



State of the art of Blockchain for Real Estate and Land Registration

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Abstract

Research has shown that Blockchain has been studied to be introduced to support transformation over the real estate realm and the land registry process. This research aims to analyze the potential of this technology on these applications. It was conducted using the Systematic Literature Review (SLR) methodology, which is a means to identify, evaluate and interpret the available research; and the case study protocol by conducting a multiple case research and combining it with a psychological framework named Theory of Planned Behavior (TPB). By performing a multiple case study, four case analyzes were built, and each one contains contributions from the interviewees contacted and previous literature, with the intention to give an overview of Blockchain for real estate in each case.

As for results, we present the advantages and disadvantages of the use of Blockchain in the land registry process and the countries which already have implemented Blockchain in the mentioned system; and analysis of Blockchain for real estate cases about four different countries that are in four different continents and context about how this technology is already ingrained in them. For each one of the results, there is a discussion in which topics are expanded.

These artifacts can help when evaluating the need to adopt the technology and they show that in previous literature, Blockchain isn't agreed upon by researchers, governments, and other parties. This is emphasized by the heterogeneity of the countries which already have implemented the tech and the prospect of its growing use.

Keywords

Blockchain, Real Estate, Case Study, Literature review

Resumo

A investigação demonstrou que o Blockchain tem sido estudado com o objetivo de apoiar a transformação do ramo imobiliário e do sistema de registo predial em particular. Esta investigação visa analisar o potencial desta tecnologia sobre esta aplicação e foi conduzida utilizando a metodologia revisão sistemática da literatura, que é um meio de identificar, avaliar e interpretar a investigação feita até ao momento; e o caso de estudo, feito assim uma investigação de casos de estudo múltiplos, combinando com uma framework ligada à psicologia chamada teoria do comportamento planeado. Com a ajuda destes dois, foram produzidas quatro análises de casos, contendo cada uma citações dos entrevistados e literatura anterior, com o objectivo de dar uma visão geral do problema em questão.

Quanto aos resultados, apresentamos as vantagens e desvantagens da utilização de Blockchain no registo predial e os países que já implementaram Blockchain no referido sistema; e expomos análise de casos para quatro países em quatro continentes diferentes, e contexto sobre como esta tecnologia já está enraizada neles. Para ambos, há uma discussão em que os tópicos são desenvolvidos.

Estes artefactos podem ajudar na avaliação da necessidade de adoptar a tecnologia e mostram que na literatura a Blockchain não está em sintonia entre investigadores, governos, entre outras entidades. Isto é enfatizado pela heterogeneidade dos países que já implementaram a tecnologia e a perspectiva da sua crescente utilização.

Palavras Chave

Blockchain, Ramo Imobiliário, Caso de Estudo, Revisão da literatura

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Acronyms

DLT	Distributed Ledger Technologies
EU	European Union
SLR	Systematic Literature Review
TPB	Theory of Planned Behavior
ILT	Living Environment and Transportation Inspectorate
NAPR	National Agency of the Public Registry
SaaS	Software as a Service
MLS	Multiple Listing System
P2P	Peer-to-Peer
TRA	Theory of Reasoned Action

1

Introduction

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1.1 Research Structure and Objectives	3
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1.1 Research Structure and Objectives

The first objective of this master's thesis was to include a proposal of a software tool for supporting a real estate (housing) business transaction using Blockchain, and the supposed tool would be evaluated with simulations in a lab and interviews with experts.

However, the path chosen was a Systematic Literature Review (SLR) followed by a multiple case study. This was thought to provide an abstract and a qualitative overview of how Blockchain was, is, or will be thought to integrate the real estate domain in a general sense, but we came across mostly about one area of it which was the land registry. Hence, the objective for the first research was to seize all advantages and challenges, from the previous literature, of this technology in the land registry system, and also examples of pilot projects. With this in mind and interviews with researchers, the objective of the latter research was to know which challenges, benefits, and how this technology was perceived by governments, banks, and other parties in four different continents of the world. Then, using contributions from the interviewees contacted, TPB was made use of so that in the form of quotes, three kinds of beliefs could be extracted, and compared with previous literature.

Before the instantiation of the research methodologies, real estate, the Blockchain technology, the SLR and the case study concepts are described. Afterwards, the first research, which is presented in the Systematic Literature Review section, intends to: explain how it was carried out by describing how the SLR was done and its steps - Planning, Conducting, and Reporting; and the latter step presents the results which consists of various tables showing the advantages and disadvantages of Blockchain when addressed to the real estate realm, particularly land registry, and also shows that there are no successful examples of countries that already have or are developing pilot projects. In the end, a discussion section builds up the results.

The second research presents how the case study protocol was guided, the analysis framework adopted to examine the responses of the four interviews done, each case analysis, and finally, a discussion section to introduce a social perspective that may influence the general adoption and impact of the application of the technology for the real estate realm. The study terminates with the the main contributions of the research, research limitations, and future work, along with the bibliography.

The main objectives of this study are: to enrich the reader's knowledge about how Blockchain can influence the land registry system; provide several points-of-view from researchers about how Blockchain is being adopted in a specific country, its main challenges, benefits, advantages, and how it is perceived by most parties involved in the process; and finally, supply data for speculation about the reasons for governments to adopt the technology.

1.2 Real Estate

Real estate can be described as property consisting of land and the buildings on it, along with its natural resources such as crops, minerals, or water; immovable property of this nature; an interest vested in this (also) an item of real property, (more generally) buildings or housing in general. Currently, real estate has become the largest asset class of the global stock market next to equities and bonds, however, real estate assets are distinctly different compared to equities and bonds by having high transaction costs, long-term commitment, regulations, and other barriers to entry [4].

Real estate conveyance is a heterogeneous phenomenon in which several intermediaries and public services might be involved, depending on the type of transaction, on the step being taken as well as on the country [5]. The real estate market involves multiple untrusted actors with contrasting objectives and it is a complex subject with many facets [6], and although highly regulated, is known for its resistance to change [7], being an example in 2015 the European Parliament was worried that the European Union (EU) member state citizens' difficulties in acquiring real estate (homes in particular) in another member state, which is against the creation of a true cross-border land-acquisition internal market [8].

"Several aspects of its operations such as property sale prices, sale history, lease rental rates, market valuation, and so on expect greater demand for transparency, data integrity, and security—a trusted environment." [1]

Besides this, the existing problems in the current real estate sector identified are:

- Lack of transparency in peer-to-peer economy.
- A direct relationship between the asset holders (host) and investors (tenant) is missing;
- High middleman or brokerage fees;
- Fake reviews and description of the property and quality of the amenities—leading to asymmetric property information;
- A mutable internal centralized database of online property listing;
- Overhead cost and time in identifying, preparing, and maintaining property listing;
- Huge processing time—gathering and validating relevant document from legal sources takes over a month;
- Floating transaction costs, property rights opaqueness, variability in taxes, and a host of other issues [1].

To solve most of these problems, it is argued that Blockchain technology has the potential to transform the current real estate conveyancing and land registration processes [8].

1.3 Blockchain

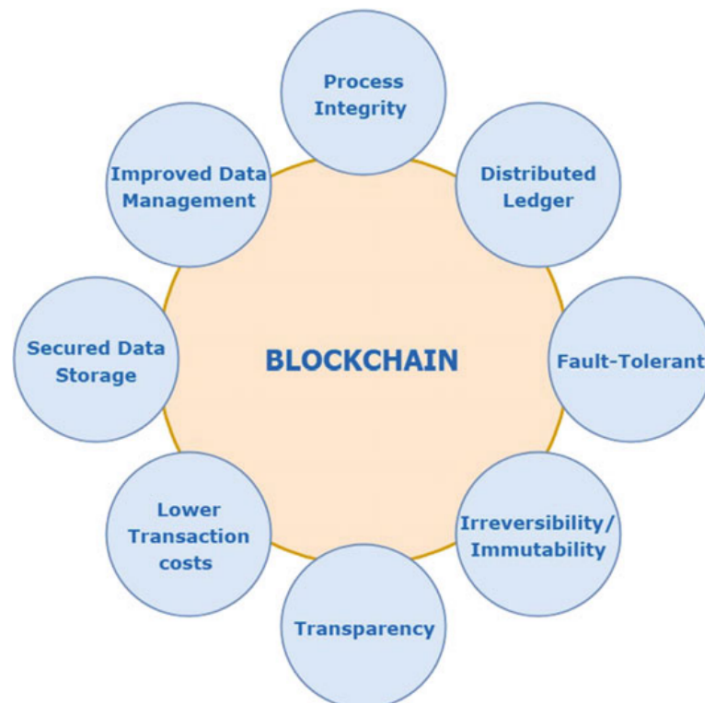


Figure 1.1: Krupa et al, (2019). *Benefits of blockchain technology* [1]

Blockchain and other Distributed Ledger Technologies (DLT) have been catching the attention of the real estate industry and governments [9]. The blockchain was first acquainted as an instrument with forestall twofold spending in the shared electronic money framework known as Bitcoin [10]. Satoshi Nakamoto, the inventor of Blockchain, proposes with the introduction of Blockchain, a solution to the double-spending problem using a peer-to-peer network: “The network timestamps transactions by hashing them into an ongoing chain of hash-based proof-of-work, forming a record that cannot be changed without redoing the proof-of-work” [11]. Blockchain is one of the breakthrough technologies for the transition to the fourth industrial revolution, and if the first two industrial revolutions radically changed the sphere of production, the third one prepared the basis for changing the ways of communication between people [12].

Blockchain, although thought to bypass the traditional intermediaries in currency issuance, academics, governments, and stakeholders envisaged the potential opportunities that this technology offers for their own activities and even the financial sector, which was the one most directly affected by the creation of the bitcoin currency and therefore the blockchain systems, considered this technology as an opportunity for improving their processes as well as lowering their expenses [5]. The ability of blockchain to secure the data and history of transactions lead it to be called “The Trust Machine” by

the Economist [13]. World Economic Forum conducted an expert survey in 2015 and reported that the majority (57%) of respondents estimated that by the year 2025 the 10% of the world GDP would be registered in a blockchain [14].

The Blockchain technology can be described as:

"A blockchain contains a secure history of data exchanges, utilizes peer to peer timestamp and verifies the exchanges, and can be managed without the interference of a third party. The verification happens with the help of other peers in the network (through a consensus) and every transaction is saved in the block. Every user connected to the blockchain is entangled by two kinds of keys, private keys and public keys linked to a wallet using which a user can perform transactions. A user can access his wallet using private keys and the public key (wallet address) is the one which is available for other peers in the network to perform transactions. Private keys gives an user the power to digitally sign and validate every action initiated with his public key. Since the wallet address is a key that comes out of an encryption algorithm, it is a string of random characters for an unintended user. This makes a wallet owner anonymous to the outside world. The copy of the blockchain is kept in every machine connected to the network and hence there is no concept of centralized access. In addition, because of these multiple copies it is unable for anyone to tamper the contents of a chain. Anonymity and decentralization are the major backbones of blockchain technology." [15]

Additionally, one might find different types of blockchain, i.e., private and public ones. The public ones (e.g., Bitcoin) allow any person to connect to the network, to check the information included in the blockchain, and to validate transactions, whereas a private one allows only certain people to use it, and a person or an authority manages it, meaning that these latter are not decentralized but only distributed [5].

Summary

In this section, the structure and the objectives of the research are presented. Then, a context about the current scene of the real estate realm, and the existing known problems of the sector are introduced. And finally, there is a comprehensive definition and context of the Blockchain technology.

In the next section, the adopted research methodologies are explained.

2

Research Methodologies

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2.1 Systematic Literature Review

"A systematic literature review, or a systematic review, is a means of identifying, evaluating, and interpreting all available research relevant to a particular research question, or topic area, or phenomenon of interest [16]."

The guidelines for the process of making a systematic review are different according to each source. To do the SLR, we have adopted the main stages explained in a systematic review which consist in:

1. Planning the Review

- Identification of the need for a review
- Specifying the research question(s)
- Developing a review protocol
- Evaluating the review protocol

2. Conducting the Review

- Identification of research
- Selection of primary studies
- Data extraction
- Data synthesis

3. Reporting the Review

- Specifying dissemination mechanisms
- Formatting the main report
- Evaluating the report

There are many reasons for undertaking a systematic literature review, however, [16] say the most common is to summarize the existing evidence concerning a treatment or technology; to identify any gaps in current research to suggest areas for further investigation; to provide a framework/background in order to appropriately position new research activities.

According to them, the advantages of doing a systematic literature review are the well-defined methodology that makes it less likely that the results of the literature are biased, the provision of information about the effects of some phenomenon across a wide range of settings and empirical methods and in the case of quantitative studies, it is possible to combine data using metanalytic techniques. The major disadvantage is that they require considerably more effort than traditional literature reviews.

2.2 Case Study

Before doing case study research, one should clarify what are the intentions for the research because the more questions asked to seek to explain some contemporary circumstance (e.g., “how” or “why” some social phenomenon works), and the more these require an extensive and “in-depth” description of some social phenomenon, the more that case study research will be relevant [17]. Since this type of research is very complex and has a lot to be told about, here it’s only briefly described its main steps. This section and how the multiple-case studies were conducted are based on [17], which offers a comprehensive coverage of the design and use of the case study method as well as discussion of design and analysis techniques.

2.2.1 Design a Case Study

In a case study research, five components of a research design are especially important: the case study’s questions; its propositions, if any; its case(s); the logic linking the data to the propositions; and finally, the criteria for interpreting the findings [17].

The multiple-case study design should follow a replication logic. This logic can be divided into: *literal* replication - individual case studies predict similar results - or *theoretical* replication - individual case studies predict contrasting results but for anticipated reasons. The individual cases within a multiple-case study design may be either holistic or embedded. When an embedded design is used, each individual case study may in fact include the collection and analysis of quantitative data, including the use of surveys within each case study [17].

2.2.2 Before Collecting Case Study Data

An example of an important step to take before collecting case study data is the case study protocol. The case study protocol is a group of comprehensive guidelines which contain procedures for conducting and reporting the research. As a general example, a case study protocol should have four sections:

- Section A: an overview of the case study (objectives and auspices, case study issues, and relevant readings about the topic being investigated);
- Section B: data collection procedures (procedures for protecting human subjects, identification of likely sources of data, presentation of credentials to field contacts, and other logistical reminders);
- Section C: protocol questions (the specific questions that the case study researcher must keep in mind in collecting data and the potential sources of evidence for addressing each question);

- Section D: a tentative outline for the case study report (e.g., format for the data, use and presentation of other documentation, and bibliographic information) [17].

Another essential step of this phase is the selection of the case(s). To perform this step, there are two approaches: one-phased and two-phased. The one-phased approach should consist of querying people knowledgeable about each candidate and the two-phased approach should consist of collecting relevant quantitative data about the entire pool of candidates to reduce the number, and then conduct the one-phased approach previously described [17].

2.2.3 Collecting Case Study Evidence

One can gather case study evidence from at least six sources: documents, archival records, interviews, direct observations, participant observation, and physical artifacts. These various sources can complement and the more the sources used, the stronger and reliable the case study [17].

The benefits from these six sources of evidence can be maximized if four principles of data collection are followed: use multiple sources of evidence; create a case study database; maintain a chain of evidence; and finally, exercise care when using data from social media sources.

2.2.4 Analyzing Case Study Evidence

One can analyze case study evidence by pursuing any combination of procedures, such as by examining, categorizing, tabulating, testing and then adapt any of these general strategies in practicing five specific techniques for analyzing case studies: pattern matching, explanation building, time-series analysis, logic models, and cross-case synthesis [17].

Throughout the analysis, the challenge is to attend to all the evidence collected, investigate plausible rival interpretations, address the most significant aspects of your case study, and demonstrate a familiarity with the prevailing thinking and literature about the case study topic [17].

2.2.5 Reporting a Case Study

Sharing the conclusions from a case study, whether in writing or orally, means bringing its results and findings to closure.

One should give some initial thought regarding the potential audience for the case study research presentation as well as consider the six compositional structures of the presentation; linear-analytic, comparative, chronological, theory-building, “suspense”, and unsequenced structures. The final steps in doing the case study include how and when to start composing, choices regarding the disclosure or anonymity of the case identities in your case study, and reviews of your draft case study as a validating procedure [17].

Summary

In this section, the adopted research methodologies were presented. The first methodology used was the SLR and its instantiation and results are presented in the next section. It consists of its three phases and it finishes with the discussion of the results.

3

Systematic Literature Review

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In the third section, the instantiation of the first research methodology and its results are presented. As seen previously, the SLR is divided into Planning the review (section 3.1), Conducting the review (section 3.2), and Reporting the review (section 3.3). In the end, the Discussion of the results is presented as well (section 3.4).

3.1 Planning the Review

Prior to undertaking a systematic review, it is necessary to confirm the need for such a review [16]. Besides, there are pre-review activities needed to do such as defining the research question(s) that the review will address and producing a review. Our planning consists in giving a background of the review (explained in the Background review section) and the research goal and questions (explained in the Research goal and questions section).

3.1.1 Background of the Review

The need for this systematic review arises from the fact that while there are diversified studies about blockchain in real estate, there isn't one that comprehends all (or at least all the surveyed) advantages and disadvantages of the use of the technology in the sector and the examples of the use.

The researched literature on the use of blockchain in real estate constitutes case studies, frameworks, surveys, and theory about the challenges/constraints and opportunities/benefits.

3.1.2 Research Goal and Questions

Although there are some systematic reviews on blockchain applied to real estate, to our knowledge, it doesn't exist one which comprises so many advantages and disadvantages and specifies in which countries blockchain is already implemented. For this reason, we developed three guiding research questions:

RQ1. What are the advantages associated with the implementation of blockchain in the process of the land registry?

RQ2. What are the disadvantages associated with the implementation of blockchain in the process of the land registry?

RQ3. What examples of blockchain already exist for the land registry?

3.2 Conducting the Review

The protocol for the review was agreed upon by the author and his supervisors prior to commencement. It followed all aspects recommended in the reporting of systematic reviews, namely the Guidelines for performing Systematic Literature Reviews in Software Engineering [16]. All studies that explored the association between real estate and the Blockchain technology were considered for this review. This section integrates the subsections Data Collection – in which we present the data sources -, the Search Terms – where is presented the search string and the fields in which we applied it -, and finally the Exclusion Criteria – includes the number, reasons, and stages regarding the studies found that were excluded.

3.2.1 Data Collection

The electronic databases in this review were searched on November 12th, 2020 and included those identified with the search terms described in the next section. The search terms were used on these 7 digital libraries:

- Google Scholar (IOPScience, emerald) (n = 35);
- ACM (n = 5);
- Springer (n = 151);
- IEEE (n = 11);
- Scopus (n = 80);
- AIS (n = 1);
- EBSCO (n = 58).

3.2.2 Search Terms

We used full and truncated search terms capturing blockchain and real estate with the following search string: blockchain AND "real estate". The search string was applied in the title of the papers (Springer, IEEE, and Google Scholar), in the abstract (ACM), in the abstract and title (AIS and EBSCO), and in the abstract, title, and keyword (Scopus).

3.2.3 Exclusion Criteria

Our exclusion criteria mirror the focus on the studies that report direct evidence regarding the advantages and disadvantages of the use of blockchain for real estate or examples of pilot projects in various countries.

We excluded papers with the following features:

- Studies that we only had access to the abstract;
- Duplicates;
- Studies that cover real estate but not blockchain and vice-versa (out of scope);
- Studies written in another language than English;
- Studies that were Master Thesis;

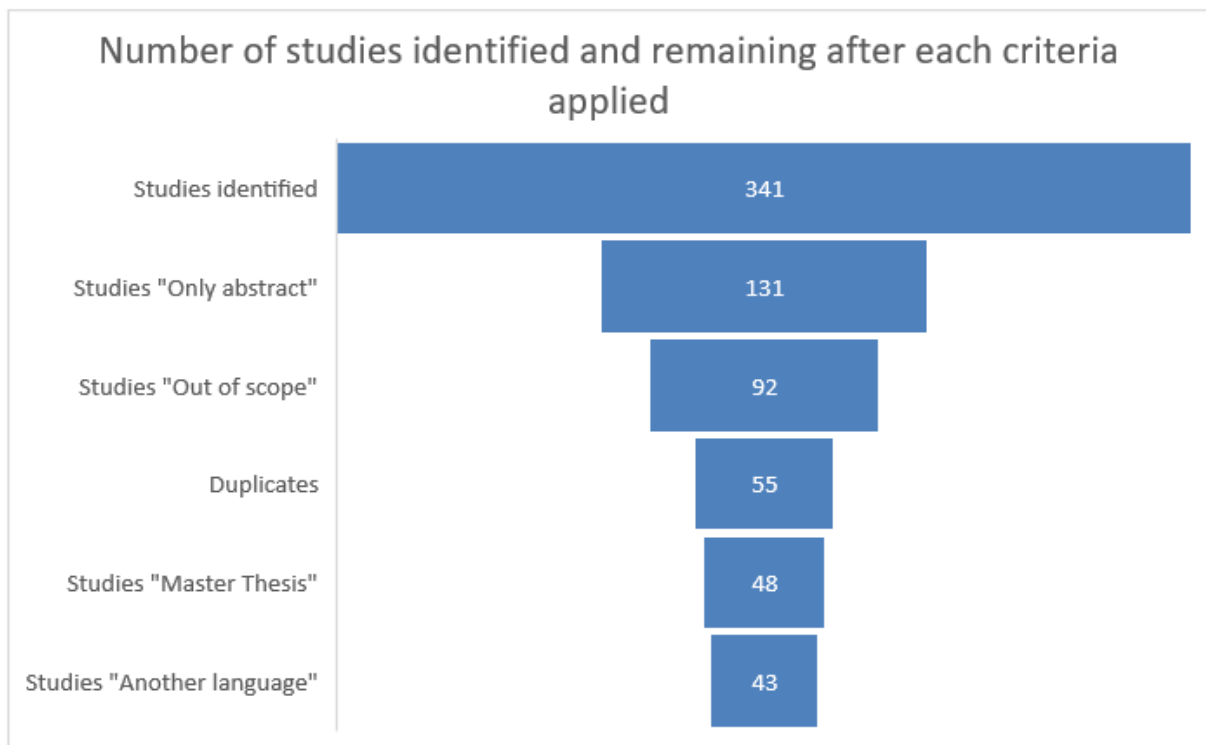


Figure 3.1: Funnel chart representing the number of papers identified, and the remaining after exclusions from each criterion.

The fig. 3.1 is a funnel chart representing the process of excluding papers by the criteria mentioned. Below the first section that represents the total number of papers gathered from the digital libraries, there is a section for each criterion and the number of papers that remain eligible for our review. As shown by the funnel chart, the number of eligible papers for our work is 43. The link for an Excel with all the eligible papers for the review: <https://bit.ly/3dwugQF>.

Table 3.1: Advantages for Blockchain in Land Registry

Advantage	Description
P2P	P2P transactions are possible without needed a trusted third party such a as bank, notary, broker or cadastre [18].
Transparency	All participants may freely access data and/or make transactions. Information is publicly available to all parties at the same time with a single version of data [7].
Efficiency/ Speed up the process	The system is easily established, connected and expanded [19]. Structured and standardized data can form the input for internal workflows and analyses. [4]
Decentralization	“Decentralization in blockchain is very useful because there is no single point of failure which makes it resistant to attacks.” [20]
Tokenization	“Tokenization of real estate represents the release of tokens, indicating the right to a part of the property.” [12].
Immutability of records	“Blockchain data is (theoretically) immutable and thus not subject to arbitrary manipulation.” [7]
Smart Contracts	“Revolutionize real estate transactions by enabling lower costs, and better accessibility and speed.” [7]

3.3 Reporting the Review

In this section, there are presented the advantages and challenges gathered from the studies considered. Besides, we also collect information about most of the countries which already have, are developing, or ceased to develop pilot projects on Blockchain in the land registry. The results are shown in the next sections.

3.3.1 Advantages of Blockchain in Land Registry

This section consists of a table - Table 3.1 - that comprises the advantages of Blockchain in land registry. The advantages are defined as features or opportunities of the Blockchain technology that contribute or add benefit to land registry. These were mainly chosen based on how many studies cited them and are predominantly characteristics of the technology that may be used in a beneficial way for its potential applications.

3.3.2 Challenges of Blockchain in Land Registry

This section consists of three tables that merge the challenges of Blockchain in the land registry, each one representing a category: security of Blockchain (Table 3.2), properties of Blockchain (Table 3.3), and associated with the society (Table 3.4). These are chosen due to three main challenges reported in the literature respectively: the aspect of the security of the technology - Blockchain' weaknesses from a

Table 3.2: Challenges of Blockchain – Associated with Society

Challenge	Description
Legality	“A legal framework for blockchain transactions is needed which enables international adoption.” [7]
Human involvement	Dealing with systems instead of people means less flexibility and potential for job losses.” [7]
Initial information capture	Getting correct and agreed upon initial information transferred onto the blockchain is a bottleneck [7].
Human adoption	It should benefit their target users to bring incentives for adoption and the long-term financial benefits must be clearly understood [21]. “Trust and support from all stakeholders are required to develop and for the adoption of the system.” [7]
The need to check the real ID of the parties	Blockchain by itself does not check the ID of the parties (public blockchains are anonymous) [5].

Table 3.3: Challenges of Blockchain – Properties of Blockchain

Challenge	Description
Immutability	To be achieved, private keys must be used - when hacked or lost, there is no general solution to restore it [19].
Anonymity	Addresses could be deanonymized by different digital fingerprints, i.e. IPs, behaviour patterns. Anonymity may veil money laundering, financing terrorism, or other unlawful activity [9].
Standardization of data	Current real estate data are not created or held in a standard format and everyone interviewed spoke about the challenge faced by data standardization [4].
Scalability of the network	“It’s difficult to execute real-time, large volume handling.” [19]; “Overload with the transactions creates the problem of high transaction fees and price volatility.” [9]

security point-of-view, problems regarding Blockchain’ properties - poor consequences that can happen due to the technology’s currently used features, and society-associated constraints - problems that can arise due to the human nature. The challenges are defined as features or consequences of Blockchain that don’t contribute to the land registry or add barriers to the adoption.

3.3.3 Examples of Pilot Projects

Since 2016, the projects on the transfer of the registers to the blockchain system have been carried out in a number of countries [12]. It’s intended to present the countries which have or had already implementations of Blockchain in Real Estate. [23] says Estonia and Dubai are also running pilots but doing so in silence [18]. Georgia, Sweden, and Ghana are some examples of countries shown here.

Sweden

In 2016 the Swedish land registration authority, Lantmäteriet, together with a group of partners (including a blockchain startup ChromaWay, a consulting company Kairos Future and a telecom com-

Table 3.4: Challenges of Blockchain - Security of Blockchain

Challenge	Description
Privacy leakage	The blockchain is designed to be publicly visible and if someone stores data that is supposed to be confidential and everyone can see the data, no privacy will be achieved [20].
Fraud in Programming	The frauds inside code can be exploited by attackers to take out properties of Blockchain [22].
Private key leakage	Attackers can take control of an account by stealing its private key and this can be readily done by attacks on the network or by capturing the nodes which are physical [22].
Eclipse attacks	In these attacks, adversaries stop the legitimate nodes from making a connection to honest peers [22].
Distributed Denial of Service (DDoS)	With the help of collaborative attacks, the Blockchain resources are exhausted by the adversaries [22].
Smart contracts vulnerability	Due to the irreversibility and openness of Blockchain, smart contracts are very susceptible [22].
Attacks targeting consensus protocols	Attackers who are having with them more than half of the power of hashing can easily control blockchain and make it accept blocks that are illegitimate, by just solving problem of consensus faster and quicker than the rest of all peers [22].

pany Telia) launched a pilot project to evaluate potential blockchain applications for real estate transactions [24]. This technology's pilot trial in the land registry is predicted to save about €100 million [8]. The project focuses on the contracting process because currently, and according to its legal system, it consists of two steps: a contract sale and a deed of sale (the former can be registered as a pending sale and the latter as the final sale) [25]. The architecture of the project can be diagrammatically described in the fig. 3.2.

Netherlands

At the national level in the Netherlands, there are several Blockchain pilots with real estate: (1) open data from the cadastre; (2) government-wide pilot on the possibilities for processes; and (3) a pilot by the Living Environment and Transportation Inspectorate (ILT) [23]. Blandlord crowd ownership has been introduced and is utilizing Blockchain, where the ownership of the real estate is then divided among many owners and fits into the philosophy of a sharing economy: a group of equals collectively take responsibility for the property without debt or mortgages [23].

Georgia

The Republic of Georgia is the first country that has started registering land titles using blockchain, with the aim to increase the level of trust [24] and before introducing blockchain technology the Georgian land registration system has been reformed for decades so that it has become relatively efficient and corruption-free.

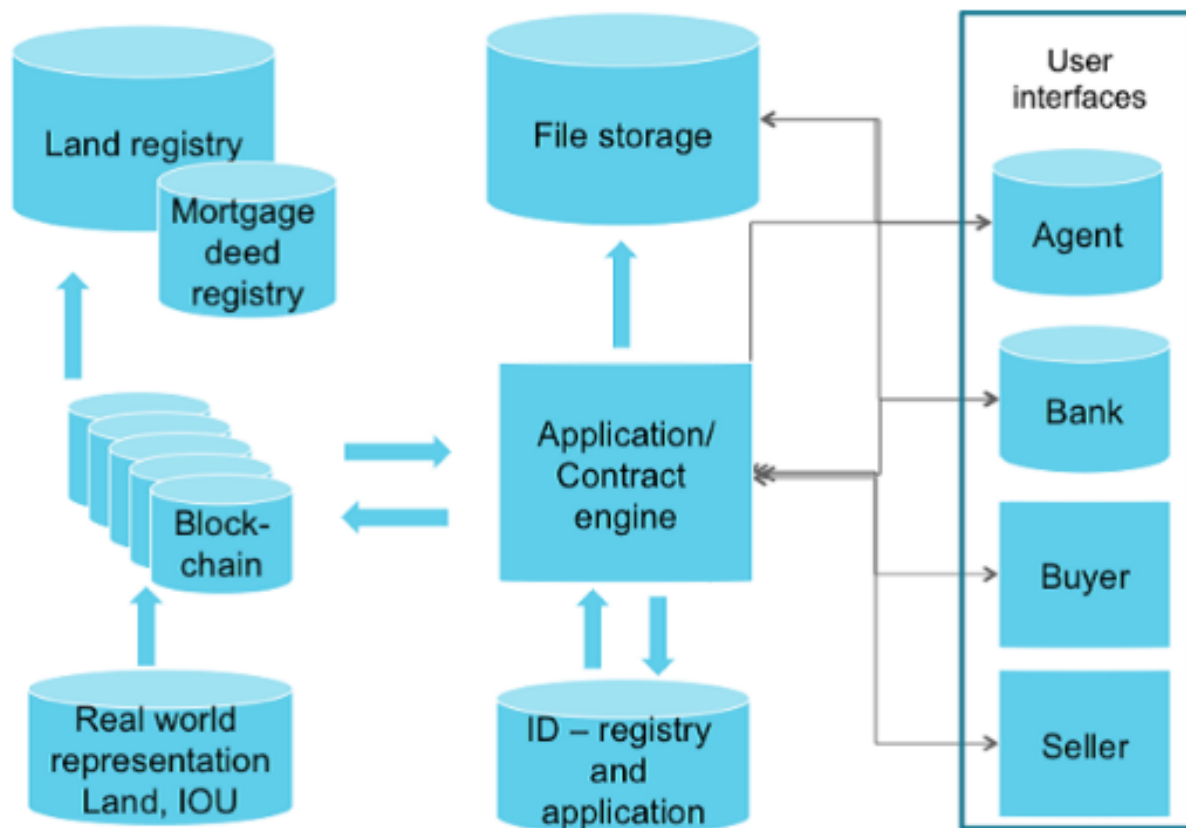


Figure 3.2: Nandi et al, (2020). *The architecture of the Sweden land registry project* [2]

To highlight a use case of a hybrid Blockchain - where land information is first recorded in a private Blockchain that creates hashes, a fixed-length bit string generated from variable-length input, then posted on a public Blockchain for land registry, this paper discusses the development of a Blockchain-based land titling system in the Republic of Georgia, a pilot project developed in collaboration with the Bitfury Group, the National Agency of the Public Registry (NAPR), and the Blockchain Trust Accelerator [26]. They also say that the Bitfury Group and the Republic of Georgia formed a partnership to create a one-year pilot project to move the country's land registry system to a Blockchain platform.

Brazil

A blockchain pilot project was launched in 2017 by the real estate registry office, Cartório de Registro de Imóveis, in cooperation with a blockchain technology company Ubitquity in the State of Rio Grande do Sul, Municipalities of Pelotas and Morro Redondo [24]. According to [24], Brazil lacks a modern integrated land registration system and faces challenges connected with corruption and frauds and it is expected that this initiative will improve accuracy, security, and transparency of the land registration process as well as lower costs. [24] concludes by saying the purpose of the project is to introduce a parallel blockchain platform to replicate the existing legal structure of property recording and transfer

processes, with the use of the Software as a Service (SaaS) business model to record land transactions on behalf of companies and government agencies.

Honduras

One of the earliest pieces of news in the field of the use of blockchain for land registry proliferated in media in 2015 from Honduras with the help of Epigraph and Factom Inc. However, there is no evidence found that the government has ever supported this initiative [27]. [8] agrees with this by saying the project was announced in 2015 and abandoned by the end of that year for non-technological reasons .

Ghana

Bitland has been in Ghana since 2014 on a project to “register land and real property ownership and use rights” using blockchain [9]. [9] also says the available updates on the website do not specify the stage of development of the blockchain infrastructure and achievement of objectives, however, during its ICO in 2017, stated that their far-reaching plans were to disrupt the industry by eliminating third parties with a global real estate supermarket on blockchain, driven by smart contracts. They use OpenLedger to create a distributed public blockchain, which more companies are expected to connect to overtime [25]. Their system at this stage has no connection to any land registry, and their demo is closed for public use; only private access is available upon requests [9].

USA

REX, founded in the USA in 2016, promised a new Multiple Listing System (MLS) standard for real estate brokers [9]. It's stated also that they introduced IMBREX – an online ad listing protocol for brokers and landlords and this example shows blockchain may be useful for intermediaries and may not trigger the public sector. There isn't information on the mass adoption of this protocol, and so it's too early to say if the protocol found its wide applicability. Velox.re demonstrated in Cook County, IL (USA) how hashing on a blockchain can be applied for land registry but ceased its activities in this direction. No intentions to continue were found, and neither the land registry office nor Velox.re added reasons for that [9].

Ukraine

In June 2017, Bitfury and the State Agency for the Electronic Government of Ukraine signed a memorandum on the transfer of the state land cadaster of Ukraine to the blockchain. The project will be developed on the Exonum platform [12].

Japan

Blockchain technology is also beginning to be applied at the government level in Asia. The government of Japan is developing projects on the uses of blockchain technology for property registration, management, and unification of all procedures related to property [25]. [25] say the intention is to unify all data on empty or unowned properties, land and unproductive spaces, unknown owners, and unidentified tenants or users before agencies. To conclude, although there's no more information about the trials carried out in Japanese cities since the summer of 2018, it's expected to cover all of Japan in 2022.

3.4 Discussion of the Results

For most part of the literature, Blockchain is considered a relevant and suitable technology for the land registry system; however, it also brings constraints. Our review highlights the significant contribution research has made towards the understanding of the theoretical and practical uses of Blockchain in land registry. In this section, we outline how this tech can improve, or not, the general land registry system.

We highlight tokens and smart contracts - which are abstract ideas in Blockchain that can be materialized in the existing services [27], consensus – which is the mechanism that provides the agreement of decisions of the peers, and decentralization – the move of control from a single source to several smaller ones; four features of Blockchain that are fundamental to the discussion about the possible adoption of the technology.

3.4.1 Advantages of the Use of Blockchain in Land Registry

Blockchain can assure the existence, integrity, the non-centralized record, the authorship, the tracking back, and the date of any document or fact with legal relevance, which adds value to real estate transaction in all jurisdictions [8].

Tokens and Tokenization

A token is a record of a number that is kept by a specific address and can be divided and transferred to another address [28]. Thus, a token is part of the ledger and can be distinguished as a unique unit of account, which makes it the technology around which users may establish legal relations by connecting it to some property rights [9]. Tokens are a digital representation of the economic value and ownership of property [28] and these, as a technological concept, are the closest solution to the legal concept of titles [4]. Users create, update, delete tokens and transfer them within the blockchain via a mechanism of public-key cryptography.

[27] infers that the blockchain technology has a dichotomous nature that corresponds with both title and deed centric ways of registration, where a token is the evidence of a property right, which is an equivalent of the concept of a title and at the same time a token is a result of a transaction, which is an equivalent of the concept of a deed [9]. [9] also states it fits both conventional systems of keeping records in a public registry as a chain of deeds and maintaining the registry of title records (e.g. torrens system, civil law countries), where the latest entry reflects the title and its current owner.

Tokenisation of property rights – that is, the creation of a parallel (in virtual world) way of creating and transferring rights over land, either full ownership or any other limited real or personal right over or related to it [8]. When the land title and property rights are tokenized, there is no need to keep this kind of records elsewhere, for example, in a traditional land registry system, because blockchain is a registry itself and a secure repository, where no transaction can be revoked or altered [27]. If the record

of property rights and titles are tokenized, then there is no need for a public body to keep this registry since there is no need to prevent the database from corruption [28].

Smart Contracts

Smart contracts are computer programs, whose codes allow for the automatization of specific processes without the necessity for trust between the parties since they're checked and executed automatically. Smart contracts might include several kinds of clauses to design more complex transactions (e.g. payment of loans) and, as they run through a blockchain system, these transactions are secure and trusted; Ethereum was the first blockchain protocol to allow users to write smart contracts through Solidity language, but other protocols are also offering this possibility, such as NXT (public blockchain) or Corda (private blockchain).

Blockchain, linked to smart contracts, has the potential to check against legal and physical features of the land before the transaction, to undertake due to payments between the parties and the payment of taxes, to tokenize real rights, to check whether there are abusive clauses included in the terms of a loan contract or to even solve a legal issue in a digital arbitration court [8].

3.4.2 Challenges of the Use of Blockchain in Land Registry

The challenges presented by the tokens, tokenization, consensus, and decentralization features offered by Blockchain are now presented.

Tokens and Tokenization

A token does not necessarily have any legal side, the same as not every record on paper creates any legal relationship [9]. Hence, the use of tokens for real estate requires legislative changes that legitimize new procedures of acknowledgment and recording on the blockchain [28]. So, when the jurisdiction provides for a certain way of performing some legal relationships, the creation of the token out of the existing legal framework makes it legally invalid or void [9], hence tokens shan't be capable of subdividing or transfer, although the records of the initial owners shall remain valid. Another problem with tokens is the difficulty to define the characteristics of a property, due to lack of data structure and quality [4] and one barrier to adoption is the absence of standardized digital data, while the benefit can only be effective if it's accepted as a standardized tool by all parties involved in transacting real estate.

Consensus and Decentralization

Transactions in this Peer-to-Peer (P2P) network are validated according to standards of a specific consensus mechanism which has an authorization method that allows some nodes to create new blocks after a set of predetermined validity rules is reached – validation of transactions [4]. This feature has several consequences such as the disallowance of the deletion of data, meaning once something is published - a transaction or user's data -, it cannot be altered which raises concerns about privacy [27]. Although the idea of decentralized governance is attractive, practical implementation is not viable now

and some additional development at the technical, political, and legislative level is needed [9]. Regarding the legislative level, seven EU countries (Cyprus, France, Greece, Italy, Malta, Portugal, and Spain) signed in December 2018 a Ministerial Declaration on DLT in which these countries confirm that “any legislation on DLT should take into account the decentralized nature of such technology and should be based on European fundamental principles and technological neutrality” [5]. Using any decentralized system (including the blockchain) is limited because it may create issues with registry forking, resulting in the split into two or more branches or “forks”, hence tokens are duplicated, which creates legal collisions for example; in one system, the user sells an asset, but in the other, the user still owns it [9]. Disintermediation, not only but as a consequence of decentralization, makes illegitimate the presumption of accuracy of an entry, i.e. a presumption of validity of a transaction, nor a proof of ownership (in the sense of indicating the legitimate owner), which is the case of title registration systems because validation of a transaction performed by miners may be considered in a technical sense but not in a legal sense, hence it can't be treated as an equivalent of examination of the title carried out by the registrar [24]. In consequence, the information stored in the blockchain cannot be regarded as reliable and the only data that can be proved is on the blockchain, i.e. the timestamp, recipient's wallet, sender's wallet, the amount of crypto-currency, and declarations made by them.

Summary

In this section, it is shown how the SLR was planned and conducted, its report and the discussion of the results. In the form of tables, it's presented the gathered advantages and challenges gathered from 43 studies. In the next section, it is presented the second instantiation (e.g. of the Case Study protocol). It consists in the phases of the protocol (section 4.1), the analysis framework (section 4.2), the analysis of each case (section 4.3) and the discussion of the results (section 4.5).

4

Multiple Case Studies

Contents

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A multiple case study enables the researcher to explore differences within and between cases [29]. To collect evidence of the application of Blockchain (or at least the ponderation of a possible application) in target countries, the adoption of a case study approach seems suitable since “case studies are preferred when the relevant behaviors still cannot be manipulated and when the desire is to study some contemporary event or set of events” [17], meaning that, in this case, the Blockchain use in real estate transactions is an advanced use of technology yet to be thoroughly explored and hence the topic represents a good fit for case study methodology.

Besides being descriptive, this research also gives a relativist perspective, that is, trying to capture the distinctive perspectives of the case study participants and focusing on how their different meanings illuminate the topic of study so that one may appreciate the possibility of multiple realities [17].

No propositions were made since these wouldn't be based on nothing more than personal and biased theories. However, the purpose of the research is to give the readers an overview of a particular contemporary circumstance, its advantages and disadvantages, how it's seen by various entities, and clues to predict the future of this phenomenon.

4.1 The Phases of the Case Study

The four phases of the multiple case studies followed were: to define the research questions, the selection of the cases, the collection of data and each case analysis. Each one of them is explained below.

4.1.1 Research Questions

In this research, it is mostly used “how”, “why”, and “what” questions. The “how” and “why” questions refer to the case study, while the “what” questions are mirrored from the SLR ones. With the responses gathered from the “what” questions, individualization of their scope is trying to be achieved. For the rest of the questions, since every interviewee responded regarding one country, the goals are to: compare the responses and consequently between countries; assess the maturity and scope of the implementation; and perceive how multiple parties understand this transformation. The research questions have the purpose of requesting an overview of how this particular technology fits in, and if it's being recognized or not, as applicable in the real estate realm of certain countries. With this aim, the questions below were presented to the interviewees:

1. Why is Blockchain being adopted in this case study, i.e., for supporting real estate in your country?
2. How is Blockchain being adopted in this case study (only in land registration or another part of the real estate domain)?

3. What are the major challenges of Blockchain in this case study?
4. What are the major benefits of Blockchain in this case study?
5. What are the major disadvantages of Blockchain in this case study?
6. How is this case study perceived by:
 - 6.1 government/politicians
 - 6.2 enterprises
 - 6.3 middlemen (e.g., notaries)
 - 6.4 banks
 - 6.5 other entities (e.g., researchers)
7. How do you assess the maturity level of this case study?
8. What is your prediction for this case study in the near future?

4.1.2 Case Selection

Case studies based on literal replication were selected [17], which means the individual case studies predict similar results although the reasons were different among them. The search was deliberately pointed to countries cited on the literature review and in different geographic regions. To identify the interviewees, who are all researchers, a search on the previous literature was made and contact was attempted through the social networks LinkedIn and ResearchGate.

Nine researchers were contacted and introduced to: the area and purpose of the study, the research team and a brief outline of the interview protocol, and then, their willingness was ascertained to participate in the study. It was also promised to give the final study report and guaranteed data confidentiality. Six of them agreed and three replied with the responses to the research questions.

Ideally, the unit of analysis for the study would be how much is Blockchain already ingrained on the real estate of the target countries. However, the case studies selected were, haven't been yet or are in a pilot phase and therefore don't have the amount of information yet to measure the unit of analysis, so the adopted one is: how much Blockchain is thought to be ingrained on the real estate of a target country by the respective country's interviewee.

4.1.3 Data Collection

Data collection took place between March and April 2021. Semi-structured interviews were chosen as the primary data source because they represent a highly efficient way to gather rich empirical data [30].

Data was collected through online questionnaires for two interviewees and through a face-to-face online interview with the remaining one. To improve accuracy, the online interview was first recorded and then transcribed. To enhance reliability and validity, an interview protocol was developed based on the existing literature and our research question [17].

To ensure the maximization of the used source of evidence, we followed the four principles of data collection: use multiple sources of evidence (e.g. knowledge gathered from previous literature review and interviewees' contributions); create a case study database; maintain a chain of evidence; and exercise care when using data from social media sources.

4.1.4 Case Study Methodology Analysis

Analysis was important as it assisted the development of the individual case analysis. The qualitative method used to analyse the case research is represented in the table 4.1 below, that shows a combination of areas and criteria that were identified in order to assess its quality [3].

Table 4.1: Assessment of quality criteria for this case study based on [3].

Area	Criteria	Assessment
Design of the case study	Research purpose	Descriptive and relativist.
	Clear research questions	Described in the Research Questions section.
	Single versus multiple-case design	Four cases have been included in our research to yield more compelling evidence.
	Selection of case(s)	Described in the Case Selection section.
	Unit of analysis	The unit of analysis is blockchain applied in real estate.
	Research context	We describe details of the case period and the nature of the data.
Conduct of the case study	Elucidation of the data collection process	Described in the Data Collection section.
	Data collection methods	Interviews and previous literature.
	Use of multiple data collection methods	Only qualitative methods.
Analysis of the case study evidence	Elucidation of the data analysis process	Described in the Case Analysis section.
	Data analysis techniques and tools	We use "Explanation building" and "logic model" described in the Analysis framework section.
Strategies for enhancing case study rigor	Quotes	Quotes from interviews and documents are presented.
	Triangulation	Triangulation made on the Discussion of the Results section.
	Subject review	Not yet done.
	Case study protocol	Please contact me for it.
	Case study database	Please contact me for it.
	Solo vs team-based case research	Team-based case research.
Limits and relevance of the case study	Methodological limitations	Described in the Research Limitations section.
	Recommendations for researchers	Described in the Future Work section.
	Implications for practitioners	It doesn't apply.

4.1.5 Analysis Framework

From a psychological point of view, to interpret the contributions of the interviewees, the theory of planned behavior (TPB) was utilized. [31] developed the TPB, where he states that the human behaviour can be explained by intention, social norms and the degree of perceived behavioral control.

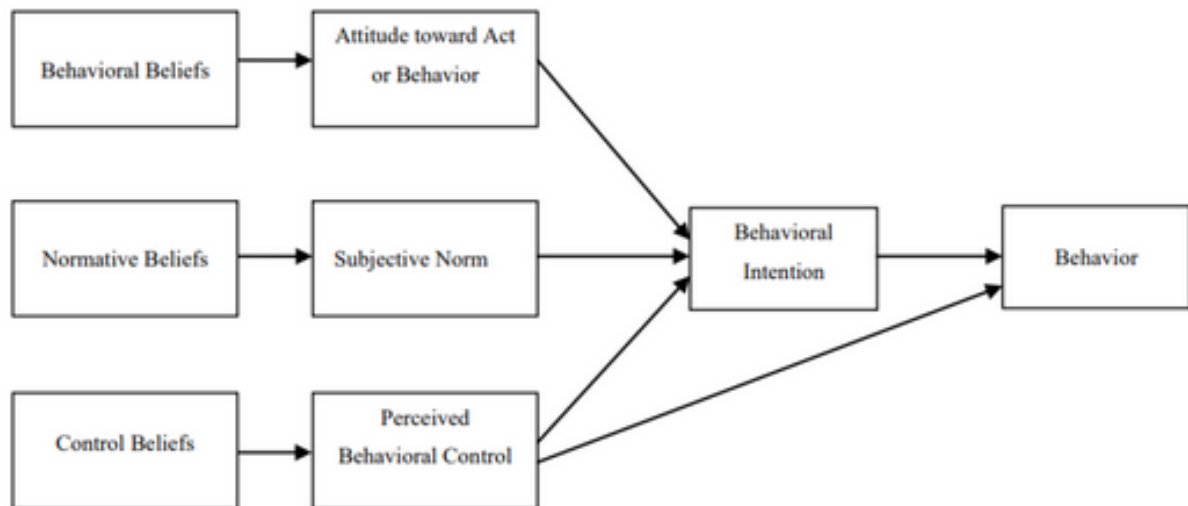


Figure 4.1: The TPB model

The TPB is an extension of the Theory of Reasoned Action (TRA) and as in the original TRA, a central factor in the TPB is the individual's intention to perform a given behavior; these are assumed to capture the motivational factors that influence a behavior and are indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior [31].

The TPB - represented in fig. 4.1 - postulates three conceptually independent determinants of intention: the first is the attitude toward the act or behavior and refers to the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question; the second predictor is a social factor termed subjective norm and it refers to the perceived social pressure to perform or not to perform the behavior; and the third antecedent of intention is the degree of perceived behavioral control which refers to the perceived ease or difficulty of performing the behavior and it is assumed to reflect past experience as well as anticipated impediments and obstacles [31].

This framework is suitable for our research since it captures the willingness of an individual to perform a certain action based on behavioral, normative, and control beliefs. Our interpretation of these variables for each country studied is the result of a measure combining the responses of each person interviewed - that can be corroborated or not - with the information gathered from the existing literature. In our case, the variable Normative beliefs refers to the entities enumerated in the sixth question (i.e. governments, politicians, enterprises, middlemen and banks).

4.2 Case Studies

It's now presented each case and its respective analysis. The analysis is composed by an instantiation of the TPB, representing a table that associates each belief (e.g. behavioral, normative and control) with quotes from the responses of the interviewees. Along with the table, a brief context related to the questionnaire was collected from the previous literature, to reduce the bias and improve the accuracy of the reality of each case.

4.2.1 Canada

Although Canada has been already rolling out blockchain-based applications - for example, in public administration [32], or in the digital identity field with the blockchain-based national ID system named secure key [33] - there isn't a pilot(s) from the government of Canada for blockchain applied on land registry nor real estate. Our interviewee shares the same opinion (table 4.2) and says the application is being explored by the government only for land registration, and specifically the process of changing the name on a legally registered land title, which is in an early state. In Canada, transaction costs for real estate can include title search fees, land transfer taxes, appraisal costs, legal fees, agent fees, listing fees, estoppel certificate fees, and notary fees [34], and while a Blockchain system may not be able to eliminate all transaction costs, it could likely simplify the process in most jurisdictions and it could improve the transparency of a system by enabling regulators to catch and prevent fraudulent behavior [35]. This system is also attractive because it could reduce the total transaction time to complete a sale and reduce fraud by providing greater transparency to title ownership records and the bidding process [35].

Table 4.2: Canada' interviewee quotes related to a certain belief.

Category	Quotes from interviewees
Behavioral beliefs	"I expect that, in time, they (land title authority) will adopt a blockchain solution of some sort."
Normative beliefs	"The land title authority has recently expressed interest in exploring new cases for the application of blockchain."
Control beliefs	"In 2018, the province of British Columbia in Canada wished to explore the possibility of using blockchain in land titles administration and real estate transactions. As a first experiment with the possible future adoption of blockchain, so interesting but not critical." "The case study was undertaken in 2018, and so the technology and the land titles authorities' understanding of blockchain was very limited."

4.2.2 Dubai

Blockchain in the realm of Real Estate transactions and land/title registries has drawn considerable attention and support from governments such as Dubai [36], which is running pilots in silence [23].

Our interviewee says (table 4.3): “I don’t know if any blockchain is in use at this point, but I know they use blockchain more for the e-governance systems.”. [18] agrees by saying “For example, in Dubai there are already plans to have all government documents in Blockchain by 2020”; the idea is also corroborated by [2] that says Dubai has become the world’s first government entity to adopt the technology for land ownership registration. They also say Blockchain has been used for the telecommunications system, various property related billing systems, and the Dubai Electricity and Water Authority. [33] adds that the country is building its own identity platform with the help of the technology. Some go even further by stating that in 2-3 years (2022-2023), all real estate in Dubai will be fixed in a single decentralized system.

The government is looking positively at developing innovative technology and the Department of Land Resources of the Emirate may take the title of the first state institution to use blockchain in the real estate market [37].

Table 4.3: Dubai’ interviewee quotes related to a certain belief.

Category	Quotes from interviewees
Behavioral beliefs	“It’s very promising, it’s very promising but I think at the moment there are still the bottlenecks.”
Normative beliefs	“...other people in Dubai are amazingly pro-innovative...” “But my experience has been in Dubai. It’s quite crazy actually how eager they are to just have the best innovations in capacitance, the best tech and everything they have the money and they have the mentality...” “Dubai’s full of blockchain startups.” “Many blockchain companies don’t have any tax issues, the legal environment is amazing and there are tons of investors.”
Control beliefs	“I must say I’m not aware that blockchain is in fact used at this point...” “...they have the money and also the laws are in place to allow for this innovation.”

4.2.3 Georgia

In Georgia, in 2017, the company Bitfury, a software provider, the NAPR of Georgia, the economist Hernando De Soto and Blockchain Trust Accelerator launched a pilot project on the cadastral registration of real estate on the basis of blockchain [12]. The Georgians can register their lands and transact on Blockchain for the same thus, reducing the conflicts in registration process and property exchange [38].

With Blockchain technology, the Georgian government aims to be a leader in governance and security, to restore public trust in institutions and government agencies, and as of 2018, a total of 1.5 million land titles in the country were published on the Blockchain [26].

Our interviewee agrees with the opinion (table 4.4) of the Georgian government restoring trust in institutions and government agencies and services but he/she looks at this subject with some resistance due to the need to overcome legacy and deepen institutional structures.

Table 4.4: Georgia' interviewee quotes related to a certain belief.

Category	Quotes from interviewees
Behavioral beliefs	<p>"It's very promising, it's very promising but I think at the moment there are still the bottlenecks."</p> <p>"In Georgia, this has only been possible recently to develop and they still have a lot of legacy to overcome."</p> <p>"But that is not using the opportunity of the blockchain technology to change any processes or anything so that option is really very very shallow at least in this case and shows an enormous amount of resistance to structural change."</p>
Normative beliefs	"In Georgia, they know corruption is a much bigger problem in the country".
Control beliefs	"In Georgia, you have established structures that are entrenched and embedded or middlemen and all this stuff you know also enforced by the law which does not change so quickly. The jurisdiction in Georgia does not allow for a high degree of innovation and getting rid of middlemen and so on is more of a challenge because it's backed by the law."

4.2.4 Ghana

Ghana has joined the blockchain project together with multinationals that have been working for years in the sector, along with local startups that know the area and the possible disadvantages that may exist [25], "not only to enhance the land management, land circulation and real credit market and help solving land disputes, but also to avoid corrupt government interventions, fraud and real estate bubbles." [39]. Bitland has been in Ghana since 2014 on a project to "register land and real property ownership and use rights" [9] with the official permission of the government [12] and in 2016, it had its test project running in 28 communities in Ghana and the first results are positive [39].

The country faces problems of safety of the real estate registers - where an earthquake provoked the loss of the property register [12] - and since it is a less developed country and where the political situation is quite unstable, it is not strange that there are cases of corruption in terms of citizens' property [25].

Table 4.5: Ghana' interviewee quotes related to a certain belief.

Category	Quotes from interviewees
Behavioral beliefs	<p>"I believe western academics are looking to justify neo-colonialism and are just attempting to validate that African governments have created a safer environment for exploitative business practices from the west."</p> <p>"It is interesting to see how western academia has really only been interested in attempting to exploit African real-estate through blockchain rather than study how land-right protection could advance the female population."</p>
Normative beliefs	<p>"Politicians either see it as a potential bane against their opacity or a means to gather support to make the government more transparent. Nowhere in between."</p> <p>"Banks see crypto and blockchain as a general threat."</p>
Control beliefs	<p>"The technology is too nascent and UI/UX is not developed enough to be useful in the real world."</p> <p>"Blockchain technology is currently not scalable, not user-friendly, not easily deployable, not easily understood."</p>

4.3 Discussion of the Results

The application of this technology on the real estate realm presents complexity in many ways: “There is a need to provide identification, authorization, and authentication because blockchain provides only for pseudonymous authentication” [9]; the social impact as a result of designating the users of real estate, meaning that existing institutions will disappear or change significantly, and other parties will rise [23]; one problem that can arise over time is the compatibility of the existing computer hardware and software with ways of storing information [12].

However, real estate is a uniquely good target for the Blockchain technology because it has a complex transaction process that is built to prevent fraudulent behavior and enable strict ownership protection, traits required by the real estate market where Blockchain is uniquely strong [35]. These traits can also be applied to the land registry system in particular, where poor land management also adversely impacts society’s long-term prosperity and insecure land rights have long been considered a major driver of global poverty, inequality, and political instability and past disputes over land ownership have in fact led to social unrest and violence [26].

In this section, it’s presented information about an element that influence the general adoption and impact of Blockchain for the real estate actors. As so, one major perspective - the social - is elaborated, which will caught information about the general impact of Blockchain, not only for the real estate actors, but people in general as well.

Social perspective

One possible major change - if Blockchain would get adopted - is the social impact as a result of designating the users of real estate. If we draw a comparison with the developments with the internet and its impact - e.g. the social impact of smartphones - new patterns of users or real estate will change significantly and existing institutions will disappear or change significantly, other parties will rise [23].

4.3.1 Canada

Real estate transparency and environmental sustainability market transparency entails the incorporation of the objectives of smart sustainable development and growth, digital and investment performance, into the operational practices of government and industries and Canada, along with other developed countries, has joined the “Highly Transparent” group of the Real Estate Environmental Sustainability Transparency Index in 2018 [40].

Numerous reports indicate that fraud is a serious problem in the Canadian real estate market, with title fraud being the most devastating to the victims financially [35]. Also, and because the current bidding process is primarily paper-based and controlled by the agent representing the property seller, in the current system, bids are submitted by the buyers’ agents to the seller’s agent who compiles them

and communicates the offers to the seller, and , agents are legally allowed to represent both buyers and sellers in a single real estate transaction [35]. This practice enables the “double-ending” fraud, that is, a type of transactional fraud wherein agents handling real estate transactions unfairly benefit. These real estate agents can give confidential information about the existing bids to buyers they represent to allow that buyer to win by a small margin and effectively double the agent’s commission at the expense of the seller and potential buyers who are represented by their agents and are willing to pay more [35].

The interviewee didn’t give information that can help speculate social factors for the application of Blockchain for real estate and we got mixed and contradicted information from the previous literature. Hence, it’s not possible to reach any conclusion.

4.3.2 Dubai

In the Dubai’s interview, two major aspects are highlighted : the laws and the mindset of the people.

Dubai has a vision to become a world leader in adopting blockchain technology in the public domain by 2020 and its strategy aims to record all government transactions on the blockchain, and this will result in an estimated EUR 1.2-billion savings per annum, from the documents processing only, part of this being on the land registry [41].

The interview and the report [42] where the Sheikh Hamdan bin Mohammed bin Rashid Al Maktoum says “Dubai will be the first city in the world to conduct applicable Government transactions via Blockchain by 2020”, uplift the idea that this country want to be ahead of the rest in the adoption of this technology for most public services. In this report, we can see 25 Blockchain use cases, most of them implemented, in diversified areas such as finance, real estate, tourism, health and education. In the real estate realm, projects such as verification of property title deeds, completion of property rent procedures and the SmartCrowd real estate investment are already implemented.

4.3.3 Georgia

For Georgia, public trust in the government and the latter’s will to change this is the factor most highlighted by both the interviewee and the previous literature. However, the opinion of the interviewee about the willingness of other parties, e.g. notaries, differs from the literature.

The land registry system in the Republic of Georgia was previously managed by the Bureau of Technical Inventory and the State Department of Land Management which had significant functional overlap, as each ran its own system of land registry that was generally opaque and this enabled government officials to illegally change land records in the system for their own benefit, as such misconduct was difficult to detect or identify [26]. Countries like Georgia are exploring the blockchain approach to combat problems associated with the traditional land administration system [43].

Nowadays, the Land Registry of Georgia has been working with Blockchain for about a year and that the notary in this buying process only was involved in the validation of the inserted documents and because the notary only validated the documents, the total transaction costs were estimated at €162, resulting in a major cost reduction [11]. But the country had still a reputation crisis amongst its citizens that wasn't solved just by creating a digital NAPR database which introduced policies to simplify the land registry process, allowed more stakeholders to participate in land-related services, and facilitated legislative reforms to the processes of drafting and certifying property transactions [26].

Hence, the Georgian government has shown strong interest in adopting Blockchain technology as part of its effort to restore public trust in government agencies. Papuna Ugrekhelidze, former chairman of the NAPR, said in a 2016 statement that, "by building a Blockchain-based property registry and taking full advantage of the security provided by the Blockchain technology, the Republic of Georgia can show the world that we are a modern, transparent and corruption-free country that can lead the world in changing the way land titling is done and pave the way to additional prosperity for all." [26].

4.3.4 Ghana

In poor nations like Ghana, it can be incredibly difficult for citizens to attain property rights and the lack of services to provide landowners with deeds and official paperwork poses a challenge in providing proof of ownership for the land they occupy [44]. "According to Ghana's land commission, 80% percent of landowner's lack title deeds as most land is customarily held with oral agreements." [41], which represents a problem since these agreements are not honoured gracefully. Another situation was the case of the complete loss of the property register in Ghana during an earthquake [12], so, even without confirmation, Ghanaians certainly don't trust the government for the service of land registration.

Adding to this, where the political situation is quite unstable, it is not strange that there are cases of corruption in terms of citizens' property, where the government's own corruption rates are very high and government officials alter titles to registered properties by assigning them to others or to themselves [25].

Hence, Bitland, in cooperation with the Ghana Land Commission, launched a project and in 2016, it had its test project running in 28 communities in Ghana and the first results were positive and at the same time, Bitland develops educational initiatives that enable people to get involved in the digitalising society [39].

Our interviewee's feedback (table 4.5) tells she/he seems somewhat suspicious for this research in Ghana since, and quoting, "western academics are looking to justify neo-colonialism" and "in attempting to exploit African real-estate through blockchain rather than study how land-right protection could advance the female population". As for other parties, "Politicians either see it as a potential bane against their opacity or a means to gather support to make the government more transparent."; "Banks see crypto and blockchain as a general threat." In this research, comments about the situations mentioned

and the responses from the interviewee won't be made, leaving accurate and legitimate conclusions for experts or other people experiencing this reality in Ghana.

Conclusions

With no surprise but worth mentioning, much of what is written here occurs because of decisions made by governments. However, each countries' government seems to have different reasons and views about the use of Blockchain in the real estate realm.

Dubai wants to become the leader of Blockchain and the Sheikh does all he can (that is, pretty much everything), like creating use cases for many of the public services, smart city academies, and also a blockchain shared platform which means a standard platform for government entities to implement use cases. For Georgia, the main objective seems to be the restoring of public trust in its government agencies and services. For Canada, we couldn't reach a conclusion about why the government thinks of adopting the technology and in Ghana, it seems to us, the government's thoughts rely on the problem of corruption and giving its citizens better services.

Summary

In this section, it is shown how the multiple case study was planned and conducted, the analysis framework used to leverage interviewee's contributions and the discussion of the results.

The next section will conclude the research and its contents consist in the main contributions of the report (section 5.1), the research limitations (section 5.2) and the suggested future work (section 5.3).

5

Conclusion

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5.1 Main Contributions

The purpose of this work was to summarize the knowledge of the existing literature about Blockchain and Real Estate and to study the different perspectives of many parties (e.g. banks, government, enterprises) about the recognition and suitability of this technology, not only for real estate but also for land registration, in four countries that sit on four different continents.

Previous research demonstrated that Blockchain already has a word in real estate conveyancing. Notwithstanding this fact, we want to remain neutral in the opinion of the adoption of Blockchain. This research demonstrates that the use of Blockchain has its constraints and benefits, and some countries have been developing pilot projects and are exploring the technology.

The contribution rests on presenting all the gathered characteristics of Blockchain to analyze the use of the technology in the land registry domain, contrary to the literature we analyzed which is often biased. Besides this, reasons for the adoption of this technology from, not only but mostly, a government point-of-view can be speculated in a more informed way, as well as some countries' structural problems.

5.2 Research Limitations

The limitations faced during the SLR were mainly related to the data extraction analysis that may be biased since it was only performed by one researcher. Another problem regards the “only abstract” papers that weren't made use of and are a notable share of data from the digital libraries, consequently reducing knowledge disseminated between the scientific community. The limitations faced while doing the multiple case studies research were the data collection, i.e. little knowledge of this subject in the countries analyzed and gathered from the interviews.

5.3 Future Work

By leveraging this research, the next steps could be to develop a theory about the need and/or willingness for governments to adopt Blockchain for real estate or just the land registry system. In addition, research about how Blockchain can impact the entire real estate area, not just the land registry, is essential to make a conscious decision. Considerations about the use of one or more types of Blockchain (private, public, or consortium) and the possibility of creating a specific DLT for this sector are important as well since real estate transactions happen between public and private entities.

Bibliography

- [1] K. S. J. Krupa and M. S. Akhil, "Reshaping the Real Estate Industry Using Blockchain," in *Lecture Notes in Electrical Engineering*, vol. 545. Springer Verlag, 2019, pp. 255–263.
- [2] M. Nandi, R. K. Bhattacharjee, A. Jha, and F. A. Barbhuiya, "A secured land registration framework on Blockchain," in *ISEA-ISAP 2020 - Proceedings of the 3rd ISEA International Conference on Security and Privacy 2020*. Institute of Electrical and Electronics Engineers Inc., feb 2020, pp. 130–138.
- [3] L. Dubé and G. Paré, "Rigor in information systems positivist case research: Current practices, trends, and recommendations," *MIS Quarterly: Management Information Systems*, vol. 27, no. 4, pp. 597–635, 2003.
- [4] H. P. Wouda and R. Opdenakker, "Blockchain technology in commercial real estate transactions," *Journal of Property Investment and Finance*, vol. 37, no. 6, pp. 570–579, sep 2019.
- [5] R. M. Garcia-Teruel, "Legal challenges and opportunities of blockchain technology in the real estate sector," *Journal of Property, Planning and Environmental Law*, vol. 12, no. 2, pp. 129–145, jan 2020.
- [6] M. Avantaggiato and P. Gallo, "Challenges and Opportunities using MultiChain for Real Estate," in *2019 IEEE International Black Sea Conference on Communications and Networking (BlackSea-Com)*. IEEE, jun 2019.
- [7] J. L. Tilbury, E. De La Rey, and K. Van Der Schyff, "Business process models of blockchain and south african real estate transactions," Tech. Rep., 2019. [Online]. Available: <https://propv.com/>
- [8] S. Nasarre-Aznar, "Collaborative housing and blockchain," *Administration*, vol. 66, no. 2, pp. 59–82, may 2018.
- [9] O. Konashevych, "Constraints and benefits of the blockchain use for real estate and property rights," *Journal of Property, Planning and Environmental Law*, vol. 12, no. 2, pp. 109–127, jun 2020.

- [10] N. Matai, K. Vibho, and R. Annie Uthra, "Blockchain implementation using smart contracts to secure the online real estate business transactions," *International Journal of Advanced Science and Technology*, vol. 29, no. 6, pp. 2462–2473, 2020.
- [11] M. Nijland and J. Veuger, "Influence of Blockchain in the Real Estate Sector," *International Journal of Applied Science*, vol. 2, no. 2, p. p22, jun 2019.
- [12] N. Kalyuzhnova, "Transformation of the real estate market on the basis of use of the blockchain technologies: Opportunities and problems," in *MATEC Web of Conferences*, vol. 212. EDP Sciences, oct 2018.
- [13] "The trust machine." [Online]. Available: <https://www.economist.com/leaders/2015/10/31/the-trust-machine>
- [14] "Deep shift: Technology tipping points and societal impact." [Online]. Available: <https://www.weforum.org/reports/deep-shift-technology-tipping-points-and-societal-impact>
- [15] S. K. E, V. Talasila, and R. Pasumarthy, "A novel architecture to identify locations for Real Estate Investment," *International Journal of Information Management*, vol. 56, 2021.
- [16] B. Kitchenham and S. Charters, "Guidelines for performing systematic literature reviews in software engineering," Keele University and Durham University Joint Report, Tech. Rep. EBSE 2007-001, 2007. [Online]. Available: <http://www.dur.ac.uk/ebse/resources/Systematic-reviews-5-8.pdf>
- [17] R. Yin, *Case Study Research and Applications: Design and Methods*. SAGE Publications, 2017. [Online]. Available: <https://books.google.pt/books?id=6DwmDwAAQBAJ>
- [18] J. Veuger, "Trust in a viable real estate economy with disruption and blockchain," *Facilities*, vol. 36, no. 1-2, pp. 103–120, jan 2018. [Online]. Available: <https://doi.org/10.1108/F-11-2017-0106>
- [19] J. Oh and I. Shong, "A case study on business model innovations using Blockchain: focusing on financial institutions," *Asia Pacific Journal of Innovation and Entrepreneurship*, vol. 11, no. 3, pp. 335–344, dec 2017.
- [20] S. Yeasmin and A. Baig, "Unlocking the Potential of Blockchain," in *2019 International Conference on Electrical and Computing Technologies and Applications (ICECTA)*. IEEE, nov 2019.
- [21] A. Saull, A. Baum, and F. Braesemann, "Can digital technologies speed up real estate transactions?" *Journal of Property Investment and Finance*, vol. 38, no. 4, pp. 349–361, may 2020.
- [22] S. Soni and B. Bhushan, "A Comprehensive survey on Blockchain: Working, security analysis, privacy threats and potential applications," Tech. Rep., 2019.

- [23] Jan Veuger, "Attention to Disruption and Blockchain Creates a Viable Real Estate Economy," *Journal of US-China Public Administration*, vol. 14, no. 5, may 2017.
- [24] M. Kaczorowska, "Blockchain-based land registration: Possibilities and challenges," *Masaryk University Journal of Law and Technology*, vol. 13, no. 2, pp. 339–360, 2019.
- [25] Y. Mezquita, J. Parra, E. Perez, J. Prieto, and J. M. Corchado, "Blockchain-based systems in land registry, a survey of their use and economic implications," Cham, Tech. Rep., 2021.
- [26] Q. Shang and A. Price, "A Blockchain-based Land Titling Project for the Republic of Georgia," *Innovations*, vol. 12, no. 3/4, pp. 72–78, 2018.
- [27] O. Konashevych, "General Concept of Real Estate Tokenization on Blockchain The Use of the Blockchain in e-Governance and e-Democracy View project Blockchain Land Registry View project." [Online]. Available: <https://www.researchgate.net/publication/341149204>
- [28] —, "Comparative analysis of the legal concept of title rights in real estate and the technology of tokens: How can titles become tokens?" Tech. Rep., 2019. [Online]. Available: <https://www.researchgate.net/publication/330104641>
- [29] P. Baxter and S. Jack, "Qualitative case study methodology: Study design and implementation for novice researchers," *Qualitative Report*, vol. 13, 01 2010.
- [30] K. Eisenhardt and M. Graebner, "Theory building from cases: Opportunities and challenges," *The Academy of Management Journal*, vol. 50, pp. 25–32, 02 2007.
- [31] I. Ajzen, "The theory of planned behavior," *Organizational Behavior and Human Decision Processes*, vol. 50, pp. 179–211, 12 1991.
- [32] E. Ducas and A. Wilner, "The security and financial implications of blockchain technologies: Regulating emerging technologies in canada," *International Journal: Canada's Journal of Global Policy Analysis*, vol. 72, pp. 538–562, 12 2017.
- [33] B. Benhala, Jaṁmi [U+02BB] at al-Mawlaṁy Ismaṁ [U+02BB]iṁ. Faculty of Sciences, Institute of Electrical and Electronics Engineers. Morocco Section, and Institute of Electrical and Electronics Engineers, *IRASET'2020 : 2020 1st International Conference on Innovative Research in Applied Science, Engineering and Technology (IRASET) : March 19-20, 2020, Faculty of Sciences, Meknes University of Moulay Ismail - Morocco*.
- [34] "Closing Costs Overview Canada | Home Purchase Expenses." [Online]. Available: <https://www.ratehub.ca/closing-costs-overview>

- [35] A. Mashatan and Z. Roberts, "A Real Estate Transaction Process Based on Blockchain An Enhanced Real Estate Transaction Process Based on Blockchain Technology Emergent Research Forum Paper," Tech. Rep. Swan 2015, 2017.
- [36] S. Latifi, Y. Zhang, and L. C. Cheng, "Blockchain-based real estate market: One method for applying blockchain technology in commercial real estate market," in *Proceedings - 2019 2nd IEEE International Conference on Blockchain, Blockchain 2019*. Institute of Electrical and Electronics Engineers Inc., jul 2019, pp. 528–535.
- [37] E. Pankratov, V. Grigoryev, and O. Pankratov, "The blockchain technology in real estate sector: Experience and prospects," in *IOP Conference Series: Materials Science and Engineering*, vol. 869, no. 6. Institute of Physics Publishing, jul 2020.
- [38] V. Thakur, M. N. Doja, Y. K. Dwivedi, T. Ahmad, and G. Khadanga, "Land records on Blockchain for implementation of Land Titling in India," *International Journal of Information Management*, vol. 52, no. April 2019, p. 101940, 2020. [Online]. Available: <https://doi.org/10.1016/j.ijinfomgt.2019.04.013>
- [39] B. Verheye, "Real estate publicity in a blockchain world: a critical assessment," *European Property Law Journal*, vol. 6, no. 3, dec 2017.
- [40] N. Siniak, T. Kauko, S. Shavrov, and N. Marina, "The impact of proptech on real estate industry growth," in *IOP Conference Series: Materials Science and Engineering*, vol. 869, no. 6. Institute of Physics Publishing, jul 2020.
- [41] M. Themistocleous, "Blockchain Technology and Land Registry," Tech. Rep. [Online]. Available: <http://www2.aueb.gr/>
- [42] [Online]. Available: <https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwibu6D4IO7zAhUIshQKHWsMA9gQFnoECAIQAA&url=https%3A%2F%2Fwww.mbrsg.ae%2Fgetattachment%2Fa885d97a-1a31-46b1-ad24-afeacead73fc%2Fattachment.aspx&usg=AOvVaw2EzySCtBuZ5Nf-n4u2pPsl>
- [43] N. Gupta, M. L. Das, and S. Nandi, "LandLedger: Blockchain-powered Land Property Administration System," Tech. Rep., 2019.
- [44] "Bitland: Property Rights for The World's Poor," Sep. 2020. [Online]. Available: <https://borgenproject.org/property-rights-for-the-worlds-poor/>

