Blockchain for Real Estate: A Systematic Literature Review

Francisco Ferreira Santana
Instituto Superior Técnico
Lisboa, Portugal *francisco.santana@tecnico.ulisboa.pt*

Miguel Mira da Silva
Instituto Superior Técnico
Lisboa, Portugal *mms@tecnico.ulisboa.pt*

Florbela Galvão da Cunha
Instituto Superior Técnico
Lisboa, Portugal *florbelacunha@tecnico.ulisboa.pt*

Abstract

Research has shown that Blockchain has been studied to be introduced to support transformation over the land registry process. This study aims to analyze the potential of this technology to improve land registry. The research was conducted using the Systematic Literature Review Methodology, which is a means to identify, evaluate and interpret the available research. As a result, we present the advantages and disadvantages of the use of Blockchain in land registry and the countries which already have implemented Blockchain in the system. These artifacts show that researchers have divergent opinions about the adoption of Blockchain in land registry and are meant to help to evaluate the need to adopt the technology. This subject is emphasized by the heterogeneity of the countries which already have implemented the tech and its prospect of the growing use.

Keywords: Blockchain, Land Registry, Advantages, Challenges, Pilots.

1. Introduction

Blockchain and other distributed ledger technologies (DLT) have been catching the attention of the real estate industry and governments [8]. This research intends to give an overview of characteristics of Blockchain, gathered by performing a systematic literature review (SLR), that can be addressed to real estate, particularly land registry, and also shows that there are no successful examples of countries that already have or are developing pilot projects.

This report is composed of the theoretical background about Real Estate and Blockchain. Then we explain how it was carried out by describing how the SLR was done and its steps - Planning, Conducting, and Reporting. After, we present a discussion about the results and the paper ends with the conclusion.

Our contribution rests on presenting all the gathered characteristics of Blockchain to analyse the use of the technology in the land registry domain, contrary to the literature we analyzed which is often biased.

2. Real Estate

The real estate market is a complex subject with many facets, and although highly regulated, is known for its resistance to change [1], [19]. An example can be when in 2015 the European Parliament was worried that the European Union 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 [13]. Besides this, the existing problems in the current real estate sector identified are [10]:

- 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 its quality —leading to asymmetric property information;
- A mutable internal centralized database of online property listing;
- Overhead cost and time in identifying and maintaining property listing;
- High time-consuming process —gathering and validating relevant document from legal sources takes over a month;
- Floating transaction costs, property rights opaqueness, and variability in taxes;
- The manual verification process is prone to fraud and loss of information.

To solve most of these problems, it is argued that blockchain technology has the potential to achieve the disintermediation of real estate conveyancing and land registration processes [13].

3. Blockchain

Blockchain, although originally created 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. Blockchain technology can be described as:

> "A blockchain contains secure history of data exchanges, utilizes peer to peer time stamp and verify 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 key 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 transaction. Private keys gives a 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 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." [2]

The blockchain was first acquainted as an instrument with forestall twofold spending in the shared electronic money framework Bitcoin [11]. Nakamoto, the inventor of Blockchain, proposes 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" [14].

4. Research Methodology

A SLR, 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 [5]. The guidelines to make a SLR are different according to each source. To do the SLR, we've adopted the stages of Kitchenham and Charters which consist in:

1. Planning the Review
  1.1 Identification of the need for a review
  1.2 Commissioning a review
  1.3 Specifying the research question(s)
  1.4 Developing a review protocol
  1.5 Evaluating the review protocol
2. Conducting the Review
  2.1 Identification of research
  2.2 Selection of primary studies
  2.3 Study quality assessment
  2.4 Data extraction and monitoring
  2.5 Data synthesis
3. Reporting the Review
  3.1 Specifying dissemination mechanisms
  3.2 Formatting the main report
  3.3 Evaluating the report

There are many reasons for undertaking a SLR; Kitchenham and Charters 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 to appropriately position new research activities.

According to them, the advantages of doing a SLR 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. The major disadvantage is that they require considerably more effort than traditional literature reviews.

4.1 Planning the Review

Before undertaking a SLR, it's necessary to confirm the need for such a review [5]. Our Planning consists of explaining the background of the review and the research goal and questions.

Background of the review

The need for this SLR arises from the fact that while there exists diversified studies about blockchain in real estate, there isn't one that comprehends all (or at least all the surveyed) advantages and challenges of the use of the technology in the sector with examples of pilot projects. Literature of blockchain in real estate constitutes case studies, frameworks, surveys, and theory about the challenges/constraints and opportunities/benefits.

Research goal and questions

Although there are several studies on blockchain applied to real estate, to our knowledge, it doesn't exist one which comprises so many advantages and challenges and specifies in which countries blockchain is already implemented. Thus, we developed three guiding research questions:

- RQ1. What are the advantages associated with the implementation of blockchain in the process of land registry?
- RQ2. What are the challenges associated with the implementation of blockchain in the process of land registry?
- RQ3. Which examples of pilot projects of blockchain already exist for land registry?

4.2 Conducting the Review

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 which presents the data sources, the Search Terms where its presented the search string and the fields in which we applied it, and finally the Exclusion Criteria which includes the reasons and stages regarding the studies found that were excluded.

Search Term

To capture blockchain and real estate we used the search string; blockchain AND "real estate". The reason we used “real estate” instead of “land registry” is that “real estate” is more comprehensive in its approach to apply Blockchain. 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 the abstract, title, and keyword (Scopus).

Data collection

The electronic databases were searched on November 12th, 2020 and included reviews identified as relevant to real estate and blockchain. 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).

Exclusion Criteria

Our exclusion criteria mirror the focus on studies that report direct evidence regarding the advantages and challenges of the use of blockchain for real estate and/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 covered real estate but not blockchain and vice-versa (out of scope); Studies written in another language than English; Studies that were Master Thesis.

The figure below represents a funnel chart that shows the number 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 containing the number of papers that remains eligible for our review. As shown by the funnel chart, the number of eligible papers for our work is 43.

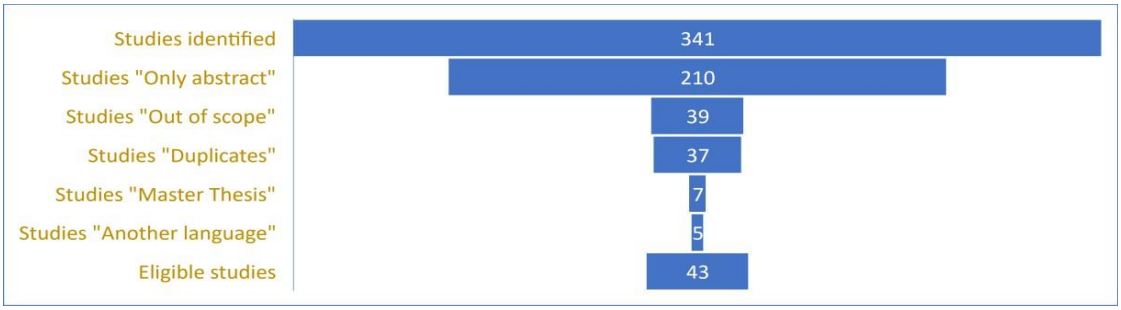

Figure 1. Funnel chart representing the number of papers identified, excluded from each criterion and eligible for our review.

4.3 Reporting the Review

In this section, we present 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 land registry.

Advantages of Blockchain in land registry

This section consists of a table that comprises the advantages of Blockchain in land registry. The advantages are defined as characteristics or opportunities of Blockchain that contribute or add benefit to land registry.

Table 1: Opportunities 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 [21].
Transparency of the process	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 [19].
Efficiency/Speed up the process	The system is easily established, connected and expanded. Structured and standardized data can form the input for internal workflows and analyses [15], [22].
Decentralization	"Decentralization in blockchain is very useful because there is no single point of failure which makes it resistant to attacks." [23]
Tokenization	"Tokenization of real estate represents the release of tokens, indicating the right to a part of the property." [6]
Immutability of records	"Blockchain data is (theoretically) immutable and thus not subject to arbitrary manipulation" [19].
Smart Contracts	"Revolutionise real estate transactions by enabling lower costs, and better accessibility and speed" [19].

Challenges of Blockchain in land registry

This section consists of three tables that merge the challenges of Blockchain in land registry, each one being a category: **security of blockchain**, **properties of blockchain**, and **associated with the society**. These are associated respectively with three main challenges reported in the literature: the aspect of the security Blockchain, problems regarding blockchain' properties, and society-associated constraints. The challenges are defined as characteristics or consequences of Blockchain that don't contribute to land registry or add barriers to the adoption.

Table 2: Challenges of Blockchain – Associated with Society

Challenge	**Description**
Legality (legal framework needed which enables international adoption)	"A legal framework for blockchain transactions is needed which enables international adoption" [19].
Human involvement (job losses, less flexibility)	"Dealing with systems instead of people means less flexibility and potential for job losses" [19].
Initial information capture	Getting correct and agreed upon initial information transferred onto the blockchain is a bottleneck [19].
Human adoption	It should benefit their target users to bring incentives for adoption. The long-term financial benefits must be clearly understood. "Trust and support from all stakeholders are required to develop and for the adoption of the system" [17], [19].
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) [3].

Table 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 [15].
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 [8].
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 [22].

Scalability of the network	"It's difficult to execute real-time, large volume handling". "Overload with the transactions creates the problem of high transaction fees and price volatility" [15], [8].

Table 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 [23].
Fraud in Programming	The frauds inside code can be exploited by attackers to take out properties of Blockchain [18].
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 [18].
Eclipse attacks	In these attacks, adversaries stop the legitimate nodes from making a connection to honest peers [18].
Distributed denial-of-service attack (DDoS)	With the help of collaborative attacks, the Blockchain resources are exhausted by the adversaries [18].
Smart contracts vulnerability	Due to the irreversibility and openness of Blockchain, smart contracts are very susceptible [18].
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 [18].

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." [6]. In this section, we present the countries which have or had already implementations of Blockchain in Real Estate. Veuger says Estonia and Dubai are also running pilots but doing so in silence [21]. Georgia, Sweden, Ghana or The Netherlands are some examples of countries shown in this section.

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 company Telia) launched a pilot project to evaluate potential blockchain applications for real estate transactions [4]. This technology's pilot trial in the land registry is predicted to save about €100 million [13]. 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) [12].

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) [4]. 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 [4].

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 [4] 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.

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 [16]. 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 [4]. According to her, 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. She 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, the project never kicked off [8] and no evidence is found that the government has

ever supported this initiative. Nasarre-Aznar agrees with this by saying the project was announced in 2015 and abandoned by the end of that year for non-technological reasons [13].

Ghana

Bitland has been in Ghana since 2014 on a project to "register land and real property ownership and use rights" using blockchain [8]. He 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 [12]. 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 [8].

USA

REX, founded in the USA in 2016, promised a new multiple listing system (MLS) standard for real estate brokers [8]. 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 [8].

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 [6].

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 and the management and unification of all procedures related to property "[12]. Mezquita et al also say the intention of using blockchain technology in Japan is to unify all data on empty or unowned properties, land and unproductive spaces, unknown owners, and unidentified tenants or users before agencies [12]. To conclude, although there is no more information about the trials carried out in different Japanese cities since the summer of 2018, it is expected to cover all of Japan in 2022.

5. Discussion

For most part of the literature, Blockchain is considered relevant and suitable to land registry; 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 [8], 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.

5.1 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 [13].

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 [7]. 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 [8]. Tokens are a digital representation of the economic value and ownership of property and these, as a technological concept, are the closest solution to the legal concept of titles [22,8]. Users create, update, delete tokens and transfer them within the blockchain via a mechanism of public-key cryptography.

Konashevych 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 [8]. He 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 (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 [13]. 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 (cadaster) registry, because blockchain is a registry itself and a secure repository, where no transaction can be revoked or altered [9]. 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 [7].

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 [13].

5.2 Challenges of the use of Blockchain in land registry

Tokens and Tokenization

A token does not necessarily have any legal side, the same as not every record on paper creates

any legal relationship [8]. “Thus, the use of tokens for real estate requires legislative changes that legitimize new procedures of acknowledgment and recording on the blockchain” [7]. 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 [8], hence the tokens shall not 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 [22] 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 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 [22].

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 [9]. 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 [8]. Regarding the legislative level, seven European Union countries (Cyprus, France, Greece, Italy, Malta, Portugal, and Spain) signed in December 2018 a Ministerial Declaration on Distributed Ledger Technologies in which these countries confirm that “any legislation on DLTs should take into account the decentralized nature of such technology and should be based on European fundamental principles and technological neutrality” [3]. 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 [8].

6. Conclusion

The purpose of this work was to summarize the knowledge of the existing literature about Blockchain and Real Estate, but we came across mostly about one area which was land registry. 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 constraints and benefits and some countries have been developing pilot projects and are exploring the technology.

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 make use of and are a notable share of data from the digital libraries, consequently reducing knowledge disseminated between the scientific community.

Utilizing the summarized information, we suggest for next steps to analyze each implementation of blockchain in land registry in each country and compare the results. In addition, we suggest how Blockchain can impact the entire real estate area, not just the land registry, and discuss the adoption of one or more types of Blockchain (private, public, and consortium) and the possibility of creating a specific DLT for this sector.

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