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REAL ESTATE SECTOR**

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IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

SWORN DECLARATION In Madrid, on September 27th, 2023

I, Samuel García García , of legal age, with DNI/NIF núm.02564985W and domiciled at C/del Alerce 13, declare under solemn promise that I make to all legal effects, aware of the responsibilities of legislative order that this entails. And for the record and for the appropriate effects, I sign this declaration in Madrid, on September 27th, 2023.

Signed by Samuel García García

A handwritten signature in black ink, appearing to read 'Samuel', written in a cursive style.

INDEX

INDEX	3
ABSTRACT	5
ACKNOWLEDGEMENTS	6
SUBJECT OF STUDY (DELIMITATION)	7
STUDY OBJECTIVES	8
JUSTIFICATION OF THE SUBJECT OF STUDY	9
STATE OF THE ART	10
I. History and evolution	11
II. Blockchain applications in different sectors	12
III. Current status of the blockchain technology in the real estate sector	13
IV. Current problems in the real estate sector	15
1. Legal challenges	16
1.1 Verification of the identity of the involved parties	16
1.2 Control of the legality and effectiveness of the contract	16
1.3 Co-ownership and other rights in rem	17
1.4 Possibility of amending the blockchain	18
V. Solutions proposed by the blockchain technology in the real estate sector	18
1. Improved Transparency:	19
2. Efficient and Secure Transactions:	19
3. Tokenization of Real Estate Assets:	20
4. Enhanced Property Management:	21
5. Improved Land Administration:	21
6. Improved Due Diligence:	22
7. Secure and Immutable Records:	23
8. Data Sharing and Interoperability:	23
VI. Cases of empirical applications on the real world	24
1. Construction	24
2. Transactions and management of properties	25
ANALYSIS OF RESULTS	28
I. Analysis	28
II. Evaluation	28
III. Discussion	29
PRACTICAL APPLICATIONS	30
I. Impact and role of blockchain in the construction sector	30
1. Role of Blockchain in Construction	30
1.1 Implications:	30
1.2 Notion of value:	31
1.3 The construction of the Value Chain (Visual representations)	31
II. Conceptual framework for blockchain adoption in the smart real estate buy/rent process	33
III. Intermediaries involved in a real estate transactions	35
1. The role of intermediaries in the acquisition of property and the creation of mortgages	36
1.1 The Latin notary system	
1.2 The central and eastern European system	36

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

1.3 The solicitor or licensed conveyancer system	36
1.4 The Nordic countries' system	36
2 The role of intermediaries in the acquisition of property and the creation of mortgages	37
IV. Smart contract delivery through decentralized applications and Ethereum Virtual Machine (EVM)	39
1. Decentralized applications (DApps)	39
2. Ethereum virtual machine (EVM)	40
V. Implementation and termination of the Smart Contract	40
FUTURE TRENDS	42
CONCLUSIONS OF THE RESEARCH	44
LIMITATIONS OF THE RESEARCH	46
BIBLIOGRAPHY	48
RESEARCHER CV	51

ABSTRACT

The real estate sector is characterized by complex transactions, heavily relying on intermediaries, leading to inefficiencies and potential security vulnerabilities. This research examines the incorporation of blockchain technology as a revolutionary solution to enhance transparency, security, and operational efficiency in real estate transactions and processes. Through a qualitative case study methodology, it is evaluated the influence of integrating blockchain in a diverse range of real estate transactions, going from property transfers to the utilization of smart contracts for lease agreements. The results indicate a notable decrease in transactional friction, a reduction in instances of fraudulent activities, and an increase in transparency through the immutable ledger. Moreover, smart contracts executed on the blockchain show promise in automating aspects of property management, streamlining rental procedures, and ensuring adherence to regulatory requirements. This paper aims to address potential difficulties related to regulatory frameworks and scalability and offer recommendations to overcome them. This study contributes to the expanding body of work on the practical application of blockchain technology across various industries, presenting valuable insights for stakeholders keen on harnessing blockchain's potential in the real estate sector.

Keywords: Blockchain Technology, Real Estate, Smart Contracts, Transparency, Security, Efficiency.

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

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SUBJECT OF STUDY (DELIMITATION)

The object of study of this research project refers to the integration of blockchain technology in the context of the real estate sector. The aim is to explore in detail and analyze how this innovation and possibility of application can influence and transform the processes and transactions used in the construction, purchase, sale, management and registration of real estate. Blockchain technology, known and used for its ability to have transparent and immutable records, emerges as a potential possibility to address the integrity and security concerns that have historically characterized the real estate sector.

Throughout this research, the fundamentals of blockchain technology will be delved into, highlighting its decentralized nature and its ability to generate consensus within a distributed network. It will analyze how these features translate into tangible and intangible benefits for the real estate sector, including reducing intermediaries, verifying the authenticity of properties and simplifying processes and transactions. Also, the challenges that have to do with the implementation of this technology will be addressed, taking into account technical, legal and regulatory aspects. Through these different perspectives and aspects, it is intended to provide a complete and updated vision of the application of blockchain technology in the real estate sector, with the aim of contributing to the modernization, development and strengthening of the real estate sector, economically and socially.

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

STUDY OBJECTIVES

Once the entire theoretical framework on which the entire research project is based has been defined, the description of the topic and the problems that the application of blockchain technology in the real estate sector may incur and the way in which it can help to solve the major problems that the brick industry presents internationally, there must be presented the objectives on which this project should focus.

Mainly, there is a core objective and it is about being able to provide the reader of this paper with the wide knowledge needed to understand this specific industry correlating the blockchain technology and the real estate sector by achieving the following objectives shown below

-Provide a detailed global view of the real estate industry and the blockchain technology

This first objective aims to offer a comprehensive overview of both the global real estate industry and the underlying blockchain technology, providing a detailed understanding of their current state and potential synergies.

-Demonstrate how blockchain technology can help increase transparency in real estate transactions and reduce the need of intermediaries

This objective seeks to illustrate how blockchain can revolutionize real estate transactions by enhancing transparency and minimizing reliance on intermediaries. It will showcase the transformative impact of blockchain on the industry's traditional transactional processes.

-Show how blockchain technology can be applied to change real estate transactions through the detailed use of smart contracts in them.

This objective delves into the practical application of blockchain technology within real estate transactions, emphasizing the implementation of smart contracts. It will provide in-depth examples of how these self-executing contracts can streamline and redefine real estate dealings and construction

-Exhibit various previous successful real case applications on this industry

This objective aims to present a collection of notable real-world instances where blockchain technology has been successfully integrated into the real estate industry. These case studies will serve as compelling evidence of the technology's potential and effectiveness.

-Offer tips for future researchers in this area to continue investigating

The final objective is to provide valuable guidance for future researchers interested in exploring the intersection of blockchain and real estate. It will offer insights, methodologies, and areas of focus to support ongoing investigations in this dynamic and promising field.

JUSTIFICATION OF THE SUBJECT OF STUDY

The integration of blockchain technology into the real estate sector represents a critical frontier in modernizing and streamlining property transactions. This research pretends to highlight the pressing need for a comprehensive understanding of the implications, challenges, and potential benefits associated with such implementation. Real estate transactions, which are characterized by their complexity and reliance on intermediaries, are bound to benefit significantly from the inherent transparency, security, and efficiency that blockchain technology promises to offer.

Moreover, as the real estate industry stands on the peak of a technological revolution, the need for empirical research and rigorous analysis is required. Blockchain's potential to revolutionize property transactions is widely acknowledged, but a deepened understanding of its real-world applications and implications is requisite. By undertaking this study, the author aims to connect the gap between theoretical potential and practical implementation, providing stakeholders in the real estate sector with actionable insights grounded in empirical evidence.

In a rapidly evolving digital landscape, it is imperative to explore innovative solutions that not only enhance the efficiency of real estate transactions but also more secure and integral property records. Blockchain technology has arisen as a solution for this topic, with its immutable ledger and decentralized architecture offering a robust foundation for a more secure and transparent real estate ecosystem. This study seeks to elucidate the precise mechanisms through which blockchain can be harnessed to address longstanding challenges within the sector, thereby facilitating a seamless transition towards a more technologically advanced real estate industry.

Furthermore, the timing of this research is acutely pertinent, as the global real estate market grapples with the need for greater digitization and modernization. Also, the COVID-19 pandemic has accelerated the shift towards digital platforms and remote transactions, making the integration of blockchain technology even more pressing. With physical proximity and traditional methods of transaction being challenged, the need for secure, remote, and transparent property transactions has become an urgent priority. This study is led to design timely insights and recommendations that can inform strategic decisions in the real estate sector, ensuring its resilience and adaptability in an increasingly digital landscape.

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

STATE OF THE ART

For the last decade, the blockchain technology has created a whole new way of transmitting information, and even though it has been known for a couple decades, the importance of it has been on the rise lately. Much is it, that it has changed the Information Technology industry forever.

Through this technology, the informational flow of things and computers is not only bidirectional, they are not anymore centralized, with a central receiver antenna and storage space, but instead, all the computers, or better known in the industry as nodes (senders), communicate between them, leaving the old bilateral communication flow aside, leaving space for this new disruptive technology, in which, with a distributed ledger (DLT), the computers connected allow for a more secure, efficient and most importantly, disruptive information flow take more room in the space.

Due to the importance of this, the author has made the aim of this paper, to make a bibliographic review and evaluation of this technology to dig deeper on the use cases of the blockchain technology. Even though it could be applied to many industries, the author has led the study to blend this technology with one of the biggest sectors in the whole planet, and to one with vast investment around the world, and it is real estate.

For the last few years, the convergence of blockchain technology and the real estate sector has garnered significant attention, promising transformative changes in transaction management and construction. Blockchain, founded on principles of decentralization and transparency, offers an immutable ledger, reducing risks of fraud and manipulation, therefore, this integration holds potential for substantial cost savings and heightened trust among transaction participants, being these very important totems within the real estate industry.

“Currently, only around 9% of real estate companies have implemented blockchain-based solutions, indicating room for expansion” (Deloitte, 2021). Overcoming technological barriers and establishing regulatory frameworks are key for wider adoption, through the address of the critical challenge of transparency and security within transactions is paramount, with blockchain providing an immutable and transparent record, fostering trust.

Related to it, *“the adoption of smart contracts, carried by blockchain, can significantly streamline transactional processes, potentially reducing operating costs by up to 25%”* (Capgemini, 2020). These self-executing contracts, are key to be able to develop the blockchain technology within any sector, it is the communication between nodes and the fuel of the value of this disruptive technology, this term of smart-contract, might sound new and difficult, but the paper will later delve deeper into them.

This efficiency not only benefits the industry internally but also enhances client satisfaction and revenue, due to this, it is said that blockchain's impact extends beyond efficiency, *“with transaction speed becoming a priority for 64% of buyers and sellers”* (PwC,2022).

The integration of blockchain technology will be in need of substantial transformations in legal, IT, and operations departments within real estate companies or any other sector, through the collaboration across these departments which, will be crucial for successful implementation, blockchain promises to revolutionize real estate operations,

offering opportunities for efficiency, transparency, and trust in property transactions.

Foundational concepts of blockchain technology, including decentralization, distributed ledger, and cryptographic security, form the bedrock of its robustness. The process would be impossible and inaccessible without the involvement of miners and the process of mining which, ensure the integrity of the blockchain by solving complex computing calculations or puzzles in order to create nodes and Bitcoins (the money or payment within the blockchain), in exchange of a percentage of it as a reward, and together with the cryptographic signatures and smart contracts, it strengthens security, immutability, and efficiency.

However, challenges such as scalability, regulatory frameworks, data storage, and adaptability constitute hurdles to widespread implementation of blockchain technology, so addressing these challenges is crucial for realizing the full potential of blockchain across various industries.

Even though this technology is very new and disruptive it has had some real use cases across most of the industries and has tackled a variety of problems, solving them and creating new ways of stacking knowledge. Although these research studies have provided society with vast knowledge and applications, there is way more room to fill and way more fields to take this blockchain technology into, in order to explore its full potential.

Due to this, the author has deployed some of the research made in the past few years, together with the real cases applying the technology, but there is a lot of research to do and more trends that will come up in the near future and will be in need of the blockchain to solve their problems little by little.

To sum up, the incorporation of blockchain technology into the real estate industry holds significant potential. It tackles crucial issues, improves transparency, and simplifies operations. Fundamental principles of blockchain, such as decentralization and cryptographic security, form a strong foundation for its utilization, therefore effectively addressing obstacles is essential for unlocking the revolutionary capabilities of blockchain in real estate and beyond. These fundamental ideas will be fundamental for deeper investigations in this field, and because it is very new and disruptive, it has a huge room to fill and investigation to go, in order to squeeze out all of its potential.

I. History and evolution

The genesis or beginning of blockchain technology can be traced back to 2008 with the introduction of Bitcoin by the mysterious figure, or group, known as Satoshi Nakamoto. Bitcoin, a decentralized digital currency, operated on a pioneering peer-to-peer network, offering a glimpse into the transformative potential of blockchain. The subsequent launch of the Bitcoin blockchain in 2009 established the foundation for secure transaction recording and distributed ledger creation. This seminal moment marked the birth of blockchain technology in its recognizable form.

As blockchain technology matured, it extended its reach far beyond its initial association with cryptocurrencies. The year 2013 witnessed the creation of Ethereum, a groundbreaking platform that introduced the concept of smart contracts. *“These self-executing agreements unlocked the potential for programmable transactions without the need for intermediary*

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

intervention, opening up new fields of possibilities within the blockchain ecosystem” (Buterin, V. 2014). This pivotal development signified a shift towards broader applications in diverse industries.

The subsequent years witnessed a surge in interest and adoption of blockchain technology across various sectors. *“Organizations and enterprises began to explore its potential in domains such as supply chain management, healthcare, finance, and notably, real estate. This exploration heralded a new era where blockchain's decentralized, transparent, and secure nature promised to revolutionize established industry practices”* (Swan, M. 2015)

The evolution of blockchain technology led to the emergence of different blockchain types, each tailored to specific use cases. Public blockchains, open to all participants, coexisted with private blockchains, offering restricted access to a select group. Consortium blockchains, shared among a collective of organizations, demonstrated the adaptability and versatility of blockchain technology to meet a diverse array of needs.

Recognizing the challenges and limitations associated with blockchain, big steps were made in addressing issues of scalability, privacy, and interoperability. *New consensus algorithms, such as Proof of Stake (PoS) and Byzantine Fault Tolerance (BFT), were developed to enhance the speed and efficiency of blockchain networks* (Cachin, C. 2016). These advancements represented critical milestones in enhancing the practicality and viability of blockchain technology across industries.

Basically, the journey of blockchain technology from its beginnings in cryptocurrencies to its current state as a multifaceted, industry-transforming force is proof of its remarkable evolution. With its decentralized, transparent, and secure attributes, blockchain stands poised to redefine conventional practices across various sectors, including the dynamic realm of real estate.

II. Blockchain applications in different sectors

Blockchain technology, with its fundamental principles of decentralization, transparency, and security, has demonstrated remarkable potential in revolutionizing various industries. The applications of blockchain extend far beyond its initial association with cryptocurrencies. Some of the key sectors where blockchain technology is poised to bring transformative changes include some of the following.

Blockchain's impact on the financial and banking sector is profound. Its ability to facilitate secure and transparent transactions, coupled with features like smart contracts and identity verification, promises to reshape traditional banking operations. Moreover, blockchain has the potential to bridge the gap in financial accessibility, opening up banking services to previously underserved populations all around the world.

Adding up, blockchain technology's role in enhancing transparency and traceability within supply chains is key, because, by recording and verifying the movement of goods, it provides an immutable ledger that ensures the authenticity of products. This application of blockchain not only combats fraud and counterfeiting but also streamlines logistics operations, improving overall efficiency.

Another one is the healthcare sector , which stands to benefit significantly from

blockchain's capabilities. The secure storage and sharing of patient health records not only safeguard privacy but also enable seamless interoperability among various healthcare providers. Additionally, blockchain can revolutionize clinical trials, drug traceability, and administrative processes in healthcare, creating with it a huge number of options to be developed in the near future.

Then comes the most important impact for this research paper, and it is the real estate sector, in which blockchain has the potential to revolutionize property transactions. Through automated property title transfers and the introduction of fractional ownership, blockchain streamlines the cumbersome processes associated with real estate transactions. By providing a transparent ledger of property ownership, it addresses concerns related to fraud in the real estate market and many more changes that it could provide, which idea will be later developed.

Also its application in voting systems addresses a critical need for secure and transparent elections. By providing an unalterable record of votes, blockchain ensures the integrity of the electoral process and safeguards against voter fraud. This technology introduces an auditable system that enhances trust in democratic processes.

Next comes its introduction into the energy sector, which brings about the potential for groundbreaking changes, through the facilitation of peer-to-peer energy trading and the establishment of decentralized energy grids, blockchain empowers consumers in the energy landscape. Additionally, it offers transparent tracking of energy transactions, optimizing the distribution of energy resources.

Linking with every other sector or industry, it also applies to the way, processes are made and products are created, in the realm of intellectual property rights, blockchain offers robust protection and serves as an unforgeable ledger for tracking ownership and managing digital rights by providing indisputable proof of ownership, blockchain safeguards the creative and intellectual endeavors of individuals and entities.

In conclusion, the applications of blockchain technology extend across a diverse array of sectors, promising to revolutionize established practices and systems. Its decentralized, transparent, and secure nature positions blockchain as a transformative force with far-reaching implications for industries worldwide. The continued exploration and integration of blockchain technology hold the key to unlocking its full potential in driving innovation and efficiency across sectors.

III. Current status of the blockchain technology in the real estate sector

The application of blockchain technology in the real estate sector is currently in its nascent stage, characterized by a growing interest in its potential benefits. *“Empirical research indicates that while there is significant promise, the actual implementation and utilization of blockchain in the sector remain limited”* (Saari, A., Vimpari, J., & Junnila, S. 2022).

The existing applications of blockchain in real estate primarily revolve around land administration, where the technology's capabilities in enhancing efficiency, transparency, and automation have been demonstrated. These applications showcase blockchain's potential to revolutionize processes related to property ownership and land registration.

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

Pilot projects and initiatives have emerged as promising indicators of blockchain's

potential impact on the real estate sector. For instance, Sweden has conducted a notable pilot project utilizing blockchain for property transactions, demonstrating the feasibility and advantages of the technology in this context. The project showcased the secure and transparent recording of property transactions, highlighting how blockchain can mitigate fraud and enhance the overall integrity of property transactions. Additionally, Dubai's "Blockchain Strategy" represents a significant step towards digitizing government transactions, including those related to real estate. Such ambitious initiatives reflect a growing recognition of blockchain's transformative potential in the real estate sector and signify a willingness to invest in its development and implementation.

However, *“it is essential to note that the adoption of blockchain in the real estate sector is more prevalent in smaller-scale, hybrid settings. In such scenarios, blockchain serves as a supplementary layer to existing systems, showcasing its potential as an add-on solution to enhance existing processes”* (Saari, A., Vimpari, J., & Junnila, S. 2022). This approach allows for a gradual integration of blockchain technology into the real estate sector.

The challenges and barriers hindering the widespread adoption of blockchain in real estate are multifaceted. Regulatory frameworks, or the lack of them, play a pivotal role in shaping the landscape for blockchain adoption. Additionally, *“the political will to implement blockchain solutions, availability of reliable digital data, and the establishment of public-private partnerships are crucial factors influencing the technology's integration into the sector”* (Saari, A., Vimpari, J., & Junnila, S. 2022).

Furthermore, education and awareness regarding blockchain technology among stakeholders in the real estate industry are key for successful implementation. It is essential to educate and provide a comprehensive understanding of blockchain's potential benefits to the population in order to take steps towards realizing its transformative impact in the real estate sector.

While blockchain's current status in the real estate sector is characterized by early-stage adoption and limited empirical applications, it is important to acknowledge the technology's trajectory. The trajectory suggests a steady progression towards broader adoption and integration within the sector. As regulatory frameworks evolve to accommodate blockchain applications, and as industry stakeholders gain a deeper understanding of its benefits, we can anticipate a more extensive utilization of blockchain technology in real estate. Moreover, ongoing research and development endeavors continue to explore innovative use cases and refine the technology's application, further laying the groundwork for its future prominence in revolutionizing real estate processes and transactions and, therefore, this dynamic landscape positions blockchain as a pivotal force in shaping the future of the real estate industry.

In conclusion, while the potential for blockchain technology in the real estate sector is significant, its current status is characterized by a promising yet early stage of development. The empirical applications and explorations serve as foundational steps towards realizing the full potential of blockchain in revolutionizing real estate processes. As regulatory frameworks evolve, and industry stakeholders continue to embrace this innovative technology, blockchain's role in the real estate sector is expected to evolve and expand, ushering in a new era of efficiency, transparency, and security.

IV. Current problems in the real estate sector

The real estate sector stands as a cornerstone of global economies, playing a pivotal role in shaping communities and facilitating economic growth. However, this vital industry is not without its share of challenges. From issues of transparency and accessibility to environmental sustainability, the real estate sector grapples with an array of complex problems that necessitate innovative solutions. In this context, it is imperative to delve into the current problems afflicting the real estate sector, as a precursor to exploring how blockchain technology may offer a transformative path forward.

The accessibility of financing for real estate purchases remains a persistent challenge, particularly for individuals with limited credit history or those seeking to enter the housing market for the first time. This issue can impede potential buyers from realizing their homeownership aspirations and can also have broader implications for the growth and vitality of the real estate market. Efforts to improve access to financing, including innovative lending models and policies aimed at supporting first-time buyers, are essential in addressing this concern.

The management of properties, including tasks such as rent collection, maintenance, and tenant screening, can often be characterized by inefficiencies. *“Outdated and manual processes can lead to administrative burdens for property owners and managers, potentially resulting in decreased overall profitability and tenant satisfaction”* (Swan, M. 2015). The implementation of modern technologies and platforms, including blockchain-based solutions, offers opportunities to streamline property management and enhance operational efficiency.

The shortage of affordable housing remains a pressing issue in many regions, driven by factors such as escalating property prices, stagnant wage growth, and limited housing supply. This affordability crisis poses significant challenges for individuals and families seeking suitable and reasonably priced housing options, and it necessitates comprehensive strategies that address both supply and demand factors. Policy interventions, such as incentives for affordable housing development and rent control measures, are among the approaches employed to mitigate this concern.

The real estate sector exerts a substantial environmental footprint, encompassing areas such as energy consumption, carbon emissions, and land use. Balancing the demand for development with sustainable practices is a critical challenge for the industry. *“Implementing environmentally conscious construction techniques, energy-efficient building designs, and adopting renewable energy sources are pivotal steps in mitigating the sector's environmental impact”* (Miceli, T. J., Sirmans, C. F., & Turnbull, G. K. 2015). This is a subsequent condition related to the next point.

The rapid pace of urbanization and population growth places considerable strain on the real estate sector, necessitating adequate urban planning and infrastructure development. *“Meeting the demand for housing, transportation, and other critical infrastructure components in burgeoning cities requires strategic planning and investment”* (Geltner, D., Miller, N. G., Clayton, J., & Eichholtz, P. 2014). Collaboration between public and private entities, as well as innovative urban planning approaches, are essential in effectively addressing this challenge.

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

1. Legal challenges

In the establishment of a real estate conveyancing system, it is vital to address both the costs related to smart contracts and the network's scalability. To mitigate these expenses, potential approaches involve utilizing a permissioned blockchain regulated by a central authority for cost control, or employing a proof of authority mechanism (POA) with the administration as the transaction validator. This ensures that financial considerations do not impede individuals from registering their property rights.

At the same time, adopting a blockchain-based real estate conveyancing system, also known in the industry as “proptech” poses specific hurdles which encompass:

- Verification of parties' identities
- Ensuring contract legality and protecting rights in rem
- Facilitating co-ownership registration
- Enabling ledger modifications

1.1 Verification of the identity of the involved parties

In contemplating the adoption of blockchain technology for real estate transactions, a fundamental consideration lies in verifying the true identities of involved parties, a matter subject to public oversight.

Supplementing the blockchain with an official identification system becomes essential for establishing a robust real estate conveyancing system, therefore, this measure not only enhances security but also empowers legitimate digital property owners to substantiate their rights over a specific asset.

Scholars have underscored the creation of a transnational e-ID through blockchain as a pivotal stride towards broader incorporation in real estate applications.

Simultaneously, aligning the blockchain with an official ID acts as a safeguard against potential legal complications stemming from the loss of a private key for a digital wallet. This circumstance could lead to the forfeiture of access to the cryptocurrency it holds. It is crucial to understand that the mere loss of a key does not imply abandonment of property; rather, an explicit intention to relinquish it is required.

1.2 Control of the legality and effectiveness of the contract

It is key to mention that lawyers, notaries, and, in specific jurisdictions, land registries play a vital role in ensuring that a given real estate transaction adheres to the minimal legal prerequisites. They also provide the purchaser with information concerning any existing encumbrances and property rights.

Unlike a distributed database, blockchain cannot offer similar guidance on the ramifications of a specific transaction, nor can it autonomously conduct a prior examination of the legal prerequisites. At present, blockchain and smart contracts are confined to verifying the satisfaction of predetermined conditions.

Due to this, it is imperative that this supervision is conducted. A swift resolution might involve engaging a lawyer, notary, or other authorized entities responsible for authenticating the transaction in permissioned distributed ledgers. Alternatively, this validation could be accomplished through the utilization of "oracles", which are external entities tasked with verifying real-world events and providing the information to the blockchain.

As a proposed solution for this, artificial intelligence (AI) could be utilized to compare clauses within the smart contract against a database of unfair terms (e.g., a registry of general conditions, like the Spanish Registro de las Condiciones Generales de la Contratación). This approach would facilitate genuine disintermediation without compromising safeguards.

1.3 Co-ownership and other rights in rem ¹

Contemporary initiatives focused on blockchain and smart contract deployment enable property proprietors to engage in sales while simultaneously logging the transaction. Nevertheless, the spectrum of rights feasible for establishment and recording in land registers extends beyond. Translating particular rights into smart contract code, encompassing both rights in rem and even stipulations within tenancy contracts, can pose a challenge.

Moreover, a diverse variety of scenarios might present more complexities when integrating them into a blockchain (e.g., co-ownership with varying shares, shared ownership, temporal ownership, etc.). Similar intricacies arise concerning usufruct, right to construct, right to utilize, servitudes, options, and analogous rights.

As proposed by Pilkington in 2006, *“a prospective remedy for this challenge involves the concept of a sidechain. This operates as a distinctively managed ledger, equipped with its own software code, and is 'pegged' to the principal blockchain ledger. This arrangement facilitates the transfer of crucial information from one chain to another.”* (Pilkington,2006).

“Certain advances have been made through tokens or colored coins, associating specific rights with a token in a manner such that when parties effectuate token transfers via blockchain, the corresponding right is either established or transferred” (EU Parliament, 2018). For example, Altestate pioneered the inception of tokens symbolizing housing rights, which users employ to exchange square meters of their properties. Likewise, Homelend empowers parties to establish mortgages.

However, conferring distinct rights over the same property may not represent the most prudent recourse. In such instances, prospective third-party acquirers might remain uninformed about potential encumbrances.

¹ A right in rem, which constitutes an enforceable claim against any party worldwide, is contingent on distinct relationships, statuses, or specific properties. (Aarika. n.d. “Rights in Rem and Rights in Personam.” CAclubindia. Accessed September 28, 2023. <https://www.caclubindia.com/articles/rights-in-rem-and-rights-in-personam-49596.asp>.)

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

1.4 Possibility of amending the blockchain

Finally, legal systems commonly account for situations where property ownership can be transferred without the former owner's agreement or the alteration of specific rights or properties under certain circumstances.

Challenges to property ownership may arise due to declaratory actions, potentially leading to a change in ownership rights. Similar situations can occur in cases involving illegal activities requiring annulment, operational mistakes, or alterations in a property's physical condition.

Within blockchain systems, addressing this challenge can be approached in two distinct ways:

1. Appointing a specific authority with the power to initiate a new transaction in favor of the rightful owner (e.g., in cases disputing property ownership or instances of accession), with the costs of this new transaction borne by the party that did not prevail.

2. Establishing a blockchain platform that allows for modifications. Some administrators of the blockchain may possess the capability to make changes, potentially enabling public authorities to alter the blockchain if circumstances demand it (e.g., as a means to grant an heir ownership of a particular asset without the explicit consent of the testator or in cases where property ownership is contested). While this application differs from the initial aim of disintermediation pursued by blockchain technology, it is vital for upholding the current level of protection provided to parties involved.

These issues collectively underscore the multifaceted nature of challenges facing the real estate sector. Finding innovative, scalable, and sustainable solutions to these problems is crucial for the continued growth and evolution of the industry.

In the next section, the implications of these challenges on the adoption and implementation of blockchain technology within the real estate sector will be explored, providing a comprehensive overview of the potential benefits and considerations for this transformative technology.

V. Solutions proposed by the blockchain technology in the real estate sector

Blockchain technology can be used for many aspects of industries and life, but in this research paper it is prone to revolutionize the real estate sector, offering a spectrum of transformative solutions to entrenched challenges. These proposed solutions have the potential to redefine the way transactions are conducted, data is managed, and ownership is recorded within the real estate industry. By leveraging the inherent strengths of blockchain, the following solutions can be realized to help solve the proper problems of the real estate industry, and these solutions are explained in the following points.

1. Improved Transparency:

Blockchain technology holds the promise of transforming the real estate industry by coming along in an era of unprecedented transparency. At its core, blockchain provides an immutable ledger that records all real estate transactions, ownership records, and comprehensive property histories. This foundational shift addresses a long-lasting issue in the sector, where opacity and lack of clarity have been ongoing challenges. By creating a permanent record accessible to all relevant parties, blockchain mitigates the risk of fraud and corruption. It significantly reduces the scope for dubious practices that have flooded the industry. *“This newfound transparency produces trust among stakeholders, enhancing confidence in the accuracy of property records and bolstering the overall integrity of real estate transactions”* (Ullah, F., & Al-Turjman, F. 2021) .

Furthermore, blockchain's transparent ledger introduces a level of accountability previously unseen in the industry. Every transaction, from property acquisition to transfer of ownership, is documented in an incorruptible manner, supporting this explanation, by implementing the blockchain structure to the transactions, *“could provide a 40% reduction in cases of fraud or misunderstandings in real estate transactions”* (NAR, 2022). This clarity of information minimizes disputes and disputes, as any discrepancies can be readily identified and addressed. It fundamentally shifts the dynamics of real estate transactions, making them more equitable and just. Additionally, the availability of a comprehensive property history can be a powerful tool for buyers and sellers. It offers an invaluable resource for evaluating the true value of a property, taking into account its transactional history, improvements, and market trends. *“This level of transparency ultimately empowers all parties involved, facilitating more informed decision-making processes”* (Veuger, J. ,2017) .

Beyond the immediate stakeholders, this enhanced transparency also benefits regulatory authorities and policymakers. They can leverage the wealth of data available on the blockchain to gain insights into market trends, transaction volumes, and patterns of property ownership. This can inform policy decisions, enabling the implementation of targeted interventions to address specific challenges or seize emerging opportunities in the real estate sector. By benefiting from blockchain's transparency, the industry can transition towards a more accountable and responsive framework, positioning it for sustained growth and resilience in an evolving market landscape.

2. Efficient and Secure Transactions:

This technology introduces a transformative approach to real estate transactions, streamlining processes and enhancing security. At its core, blockchain enables direct peer-to-peer transactions without the need for traditional intermediaries like brokers or supervision agents. This change significantly facilitates the transaction process, reducing both time and costs. Smart contracts, a cornerstone of blockchain functionality, play an important role in this transformation. These self-executing contracts are encoded with predefined rules and conditions. Once these conditions are met, the contract will be automatically executed. *“In the context of real estate, smart contracts can automate various aspects of a transaction, from verifying the completion of due diligence to executing the transfer of ownership. This level of automation minimizes the need for manual oversight, reducing the risk of errors and expediting the entire process”* (Tapscott, D., & Tapscott, A. 2016).

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

This greater level of security extends to the verification of identities, increasing even more the integrity of real estate transactions. With blockchain, individuals and entities can establish their identity securely, reducing the risk of impersonation or fraudulent representation.

Additionally, blockchain technology also has the potential to streamline the due diligence process. By recording all relevant information on the blockchain, parties can readily access and verify critical details about a property. This includes information on ownership history, liens, encumbrances, and property conditions. This comprehensive due diligence process can be conducted in a more efficient and accurate manner, which could result in the achievement of a 25% reduction in operating costs associated with administrative and legal processes, according to reports carried out by Capgemini in 2020. , reducing the risk of oversight or incomplete information. Overall, blockchain's capacity to facilitate efficient and secure transactions marks a significant leap forward for the real estate sector, promising a more streamlined and trustworthy process for all stakeholders involved.

3. Tokenization of Real Estate Assets:

Apart from the previously mentioned solutions, this technology introduces the groundbreaking concept of tokenization in the real estate sector. This innovation allows for the representation of ownership rights as digital tokens. These tokens are secured on a blockchain, providing a clear and verifiable record of ownership. This shift toward tokenization offers endless benefits for the industry. One of the most notable advantages is the ability to enable fractional ownership. Traditional real estate purchases often require significant capital outlays, potentially limiting accessibility for many investors. With tokenization, properties can be divided into smaller, more affordable units, allowing a broader range of individuals to participate in real estate investment. This democratization of access not only opens up new opportunities for investors but also injects a new level of liquidity into the market, *“which could present a historical rise, contributing up to 50% increased liquidity and 20% increase in the number of retail investors”* (Forbes,2023), as tokens can be readily bought, sold, and traded on compatible platforms.

Develop a tokenization platform that allows the fractionation of properties and the participation of investors with minimum amounts, contributing to a 50% increase in the liquidity of the real estate market, according to Forbes.

Furthermore, tokenization provides a more streamlined and efficient process for property transactions. Traditional methods of property transfer can be time-consuming and encumbered by a range of bureaucratic processes. Tokenized assets, on the other hand, can be transferred swiftly and seamlessly, often facilitated by smart contracts. *“This not only accelerates transactions but also significantly reduces associated costs. Additionally, tokenization can enhance the accessibility of real estate investments to a global audience. Through blockchain-powered platforms, investors from different parts of the world can participate in the real estate market, contributing to a more diverse and dynamic ecosystem”* (Dijkstra, P, 2017).

On top of that, the transparency inherent in blockchain technology ensures that the ownership of tokenized assets is unambiguous and secure. The immutable ledger provides an auditable history of ownership transfers, creating a level of trust and confidence among investors. This transparency also extends to the valuation of tokenized properties, as the

historical data captured on the blockchain can be leveraged to assess the performance and potential of a given asset. Overall, the tokenization of real estate assets presents a paradigm shift in the way properties are bought, sold, and invested in, enabling a new era of accessibility, liquidity, and efficiency in the real estate market.

4. Enhanced Property Management:

Blockchain technology has the potential to revolutionize property management by introducing a transparent, decentralized platform for key processes. This includes areas such as rental agreements, maintenance records, and tenant verification. Traditional property management can be full of challenges, including disputes over lease terms, maintenance issues, and difficulties in verifying tenant credentials. Blockchain addresses these concerns by providing a secure and immutable ledger for recording all pertinent information as previously mentioned.

One of the most significant aspects of this point is the use of smart contracts, as these contracts can stipulate the terms of the lease, including rental amounts, due dates, and penalties for late payments. Through blockchain, the terms of the agreement are securely stored and automatically executed when conditions are met. This not only reduces the potential for disputes but also provides both landlords and tenants with a clear understanding of their rights and responsibilities.

Besides the managing of properties on the contracts and process aspects, the maintenance records are a critical aspect of property management. Ensuring that properties are well-maintained is essential for both the landlord and the tenant. Blockchain provides a platform for recording and verifying maintenance activities. This includes details such as the nature of the maintenance, the date of service, and any associated costs. By having a transparent record of maintenance, disputes over responsibility for repairs can be minimized. “This contributes to the overall trust and transparency in the landlord-tenant relationship. Furthermore, tenant verification, which traditionally involves sharing sensitive personal information, can be handled securely through blockchain. Encrypted data on the blockchain ensures that sensitive information is kept confidential, reducing the risk of identity theft or fraud” (Spielman, A, 2016).

Overall, the application of blockchain in property management and maintenance, holds immense potential for improving transparency, efficiency, and trust in the landlord-tenant relationship. By leveraging the technology's capabilities, the real estate industry can create a more seamless and secure experience for all parties involved in property management.

5. Improved Land Administration:

Beside all the potential solutions that blockchain technology provides us with, the use in land administration systems is a game-changer for the real estate sector. At its core, it offers a secure and transparent platform for recording land ownership, transfers, and title deeds. Traditional land administration systems can be shadowed by inefficiencies, lack of transparency, and susceptibility to fraud. Blockchain addresses these challenges by providing a tamper-proof ledger that records all pertinent land information.

One of the key advantages of blockchain in land administration is the elimination of fraudulent land transactions. The immutable nature of the blockchain ensures that once a transaction is recorded, it cannot be altered or tampered with. This drastically reduces the risk

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

of fraudulent land grabs or illegal transfers. Furthermore, “the transparency provided by

blockchain means that all relevant stakeholders can readily access and verify land records. This includes individuals, government authorities, and legal entities. This accessibility ensures that the ownership of land is clear and unambiguous, reducing the potential for disputes and conflicts over land rights”(Veuger, J. 2017) .

Together with it, the efficiency gains brought about by blockchain in land administration are substantial. Traditional methods of recording land ownership and transfers can be laborious, involving extensive paperwork and manual record-keeping, so, with blockchain, this process is streamlined, with all relevant information securely stored on the ledger. This reduces the risk of errors and ensures that land records are accurate and up-to-date. “Additionally, the blockchain's capacity for smart contracts can automate aspects of land administration, such as the execution of title transfers. This not only expedites the process but also reduces the need for intermediaries, further enhancing efficiency” (Miceli, T. J., Sirmans, C. F., & Turnbull, G. K. (2015)).

To sum up the point, the use of blockchain in land administration can have far-reaching socio-economic implications. By providing a secure and transparent platform for land ownership, blockchain can empower individuals and communities, particularly in regions where land rights are a critical issue. It can serve as a tool for promoting equitable access to land and preventing land-related conflicts. This, in turn, can stimulate economic development and social stability.

6. Improved Due Diligence:

This technology can also be applied to greatly enhance the due diligence process in real estate transactions. Due diligence is what involves the careful investigation and verification of property information, ownership history, liens, and encumbrances. Traditionally, this process can be time-consuming and fraught with risks related to incomplete or inaccurate data. Blockchain introduces transparency, security, and efficiency into this crucial aspect of real estate.

Due to blockchain's characteristic of being transparent and immutable ledger ensures that property information is accurate and up-to-date. Property data, including ownership records, transaction history, and property characteristics, can be securely stored on the blockchain. This information is easily accessible to all relevant parties, such as buyers, sellers, lenders, and real estate professionals, so as a result, due diligence can be conducted more efficiently, with all stakeholders confident in the accuracy of the data they are reviewing. Smart contracts can automate the verification process, ensuring that the documents presented are legitimate and up-to-date. This eliminates a significant source of risk in real estate transactions, where the validity of documents is crucial .

Furthermore, the use of blockchain in due diligence can also streamline interactions with third-party service providers. For example, property appraisals and inspections can be recorded on the blockchain, providing a clear and verifiable record of these activities. This not only reduces the potential for disputes but also accelerates the due diligence process, as relevant parties can readily access the results of these assessments.

As a summary, blockchain technology offers a powerful solution for improving due diligence in real estate transactions. By enhancing the accuracy, security, and efficiency of this critical process, blockchain can reduce risks and uncertainties associated with property transactions.

7. Secure and Immutable Records:

One of the foundational features of blockchain technology is its ability to create secure and immutable records. In the context of real estate, this capability has far-reaching implications as it ensures the integrity and security of property records by creating a tamper-proof and auditable history of transactions.

The immutability of blockchain means that once a property transaction is recorded, it cannot be altered or deleted. This eliminates the risk of fraud and manipulation of records. Every change or transfer of property ownership is securely and transparently documented on the blockchain, providing a clear and unassailable history of ownership. This level of security and transparency instills confidence in property transactions and reduces the potential for disputes, as it was stated on the previous points, to support these statements, according to rates indicated by PwC studies, implementing these security measures, can result in a 30% decrease in incidents of data breaches or cyberattacks, also obtaining a better rating than the current one in terms of perceived security in real estate transactions, in customer satisfaction surveys.

Moreover, the security provided by blockchain extends to data privacy. Property-related data stored on the blockchain is encrypted and can only be accessed by authorized parties. This safeguards sensitive information, such as personal details in rental agreements or financial data in mortgage transactions. “Blockchain's cryptographic mechanisms ensure that data breaches and unauthorized access are minimized, enhancing the overall security of real estate records” (Dijkstra, P, 2017).

To add up, the permanence of blockchain records means that historical property data is readily available for reference and analysis. This can be valuable for property appraisals, market research, and assessing the performance of real estate assets over time. The availability of comprehensive historical data on the blockchain empowers stakeholders with insights and information critical to their decision-making processes.

In conclusion, the use of blockchain in creating secure and immutable property records is a fundamental transformation in real estate, because it establishes a level of trust, transparency, and security that has the potential to significantly reduce fraud, disputes, and risks in property transactions.

8. Data Sharing and Interoperability:

Engaging with the last point, this facilitates secure and efficient data sharing and interoperability in the real estate sector. Traditional data management systems can be fragmented, leading to data silos and inefficiencies. Blockchain addresses these challenges by providing a standardized and decentralized database for storing and managing real estate data.

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

One of the key advantages of blockchain in data sharing is the elimination of data fragmentation. The decentralized nature of blockchain ensures that data is synchronized

across all nodes in the network, reducing the risk of discrepancies and errors that often result from disparate data sources .

On top of that, blockchain's ability to facilitate interoperability means that different systems and parties involved in real estate transactions can seamlessly exchange data. Whether it's integrating property data into real estate platforms, sharing information with regulatory authorities, or collaborating with financial institutions, blockchain simplifies the process with the smart contracts, which can automate data-sharing agreements, ensuring that data is exchanged securely and in accordance with predefined rules. This interoperability reduces the administrative burden on real estate professionals and enhances the overall efficiency of the exchange of data.

Furthermore, it could be said that, the transparency provided by blockchain can lead to greater accountability in data sharing, because all data transactions on the blockchain are securely recorded, creating an auditable trail. This can be particularly valuable in situations involving regulatory compliance, where a transparent and immutable record of data sharing activities can demonstrate adherence to legal requirements.

The transformative potential of blockchain technology in the real estate sector is indisputable, as evidenced by the myriad solutions it brings to address long standing challenges. From enhancing transparency and efficiency in transactions to revolutionizing due diligence processes, blockchain is poised to reshape the very foundation of property dealings. The secure and immutable nature of blockchain records provides an unassailable foundation for property ownership, virtually eliminating the risk of fraud and manipulation. Furthermore, the introduction of smart contracts streamlines transactions, automating various stages of the buying and selling process. These advancements not only reduce costs but also expedite proceedings, making real estate investments more accessible and efficient for a broader spectrum of stakeholders.

Moreover, the integration of blockchain technology in real estate promises to unlock new avenues of investment, particularly through fractional ownership and tokenization. This revolutionary approach allows individuals to own fractions of high-value properties, democratizing access to real estate assets. The benefits ripple through to property management, where blockchain's decentralized platform ensures seamless rental agreements, maintenance records, and tenant verification. Such transparency minimizes disputes and fosters trust between landlords and tenants. Yet, the true potential of blockchain in real estate lies not only in isolated solutions but in the comprehensive overhaul of the industry's data infrastructure. By providing standardized, decentralized data management, blockchain offers a singular source of truth, fostering interoperability, data accuracy, and transparency across all facets of real estate operations.

VI. Cases of empirical applications on the real world

1. Construction

A case study was conducted to estimate the potential cost savings that could result from implementing blockchain technology for a real estate developer. This study analyzed a total of 56 housing building programs drawn from the developer's database, which were spread across different regions in France. The findings indicated that deploying blockchain technology could lead to a significant cost reduction, specifically amounting to 8.3% of the total construction expenses for housing buildings. The standard deviation associated with this estimate was determined to be 1.26%.

Future research should concentrate on corroborating the assumptions made in this study and establishing a structured framework for gauging the impact of blockchain in the construction sector. The effectiveness of this framework is expected to be contingent on the active involvement and cooperation of stakeholders throughout the construction value chain.

2. Transactions and management of properties

In recent years, there has been a growing emphasis on the adoption of blockchain in the real estate sector, particularly in the areas of land administration and tokenization. Empirical applications have demonstrated the potential benefits of blockchain in these areas, highlighting increased trust, verifiability, transparency, and efficiency.

Notably, the empirical applications have primarily focused on blockchain's role in land administration, with examples in countries such as Afghanistan, Estonia, Georgia, India (Andhra Pradesh), and the United Arab Emirates (Dubai). For instance, Afghanistan has implemented a blockchain-based land administration system to enhance transparency and reduce corruption. In Estonia, blockchain has been used to create a secure and tamper-proof land registry. Georgia has introduced blockchain technology to streamline the process of property registration and reduce administrative burdens. In Andhra Pradesh, India, blockchain has been utilized for land registration and to prevent fraudulent practices. In Dubai, the government has collaborated with blockchain technology providers to develop a blockchain-based system for recording real estate transactions.

The real estate industry is witnessing the emergence of distributed ledger technologies, such as blockchain, as a potential solution for streamlining property sales processes. Several private companies, including Househodl, Averspace, Urbit Data, Zillios, and Velow.re, are actively studying the feasibility of leveraging blockchain for completing the entire property selling process. Velow.re, for instance, is a permissionless real estate blockchain currently piloting a project in Cook County, USA.

One company, Atlant, which is implementing the tokenization of property, believes that blockchain technology is the ideal way to promote the adoption of the sharing economy and enhance transparency in real estate transactions. It also enables liquidity for trading these assets and facilitates cross-border transactions while addressing tax inefficiencies. Similarly, Ethernity confirms that their trading platform makes it relatively easier to liquidate traditionally illiquid real estate assets.

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

The impact of blockchain on the real estate sector is expected to be significant due to its economic importance. According to the European Commission, *“the real estate sector's contribution to national economies ranged from 5.7% to 15.8% of total value added produced in different countries in 2012. Furthermore, the real estate sector has demonstrated stronger growth compared to the overall economy”* European Commission (2015).

However, it is crucial to consider the legal challenges and opportunities associated with implementing blockchain in real estate conveyancing. Each country has its own process and requirements, making cross-border transactions complex. Various intermediaries, such as notaries, lawyers, and real estate agents, play different roles in different systems, ensuring the legality and effectiveness of transactions.

When it comes to the acquisition of property and the creation of mortgages, the involvement of notaries and lawyers is common in some systems, while in others, real estate agents handle the entire process. The registration of completed transactions in the land registry provides security and information about the property and rights associated with it. Although the involvement of professionals is not mandatory in most countries, blockchain technology offers the potential for disintermediation.

Implementing a blockchain-based real estate conveyancing system requires addressing specific challenges. Verifying the identity of parties involved is crucial, and connecting blockchain with an official ID can enhance security and prove ownership rights. Ensuring the legality and effectiveness of contracts is another challenge, as smart contracts alone cannot fulfill the role of lawyers or notaries. Incorporating co-ownership and other rights in rem into blockchain can be complex, but tokenization and side chains offer possible solutions. Additionally, amending the blockchain to reflect changes in ownership or other circumstances requires careful consideration.

“Despite these challenges, blockchain and smart contracts offer opportunities in the real estate sector. They can enable automatic payments, registration of rental agreements, and payment of taxes, reducing the black market and promoting transparency” Goldman Sachs (Schneider et al., 2016). Land registration on the blockchain can lead to cost savings and increased efficiency, which, according to Goldman Sachs, *“blockchain-driven property records could drive up to \$4 billion in cost savings due to reductions in headcount and actuarial risk in the US alone”* Goldman Sachs (Schneider et al., 2016).

“It is important to note that blockchain has often been used as a complementary tool or a partial substitute for existing online public services in the real estate sector” (Bennett et al., 2021). While the theoretical benefits of blockchain include increased trust through verifiability, some empirical applications have raised new trust issues related to data efficiency.

The empirical studies have suggested that blockchain implementation in real estate has the potential to enhance verifiability, transparency, and prevent fraud and corruption. Notably, fraud reduction in these applications has been primarily achieved through publicity.

Interestingly, the empirical findings have indicated that the removal of the governmental role has not been the primary objective of many blockchain applications in the real estate sector. Instead, these applications have required governmental support and political

will to increase transparency and reduce fraud. Public-private partnerships have played a crucial role in implementing blockchain land administration applications, with government support being a critical driving factor.

Furthermore, the empirical assessments have highlighted the importance of the autonomy of the governmental actor in blockchain implementation. The central role of smart contracts in real estate blockchain applications has also been emphasized in empirical studies.

In terms of tokenization, empirical applications have shown that smart contracts can become increasingly valuable with the growth in portfolio size and the number of investors. However, *“it is important to note that tokenization in the real estate sector has predominantly been limited to accredited institutional investors, leaving the grand promises of tokenization unconfirmed”* (Chang and Wang, 2021).

While the empirical conclusions have acknowledged that the full benefits of blockchain adoption in the real estate sector are yet to be realized, they have indicated the potential of blockchain in addressing various challenges. Even so, it is crucial to recognize that blockchain alone cannot solve the primary land administration challenges and requires institutional infrastructure and broader socio technical arrangements.

Overall, the empirical applications and insights have shed light on the potential of blockchain in the real estate sector, particularly in land administration and tokenization. However, further development, experimentation, and collaboration are needed to fully leverage the benefits of blockchain and overcome the existing challenges in the real estate industry.

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

ANALYSIS OF RESULTS

I. Analysis

The analysis of the data collected from the documents provides valuable insights into the potential applications and challenges of implementing blockchain technology in the real estate sector. The focus on identifying and categorizing conceptual proposals, recent adoption themes, and empirical applications offers a comprehensive view of how blockchain is envisioned, could be used and utilized in this industry.

Furthermore, the analysis delves into the benefits and challenges associated with blockchain adoption in the real estate sector. By assigning explanation keys to articulate these advantages and obstacles, the study gains valuable insights into the complex nature of blockchain integration. These keys were merged to create different concept categories, offering a consolidated view of the perceived benefits and challenges. This process ensures a whole understanding of the complexities involved in the application of blockchain technology within the real estate sector.

Moreover, the analysis extends to the examination of recent adoption themes from 2016 onwards. This temporal consideration is crucial in showing the evolution and contemporary relevance of blockchain in real estate. This allows for a comparison between the initial conceptual proposals and the more recent trends, shedding light on any shifts or developments in the application of blockchain technology within the industry.

II. Evaluation

These case studies and empirical conclusions underscore the significant potential of blockchain to address various challenges within the industry. One key observation is the acknowledgement that blockchain alone cannot resolve all the complexities in land administration. Instead, it highlights the necessity of a robust institutional infrastructure and comprehensive sociotechnical arrangements to ensure the successful implementation of blockchain technology. This recognition emphasizes the importance of a holistic approach that considers not only the technological aspects but also the broader ecosystem in which blockchain operates.

Furthermore, the literature calls for a more detailed and context-specific analysis of blockchain applications in the real estate sector. This evaluation recognizes the need to tailor blockchain solutions to the specific challenges and requirements of different countries and regions. It underscores the significance of understanding the unique institutional, environmental, and organizational factors that can shape the outcomes of blockchain implementations. Such a whole approach is essential for effectively harnessing blockchain's potential in the real estate domain.

Additionally, the information in this paper proposes conceptual frameworks, practical models, and avenues for future research related to blockchain adoption in real estate. This evaluation signifies the proactive efforts to not only identify opportunities but also provide actionable frameworks and directions for stakeholders in the industry. It underscores the importance of structured approaches and ongoing research to unlock the full benefits of blockchain technology in real estate.

In conclusion, the evaluation of the case studies and empirical findings within the documents highlights the promising potential of blockchain technology in the real estate sector. It emphasizes the need for a comprehensive approach, context-specific analysis, and continued research to leverage blockchain's capabilities effectively and address the industry's challenges.

III. Discussion

The discussion regarding the results from the case studies and literature analysis paints a refined picture of blockchain's integration into the real estate sector. It's evident that estimating the economic viability of blockchain applications in real estate is no small feat. The landscape is intricate, and a comprehensive understanding of the public economic benefits necessitates further research and a careful comparison of different systems and parameters. This emphasizes the dynamic nature of this field and the importance of robust economic evaluations and impact assessments.

Delving deeper, the literature and case studies shed light on several pivotal aspects of blockchain's role in real estate. They unveil its potential to revolutionize real estate transactions and emphasize the pivotal role of smart contracts in managing real estate deals. Notably, the impact on data security and privacy, as well as the transformative potential for enabling smart cities and homes, cannot be overlooked. It's a multifaceted landscape that demands attention to various factors, including computer difficulties, transaction specifics, legal considerations, and organizational characteristics in the real estate industry .

Moreover, the paper ventures into proposing conceptual frameworks and practical models for blockchain adoption in real estate, offering stakeholders structured approaches. While showing the potential benefits, they don't go away from acknowledging the challenges intertwined with implementation. This dynamic discussion reveals a proactive stance, setting a foundation for thoughtful decision-making within the industry.

In sum, the conversation surrounding the results from case studies and literature analysis paints a vivid picture of blockchain's potential in real estate. It's a potential change with opportunities to enhance transparency, security, and efficiency. Yet, it's also marked with complexities and obstacles. The need for further research, meticulous economic assessments, and a holistic consideration of various facets resonates strongly. This journey toward fully realizing blockchain's potential in real estate is a voyage marked by progress and ongoing exploration.

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

PRACTICAL APPLICATIONS

I. Impact and role of blockchain in the construction sector

The hypothesis postulates that in Construction, blockchain serves to streamline operations by reducing reliance on intermediaries and bolstering risk management. The impact of blockchain in this particular case study is evaluated as detailed below:

$$\frac{\text{Risk} + \text{Project Management} + \text{Sales support}}{\text{Total Cost}}$$

The result of this calculation yields a percentage, serving as an estimate of potential cost savings.

Within the realm of housing building programs, the real estate sector maintains an average net margin of 6%. It's important to note that the potential cost savings achievable through blockchain technology exceed the existing net margin.

1. Role of Blockchain in Construction

Transaction costs, which constitute a significant portion of overall construction expenses, can also be applied to both physical processes (such as material movement) and informational flows.

1.1 Implications:

Payment procedures would no longer necessitate invoices, as they do not add value for any party involved, given the existence of smart contracts. Deriving from this, smart contracts in the construction domain must encompass these two crucial components:

→ A precise definition of the specific tasks involved in the construction process.

→ A comprehensive catalog of all conceivable variations associated with a given task.

For instance, it must account for scenarios like the absence of a tiler leading to a delay in the electrician's work. The smart contract must accommodate all potential scenarios, addressing the definition, rectification, and updates of tasks to address unforeseen events on a daily basis at the construction site.

Thus, the realization of smart contracts (contract automation) during the construction phase will remain an aspirational goal until these two key aspects are addressed.

1.2 Notion of value:

Determining value is fundamentally a prerogative of the customer, but within the intricate web of stakeholders in the construction value chain, identifying the primary customer requires clarification.

In the realm of construction, a multitude of potential customers emerge for every process. Given this complexity, suppliers must engage in negotiations to define what "value" signifies to all relevant stakeholders in order to align expectations. Multiple stakeholders need to experience satisfaction. If it becomes feasible to comprehensively record this complexity and quantify each requirement, then capturing it within a blockchain and associating it with a smart contract becomes a viable prospect.

1.3 The construction of the Value Chain (Visual representations)

A value stream encompasses a series of actions aimed at delivering the value desired by a customer or customers. Similar to many other industries, certain activities within the construction value stream contribute value to one or more of the system's customers, while others do not. As a result, those activities that do not directly contribute to delivering the desired value to customers are presently not taken into consideration. This paper's objective is to delve into the potential of blockchain technology in streamlining processes to minimize the expenditure of time, money, and effort on activities that do not add value for customers, even if they yield profits for certain stakeholders, such as intermediaries within the construction sector.

One form of project delivery approach, particularly potential for the integration of blockchain technology, is the Design-Bid-Build methodology. This method progresses as follows: Following the client's briefing, the process commences with programming and studies where the lead designer and the design team conceptualize and subsequently detail the project.

After this, the tendering phase begins, and the chosen construction company starts its work. Ultimately, the delivery of the final product, whether a building or another form of construction, marks the finalization of the construction project. The project owner may be a real estate developer, social landlord, etc., and their clientele comprises the tenants and/or buyers of the residential units and associated commercial spaces. The direct customer of the construction company is the developer. If the construction company engages subcontractors, their direct customer is not only the construction company but also the subsequent trades in line, along with the developer and their respective customers. Members of the design team serve as both customers and suppliers to one another, and they also supply services to the developer, the constructor, the sub-contractors, and the constructor's own detail designers.

Ultimately, the quality of their designs can either enhance or diminish the developer's reputation. This system is complex, and it is visually represented in the accompanying figure (Image 1). To elaborate more, transaction costs are represented by the black arrows. This signifies, for example, that the subcontractor is remunerated by the general contractor, and the latter, in turn, is compensated by the client. The general contractor pays the subcontractor, who subsequently pays their suppliers. Transactions extend beyond mere financial transactions; they encompass relationships and collaborations between various entities. Therefore, these interactions rely on trust, and they tend to delay when blame is assigned.

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

By definition, a transaction cost encompasses the expenses incurred in conducting an economic exchange, constituting an inherent cost of conducting business. A contract is the result of transactions, and agreements arise from a multitude of transactions, as does collaboration.

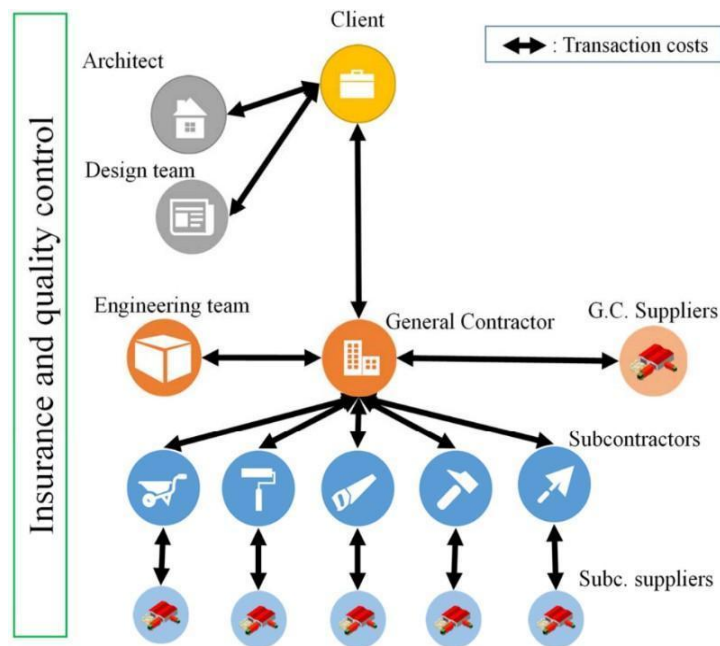


Image 1. The contractual relationships and the flows of money. Source: The Potential of Blockchain in building construction (Dakhli et al, 2019)

Once the Design-Bid-Build model has been explained, it is important to understand the transaction costs that come when the blockchain is implanted for the construction (Image 2). And when the intermediaries are reduced as previously stated and the flow of value comes across the stakeholders, it is important to identify the two types of the involved intermediaries in the construction stage of the design-bid-build model:

- Those who are inherent to the construction value chain, such as the project managers, the accountants, or the cost consultants.
- There are also the intermediaries who are outside the chain of value in construction, but still add a huge value, integrity and reassurance to it, such as the lawyers or the banks needed for loans.

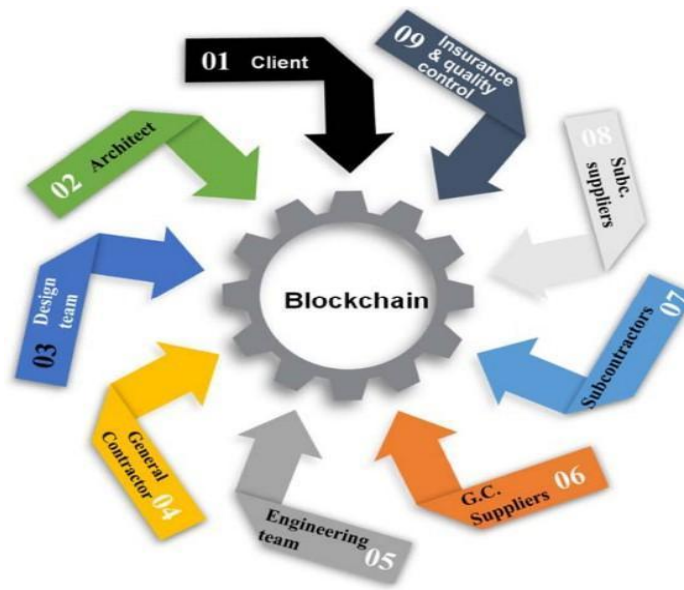


Image 2. Blockchain-based construction. Source: The Potential of Blockchain in building construction (Dakhli et al, 2019)

II. Conceptual framework for blockchain adoption in the smart real estate buy/rent process

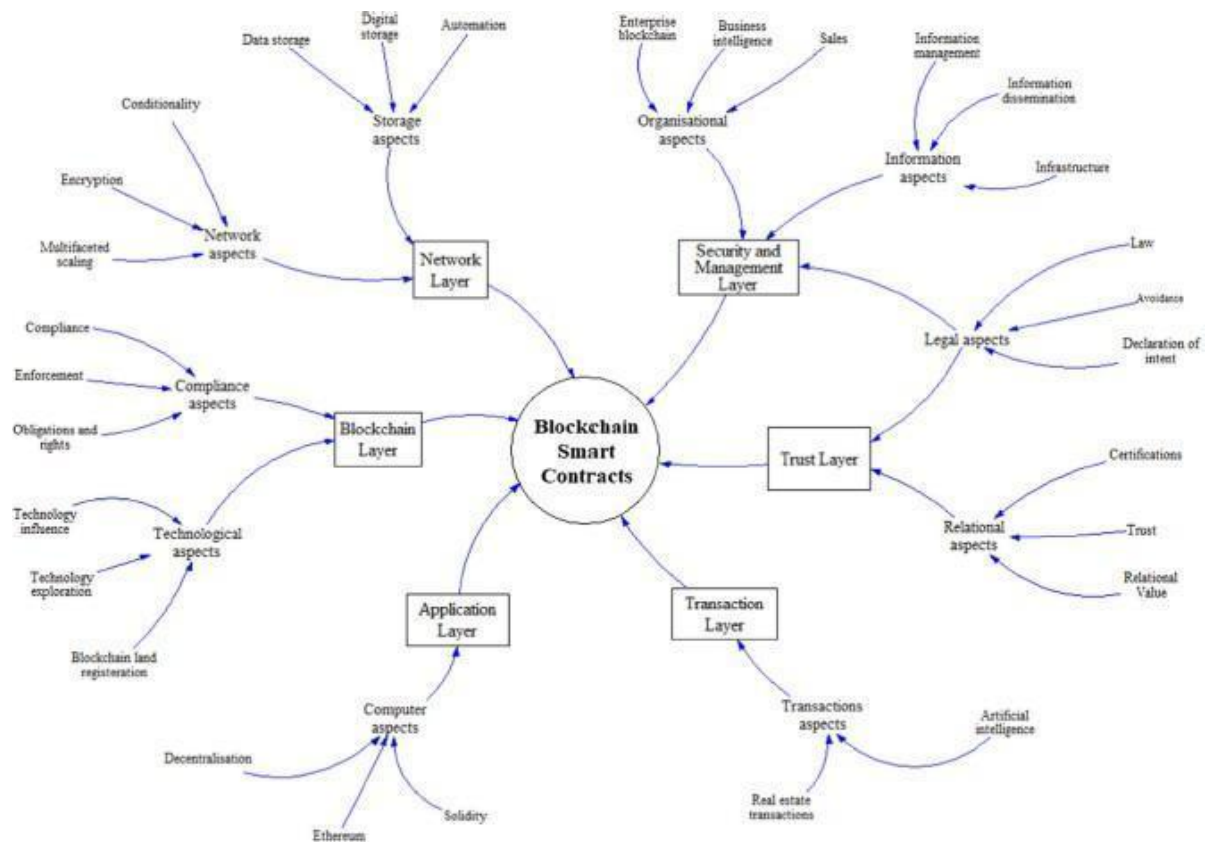


Image 3. Systems diagram showing the linkage between the layers, aspects, and keywords. Source: Conceptual framework for blockchain adoption (Ullah et al, 2020)

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

The proposed framework for managing real estate in smart cities through blockchain technology consists of multiple layers, each with a specific role. These layers are interconnected and interdependent, forming the foundation for the efficient functioning of smart cities as shown in the upper graphic (Image 3). Here is a detailed breakdown of these layers:

1. **Network Layer:** This foundational layer includes servers, storage devices, P2P network nodes in platforms like Ethereum or Hyperledger, along with their corresponding communication and verification mechanisms.
2. **Transaction Layer:** This layer manages transaction initiation, validation, processing, and currency mining, and can be initiated either by users or directly by smart contracts.
3. **Blockchain Layer:** Central to the framework, this layer houses blocks containing essential smart contract data. Its permissions may vary based on the type of smart contracts involved. It also encompasses critical components like data blocks, timestamps, hash functions, chain structures, encrypted layers, Merkle trees, and other imperative block requirements.
4. **Trust Layer:** Operating on consensus development mechanisms, this layer leverages consensus algorithms to establish agreement among parties engaged in a smart contract. It plays a vital role in authenticating transactions within the network, employing methodologies such as proof of work, proof of state, fault tolerance, and distributed ledgers.
5. **Application Layer:** This layer includes both front-end and back-end applications, decentralized applications (DApps), as well as smart contracts and their associated digital wallets. Users and owners can access and execute smart contracts through this layer using their computers or mobile devices.
6. **Security and Management Layer:** Operating seamlessly throughout the process, this layer is dedicated to fortifying and overseeing blockchain smart contracts. Given the susceptibility of blockchains to various attacks, such as eclipse attacks, self-mining, and 51% attacks, this layer serves as a crucial safeguard. It addresses concerns related to data privacy, identity management, transaction and account security, as well as implements measures to prevent potential attacks.

To be able to have a clear view of the explanation, here is presented the structure of these layers (Image 4):

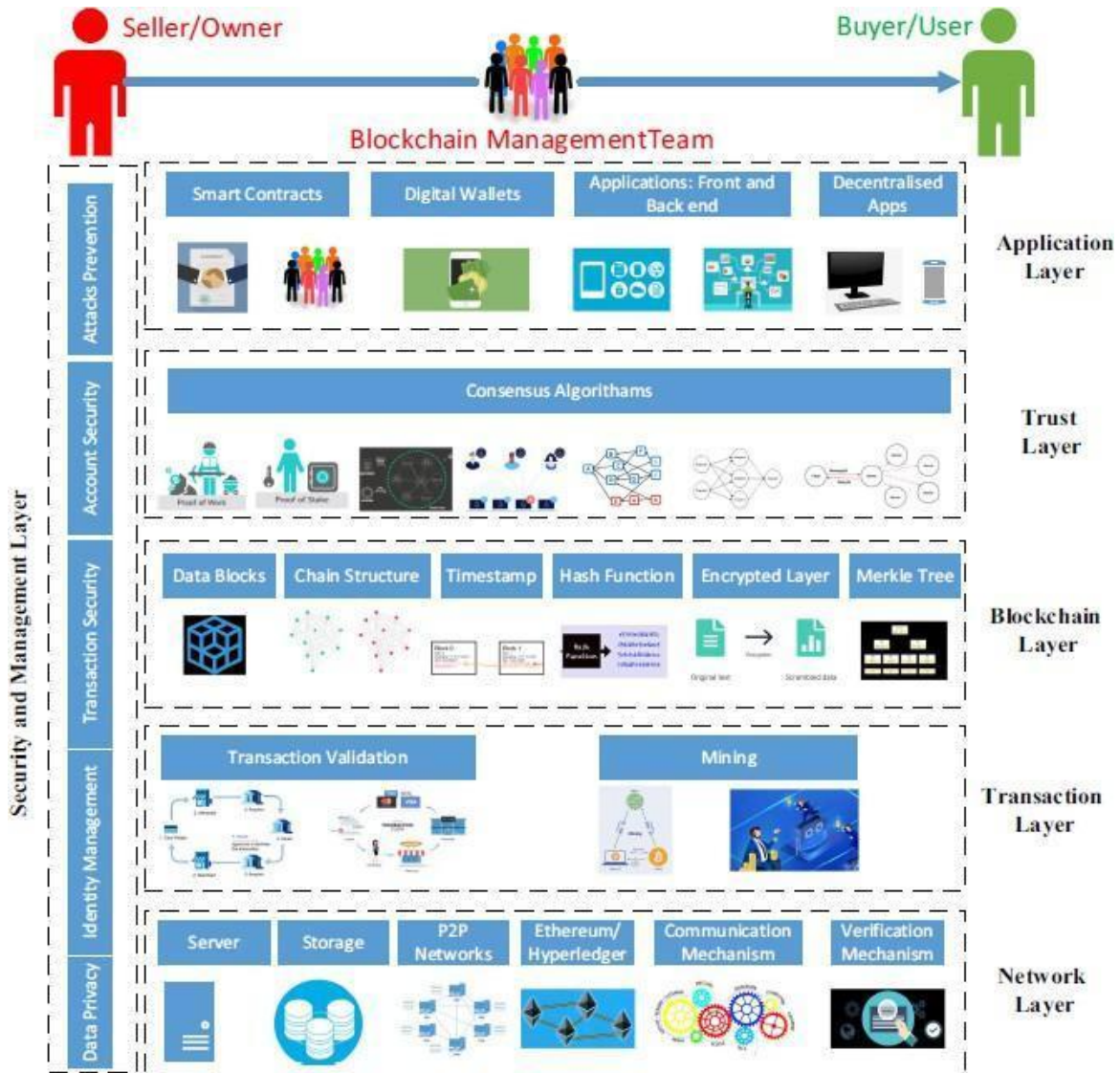


Image 4. Blockchain layers in smart real estate deals and transactions. Source: Conceptual framework for blockchain adoption (Ullah et al, 2020)

III. Intermediaries involved in a real estate transactions

Once the explanation of how the framework works in the application of the blockchain technology in the real estate industry, it is key to know what are the intermediaries that play part in these transaction, their roles, and it is also important know their magnitude, in order to comprehend, why the blockchain technology would facilitate the process and make it more agile.

Undoubtedly, every EU nation upholds its individual procedures and prerequisites, rendering cross-border transactions notably challenging.

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

Hence, it is crucial to establish a differentiation when scrutinizing the potential ramifications of blockchain technology on the real estate sector, taking into account the type of transaction and the respective country. This entails an assessment of both prolonged and concise lease arrangements, property procurements, and mortgages within the framework of civil law perspectives.

1. The role of intermediaries in the acquisition of property and the creation of mortgages

The participation of various intermediaries and their specific roles in finalizing a transaction is contingent on the established system. These systems can be categorized as follows:

1.1 The Latin notary system, which necessitates the involvement of a notary in diverse capacities:

- Verification of the parties' identities.
- Prevention of premature contracting through the provision of legal counsel and consumer safeguarding.
- Assurance of title security, thereby guaranteeing the efficacy of the purchase by scrutinizing registered titles, prioritizing them, and ensuring proper adherence to registration formalities.
- Validation of the legality of land transactions, leading to a notable reduction in legal disputes.

1.2 The central and eastern European system, which predominantly relies on Latin notaries but also encompasses lawyers in specific countries like the Czech Republic (CZ) and Hungary (HU).

1.3 The solicitor or licensed conveyancer system in England and Ireland. These professionals are mandated to furnish transactional guidance on title, financial aspects, taxation, and public law, and are held accountable if they fail to do so.

1.4 The Nordic countries' system, wherein the entire process is overseen by real estate agents, who often provide both real estate and legal counsel, or by lawyers in some cases.

Following the completion of a transaction, it may be recorded in the land registry, overseen by "*the competent authority for registering the transfer of ownership and the creation of interests in land*" (Schmid and Hertel, 2005). "*This registry offers both the administration and individuals insights into the object (e.g., a parcel of land), the rights associated with it (e.g., rights in rem, ownership, mortgage), and the entities holding these rights*" (Vos et al., 2017).

“The maintenance of the land registry falls under the overview of an impartial public authority, the courts, or a public authority operating under specific directives” (Stöcker and Stürner, 2008). While the validity of real property generally isn't an object for registration (except in select countries or for mortgage creation), the involvement of these professionals is often discretionary, allowing room for the integration of blockchain technology.

In cases involving property acquisition through a mortgage loan, the roster of professionals expands. In addition to the optional involvement of attorneys, it necessitates the engagement of a property appraiser and the lending institution facilitating the mortgage for property acquisition.

Consequently, implementing blockchain for mortgage grants would pose a more intricate scenario, demanding either integration with existing registries or an amendment of prevailing legislation.

2 The role of intermediaries in the acquisition of property and the creation of mortgages

“Rental agreements, while often facilitated by real estate agents and attorneys, do not inherently involve intermediaries. These contracts, as a rule, do not require formal entry into a land registry” (Hoekstra and Cornette, 2014; Cornelius and Rzeznik, 2014). *“However, they do need to be reported to tax authorities”* (Bianchi, 2014). *“In select jurisdictions, there is a stipulation for registration in specific administrative registries, and failure to comply may pose validity concerns for the contract”* (Haffner and Bounjough, 2014).

Given the absence of obligatory registration, blockchain technology offers a potential means of encouraging illicit activities within lease agreements. This aspect is particularly pertinent in countries where such activities are notably prevalent, such as Spain, where they account for 38.6 percent of cases. In addition to addressing this concern, implementing blockchain could serve to diminish instances of tax evasion and enhance legal protections for tenants.

In order to offer a clear view of which are the roles played by the intermediaries and when they are played in the transaction process, here is a table that gives a visual representation of what has been explained on this point (Image 5).

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

Intermediaries/ transaction	Real estate agent	Notary	Land registry	Other
Renting a property	Common practice	Not a common practice	Not a common practice	An administrative registry might be compulsory (e.g. registry of bad landlords or registry of deposits)
Purchase a property	Common practice	Common practice (in countries where they exist). If parties intend to register their rights, a notarial deed is usually required to do so (ES, DE)	Common practice. In some countries, registration is compulsory (DE, NL, CH)	In some countries, although registration is not compulsory, parties need to validate their signatures before a notary to access the land registry (e.g. FR, IT, LX, PT)
Purchase a property with mortgage loan	Real estate agents in Nordic countries are usually involved in this process; this is normally due to the shortage of notaries. In other countries, it is common practice to use a real estate agent	Compulsory in some countries	Compulsory in some countries	When mortgaging a property, the participation of a bank and a property valuator is also required

Source: Own elaboration

Image 5. Role of intermediaries in real estate conveyancing. Source: Legal challenges and opportunities (Garcia-Teruel, 2019)

IV. Smart contract delivery through decentralized applications and Ethereum Virtual Machine (EVM)

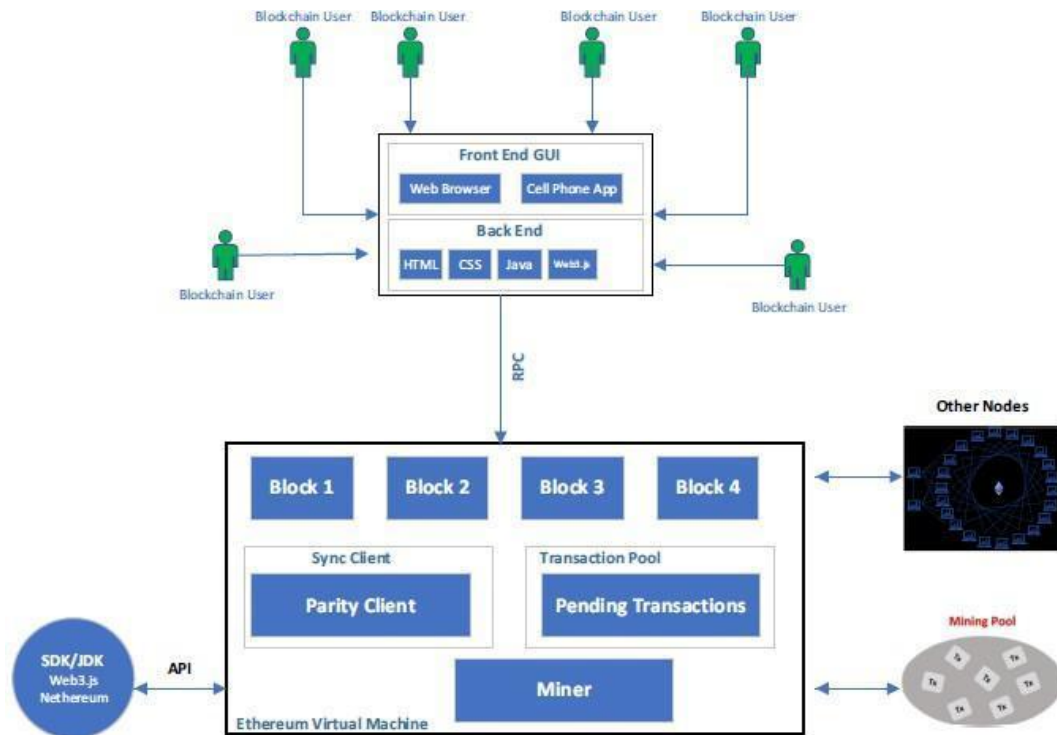


Fig. 12 The decentralized application and its interactions with Ethereum Virtual Machine

Image 6. The decentralized application and its interactions with the Ethereum Virtual Machine. Source: Conceptual framework for blockchain adoption (Ullah et al, 2019)

The picture above (Image 6) presents how the smart contracts are created and sent between users as a visual representation.

The communication between decentralized applications (DApps) and the Ethereum Virtual Machine (EVM) enables the distribution of smart contracts to users. Smart contracts are created using Solidity programming code in the Ethereum platform. These contracts are then deployed to users and owners through the blockchain network. GoEthereum (Geth) and PyEthereum (PyEth) apps are commonly used for this deployment process. Users can conveniently access the smart contract through web browsers and mobile applications, which offer a user-friendly interface.

1. Decentralized applications (DApps)

Smart contracts are developed using DApps on the blockchain network, which offer a user-friendly interface, making it accessible for non-technical users and owners to utilize smart contracts effortlessly.

DApps communicate with an EVM (Ethereum Virtual Machine) through the remote protocol call (RPC). This mechanism enables smooth interaction between DApps and the EVM through smart contracts, which are built on the blockchain network with the help of DApps and these provide a user-friendly interface, allowing individuals without technical expertise to easily engage with smart contracts.

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

2. Ethereum virtual machine (EVM)

The EVM, or Ethereum Virtual Machine, is a crucial component within the Ethereum network. It acts as a virtual stack that contains Ethereum nodes and is responsible for executing smart contracts. These contracts are written in languages like Solidity and then compiled into bytecode for execution on the EVM.

One of the key features of the EVM is its complete isolation from the network, ensuring the security and integrity of smart contract execution. This isolation creates a trustless environment where anyone within the system can utilize the EVM's functions, leading to the creation of smart contracts. To interact with the EVM and access its capabilities, the system provides an API that can be accessed through various development kits, such as Java or web.js. These kits enable developers to build applications that can communicate with the EVM.

The EVM is also connected to multiple other nodes and mining pools within the Ethereum network, enhancing its scalability and reliability. When a smart contract is generated within the EVM, it can be deployed through DApps, which act as intermediaries between users and the EVM and through user-friendly GUIs (Graphical User Interface), users can sign and interact with the smart contracts.

In summary, the EVM is a vital component of the Ethereum network, executing smart contracts in a secure and isolated manner. Its connectivity with other nodes and mining pools ensures the smooth functioning of the Ethereum ecosystem, while the API and DApps provide accessible interfaces for users to interact with smart contracts.

V. Implementation and termination of the Smart Contract

Once the finalization of smart contract format and templates, including their layers, design, and codes, has been accomplished as previously outlined, the implementation of smart contracts in smart real estate involves a series of steps and stakeholders that take play into this scene (Image 7), and is displayed and explained below:

3. The property owner initiates the process by accessing the portal or utilizing a web interface via their web browser or mobile application.
4. Subsequently, the owner inputs various details such as contact information, property specifics, email address, encrypted keys, and other relevant information.
5. Additionally, the owner provides information regarding the agent or any third party responsible for managing the contract.
6. On the other side, the renter or buyer accesses the portal's web interface through their web browser or mobile application.
7. The renter or buyer then provides their contact information, email address, and other necessary particulars.

8. The web platform gains access to the smart contract template, which is then auto-populated with pertinent information derived from the provided data.
9. Following this, the contract is poised for digital signatures from both parties.
10. The renter or buyer proceeds to authorize payments, which may encompass bonds, installments, or lump sum payments made to the owner.
11. Subsequently, charges incurred by the management team, agents, and blockchain managers are deducted, with the remaining sum being transferred to the owner's designated account. This deduction data is subsequently shared with the owner.
12. The owner acknowledges the received payments, a confirmation that is logged by the system, officially concluding the contract. In cases of property purchases, ownership rights are transferred to the buyer.
13. In situations involving rental agreements, after step 9, the renter continues to make regular rental payments, either through manual methods or through direct debits from their designated account. The system consistently generates notifications for both parties, providing updates on the transaction status.
14. This process endures until the expiration of the contract term.

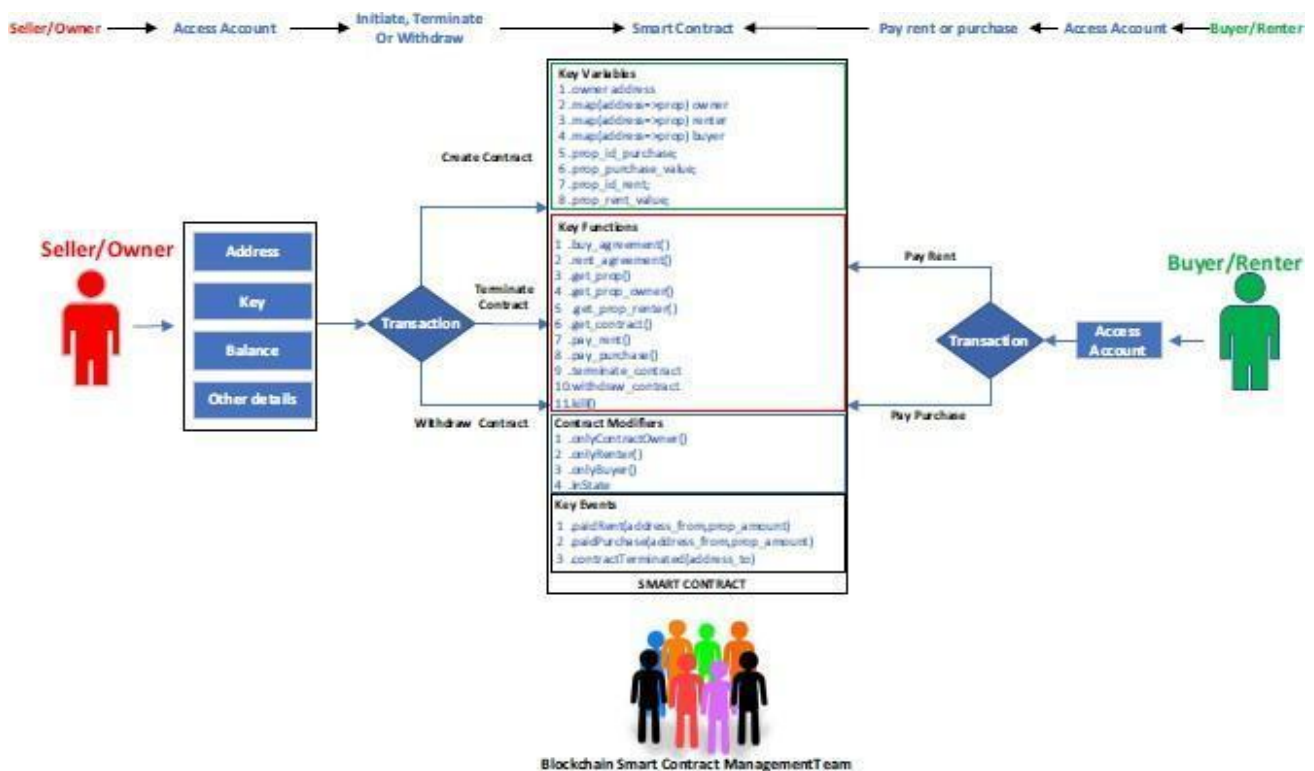


Image 7. Smart contract stakeholders' interactions in smart real estate. Source: Conceptual framework for blockchain adoption (Ullah et al, 2019)

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

FUTURE TRENDS

In order to advance the integration of blockchain technology into the real estate sector, it is imperative to conduct rigorous empirical research and observations. This approach will provide a more comprehensive understanding of the benefits, challenges, barriers, and enablers associated with blockchain applications in real estate transactions. By delving into practical applications, researchers can gather valuable insights that may pave the way for more effective implementation strategies.

Furthermore, an in-depth exploration of the economic viability and public benefits of blockchain applications within the real estate sector is crucial. This necessitates comprehensive impact assessments and meticulous comparisons with existing systems and parameters. Such analyses will shed light on the potential economic advantages and guide decision-makers in assessing the feasibility of adopting blockchain technology in this domain.

Different types of blockchains, be they permissioned or permissionless, which provide varying potentials within the real estate sector. Future research efforts should delve into a comparative analysis to ascertain which type of blockchain offers the most value and efficacy and which one has the most viability in real-world applications. Moreover, addressing scalability and interoperability challenges is paramount. Exploring solutions to enhance the scalability of blockchain networks and improve interoperability between different platforms is a crucial step towards wider adoption.

The potential impact on data security and privacy is a critical facet of blockchain integration in real estate. Research should delve into the effectiveness of blockchain in safeguarding sensitive real estate data, while also exploring mechanisms that maintain privacy without compromising transparency. This delicate balance is central to building trust and confidence in blockchain technology within the industry.

A comprehensive investigation of the broader ecosystem surrounding blockchain implementation in real estate is imperative. This includes examining the influence of political will, regulatory frameworks, availability of reliable digital data, public-private partnerships, and educational initiatives. Additionally, the legal and regulatory aspects must be addressed. Future research should focus on dissecting the legal implications of utilizing blockchain for real estate transactions and formulating frameworks to ensure compliance with existing regulations.

To achieve a distinct understanding of the impact of blockchain applications in the real estate sector, it is imperative to conduct country- and context-specific analyses. These analyses will illuminate how unique institutional, environmental, and organizational factors in each country shape the outcomes of blockchain implementation. Tailoring strategies to specific contexts will optimize the effectiveness of blockchain technology in diverse real estate environments.

Staying updated of the rapid evolution of blockchain technology and remaining attuned to the latest industry developments is important. This ongoing awareness ensures that researchers and practitioners are equipped with the most current knowledge and are poised to leverage the full potential of blockchain in the real estate sector.

Understanding the user experience and adoption challenges associated with blockchain implementation in real estate is essential. This involves comprehensive studies on user acceptance, usability, and potential barriers to adoption. By identifying and addressing user-centric concerns, the integration process can be made more seamless and user-friendly.

Examining stakeholder perspectives is fundamental in gauging the readiness and receptiveness of various parties involved. This encompasses real estate professionals, government agencies, and consumers. Surveys, interviews, and focus groups can be employed to discern their concerns, expectations, and potential barriers to adoption. This stakeholder-centric approach facilitates a more holistic and inclusive implementation strategy.

Conducting thorough cost-benefit analyses is vital in assessing the economic viability and potential return on investment associated with implementing blockchain technology in the real estate sector. This empirical evaluation provides decision-makers with the necessary data to make informed choices regarding resource allocation and investment in blockchain initiatives.

Lastly, addressing the challenges of standardization and data validation in the proposed blockchain model is a crucial avenue for further research. Establishing robust standards and validation protocols is essential in ensuring the reliability and integrity of blockchain-based real estate transactions.

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

CONCLUSIONS OF THE RESEARCH

After the analysis of results and the deepening of research on the applications of blockchain technology in the real estate industry, it could be said that the implementation of blockchain technology in the real estate sector holds immense promise, offering solutions to address various long-standing challenges. Blockchain's potential, however, is not a standalone solution but requires a broader ecosystem encompassing institutional infrastructure and sociotechnical arrangements for successful integration. While empirical applications have shown promise, they are still in the development stage, necessitating ongoing refinement and improvement. It's important to recognize that the benefits and challenges of blockchain adoption in real estate are context-dependent, varying across countries due to specific institutional, environmental, and organizational factors.

The successful implementation of blockchain in real estate hinges on several critical factors, including political will, regulatory frameworks, access to reliable digital data, public-private partnerships, and educational aspects. Moreover, the economic viability and public economic benefits of blockchain applications in real estate require further research and in-depth impact assessments, comparing blockchain systems with other parameters. In essence, while blockchain shows tremendous potential in the real estate sector, its realization depends on continued research, development, and an intricate understanding of the diverse contexts and challenges within the industry.

These findings underscore the need for a conceptual framework to guide the adoption of blockchain smart contracts in real estate dealings, emphasizing the importance of conceptual clarity. The documents also highlight key aspects and themes, including the significance of data security, user privacy, financial management, and city management in blockchain applications in real estate. Global interest in this technology is on the rise, indicating a growing awareness of its potential benefits, particularly in countries like Australia, Canada, India, the USA, and the UK. To add up, practical models and frameworks have been proposed to facilitate the incorporation of smart contracts in real estate management, aiming to expedite the adoption of blockchain technology in the industry.

Once the conclusions for the research have been displayed, it is of key importance to highlight the achievement of the objectives and evaluate how they have been fulfilled and attained.

By stating a quality state of the art, that includes basic concepts, frameworks, and how the research is going to be displayed, the author has been able to provide the readers with a global view of both, the real estate industry and the blockchain technology, not only by explaining it, but showing all the potential benefits and also challenges that the use of this technology could arise.

Moreover, by supplying the readers with a holistic view of all the problems and global market that the real estate sector has and the benefits and challenges that the technology has, the people who read this research paper, are able to see where the problem or gap is and therefore, how the use of the blockchain technologies can help in the successful improvement of the real estate sector and how it can help it to be renewed.

On the other hand, because it is not only important to give information and flood the

paper with concepts, it is also important to showcase the real case studies that have been deploying this specific technology into the real estate sector. With these real facts, the promising or potential sand castle on the sky now has meaning and foundations to stand on, and not only on promises and potential uses.

However, due to the novelty of this researched topic, there is not a lot of information to look for and also not a lot of real case studies on which to look at to apply the technology safely on a bigger scale. Therefore, the author of the paper has offered valuable insights, methodologies and new areas on which new researchers on the matter could focus on in order to support their investigations in this new and promising field.

To summarize, the integration of blockchain technology in real estate presents a transformative opportunity. However, it necessitates careful consideration of context, regulation, and a commitment to ongoing research and development. A conceptual framework can guide this process, ensuring that the technology is implemented effectively. With increasing global interest and practical frameworks emerging, the real estate sector is poised for a digital revolution that promises enhanced transparency, security, and efficiency.

Nonetheless, realizing these benefits will require continued collaboration, innovation, and adaptation to address the unique challenges presented by each market and region.

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

LIMITATIONS OF THE RESEARCH

While this research endeavor has yielded valuable insights and contributed significantly to the understanding of the application of the blockchain technology to the real estate sector, it is imperative to acknowledge the inherent limitations that have influenced the scope and applicability of our findings. Recognizing these constraints is essential for a comprehensive and transparent evaluation of the study's outcomes. This section aims to delineate the specific areas where the research may have encountered constraints, and to provide an assessment of their potential impact on the interpretation of the results.

The foundation of the investigation was laid through an examination of available literature sourced from academic databases and platforms like Google Scholar, Wikipedia, Goldman Sachs Global Investment Research, and the American Land Title Association. However, this approach may have led to an omission of the most recent advancements within the real estate sector. As the industry evolves swiftly, some cutting-edge developments may not have been captured within the confines of the selected sources.

The dynamic nature of blockchain technology has posed a challenge for the academic community. Not all real-world applications of blockchain find their way into scholar publications due to the speed of technological progress. Consequently, our study may not encompass all potential applications or innovations within the real estate sector, as not all have been examined and documented within the academic literature.

An additional limitation arises from the potential language bias inherent in our study. The research predominantly focuses on articles published in English, Spanish or German, as there are not many other documents available in other languages. This may have led to the omission of valuable insights and developments present in literature of other languages besides the mentioned ones.

Publication bias is a recognized constraint in this study. The selected articles are drawn from repositories, and thus, the analysis exclusively encompasses published and indexed sources. Consequently, unpublished or non-indexed studies may not have been incorporated, potentially resulting in an incomplete representation of the landscape.

While efforts were made to remove duplicate studies during the screening process, there remains a possibility that some duplicates may have been overlooked. This could lead to the inadvertent inclusion of redundant information, potentially influencing the overall analysis, but this limitation has been tried to be avoided by the researcher of the paper.

It is essential to note that this study does not entail primary data collection. Instead, it relies on a systematic literature review and the analysis of existing research. While this approach offers a comprehensive overview, it may not capture nuanced insights that could be gleaned from direct data collection.

Given that blockchain technology emerged within the last two decades, our study focuses on articles published within this timeframe. It is important to acknowledge that this decision inherently excludes relevant studies previous to this period, highlighting the relatively recent emergence of blockchain technology within the real estate sector. Therefore

it is important to note that, because the technology is so new, there is not a lot of information available to dig deeper into the topic to offer an even more holistic understanding and research.

The findings and conclusions derived from this study are based on a specific set of articles obtained from selected repositories. Consequently, it is essential to recognize that the applicability of these findings may not extend universally to all contexts and regions, as the analysis is delimited by the chosen sample.

The information sources extracted for this study were primarily limited to advisors within the real estate transaction process. While they provide valuable insights, it is imperative to acknowledge that this scope may result in limited external validity. To enhance external validity, future studies may consider expanding the stakeholder pool to include perspectives from investors and other relevant parties. Additionally, it is worth noting that the proposed blockchain model is contingent on certain assumptions and may necessitate further research and validation to ascertain its feasibility and effectiveness.

IMPLEMENTATION OF THE BLOCKCHAIN TECHNOLOGY TO THE REAL ESTATE SECTOR

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PROGRAMS	LANGUAGES
<ul style="list-style-type: none">• Notion• AI Programs• SPSS• Microsoft Office Pack	Spanish: Native
MORE INFO <ul style="list-style-type: none">• Driving license• Willing to move	English: High Level
	German: High Level