (2013) defines Building Information Modeling (BIM) as “A digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming, a reliable basis for decisions during its life cycle; defined as existing from earliest conception to demolition. A basic premise of BIM is a collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder.” BIM is a revolutionary tool that is transforming all the process for development, execution, and utilization of real property (Hardin 2015). BIM tends to become a standard tool in Finland, Norway, Denmark, USA, Singapore ,and Hong Kong (Wong et al. 2010).

It is essential to understand that BIM is a technology and not just an application. By bringing new possibilities to manage data from conceptual development to demolition, BIM enables instant knowledge and direct cooperation between all participants of real property, says Eastman et al. (2013) and offers Figure 4 as the current boundaries that BIM can help participants to overcome.

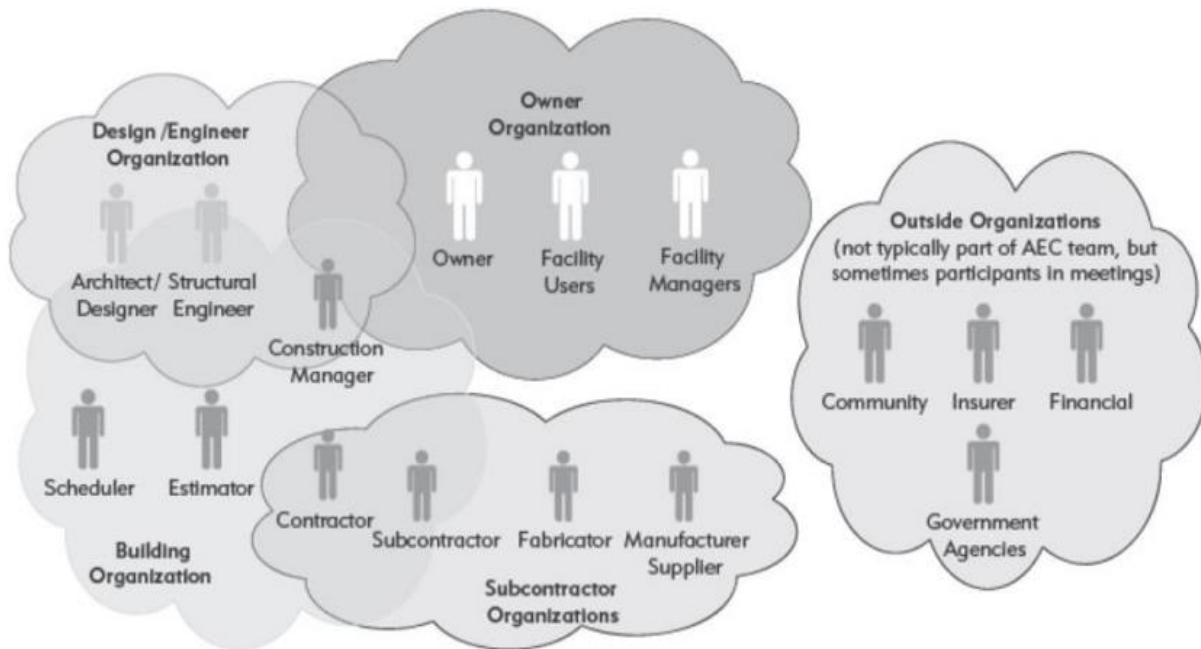


Figure 4: Project team and the collective organization boundaries⁶

The scope of studying BIM in detail is beyond this study, but some features that can facilitate implementation of blockchain, shortly discussed below.

2.2.1.1. BIM in development and construction phases

BIM has several abilities and standards for collaborative and integrated development of the real estate industry (NBIMS 2010). As mentioned before the perspective is to highlight the tools that can facilitate implementation blockchain within the industry, and in order to do so, IFC files and Vico Office software shortly discussed.

IFC (Industry Foundation Classes) are text files to facilitate data sharing across all participants of a project. The plain text format enables all participants to use it no matter

⁶ Eastman et al. 2013, p. 4

what vendor they are using. Whereas graphical software delivers the visual communications, the IFC files aim to become the universal language that is “rich in internal representations on building components to transfer consistently data between applications maintaining the meaning of different pieces of information during the transfer between applications” (Solibri 2018). The same source follows that modern BIM tools can import and export IFC files to create this connectivity. It can reduce modification costs and increase transparency (Plume and Mitchell 2007).

Vico office suit aims to create a core mode and set of discipline-specific modules that use the same integrated database. This connectivity brings the ability for changes to take place across all modules of the project instantly and creating an automated data flow within the project. Figure 5 illustrates an overview of Vico Office (Trimble 2016).

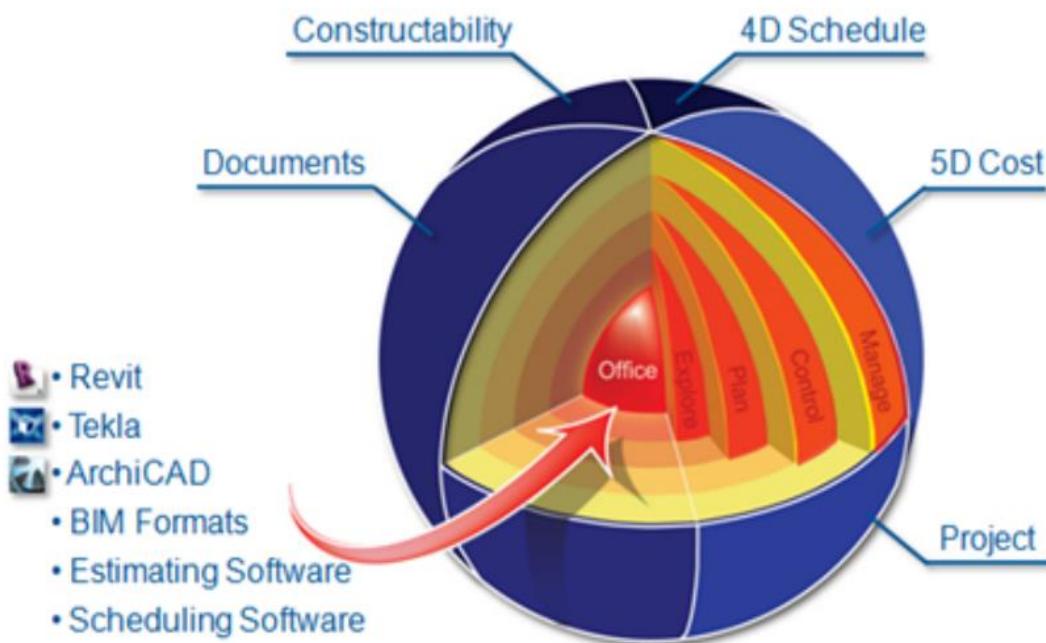


Figure 5: The Vico Office Suite overview⁷

The 4D and 5D are classifications to enlighten the level of information within the BIM software files. The 4D models are 3D models that contain data about time. These new dimensions enable automated simulation and scheduling for projects. The 5D models contain cost as another dimension of data that facilitate commercial management and earned-value tracking. The 6D classification refers to the 3D representative of already

⁷ Trimble 2016.

built facilities that contains information about operation status and maintenance data as a tool for more efficient management (Kiong 2018).

Vico office offers different outputs based on user's interests, the combination of data flow with zoning and timing within the software brings the possibilities for a feasible construction planning that contains procurement and labor inputs. This data flow enables managers to have a clear view of the costs and schedules at the early stages of the project (Hardin and McCool 2015). Figure 6 visualizes the outcome of this data flow.

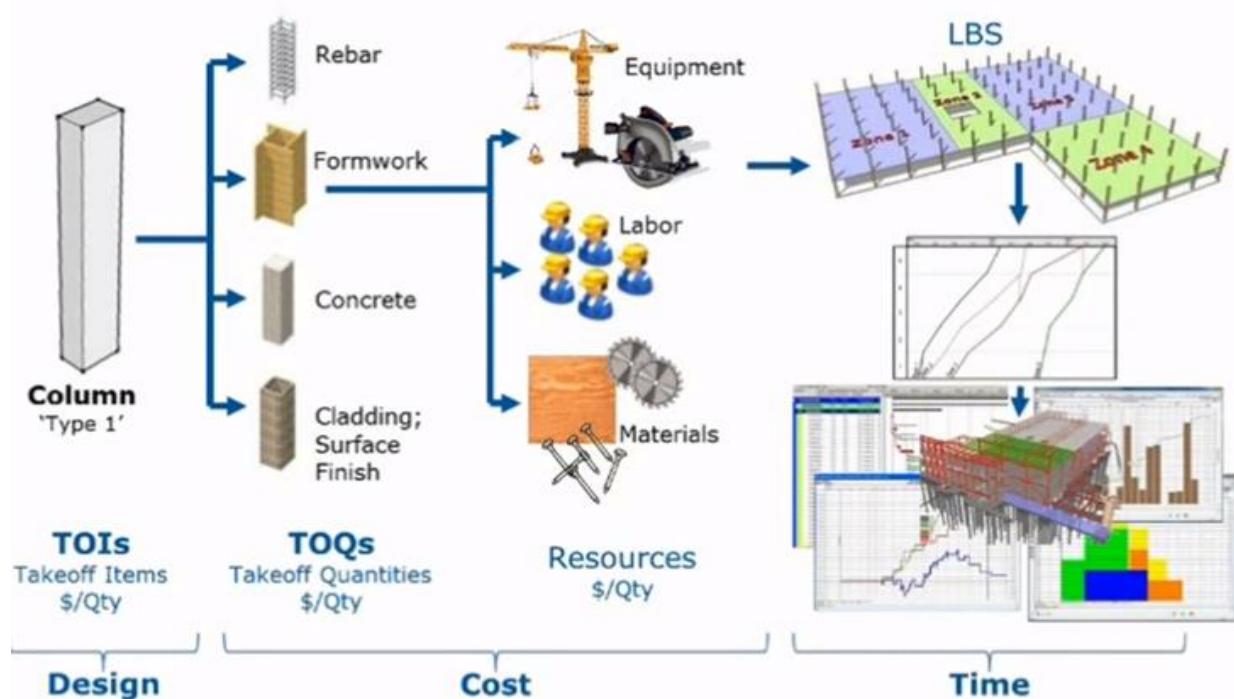


Figure 6: Data flow within the Vico Office⁸

This data flow brings different possibilities for different participants of the project by providing (ibid):

- Material costs and procurement schedule
- Labor requirement and their schedule
- Equipment requirement and their use period
- Cash flow

⁸ FridaysWithVico 2011.

The need for this detailed data has been a concern for different participants of the industry. For example, Liu et al. (1990) concluded, "Segmentation does exist as the result of indirect barriers such as the cost, amount, and quality of information for real estate." The same source follows that the rise of information creates the possibilities for direct integration of the real estate market with the stock market. The higher level of integration of participants can also liquidize and modify roles of the participant as their collaboration level increases (Sebastian and Rizal 2011).

2.2.1.2. BIM in the utilization phase

However most of a facility's cost (60-85%) is spent during the utilization phase, the importance of the Facility Management (FM) has been underrated even sometimes neglected (Hardin 2015). The traditional perspective of FM that did not consider it as a core business is changing as more facility managers managed to illustrate their additive value for properties (Wang et al. 2013).

Facility management is not influenced by BIM deeply, and more collaborations are needed (Nicał and Wodyński 2016; Kiong 2018). In their research, Aziz et al. (2016) concludes that BIM can improve the quality of life for the facilities by facilitating various aspects as follows:

- Effective operational cost
- Shorter time for decision making
- Resource for decision making
- Better documentation system
- Collaboration and work flexibility
- Updated information and clash detection

To illustrate an overview of applied BIM in FM Hitchcock (2011) offers Figure 7 illustrated in the next page.

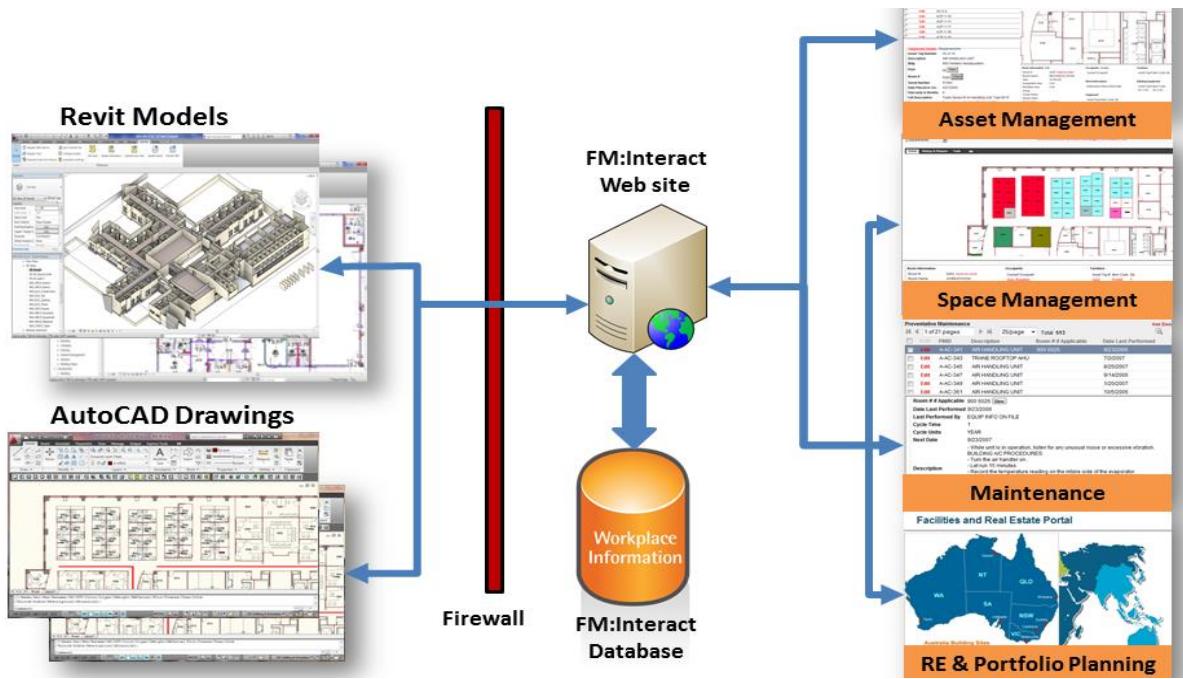


Figure 7: Overview of applied BIM in FM⁹

BIM in FM would be the final step of implementation of BIM technology within the real estate industry says Kiong (2018) and offers five levels for maturity in order to achieve the digital sustainability :

- Level 0: Low collaboration
- Level 1: Partial collaboration
- Level 2: Full collaboration
- Level 3: Full Integration
- Level 4: Digital sustainability

As shown in Figure 8 in the next page, the same source claims that the implementation of BIM as a tool being used within operating companies is somewhere between partial and full collaboration. Despite its potential for uprising the collaboration and integration level, it is up to industry professional's aim on how much efficiencies and group synergies maximized from the various stages of integration. Unfortunately, the slow and conservative nature of the industry has become a brocade for the full integration of advanced BIM concepts. Nevertheless, as the awareness rises by educators within the industry, there are hopes for acceleration for this adoption at a higher pace than today.

⁹ Hitchcock 2011.

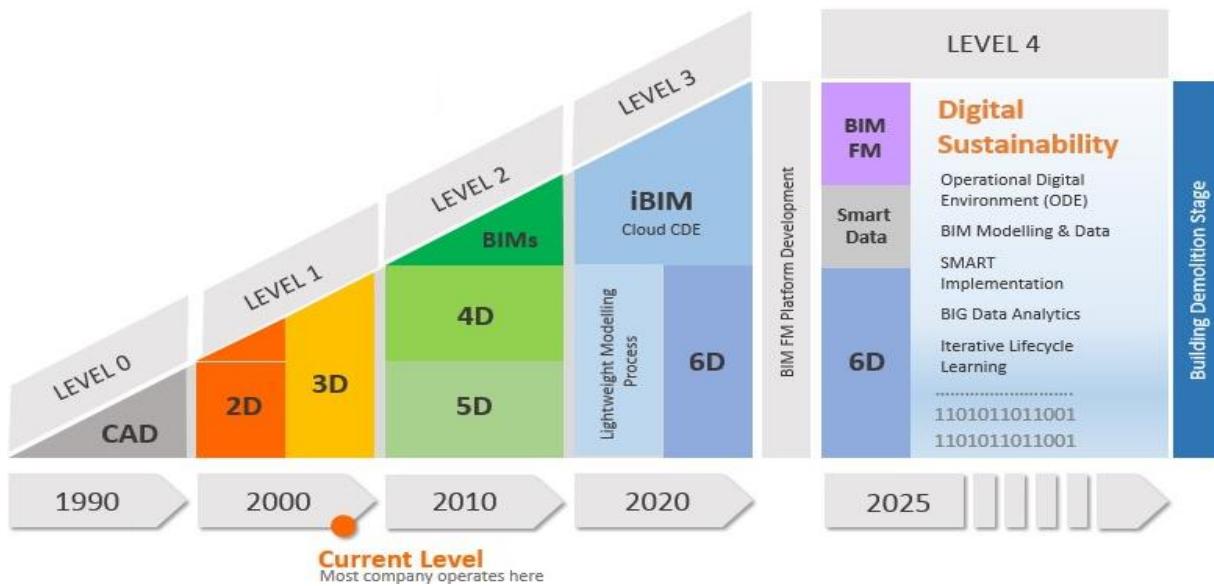


Figure 8: BIM maturity towards digital sustainability ¹⁰

2.2.2. Internet of Thing

Internet of Things (IoT) is the pervasive presence of our sounding objects with a unique address that enables them to communicate and interact with each other, mostly on wireless platforms, in order to achieve their desired goals (Giusto 2010). The invention of IoT took place in the early 80s where David Nichols used Pittsburgh Pennsylvania's campus network in order to make sure that when he goes for soda, the machine has cold sodas to offer. In order to do so, he used the refilling data to know about the last refilled time (Teicher 2018). The number of IoT connected devices are currently about 26 billion with estimation of passing 75 billion devices by 2025 (Statista 2019a).

The use cases of IoT can vary from a yoga mat that can coach its users and evaluate their daily performance (Indiegogo 2019), to one of the fundamental tools to reach the smart cities by facilitating smart governance, smart mobility, smart utilities, smart buildings, and smart environment (Bellavista et al. 2013).

¹⁰ Kiong 2018.

The fundamental technologies within this industry offered by Lee and Lee (2015) are listed below:

- Radio frequency identification (RFID)
- Wireless sensor networks (WSN)
- Middleware
- Cloud computing IoT application software

Discussing all technologies that empower IoT and their individual use cases are not within the scope of this study, for example, RFID and its use shortly explained: The real-time monitoring systems are only one the many applications of IoT within the BIM, both for construction and utilization phase. Passive and active RFID systems enable live data input at an affordable price making them useful and feasible methods of keeping tracks of both human and material resources. The integration of RFID and BIM optimizes management and increases safety. By storing the data on a database, further analyzes can take place based on automated data (Costin et al. 2012). IoT related technologies closed to become a standard, and the industry is actively moving through the mass production of IoT devices that results in the technologies' maturity and affordability (Zanella et al. 2014). Lately two computer technology giants: Intel and Microsoft have launched their own IoT platform for business users. Whereas Microsoft announced 5 billion investment in IoT and Intel claimed to make every built facility smarter (Intel 2019; Microsoft 2019). Segments of IoT implementations illustrated in Figure 9.

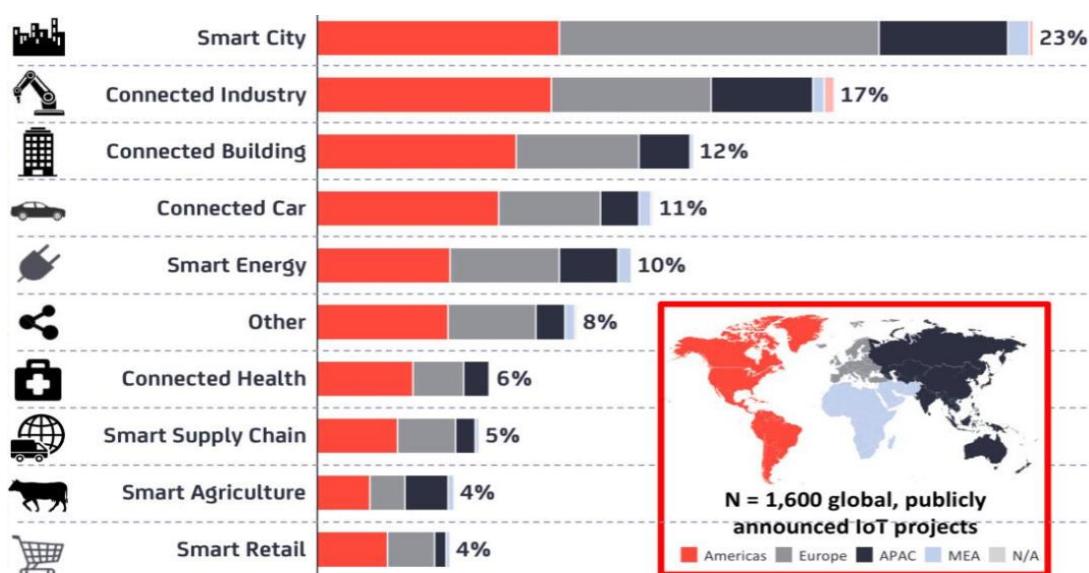


Figure 9: The Top 10 IoT Segments in 2018 – based on 1,600 real IoT projects¹¹

¹¹ Source: Scully 2018.

IoT can feed and interact with artificial intelligence in order to put many complex concepts into practice. The new developments of smartphones combined with facial and body type recognition are promising to put many previously done with human tasks on the machines shoulders (Arsénio et al. 2014).

As an ultimate example, that how discussed concepts can create an smart infrastructure, the Amazon Go concept explained by Polacco (2018) is discussed. The concept is to offer a checkout free shopping experience with zero human interaction. Costumers walk in the shop using a Quick Response (QR) Code provided by their Amazon smartphone application, pick what they want and leave the shop. The reciting of their stoppings appears on their application and after the users' confirmation; the shopping cost deducts from their account. The supporting technology known as "just walk out" is a combination of 3D computer vision, machine learning, body habit, and sensor fusion that all are in contact with company's cloud and online banking system. Figure 10 illustrates the shopping progress with "Amazon go's just walk out" technology.



Figure 10: Amazon Go guideline¹²

¹² Source: Du Meiling 2018.

2.2.3. Green and smart environments

In this section, the author discusses smart and green buildings, smart and ecological cities to create an overview of the future of our surroundings. The aim is not to identify each aspect in details but to illustrate the rise of communication and alternative energy methods within the built environments. “High performance, green buildings are energy and resource efficient, non-wasteful and non-polluting, highly flexible and adaptable for long-term functionality; they are easy to operate and maintain, and are supportive of the productivity and wellbeing of the occupants.” Is how Traugott (1999) defines an “intelligent” building. However, Green and Smart buildings are two separate concepts; most reviewed sources tend to mix both concepts in order to achieve the final goal of both concepts that is sustainability. Same ambiguity exists within the definition of smart buildings also that are named Automated Buildings or Intelligent buildings (Croome 2004). In their research, Frost & Sullivan (2008) name this overlapping “bright green” and offer Figure 11 as details of this overlapping.

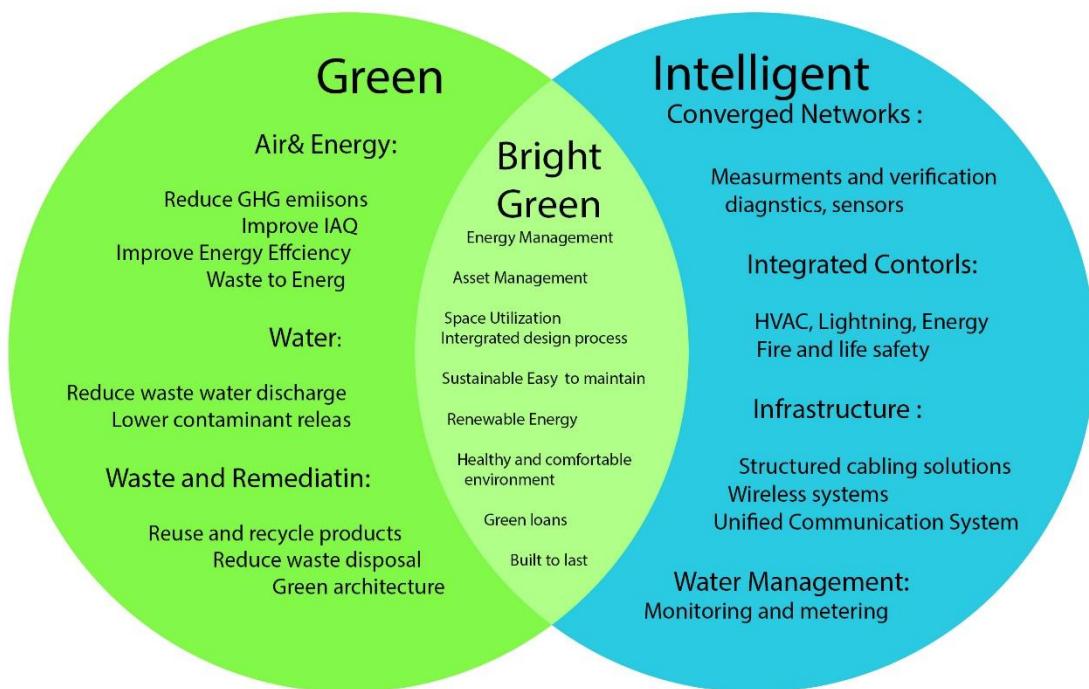


Figure 11: Bright green buildings¹³

¹³ Frost & Sullivan 2008 .(Figure recreated by the author to fit the print)

The concept of ecological cities are traceable back to the late 80s and early 90s. It is defined as sustainable urban development at a substantial scale in terms of area, infrastructure ,and innovation whereas key developments take place in all major sectors such as land, housing, transport, energy, waste, and water. Three primary keys in the implementation of ecological cities according to Joss (2011) are:

1. Technological innovation
2. Integrated sustainability planning
3. Civic empowerment and involvement

Smart cities are complex concepts yet to achieve in reality. The definitions of smart environments vary between resources, the same about their growth paste and level of application, for example Albino et al. (2015) presented 23 different definitions about smart cities. However, intentions are to create smart buildings, which create smart cities, policies about smart cities that need smart buildings are also developing (BSRIA 2018). The market capitalization of smart environments is growing beyond expectations. Whereas BSRIA (2014) estimated smart cities market in the European zone, that account for half of the world's smart cities, will not pass one billion dollars by 2015, SmartCitiesWorld (2019) claims that this capitalization will pass 200 billion dollars by 2026. The concept of "Smart Environment" offered by Peris-Ortiz et al. (2017) as an outcome of smart cities in practice.

Another concept within smart environments that is important for this study is Microgrid. "Microgrid works as a local energy provider for domestic buildings to reduce energy expenses and gas emissions by utilizing distributed energy resources" (Di Zhang et al. 2013). Microgrids, when developed and applied fully, can mix energy consumption resources resulting in localization of the energy market that will improve the efficiency by reducing transportation costs and energy lost. Furthermore, this efficiency can reduce carbon emissions also. Smart grids can apply to Microgrids in order to bring the possibilities for energy resource selection (Miceli 2013).

City Information Modeling (CIM) tends to scale BIM's abilities to an urban scale by utilizing CityGML (City Geography Markup Language) files that play the intermediary role as IFC does for BIM (Isikdag and Zlatanova 2009).

"CityGML is a standard for the exchange and representation of 3D city models. It allows for the multiresolution representation of virtual 3D city models and provides a rich semantic model with well-defined meanings" (Gröger and Plümer 2012, p. 14).

The characteristics of a smart environment that are important for this study are:

- Observe their environment through IoT inputs such as RFID, QR codes.
- Measure energy consumption and environment qualities through sensors.
- Connect with other smart buildings and transfer data through the cloud
- Produce energy from various sources such as solar, geothermal.
- Transfer energy through microgrids.



Figure 12: A schematic overview of a smart city¹⁴

¹⁴ Source: SmartCitiesWorld 2019.

2.3. Globalization and Internationalization

Globalization and internationalization as concepts that can use blockchain technology for implementation are introduced here. However, vary in the definition; globalization and internationalization are the intentions for collaboration beyond national borders. Internationalization understood as an application in order to achieve globalization (Fujita et al. 2001). “Globalization is the worldwide effort and interaction of the public and private sectors toward cultural and economic communications. Integration through allowing and easing the cross-border movement and transfer of people, capital, data, goods, and services” (Prahalad 2007). Internationalization is at the business scale within the private sector whereas companies tend to do business in one or more foreign countries. these activities can be as varied as “sourcing, producing and selling materials, components, goods, and services.” In order to facilitate this cooperation to take place agreements for “procurement or sales offices, or operational sites through foreign direct investment” are required (Lehmacher 2017).

Globalization is an inevitable phenomenon of the modern economy and effects living environments from various aspects such as capital flows, labor and commodity market, information, raw materials, management, and organization (Mohan 2000).

The rise of communication and economic liberties that facilitate the liquidity of capital beyond national borders has created an interest for investors to globalize their investments to diversify their portfolio and reduce risk (Keivani et al. 2001). Academic literature covering interaction between globalization and real estate in specific sparse, claims Bardhan and Kroll (2007) and follows that most of their reviewed sources focus on the finance perspective of globalization on the real estate industry instead of multinational collaboration. Same research head studies “Global Financial Integration and Real Estate Security Returns” and concludes that the boundaries are yet to overcome for a global real estate market (Bardhan et al. 2008).

However, globalization can play a critical role for the capital to meet its most productive users and can be a key to overcome poverty, bad local policies in adopting the concept have created a backlash against globalization (Helleiner 2010). Argentina’s financial crisis that resulted in the cancelation of the international financing agenda is an example of how sensitive global policymaking can be (Mishkin 2007).

Various resources have discussed obstacles in the implementation of global collaboration, both from real estate and general perspective (Weiss 1997; Dixit and Jayaraman 2001; Martinez et al. 2012; Abdelal and Segal 2007). Most of the reviewed resource classify these brocades to three levels of political, social and economic. For example; Dixit and Jayaraman (2001) summarize obstacles for internationalization as “differences in private equity environments by geography, fund management, Investor management, risk management, investment process, organizational issues, cross-border deals problems, building local networks, and avoid systematic geographic bias.” The differences in solutions to tackle these obstacles take two perspectives. Firstly, up to down approaches, that demand application of agreed policies from governments such as what Fischer (2003, p. 30) offers: “Implementing the right policies, Making the international financial system less crisis-prone, and Improving governance.” Secondly, down to up approaches that offer collaboration between enterprises and firms can lead to globalization that which naturally created instead of dictated (Weiss 1997). However, a third approach offered by Santos (2002) is to homogenize development of first two approaches in order to achieve a “globalized localisms and localized globalism that allow us to anticipate greater homogeneity and internal coherence.” In his book: “The moral consequences of economic growth,” Friedman (2006) debates that unless the growth is not experienced with the majority of the population, the mood will not be set for accepting the change. The same resource follows that a balanced growth that is applicable for everyone within the society can help to close the gap between the reach and the poor that results in a moral growth and offers micro-economy as an application to achieve equal growth. The real merit of globalization happens through global democracy (Falk 1997).

2.4. Share economy and Gig economy

Share and gig economy are two separate phenomenon that both had stepped into practice due to the rise of communication. Their importance for this study is firstly to highlight their rising effects, obstacles on the real estate industry, as freelancers will do more tasks, and more shared properties will be available. Secondly, to discuss how the implementation of blockchain technology within them can facilitate their implementation and overcome the obstacles.

Gig economy refers to two formats of jobs; firstly “crowdworks” that is to complete tasks published through the internet that are mostly designed remote tasks, and secondly work on demand via applications that replace traditional services such as cleaning and delivering using applications developed by firms (Stefano 2016). It is difficult to estimate the exact number of participants in gig economy due to its complex nature, says Smith and Leberstein (2015) where they study 11 gig economy companies with more than 20 million participants. For example Gigeconomydata (2019), that is a partnership between the Cornell University School of industrial and labor relations ,and the Aspen institute’s future of work initiative, that studies gig economy individually address the difficulty of tracing gig economy due to lack of similar identification for gig economy within different areas. On a survey of 1267 American adults, Marist (2018) claims that contract-holder workers do 20% more tasks. If the same trend of growth in gig economy participant keeps up, more than 50% of American workforce will work through freelancing by 2027 (Pofeldt 2017). The same estimation is offered by Upwork (2017) with an estimate of 1.4 trillion dollars market size as the current value of the gig economy. From the American Bureau of labor statistics report, (USDL 2017), it can be understood that almost a quarter of construction participants are working independently and are part of the gig economy. Gig economy is interesting for millennial employees because of the soft economy possibilities, growing freelance opportunities and technology-enabled freedom (Deloitte 2017). From the business owners point of view, Wonolo (2018) accumulated responses from 31 entrepreneurs about the gig economy’s ability to boost the business that the highlights are:

- Lowers overhead costs for businesses with high seasonal load fluctuation
- Increases efficiency by finding the right person for the right task
- Expands the talent pool without crossing the budget
- Helps to find employees with higher performance, suitable for extended contracts
- Cuts the office requirements and costs

An example of a gig economy in real estate can be Stealthforce Company. The company aims to cover the gap between real estate stakeholders and experts. The service can vary from pricing and listing to a complete project development

service. Currently, 40 percent of the employees are independent and part of the gig economy. The company has scaled to become global expanding their business to Asia (FitzGerald 2017). Peter Miscovich, Managing Director for Corporate Solutions with JLL sees the future of real estate projects using “Hollywood model of work” whereas most participants of the project are hired for the particular known task within the project (CoreNet 2017).

However, drawbacks of the gig economy discussed with various resources (Stefano 2016; Chan and Tweedie 2015; Paulin et al. 2017). The common claims are mostly about lower wage in practice, incompatibility between expectation and practice for clients, the possibility for low qualified freelancers due to the lack of reputation records, job insecurity for employees and massive legal challenges, due invoices that need complex legal procedures. In their research, Tran and Sokas (2017) studied occupational health for gig economy participants in specific and claimed that workers will experience: compensation decrease, misclassification in employment rights, need for individual security and insurance accounts, working for a company and not being treated as other employees unless winning lawsuits in courts, no labor association. These drawbacks are mainly rooted in lack of transparency and unclear status of law both on the national and international scale.

Definition of a shared economy according to European Commission (2016) is "business models where activities are facilitated by collaborative platforms that create an open marketplace for the temporary use of goods or services often provided by private individuals." The fame of the shared economy in direct correlation of Airbnb's success to accumulate over ten billion dollars within seven years (Konrad and Mac 2014). By the beginning of 2019, there are 150 million Airbnb users having access to over four million listings within 190 countries (Smith 2019). Smaller example can be Equipmentshare.com where offers construction companies to share their machinery or Spacer.com.au where individuals can share their extra spaces used for parking and store. The sharing economy will account for 335 billion dollars by 2025 (PwC 2014). Advantages of a sharing economy can commence with encouragement for more fair and sustainable resource distribution with reducing overhead costs and increasing end user's satisfaction, as smaller enterprises are more dependent on reputation (Rogers and Botsman 2010). Shared economy enables micro-entrepreneurship at a lower cost that can enhance global economic growth (Martin 2016). In their study "The Sharing

Economy and Real Estate Market: The Phenomenon of Shared Houses" Sdino and Magoni (2018) debate that regulation and taxations are the current challenges in the application of this new format of economy within the real estate industry. The lack of regulation can threaten end users and put them at risk. On a report for The Independent, Cox (2017) surmises the reason that can break the sharing economy is back to human nature and says: "The sharing economy is failing for one simple reason – people cannot be trusted." Several cases demonstrated in her report such as a Chinese umbrella sharing startup, losing 300,000 of its umbrellas in less than a month, or napping pod start-up shutting down due to the police's suspicion that pods are becoming hiding spots for criminals. She addresses Rogers and Botsman (2010) idea of "a seismic shift from individual getting and spending towards a rediscovery of collective good" and doubts it as people are not essentially hardwired to the collective good. As the Airbnb is the pioneer of the sharing economy, there are endless numbers of claims about catastrophes happening within or around this business. There even exist a website www.airbnbhell.com focusing on these problems. To summarize the current challenges for the sharing economy are the doubts about trust, ethics, and problems about solutions in a case of trust or ethics violations.

2.5. Challenges

2.5.1. Inefficiencies

Low yields from stock markets did attract investors to lean their investments through real estate though financial analysis became more available for the real estate market (Anderson et al. 2004). Malkiel and Fama (1970) claim about asset market is an efficient market as the price reflects the information is the source of efficient market hypothesis where imperial studies such as Case and Shiller (1989) claimed that costs within the housing industry overcome the real estate rates and though the real estate market is not efficient. Inefficiencies within the real estate market can have various reasons. It can be sourced to underestimating risk factors according to Farlow (2004), or common misunderstanding about the real value growth of properties creating bubbles (Stiglitz 1990). This subchapter also aims to highlight some of the general inefficiencies within the real estate market as a statement of the problems.

2.5.1.1. Development

However there is no universal development process of property, most of the development methods are formed within three significant steps of acquisition, production, and disposal and need to complete the following steps according to Byrne (2002):

- Market analyses for demands
- Site selection
- Designs to meet demands
- Financing
- Design and construction management
- Transaction and facility management

Subtasks within the mentioned tasks can vary depending on the local government, for example; the execution permit of a commercial real estate in India requires 60 different approvals from the various organizations (Thompson 2000). Property development is a time consuming and complex process that relies on its diverse nature and gaps between the specialists (Rybaczynski 2008). Development models can vary depending on the developers' status, nature, and scope of the project, location's demographic, fundraising, and collaboration model. Each model has its challenges also, for example: whereas governmental developers have the privilege of information and lobbies compared to agent developers, they face inefficiencies within their very own organizational charts (Healey 1991). The developers' objectives can affect their intention for choosing the type of development also, developers with the intention to sell their built project tend to minimize the procedures in order to shorten the time and save the costs that will leave many tasks for facility managers That can be more expensive during the utilization phase.

On the other hand, developers tending to utilize their built property need to dive deeper in order to minimize utilization costs (Schüssler and Thalmann 2005).

Pointing out an accurate list about the roots of inefficiencies in real estate development appears to be tricky. Different resources claim different reasons (Kimelberg 2011; Graff and Webb 1997; Gau 1987; Anderson et al. 2000; Kazimoto 2016; Choudhry et al.

2018). However, the unclear path from idea to utilization and even renovation observable as a common ground. The other challenge to determine the sources of inefficiencies is that many challenges appear to have a domino effect on others. For example; in their study, Choudhry et al. (2018) tracked design errors to be an outstanding challenge that drifts the expectations from reality resulting in time and cost incompatibilities. In short, current challenges within the real estate development, despite their ambiguity and diversity, resulting in incompatibilities between time and cost prediction that can be frustrating for all participants of the industry.

2.5.1.2. Title Transaction

A transaction is displacement of ownership, rights, control of an asset, claims Kim and Mahoney (2005) and follows that there are several theories to offer a suitable procedure of a transaction such as transaction cost and agency theory. Transaction cost theory practically used in many areas of political, financial, economic and social sciences. Transaction costs are a combination of elements that can hold back, blockade, or add more cost to a transaction (Skogh and Lane 2000). The transaction cost does not address only to the monetary costs. A transaction's cost can be a due combination of separate time and effort consuming progress that can happen before, during, and after execution of the transaction (Williamson 1981). In an ideal market, per-transaction costs that are spent on the preparation of the contract are minimized (Skogh and Lane 2000). Estimation of transaction cost is a complex process 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" (Corluka and Lindh 2017, p. 25). This transaction within the real estate industry that is transacting ownership of real property is called real estate process that its dimensions are divided to "asset specificity, frequency ,and uncertainty." Asset specificity applies typically for real estate properties that are built as a contract for the final user or utilizer such as public projects. Residential projects are not specified to its end user. The frequency of real estate transactions are one time, and there exist many uncertainties within the transaction. For example, price fluctuation during the process is an

uncertainty. The nature of many inefficiencies in title transaction within the real estate market can be traced to the connection of named diminutions with two human characteristics in practice: bounded rationality and opportunism. Opportunism is an individual's uncompleted honesty in order to achieve desired goals (Williamson 1991). Bounded rationality directly addresses the human's lack of ability to predict upcoming events and plan them optimally (Milgrom and Roberts 1992). Real estate title transactions procedures are tools to guarantee that the transaction is based on authentic inputs in order to make sure the transaction itself is lawful. These authentications can vary depending on the region, the legal status of the participants and type of the real estate. Real estate agents act as intermediaries, who represent participants, in order to deal with the other participants and authorities. Sweden is an example of a region with the use of agents as a practice that is not obligated by law. The six steps for this transaction according to Lindqvist (2006) are listed below:

- Seller hires a real estate agent through a contract
- The real estate agent markets the property
- The potential buyers inspect the property
- The potential buyers start to bid and negotiate
- The real estate agent gives a contract of sale
- The buyer and seller sign the contract to make it final

However, there are 33 subtasks within these six steps, and on average it takes 114 days to complete (Corluka and Lindh 2017). Appendix A shows these steps in details. The average cost for a real estate transaction is about seven percent of total value whereas less than 25 percent of the total cost is about requirements and the rest is the brokers' share (Murray 2007). To summarize, no matter where the land title transaction takes place, there are several intermediaries to meet in order for a transaction to take place. However, the complexity of the procedures are to grant the feasibility of transactions in a safe environment; they are beyond time and effort consuming that reduce the liquidity. However, non-efficient, real estate title transactions are not discriminated from illegal activities. The next section discusses how these complex procedures can be compromised.

2.5.2. Fraud

Transaction frauds in real estate have deep roots within every society (Gibbs 1891). One of the famous frauds in real estate is credited to Victor Lustig who successfully sold the Eiffel tower, twice (Margo Lestz 2016). The high value of transactions and uncertainties about the genuine status of real property, combined with the fact that real estate deals are not a typical deal and an average person has no or very few experiences about the transaction procedures, make the real estate frauds interesting for fraudsters (Unger et al. 2010; Fegeas 1983).

According to the American Internal Revenue Service, property flipping, two sets of settlement statements and fraudulent qualifications are the most common schemes in the U.S (IRS 2005). By growing more than ten percent each year, 82 percent of American mortgage application in 2017 were considered fraudulent with a 20 percent chance of being successful using one of the following schemes arranged by popularity according to (CoreLogic 2017):

- Identity fraud
- Occupancy type fraud
- Transaction fraud
- Income fraud
- Undisclosed debt fraud
- Property fraud

Keeping track of a property is the key to prevent most of the frauds. For example, some fraud indicators offer the following signs as a fraud alert by Unger et al. (2010):

- Unusual number of property transfer with one specific party involved with them
- Unusual changes in ownership socially in short intervals
- Unusual fluctuation in the price exceptional to the market trends

Wire frauds as a new format of frauds in real estate, where cybercriminals observe transaction's progress and tamper participants' data such as bank account number at final stages. That lack using one platform and being depended on vulnerable communication methods such as email, exposes the participants to substantial risks such as account compromisation possibilities. Accounted for more than three thousand FBI involved cases during 2017 that accounted for more than 1.4 billion-dollar losses,

wire frauds are the most common type of fraud in real estate transactions today in the states (IC3 2017).

What most fraud methods appear to have in common is to take advantage of real estate's complexity and ambiguity. The fraudster claims on any statement is not so easy to verify, it can be the ownership, property records or even identity theft.

2.5.3. Transparency

Importance of transparency for this study has two separate aspects. Firstly is to highlight the current level of transparency within the industry that can facilitate implementation of blockchain by acting as a reliable source of data. Second, by pointing obstacles in order to achieve transparency at an acceptable level, possibilities of using blockchain as a solution will be discussed in later chapters. Project documentation transparency and real estate record transparency are two main interests in this section.

Digital documentation of the projects is in direct correlation of application of CAD files within the industry. The possibility of utilizing 3D models enabled professionals' communication from the planning and design phase. By linking the 3D model to schedules and creating 4D models resulting in more convenience in conflict detection, registration, and removal (Koo and Fischer 2000). Scaling up to 5D models by adding cost that could be traced from the development, reacting to the impacts of changes that can be used as a decision-making tool for owners, project engineers, or managers (Tanyer and Aouad 2005). There is an estimate of 18.5 billion dollars for losses due to documentation inefficiencies within American capital facilities (O'Connor et al. 2004). Several resources have discussed various advantages of digital documentation over traditional paper-based documentation (Björk 2003; Hajjar and AbouRizk 2000; Hjelt and Björk 2006).

In their study on "Integrating Construction Process Documentation into Building Information Modeling," Goedert and Meadati (2008) concluded that with few modifications and some paradigm shifts it is possible to store documentation in different aspects of a project such as:

- Capture 3D As-Built data into BIM model
- Document actual construction schedule
- Use BIM to capture and store construction documents

Documentation in larger scale projects, especially for public construction can be a frustrating challenge that BIM can solve. By keeping the record of the orders, attempts, permits, and requests, there is a possibility to have well documented mega projects as results of a collaboration between separate organizations who used BIM as a framework (Porwal and Hewage 2013). By utilizing BIM at its high level, we can assume that we can answer these questions about any element of a built environment:

- Who designed it? Who permitted it? Who built it? Who approved it?
- When was it built? Who built it? How much did it cost?
- When was the last maintenance? When is the next maintenance?
- What is its status now? When should it be overhauled/refurbished/changed?

Importance of digitalization within the real estate records has been emphasized by Whitman (1998) to overcome American's unique method for land ownership. As he describes it, "We will not tell you who owns a parcel of land, but you are welcome to review all of the recorded documents that are held in our archives, and decide for yourself about the land's ownership." Digitalization of real estate titles will create transparency on a practical level; a paper form of real estate transaction is beyond vulnerable and confirmation for documents authentication requires much effort. Digitalization also has its costs. For example, only the hardware cost for creating a decentralized connected real estate recording system for the state of Iowa has an estimated up to 620 million dollars. Because this state has 100 land registry offices, the required budget can be 620 thousand dollars per office, which is a too hefty cut from the state's budget (Stonefield 2002). Geographic Information Retrieval and Analysis System (GIRAS) assumed to the first actual digitalization of land use and ownership. However, the GIRAS data system contains more data than just the mentioned ones (Mitchell 1977).

No matter what tool used to create transparency, in today's market, transparency is the most important indicator for international collaborations. On a study over 158 cities, all top 30 most exciting cities for investors had the rank of highly transparent, except from China's Shanghai and Beijing from semi-transparent cities (Kelly and McAuley 2018). Figure 13 illustrates an overview of the world's real estate transparency.

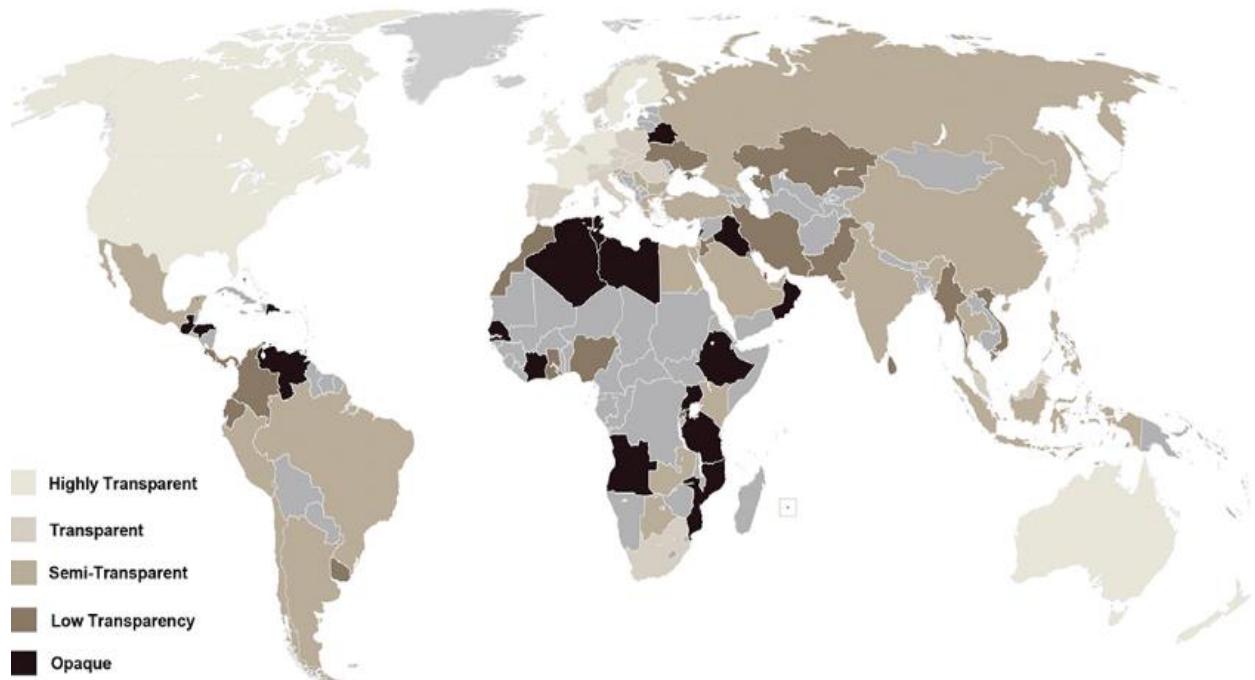


Figure 13: the World of Real Estate Transparency¹⁵

2.5.4. Corruption

"Corruption is both pervasive and significant around the world. In some developing countries, such as Zaire and Kenya, it probably amounts to a large fraction of the Gross National Product" (Shleifer and Vishny 1993, p. 599). Corruption is not the direct output of a corrupted man; it is in nature of power to create corruption. It is a corrupted system that creates a corrupted man, and a corrupted man will commit corruption to gain more power, the same power that was the source of the corruption. This dilapidated cycle can grow until the system loses its efficiency and most of the resources are spent to feed the corruption instead of the system itself (Heidenheimer 1970). The real estate industry, as mentioned before, is one the most significant sources of the commodity. Almost 30 percent of all criminal confiscated assets around the world between 2010 and 2013 were real estate assets. This cleared the vulnerability of the real estate market for abduction with money laundering and interest of criminals holding dirty money to invest in the real estate market (FATF 2013).

Governments can be the source of corruption also. Governmental corruption is that officials are selling governmental assets such as permits to gain personal favors. The

¹⁵ Jones Lang LaSalle 2019.

first drawback is the destruction of honest businesses. If a company bribes the officials and gain control over permits faster than what its honest competitors regularly do, the market will be honestly free and in the long run losses its efficiency. The Second reason is that corruption becomes costly and can paralyze the economy as the corrupted companies tend to be inefficient and trained to cover their inefficiencies by non-ethical options (Shleifer and Vishny 1993). To summarize the corruption's drawbacks in real estate that blockchain technology may prevent four aspects highlighted below:

- Use of a real estate asset as a money laundry tool by criminals
- Use of non-ethical methods such as bribery to gain access to permits
- The uncertainty that is costly and time-consuming to clarify
- Loss of reputation resulting in lower interest among investors

2.6. Summary

The real estate industry, despite theoretical and practical developments, is facing many challenges that reduce the market's efficiency and increases risks for its participants in different ways. Digitalization offered by various resources as the ultimate tool to overcome these challenges, however, implementation challenges are preventing these developments. BIM is the only digital solution that had stepped into practice during the past years. However there are several applications offered by BIM developers, such as Vico office and other 5D BIM frameworks, the general usage of BIM is limited to its basic abilities. The IFC files that play a fundamental rule in BIM has attracted professionals within the industry, but unfortunately, its practical implementation is limited mostly to the development phase and partly in the execution phase. The rise of technology within facilities themselves is creating smart and green environments more and more feasible. Bright green facilities can create energy and communicate with both its users and nearby facilities. This rise of communication combined with smart grids bring the possibilities for smart local energy markets that we will discuss in the use cases.

There are several types of economies rising based on technology developments and facilitated communication that created more objective oriented and service oriented industry with reducing the necessity of full commitments and ownership. In a sharing economy and gig economy, people can receive and provide service without full

commitment to the service or the product. These new formats of economics can boost efficiency and reduce overhead cost resulting in a higher level of service at an affordable cost. Freelancers who provide digital services can participate in a global scale remotely that raises the possibility for higher talents to participate in a project despite their location.

There are several challenges to overcome within the real estate industry. After introducing the blockchain technology in the next chapter. We will illustrate how blockchain can be a tool to tackle the following chapters. The main understandings about improvement needed within the industry are about information management. Several technological breakthroughs brought access to the information, but few resources discussed data management. Pain points that reduce the efficiency and interests for the real estates market such as fraud, corruption and lack of transparency where explained shortly and the main understanding was that a corruption-free and transparent real estate market attracts investors that are the fuel for the industry, and creation of this environment benefits all participants. The key findings listed below:

- There are several technological developments within the industry such as BIM that despite their abilities are yet to integrate fully within the environment
- Smart and green buildings have enormous advantages that can benefit from new concepts such as smart grids by rising communication.
- Adopted of technologies such as IoT has defined new possibilities for efficient interaction between different participants.
- The rise of combination resulting in new types of economies such as share and gig economy, that despite their enormous advantages are facing many challenges in practice.
- There are several inefficiencies in project development and title transaction that reduces transparency, and increases the risks of fraud or corruption.

3. Blockchain

3.1. Introduction

Blockchain, despite its technical definition, should be considered as a new level of thinking. It is considered the latest revolutionary, disruptive technology after the internet. As the internet brought a new level of communication for its previous technology, Personal Computer (PC), blockchain brings a new level of trust for the internet without the need for participation of a third trusted party. In technical definition, blockchain is a public ledger used by the Bitcoin network. Bitcoin uses a 1976 invention, public key cryptography and an internet-based concept: peer-to-peer communication, as well as blockchain to enhance its network to reach an automated consensus (Kayne 2017a; Beal 2015). Peer-to-peer communications are not new also, for instance BitTorrent serves its 45 millions using such a communication (Kayne 2017b). This new paradigm can be used in various aspects. Decentralized payments and exchanges, asset invocation and transfer, issuance and execution of smart contracts, and peer to peer value transaction are only a few abilities of blockchain technology (Swan 2015).

To understand the scope of this technology better and how vital this ledger can be, the definition of the internet may help. The Internet is a globally connected network that uses the transport protocols to establish communication between every two given nodes connected to the network. These communications allow participants to transmit data in order to achieve the desired level of communication. As in early 90, E-mail was the only generally known application of the internet (Gromov 1999). Having said that, it is not difficult to imagine how impossible current applications of the internet could sound back in the 90s. However, IBM managers had the idea that there is no need for more than four mainframe computers worldwide2016 (Antonopoulos 2016), current users of the internet by July 2018, that for sure have access to a sort of computer, are estimated to be more than four billion (Miniwatts Group 2018).

In this chapter, firstly, the basics of blockchain technology will be studied to explain its capabilities. Then three classifications of this technology will be discussed individually. For each classification, one highlight application and its use for the real estate Industry will be discussed. Other applications of each class will be shortly introduced, and ideas

about its use in real estate industry will be given in brief. Melanie Swan's book "Blockchain, Blueprint for a New Economy" inspires this breakdown. The reason behind using her break down is due to her philosophical tendencies aligned with blockchain technology (MS Futures Group 2019). This break down manages to keep a silver lining between a technical and conceptual understanding of the blockchain phenomenon.

This chapter aims to cover the basics of blockchain technology as is necessary for the managers in the real estate industry by answering the following: questions:

- What is blockchain?
- What are blockchain's classifications?
- How can each class be used?
- What are the outcomes of each class for the real estate industry?

The technical details about blockchain codes are excluded from this study, However, vital information that the author believes are needed to be gained for a better understanding this phenomenon will be provided while answering the first question.

3.2. Blockchain basics

3.2.1. Definition

The blockchain is a technology of validation (Ammous 2016). The exact definition of blockchain varies between different resources (Swan 2015, p.ix; Antonopoulos 2018, p. 66). However, most of the reviewed resources refer to blockchain as the technology which is the backbone to the Bitcoin cryptocurrency; it was not even mentioned in Satoshi's whitepaper. The confusion goes that deep that some users can not distinguish the differences between the technology, as an independent phenomenon, and as a single application that facilitates Bitcoin transaction's security (Tapscott and Tapscott 2016). The public confusion about the concetp during the hype could be seen when some people bought metalic coins with the letter B on it from online shops assuming that they are investing in the cryptocurrency. In the Bitcoin network, the blocks that are chained using a hashing system are the core to secure the network

from the double spending problem in a decentralized way (Nakamoto 2008). This confusion is rooted in Bitcoin's lack of skeuomorphic design and correct metaphors. Andreas M. Antonopoulos, one of the most famous blockchain experts, who runs educational programs as high as Canadian Senate (Antonopoulos 2017), addresses this confusion by: "In Bitcoin, every single term and design metaphor is wrong and broken" (Antonopoulos 2016, p. 16).

To deliver a direct understanding of blockchain technology, a non-technical explanation of blockchain technology offered by Hill (2016) is discussed shortly and explained in Figure 15. In 500 AD, in the island of Yap, during their evolution from barter trade to adaption of currency, inhabitant curved two-meter limestones that weighed 200 kilograms and used them as their currency. Their money, Rai, shown in Figure 14 with two inhabitants standing on its sides.



Figure 14: Two Yap islanders standing next to their ancient currency, a Rai¹⁶

They decided, instead of trading the stone when purchasing goods, they announce that the Rai stone's ownership now belongs to the supplier of the service. The announcement recorded by other inhabitants, updating the previous record of announcements.

¹⁶ Barach 2016.

When a Yapi reached the adulthood age, she would receive the information about the current owner of the Rais and join the market by acting as a new node in the Yapi economic platform which illustrated below.

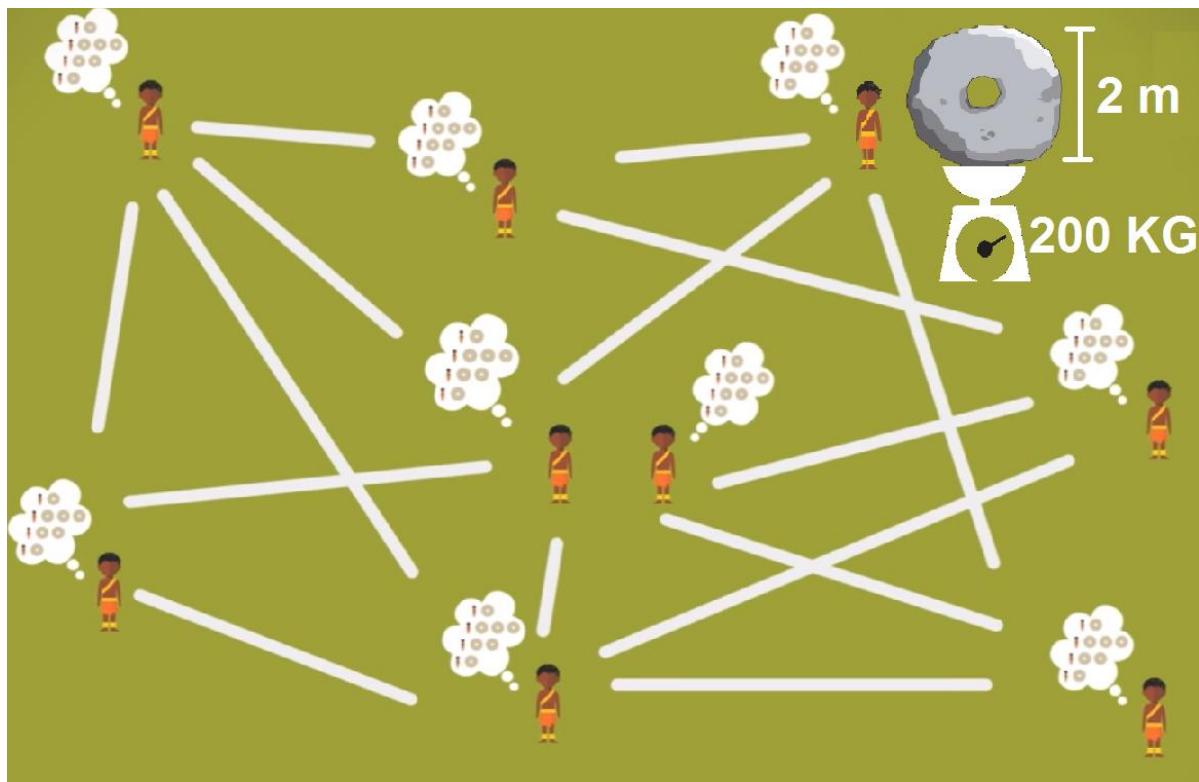


Figure 15: Yapi's trading concept using Rai currency¹⁷

There was no need for updating all the inhabitants about the trade, as long as the majority of inhabitants informed the trade validation accrued and non-presents could update their records later. If a Yapi tried to spend a Rai that did not belong to her, the consensus within the society declined to validate the trade objecting that the claimed Rai does not belong to her. A closer look at their economy unveils that, due to difficulties of exchanging the physical format of their currency, Yapis transferred the information about the ownership of the currency meaning, the owner of a Rai is whomever that people can verify her ownership, not the person who has the Rai at her possession (Cora 1975). Getting more profound in their phenomenal evolution of ownership concept, the existence of the physical Rai did not affect its owner and the society, in case of a stone destruction, the information addressing the specific stone would be assigned to a new stone. Blockchain is the same concept of keeping records

¹⁷ Hill 2016 (Diameter and weight added by the author)

that securely keeps records of transactions without violating the privacy. On a blockchain's ledger, through a public access to the transactions history, everyone can see an address that is the owner of an asset, but the ownership of the address is only viewable to the owner of a private key associated with the address.

The blockchain is a decentralized system of data transaction that has canceled the need for the participation of a third trusted party in order to validate the transactions. It can be assumed as a chronological database that contains every transaction's record on a network of computers known as distributed ledgers (Peters and Efstathios 2016). This validation takes place through a phenomenon known as consensus protocol. Different blockchains can serve different needs, though they can adopt different approaches for validating a transaction. In order to protect the network against unauthorized individuals, a combination of different techniques such as public key cryptography is being used in the technology (Backlund 2016).

Goldman Sachs Global Investment Research (2016) offers an interesting definition for blockchain as a database of transactions, shared and distributed among participants. It is designed to increase transparency, security, and efficiency. The anatomy is because the database split into blocks which are validated by the entire network via encryption, by combining the current transaction details with the unique public key of two parties. The transaction is valid if the result of the encoding is the same for all nodes and added to the chain of prior transactions. If the block is invalid, a consensus of nodes will correct the result in the non-conforming node(Goldman Sachs Global Investment Research, 2016).

Although blockchains are made to function as a public ledger allowing universal access to the stored data within the blockchain, private blockchains can be used for private ledgers also. Public blockchains can gain an endless number of participants, whereas private blockchain allows members of predefined list access the network and its data (ENISA 2016). Public access to the ledger can be named as a drawback for public blockchains (Spielman 2016) .

3.2.2. Block

The very first step for understanding the blockchain is to understand the block itself. Each block can be taken as a container of data that can contain various kinds of data. However, in order to maintain the security of their network each block needs to contain specific information about the block itself that is apart from the data that is stored within the block. This information is called the block's header. It indicates information about the block itself and addresses its previous block indicator known as the block's hash. Tracing blocks backward will end by reaching the very first block in the blockchain that refers to no previous block as there is no any.

The first block of a blockchain is known as the genesis block. This array of blocks that are chained to each other are called the blockchain. Hashing and chaining blocks from the most recent one to the genesis block is one of the key figures that provides security of the network. Meaning, in order to change any information on any block on the network, all the headers of all blocks in the network need to be changed, and outcome needs to be validated by the majority of participants within the network (Antonopoulos 2016). Block's header contains information as listed below:

- A version number that refers to the used protocol for creation of the block
- A reference to the hash of the previous (parent) block in the chain
- Merkle Root-hash of the root of the Merkle-Tree of this block's transactions
- Timestamp: The approximate creation time of this block
- Difficulty Target: The proof-of-work algorithm difficulty target for this block
- Nonce: A counter used for the proof-of-work algorithm

3.2.3. Distributed Ledgers

Ledgers, divided into three categories, based on their accessibilities: the public ledgers are the ones in which, anyone with a connection can access the data and request to add data. However, the request for adding new data is possible by everyone; it does not necessarily mean that the data added to the ledger. The acceptance of adding data to the ledger, depending on the networks' protocol, is due to permission of the majority nodes of the network and has no selected nodes as gatekeepers. The Ledgers mostly

used for cryptocurrencies are public and different protocols that created the authentication mechanism, enables trust between two nodes, the details explained in consensus protocols in this chapter (Buterin 2014).

Private ledgers limit the access for both viewing and updating data. There are limited nodes that grant access and update rights for any request at any time. The mostly act as a database that is accessible only under gatekeepers permission. These types of ledgers have been exciting for financial institutions as the information access is faster, transactions are cheaper and to the possibility to control over the level of privacy is higher. Consortium ledgers are ledgers that aim to create a hybrid between public and private ledgers. Either access to data or the rights to update the existing data can be done based on a consensus protocol that is modified to serve to purpose of the ledger the best. An example use of this protocol is voting. If the majority of selected nodes, or a minimum number of the required node, accept the authenticity of an input, the data assumed valid and added to the ledger. There are merits and drawbacks for each type of ledgers. Public ledgers tend to be immune and trust free because there is no efficient way to tamper with the balances, revert transactions or modify the system rules. This is a crucial aspect of cryptocurrencies (Ibid). There are several risks of using public ledgers, especially for assets with high value or ownership subjected to privacy. There is a need for a clear understanding of the ledgers and their risks before their implementation for any assets. The actual merits of distributed ledgers are within the public ledgers; however, risks such as 51 percent attacks for sensitive assets create a tendency toward private or consortium ledgers (ENISA 2016).

3.2.4. Cryptography

In essence, cryptography is the function that allows participants to use an unsecured channel of communication as a medium to establish a secure connection (Coron 2006).

Cryptography has always been used in order to protect content, mostly a message, from being meaningless to anyone but the people who have the authority to access the content (Katz et al. 1996). Caesar used symmetric cryptography as protection for his communications with his generals during war times. Symmetric cryptography is also known as classical cryptography (Singh 2000). During the second world war, German troops used the Enigma machine, built on cryptography to protect their radio

communications (Garliński 1980). The drawback of symmetric cryptography is the key dissertation. The key to decrypt contents had to be sent in a separate message that abduction of the key by a third party could jeopardize the security of the communication. In the case of the Enigma machine, a decryption key that was hidden in the daily weather forecast was decrypted by allies, resulting in a significant privilege against Germans (Welchman 1982, p. 326). This vulnerability is known by Kerckhoffs' principle that claims any algorithm made for security can be compromised with higher intelligence. In order to guarantee the security, a private key should be kept by participants of the communication and the algorithm can even be published also known as public key encryption (Mrdovic and Perunicic 2008).

Franco (2014) highlights three types of cryptography used in Bitcoin's network as follows:

- Public key cryptography for transactions
- Hash functions to protect the data within the blockchain.
- Symmetric key cryptography secures the private key within the user's wallet.

In today's world of internet, with the massive amount of security-sensitive information transmitted over the globe through the internet, cryptography is essential in order to ensure the security for transmitting data (Buchmann 2013).

3.2.5. Public key cryptography

Public key cryptography is a fundamental security asset in computer and information. Invented in the 1970s, it is a mathematical function that overcomes the flaws in symmetric cryptography. It is a one-way mathematical function that enables users to sign their requested transaction using their digital signature known as Private Key. Whereas Public keys are calculated based on the private keys, it is infeasible to guess the private key based on a public key. It can be assumed as two keys for a safe, where public key can be used to lock the safe but in order to unlock the safe but it is useless for unlocking the safe (Franco 2014).

In public key cryptography, the public key encrypts the message before transmission through an open channel. The transmitted data is meaningless to anyone but the holder of the private key (Segendorf 2014). Within the blockchain, all the data that is being transmitted, saved and secured within the ledger are encrypted using public keys. Meaning, all the participants of the network have access to the data that is worthless to them without access to the public key that was used to create the specific data.

3.2.6. Hashing and chaining the blocks

Running any hash function on any data is called hashing. A hash function maps the data, no matter how big, into fixed-length data. It is not an exclusive technology to the blockchain, for example, the hashing protocol used in Bitcoin network “SHA256” was created by the NASA under Secure Hashing (Penard and van Werkhoven 2009).

The outcome of this function is called the hash value. The importance of hashing function lies within two merits: First, if any point on the original data is changed, the hash will change. Second, it is impossible to retrieve the original data from the hash function output. That is the reason which hashing is also called one-way compression function (Katz et al. 1996).

A block’s hash is the unique identifier of the block, also known as, the block’s fingerprint. The hash value of each block is stored within the block and on the next block, meaning changing any data on any block will change its hash value, and through its hash value is stored on the next block, the hash value of the next block will change also. This clarifies that tampering any data on any block will change the hash value of the block resulting in a domino effect that changes the hash value of next blocks on the tampering node and making them invalid to other nodes (Antonopoulos 2018, pp. 165–169).

3.2.7. Merkle Tree

It can be understood that as the blockchain grows the amount of data that needs to be stored and analyzed by each node will grow simultaneously. Nakamoto (2008, p. 4) offers using the Merkle Tree to avoid metadata analysis. Merkle tree is used for verification of data that has been saved, moved or transferred by computers. This can be either within a system or in communication between two or more systems.

Merkle Tree is a binary data structure that hashes data from the lower layers of data named leaves separately and saves the hash value in one level higher. As shown in Figure 16 same hashing function takes place until the whole set of data has only one hash that is called root hash . In blockchain, incoming transactions to the block are considered as the Merkle Tree's leaves, and the top hash is the Merkle Root which is included in the block's header. Merkle Tree increases network's efficiency by decreasing the amount of data that needs to be verified in the network. For example, a block that contains 512 transactions and has a size of 128 kilobytes, will have a 288-byte size Merkle path. When transaction in the block reaches 65'353, block size will grow to 16 megabytes, but, the Merkle path size will barely double up to 512 bytes.

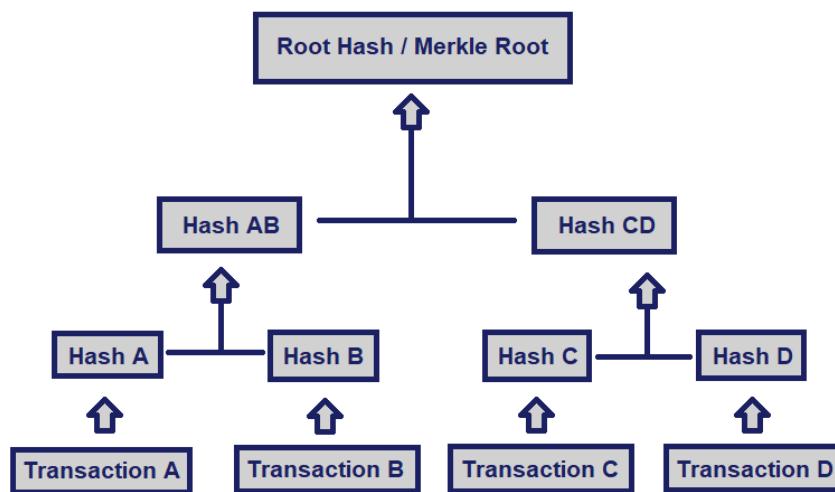


Figure 16: The Merkle Tree of transactions A, B, C & D¹⁸

Merkle Trees are the core to Simplified Payment Verification (SPV) where nodes can verify a transaction with no need to have access to all the blocks in the network but only their headers (Antonopoulos 2018, p. 124).

¹⁸ Ray 2017.

3.2.8. Consensus Protocol

This protocol is the real merit of blockchain technology. It assumes that the nodes of the network can reach a certain level consensus that can distinguish true and false data. Once nodes in the network verify the legibility of data, the data is stored in a block and block is added to the blockchain (Kraft 2015). Validation of transactions within the block can be done through various methods. Currently, the Proof-of-Work protocol is being used for most of the cryptocurrencies. Other methods such as Proof-of-Stacke which is being used with the BlackCoin cryptocurrency can also be used (BlackCoin 2019). The protocol's ability to maintain the correct order of transactions within the network cannot be guaranteed. Failures such as Practical Byzantine Fault can threaten the right array of the transaction. As the blockchain networks scale during time new protocols to prevent failure are added to raise the networks consensus such as Practical Byzantine Fault Tolerance (Corluka and Lindh 2017).

3.2.8.1. Mining and Proof-of-Work

Proof-of-Work was Nakamoto's solution for allowing a tamper-free voting system in order to decide which block should be added to the blockchain next. In general, it ensures that voters in the network are real. This process in the Bitcoin network is done by using computing power to solve a mathematical problem that the network automatically adjusts its difficulty.

The progress of creating and adding a block is called mining. The difficulty adjustment is based on the time that took for the network to add the previous block. In Bitcoin's network, each block is made in approximately ten minutes. If the previous block was added too soon, the difficulty will rise and vice versa. In the end, the miner that offered the block which has been accepted by most of the networks participant gets rewarded for the effort (Nakamoto 2008; Blockchain Database 2019).

In theory, participants of the network can directly express their idea by placing their votes. In practice, schemes like Sybil attack can happen to an open network. Sybil attack happens when a user creates multiple accounts in order to improve its influence over the network. This influence can be boosted by the attacker to gain control over

the network by creating fake votes for its desired, however not legitimate, block (Backlund 2016).

Due to its hype in 2017, Bitcoin's price broke 18,000\$ (Coinbase 2019). Before 2015, the computing power required to create and add a block to Bitcoin's blockchain could be found on the most home computers that had a Pentium 4 CPU or higher. First Bitcoin miners, also known as hobby miners, could use their computer's idle time to mine Bitcoin and earn 50 BTC for each block (Tristan Greene 2018). In contrast, during the hype, the same 50 BTC could bring the miner more than 800,000 Dollars (Greene 2019). The considerable rise in the price, attracted miners to invest in more powerful hardware, and mining moved from home personal computers to mining farms. Malmo (2015) Argued that 215 Million Watts of energy used annually are one of the main reason for Bitcoin to be unsustainable. However, energy consumption did not stop at that rate. The vast range of investment in hardware that consume at least 50 trillion what hour per year is currently a significant problem in Bitcoin's network. This energy consumption is higher than countries like Singapore or Portugal (Digiconomist 2019).

However the trend of using renewable energy resources is on the rise and by May 2018 more than 70 percent of the Chinese miners reported to use green energy (Bendiksen and Gibbons 2018). Tackling energy consumption is becoming a new concern. Hall (2018) Offers solutions such as a lighter consensus algorithm, cloud-based mining, and using renewable energies as alternatives to reduce the massive environmental effects. Algorithm modifications offered by Jacquet (2018) aims to modify hash race between miners by introducing green blockchain protocol. However, ideas to improve the sustainability of blockchains are being discussed in the blockchain world, using direct green energy for mining has been the first solution that could offer this theory in practice (Hydrominer 2019). Even though the discussed environmental issues with Proof-of-Work, Courtious (2014) claims that miners with higher computing power can outplay miners with lower computing powers resulting in a centralization inside the decentralized network. This centralization will make the network vulnerable by allowing the attackers to gain control over the network by hacking nodes that have higher influence within the network. As said before, a block can be added to the blockchain when the majority of nodes agree about it, and in order to tamper with the network, attackers need to gain control over the 51 percent. Meaning, hacking fewer nodes that have the most computing power is much easier to hack thousands of nodes

that have a similar influence over the network. This phenomenon is also known as a 51 percent attack.

3.2.8.2. Proof-of-Stake

Currently, the only alternative to proof of work that is being used by other cryptocurrencies in practice is Proof of Stake. The difference is to replace computing power, as an indicator for a node's influence over the network, with stake size being held by the node. The logic comes from the idea that the owners of the stakes tend keeping the value of their stake at its highest, therefore the owners of more stakes get more influence over the network. The network is secure as long as the data within its ledger has a value to someone who keeps mining it.(Gabizon et al. 2014). PPCoin is a cryptocurrency that uses proof of stake (King and Nadal 2017). As other consensus protocols such as proof of burn, proof of capacity, are being introduced over the blockchain community, blockchain giant Ethereum plans to move from using proof of work to a new alternative (Cavicchioli 2018). In essence, the progress of the blockchain transaction, as shown in Figure 17, starts with a request that is sent across the nodes within the network to get verified. The verified transaction, among other transaction, is stored in a block that the majority of nodes approved its authentication, the block gets chained to the previous blocks and transactions are permanently available for everyone for verification,

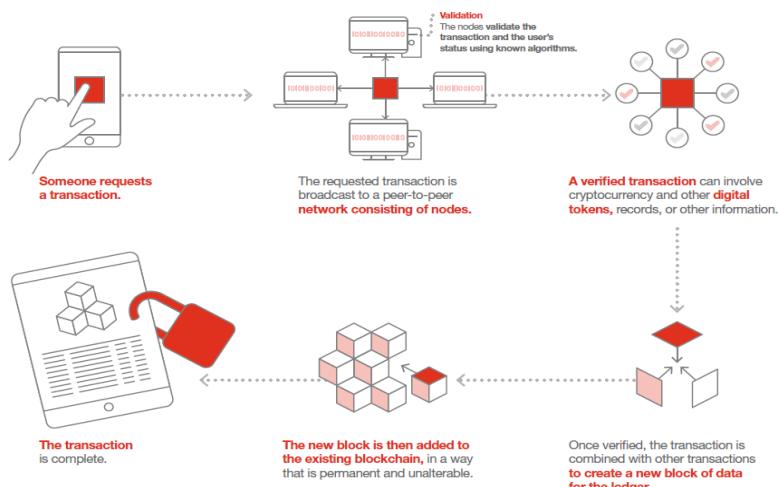


Figure 17: A schematic overview of the transaction process on a blockchain¹⁹

¹⁹ PwC 2018.

3.3. Blockchain 1.0 Currency

As the first application of blockchain technology, cryptocurrencies, have brought new paradigm, opportunities, and vocabulary for payment industry, Says Jonathan Vaux, executive director of an innovation center at Visa (Hileman and Rauchs 2017). Money as we know today is an abstraction, the medium itself has no value. The value of money comes from a general agreement that it has value (Antonopoulos 2016). Currently the 195 countries in the world are using 273 different currencies (Swiss Association for Standardization 2016). In contrast, currently, there are over twenty thousand cryptocurrencies listed (CoinMarketCap 2019).

Unlike other currencies that their characteristics mostly aspire to the countries of origin, cryptocurrencies' characteristics come from their ability. In the following, current currencies and their functions will be shortly discussed and compared with cryptocurrencies

3.3.1. Currency

In order to have a better understanding of how this new type of currency can bring any aid to the modern world's economy and real estate industry, some highlights of currency developments, its current applications, and drawbacks are discussed.

3.3.1.1. Concept of currency

Money is a medium of exchanging value (North 2012). Surprisingly, the utilization of money is not limited to humans. Other animals such as dolphins use tokens to express themselves among their mates (National Geographic 2017). Drawbacks of money seen on animals too, animal rights organizations stopped an experiment on silver discs as money among monkey due to prostitution becoming trendy among them, says Dubner and Levitt (2005) on a New York Times article. Money is older than writing; in fact, first discoveries of writings are the ledgers that explain financials among the ancient societies (Antonopoulos 2016).

3.3.1.2. Representative currency

As the name claims, the representative currency is a currency where its value comes from its direct connection to a valuable source. It was a facilitating breakthrough to barter era (Ritter 1995). The American “I OWE YOU” is a famous example of this format. In gold hype era, banks offered a paper, same as bank checks today, in exchange for gold. The paper could be traded as same as the gold it was representing. This protocol is also known as the gold standard. Formation of currencies as we know them today is based on this concept. The value of a representative currency comes from its connection to the valuable resource such as the gold that is owned by the government which has issued the currency (North 2012). With the rise of fiat currencies, that will be explained next, most countries printed notes and added credit irrespective of the amounts of valuables at their possession (Kotlikoff 2006).

3.3.1.3. Fiat currency

The origins of fiat currencies can be traced back to the invention of Persia in the 12th century. Genghis Khan forced Persians to use paper money issued by his empire. Natives did not accept the concept, and the experiment failed soon (Tullock 1957). Fiat currencies’ value comes from society’s faith and demand. The first major step in the creation of the fiat currencies in the modern world’s economics was taken place at the 1910s in the U.S. During this time; the government prohibited the trade of federal gold for dollars within the country which is known as Federal Reserve Act (National Bureau of Standards 2006). The Bretton Woods agreement after the second world war forced the winners of the war to use U.S dollar as their reserves instead of gold. The idea was that if all the currencies are backed by dollar, that was backed with gold, there would be less fluctuation and business could be done internationally (Helleiner 2010). The standard gold era officially ended in the 1970s when the U.S government applied the same rule of no gold for the dollar to its foreign debts also. This act was executed by Richard Nixon in 1973 and is also known as Nixon’s shock (Ritter 1995).

The final step to the world of fiat currency can be marked to the 1999 Swiss referendum that reformed a 125-year-old constitution. The aftermath was to bail out from gold standard that forced the Swiss government to back up 40 percent of its in-circulation currency by gold (The New York Times 1999).

3.3.1.4. Euro: An international currency

The first idea of international currency was formed after the first world war in 1929. The goal was to prevent the world from repeating the same catastrophe and embrace peace around the globe (Christian Tomuschat 1995). However, it took more than 40 years and another world war long for this idea to take any step in practice. Nixon's shock brought the european countries to establish a new protocol to enhance business internationally(Pickford et al. 2014).

Euro, as a first international currency, both in design and practice, emerged from the rise and fall of European exchange rate mechanism that started in 1970 in response to inflation and chaos after Nixon's shock. The collapse of USSR and reunification of Germany had a significant impact on European policy and on the first day of 1999, the Euro was introduced (Obstfeld and Kenneth Rogoff 1995).

3.3.1.5. Drawbacks of fiat currencies

Debates on fiat currencies has a long history, Voltaire, 17th century french philosopher believed that “Paper money eventually returns to its intrinsic value- zero” (LibertyTree 2009). Murphy (2018) claims that currencies are so objective that creating list of factors that affect a currency is not simple. To begin with, one of the drawbacks of the fiat currencies is the extreme political influences on their value, political agendas such as sanctions on a targeted economy can create catastrophic consequences. Sanctions can create hyperinflation on the target economy by reducing interest for the targeted economy’s currency(Drezner 2015). For example, the recent withdrawal of the current U.S' administration from an agreement with Iranian government as well as with Russia, China, Germany, France, the UK, and the EU during the past administration and opposing sanctions instead, created a hyperinflation on the Iranian currency highlighted with colored dots in Figure 18 on the next page.

Current banking system acts as the tool for this sanction by limiting a specific country from accessing international banking platforms such as The Society for Worldwide Interbank Financial Telecommunication (SWIFT). Fiat currencies have created an economy in which, sanctions are applicable at a level that a country can prevent third countries from transacting with the targeted economy in a threat of cutting business

with account holders who had transactions with the sanctioned country's accounts (Blake 2017).

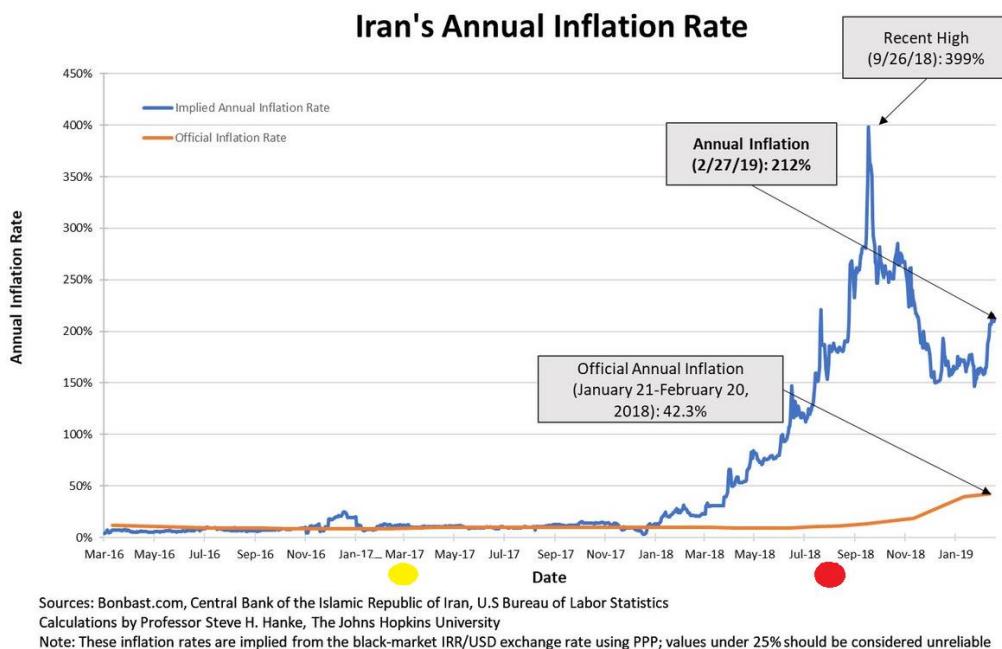


Figure 18: Iran's annual inflation rate, official compared with its actual²⁰

Transparency is another subject of an issue for a fiat currency. For instance, according to Proff Hanke, (2019) Applied Economist from Johns Hopkins University, the 42.3 percent claimed annual inflation of Iranian government is four times smaller than its actual rate illustrated above.

Various resources take the Federal Reserve Act, that is the origin of fiat currencies, as one of the fundamental problems with the modern economy (Fetter 1916; Klein 1994). They consider Inflation as one of the main characteristics of fiat money as there is no cap for the money in circulation. Fiat money can come to existence as a decision of policymakers. The new volume of money will reduce the purchasing power resulting in devaluation of a currency (Formosa Financial 2018).

On the other hand, studies from Federal Banks such as Rolnick and Weber (1997) claim that developments in financial growth are in correlation with inflation. As 27 Feb 2019, Inflation is not the only source for the devaluation of fiat currencies. As the value

²⁰ Hanke 2019 Two dates highlighted with the author from Blake 2017; USRB And Independent 2018.

of the fiat currencies comes from the balance between supply and demand. Policymakers can decide about supply and lead the real purchasing power of the currency in their desired direction. For instance, in 2012, Federal Reserves decided to devalue the US dollar by 33 percent throughout 20 years (Charles Kadlec 2012). To clarify this effect in the long run, the consumer price index for all urban consumers, the purchasing power of the consumer dollar is illustrated below. Kotlikoff (2006) debates that United States is experiencing a hidden federal bankruptcy being covered by devaluating the U.S dollar.

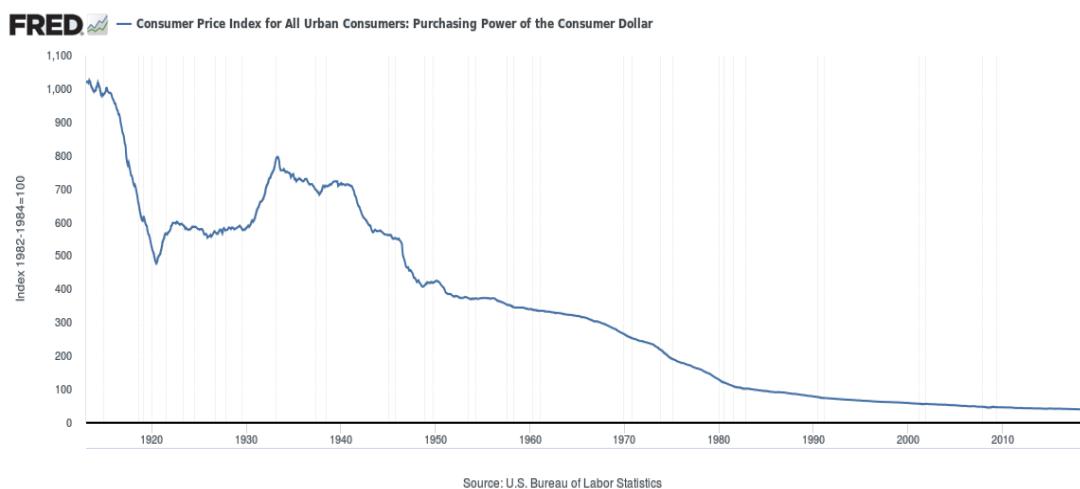


Figure 19: The purchasing power of the consumer dollar (1920-2019)²¹

3.3.1.6. The market crash of 2008

As an example of problems with fundamentals of the modern economy policies, the market crash of 2008 can be a good example, as it is an aftereffect of a real estate bubble burst. On their research Haughwout et al. (2011) broke down the role of real estate investors and their privilege in credit creation as the root of this crisis. In short, the catastrophe was from the house mortgage market's policies that allowed house owners to gain credits that were higher than the actual value of their property. The real estate brokers merged houses under the mortgage in the investment baskets to gain more credit over them as portfolios that are more interesting for more prominent investors firms. The aftermath was that the house owners realized this flaw and considered "house flipping" as a way to get "easy money." The bubble burst happened due to a combination of reasons such as the rise of mortgage charges and fall of house

²¹ Federal Reserve Bank of St. Louis 2019.

prices that led to houses that their mortgage payback was much higher than their actual value (Mark Thornton 2009). The contagiously of this crisis, moving from the real estate industry to the national scale, is marked to Lehman Brothers' bankruptcy. Wall Street was shut down, and if it was not for 85 billion dollar bailout from Bush's administration, it could never recover (Taylor 2009). How exactly the domino effect affected the global economy is beyond the scope of this study as the aim of highlighting this catastrophe is to illustrate one of many problems with the modern economy that can have a dramatic effect people globally. Figure 20 shows the global effect of this crisis that only a few countries like Germany and Japan managed to recover from it and countries like Italy are struggling to cover their negative GPD.

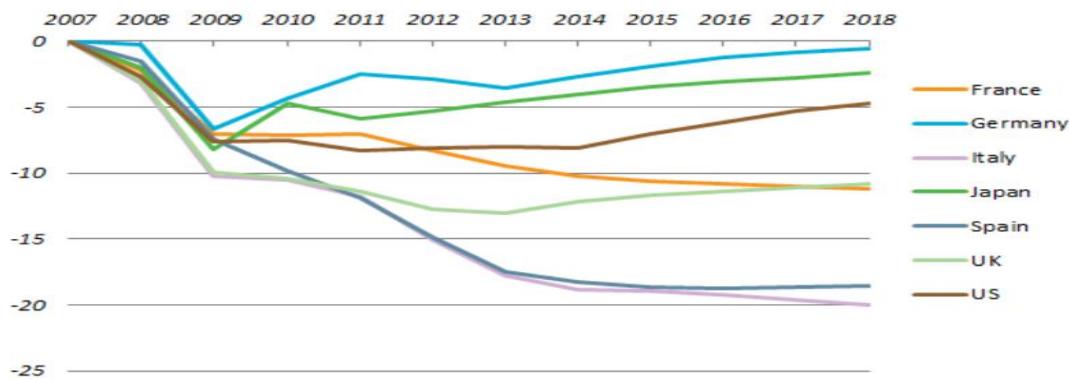


Figure 20: Deviation from Trend of GDP per Working-Age Person since 2007²²

In their paper "Effects of Global Financial Crisis on Greece Economy," Ozturk and Sozdemir (2015) discussed that how a faulty credit scheme in the U.S can jeopardize the life of many on the other side of the world.

The market crash of 2008 followed by the Greece financial crisis broke the illusion of trust in banks and governments. Also, what governments did was to inject 85 billions of dollars to overcome the crisis momentarily. The problem is not solved and injection of credit, instead of solving the real cause behind the catastrophe, has stopped the catastrophe momentarily (Antonopoulos 2016).

²² Lydia Gordon 2014.

3.3.1.7. Comparison of Cryptocurrency and Fiat currency

One of the fascinating facts about cryptocurrencies is that they do not belong to a country; they are neutral and global. They are not subject to inflation by their nature as they have limited and transparent distribution capacity. For example, there would be 21 million Bitcoin s, and a current number of in circulation Bitcoins can be observed at wish. 689 billion dollars worldwide remittance money circulation is exposed to an average cost of 10.3 percent despite the currency conversion costs (The World Bank Group 2019).

On the other hand, Bitcoin, for example, has a min cost of 6 cents per transaction for the slowest method that takes 40 minutes. This slowest 40 minutes can be compared by one to five business days that an international transaction can take (Bitcoinfees 2019; TransferWise 2019). As said, the transaction cost in the Bitcoin network is independent of the amount of value being transferred. Meaning, unlike the remittance charges, the volume of the transaction does not affect the transaction cost, and transaction cost is fixed per transaction.

Cryptocurrencies are programmable, and their ownership is not limited to humans, meaning they can be used for transactions that their executions can be done automatically. This can be foundation for implementing the Internet of Things (Popov 2018).

However, cryptocurrencies are yet to be used by the majority of participants, and their popularity among the masses is minimal at the moment. On a survey with more than 29 thousand participants from the US, the UK, Germany, Brazil, Japan, South Korea, China, and India, Dalia (2018) claims that only seven percent of the participants own a cryptocurrency.

3.3.1.8. Summary

Fiat currencies are economic tools at the will of politicians and high-level bankers that can create financial problems globally. Inflation is an inevitable consequence of fiat currencies that reduces the purchasing power of the people. Transactions of fiat currencies need the participation of a third trusted party that makes these transactions

both costly and slow. In contrast, cryptocurrencies can be used to overcome these flaws due to their decentralized, trust free, and transparent nature.

3.3.2. Cryptocurrency

Cryptocurrencies are digital cash; they are a new way of transacting value over the internet. This transaction happens using wallets that are accessible through the web and smartphone applications. In order to use a cryptocurrency, the user needs a public and private key generated by their wallet at an instance. To simplify, public key acts as an email address and the private key gives the owner access and control over the information within the wallet. Public keys usually are alphanumeric values or in the QR code formats readable by smartphones. The public key is the only requirement for receiving cryptocurrencies; however, in order to spend them, the private key required (Swan 2015).

3.3.2.1. Bitcoin

Bitcoin is the first form of cryptocurrencies. It is confused with blockchain technology most of the times as the blockchain technology was introduced with Bitcoin. Created in 2008, Bitcoin is the first virtual cash that it is not representing any physical format of money. Furthermore, this new format of currency used in order to validate other transactions also. For example, everyone can use it in order to sign statements and contracts because its ledger is public. Bitcoin ATM experience can be mentioned as it surprised people with how a currency can have its branch of exchange with the local currency with no banking system involved (Antonopoulos 2016).

3.3.2.1.1. Lightning network

Lightning network, as a scalability solution, is off-network transactions that take place between two or more participants within a decentralized network in order to reduce the network's load and increase speed. It was offered by Dowd et al. (1996) in order to overcome latency in hierarchical networks to improve the networks' performance for

users “who do not mind incorporating the system-specific code in their applications” (Ibid, p 1386).

Bitcoin’s lightning network takes place through cooperative channels and transactions without broadcasting them continuously to the network. It assumed as a deposit box where two or more parties arrange with each other, transact values to and from the box, and in case of a request for withdrawing from the box, the final status of the box is transmitted to the network. This can reduce transaction time and cost for participants who have a high load of constant transactions. Some of the use cases of the lightning network and their benefits according to Poon and Dryja (2016) are:

- Instant Transactions: Suitable for non-revocable daily expenses
- Micropayments: Solves the high transaction fees barricade
- Financial Smart Contracts: Enabling highly complex transaction contracts
- Cross-Chain Payments: Avoiding exchange delays and costs

3.3.2.2. Other Cryptocurrencies

Currently, there are more than twenty thousand cryptocurrencies, and this number is growing every day. This number is for the currencies already listed in exchanges and does not cover personal currencies (CoinMarketCap 2019). Everyone can create their own cryptocurrencies using a Bitcoin fork as altcoins do, Ethereum ERC-20 as the majority do, or creating their very own blockchain. Each cryptocurrency can have its own characteristics. For example, Matt Farley created his own home cryptocurrency to manage his home activities, on his platform; children can earn cryptocurrencies as a reward for doing certain tasks such as cleaning their room or doing their homework and spend it for watching television (Matt Farley 2019).

3.3.2.3. Colored Coins

Colored coins are not an individual type of cryptocurrency; their purpose differs them from other cryptocurrencies. A colored coin, or tagged coin, can be a Bitcoin or any other cryptocurrencies with a smart asset assigned to that particular coin (Hajdarbegovic 2014). Smart assets can vary from stocks, bonds, commodities, real

estate, fiat currencies, and even other cryptocurrencies. In Bitcoin, for example, each Bitcoin dividable into one million parts that are known as Satoshi. Each Satoshi is linkable to any of the mentioned assets, and the owner of the colored coin can transact her ownership over the asset by sending the coin through a Bitcoin transaction. ChromaWallet is a color-aware wallet that enables colored coins trades (Walters 2018).

3.3.2.4. Wallets

Wallets are the first applications developed for users' interaction with blockchains. A cryptocurrency wallet does not store any balance as an indicator. By accessing the blockchain, wallet makes a balance between received and spent volumes. Statista (2019b) claims that there are more than 30 million wallet users by the end of 2018. Hileman and Rauchs (2017) claim number of active wallets can vary between 7 to 40 percent of total wallets. Wallets can connect to multiple cryptocurrencies and at their advanced function, connected to exchanges; they can exchange the currencies within them at will. Multisignature wallets are the new format of wallets that can allow more than one participant to involve in transactions. The aim for a universal wallet started by a 50 thousand dollars bounty from Blockstack Company for developers who can build a universal wallet application (IBINEX 2018).

3.3.2.5. Drawbacks of cryptocurrencies

There are many problems with the cryptocurrencies, as they tend to change the fundamental concept of money, one of the oldest invention of the human race. Chohan (2018) lists more than 500 million dollars lost due to theft and exchange shut down. However, none of the hacks has affected the Bitcoin's blockchain but only the exchanges and private keys. Meaning that the owners of private keys have been hacked and their funds transferred to another account. In the biggest hack in the list refers to Mt Gox exchange that they managed to trace and return about one-third of the lost Bitcoins (Norry 2018). However, legal status and taxation policies are developing; they are vague at this point. For example, German blockchain lawyer, Kirschbaum (2018) offers that taxation per case can vary and personal evaluation should be consulted (Miles 2014).

More points of view that are radical found in both academic and social environments, For instance, Brill et al. (2014) claims that cryptocurrencies made to facilitate terrorist activities. The blockchain is on the scaling level; needs design at the first place. Regulations are yet to be made, and problems are yet to be solved(Antonopoulos 2016). To summarize, the current challenges listed below:

- High price fluctuations
- Big carbon footprint due to proof-of-work mining
- Irreversible transactions
- Local government's prohibition
- Unclear taxation regulation
- Lack of design for basic users

3.3.3. Cryptocurrencies and real estate industry

First Nordic real estate purchase using cryptocurrency took place in Mørkøv, Denmark at 2016 upon of the buyer's request to pay for his purchase in Bitcoins. Jesper Jørgensen, CEO at Just-Sold, expresses this experience to be fascinating as there were fewer efforts with bank's regulations(Coinify 2016). Currently, cryptocurrency payments for real estate purchases are not news anymore. There are already platforms such as Propy that accept cryptocurrencies as a method of payment (Propy 2019).There are many companies offering bill management service on cryptocurrency; however, due to regulations that do not accept a cryptocurrency as a payment method, they are just new intermediaries that receive a cryptocurrency from a user and pay in fiat currencies. To name a few bitbill.eu and piixpay.com are mentioned. Property taxes are payable in Florida's Seminole County from May 2018 using a cryptocurrency.

As the elected tax collector of the first state to accept Bitcoin for taxes, ID and plate costs, Joel Greenberg believes this new payment method is faster, smarter, and more efficient. It will save one to two percent for taxpayers and brings in customer satisfaction for the state (Trustnodes 2018). Later on, Ohio business owners were allowed to pay their business taxes using Bitcoin (Mearian 2018). Facility managers can utilize this tool as a new method to reduce their tax costs.

Investments in real estate can be one of the best outcomes of blockchain technology for the industry. Cryptocurrencies bring the ability to tokenize a real property to the shares that cost less than one thousand dollars. Now investments are limited to people with information and wealth privilege. This opportunity has brought significant attention for real estate experts such as Svirsky et al. (2017) to start investing platforms that are at their development phase. Top ten real estate cryptocurrencies based on their market capitalization according to CryptoSlate (2019) as for February 23rd, 2019 with a short description of their purpose and market capitalization size in a million dollars are shown in Table 1.

Table 1 Real Estate cryptocurrencies by market capitalization size in million dollars²³

Name	Token	Description	Capitalization
LAToken	LA	Tokenize and trade real assets via cryptocurrency	32.8M\$
Ecoreal	ECOREAL	Real estate asset-backed global security token	15.4M\$
Breeze	BRZC	A cryptocurrency linked to real estate assets	9.2M\$
Propy	PRO	Decentralized title registry	7M\$
IHT	IHT	Global Real Estate Blockchain Cloud Platform	6.5M\$
Winco	WCO	Cryptocurrency of the startups and real estate market	1.9M\$
Atlant	ATL	Real estate blockchain platform	1.5M\$
REAL	REAL	Tokenized real estate ownership	0.6M\$
Relex	RLX	Blockchain-based proxy real estate developer platform	0.5M\$
Alt.Estate	ALT	Platform for trading tokenized real estate	0.4M\$

3.3.4. Summary

Cryptocurrencies and their new payment methods used globally and are making their way through the real estate industry as well as other industries. However, payments themselves are not the ultimate function of cryptocurrencies, but their characteristics are the cornerstone to bring other functions of the blockchain technology for the industry. Cryptocurrencies have to manage to gain global trust in blockchain technology, and if it were not for the Bitcoin's success in market capitalization, this technology would not be as popular as it is today. Cryptocurrencies are the first application of blockchain technology as the email was for the internet. On a survey on a sample size of 14828 persons within 15 countries Statista (2018) asked the participants if they own a cryptocurrency and the results are as illustrated in Figure 21.

²³ Own table, data retrieved from CryptoSlate 2019

The results offer that on average, less than ten percent of participants claimed that they own some cryptocurrencies. Figure 21 shows how early in adoption the cryptocurrencies even within the developed countries. East Europeans are in the lead.

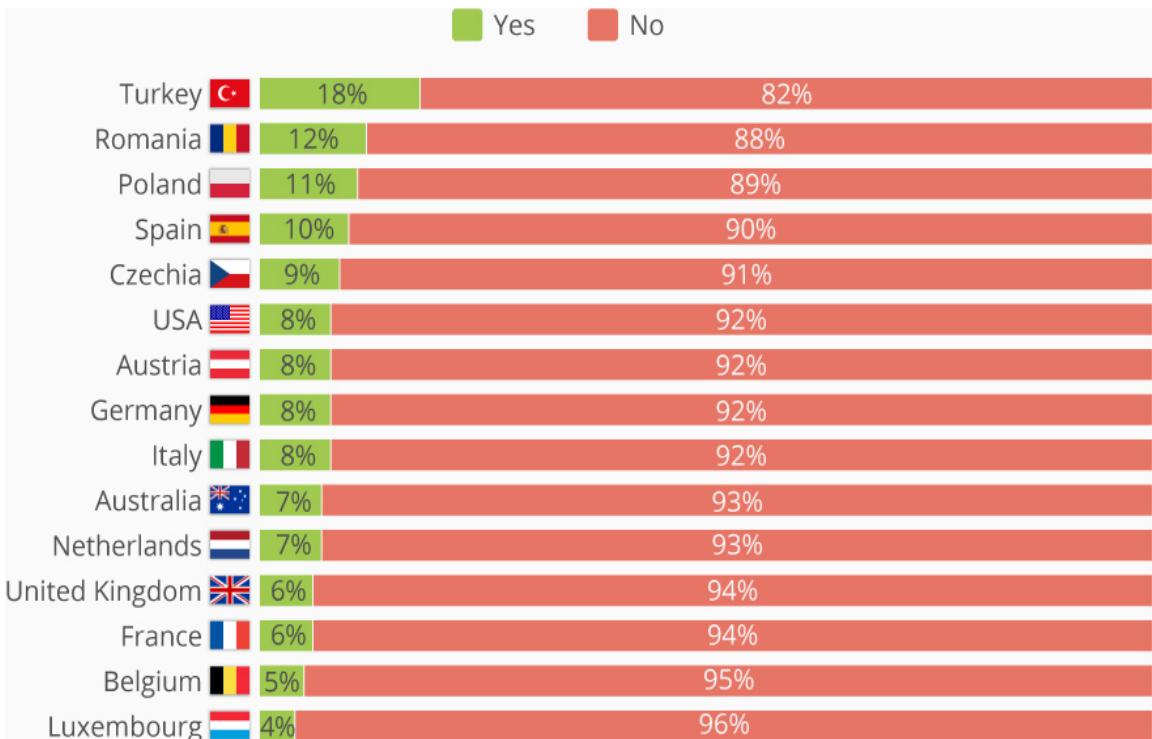


Figure 21: Results for survey question, "Do you own some cryptocurrency?"²⁴

3.4. Blockchain 2.0: Smart Contracts

The notion of smart contract is “some business logic that runs on the network, semi-autonomously moving value and enforcing payment agreements between parties” (Dannen 2017). The first attempts to create automated contracts go before blockchain technology. Formed in 1993 as an attempt to reduce paperwork and increase efficiency. However, the idea seemed practical due to the new computing possibilities; markets did not adopt the concept (Omohundro 2014).

The most straightforward example of a smart contract is a vending machine. Unless it is broken, it can execute the protocol within the machine as long as the requirements for the execution meet. The smart contract is a piece of code that, either the code itself or the code’s hash, is stored on the blockchain. It can access and call other blockchains, gather information about the progress and finally execute its purpose.

²⁴ Statista 2018. Question Cropped by author and written in text

This purpose can vary; it can be the execution of a payment on a blockchain or change the ownership of a smart asset. A smart asset is an object that its ownership digitalized, stored and managed through the blockchain. Smart contracts can lead to decentralization, whereas there are less central authorities involved in the progress of executing a contract. This less involvement of human being can reduce errors and improve efficiency (Swan 2015, p. 61).

The smart contract is to change the concept of contract by automation in more complex types of contracts. However, in developing phase to become more flexible and legally binding, smart contracts are the most used function of blockchain technology after cryptocurrencies (Bhargavan et al. 2016). On his research for North Carolina Banking Institute, O'Shields (2017) offers that smart contracts, despite their potential for creating a new definition for contracts as we know them today, need consistent cooperation of professionals from blockchain, law, and the target industry.

It is important to keep in note that smart contracts, as an application of the blockchain technology, is on the developing phase and its practicality is minimal currently. However, their potential to lubricate the business is not doubted anymore.

3.4.1. Ethereum

In a fundamental understanding, Ethereum to smart contracts is as what Bitcoin is to the blockchain technology. However, the concept of smart and automated contracts has been before, Ethereum put them in practice. On its virtual machine, the platform tends to create an environment that is understandable for both technicians and economists. Coding on Ethereum is in Solidity that is a JavaScript-like language. The ultimate goal is to build an economic system in the pure software environment. To break it down: it is possible to pay hundreds of people, who live in hundred different countries, a minimal amount of value, on flexible periods as small as few do minutes, on this platform using the code. On the current banking platform, this can take weeks and hours of experts' effort (Dannen 2017). There are security vulnerabilities and bugs

within the Ethereum platform that can result in hacks and functionality problems. Problems are being solved as the platform scales to new versions (Luu et al. 2016)

On his project's paper Wood (2017) claims that Ethereum's goal to facilitate transactions between consenting individuals who cannot establish trust do to the following reasons:

- Geographical separation
- Interfacing difficulty
- Incompatibility and uncertainty of existing legal systems
- The expense of matching the existing legal systems
- Corruption of existing legal systems

The legal boundaries for smart contracts are under development. For example Raskin (2016) concludes that a jurisdiction paradigm shift is needed to put smart contracts to practice. Platforms such as OpenLaw and Rhombus, aim to tackle this legal uncertainty and connect smart contracts to real-world data (OpenLaw 2018; Rhombus 2018).

3.4.2. Crowdfunding

Originated from crowd resourcing, crowdfunding brings the possibility to solve problems over the internet (Bradford 2012). With adopting possibilities from cryptocurrencies and smart contracts, crowdfunding is becoming much easier for developing ideas. It allows international cooperation to smoothen the pass for ideas to step in reality. At its basics, crowd blockchain enabled crowdfunding allows international participants to have a more transparent view about the status of the project they are involved. Connected to a smart contract, if crowdfunding fails to accumulate the required funds, funds will return to potential investors automatically reducing fraud possibilities (Belleflamme et al. 2014). Crowdfunding in the real estate industry can help to improve equality and participant of goodwill. It can be a significant step for the real estate industry's investment structure (Marchand 2016).

3.4.3. Artificial intelligence

Artificial intelligence is a machine's ability to analyze the data in order to achieve a consciousness that can be trusted to replace human brain functions. The main advantage is that machines can process a broader range of data faster than humans can. However, to trust a machine in real life functions, it is yet to be developed (McDermott 1980). The best example of computers' ability to outplay a human is the chess game between IBM's Deep Blue and Garry Kasparov. The game took place in the 90s and became famous as the battle of the century (Munakata 1996).

There are several challenges for artificial intelligence to overcome, Amodei et al. (2016) categorize these problems in five as follows:

- Negative Side Effects: The machines aim to reach its goal and their goal only
- Reward Hacking: Machines can find a way to get their rewards by hacking
- Scalable Oversight: Decision making on non-frequent problems
- Safe Exploration: Creating catastrophes due to lack of information
- Robustness to Distributional Shift: The lack of ability to overcome the incompatibilities between the training environment and the real world

They conclude that regular end-to-end evaluations and solutions are more practical than centralized case-by-case fixes (*Ibid*).

Resources discuss how blockchain and artificial intelligence can interact with two different approaches. The differences come from the point of how artificial intelligence can facilitate smart contracts and how smart contract can influence artificial intelligence in practice. For instance, a farm's insurance against bad weather, written and executed as a smart contract, can use artificial intelligence to interpret the data from different sensors in order to determine if the "bad weather" have had happened or not. This interpretation can result in fund release for the farmer (Omohundro 2014). The other approach that explains about how blockchain, in its first implementations that covers smart contracts and cryptocurrencies, can adopt artificial intelligence as its brain and use decisions that are made by the artificial intelligence and execute transactions on the blockchain (Shilov 2018). The third approach can be to use the blockchains' safe

and constantly updated public ledger for a decentralized decision-making tool between different artificial intelligence. This can decrease cost and increase efficiency (Castelló Ferrer 2019). as another example for how the artificial intelligence can improve the quality of blockchain services, Marwala and Xing (2018) offer the capability of the artificial intelligence to test and find the flaws in smart contracts by virtually running them on different environments.

(Marr 2018a) offers three major benefits from the interaction between artificial intelligence and blockchain as follows:

- Cryptography reduces privacy threats for data being used by artificial intelligence
- Blockchain helps to trace and understand artificial intelligence's logic
- Artificial intelligence can manage blockchains more efficiently

3.4.4. Internet of things

The number of devices connected to the internet will pass 75 billion by 2025(Statista 2019a). The race to own and analyze the data is among the most exciting fields for the companies as the profit would be tremendous. However, the number of devices and the market share of connected devices are enormous and growing exponentially, the new scale of billion devices, soon becoming thousands of billions, is facing significant problems says Brody and Pureswaran (2014) and list the major problems as follows:

- High connectivity cost due to centralized server farms and clouds' costs
- Low privacy at a high cost due to security through obscurity
- No long term proof due to the high softer update and debug costs even beyond manufacturer obsolescence
- Lack of functional value if just being connected is the only advantage and this connectivity brings no additive value
- Broken business models that are not compelling and sustainably profitable

Some sources argue that the decentralized nature of blockchain combined with cryptography that ensures the privacy can be the golden key for a device democracy

that within its environment, connected devices can coexist. On their research, Middleton et al. (2013) estimated that the market for the internet of things would pass a 1.3 trillion dollar mark by 2020. Huckle et al. (2016) finds the blockchain's role in this market beyond critical in order for conceded devices to serve a shared economy in which the end-users can profit the most safely.

3.4.5. Limitations and Drawbacks

Even though smart contracts are yet to be applied within everyday life, the main discussion about the problems with smart contracts is about their lack of legal boundaries and doubts about their smartness (Levy 2017). Technical limitations are excluded from this research.

Legal confusions are taller obstacles to overcome, and in many cases, it is not about the smart contracts but the nature of contracting. For instance, (Restatement 1981 § 178) limits promises and agreement that considers them as unenforceable. This problem is not for the smart contract but all contracts. In real estate cases, the property owner and tenant contracts contain clauses that are not enforceable. However, these contracts are made and executed every day, but in case, courts will not enforce the clause to take place and do not consider the act of not executing promises as a violation to the law (Sullivan 2009).

By breaking down the existing law, Clack et al. (2016) offers that if a smart contract aims to be legally binding needs to meet the essentials as listed below:

- Methods to create and edit the contract
- Standard formats for storing and transmitting contracts and values
- Methods to bind a smart contract and its code to a legally-enforceable law
- Methods to offer a smart contract on an acceptable format for courts

Smart contract address complex issues through the code and, despite their technical developing stage, legal formats that are the main concern in the functionality of smart contracts that need the cooperation between professionals from blockchain, legal, and the industry that the smart contracts are formed within their environment (OpenLaw 2018).

3.4.6. Smart contracts and real estate industry

Smart contracts, combined with cryptocurrencies can be a game changer tool to disrupt the real estate industry from different aspects. From the early steps of the project development to tenants' contract and payment management (Karamitsos et al. 2018). Smart contracts' implementation is not limited to any of a property's lifecycle, claims Wang et al. (2017) and follows that in the construction phase, that many contracts are limited by the amount of previous knowledge and trust between participants, smart contracts can create a new trust-free environment whereas cooperation with a lower level of knowledge is possible. As happening today, most of the mentioned resources are claiming the possibilities of using smart contracts in the industry. However, in practice, the title transaction through a smart contract has already started in 2017. An apartment deed deal in Ukraine's capital, Kiev, registered as the very first Ethereum based real estate transaction (Propy 2017a). A year after, Katherine Purcell registers first American house deed using the Ethereum's smart contract platform. Natalia Karayaneva, CEO of Propy, the used platform for this transaction, said this is the very first step to disrupt the 217 trillion dollars real estate market with blockchain (Shedlock 2018). The only paper signed for this transaction illustrated in Figure 22 shows the property deed with the referral to the smart contract registered on Ethereum supporting the deed progress and its transaction number.

This conveyance has been recorded in smart contract [0xa188e5a3da203f8ebc72ec7578532926de1d3bec](https://etherscan.io/tx/0xa188e5a3da203f8ebc72ec7578532926de1d3bec) of the public Ethereum blockchain.



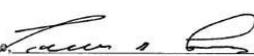
IN WITNESS WHEREOF, the parties do hereby execute this Warranty Deed this 20th day of February, 2018.



Katherine M. Purcell

STATE OF VERMONT
COUNTY OF CHITTENDEN, SS.

On this 20th day of February, 2018, personally **KATHERINE M. PURCELL**, to me known to be the person who executed the foregoing instrument, and she acknowledged this instrument, by her signed, to be her free act and deed.

Before me: 

Notary Public
Printed Name: Michelle N Farkas
Notary commission issued in Chittenden County
My commission expires: 2/10/19

Figure 22: The first American house deed using a smart contract ²⁵

²⁵ Shedlock 2018

3.4.7. Summary

Smart contracts as the second application of blockchain technology are the codes that can understand and execute contracts using various coding methods. They are at the early stages of development, and their legal status is mostly unclear. Smart contracts have abilities to eliminate trust barriers between participants of a complex partnership. The most known use of smart contracts is crowdfunding due to the simplicity of their tasks within this procedure. Investors, instead of paying to invest, make a promise to invest if enough other investors are participating in generating sufficient funds for a project. If the goal met, the funds released to the fundraiser, and if not, the smart contracts finish the contract and make the funds available to flow. Smart contracts have different uses and getting intentions from artificial intelligence as well as the internet of things industry. Their ability to execute commands generates interests for becoming an execution tool for artificial intelligence applications. The cryptographic nature of smart contracts can solve one of the major issues of the internet of things, which is privacy. There are several needs for improvements for their functionality in practice such ability to edit.

Smart contracts in the real estate industry have experienced some breakthroughs. Their application for title transfer has stepped into practice already, and the first American house deed using a smart contract took place in 2018.

3.5. Blockchain 3.0: Beyond Currency, Economics, and Markets

As technology develops every day and new aspects added, the third class of blockchain technology is to cover the concepts beyond currency and economics. Blockchain can underline the web by a broader scope. Its ability is beyond just a new or better organizational chart. As the network gains consciousness through the nodes within it, it can offer a new level of liberty and equality. The mindset is that there non-economic activities in society that have economic behavior. Voting, for example, is to contribute value through a voting paper. Blockchain can facilitate these activities, as it is a medium of trust for transacting value (Swan 2015, p. 51).

However, these sub-applications of blockchain are yet to develop and step in practice; they can outline what kind of activities can take place on blockchain in a blockchain

friendly environment. Covering all the current developing concepts beyond the economics are beyond the scope of this study, therefore, some of the concepts that have the adoption potential by the real estate industry chosen and described below.

3.5.1. Blockchain for organizing activity model

The current concept of governments will change as the blockchain steps in organizational activities. The government, as we know them today, are the gatekeepers to ensure the creation and execution of the law within the society that can be replaced with the consciousness brought from the blockchain network. Claims Atzori (2015) and follows: governments as the primary source of power tend to become corrupted and inefficient as the power emerges within the higher levels of the hierarchy. Blockchain offers direct democracy at a lower cost and effort. The need for governments, as elected authorities so they can vote on passing the law, drops dramatically (Osgood 2016). In their book “why nations fail?”, Acemoglu and Robinson (2013) argues that in fact, governments fail to fulfill their primary duty which is to serve the people. Instead, governments tend to serve the benefits of the elite, as they are part of them and receive most of their support from them. Swan (2015, p. 44) concludes this new type of government, not only as a new transparent model for organizing activities within a specific society but in a higher scale, as a fundament to establish a global government that can be trusted to serve the people rather than the elite.

3.5.2. Extensibility of Blockchain concepts

Blockchain can adapt in various ways if the developers understand the concept in the right way. This can be a crucial element for the blockchain technology to break through the daily life like the internet, says Swan (2015, p. 28) and follows that blockchain shares the same ability with the internet “ everything could be done in a new way, quicker, with greater reach, in real time, on demand, via worldwide broadcast, at lower cost.”

The other concept of extensibility is about the extensions within the existing blockchains also known as “Forks.” When a protocol update, the block size in Bitcoin,

for example, takes place there are two ways to apply the update within the network. First is that the nodes accept the new protocol and discard the previous one creating a Hard Fork. The second approach is to keep the previous protocol acceptable but to move on from a pointed block with the new protocol. Hard forks are costly and difficult to convince most of the nodes to agree on the new protocol. Soft forks are more accessible to apply but create some security issues. The extension points in design in design can prevent difficulties (Séchet 2018). Other resources claim extensibility within the existing blockchains as a critical problem. For example, Natoli and Gramoli (2016) concludes that overcoming anomalies and applying the changes within the blockchain is facing difficulties and needs more work to become a practical tool that can be used as smooth as other updates within the internet world.

3.5.3. Digital Identity

Digital identity is an exciting subject in the digital world as it brings a validation system for humans interacting in the digital world and an identification system for the non-human participants. For instance, robotic identity is one of the current issues of possible adoption of robotics and machines. The output of the machines need to be controlled and interpreted with a human being, and the output from a robot has no value on its own mainly because the machine has no identity on its own (Warwick 2011).

Digital identity on cryptocurrencies today is the public key and the fact that the creation of a public key that is sufficient for transactions needs no verification creates some security problems (Brenner et al. 2017). Currently, identification of the individuals is based on the country of issuing the identity, and international digital identities are not a mainstream thing.

Blockchain-based identification companies such as Bitnation and e-Residency are aiming to tackle this blockade. Bitnation offers global identity and marriage certificates. The creation of identity on this blockchain happens with a picture from the user with Bitcoin's latest Merkle-Tree. The e-Residency blockchain aims to act as a digital signature that has legal authorities in Estonia, which does not discriminate natives and

foreigners. By using the digital signature, users can do various financial and social activities such as company formation, banking, payment processing, and taxation. This can facilitate international entrepreneurship (Jacobovitz 2016).

3.5.4. Hashing and timestamping

As explained before hashing is a one-way function that creates an output from any form of data in a way that if any piece of the original data is changed the output will vary dramatically. Different hash functions chosen based on the type of input data and the use of the output data. Hash functions are vital features in network security and banks benefit from them to secure their databases (Carter and Wegman 1979). Hashing and timestamping is not a blockchain only feature, Bayer et al. (1993) offered the combination of these two technics to create a proof about the existence of a document at a certain point of time.

As explained in the blockchain basics section, the output of a hash function can be as small as 256 bit. Therefore, they could be stored in a blockchain and viewed in the public ledger. Says Gipp et al. (2015) and follows; a Bitcoin transaction can be used to save the output from the hash function on the Bitcoin's public ledger. Using this method, the ownership of any digital asset such as designs, concepts, and analysis outputs are recorded. Later on, these assets are tradable, or the ownership is claimed. This can facilitate an international partnership in with a lower level of trust.

3.5.5. Proof of existence, location, and ownership of physical and digital assets

Several developing and developed applications, using blockchain or not, are aiming to create proofs for different assets on the internet. For instance, at e-resident.gov.ee, Estonian government offers the digital equivalent of an identification document that is sufficient for several financial activates in Estonia remotely. The other example is chromaway.com that offers proofs on ownership of real property such as real estate, cars, and arts. Legal developments within the digital world are simultaneously developing.

For instance, the Official Journal of the European Union (2014) allowed digital signatures to become legally binding within the European Union for:

- Contracts (sales, employment, lease, insurance)
- Transactions (e-commerce, online banking)
- Administrative procedures (tax declarations, requests for birth certificates)

Despite their technical details, the general concept is about to create an infrastructure for a cloud-based environment whereas internet activates can act as a real-life activates. By adopting blockchain in further steps, these services will take another deep step into functionality by becoming a safe place to store various types of data such as “wills, deeds, powers of attorney, health care directives, promissory notes, the satisfaction of a promissory note, and so on without disclosing the contents of the document” (Swan 2015, p. 39).

3.5.6. Decentralized autonomous organizations

Decentralized autonomous organizations (DAOs) are pieces of codes written in solidity coding language that aims to solve problems within organizations by bringing the possibility for all participants of an organization to observe and interact practically. The main problems with person-oriented organizations are that people do not always follow the rules, and, when they do, different understandings from the same rule can result in chaos within the organization. DAOs aim to facilitate the participation of all members of any organization, no matter how big the organization is, or how small their shares are. By giving direct real-time access to the contributed assets and by formalizing, automating, and enforcing of the rules through their software (Jentzsch 2016). DAOs are a complicated phenomenon with outrages outcomes to empower democracy.

3.5.7. Blockchain Government

The blockchain is neutral and non-political technology that does not discriminate the users from each other. This makes blockchain a functional tool in politics due to its neutrality. Meaning, it cannot be formed and shaped to serve a select group of people

or result in the answer that is in someone's favor (Reijers et al. 2016). Blockchains have the potential to be used as a more efficient and decentralized method to run the government but the lack in official literature. The reason behind this lack of studies can be the benefits of using blockchain in the public sector has not been highlighted by researchers to grab the attention of decision makers within the sector. This high potential does not guarantee the success and there are yet to do that requires an integrated partnership from professionals within different sectors (Ølnes 2016). The missing connection from governmental actors with blockchain professionals becomes more critical as the technology grows and the potentials expose. Meaning, blockchain implications and the need for institutional changes mostly misunderstood. The change with information stewardship needs a parallel approach from the public sector. First governance by blockchain, and second, blockchain governance (Ølnes et al. 2017).

In a study for implementation of blockchain as a backbone to the Chinese e-governance Hou (2017) offers the following steps:

- Establish standards
- Deploy solid management systems
- Ensure adequate security
- Authoritative and supportive of long-term preservation

3.5.8. Decentralized Governance Services

Decentralization and privatization have been governments concerns after the Second World War says Cohen (2007) and follows that Emanuel Savas' 1971 article, "Breaking Municipal Monopoly" was the beginning of the mass privatization era. In his study, Ullrich (2001) considers European Charter of Local Self Government and Worldwide Declaration of Local Self Government that adopted by the International Union of Local Authorities are the two main protocols for decentralization that happen in four main categories:

- Political decentralization
- Administrative decentralization
- Fiscal decentralization
- Market decentralization

Blockchain-based governmental services such as “dispute resolution, voting, national income distribution, and registration of all manner of legal documents such as land deeds, wills, childcare contracts, marriage contracts, and corporate incorporations” are offered by Swan (2015, p. 45) ,for example, the first blockchain marriage was recorded at Bitcoin’s ledger at August of 2014 in Orlando, Florida (Marty 2014).

Blockchain enabled decentralized governance service is global and offer new possibilities when fully developed. However, they are at the concept development level and are far from being functional.

3.5.9. Liquid Democracy and Random-Sample Elections

Technological developments have smoothed the path for new ideas to advance and step in reality. One of these ideas that are gaining attention is liquid democracy that radically changes the way communal or collaborative decisions within the society can be made (Paulin et al. 2017). “Liquid democracy is a procedure for collective decision-making that combines direct democratic participation with a flexible account of representation,” defined by Blum and Zuber (2016) and listed four characteristics for a liquid democratic system when members of the society have the ability to :

- Directly vote on all policy issues
- Delegate their votes to a representative to vote on their behalf
- Delegate received votes via delegation to another representative
- Terminate the delegation of their votes at any time

Liquid democracy has several advantages to other decision-making as it creates a network of trust within the society for passing votes to participants with higher knowledge about the issue not from higher authority but the voters themselves (Parycek and Edelmann 2014).

Random sample elections are part of Athenian Democracy. Aristotle proposed this form of voting in 350 BC in order to minimize the effort for voting through the Greek democracy (Blackwell 2003). “Random-sample elections offer practical low-cost yet

unprecedented quality for almost any election” concludes Chaum (2012) and claims when correctly applied, each election can draw the society one step closer to “finer-grained democracy.”

Blockchain enabled voting systems can reduce the election cost and increase the voter’s participation. Transparency and security ensured elections are outcomes of a blockchain enabled the voting system. Moreover, in this voting system, so the risks for political valances dramatically reduced (Kshetri and Voas 2018). There have been several proposals for a more granular democracy for long, but their complexity has been an obstacle to overcome. Blockchain can act as an infrastructure for a combination of liquid-democracy and random sample elections on the internet. This combination can facilitate complex and dynamic decision-making agendas in practice (Swan 2015, p. 50).

3.5.10. Blockchain 3.0 and real estate industry

Discussed concepts in this chapter are at conceptual development and experimental level and far from the practical application within everyday life now. However, when applied, non-economical applications of blockchain can change the procedures, as we know them today. Most of the applications introduced in the next chapter are aiming to use first two classes of Blockchain (1.0 and 2.0) for payment and title transaction through smart contracts, and the only non-economical application that is about to step out of conceptual phase is title registry. The Swedish Mapping, cadaster and land registration authority lead the project in cooperation with Telia, ChromaWay, and Kairos Future companies. Their project aims to reduce bureaucracy and improve efficiency and transparency (Lantmäteriet 2016). To emphasize how the same application of blockchain technology can facilitate different purposes, the Indian land title registration project can be a good example. Whereas the Swedish application seeks efficiency and transparency, Oprunenco and Akmeemana (2018) offer the land title registration in India in order to prevent fraud and increase liability.

Blockchain at its third level can change organizational procedures, as we know them today, creating a higher level of transparency and efficiency. The organization paradigm shift is a complex phenomenon and needs the cooperation of professionals

from various industries from both the public and the private sector. Current projects within this class are at the development phase (PwC 2018).

3.6. Limitations, Drawbacks, and Challenge

In their research, (Yli-Huumo et al. 2016) studied 121 blockchain related papers and concluded that “The majority of research is focusing on revealing and improving limitations of Blockchain from privacy and security perspectives.” Most drawbacks of blockchain are yet to be discovered as the technology is at “early stages of development” (Swan 2015, p. 81). Challenges categorized within five categories and discussed in this chapter. To emphasize how young the technology is, Figure: 23, which compares the number of websites, as internet assets that received funds during 1991 to 1995, with the number of funded crypto assets and decentralized application during 2014 to 2017 shown below. It illustrates that comparing to internet crypto assets are experiencing a faster rate of growth and highlights that the blockchain technology is the same stage that the internet was in 1997 (McCann 2018).

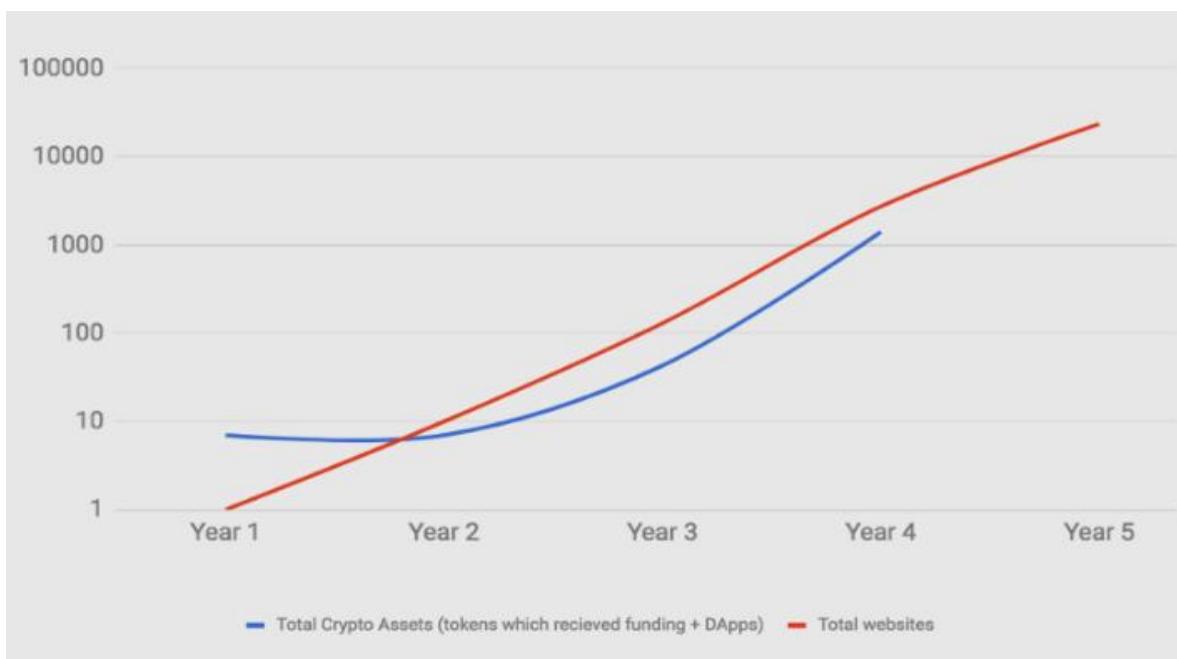


Figure: 23: Growth of crypto assets (2014-17) in comparison with the growth of websites (1991-95)²⁶

²⁶ McCann 2018

3.6.1. Technical

“There are treacherous passes in any technological revolution,” says Bauerle (2018) and follows that current technical limitations of the blockchain technology prevent this revolutionary technology from being the appropriate tool for many digital interactions. Security challenges are currently one of the main concerns within the blockchain society, as they are their core business is about financial technology, and security concerns are very high within this industry. Decentralized applications built over the blockchain platform have serious privacy leakage problems (Li et al. 2017).

Speed is another technical problem within blockchain and mostly with Bitcoin. Each Bitcoin block created approximately within ten minutes, meaning that it takes at least ten minutes to receive a transaction confirmation within the network. To ensure the transactions’ authentication for the more significant transactions, a one-hour wait is recommended by Swan (2015). Privacy leakages named a hidden technical challenge yet to expose and overcome. In their paper, Wang et al. (2018) study different methods that can connect a public key to its owners Internet Protocol (IP) revealing their location and identity.

3.6.2. Public Perception

“It seems not enough people understand and fully appreciate the implications of the blockchain technology”(Umeh 2016, p. 61). However, blockchain plays in a league far removed from previous disruptive decentralized applications such as Napster, PirateBay, and BitTorrent, the public’s mindset seems to mix the concepts up resulting in a negative tendency (*Ibid*).

Public perception is currently one of the biggest challenges of blockchain technology. The public does not recognize the technology as a mainstream functioning and has profound faith that the technology will last for long (Sharma 2018). Lack of clear understanding of the technology seen in the survey conducted by this survey available in Appendix B. For instance, a respondent commented: “I do not understand cryptocurrency. Have no desire to understand cryptocurrency. Using online credit cards is risky enough. Why use something I do not understand that has no safety

backups?" (Khalafi 2019). The other objection is the backup; this is a direct lack of knowledge of backup concept is not in practice anymore.

On a survey with 600 participants from 15 different territories regulatory uncertainty and lack of trust among the users has been two main reasons to prevent blockchain technology from the full integration (PwC 2018). Figure 24 illustrates the barriers to blockchain adoption where regulation uncertainties and lack of trust are the top barriers.

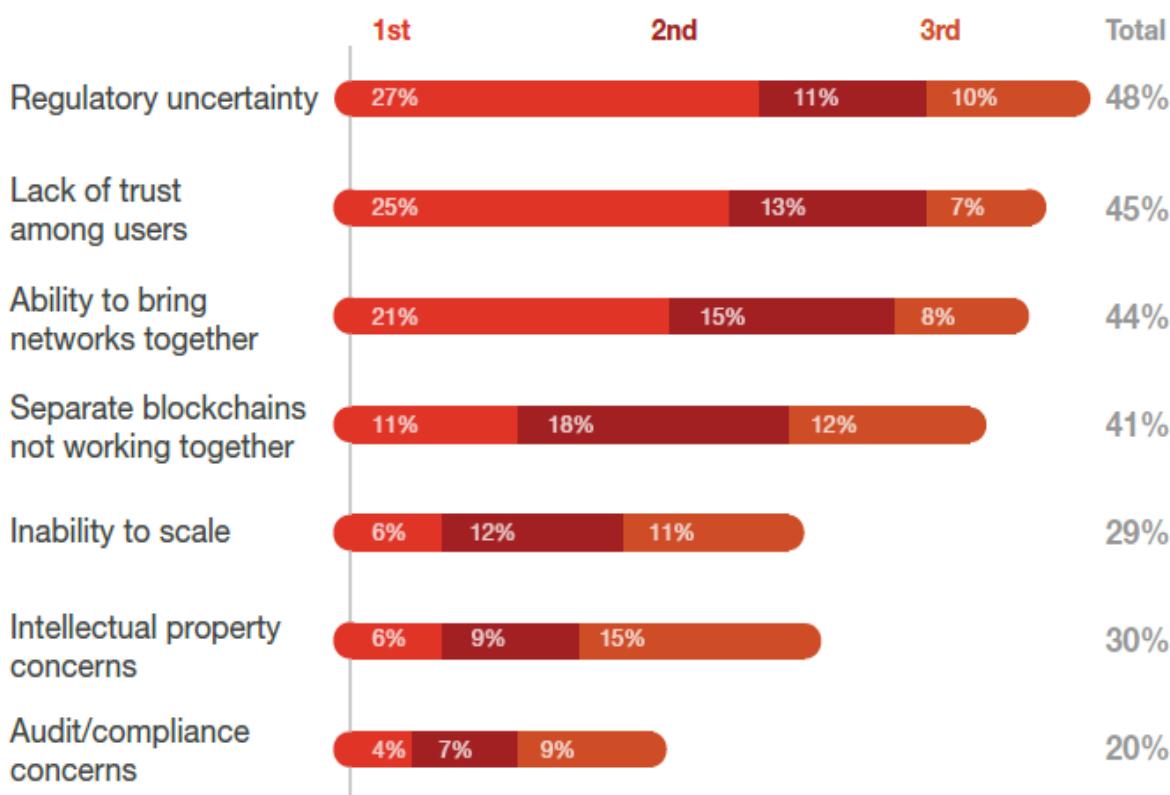


Figure 24: The biggest barriers to blockchain adoption²⁷

3.6.3. Legal, Governmental and Political

The legal status of blockchain applications is at the point of the doubt for most of the participants within the survey, the majority of participants claimed that they either they are not aware of the legal status of the blockchain technology in their living region, or the legal status is not clear for them. Lawmakers' tendency to keep the safe side adds to the ambiguity also. For example, the passed law that allows French people to use

²⁷ PwC 2018.

the blockchain technology does not even name the technology directly and allow people to use “registration in a shared electronic registration device” (JORF 2017).

Governmental points of view is another fluctuating element adding to ambiguity about the blockchain. For instance, however, most of the world’s cryptocurrency miners were established in China (Bendiksen and Gibbons 2018), the domestic use and foreign exchange of cryptocurrencies in China banned due to new regulation by People's Bank of China (Perper 2018). Figure 25 shows three turned off cryptocurrency ATMs with a note on Ethereum’s device mentioning the shutdown and offering the customers to contact for the further information using Facebook.



Figure 25: Bitcoin and Ethereum ATMs shut down after a new regulation in China ²⁸

The political conflicts, according to Columbia (2016)’s book “The Politics of Bitcoin: Software as Right-Wing Extremism” can be traced in the elite’s fear of losing control due to the freedom arose by technological liberties. In domestic scales, the different parties see Bitcoin either as a threat or as a tool, and the influence of the specific party dictates the political status about Bitcoin. Also, different party members can have

²⁸ Perper 2018

different understandings about the utilization of technology creating within-party conflicts. On an international scale, the same approach is applicable.

The rise of support for Bitcoin from cyberlibertarianism, the group of people who oppose any influence of government in cyberspace, such as Travis Kalanick, Jimmy Wales and Elon Musk that have financial abilities, arose political concerns (*Ibid*). Ambiguities caused by these constant rapid changes of legal status obviously seen in survey results illustrated in Figure 26: Responses for: What is the legal status of cryptocurrencies at your region? The ambiguity of cryptocurrencies' legal status among the participants of the survey is bold. More than 70 percent of participants did not have clear view about the legal status, they did not know the status or it was not clear for them. The most necessary legal effort can be first to define a solid status and create the tendency to keep it as a standard.

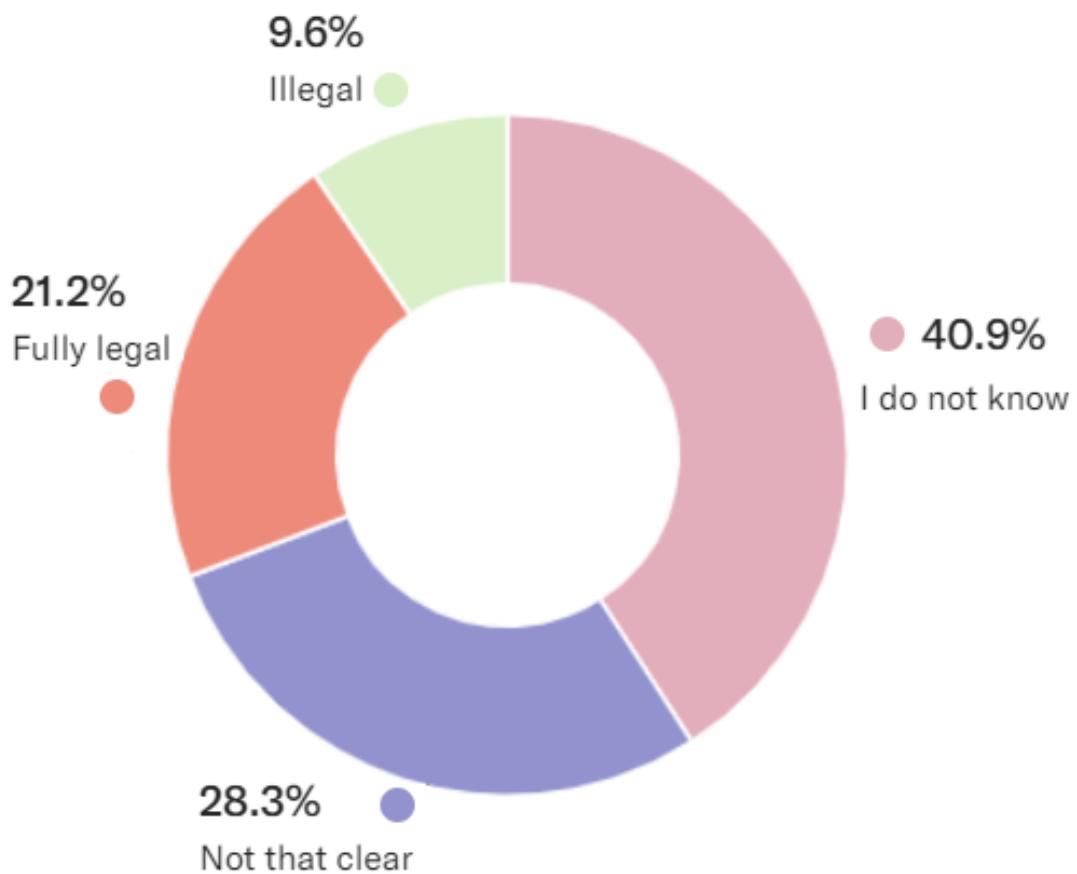


Figure 26: Responses for: What is the legal status of cryptocurrencies at your region? ²⁹

²⁹ Own figure, data from survey result

At a glance at Figure 27 that illustrates the legal status of cryptocurrencies among different countries, it is more than evident that most of the developed countries have already regulated the use of cryptocurrencies or are at the improving level. On the other hand, developing countries tend to have a hostile approach toward the cryptocurrencies, and unfortunately, the majority of underdeveloped countries, which could benefit from the technology the most, been excluded from the study due to unclear status of cryptocurrencies within their region.

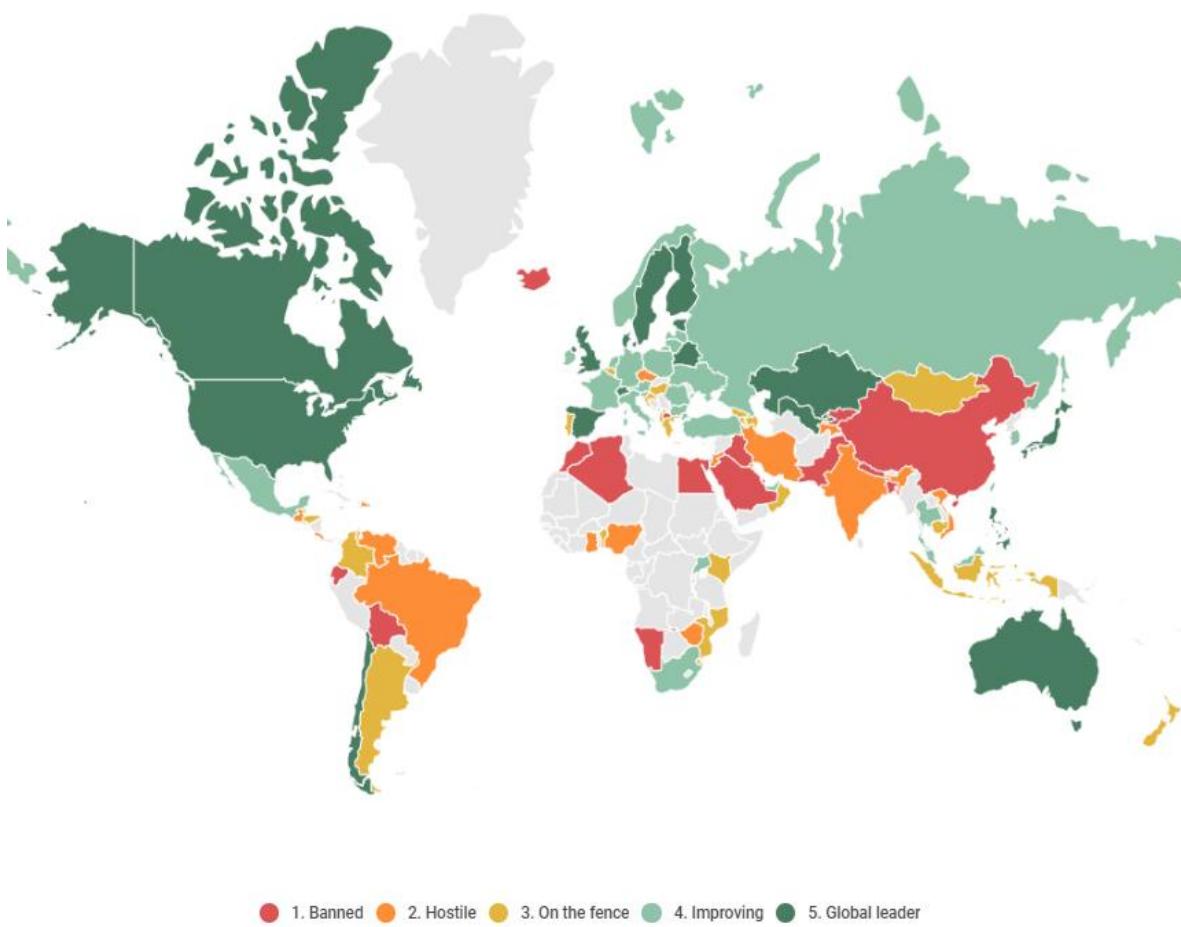


Figure 27: Global legal status of cryptocurrencies³⁰

To explain the five status in short. Banned means cryptocurrencies are illegal within these countries with possible risks of punitive sanctions on individuals caught using them. Hostile means there are steps to curtail virtual currencies, but free trade of cryptocurrencies are illegal. On the fence refers to countries that individuals are not banned from trading cryptocurrencies, but there is no clear law about it. The improving

³⁰ Finder 2019.

status described as; however, there are still some barriers, government ten to hasten the legalization. Global leaders refer to the pioneer nations whose governments have taken steps to promote cryptocurrencies and drive parity for virtual currencies and tax rules apply (Finder 2019).

3.6.4. Scalability

Scalability problem within an internet-based service happens when there are more requests to access data or use a service than what the service provider can provide (Chung 2012). It can happen anytime, and internet giants such as YouTube with more than two million active users are not immune from that (Allah 2018). However, the scalability problem of blockchain and Bitcoin in specific is not momentarily. Bitcoin's network currently cannot process more than seven transactions in every second and comparison with Visa, that can handle 50 thousand transactions per second (Karame 2016). Scaling issues for end users according to Nofer et al. (2017) are latencies for a transaction confirmation, ledger download time for new nodes and in case of incompatibility between ledgers for all nodes also known as bootstrap time, and the cost per transaction. Most of the scalability problems traced to the one-megabyte maximum capacity of the block. There are several proposals to solve the scalability problems both in the idea and in practice; tuning bitcoin protocol parameters that aim to change characteristics of the block such as size in order to increase the network's performance. These solutions are already taking place that created forks. Other solutions are mainly about off-chain payment channels such as Duplex Micropayment Channels and Lightning Channels that aim to reduce the load on the network without changing its characteristics. Both methods have their pros and cons; forking a network can result to the loss of some transactions that had taken place on the old protocol whereas off-chain payments can create some centralization within the decentralized network (Torra et al. 2016).

3.6.5. Sustainability

Bitcoin's sustainability has been a controversial topic for available resources about blockchain's sustainability which studied by Bellavista et al. (2013), the source of

unsustainability is due to high-energy consumption of the consensus protocol that thoroughly discussed on page 47. To take another perspective, there may be improvements in sustainable development achieved by using blockchain that overcomes the suitability issues of the blockchain (Giungato et al. 2017). United Nations Development Program considered blockchain as an existing tool to reach in order to manage funds for sustainable development of underdeveloped regions, as the main problem currently is not lack of funds but the trace of funds and its management (Begović 2016).

The other scale to mention is that current financial mediums sustainability. On a study for the comparison between annual energy consumption of Bitcoin and other currencies McCook (2014) offers Table 2 as the output of this comparison.

Table 2 Energy consumption of Bitcoin compared to existing methods³¹

Currency	Picojoules per year
Bitcoin	3.97
Paper currency and minting	39.6
Gold mining	475
Gold recycling	25
Banking system	2340

3.7. Conclusion: Blockchain, The internet of value

Blockchain has proven its abilities in the first step by introducing cryptocurrencies. It has no intermediary of any kind, and the will of two participants is enough to make a transaction happen. This radical technology has different abilities yet to be unveiled, and we discussed the few that with the capability of adaption within the real estate industry. The impact of blockchain appears to be bigger and more profound than the internet as it can transact value over the internet. The Internet brought the ability to

³¹ Source: McCook 2014.

transact data resulting in knowledge democracy. The blockchain is scaling the same possibilities, but for value instead of data that can result in economic democracy, internet separated data from its common mediums such as paper. The blockchain is separating value from its current mediums, mediums that are mostly under the control and manipulation of the one percent elites ruling the world. Elites that can print money to finance wars and put sanctions on people who fundamentally do not tend to obey them. Blockchain technology can end this era. Blockchain has a long way from full adoption so did internet in the 70s, but the internet is everywhere now. Freedom of payments in real estate industry provided by cryptocurrencies has the ability for equal developments and reduce transaction costs that are mostly to benefits banks, agents, and other intermediaries.

Smart contracts are one of the many to come applications of the blockchain. They reduce the need for the contract observation and can bring trust between two parties who have not much of an established trust already. As participants or a third does not control the execution of the contract, as long as each party keeps to its promises the contract will take place. If an action had coded to release funds to an account, as long as the action takes place the funds will release from the customer's wallet to the service provider's. This will eliminate many observant and agents requirements within all phases of a real property.

Prediction of the about exponential growth of technology has always been underestimated. For instance, as we discussed on page 17, there are over 26 billion connected devices in the world today. To our surprise, the chairperson of the tech giant, IBM, Thomas Watson, had a different idea about the number of the marketable devices back in 1943 as he claimed: "I think there is a world market for maybe five computers" (Altavilla 2018).

4. Current applications of blockchain in the real estate industry

4.1. Introduction

In this chapter, we discuss the applications that use blockchain technology to solve pain points in the real estate industry. There are several blockchains based real estate project at different levels; we listed some of them in Table 1 on page 61 based on their market capitalization. In this chapter, we tend to avoid duplication by introducing one project from each category.

As blockchain's first application is cryptocurrency, most of the project listed on this page has shown the tendency to create demand for their offered token in order to create additive value for their project. However, the rise of demand is the sign for the project's functionality and creation of additive value for the real estate industry; the market success was not the only logic behind this selection. The usability of the platforms to tackle the real estate challenges discussed in the second chapter was an initial indicator for this selection. In this chapter, we explain one project from the following categories:

- Real estate tokenizing and trading on the blockchain
- Real estate blockchain application as a collaboration platform
- A platform that aims to shift currently available services into the blockchain
- Real estate land title registry and trade on the blockchain
- Freelancing platform on the blockchain

The other vital highlight to consider, as shown in Figure 28 on the next page, is that most of the blockchain projects are not at the live stage. Real estate projects are not an exception of this phenomenon also. Having said that the status of these projects are not a concern of this chapter and the aim is to emphasize the possibilities of implementation of the blockchain technology within the industry from the various aspects.

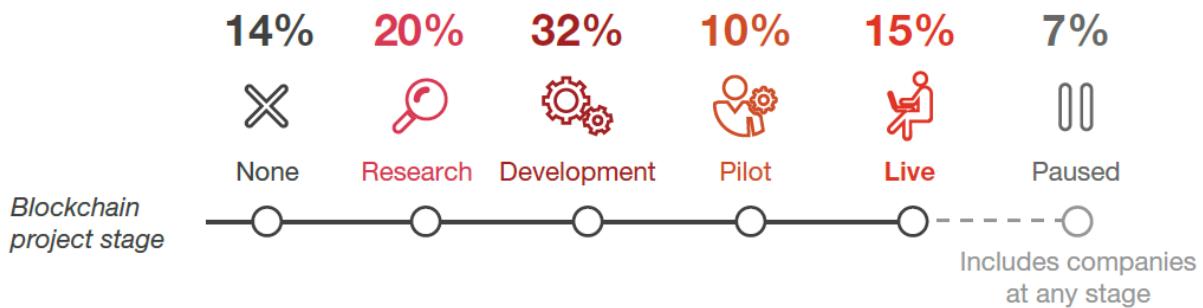


Figure 28: Blockchain projects' status ³²

4.2. Alt.Estate: Real estate asset tokenization, Investment, and trade

The company has created a platform for tokenization and trade of tokenized real estate assets. Their platform aims to manage technology, corporate structure and legal compliance aspects of tokenization. The ideology is creating an environment that investing in real estate properties is possible with investments as low as one hundred euros.

The team claims to have closed over 400 million dollars-worth deals in 2016. The reasons for choosing blockchain as a solution are:

- Decentralization: Enabling trades peer to peer unless one party request for observation
- Faster transaction: Reducing average 60 days required time to down to ten minutes
- Lower cost: Currently there is two percent transaction fee that can be reduced after network growth
- Liquidity: Full international trades both with cryptocurrencies and fiat currencies
- Tokenization: using blockchain technology brings the ability to invest in real estate by a fraction as low one-centimeter square or one hundred Euros.
- Transparency: Ownership and transactions are available for all peers and stored on a decentralized web with their hash stored on the blockchain.

³² Source: PwC 2018.

Users can benefit from the advantages of using this platform by diversifying their investment portfolio on a global scale by avoiding fraud possibilities to the secure due diligence provided by the platform's blockchain. Real estate owners can raise funds by tokenizing their asset and receive finance by selling their property-specific tokens on the platform that are exchangeable to other cryptocurrencies as well as fiat currencies (Alt.Estate 2018).

4.3. Propy: Land title registry and transaction platform

The platform aims to firstly, facilitate the real estate title registration on the blockchain, and secondly, to become a decentralized platform that enables interaction between real property owners and their customers.

At its first step, Propy is negotiation with local governments in order to set regulation for land title registry on its decentralized database. The first version of the platform as shown in Figure 29 acts as an intermediary between land registry officials, seller, owner, and their banks. In this stage, the platform acts as a ledger for keeping records and confirming the ownership, as well as the transaction (Propy 2017).

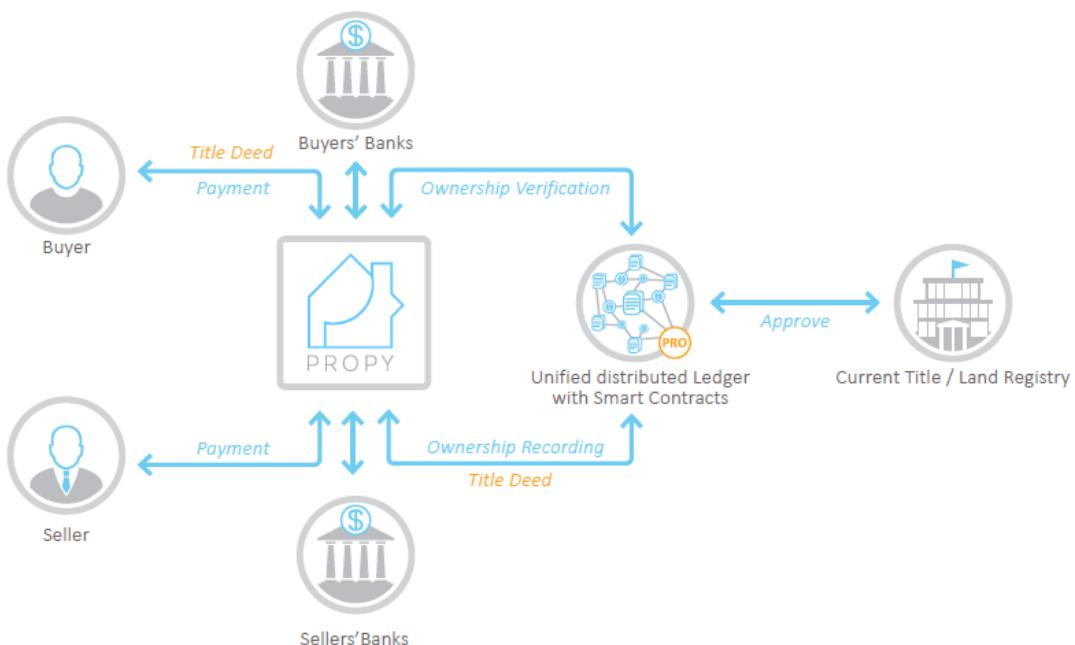


Figure 29: Interaction of transaction participants via the blockchain³³

³³ Propy 2017

The second step, after legalization and automation of registry procedures, the title transactions are executable entirely on smart contracts within the decentralized application environment as shown in Figure 30.

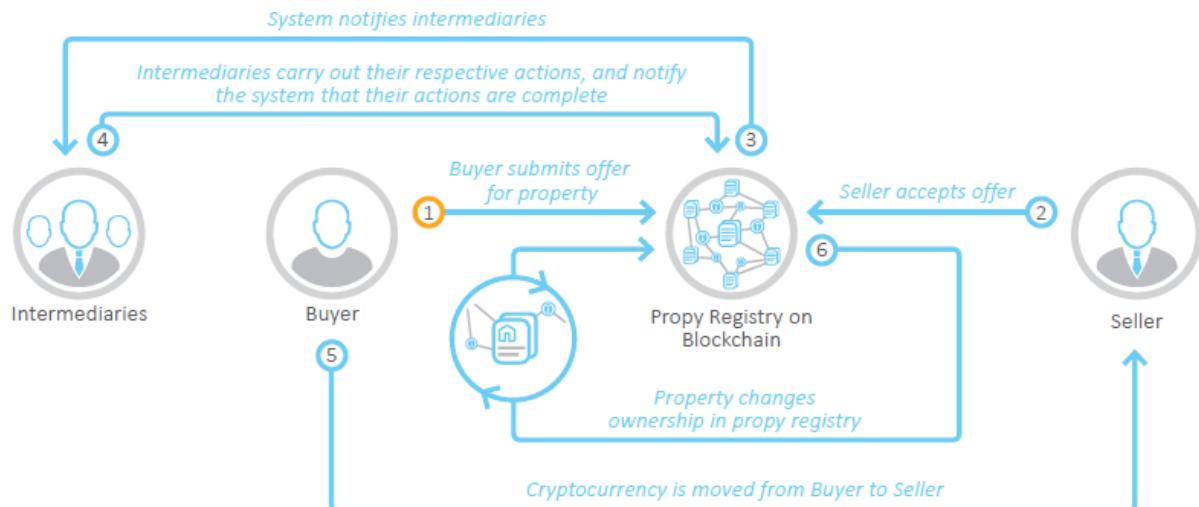


Figure 30: Peer-to-Peer Transactions in the Propy decentralized application³⁴

The whitepaper claims that in case of success, professionals, and costumers can benefit from the platform as explained below:

- It creates an online and international platform for real estate professionals to interact with customers, closing deals instantly and securely
- The unified title transaction data can create a data flow between governmental entities, legal notaries, and title companies in order to create a clear track of assets reducing risks of fraud and corruption by increasing transparency.
- Sellers and buyers can benefit from this environment by trading the real assets securely at a higher speed and lower cost

³⁴ Propy 2017

4.4. Rentberry: Decentralized renting platform

The company aims to disrupt the current trend for 641 million rental units that are the roof over the 2.3 billion people's head. Their first target group is 244 million international migrants leaving abroad who seek a clear rental alternative. Their platform is to create a unified, user-friendly environment where property owners and tenants can meet, negotiate, auction and bid, sign contracts, pay rents, and arrange a third party's interaction for maintenance and inspections.

4.5. Bitrent: Developers and investors' collaboration platform

However, the project is on the pause status, and behind schedule on their roadmap, the idea of tokenizing unbuilt assets from the development phase and interaction with BIM makes this project interesting for a short review.

The project aims to create a platform for a decentralized interaction between developers and investors. The platform uses a BIM model as a reference and tracks the construction phase using the RFID tags. The location of the RFID tags indicates that the procedure of construction is creating a real-time track of the project. Smart contracts are to manage the funds to be released for the project as the tasks complete. Other smart contracts manage the property's tokens and allow investors to trade them (Bitrent 2018).

4.6. Travala: Short term accommodation platform on the blockchain

Travala is a blockchain empowered online travel agency offering accommodation, flights and local tours on a decentralized application. The project is live now, offering more than half a million listings. The business plan offers that there exists a hidden monopoly within the top online services and nine of ten high-ranking agencies belong to two people. The company also claims to offer a minimum of 15 percent lower price to its competitors due to intermediary costs cut using blockchain technology.

Moreover, the company claims that the current reviews on the travel websites that play an essential role as an indicator for customers cannot be fully trusted for several

reasons. Firstly, most satisfied customers tend not to leave any reviews. Secondly, platform owners tend to manipulate reviews in order to gain higher rates. Thirdly, there is no direct correlation between users' purchase and the written review. Travala tried to solve the mentioned problems by connecting travel reviews cryptographically to the original purchase. Also, to motivate customers to leave reviews, no matter positive or negative, the platform rewards review writers in the platform's cryptocurrency. This can generate a higher level of trust for the new customers due to a more balanced and genuine source of knowledge for the service. The payments for this service is available in fiat currencies using PayPal, platform's own cryptocurrency "AVA," and other cryptocurrencies. However, it is not the project's concern, but the usage of blockchain technology can bring transparency for a real property's profit resulting in a more transparent investment possibility for the listed properties in the future.

4.7. Unitalent: Freelancing platform on the blockchain

As an example of the emergence of blockchain technology and gig economy, the Unitalent Company aims to shift its platform, which facilitates freelancers and corporations interaction, into the blockchain environment. The company currently provides knowledge labor service from more than 750 professionals around the globe to corporate clients such as Schindler Elevators and Volvo Construction Equipment Company. The company aims to create a more democratized market for independent work using public ledgers. The implementation of the blockchain technology within the freelancing environment secures trust, increases speed and efficiency, and reduces cost by cutting the intermediaries. This cost reduction estimated to be about 75 percent lower than the current up to 30 percent charges over freelancers' rate. The freelancers can participate in the platforms' growth by referring the platform to other freelancers and clients receiving direct rewards. The company aims to create an ecosystem for circulation of its own currency "TAT" between freelancers, clients, exchanges, and the company's treasury. This circulation of the token within the ecosystems creates an ongoing raise for the token that benefits all participants of the ecosystem. Besides, this additive value for token can create ambitions for freelancers to hold their token as investors of the company and aim to offer higher quality service, as they know the

success of the company is in direct correlation with their financial income. To create a visual understanding, Figure 31 illustrates an overview of the offered ecosystem.

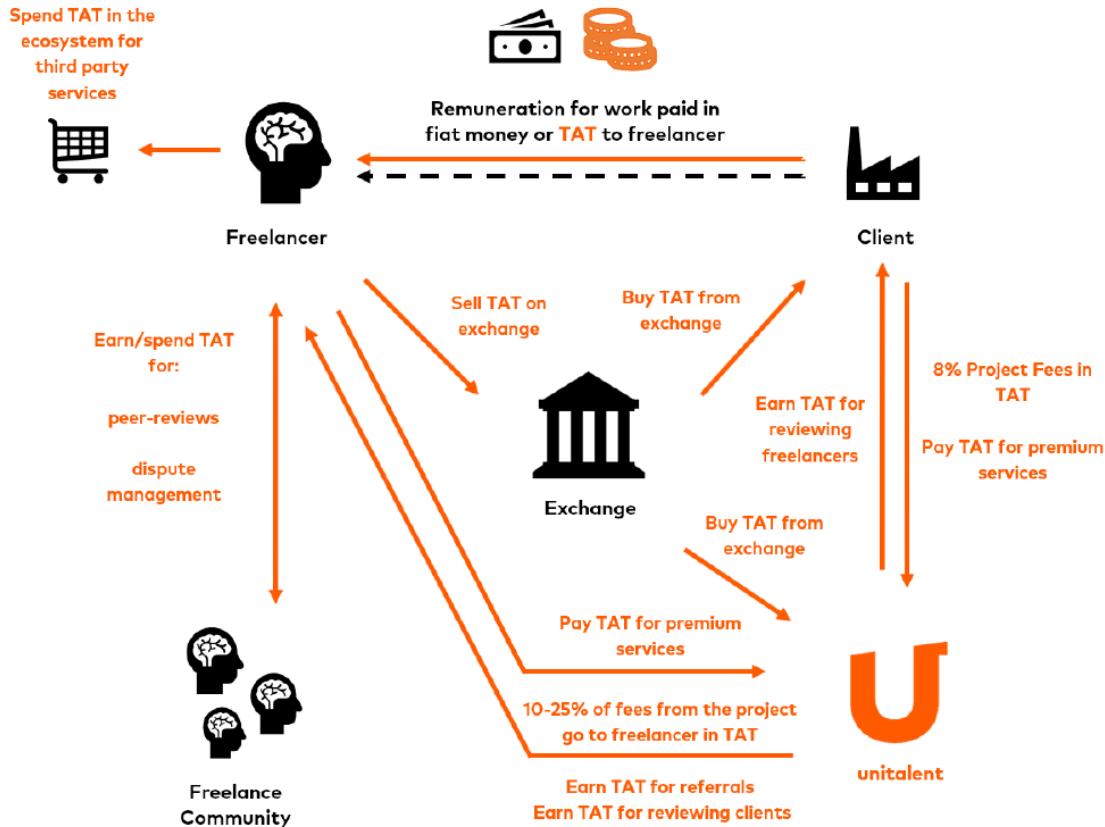


Figure 31: Token ecosystem of unitalent³⁵

Furthermore, there is a zero fee policy for freelancers and redistribution of 10 to 25 percent from companies collected fees within the community members. The advantages that the company takes over its competitors are:

- Peer-to-peer contracting
- Instant payments
- A transparent and secure reward system
- Monetize reputation and existing network
- Community dispute resolution and participation in the platform's growth

³⁵ unitalent 2018.

5 Survey

Using Typeform premium survey platform³⁶, this study conducted a survey with 201 participants from all five continents. The survey window was open for two weeks starting from February 2019. The invitation link for taking the survey shared on the author's social media networks and reposted among other social media platforms such as Linked by Metropolia University of Applied Sciences and Commercial Real Estate Executives pages (Linkedin 2019a, 2019b). Two hundred paper invitations handed out and mailed in the following locations.

- Universities: HTW Berlin (both campuses), Berlin Institute of Technology
- Coworking spaces : WeWork and Silicon Allee
- Real estate offices, civil and architecture firms : Fortress Immobilien and PWS

The hypothesis is that level of knowledge and tendency among real estate professionals is lower than other industries.

5.1 Conduction and purpose

The aim was to receive a direct data from real estate professionals in comparison with occupants of other industries. The reason to create such a data was to lack of existing solid data overlapping real estate and blockchain. The only found estimate about real estate professionals' involvement with blockchain technology was in an oral presentation by Ragnar (2018), the founder of International Blockchain Real Estate Association when he claimed there are only five present of real estate professionals in possession of a cryptocurrency which is lower than other industries. The conducted survey aims to explore the participant's knowledge and tendency toward the blockchain technology. The survey contained 59 questions but due to its dynamic design based on responses, the number could shrink to 50. The logic provided by the software hid real estate related and blockchain technical questions based on the participants response on if they are part of the industry or have blockchain knowledge. Some questions were to gather knowledge about participant's involvement with share and gig economy, internet, along with cashless and online payments. With 90 percent confidence level. Five participant's responses fell in margin of errors' interval and excluded from the study.

³⁶ <https://www.typeform.com>, Link to collected data available in Bibliography : Khalafi 2019

5.2 Key findings

- ✓ Most participants have read some articles about Bitcoin or blockchain but never heard of smart contracts.
- ✓ Tendencies for utilization of blockchain technology does not vary between the real estate professionals and occupants of other industries.
- ✓ However, the majority of participants think that the technology has some abilities, either they are not aware of its legal status in their region or the status is not clear for them.
- ✓ Thirty percent own a cryptocurrency and fifteen percent have used it as payment method, there is a 95 percent chance that participants who have used crypto payment method had read the Nakamoto's whitepaper.
- ✓ Tendencies to utilize blockchain applications for daily expenses, salary or invoice management, and lease or deed management are below the average.
- ✓ The highest tendency observed for using cryptocurrencies for daily expenses in the future and the lowest belonged to utilization of cryptocurrencies and smart contracts for a real property deed.
- ✓ The majority of participants who have read Nakamoto's white paper a correct perspective of the block creation time but wrong for difficulty settings auto adjustments.
- ✓ Pollster who are more open to internationalization are more likely to adapt blockchain applications
- ✓ Gig and share economy costumers are more open to blockchain.
- ✓ Participants with higher coding and software use skills are more keen toward blockchain.

5.3 Results

The questions designed to firstly, gather general information about surveyors such as age education, region, and the number of languages spoken. The core questions that was in rating format measured the pollsters' tendency to use cryptocurrencies and smart contracts, both in general and real estate payments such as a lease contract. The measurement made through a ranking scheme where one star meant not likely at all and five stars meant most likely. As there was no possibility for zero stars in a normal

distribution, the average should be assumed as three stars indicating below three-star rankings means low tendency and vice versa.

The average participant of the survey is from West Europe, between 30 and 40 years old, speaks two languages and does not live in the same country or state that she was born. Holding a graduate degree, she is an employee within the private sector with one source of income and pays rent for her accommodation.

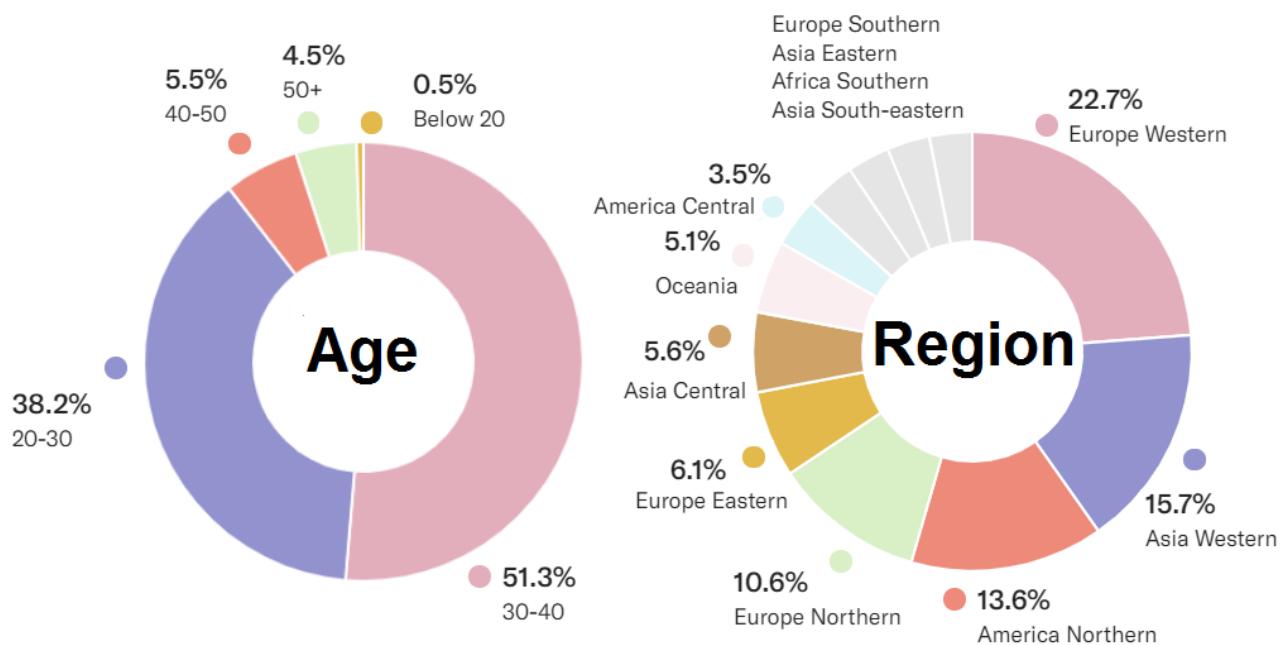


Figure 32 : Age and Region overview³⁷

With 64 percent chance, the pollster is not involved with real estate, but if involved she is a civil construction engineer and is involved in project development phase. The majority of non-real estate related occupants were involved with arts and entertainment industry.

³⁷ Own figure

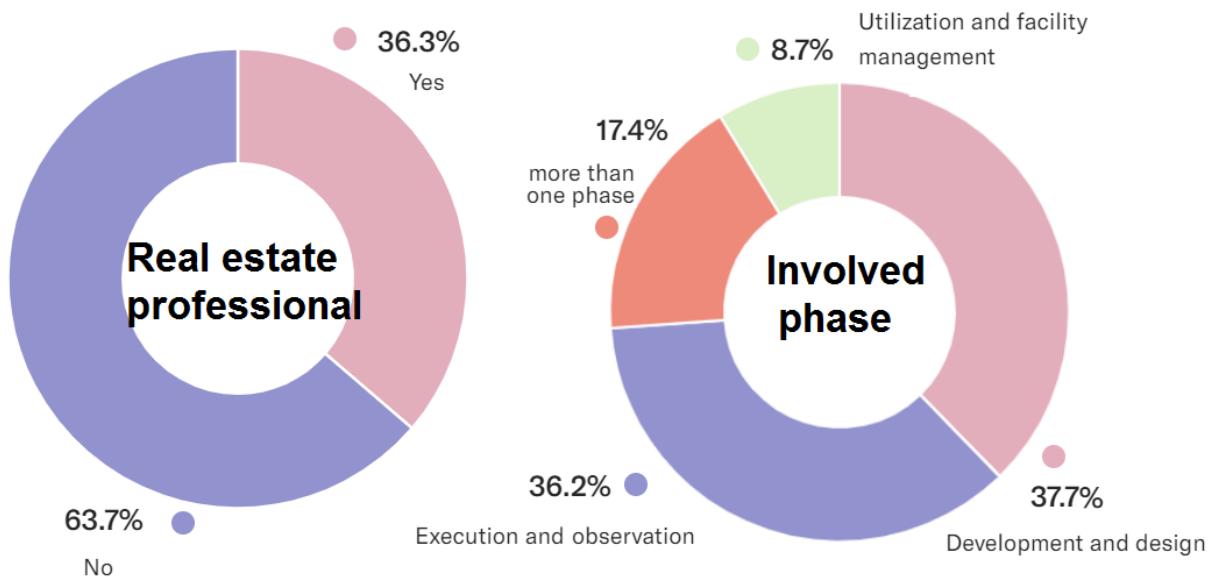


Figure 33: Real estate professionals' participation ratio and involved phase³⁸

The employment status and sector of occupancy as shown in Figure 34 shows 18 percent of pollsters are freelancers and contractors.

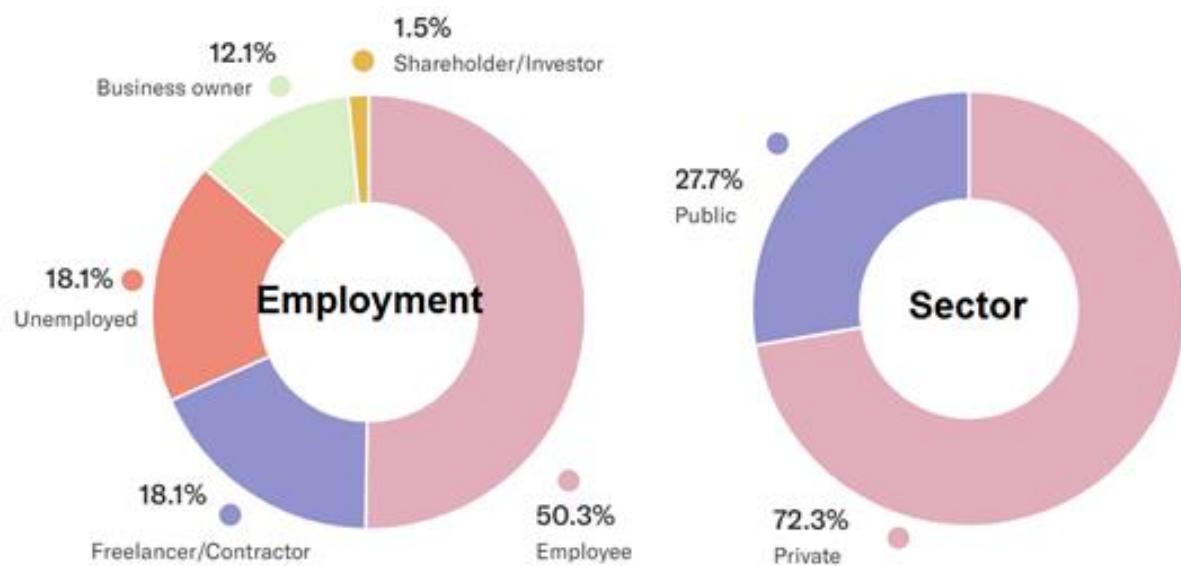
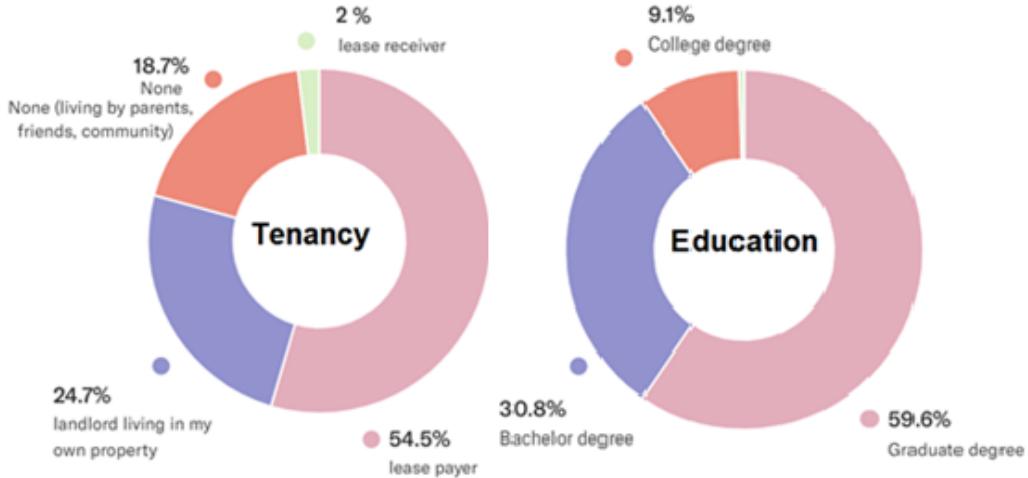


Figure 34: Employment status and sector³⁹

Most of the pollsters are lease payer and hold a graduate degree. On the next page, Figure 35 illustrates this distribution within the shown categories.

³⁸ Own figure. Note that phase involvement question was only exposed to real estate professionals

³⁹ Own figure

Figure 35: Tenancy and education status⁴⁰

From the blockchain point of view, the average participant have read some articles about Bitcoin or blockchain but never heard of smart contracts. However, the majority think that the technology has some abilities either they are not aware of its legal status in their region or the status is not clear for them. With more than 70 percent chance, they do not own a cryptocurrency, and if they do, there is a 55 percent chance that they have used the cryptocurrency for payment and the rest are just holding the currency.

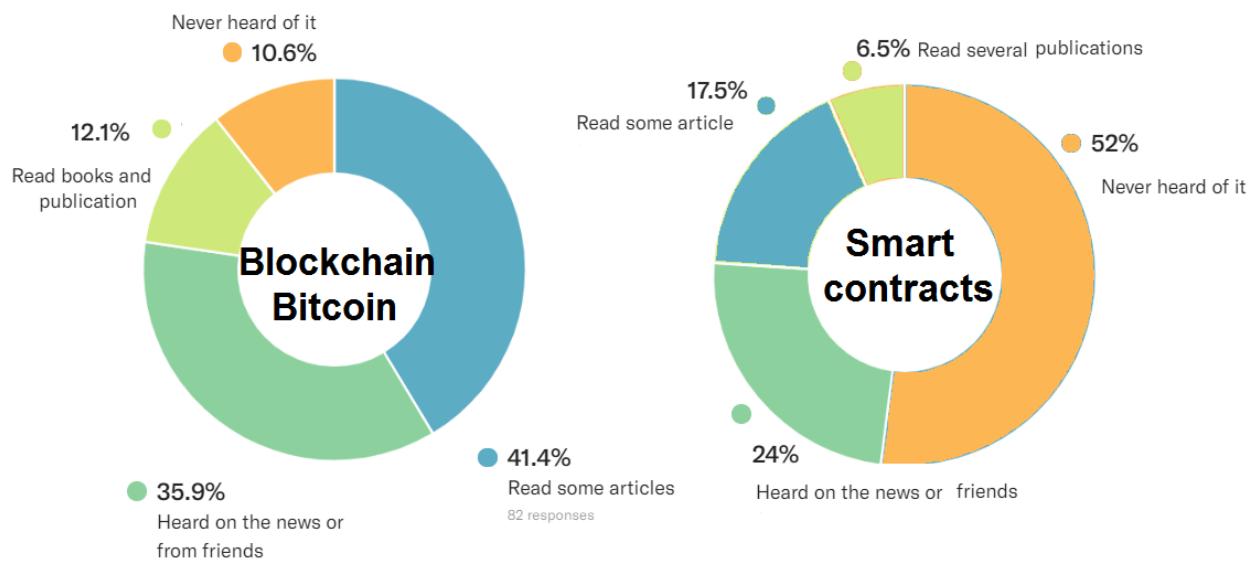


Figure 36: Source of knowledge on Bitcoin/blockchain and smart contracts

The tendency for utilization crypto payments and smart contracts for managing salary and invoice, lease and deed, and even daily expenses are below the average both for

⁴⁰ Own figure

now and future options. However, the highest tendency was to utilize the technology for daily expenses in the future and the lowest rate belonged to manage a real property deed using a crypto currency now.

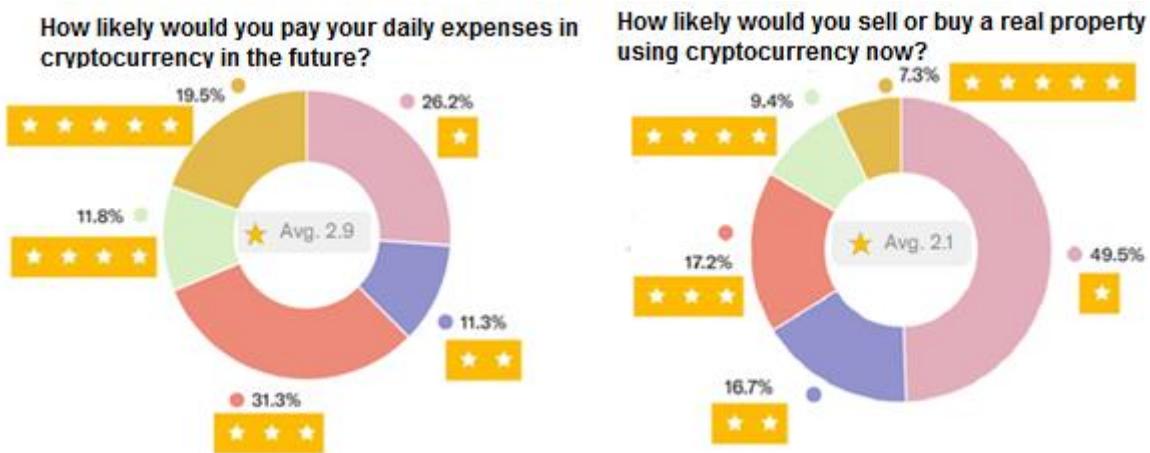


Figure 37: Highest and lowest tendencies to utilize the blockchain applications⁴¹

Figure 38 shows that 28 percent of participants hold some cryptocurrencies, however, there is a high chance that only people who had read the Nakamoto's white paper have used their cryptocurrency as a payment method and the other 13 percent are holders.

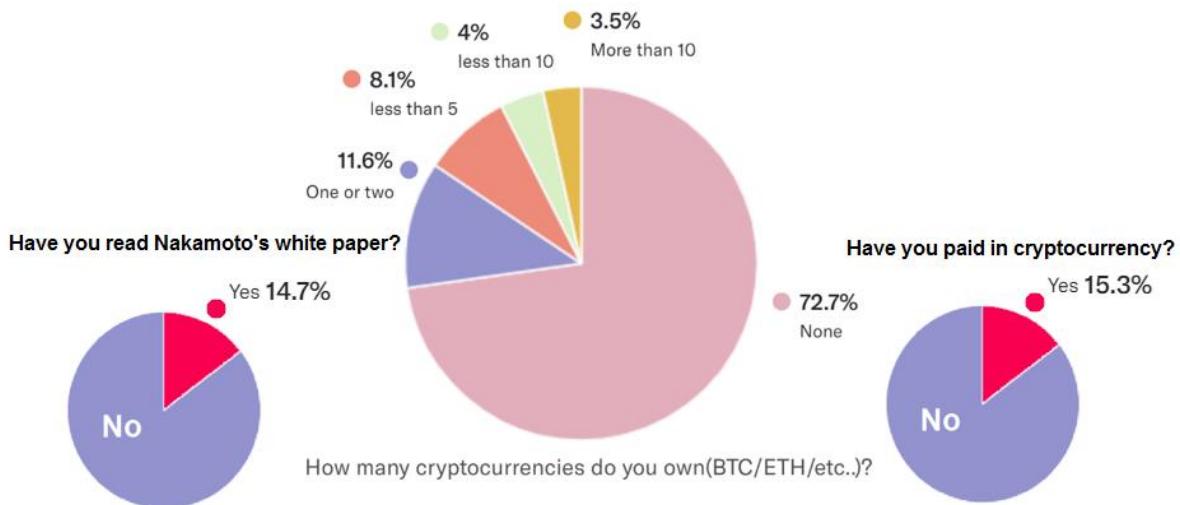


Figure 38: Ownership, knowledge, and utilization of cryptocurrencies⁴²

⁴¹ Own figure

⁴² Own figure

From the involvement with the share and gig economy along with utilization of internet and cashless alternatives perspective. The average participant receives some services from the named economies as a customer, but she is not a service provider to these economies. Having three to five connected devices to the internet; she has started using the internet in the first five years of the new millennium and uses the internet multiple times each hour. The majority of participants used online payment within the 2005-2015 interval, use cashless payments every day, and pay online few times a week. This clearly shows that online payments, as a new method of transferring value, became popular within the past decade.

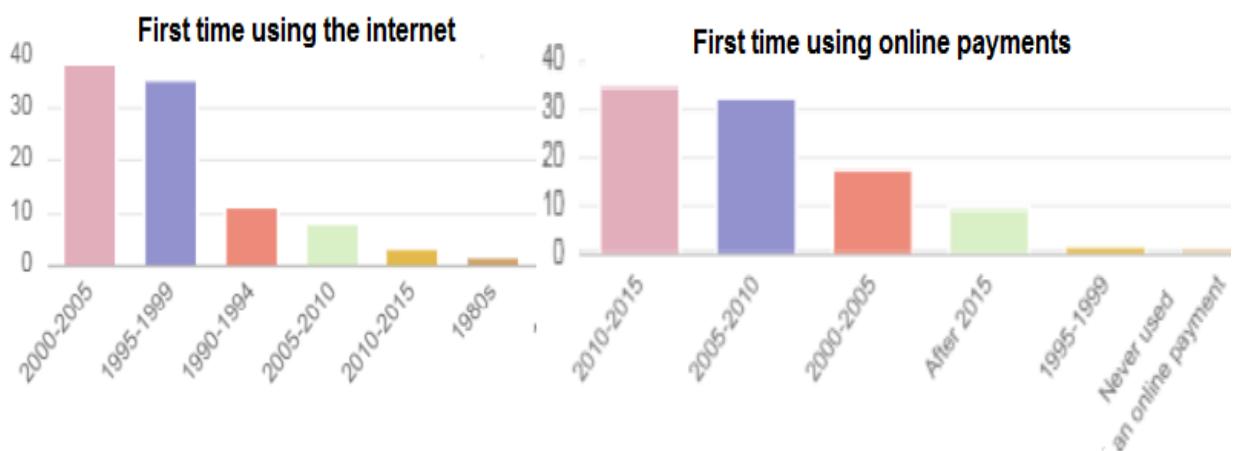


Figure 39: first time using the internet and online payments⁴³

There was no solid answer for internationalization tendencies, whereas 35 percent where optimistic about internationalization, almost the same percentage voted for being neutral. However the average participant is a skilled or average user of a software, she does not deliver any format of data as her output most of the times.

The technical questions of blockchain technology was only visible if the pollster had read the Nakamoto's white paper that about 15 percent of the pollsters did. The majority of 29 participants that had read the paper had a correct idea about block creation time for Bitcoin and 30 percent answered block difficulty settings question right. From the two las technical questions there was five correct answers to the first, and four for the second one. Scaling to the all participants, two present were blockchain experts.

⁴³ Own figure

5.4 Scoring and analysis

Scoring mechanism conducted to create a KPI for measuring the level of knowledge and tendency toward cryptocurrencies and smart contracts. 22 questions in three types of Yes/No questions, ratings, and multiple choices could create a maximum score of 230 as shown below.

- 20 → Have you paid for anything in a cryptocurrency? 30 → How likely would manage your lease contract on a smart contract in the future?

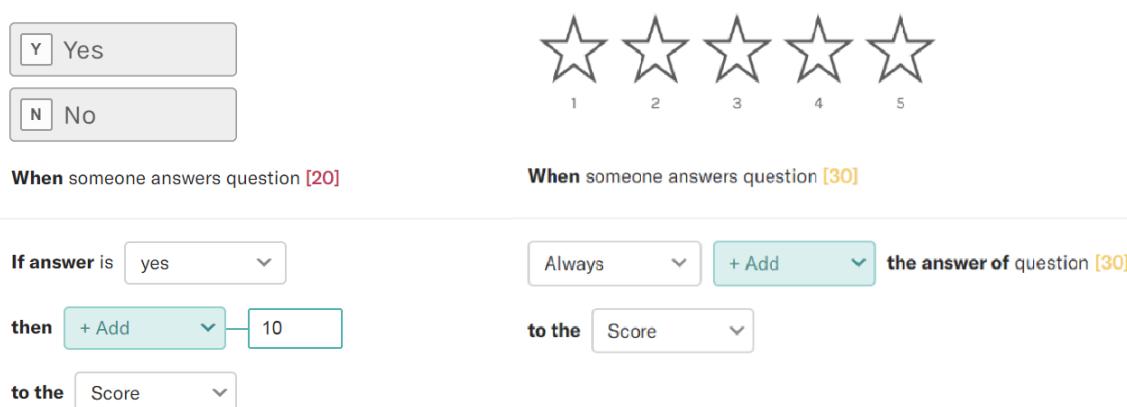


Figure 40: Scoring logic for Yes/No and rating questions ⁴⁴

To elaborate more with an example, the participant's response to what they think about the blockchain technology adds five scores for the answer "I think it has some abilities" and ten for the answer "It is the future." The 14 questions about how likely they would utilize the blockchain applications each contains maximum five scores and minimum one. Along with that, ten scores for participants who have already used crypto payments added, possession of cryptocurrencies as shown in Figure 41 had a maximum score of 25 resulting in a total score of 115.

The knowledge about blockchain recorded using the same logic with the same amount of weight. Due to the software's limitation, creating two KPIs was not possible so the author distributed the total score among the knowledge and tendency equally in order to create the scores as an suitable KPI that covers both knowledge and tendency.

⁴⁴ Own figure, captured from Typeform survey software

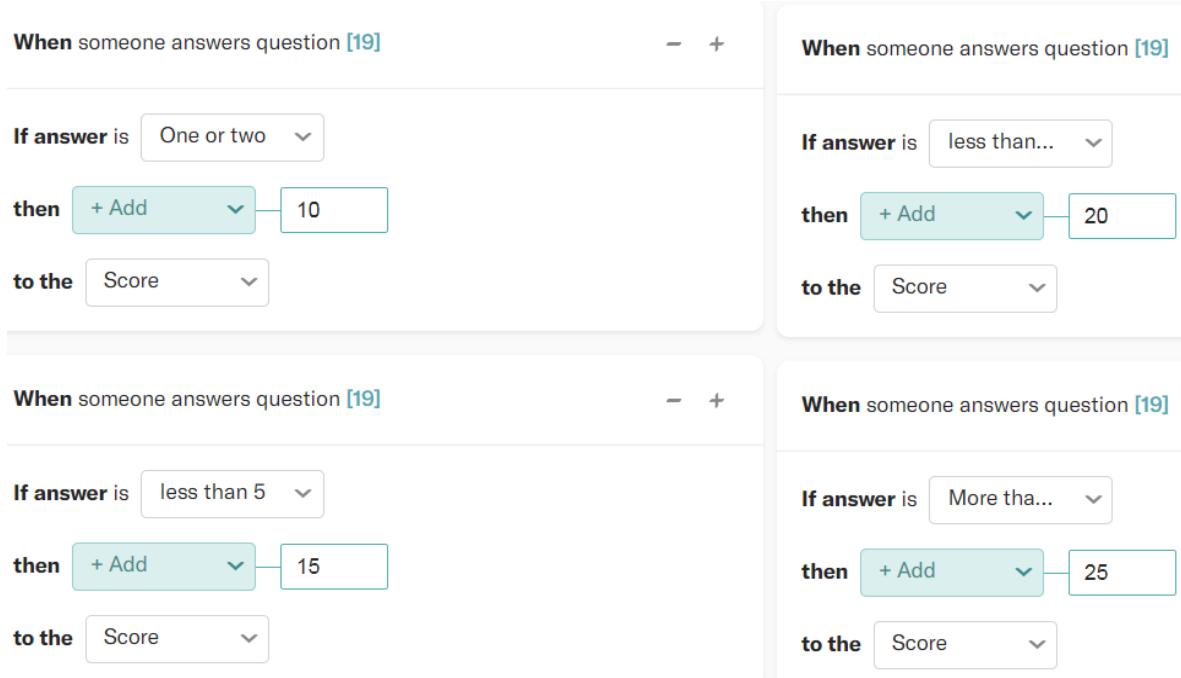


Figure 41: Scoring logic for the question "How many cryptocurrencies do you own?"⁴⁵

The results were analyzed from two major analysis perspectives. Firstly to compare the scores between real estate professionals and the professionals from other industries. Second, to analyze other characteristics of the participant in correlation with their scores such as education, region, and history of using internet or cashless payment systems.

To create more visually understandable analysis, the scores are scaled to 100 for easier comparison. The average score for all participants is 37.945 percent.

⁴⁵ Own figure, captured from Typeform survey software

As could be seen in Figure 42 there is less than one percent difference between the scores, meaning the real estate professionals are along with other industries. The hypothesis is denied and though the differences between the scores are below one percent, it can be assumed that the level of knowledge and tendencies are equal.

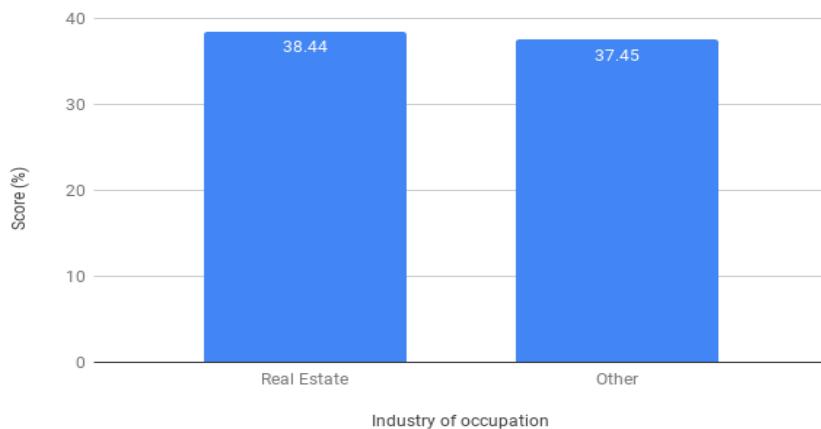


Figure 42: Score comparison between real estate and other industries⁴⁶

Age grouping does not illustrate a major difference between groups, however Figure 43 illustrates a lower tendency among seniors.

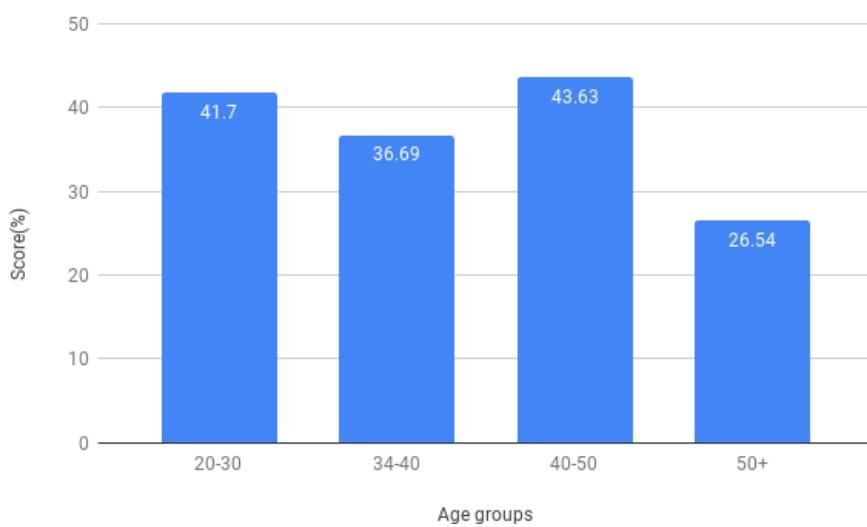


Figure 43: Score comparison between different age groups⁴⁷

Comparing the scores based on the first time that participants used the internet, shows that participants who used internet for the first time between 2005 to 2010 have had

⁴⁶ Own figure

⁴⁷ Own figure

higher scores. Same pattern is traceable for first online payment users who started using the online payments between 2010 and 2015.

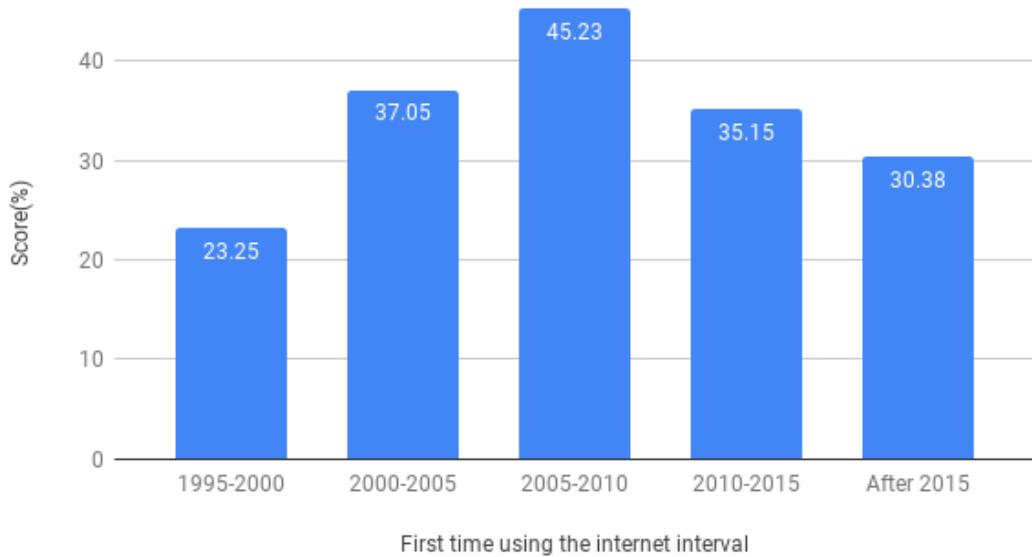


Figure 44: Comparison of scores based on the first time of using the internet⁴⁸

The survey clearly shows that participant's point of view about internationalization is in the direct correlation of their scores. The more open they are to internationalization, the more scored they earned doing the survey.

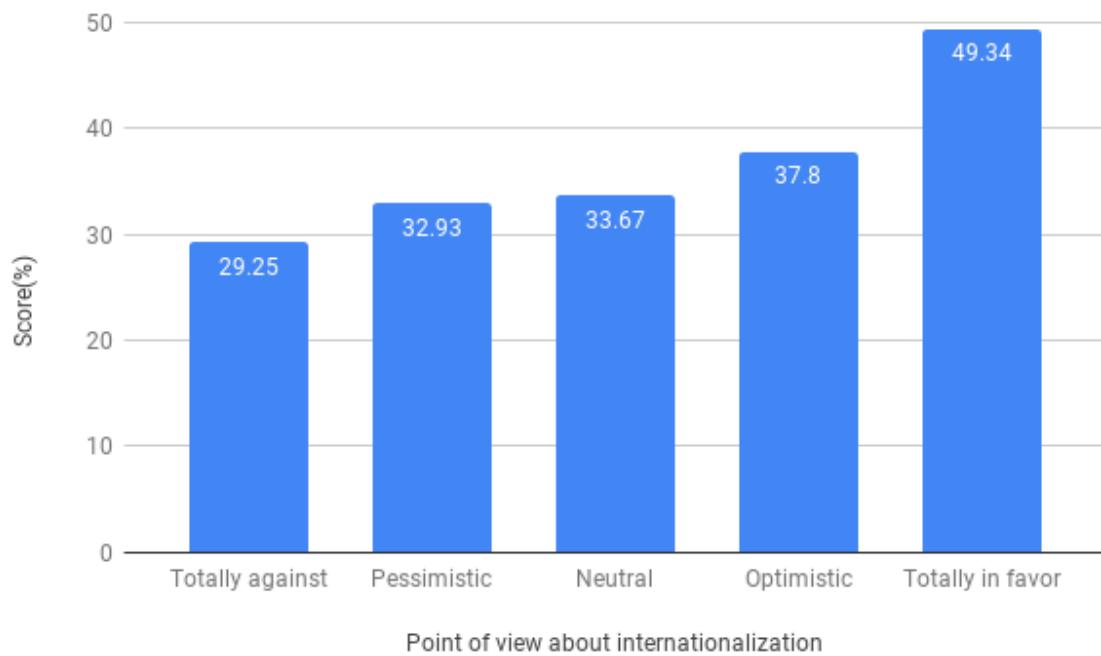


Figure 45: Comparison of scores based on point of view on internationalization⁴⁹

⁴⁸ Own figure

⁴⁹ Own figure

Based on 72 real estate professionals who took part in the survey, executive and observant professionals scored the lowest in comparison with other professionals of the industry.

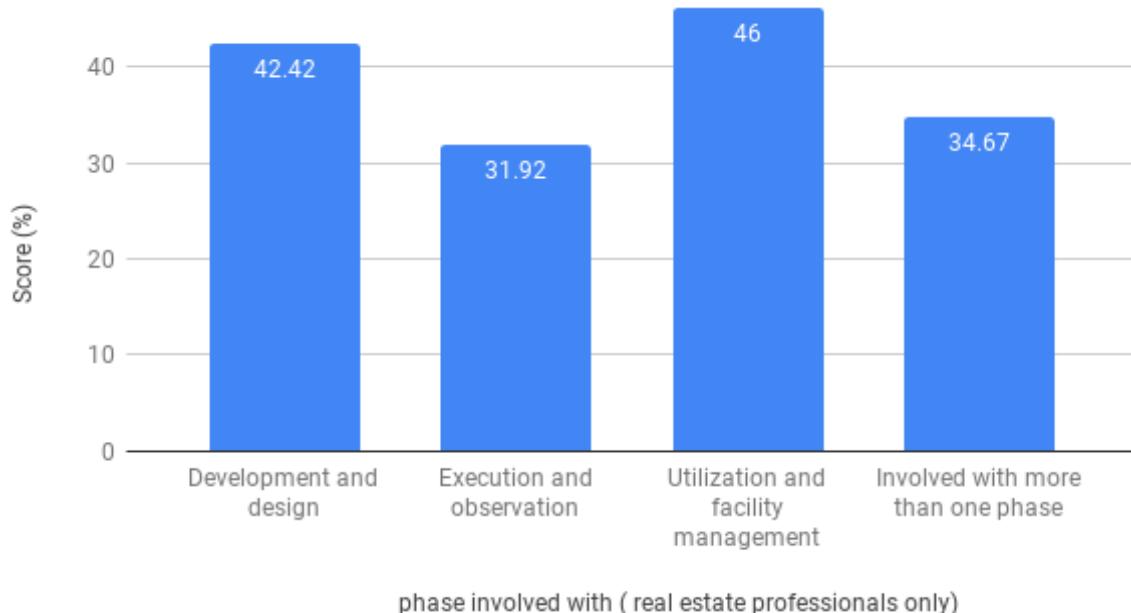


Figure 46: Comparison of scores among real estate professionals based on the phase of involvement⁵⁰

Regional comparison shows the highest tendency in Africa followed by European countries. Participants from Oceania scored the lowest after the Americas. Due to low number of participants from Africa that are 10 people accounting for less than five percent, revision advised.

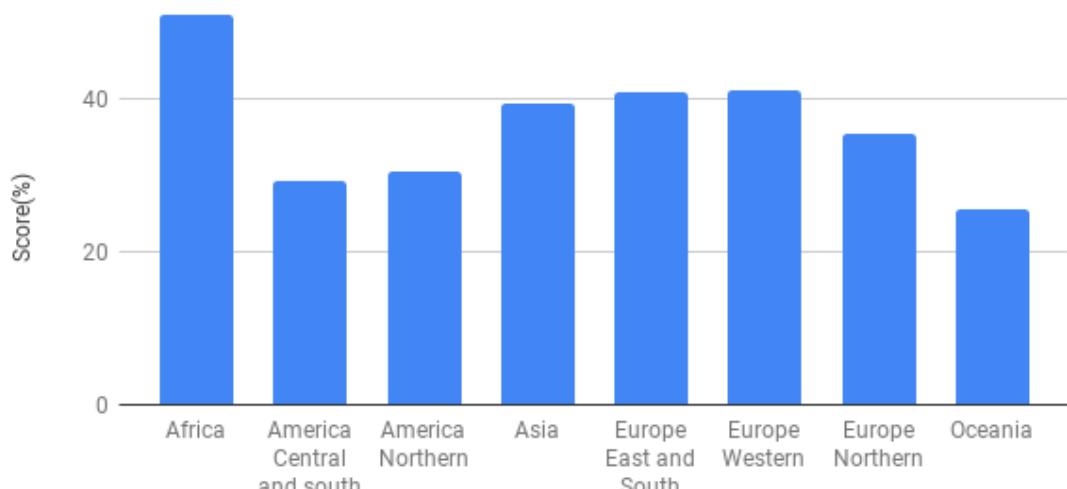


Figure 47: Comparison of scores based on region⁵¹

⁵⁰ Own figure

⁵¹ Own figure

Another correlative finding was about level of involvement with gig and share economy. As could see in Figure 48 and Figure 49, participants with higher level of utilization for share and gig economy had a higher score.

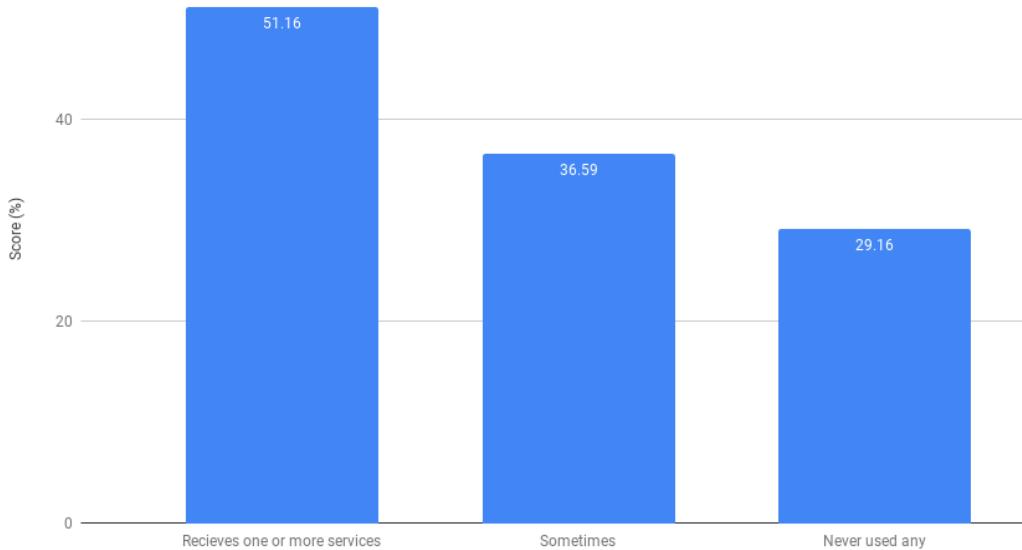


Figure 48: Comparison of scores based on using gig economy as customer⁵²

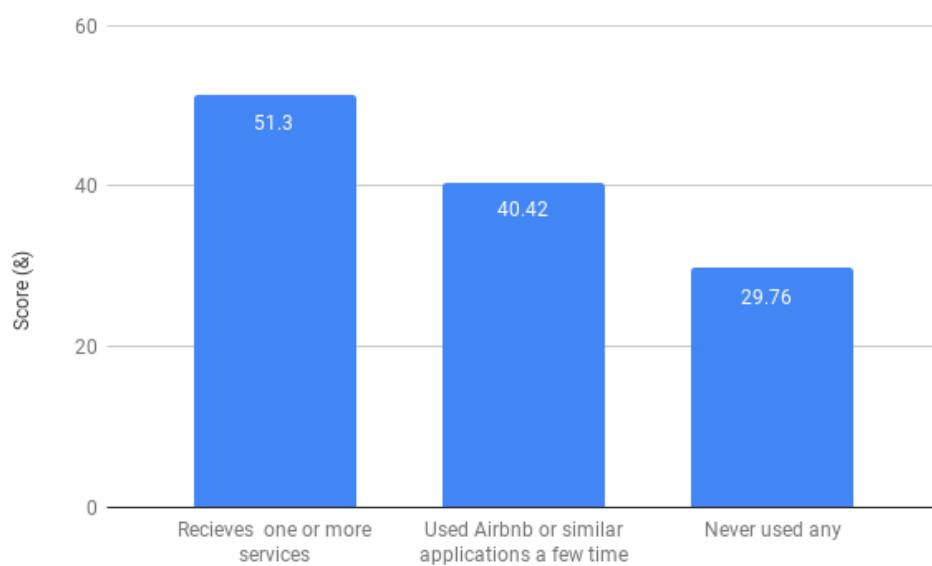


Figure 49: Comparison of scores based on using share economy as customer⁵³

⁵² Own figure

⁵³ Own figure

Last finding to highlight is the correlation between coding skills of the participants and their score, participants with higher level of coding skills are more had higher scores as shown in Figure 50.

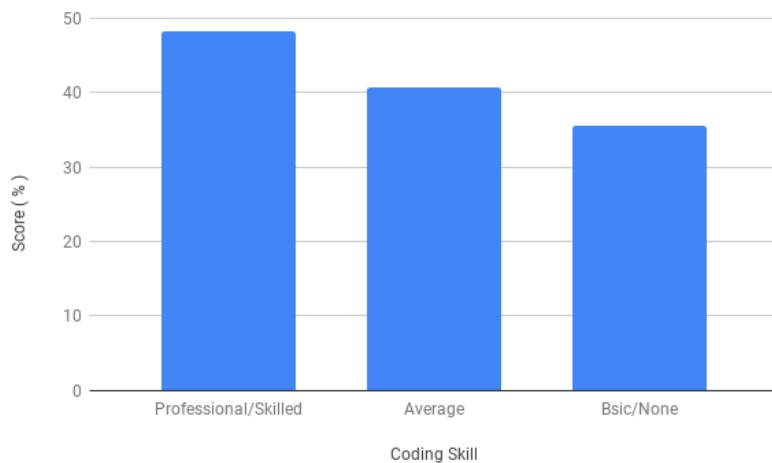


Figure 50: Comparison of scores based on coding skills⁵⁴

5.5 Summary

The survey conducted to create data about public perception about blockchain technology and the overlapping with the real estate industry. The form filled by 206 participants from all five continents, five responses excluded as noise. Comparing the results with discussed resources such Statista (2018) illustrated in Figure 21: Results for survey question, "Do you own some cryptocurrency?" on the page 62, participants in this survey had higher rate of cryptocurrency ownership, but as could see in Figure 35: Tenancy and education status on the page 97 the majority of participants are graduate degree holders which makes considerations about possibility of correlating the results.

The hypothesis that real estate professional have lower amount of knowledge and tendency toward the blockchain technology denied in Figure 42: Score comparison between real estate and other industries on page 102.

Relevant comparisons showed that internationalization point of view and tendency to utilization of gig and share economy could directly correlated with the knowledge and tendency toward the blockchain technology.

⁵⁴ Own figure.

6 Use Cases

6.1 Introduction

In this chapter, we offer four use cases of blockchain within the real estate industry. As illustrated in Figure 3: Areas of the real estate industry most likely to adopt blockchain technology in page 10 we try to offer use cases that use the areas highlighted by PwC and the Urban Land Institute (2018) and categorizing these areas in three as follows:

- Design and construction
- Tenant requirement and property management
- Big data, valuation, and financing

We offer one general use case that covers all phases of the property's lifecycle and aims to document the property from development to demolition using Bitcoin's public ledger. A use case in construction procurement management. Another use cases for a blockchain empowered artificial intelligence as a decision-making tool in real estate investments. Then, one use case in facility management for micropayment and smart grids interactions.

6.2 Project management on the blockchain

Importance of implementation of blockchain with an enterprise ontology is to create a practical use of blockchain as a cooperation platform and not just as a financial transaction tool (Kruijff and Weigand 2017).

The aim is to illustrate how the implementation of the blockchain concept in different aspects of the real estate industry can facilitate cooperation with higher efficiency by increasing transparency and reducing trust barriers on a global scale.

For sensitive data cooperation such as real estate, whereas valuable and private data is in a transaction between stakeholders of a project or business, the blockchain design approach needs to be a combination of public and private ledgers. They are using public ledger for transactions that are coordinated with the information stored on the private ledger. Private ledgers' level of data depends on the required information with

the specific stakeholder; the stakeholder either is the creator of the data or has the authority to use the data. For instance, as illustrated in Figure 51, investors are creators of financial data and authorized stakeholders to observe the observation firm's output data. Furthermore, investors, as the creators of the financial data, allow financial firms to access the data as an observer for their financial executions, in a well-developed platform stakeholder such as financial firms can shrink using smart contracts.

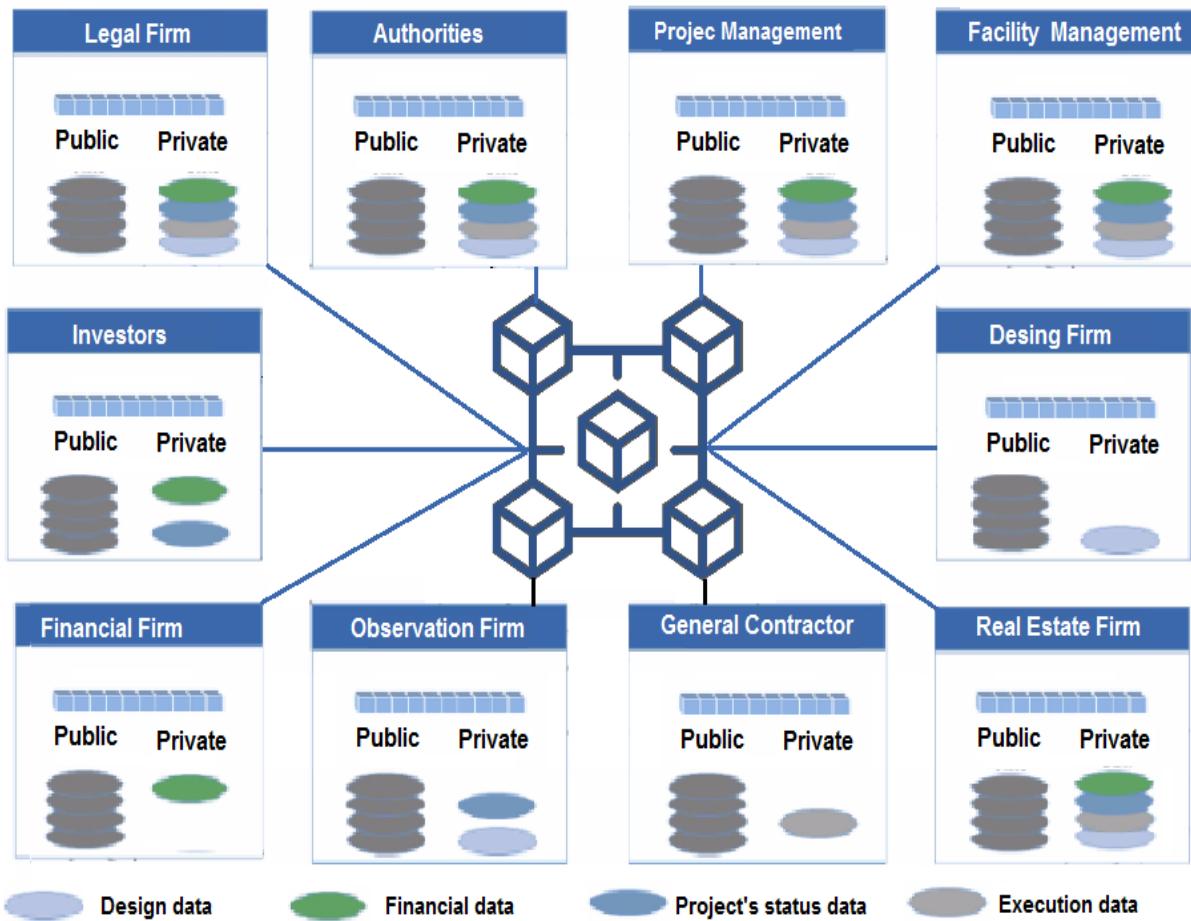


Figure 51: Project management on blockchain⁵⁵

As we discussed on page 72 about hashing and time stamping, sharing a data set created with a stakeholder on blockchain does not put the original data at any risk. The hashing and time stamping can keep the created hash of data on a public ledger such as Bitcoin's ledger and an update from other stakeholders will change the data set's hash making it invalid for other stakeholders to refer or update. Each stakeholder taken as a node that interacts with other stakeholders on the platform and the same with its

⁵⁵ Own figure

core business interactors. Taking the General contractor as a node that interacts with equipment suppliers in its core business level, the Wang et al. (2017) is enlightening. On their study: "The outlook of blockchain technology for construction engineering management," their example studies conventional leasing as one of many inefficient and time-consuming procedures of the construction phase and offers Figure 52 as the solution to tackle inefficiencies for a crane lease procedures. This IBM blockchain ecosystem-based procured which utilizes Hyperledger a reference ledger for transactions reduces ambiguity within the procedure (IBM 2019). The procedure starts with a request for a crane from the constructor that receives bids and accepts the most suitable contract after the necessary negotiations. The procedures manage insurance and payments also. The information from this lease can both created and used adapting the blockchain as explained in Figure 52.

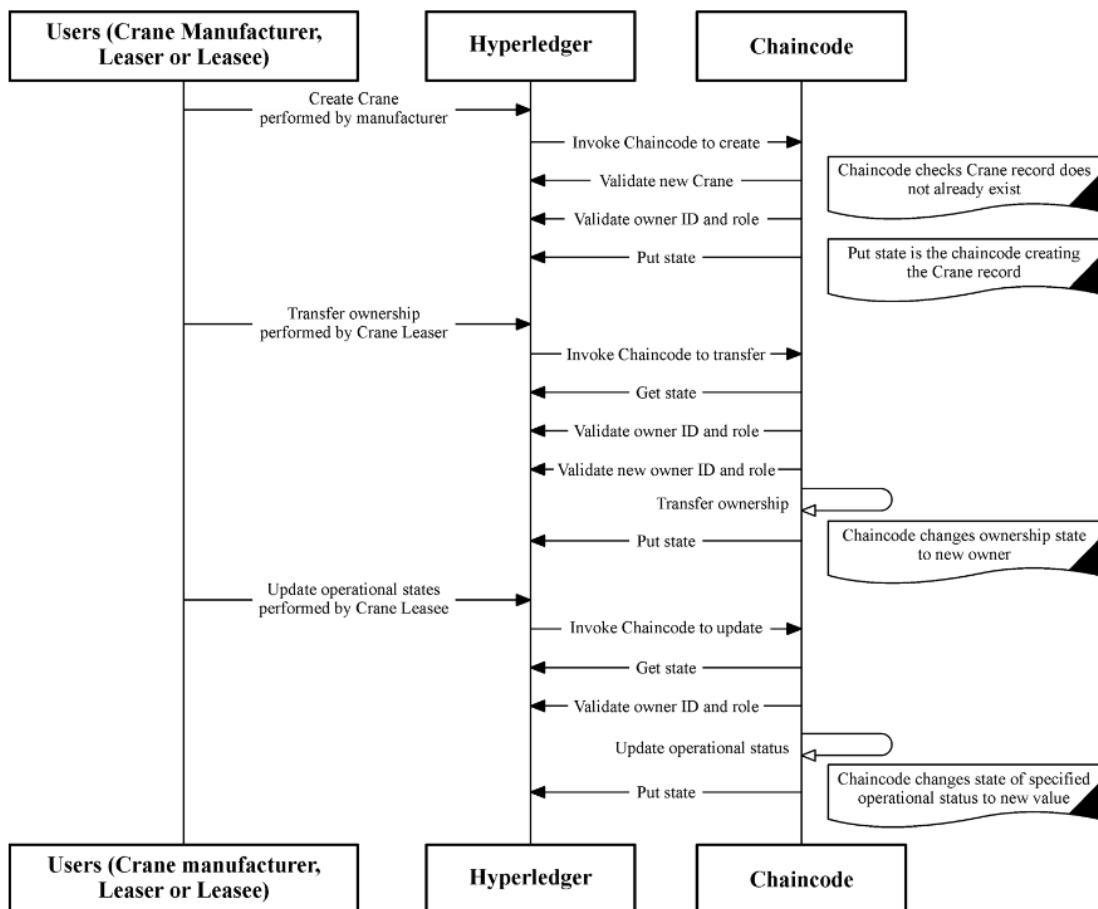


Figure 52: blockchain-enabled crane leasing⁵⁶

To extend the concept, the data created from the design node dictates the details for the required equipment. Required finance based on BIM 5D model is available for

⁵⁶ Wang et al. 2017.

investors and the financial firm node and prepayments released based on bid offers from the chosen supplier that is stored in construction firm's ledger, which feeds the financial firm. By approval from the observation firm that the crane is at site second payment that using smart contracts can release the fund from investors' wallet directly to the supplier wallet. The possibility of operating and financing an onsite action such as a crane lease transparently with a possibility of releasing funds directly from the investor's wallets is one of the many blockchain functionalities. This development scales the project management beyond its current desired techniques such as lean management methods that try to borrow just in time management from other industries in order to keep stable cash flow (Alarcón 2014, p. 99). Having said that using blockchain technology there is no need all the cash flow optimization efforts and to be exact, there is no need for cash flow when funds are transferred from the financers to the service provider. To elaborate more, we trace the financing procedure of leasing the crane on the blockchain-empowered platform. Having smart contracts, there is no need for investors to pay their investments upfront. The agreement can be flexible, and the amounts can be lower and payable in different currencies. The scenario outlined in Figure 53.

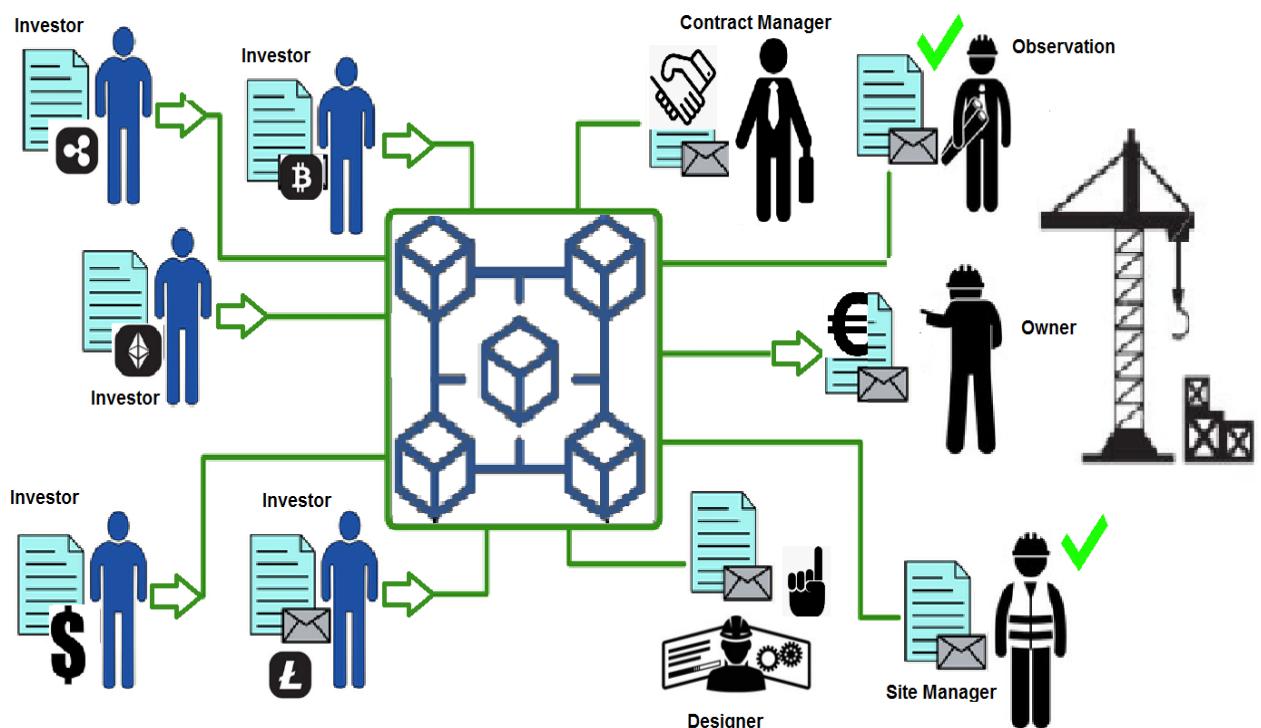


Figure 53: Funds release procedure for a rental tower crane⁵⁷

⁵⁷ Own figure

Steps for this release procedure are:

- Designer's input from 5D BIM is that there is a need for a specific tower crane during a determined interval.
- Contract Manager runs the auctions and selects the qualified bidder and prepay released from the investors' wallets
- Site managers confirm the crane's arrival and start installing procedure releasing on arrival payments to the owner
- Project observer confirms cranes functionality during the period, and final payments releases.

Leveling up the scenario, some participants input such as site engineer or observer's inputs are automatable using IoT. Keeping the same approach for all phases of a property's lifecycle creates the same opportunities at different scale depending on the exact use case of the technology and the nature of the phase in which the technology is implemented.

As there is significant uncertainty about the blockchain technology among most of the firms involved with the real estate industry, there is a need for more educative programs and the spread of knowledge among firms. Firms with a tendency to adopt the technology need to have a clear view of their target plan as well as implementation costs of the blockchain technology. After evaluating risk and costs, according to (Accenture 2015), the next steps are:

- Development of a detailed blockchain roadmap
- Creation of implementation and determination of user scenarios
- Determination of profitable uses in the short term
- Join forces to explore the technology and test use cases

6.3 Blockchain empowered artificial intelligence as a decision-making tool in real estate investments

In this section we discuss a concept that can act as an investment assistant.

6.3.1 Introduction

In this case study, we discuss the idea of using blockchain-enabled robots as a decision-making tool for the real estate market investment consultants. We cover conceptual aspects for a mindset, code architecture and one output prototype. The assumption is on a well-applied environment of blockchain technology and no privacy harassments while using the data. Briefly, we discuss the possibility of a code that can train itself using existing data or pay for its required data creation, evaluate a real property and finally trade it on a blockchain platform. The concept may look too futuristic but as we discussed earlier that we are 20 years from implementation of blockchain within real estate industry and this time creates a window for generating technologies that can benefit from that implementation the most.

6.3.2 Real estate and Artificial intelligence

Investment in the real estate considered safe with lower but guaranteed benefit (Unger et al. 2010). During past decades digitalization and globalization, as discussed on page 23, created a stabilization within the modern world and opened ways for more rational and algorithmic predictions. In the real estate industry, the market crash in 2008 considered as a turning point for the real estate investors to overcome this illusion of “guaranteed benefit” (Altman 2009). Technological changes and the possibility of powerful statistical predictive analysis today bring the possibilities of profit analysis for secure real estate investment. In his book “Predictive inference,” Geisser (2017) covers vast background research about the use of prediction developments based on artificial intelligence. The same methodology but with a focus on the housing market was offered by Nguyen and Cripps (2001) also, They both offer artificial intelligence’s ability to learn a market behavior and predict its trends if feed with useful information and provided the ability of self-training instead of human training. By referring to the mentioned resources, we present a process and

possible outcomes of a self-training artificial intelligence to analyze and predictive the real estate market. As mentioned in page 87, real estate assets are soon tokenized, tradeable on blockchain platforms such as Alt.Estate as small as one square meter, and as cheap as one-hundred Euros. Thanks to the transparency offered by blockchain technology the price fluctuation of the property are remotely accessible acting as a live feed data for machine learning. The importance is to remember that the aim is that the AI can train itself. Another possibility that blockchain provides for machines is machine-to-machine payments (Bahga and Madisetti 2016). Meaning, an AI can pay its expenses for learning and training. According to (PwC 2019) four major application areas of AI are:

- Automated intelligence: Automate manual / cognitive and routine / non-routine tasks.
- Supporting intelligence: helping people to accomplish tasks faster and better.
- Experiment intelligence: helping people to make better decisions.
- Autonomous intelligence: automation of decision-making processes without human intervention.

There is an estimate for artificial intelligence invocations to account for more than ten percent of German gross domestic product by 2030 (PwC 2019).

Webster (2019) defines "Intelligence" firstly as "... the ability to learn or understand or to deal with a new situation or the skilled use of reason." The second definition describes intelligence as an ability to apply knowledge to manipulate one's environment or to think abstractly as measured by objective criteria. The investors' point of view needs to be wider with a deeper perspective. Gathering information is a critical, time consuming and costly process (Brown and Matysiak 2000). In other words, a real estate investor's mind needs constant feed and evaluation of Key Performance Indicators (KPIs) with correlation with the market's environment. The KPIs that define a real property's value have their complexity, and their impacts on the value of the facility is another measure of complexity (Jacques et al. 1996). For instance: taking the distance to public transport as a KPI, the proximity of such services might have positive as well as negative impact. It is in favor of most location's value to be close to a public transportation station; however, being too close, in comparison to, close enough to a station might reduce the value of residential buildings where it increases commercial ones. If noise pollution would be another KPI, as noise pollution rises in

close ranges, it is too complex to indicate exactly how exactly the noise will outweigh the closeness to the station. Distinguishing close enough and too close which are two qualitative values depends on the individuals' interpretations. On the other hands, machines can correlate less than five minutes' walk to a close enough and less than 50 meters, but again choosing between 50 meters or 75 meters is putting one person's mindset ahead of other and creating a preset of a thinking mechanism. These types of machine-readable interpretations are easy to capture today through various uses of online platforms available such as Google Map.

6.3.3 Available data and AI training mindset

Technological advancements have provided numerous possibilities and have changed the way we perform our tasks in everyday life. The various outcome of City Information Models (CIM) has provided an understandable and connected platform for many participants of the industry (Isikdag and Zlatanova 2009). We believe that the rich information from BIM and CIM in combination with an AI that is empowered with blockchain can aid investors to make decisions that are more profitable.

Data at Rest (DAR) are the data that created mostly by users during their interaction with a virtual environment and are growing every day (Raizen et al. 2012). The three states of data illustrated in Figure 54.

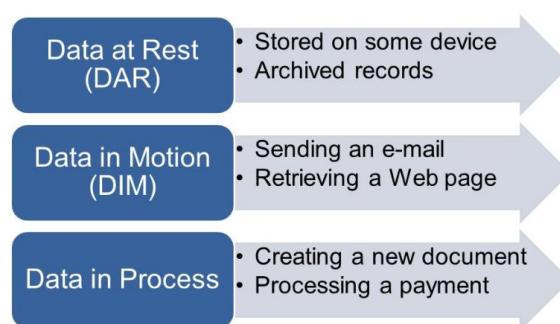


Figure 54: the three states of data⁵⁸

Investors always tend to evaluate and calculate risks in investments as accurate as possible. In order to achieve an accurate evaluation, they need to have a higher

⁵⁸ Lane 2016.

general understanding and background information. Amount of information generated today is 2.5 quintillion bytes daily (Marr 2018b). Human interpretation of this amount of generated information is impossible without proper aid of computing analyses. With the amount of useful DAR at ease, AI's have a high potential of analyzing information with high accuracy and easiness in comparison. The idea of analyzing data sets is not a post-millennium phenomenon, and resources such as Gale (1987) have discussed its implementation. Information generated in construction projects through BIM for the design, construction, and operation of individual buildings as well as through similar concepts in infrastructure design, planning, and operations provides a useful data repository and information about design history an available service. The industry furthermore applies this intelligence-modeling concept for the next broader level of human habitation. The input data modeled in the CIM model when integrated with other technologies such as big data, IoT, real-time monitoring of sensors and tracking can create a synthetic data set (Khemlani 2016). These data sets used to train AI.

The ultimate goal is to create an AI that can feed itself from various resources of data in order to extract information, using the blockchain can pay the micropayments to pay for its expenses, for instance running a survey, and use the cryptographic nature of blockchain to avoid violating privacy. The idea is to minimize the manual inputs and to maximize the AI's awareness about its surroundings.

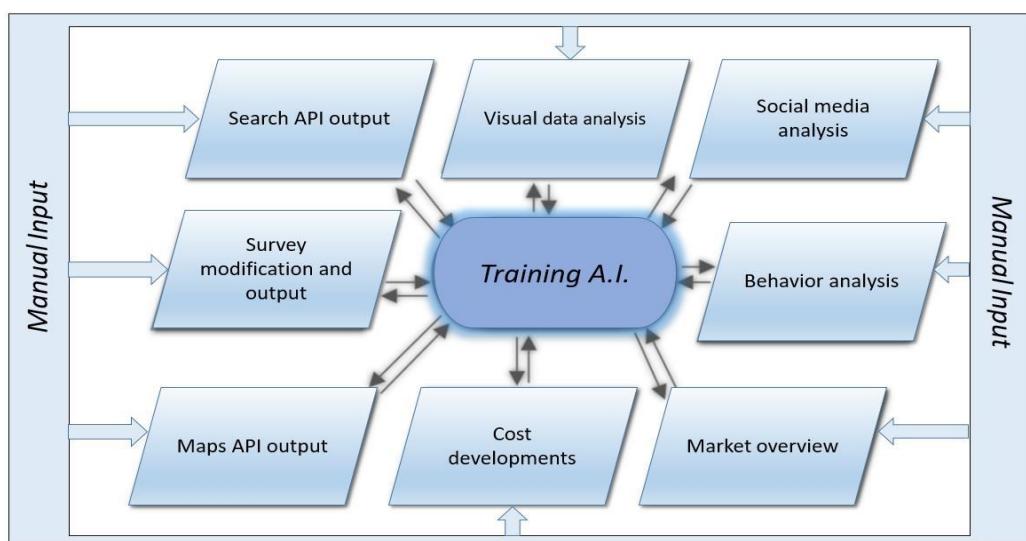


Figure 55: AI training mindset⁵⁹

⁵⁹ Own figure

Figure 55 aims to highlight the constant interacting of the AI, not only as a data receiver but also as a content creator. Assuming that the implementation of this AI is taking place when the blockchain technology is as implanted and standardized as the internet is today and having a blockchain is as common as having a website is today the AI can train itself by gathering data from listed resources without violating privacy:

- Observing social media and understand migration trends
- Create a survey and pay for social media advertising for the target group
- Analyze visual data in order to estimate the level of luxury
- Analyze map data to understand reasons for in region movements
- Use token trades related to the raw material in order to predict cost development
- Use blockchain transparency to review the market
- Interact with search platforms
- Interact with IoT devices to have and have a behavior analysis

6.3.4 Code architecture for a self-training AI

The ability of Feed Forward Neural Networks in predictions and estimation is not the subject of the question these days, the indefinite amount of required resources in training and developing casts a deep shadow on the feasibility of this outcome. In the code architecture development phase, it is more than critical to outline this architecture aiming for the minimum resource consumption training the code (Svozil et al. 1997).

The following example will try to clarify this phenomenon.

A most straightforward definition of benefit or loss in the purchase is from deducting the paid value from mart value of the object. A typical example can be the shopping process of a shirt in a boutique. If the customer evaluates the shirt for any price more than its tag price, it is more likely for the person to assume the purchase a good deal. However, how a person can train her ability to estimate the price of any random shirt? There are many ways to train this ability like studying different brands, materials, and all other KPIs, which describe a shirts value. The evaluation of these KPIs is possible

by try and error where the customer evaluates an object based on her current evaluation skills and compares the estimation with the actual price. The same logic used to train a prototype code that tries to evaluate a study pixel in an urban area.

Study pixel is measurable and definable in square meters. The pixel size can vary, starting from bigger sizes to create information at lower cost and a faster speed, then shrinking down to a one real property size. It can use the generated information at bigger study size as a source of information for a more accurate estimation for smaller sizes.

The logic for this architecture is to create a code that:

- Studies the web to estimate a price for areas near the studied pixel
- Visual analyzes KPIs specified to the pixel such as shops and transportation
- Estimates a price for the studied pixel
- Creates human feedback about KPIs' weight and the actual price of the pixel
- Compares its estimation and the actual price and tries to narrow them down

The used variants for creating an equation that can act as the AI training goal, and tries to limit the fluctuation between estimated price and the actual price explained below. Note that the equation is to create the idea of how an AI is self-trainable on the blockchain environment and it is obvious that a practical code needs much more details and adjustments.

T_i : Time of study

K'_1 : Extracted price for areas near the studied pixel

$W_1 = f(KPI_{1-n})$: Key Performance Indicators' influence on the study pixel (Wight)

K_1 : Estimated price for the studied pixel

K_2 : Study pixel's actual price received from human feedback or a trade certificate

$P = \frac{K_1}{K_2}$: Ratio between estimated price and the actual price

$\lim_{i \rightarrow \infty} P = 1$: Training object

On the next page, Figure 56 illustrated an overview about the procedure of training AI using the available data on the web as well as surveying locals and commons within

the studied pixel to create an accurate estimate about the value within the studied pixel.

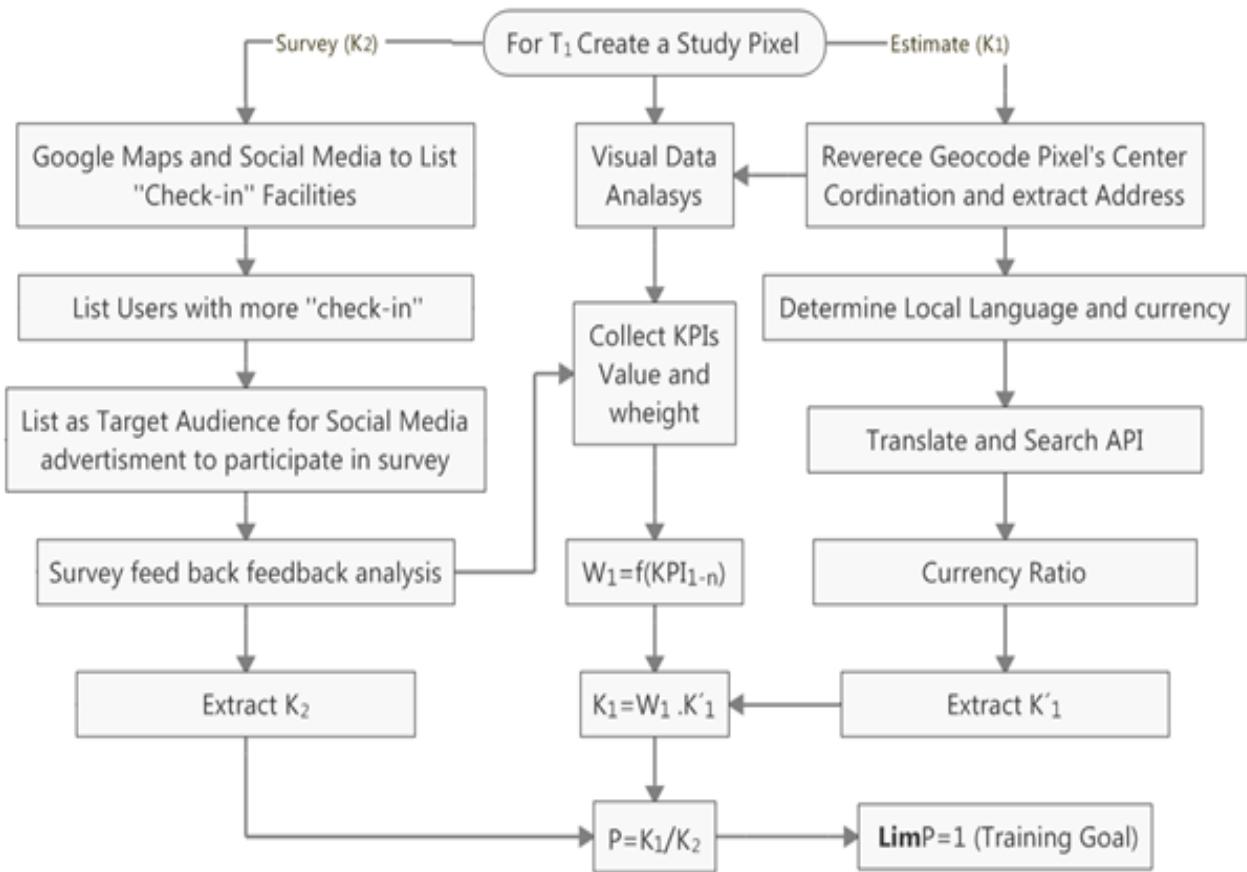


Figure 56: Overview of a self-training code architecture⁶⁰

The AI training phase finishes when $\lim_{i \rightarrow \infty} P = 1$ is true the number of study pixels grow.

As said, T_i can create different study period for the pixel, it can create a time value diagram and validate its training based on the correlations between the estimated price for a location and actual housing price index fluctuations that is available from blockchain trading platforms. On a public chain it is visible the amount of a transaction, platforms can elaborate by unveiling the location for the transaction, for privacy reasons location does not need to be an address, as long as it is accurate enough to train the AI for the area around the study pixel it is sufficient.

60 Own figure

6.3.5 Interpretation of trained AI output and conclusion

When the training phase is over, meaning, the estimated price for a pixel does not vary from much from the actual price.

Verbal it interpretation categorized in three possibilities:

- $P = 1$ Steady and calm market, not an interesting investment
- $P > 1$ Estimated price is higher than the actual price, buy alert
- $P < 1$ Estimated price is lower than the actual price, sell alert

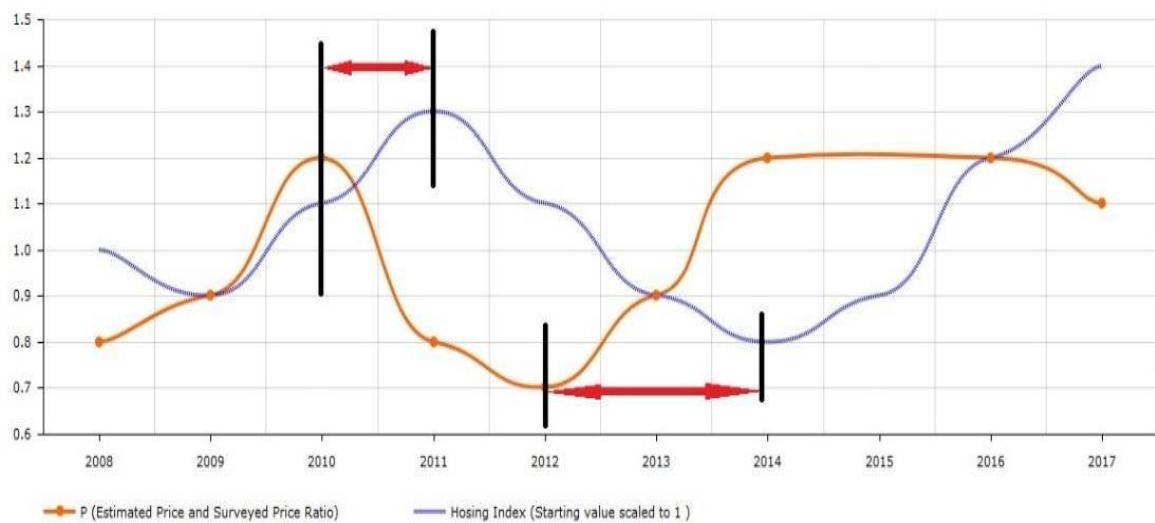


Figure 57: Comparison between P and housing market index⁶¹

Buy holding a private key a trained an AI can execute the trades and pay for them in cryptocurrencies.

There are several steps to take for this kind of algorithm to be practical. In this case study, we discussed the idea of self-training AI that can train itself feeding itself from the enormous amount of data floating over the internet, pay for training and investigation the market, self-evaluate its training procedure, and finally, predict the market and trade on it individually.

⁶¹ Own figure

6.4 Facility cost management on the blockchain

As we discussed about data flow on page 12, there exists a higher level of data flow within the project between participants. In this use case, we try to illustrate that how this data flow combined with smart contract and cryptocurrency payments can reduce the managerial effort required for managing these three assets. Assumptions are:

- Full implementation of 4D and 5D resulting in a precise idea of cost and time
- IoT implementations enough to track materials and task procedures status

Taking the assumptions for granted, at early each state of the project the project managers can answer the following question about any tasks based on their data feed:

- What should we do?
- When should we do it?
- How much labor does it need?
- What equipment are required?
- What material does it need?
- How complete is the task?
- Who has done it?

By knowing the answers to these questions and implementation of smart contracts, managers can benefit from various aspects. Having the procurements managed on smart contracts, with a definitions for delivery as the goods are a certain location, as illustrated in Figure 58, automates the payments and reduces the paper works required for a procurement delivery system on blockchain.

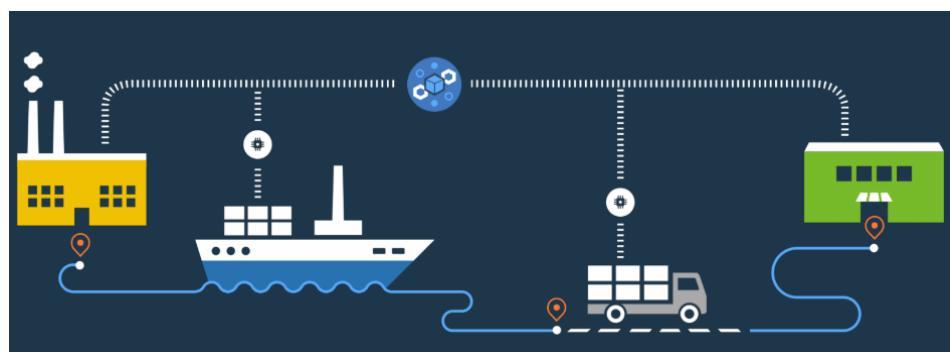


Figure 58: Procurement delivery on smart contract⁶²

⁶² Blinco 2016.

To illustrate how facility cost management are scalable to a higher level using the blockchain technology; here we discuss a smart contract for HVAC and cleaning. This example tends to utilize some of the discussed topics from the literature review: Gig economy, IoT sensors, and Smart contracts. We try to show how using a smart contract, HVAC maintenance, and floor cleaning cost will be managed in two separate examples. HVAC maintenance contract receives a continuous feed from the air quality sensors manteled within the facility, which means the maintenance contractor grantees specific range of KPIs such as temperature and humidity. As long as the contractor keeps the KPIs within their agreed interval on the smart contract, funds from the facility's wallet transfer to the contractor's wallet. To emphasize that how available the non blockchain related infrastructures are, we overview a transaction process on the proposed concept. The smart contract wants to verify if the agreements for the upcoming payment have met by the HVAC contractor. Using public and open data bases such as Luftdaten.info

The same concept can automate contract management for other facility services, such as cleaning. Cleaning contracts, using IoT makes sure that the cleaner has attended the location. Then, sensor feeds from a connected smart vacuum cleaner can indicate the quality of the cleaning by measuring the amount of collected dust by the vacuum cleaner as a KPI. Current procedure of IoT task management shown in Figure 59.



Figure 59: Task management system on IoT⁶³

There would be reduction of cost due to automated contract and payment management empowered by blockchain and IoT applications. This automation can raise the possibilities to utilize the gig economy within the real estate industry too.

⁶³ Barcodes 2019.

6.5 Local energy markets on blockchain

This concept is already has been already offered by various resources (Pieroni et al. 2018; Mengelkamp et al. 2018; Pop et al. 2018) And though the concept is under development in practice by the private sector's companies such as EnergyWeb organization along with community energy markets such as Brooklyn Microgrids that offers a microgrid energy trade platform. The concept itself cited, and the author discusses the advantages of their practical implementation briefly.

By offering Figure 60, Pop et al. (2018) claims that smart grids are applicable on the smart contracts using IoT inputs and cryptocurrency payments. In short, this concept creates an environment in which the energy provided from the nearest provider to the client on demand reducing energy costs.

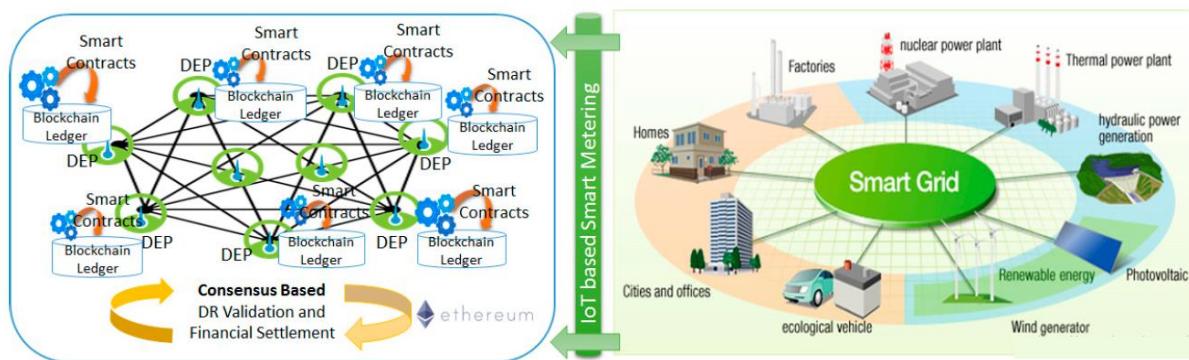


Figure 60: Blockchain based architecture for decentralized management of energy grids⁶⁴

This concept utilizes the implementation of share economy within the smart environments creating financial motives for investors toward sustainable energy production alternatives knowing that they can sell their created energy directly to the neighbor on demand. Meaning, by creating wider market for alternative energy solutions, the ideologists and providers of orthodox concepts such as Consonni et al. (2005) that offers local waste energy plants, or Zanganeh et al. (2012) that offer utilization of packed bed of rocks as a storing material, can take a private market approach toward realization of their project, independent from central governments' financial policies.

⁶⁴ Pop et al. 2018.

To elaborate more, on his article "Microgrids and the blockchain are powering our energy future," Baraniuk (2017) debates that the new format of energy market enables its participants to participate on decentralized form either as consumer, service provider, investor, or combination of each. This format of cooperation cancels the constant need of mega investments for modern solutions.

Furthermore, it allows consumers to switch between energy suppliers automatically by having the KPIs set in their smart contracts; the KPI can vary between the price or the carbon emissions. Another advantage is the flexibility of smart microgrids; operators have a more informed overview of the resources they are managing. For instance, in the case of overproduction period, reducing production rate for small providers is not costly, whereas for power plants is either not an option or if it is, the cost is binding. The same source quotes from Philip Sandwell of the imperial college of London, "blockchain empowered smart microgrids could turn the national grid from being the enemy of microgrids to being their friend" Another advantage is the flexibility of smart microgrids; operators have a more informed overview of the resources they manage. An operator might need to reduce the supply on the grid for a few hours, for example. However, asking a power station to turn down their supply will cost them money

This implementation of blockchain empowered local energy markets makes the citizens of smart cities in control of their energy reducing central grids load that delivers the energy from a distance at a lower level of efficiency.

The importance of this concept is to show how IoT friendly smart environments, which are empowered by blockchain technology, can create a powerful infrastructure for sustainability.

7 Conclusion

This study covered overlapping areas between the real estate industry and the blockchain technology from a managerial point of view on economics. The survey conducted by this study highlights the lack of knowledge among its participants with an emphasis on the lower level of awareness within the real estate industry, along with that, it clearly showed how cashless payment system became standard during the past decade. Recent technological developments such as BIM and IoT have opened new doors to automation that can use the blockchain technology to enhance their implementation.

A comparison between paradigm shifts based on the implementation of the internet within daily life can put advantages of adaption of the blockchain technology in a nutshell. One decade ago, interregional knowledge was mostly under influence of local government's policy and available knowledge affected by the other local government's policy also, and the two times modified knowledge was only available if the both governments' policy matched. Today this service is available at the instance. It is possible to receive the news live from the social media of choice or read the academic resources online, censorship and interoperation free, at the cost of zero. Today, if two parties tend to transact any form of value without the utilization of cash or barter, they need to meet several authorities' requirements. Two billion unbanked inhabitants of this planet excluded from the basic right of free trade of value due to banking systems' lack of interest for facilitating their transactions. Furthermore, holding a bank account does not grantee an international trade due to different political agendas between countries. Their transactions are vulnerable even from a third dominant country with a hostile approach to one of the countries involved in the transaction. Lastly, if the individuals received permissions from all the authorities, they experience vulnerabilities such as fraud and corruption reducing their interest in a trade. In a blockchain friendly world, such barriers does not exist.

Despite the technological developments during the past decades, the real estate industry is still facing a looming inefficiency in both resources management and procedures. Furthermore, the industry experiences a tremendous amount of risk from various aspects such as fraud and corruption that flaws the interest level. Modern concepts such as globalization and internationalization are facing blockades

preventing their practice too. The lack of homogenized growth and discriminations are the current obstacles of the named ideas that blockchain technology can facilitate a practical solution to overcome them by its natural characteristics such as micro-investment friendly or censorship-free environment. New economic concepts such as share and gig economy are experiencing are suffering from trust issues in parallel also. Lost or damaged shared assets and unpaid freelancers' invoices are avoidable by utilizing blockchain applications such as digital identity and reputation.

As discussed in use cases, blockchain can scale Building Information Modeling applications by reducing administration costs for contracting and payment procedures. Smart contracts, based on BIM outputs and fed by IoT inputs, can aid the managers in different categories such as human resources, material and equipment procurements, and sub-contractors managements. The fusion of BIM and Blockchain, along with adaptation IoT, brings a new model for cooperation for the real estate industry whereas this cooperation is international, trusted, and automated.

We discussed many obstacles within the real estate industry in different phases of a real estate property and offered some already existing solutions. For instance, we illustrated that how the three-month-long Swedish house title transaction procedure with more than thirty steps to take and many authorities' demands to meet, is already shrinking to one hour and few clicks, available globally. We also discussed some possible use cases of blockchain in various aspects of the real estate industry such as a platform for the project management, or as a tool to apply artificial intelligence in practice.

Lack of a consistent body of knowledge is the current barrier for this adaptation that this thesis aims to tackle. By eliminating the need for a third dominative trusted party from a transaction, blockchain technology is to revolutionize the paradigm of transacting globally among the real estate industry.

8 Declaration of Authorship

I hereby certify that the thesis I am submitting is entirely my own original work except where otherwise indicated. I am aware of the University's regulations concerning plagiarism, including those regulations concerning disciplinary actions that may result from plagiarism. Any use of the works of any other author, in any form, is properly acknowledged at their point of use.

Name: ALIREZA KHALAFI

Student's signature:

Date of submission: 11.03.2019

9 Appendixes

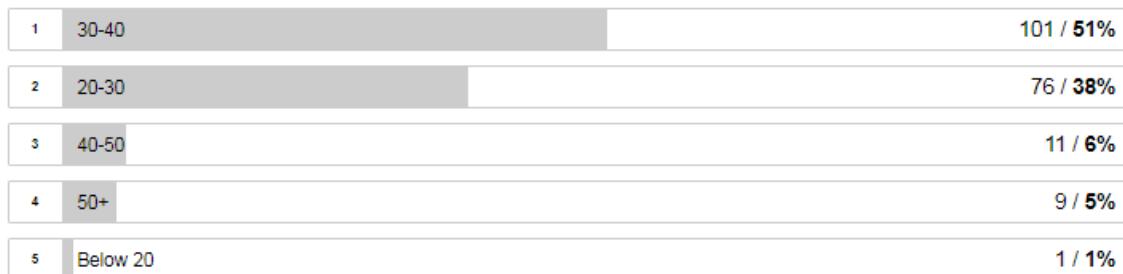
- 9.1 A: Real estate transactions today according to Swedish real estate division
1. A property owner wants to sell her property.
 2. The property owner, i.e. the Seller, contacts a real estate agent and draws up an agreement for managing the sale of the property.
 3. The agent contacts Lantmäteriet and orders an excerpt from the real estate registry database in order to check the information about the property, i.e. that the seller is in fact the owner and can sell the property.
 4. The agent puts the property up for sale and markets the property to potential buyers.
 5. The Buyer goes to a bank, the Buyer's bank, and asks for a loan commitment. The bank checks the Buyer's credit rating, often in a digital registry such as UC. The Buyer's bank approves the loan commitment.
 6. The property is put out on display to the market and eventually offers are made.
 7. The Buyer that makes the highest offer makes an initial inquiry about credit options for the specific residence with the Buyer's bank.
 8. The Buyer's bank inspects the property and evaluates the credit options for the Buyer. The property and the Buyer may be inspected again in the respective databases.
 9. The Bank approves the purchase price and the amount of the loan for Buyer, which is often communicated over the phone.
 10. Prior to signing the purchasing contract, the agent again checks on the seller and the property with Lantmäteriet. The agent also often checks that the Buyer actually has a loan commitment from the bank.
 11. A purchasing contract is drawn up between the Buyer and the Seller together with the agent, often at the agent's office. Often four copies of the contract are created, one for the seller, one for the Buyer, one for the agent and one for the Buyer's bank.
 12. The contract is sent by the Buyer to the Buyer's bank, often by regular mail.
 13. The bank sends credit documents to the Buyer, often via regular mail.
 14. The Buyer signs the loan documents and also writes a note to the bank to pay a down payment into the agent's escrow account.
 15. The Buyer sends the signed loan agreement to the Buyer's bank via regular mail.
 16. The Buyer's bank receives the loan documents and pays the down payment to the Agent.
 17. The property may be inspected by the Buyer.

18. The agreement becomes binding if there were conditions in the form of inspection.
19. The agent pays the down payment to the Seller, while deducting the agent's fees.
20. After this step, the main thing remaining is to actually sign the bill of sale, transfer the possession of the property and make the final payment. This is often done roughly 3 months after signing the purchasing contracts.
21. Closing: The agent checks on the property and the Seller in the database of Lantmäteriet again to ensure that there aren't any problems that would prevent the sale of the property.
22. The Buyer and Seller sign the bill of sale at the agent's office. The Buyer signs for the mortgage and any other mortgage deeds on the property.
23. The purchase price is paid by the Buyer's bank to the Seller's bank. Often this payment is made via a direct deposit where the Seller's bank and the Buyer's bank confirm that the transfer has been made.
24. The Buyer, Seller, as well as the agent, each save a copy of the contract, as well as a copy for the Buyer's bank, and the Buyer may now move into the property.
25. The Buyer's bank goes into the mortgage deed system of Lantmäteriet and requests the mortgage deed on the property from the registry.
26. The Seller's bank releases the mortgage deed to the Buyer's bank
27. The agent sends the bill of sale to the Buyer's bank.
The Buyer's bank sends the title registry application along with the bill of sale and any application for a new mortgage (i.e. an increase in the mort-gage beyond the existing mortgage deeds) to Lantmäteriet.
28. Registering the property title: The Buyer is granted a Property title by Lantmäteriet, and the title is registered in the land registry.
29. A new mortgage is granted, and the Buyer's bank is registered as the mortgage deed holder in the mortgage deed system.
30. Lantmäteriet decides on any service charges and stamp duty (based on the purchase price or the assessed value of the property).
31. Lantmäteriet is paid (usually from the bank) via an automatic payment account for the title and the mortgage deed.
32. Lantmäteriet notifies the Buyer's bank, i.e. the title applicant, by regular mail that the title has been granted.
33. The Buyer's bank notifies the Buyer that the title has been granted and the transaction is performed via regular mail (Lantmäteriet 2016).

9.2 B: Survey Results

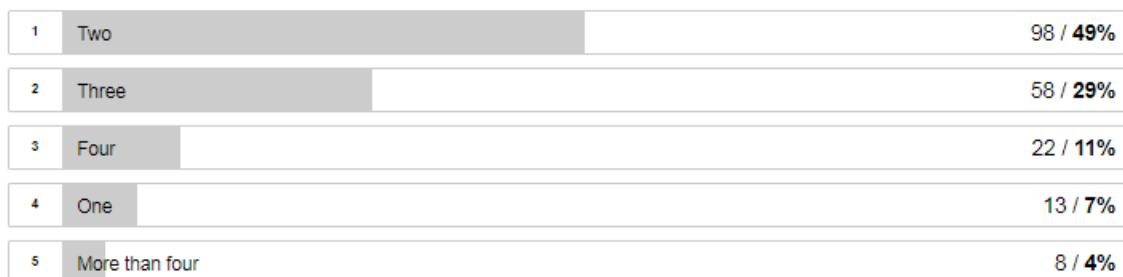
How old are you?

198 out of 200 people answered this question



How many languages do you speak?

199 out of 200 people answered this question



Do you live in the same country/state that you were born?

197 out of 200 people answered this question



In which region are you taking this survey?

197 out of 200 people answered this question

1	Europe Western	45 / 23%
2	Asia Western	30 / 15%
3	America Northern	27 / 14%
4	Europe Northern	21 / 11%
5	Europe Eastern	12 / 6%
6	Asia Central	11 / 6%
7	Oceania	10 / 5%
8	America Central	7 / 4%
9	Asia South-eastern	7 / 4%
10	Africa Southern	6 / 3%
11	Asia Eastern	6 / 3%
12	Europe Southern	6 / 3%
13	Africa Eastern	2 / 1%
14	Africa Middle	2 / 1%
***	Other	5 / 3%

Please choose your education level.

197 out of 200 people answered this question

1	Graduate degree	118 / 60%
2	Bachelor degree	60 / 30%
3	College degree	18 / 9%
4	High-school	1 / 1%
5	Elementary	0 / 0%

Please choose your occupation Industry

198 out of 200 people answered this question

1	Architecture and Engineering Occupations	59 / 30%
2	Arts, Design, Entertainment, Sports, and Media Occupations	21 / 11%
3	Computer and Mathematical Occupations	19 / 10%
4	Business and Financial Operations Occupations	17 / 9%
5	Construction and Extraction Occupations	13 / 7%
6	Education, Training, and Library Occupations	13 / 7%
7	Other	13 / 7%
8	Sales and Related Occupations	9 / 5%
9	Life, Physical, and Social Science Occupations	7 / 4%
10	Healthcare Practitioners and Technical Occupations	5 / 3%
11	Management Occupations	5 / 3%
12	Community and Social Service Occupations	3 / 2%
13	Legal Occupations	3 / 2%
14	Building and Grounds Cleaning and Maintenance Occupations	2 / 1%
***	Other	9 / 5%

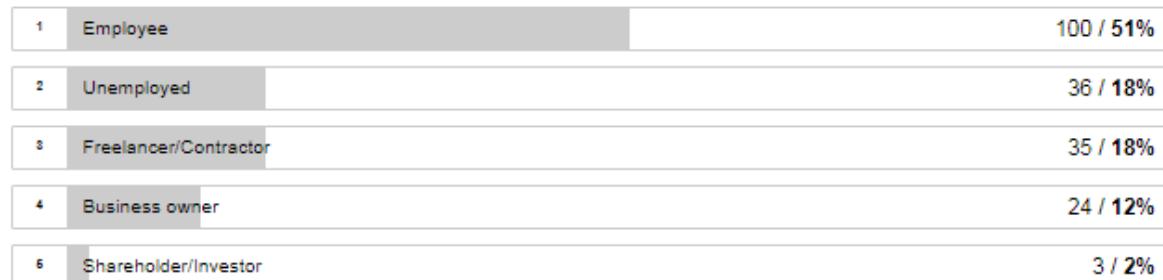
Which phase of a project are you involved with the most?

69 out of 200 people answered this question



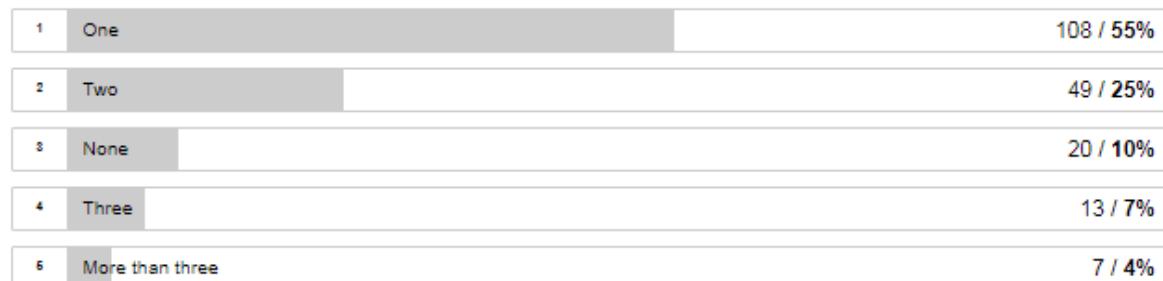
What is your working contract format?

198 out of 200 people answered this question



How many sources of income do you have?

197 out of 200 people answered this question



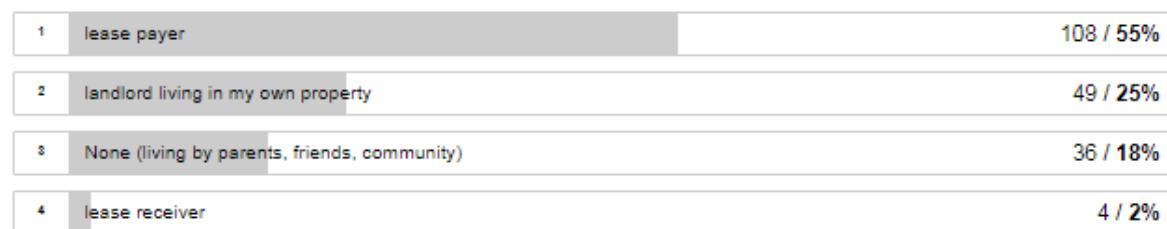
In which sector do you work?

190 out of 200 people answered this question



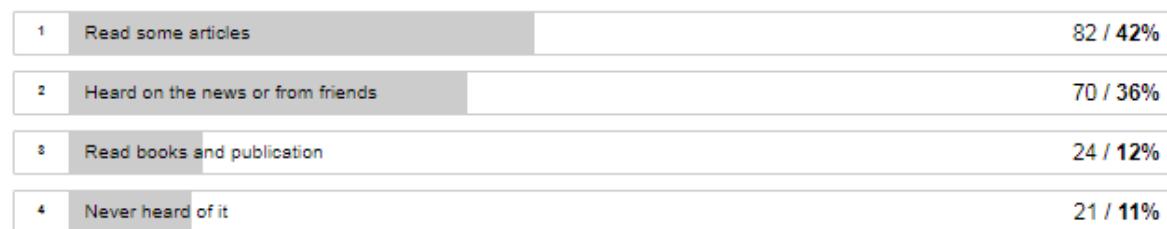
What is your tenancy status?

197 out of 200 people answered this question



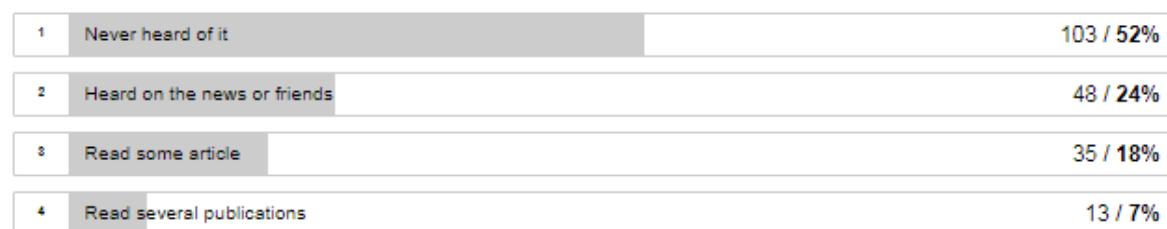
How do you categories your source of knowledge about the blockchain or bitcoin?

197 out of 200 people answered this question



How do you categories your source knowledge about smart contracts?

199 out of 200 people answered this question



What do you think about blockchain/Bitcoin?

197 out of 200 people answered this question



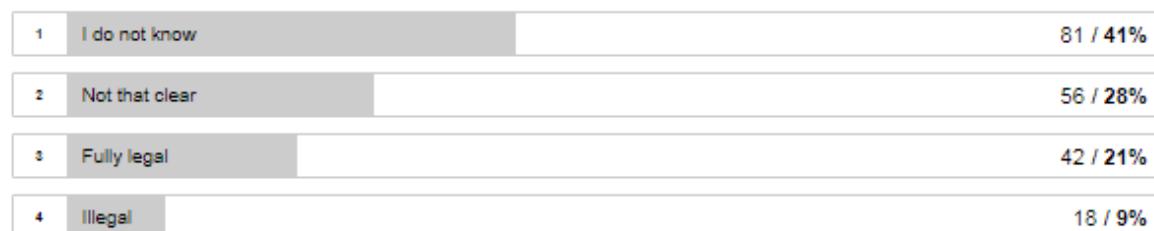
What do you think about blockchain/Bitcoin?

197 out of 200 people answered this question



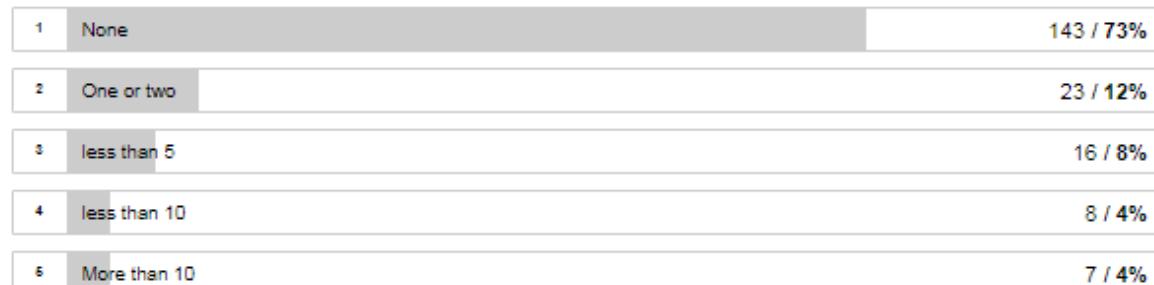
What is the legal status of cryptocurrencies at your region?

197 out of 200 people answered this question



How many cryptocurrencies do you own(BTC/ETH/etc..)?

197 out of 200 people answered this question



Have you paid for anything in a cryptocurrency?

195 out of 200 people answered this question

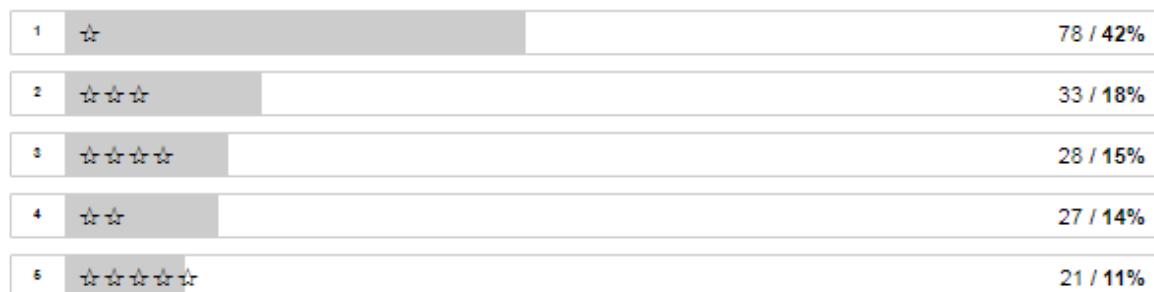


How likely would you pay your daily expenses in cryptocurrency now?

187 out of 200 people answered this question



2.40
Average rating



How likely would you pay your daily expenses in cryptocurrency in the future?

194 out of 200 people answered this question



2.87
Average rating

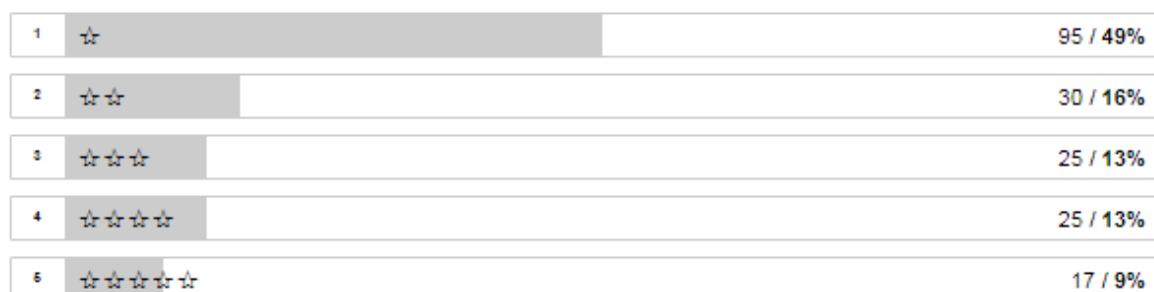


How likely would you pay/receive your salary/invoice in cryptocurrency now?

192 out of 200 people answered this question



2.16
Average rating



How likely would you pay/receive your salary/invoice in cryptocurrency in the future?

194 out of 200 people answered this question



2.53
Average rating

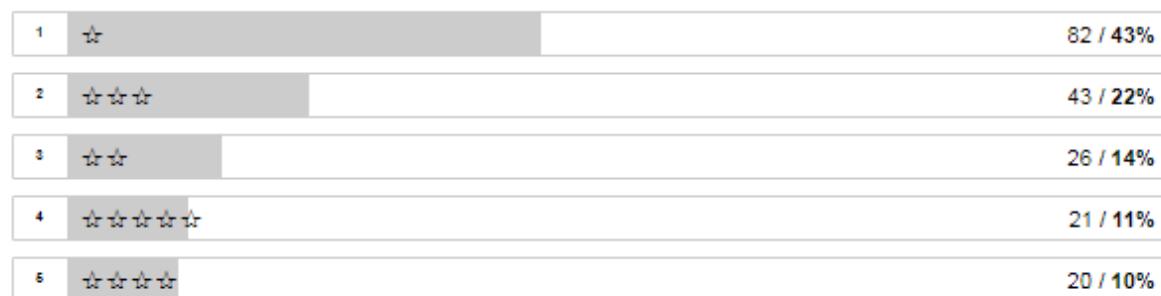


How likely would you manage your salary/invoice on a smart contract now?

192 out of 200 people answered this question



2.33
Average rating



How likely would you manage your salary/invoice on a smart contract in the future?

192 out of 200 people answered this question



2.74
Average rating



How likely would you receive /send your lease using cryptocurrency now?

194 out of 200 people answered this question



2.20
Average rating

1	☆	92 / 47%
2	☆☆☆	39 / 20%
3	☆☆	25 / 13%
4	☆☆☆☆	23 / 12%
5	☆☆☆☆☆	15 / 8%

How likely would you receive /send your lease using cryptocurrency in the future?

195 out of 200 people answered this question



2.53
Average rating

1	☆	68 / 35%
2	☆☆☆	50 / 26%
3	☆☆	28 / 14%
4	☆☆☆☆	26 / 13%
5	☆☆☆☆☆	23 / 12%

How likely would manage your lease contract on a smart contract now?

191 out of 200 people answered this question



2.23
Average rating

1	☆	87 / 46%
2	☆☆☆	39 / 20%
3	☆☆	26 / 14%
4	☆☆☆☆	26 / 14%
5	☆☆☆☆☆	13 / 7%

How likely would manage your lease contract on a smart contract in the future?

192 out of 200 people answered this question



2.64
Average rating

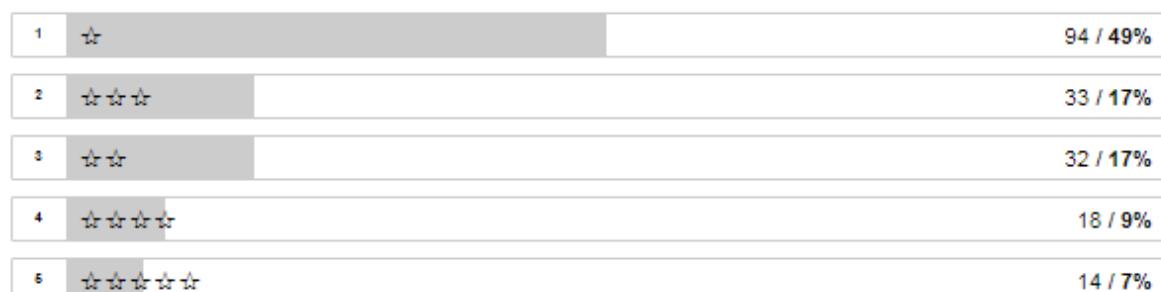


how likely would you sell/buy a real property using cryptocurrency now?

191 out of 200 people answered this question



2.09
Average rating

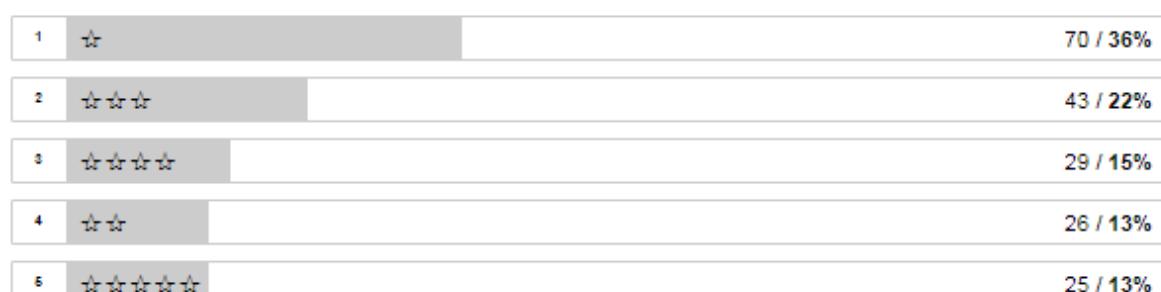


how likely would you sell/buy a real property using cryptocurrency in the future?

193 out of 200 people answered this question



2.55
Average rating



how likely would you sell/buy a real property on a smart contract now?

189 out of 200 people answered this question



2.17
Average rating

1	☆		89 / 47%
2	☆☆☆		40 / 21%
3	☆☆		27 / 14%
4	☆☆☆☆		17 / 9%
5	☆☆☆☆☆		16 / 8%

how likely would you sell/buy a real property on a smart contract in the future?

188 out of 200 people answered this question



2.61
Average rating

1	☆		64 / 34%
2	☆☆☆		50 / 27%
3	☆☆☆☆		31 / 16%
4	☆☆☆☆☆		22 / 12%
5	☆☆		21 / 11%

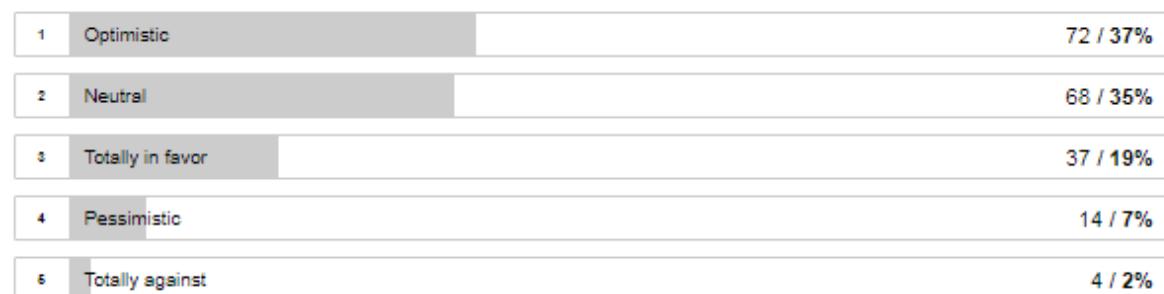
How many devices do you own that are connected to the internet?

196 out of 200 people answered this question

1	Less than five		131 / 67%
2	More than five		48 / 24%
3	One		14 / 7%
4	None		3 / 2%

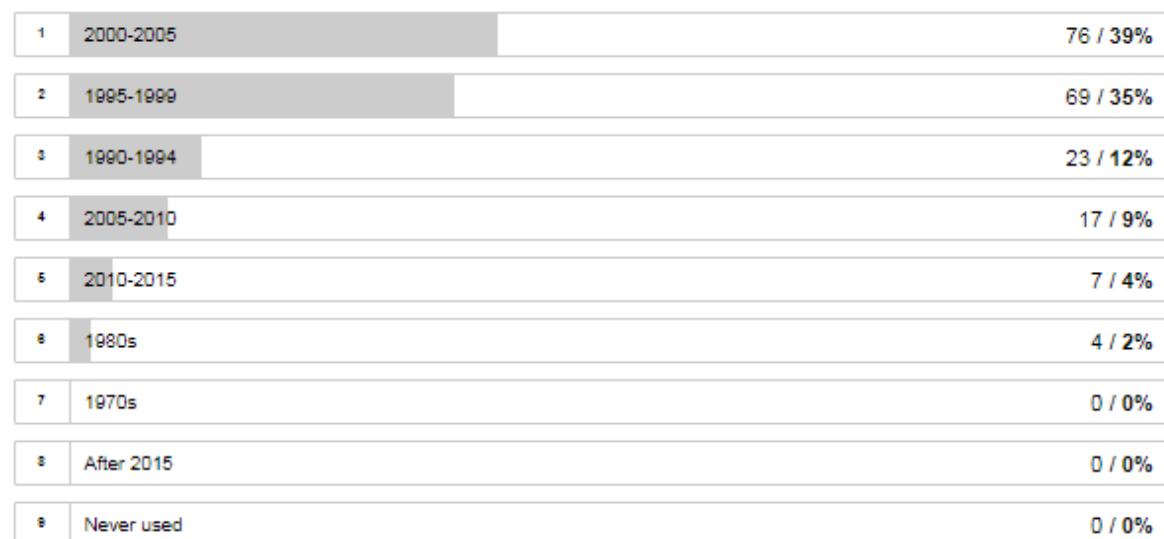
What do you think about internationalization?

195 out of 200 people answered this question



When was the first time you used the internet?

196 out of 200 people answered this question



When was the first time that you used a cashless payment service?

192 out of 200 people answered this question



When was the first time that you used an online payment service?

197 out of 200 people answered this question



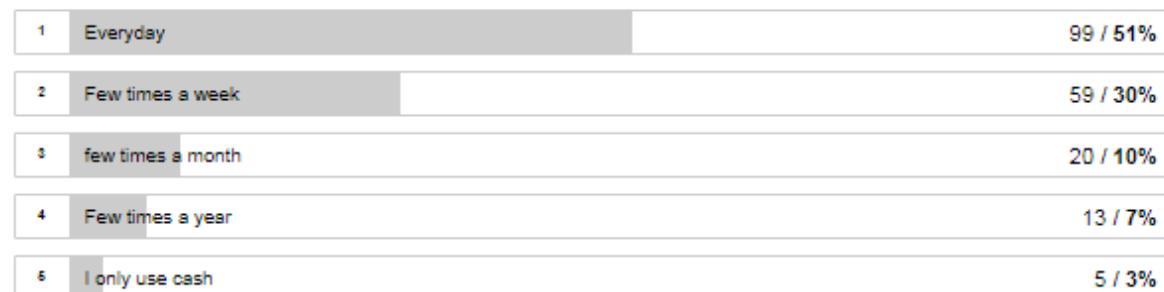
How often do you use the internet?

195 out of 200 people answered this question



How often do you use cashless payments?

196 out of 200 people answered this question



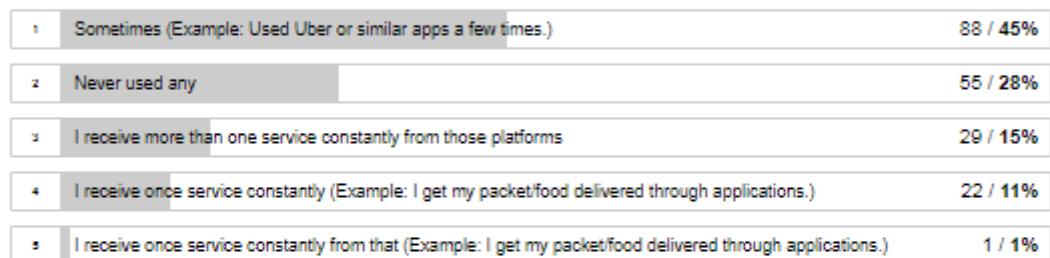
How often do you use online payments?

198 out of 200 people answered this question



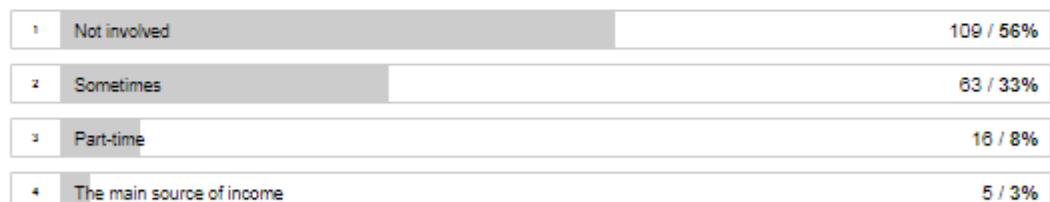
How involved are you with the gig economy as a costumer?

198 out of 200 people answered this question



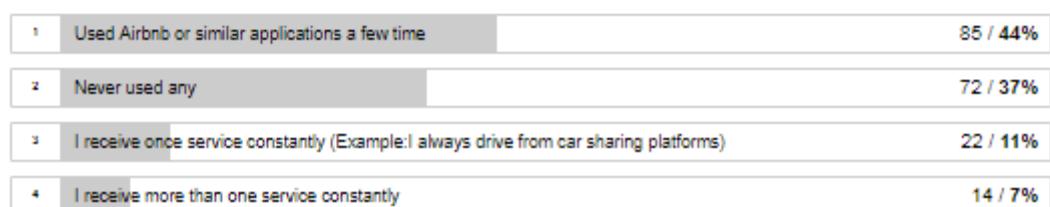
How involved are you with the gig economy a service provider?

198 out of 200 people answered this question



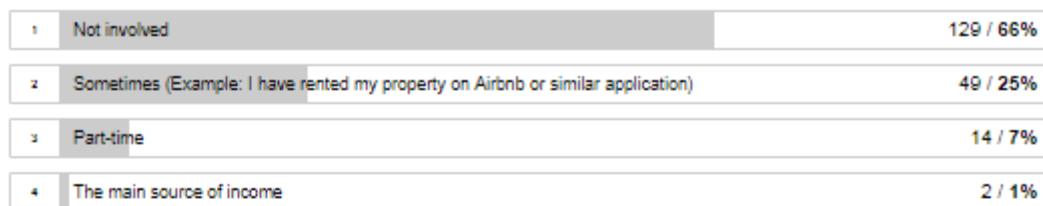
How involved are you with the share economy as a customer?

198 out of 200 people answered this question



How involved are you with the share economy as a service provider?

184 out of 200 people answered this question



As part of your job do you deliver any format of data as your output for the team/company?

188 out of 200 people answered this question



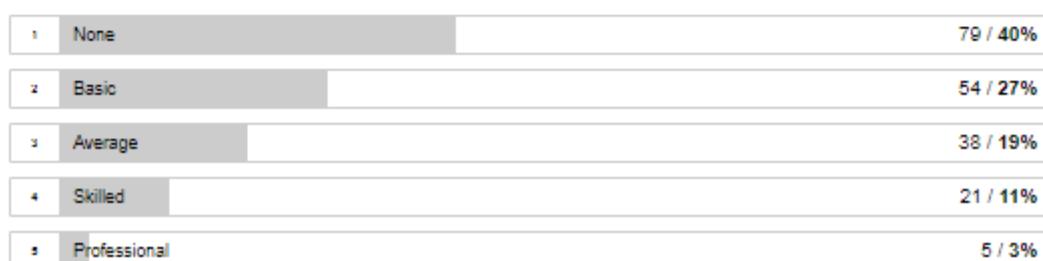
Are you a user of any software?

188 out of 200 people answered this question



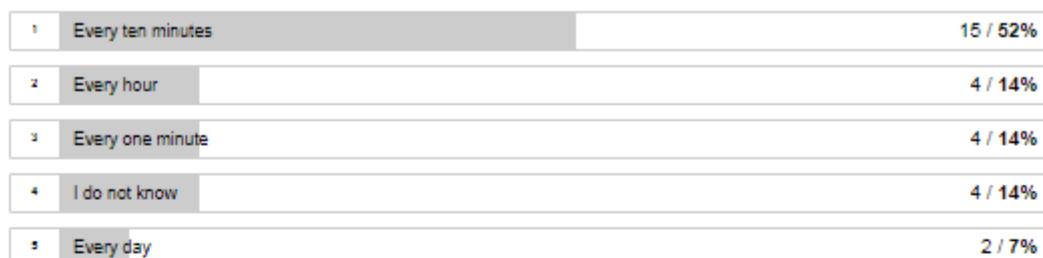
How do you rate your skill in coding?

187 out of 200 people answered this question



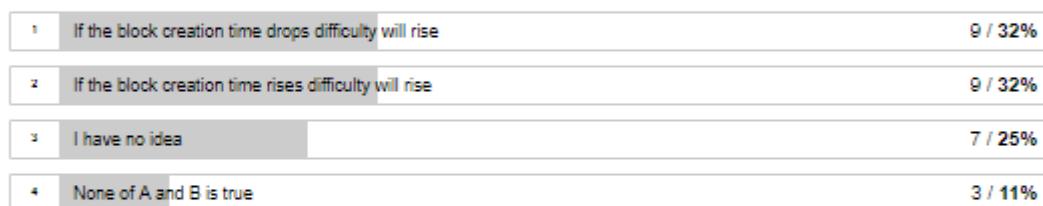
How often a new block is created?

28 out of 200 people answered this question



Which statement do you think is true about Bitcoin's network

28 out of 200 people answered this question



How do you rate this survey?

184 out of 200 people answered this question



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