PIDE Working Papers
No. 2025:12

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PAKISTAN INSTITUTE OF DEVELOPMENT ECONOMICS
ISLAMABAD
2025

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Designed, composed, and finished at the Publications Division, PIDE.

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Abbreviations

BTC	Blockchain Technology
ABM	Agent-Based Modeling
CDA	Capital Development Authority
NFTs	Non-Fungible Tokens
WTRR	Weighted Transaction Risk Reduction
AMMs	Automated Market Makers

ABSTRACT

Blockchain technology has the potential to transform Pakistan's industrial sector, particularly the real estate market, by enhancing transparency, reducing transaction costs, and minimising market frictions. While blockchain adoption is increasing globally to improve market efficiency, Pakistan remains behind in integrating this technology. This study aims to bridge this gap by simulating the impact of blockchain adoption on real estate market efficiency, focusing on Islamabad. Using an Agent-Based Modeling (ABM) approach, the study tests four key hypotheses: (i) the effect of blockchain on transparency and fraudulent cases, (ii) its impact on average sale time and liquidity, (iii) the role of price discovery in the absence of traditional dealers, and (iv) changes in transaction costs due to blockchain implementation. The simulation results reveal that blockchain adoption significantly enhances market efficiency by reducing asymmetric information, increasing transparency, improving liquidity, and drastically lowering transaction costs. Through tokenisation, smart contracts, and decentralised ledgers, blockchain disrupts the role of intermediaries, leading to a more efficient and transparent market. By eliminating dealer-centric liquidity and introducing decentralised mechanisms, Islamabad's real estate sector can achieve true price discovery based on supply-demand dynamics rather than speculation. However, the Capital Development Authority (CDA) plays a crucial role as both regulator and innovator. Balancing blockchain's disruptive potential with existing legal and institutional frameworks is essential for its successful implementation in Pakistan's real estate sector.

Keywords: Blockchain Technology, Real Estate, and Agent-Based Model

1. INTRODUCTION

Blockchain technology (BCT) has rapidly evolved, transforming industries such as hospitality, healthcare, manufacturing, education, and real estate by enhancing efficiency, security, and transparency in digital operations, over the past decade [(Acikgoz, et al. 2024); (Agbo, et al. 2024); (Li, et al. 2018); (Louki, et al. 2021) and (Wouda and Opdenakker, 2019)]. As a decentralised ledger, BCT securely records and verifies transactions, ensuring data integrity through cryptographic links between blocks. Unlike traditional centralised databases, blockchain operates on a peer-to-peer network, where any modification requires consensus from all participants, making it highly resilient to tampering [(Schmid, et al. 2023); (Esmat, et al. 2021)].

In recent years, the global real estate sector has witnessed a surge in interest regarding the integration of blockchain technology (BCT) to enhance transaction processes. Traditional real estate transactions often rely on intermediaries for verification and record-keeping, which can introduce inefficiencies, increased costs, and potential for fraud. Blockchain offers a decentralised ledger system that promises increased transparency, security, and efficiency in property dealings (Yang, et al. 2025).

Blockchain technology is increasingly being adopted in real estate globally, enhancing transparency and efficiency. Swiss urban housing firms use blockchain for secure property records, while the U.S.-based Propy has pioneered blockchain-based real estate transactions and NFTs. Singapore's government integrates blockchain into property management to streamline transactions, and Georgia has transformed its land registration system with the technology. Similarly, Japan's LIFULL HOME'S has developed a blockchain-powered real estate platform to improve transaction efficiency. These global implementations highlight blockchain's potential to revolutionise real estate markets, reinforcing its role in reducing intermediaries and enhancing trust [(Witzig and Salomon, 2019); (Park, 2020); (Chow, 2022); (Ciccio, et al. 2019) and (Rogers and Dutta, 2020)].

Blockchain technology (BTC) is transforming the real estate sector by enhancing security, efficiency, and accessibility while introducing new investment models such as fractional ownership and asset tokenisation [(Baum, 2021); (Mottaghi, et al. 2024) and (Dubrovina, 2023)]. By leveraging a decentralised and immutable ledger, blockchain minimises fraud risks, ensures transparent property records, and provides real-time tracking of transactions [(Redekar, 2024) and (Spielman, 2016)]. The elimination of intermediaries accelerates deals, reduces costs, and streamlines due diligence by automating property verification and contract execution. Additionally, blockchain facilitates fractional ownership, allowing investors to acquire property shares with lower capital, thereby increasing market liquidity. Asset tokenisation further democratises real estate investments, enabling seamless trading of digital property tokens. Moreover, blockchain enhances global accessibility by enabling secure, cross-border transactions without intermediaries, fostering international real estate investments. The integration of smart contracts automates leasing agreements, property transfers, and payments, reducing paperwork and errors while ensuring compliance and trust [(Ullah and Al-Turjman, 2023); (Laarabi, et al. 2024); and (Karamitsos, et al. 2018)]. Collectively, these innovations create a more transparent, efficient, and inclusive real estate ecosystem.

In Pakistan, the real estate industry plays a crucial role in economic development, driven by rapid urbanisation and increasing investment trends. However, the sector faces persistent challenges, including high transaction costs, fraudulent activities, unauthorised property claims, and a lack of transparency [(Uzair, et al. 2018); (Sheikh, et al. 2023); (Naz, et al. 2024)] The Pakistan Institute of Development Economics (PIDE) has

highlighted inefficiencies such as market sludge Haque, et al. (2022), asymmetric information, and the dominant role of intermediaries, which further complicate property dealings. Blockchain technology presents a viable solution by introducing transparency, reducing fraud, and streamlining transactions through secure and immutable digital records. By eliminating intermediaries and automating verification processes, blockchain can significantly lower transaction costs while enhancing trust and efficiency in Pakistan's real estate market, fostering a more secure and accessible investment environment.

The objective of this study is to simulate the impact of adopting blockchain technology (BCT) on the real estate market of Pakistan, using Rawalpindi and Islamabad as case studies. This study tests the hypothesis that adopting blockchain technology (BTC) in Pakistan's real estate market reduces market frictions and enhances market efficiency. Market efficiency is evaluated based on key parameters, including increased transparency and trust levels, reduced average selling time, improved liquidity, and enhanced price discovery effect. Additionally, the study examines whether blockchain technology minimises asymmetric information and lowers overall transaction costs. By analysing these factors in the context of Rawalpindi and Islamabad, the study provides empirical insights into the ongoing impact of blockchain adoption on the real estate sector's operational efficiency and effectiveness.

2. LITERATURE REVIEW

Wright and De Philippi made a significant advancement in academic research regarding the application of blockchain for governance by presenting their concept of "Lex Cryptographia" (Wright and De Filippi, 2015). "Lex Cryptographia" refers to regulations governed by self-executing smart contracts and decentralised autonomous organisations. The researchers highlighted that blockchain technology has the potential to diminish the role of intermediaries, who have traditionally been key economic and regulatory actors in society. Their study identified key areas for future development, including automated contract negotiation, execution, and enforcement; the expansion of the peer-to-peer economy; the rise of smart property and machine-to-machine communication; real-time distributed governance; algorithmic decision-making; and the regulation of decentralised systems (Konashevych, 2020b).

A variety of reviews have explored the potential, benefits, and challenges of blockchain technology in the real estate sector, primarily focusing on specific areas like land administration (Ekemode, et al. 2019; Ferreira, 2021). Bennett et al. incorporated blockchain into their systematic research synthesis of emerging data technologies within the global land administration sector, offering a comprehensive analysis of blockchain's potential in land administration in 2019 (Bennett, et al. 2019). Nonetheless, Bennett et al. determined that in 2019, it was premature to make extensive assertions regarding the potential effects of blockchain on the sector.

Furthermore, the real estate sector, particularly land administration, has been identified as a viable blockchain application in systematic literature reviews from various perspectives, including smart city initiatives and e-government (Khanna, et al. 2021; Majeed, et al. 2021), smart contracts (Alotaibi and Alshamrani, 2021; Xu, et al. 2021), and general industrial applications of blockchain (Sanka, et al. 2021). Nevertheless, in contrast to the frequency with

which real estate is cited as a potential application of blockchain in academic literature, there is a notable absence of systematic reviews that offer a current and comprehensive understanding of blockchain's potential across the entire real estate sector, extending beyond land administration (Ferreira, 2021).

Bennett, et al. (2021) finds that a hybrid system that combines smart contract use with current technological infrastructure preserves the position of a land registration agency as the final arbitrator of legitimate claims. This should reduce interruptions and maximise advantages. Results suggest that the hybrid strategy meets land dealing business criteria, and that proofs-of-concept are essential for development.

Yang, et al. (2025) examine the factors influencing BCT adoption in real estate using an expanded TAM and Task-technology fit. The study find that adopting BCT can increase efficiency, cut transaction costs, and boost security for real estate purchasers and sellers, according to the study. The study reveals that BCT automation can enhance title transfer and allow customised agreements. Yeoh, et al. (2024) examine the factors that affect the acceptance of blockchain technology among real estate buyers and sellers. The research indicates that real estate stakeholders ought to prioritize psychological factors over technological factors in the adoption of blockchain. This study contributes to the current body of knowledge and offers important insights for real estate stakeholders regarding the implementation of blockchain technology.

Blockchain can enhance real estate systems even in hybrid environments, complementing existing frameworks (Saari, et al. 2022). Konashevych (2020a) explores blockchain's role in real estate, emphasising the need for integrated technologies to address data accuracy, digital identity, privacy, and scalability. Konashevych (2020b) introduces real estate tokenisation and the Title Token concept, a blockchain-based ownership record. The study highlights blockchain's potential to automate legal processes while reducing bureaucracy and governance inefficiencies. Key real estate investment benefits of tokenisation include inclusion, efficiency, improved liquidity, and cost reductions. Blockchain enables inclusion by fractionalising and democratising real estate assets, lowering entry barriers, and attracting more investors [(Bennett, et al. 2021); (Baum, 2020); (Kalyushnova, 2021); and (Stoica, et al. 2019)]. A greater global pool of prospects may result in cheaper capital-raising costs and improved value for corporate real estate purchasers and sellers (Shtofman, 2019). Tokenising real estate assets allows for more diversification through fractionalisation and customisation [Latifi, et al. 2019), (Smith, et al. 2019); and (Gupta, et al. 2020).

New investment and utility products may be customised using tokenisation, opening new options. Tokenisation might increase real estate market liquidity by developing efficient secondary markets and expanding the investor pool and global investor base [(Baum, 2020); (Smith, et al. 2019); and (Gupta, et al. 2020)].

Real estate investment tokenisation faces legal issues like blockchain-based property transactions. Regulatory ambiguity and terminological disparities exist [(Smith, et al. 2019); (Morrow, 2019)]. Most governments prohibit directly tokenising real estate assets, necessitating intermediary institutions like SPVs or real estate funds. Unlike real estate, tokenised securities that provide access to real estate assets, debt, or funds are regulated (Baum, 2020).

Token categorisation is crucial for regulatory compliance, since security tokens must fulfill strict standards. Additionally, organisations doing security token operations must have license and follow applicable standards (Gupta, et al. 2020). Real estate investment tokenisation may have unintended economic consequences. Liquidity

increases through primary and secondary markets and fractionalisation may reduce real estate's illiquidity premium, hurting returns (Baum, 2020). Price volatility and a wider bid–offer spread are further concerns of higher liquidity (Baum, 2020).

Additionally, if there is insufficient market demand for real estate investment tokens, the assets remain illiquid, requiring significant participation to achieve liquidity benefits (Haddad, 2021). Currently, huge institutional investors dominate the real estate investment sector, providing liquidity. Institutional investors want funds that meet their investment and risk profile as part of their portfolio allocation (Chang and Wang, 2021). Lastly, the economic viability of tokenising specific real estate assets is uncertain due to unproven demand and fractionalised asset management (Baum, 2020).

Smart contracts might automate compliance, document verification, trading, and escrow, making token-based investment transactions quicker (Baum, 2020), cheaper, and more transparent [(Smith, et al. 2019); (Gupta, et al. 2020); and (Morrow, 2019)].

3. THEORETICAL FRAMEWORK

This section provides a detailed framework of blockchain technology and its impact on real estate market efficiency. Generally, real estate market in Pakistan is plagued with structural and deep-rooted inefficiencies—opaque pricing structure, high transaction costs due to overwhelming sludge and ingrained bureaucratic legal processes, and the dominant role of the dealer in liquidity provision. Specifically, the role of a dealer is one of the key reasons of asymmetric information in market, and its balance sheet constraints to determine shadow prices, and leading to the market deviation from its equilibrium (Akerlof, 1970). Given such a structure of the Pakistan's real estate market the Treynor's (1972) model for dealer markets will provide us a framework which theorises the relationship between adoption of blockchain technology and real estate market efficiencies for Pakistan—tokenisation, smart contracts, and decentralised ledgers, which will disrupt the role of dealer or intermediation, and will bring down the cost of sludge or transaction costs, and will be helping to determine market prices with true supply-demand dynamics rather than a market speculation. The transition of the real estate market from traditional mode to adoption of blockchain technology will evaluate the role of regulators like Capital Development Authority (CDA): making this transition successful or unsuccessful, and their role will be crucial in reconciling decentralised systems with legal frameworks.

3.1. Framework of Treynor's Dealer Model: Market Frictions

Since in real estate market, a dealer is considered as liquidity provider, Treynor's (1972) model has conceptualised the role of dealer who mitigate two key risks: (i) inventory risk (cost of holding illiquid assets), and (ii) asymmetric information or adverse selection from trading with informed market agents (Glosten & Milgrom, 1985). Similarly, real estate market in Pakistan face risks as follows: first, the dominance of a dealer is quite visible. Because dealers act as quasi-market makers and leveraging their inventory holdings to determine prices that reflect their balance sheet capacity rather than fundamental value. For example, a dealer with excess inventory may lower prices to incentivise sales, distorting market signals (Grossman & Miller, 1988). Second, transaction costs incurred due to legal procedures for transferring ownership titles (e.g., registry

verification, stamp duties) are time-intensive and costly, inflating bid-ask spreads (Coase, 1960). Finally, asymmetric information between buyers and sellers, and a dealer creates a "lemons problem" (Akerlof, 1970).

The above discussed framework of the Treynor's model has identified the inefficiencies in the real estate market due to the role of dealer and highlighting the liquidity and pricing power are more centralised rather than decentralised, which ultimately causes market inefficiencies.

3.2. Adoption of Blockchain Technology: Replacing Dealers

The adoption of Blockchain technology will reconfigure the framework presented by Treynor's model by eliminating the role of dealer's intermediation through three pillars of blockchain technology:

3.2.1. First Pillar: Tokenisation and Fractional Ownership

To eliminate the role of a dealer, there will be real estate tokenisation, representing property rights as digital tokens on a blockchain. This will dissolve the need for dealers to hold inventory or files of plot. The liquidity will be democratised or decentralised by enabling fractional ownership through blockchain technology (Tapscott & Tapscott, 2016). Decentralisation will be based on two key principles: liquidity pools, and reduced inventory risks**.** The liquidity pool will be based on automated market makers (AMMs) on decentralised exchanges (e.g., Uniswap-style protocols), and it will replace the role of dealer-mediated trading, will allow 24/7 price discovery (Chiu & Koeppl, 2019). While the adoption of blockchain technology will reduce the inventory risk through tokenisation which will shift the asset holding from centralised dealers to a more democratic and distributed network of investors, which will be aligning with the "shared liquidity" paradigm (Biais, et al. 2023). Hence, through tokenisation and fractional ownership-based principal, the adoption of blockchain technology will reduce the role of a dealer from the real market and will be reducing the market frictions.

3.2.2. Second Pillar: Smart Contracts and Transaction Automation

The second pillar of blockchain technology is smart contracts and transaction automation. The smart contracts-executing code on a blockchain will streamline the legal and financial processes. The ownership rights will be programmatically verified and updated on-chain, will reduce the episodes of delays incurred through manual registry checks (Yermack, 2017)—a smart contract could automatically transfer a tokenised title once payment is confirmed, and it will avoid weeks of bureaucratic delays. Moreover, it will be cost effective through automating compliance (e.g., KYC, stamp duties). As a result, smart contracts will cut intermediation fees, and it will be narrowing bid-ask spreads (Catalini & Gans, 2020). In a nutshell, the adoption of blockchain technology will reduce the sludge in the real estate market.

3.2.3. Third Pillar: Decentralised Price Discovery

The third pillar of blockchain will mitigate the asymmetric information from the market through transparent ledger. All transactions will be publicly visible and will reduce the chances of price manipulation (Nakamoto, 2008). Moreover, blockchain technology will be provide real-time trading data, which will reflect the true demand, and eroding the dealers' ability to set shadow prices (Böhme, et al. 2015).

3.3. Role of the Regulatory Authority in the Framework

The above-discussed transition from traditional inefficient market structure to an efficient market system, the role of regulator will be crucial. For example, CDA, as Islamabad's primary urban regulator, will play a dual role in this transition:

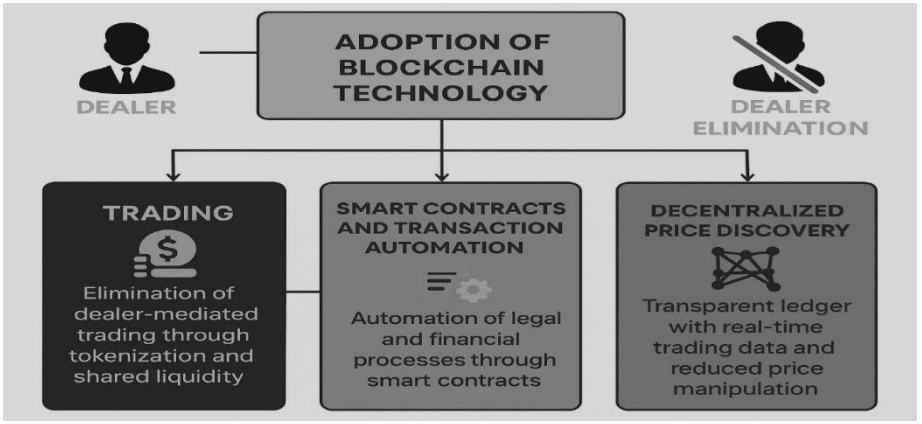
- Legal and Regulatory Enabler: CDA must formally recognise blockchain-based property tokens as legal ownership certificates, requiring amendments to the *Land Revenue Act* and collaboration with platforms like Pakistan's *Roshan Digital Initiative*. In addition, CDA could develop standardised smart contract templates that encode legal requirements (e.g., zoning laws, tax obligations), ensuring alignment with national property regulations (Allen, et al. 2020).
- Hybrid Governance Model: CDA could maintain a blockchain node to synchronize on-chain transactions with its centralised registry, creating a hybrid system that balances decentralisation with state oversight (Xu, et al. 2019). Moreover, while smart contracts automate execution, the CDA would retain authority over legal disputes, acting as an arbiter in cases of code errors or fraud (Raskin, 2017).
- Challenges for the CDA
- CDA's revenue model (e.g., stamp duties, registry fees) may conflict with blockchain's cost-reduction promise, necessitating fiscal reforms.
- Implementing blockchain infrastructure requires partnerships with tech firms and capacity-building initiatives (World Bank, 2021).

In short, the whole discussion is summed up in table 01, which synthesises the transition from Treynor's dealer model to a blockchain-driven framework, and highlighting the CDA's role.

Table 1
Transition from Treynor's Dealer Model to a Blockchain-Driven Framework

Treynor Component	Market Issue	Blockchain Solution	CDA's Role
Inventory risk	Dealers hoard properties, distorting prices	Tokenisation enables fractional ownership & direct P2P trading	Legal recognition of tokens; hybrid registry
Bid-ask spreads	High costs from legal delays	Smart contracts automate title transfers & compliance	Standardising smart contract templates
Information asymmetry	Shadow pricing due to opacity	Decentralised ledger ensures transparent history	Maintaining interoperable blockchain-CDA systems

Fig. 1. Blockchain Three-Pillar Model Reducing Dealers Roles in Real Estate



4. METHODOLOGICAL FRAMEWORK

This study would follow, Agent-Based Modelling (ABM) to simulate the impacts of adoption of blockchain technology on real estate market of Islamabad in Pakistan. Basically, ABM is a machine-based experiment and computational simulation method to model the interaction of autonomous agents. During the last decade, it is widely used by the researchers to simulate the interaction of complex nature of the agents, and its application in economics is increasing—especially to analyse a complex nature of the market structure. So, in the context of this study, the application of ABM is crucial and would give me flexibility to simulate the impacts of blockchain adoption on Islamabad's real estate market—by simulating the real estate market dynamics, price determination of property assets, market frictions, and fraudulent activities. For methodologically, the ABM model would follow the following steps.

1. *Model Scope and Objective*: the core objective is to simulate the impacts of adoption of blockchain technology on Islamabad' real estate market efficiency such as transaction cost, average sale time of a property, fraudulent cases, and asymmetric information in price discovery.
2. Defining Agents: the model will be based on the following agents.
    a. *Homogeneous Buyers*: all buyers who want to buy a residential plot from Islamabad. For simplification of analysis, we assume that all buyers are homogeneous in terms of income class, purchasing power, etc.
    b. *Homogeneous Seller: we assume that all sellers of residential plot are homogenous individuals or entities.*
    c. *Real Estate Agents (Dealers):* Brokers who are facilitating transactions. We assume that all dealers within Islamabad have the same power to influence.
    d. Regulators: Government bodies like CDA enforcing compliance and legal frameworks
    e. System of Blockchain Technology [As an Environmental Factor]: it represents the degree of adoption of blockchain technology ranging 0–100%, and its effects on real estate market of Islamabad
3. Market Structure and Assumptions
    a. For simplicity, this study will remain up to only in urban Islamabad. Even ignoring within Islamabad variation (such as sector classification). The analysis

will be only average level of Islamabad. Assuming all places within Islamabad are homogeneous

b. The only focus will be on residential plots, ignoring commercial plots.
c. Adoption of blockchain technology ranges 0 percent (No adoption of blockchain) and 100% (complete adoption of blockchain).
d. Dealer can influence price determination through speculation

4. Model Implementations
   a. Simulation Parameters
      i. Time Steps: Each time step will be based on month
      ii. Total Simulated Period: 120-time steps
      iii. Baseline Condition
      a. 0 percent blockchain adoption
      b. Baseline estimates of prices, and all other variables related to the real estate market are used for analysis. Their description is given table 02.
   b. Data Sources
      i. PIDE's Sludge Reports: baseline data of transaction cost, average selling time, fraudulent cases, etc.
      ii. Zameen.com: the data of prices is taken from Zameen.com
5. Key Mathematical Formulas and Their Application

For this study, the following are the tools to measure the performance of the real estate market. The detailed description of these statistical and mathematical formulas is given in appendix.

In a nutshell, the agent-based modelling would provide a systematic approach to simulate the impacts by modelling interaction between the individual agents and dynamics of real estate market.

Table 2

Baseline estimates Used for Simulation

Variable Name	Baseline Values	Data Source
Mean Property Prices for 5 Marla Plot	PKR 8630000	Zameen.Com
Monthly data on prices for the last three years	Based monthly data PKR 8630000	Zameen.Com
Dealer Commission Fee	1-2 percent of final price	PIDE Sludge Report
Average Transaction Cost of Acquiring a Plot	PKR 125753	PIDE Sludge Report
Average Transformation Cost of a Plot	PKR 116883	PIDE Sludge Report
Total Transaction Cost	Sum of both acquiring and Transformation cost= PKR242,636	PIDE Sludge Report
Average Sale Time of a plot	60 days	PIDE Sludge Report
Fraud cases	Out of 204, 140 housing societies are illegal	PIDE Sludge Report

5. RESULTS AND DISCUSSION

This section is replete with a detailed description of the results obtained from the application of Agent-Based Modelling (ABM).

5.1. Simulated Impacts on Transparency (Reduction of Fraudulent Cases)

The application of Agent-Based Modelling (ABM) indicates that with zero adoption of blockchain technology or baseline scenarios for Islamabad real estate, there are 204 total societies (as per the data of CDA), out of them 140 housing colonies are illegal, which is 68.6 percent, an expected fraud risk. Nonetheless, with the adoption of blockchain technology, we can witness a massive decline in the number of illegal housings societies and decline in expected fraud risk. Table 03 comprises a detailed description of simulated results for real estate market in Islamabad, Pakistan using ABM.

Table 3

Simulated Impacts of Blockchain Adoption on Transparency (Reduction in Fraudulent Cases)

Blockchain Adoption	Number of Illegal Housing Societies (Out of 204)	Expected Fraud Risk (%)	Fraud Reduction (%)
0% (No Blockchain)	140	68.6	0
10% Adoption	126	63.2	10
20% Adoption	112	58.3	20
30% Adoption	98	51.5	30
40% Adoption	84	44.6	40
50% Adoption	70	37.7	50
60% Adoption	64	30.9	54
70% Adoption	56	24	60
80% Adoption	42	17.2	70
90% Adoption	28	10.3	80
100% Adoption	4	1.6	98

It is evident from the results with the increase of level blockchain adoption, the risk of fraudulent cases is decreasing, reaching almost complete end of the fraudulent risks. In a nutshell, since 68.6% of housing societies are illegal, fraudulent transactions are a significant issue in Islamabad's real estate sector. Blockchain adoption can mitigate this in the following ways: With 50 percent adoption, fraudulent cases drop to 37.7 percent, making transactions more safer and transparent, with 80 percent adoption, fraudulent cases decrease by 75 percent, ensuring greater trust in real estate market of Islamabad, while full adoption of blockchain (at 100%) is expected to be nearly eliminating fraudulent cases, with only 1.6 percent risk, remaining due to external factors like manual errors or regulatory gaps. Hence, these results are consistent with the discussion we have hatched in theoretical framework. Moreover, these simulated results for the Islamabad real estate market are congruent with other countries' adoption of blockchain technology such as UAE, Japan, Germany, etc.

5.2. Simulated Impacts on Average Selling Time and Liquidity Improvement

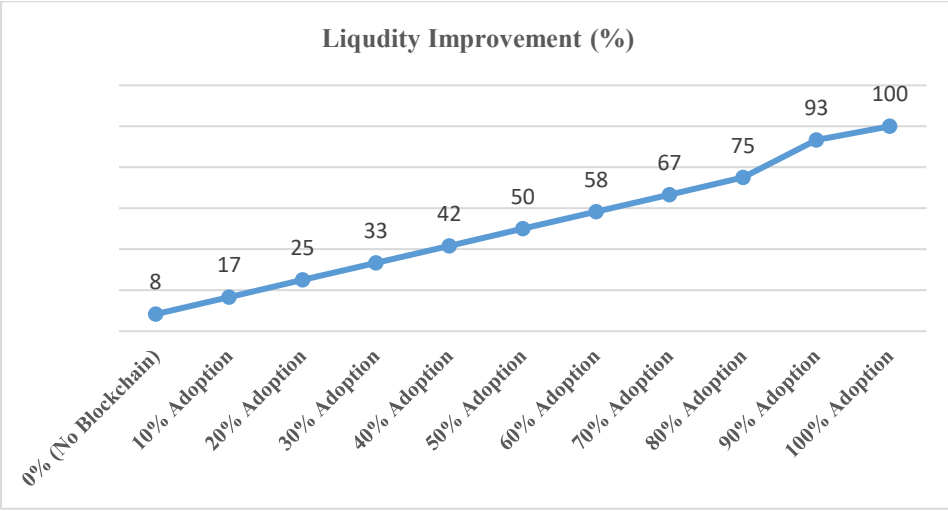
The next proposition is to test whether the adoption of blockchain technology minimises the average selling time of a property and enhances the liquidity of property assets. The application of ABM provides us with simulated impacts of the adoption of

blockchain technology on the reduction of average selling time of property and improvement in liquidity of property in Islamabad. The results are presented through figure 01 & 02.

Fig 2. Simulated Impacts of Blockchain Technology on Selling Time of a Property

Source: Simulation from Agent Based Modelling (ABM)

Fig 3. Simulated Impacts of Blockchain Technology on Liquidity Improvement (%)



Source: Simulation from Agent Based Modelling (ABM)

The above graph shows that with baseline scenarios, there are on average selling time of a property is 60 days, while with the adoption of blockchain technology we can see there is a massive decline in average selling time of a property in Islamabad. In sum, the key results are: First, with 100 percent adoption (full adoption), property sale time in Islamabad could reduce from 60 days to just 10 days, which is 83 percent reduction as

compared to baseline scenario, while 100 percent improvement in liquidity. The liquidity improvement means how quickly property is converted into cash. The adoption of reduces selling time and improving the liquidity of an asset. Second, even with 50 percent adoption, transaction time could be cut nearly in half, i.e. 35 days and increasing the liquidity of a property asset by 50 percent. This indicates that improvement in liquidity is inversely correlated with average selling time. These impacts occur owing to the effectiveness of smart contracts and digital verification, which speed up approvals, and remove bureaucratic delays. This helps buyers to gain confidence in fraud-proof transactions, leading to increasing market efficiency.

5.3. Simulated Impacts on Price Discovery

Our next hypothesis is to test whether the adoption of blockchain technology will mitigate the asymmetric information from the market through transparent ledger. All transactions will be publicly visible and will reduce the chances of price manipulation and bring down the asymmetry of information. Table 04 contains the estimated results, which demonstrate that at baseline scenario, when there is zero adoption of blockchain technology price volatility is the highest with zero percent certainty, indicating that the risk of speculation is highly prevalent—price volatility is 517,800 PKR, and price certainty index has zero value in baseline scenario.

Table 4
Simulated Impacts of Blockchain Technology on Price Discovery

Blockchain Adoption Level	Average Property Price (PKR)	Price Volatility (PKR)	Price Certainty Index (%)
0% (No Blockchain)	8,630,000	517,800	0
10% Adoption	8,436,610	493,230	5
20% Adoption	8,492,754	472,245	9
30% Adoption	8,527,902	451,335	13
40% Adoption	8,561,018	430,880	17
50% Adoption	8,586,327	410,327	21
60% Adoption	8,617,999	392,544	24
70% Adoption	8,670,845	374,533	28
80% Adoption	8,698,573	357,128	31
90% Adoption	8,731,989	340,114	34
100% Adoption	8,795,120	324,348	37

The simulated estimation for the adoption of blockchain technology shows that with the increase in level of adoption of blockchain technology, we can witness reduction in price volatility and increase in price concentration index, and reaches to 37 percent, leading to reduction in speculative risks. These results imply that as the real estate market of Islamabad matures, investment becomes more long-term rather than short-term flipping, leading to fewer price distortions.

The key takeaways from these results are: (i) the adoption of blockchain technology will improve the predictability of prices and reduce the price volatility from PKR 517800 to 324348, (ii) Islamabad real estate prices follow a U-shaped trend, first experiencing a correction due to speculation removal, then gradually appreciating due to increased trust and liquidity, (iii) market speculation decreases as evident from the increase in price certainty index, which clearly demonstrating a shift toward fair, and data-

driven pricing, and (iv) The higher adoption of blockchain technology would lead to a more efficient, transparent, and resilient real estate market, benefiting both investors and end-users.

5.4. Simulated Impacts on Transaction Cost and Overall Market Frictions

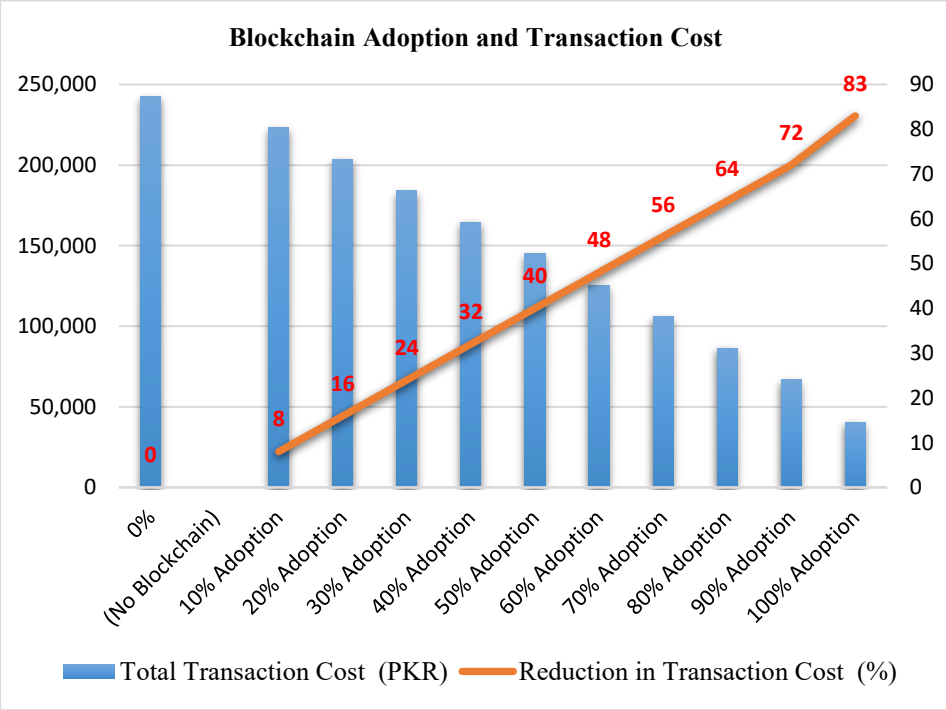
Our next hypothesis is whether the adoption of blockchain technology will help to reduce transaction costs in the real estate market of Islamabad. The transaction cost is sum of dealer cost (acquiring a property asset), and transformation cost of a property asset. In other words, blockchain will facilitate the creation, authentication and audit of contracts that can be done in real time, by geographic regions and without the need for a third party. Before going to interpret simulated results, the baseline setting (when no blockchain adoption) is given as follows: on average dealer commission is 1 to 2 percent in Islamabad which is approximately on overall average PKR123753 based on five Marla plot in Islamabad. Similarly, baseline transformation cost is on average PKR116883, while total transaction cost on a five Marla plot is PKR 242636S. So, given such a baseline setting, the simulated results indicate that with the increase in level of blockchain adoption, the overall transaction cost decreases drastically (see Table 05).

Table 5
Simulated Impacts of Blockchain Technology on Transaction Cost

Blockchain Adoption Level	Dealer Commission (PKR)	Transformation Cost (PKR)	Total Transaction Cost (PKR)	Reduction in Transaction Cost (%)
0% (No Blockchain)	125,753	116,883	242,636	0
10% Adoption	113,177	109,938	223,115	8
20% Adoption	100,602	102,993	203,595	16
30% Adoption	88,027	96,048	184,075	24
40% Adoption	75,451	89,103	164,554	32
50% Adoption	62,876	82,158	145,034	40
60% Adoption	50,301	75,214	125,515	48
70% Adoption	37,725	68,269	105,994	56
80% Adoption	25,150	61,324	86,474	64
90% Adoption	12,575	54,379	66,954	72
100% Adoption	0	40,434	40,434	83

The key findings are discussed as follows: First, at 100 percent blockchain adoption, the overall transaction costs in Islamabad real estate market could drop by 83%, from 242,636 PKR to just 40,434 PKR (see Figure 03), with zero role of dealer or any other intermediary body. Second, even partial blockchain adoption, i.e. 10-20 percent, could lead to significant reduction in transaction cost by 8-16 percent. Third, the higher the level of blockchain technology adoption, the lower transaction could be. These results come by eliminating dealer commissions and manual verification are the biggest cost-saving factors.

Fig 4. Impact of Blockchain Technology on Transaction Cost



Seeing how blockchain adoption led to reduction transaction risk in whole real estate market. For this purpose, we have calculated the weighted transaction risk reduction index, which is based on four components of market frictions such as number of fraudulent cases, average selling time of a property asset, price volatility, and transaction cost. By combining the reduction of these four components, a weighted transaction reduction (WTRR) is computed. Basically, we, first, assigned equal weights to all four components to construct this index. Nonetheless, to see sensitivity analysis we have used unequal weights as well by assigning more weights to the transaction cost.

So, the simulated results demonstrated that with complete adoption (100% adoption) of blockchain, overall market frictions from the real estate market are minimised drastically through reduction in fraudulent cases, high level of liquidity, reduction in price volatility due to asymmetric information, and drastic reduction in transaction cost (Table 06).

Moreover, the higher wights we assign to the transaction cost and zero role of dealer, the more reduction in transaction risk, would lead to complete removal of market inefficiency and market frictions in Islamabad. These findings are consistent with the literature available related to the blockchain and market frictions in real estate markets. Studies have shown that blockchain technology can significantly enhance the security and efficiency of real estate transactions through its unique technical advantages. Smart contracts, as a core component of blockchain technology, can automatically execute predefined transaction conditions, streamline the transaction process, reduce human intervention, and thereby increase transaction efficiency (Yao, 2024). Table 06: Impacts of Blockchain: Analysis of Weighted Transaction Risk Reduction (WTRR)

	W1=0.25	W2=0.40	W3=0.70
Blockchain Adoption	WTRR With Equal Weights (%)	WTRR With Unequal Weights (%)	
0% (No Blockchain)	0	0	0
10% Adoption	7	10	16
20% Adoption	16	20	30
30% Adoption	25	30	46
40% Adoption	33	40	60
50% Adoption	41	49	73
60% Adoption	50	57	84
70% Adoption	56	66	90
80% Adoption	65	75	94
90% Adoption	74	83	97
100% Adoption	84	93	99

Note: Since we have used weighted transaction risk reduction (WTRR) method which is based on four components: number of fraudulent cases, price volatility, average selling time of an asset, and transaction cost, where weighted sum of these four components would give us WTRR. So, to analyse how blockchain technology will impact the overall reduction in market frictions in real estate market. The following weighting scheme is used.
W1=when equal weights are used for all four components (1/4=0.25)
W2=when transaction cost is given 0.40 weights and rests are given equal
W3=when transaction cost is given 0.70 weights and rests are given equal

6. CONCLUSION

Blockchain technology could offer a paradigm shift for Pakistan's industrial sector specifically real estate market. It could increase transparency, reduce transaction cost, and reduce the real estate market friction. Globally, the adoption of blockchain technology has been increasing to ensure market efficiency and minimising the transaction cost. Nonetheless, Pakistan is still lagging adopting blockchain technology. We need to conduct research to obtain data-driven simulation to envisage the counterfactual impacts of the adoption of this technology, which could help the policy makers to shift the traditional to blockchain technology in different sectors of the country, especially in the real estate sector of the country. To bridge this gap up, the underlying research aims to simulate the impacts of adopting blockchain technology in real estate market efficiency. Maintaining a simple course, we have focused only on the real estate market of Islamabad. Basically, ongoing research has tested four hypotheses related to real estate market: (i) what would happen to the transparency and fraudulent cases if Pakistan adopts blockchain technology in Islamabad's real estate market, (ii) what would happen to average sale time and liquidity of a property asset if Pakistan adopts blockchain technology in Islamabad's real estate market, (iii) what would happen to price discovery if the role of dealer became zero by replacing blockchain technology, and (iv) what would happen to transaction cost of real estate market if blockchain technology is adopted. For empirical purposes, we have applied basic and simple structure of the Agent-based Modelling (ABM), a machine-

based experiment. The simulated findings demonstrate that adoption of blockchain technology would bring revolution in real estate market by enhancing the market efficiency and reducing market frictions such as asymmetric information in price discovery, enhancing transparency, and increasing the liquidity and drastic reduction transaction cost.

The structure of this technology works through tokenisation, smart contracts, and decentralised ledgers, which will disrupt the role of dealer or intermediation, and will bring down the cost of sludge or transaction costs and will help to determine market prices with true supply-demand dynamics rather than a market speculation approach. Islamabad's real estate market, replacing dealer-centric liquidity with decentralised, transparent mechanisms.

However, the CDA's role is critical: being both a regulator and an innovator, it must reconcile blockchain's disruptive potential with legal and institutional realities.

6.1. Study Implications

- This research provide an evidence-based foundation for designing blockchain integration strategies in the real estate sector. The results can inform regulations to enable secure digital property registries, policies to support tokenisation and fractional ownership, and guidelines for automating transactions through smart contracts. Moreover, the study highlights how blockchain can improve market integrity and efficiency—outcomes that align with national goals for economic modernisation. By scaling these reforms beyond Islamabad, policymakers could catalyze broader economic benefits, foster investor confidence, and position Pakistan competitively in the global digital economy.

REFERENCES

Acikgoz, F., Stylos, N. Lythreatis, S. Identifying capabilities and constraints in utilising blockchain technology in hospitality and tourism. *International Journal of Contemporary Hospitality Management*. 2024. https://doi.org/10.1108/IJCHM-07-2023-1083.

Agbo, C. C, Mahmoud. Q. H. Eklund, J. M. Blockchain technology in healthcare: a systematic review. *In Healthcare*, 2024 7, 56.

Akerlof, G. A. (1970). The Market for "Lemons": Quality Uncertainty and the Market Mechanism. QJE.

Bauer, J. Bachmaier, B. A. Framework of Blockchain Technology for Green Real Estate Bonds. Master's Thesis, KTH Royal Institute of Technology, Stockholm, Sweden, 2020.

Baum, A. (2021). Tokenisation—The future of real estate investment. *The Journal of Portfolio Management*, *47*(10), 41–61.

Baum, A. Tokenisation: The Future of Real Estate Investment? The Future of Real Estate Initiative; Saïd Business School, University of Oxford: Oxford, UK, 2020; p. 61.

Bennett, R. Miller, T. Pickering, M. Kara, A. K. Hybrid Approaches for Smart Contracts in Land Administration: Lessons from Three Blockchain Proofs-of-Concept. Land 2021, 10, 220.

Bennett, R. M, Pickering. M, Sargent. J. 2019. Transformations, transitions, or tall tales? A global review of the uptake and impact of NoSQL, blockchain, and big data analytics on the land administration sector. Land Use Policy 83, 435–448. Apr 1.

Bennett, R. M., Pickering, M., Sargent, J. Transformations, transitions, or tall tales? A global review of the uptake and impact of NoSQL, blockchain, and big data analytics on the land administration sector. Land Use Policy 2019, 83, 435.

Biais, B., et al. (2023). Blockchain, Liquidity, and Shared Ledgers. Journal of Finance.

Catalini, C., & Gans, J. S. (2020). *Some Simple Economics of the Blockchain. RAND* Journal.

CDA. (2023). Islamabad Land Registry Regulations. Government of Pakistan.

Chang, C., Wang, R. From Real to Digital: Asset Tokenisation and the Case of Brickmark; Fudan Fanhai Fintech Research Center: Shanghai, China, 2021; p. 13.

Chiu, J., & Koeppl, T. (2019). Blockchain-Based Settlement for Asset Trading. Review of Financial Studies.

Chow, Y. L., & Tan, K. K. (2022). Is Real Estate Insights tokenisation of real estate ready for lift off in APAC? *Journal of Property Investment & Finance, 40*(3), 284–290.

Di Ciccio, C., Gabryelczyk, R., García-Bañuelos, L., Hernaus, T., Hull, R., Štemberger, M. I., & Staples, M. (Eds.). (2019). Business Process Management: Blockchain and Central and Eastern Europe Forum: BPM 2019 Blockchain and CEE Forum, Vienna, Austria, September 1–6, 2019, Proceedings (Vol. 361). Springer Nature.

Dubrovina, I. (2023). Tokenisation of Real Estate: The Future Trend in Investments.

Ekemode, B. G., Olapade, D., Shiyanbola, E. 2019. Resolving the Land Title Registration Debacle: The Blockchain Technology Option. The proceedings of Environmental Design and Management International Conference. Obafemi Awolowo University, Ile-Ife, Nigeria.

Esmat, A., de Vos M., Ghiassi-Farrokhfal Y.; Palensky P., Epema D. A novel decentralised platform for peer-to-peer energy trading market with blockchain technology. *Applied Energy*, 2021 282, 116123.

Ferreira, F. S., 2021. Blockchain for real estate: a systematic literature review. 29TH Int. Conf. Inf. Syst. Dev. Valencia, Spain 12.

Grossman, S. J., & Miller, M. H. (1988). Liquidity and Market Structure. Journal of Finance.

Gupta, A., Rathod, J., Patel, D., Bothra, J., Shanbhag, S., Bhalerao, T. Tokenisation of Real Estate Using Blockchain Technology. In Applied Cryptography and Network Security Workshops; Zhou, J., Conti, M., Ahmed, C. M., Au, M. H., Batina, L., Li, Z., Lin, J., Losiouk, E., Luo, B, et al. Eds.; Springer International Publishing: Cham, Switzerland, 2020; pp. 77–90.

Haddad, D. Realium: Building the Future of Real Estate on the Blockchain. Bachelor's Thesis, Brigham Young University, Provo, UT, USA, 2021.

Haque, et al. (2022). Buying and Selling a Plot in a Private Housing Society, Section 1 the real estate Sector. *PIDE Sludge Audit Volume 1 (2022)*.

Kalyuzhnova, N. Transformation of the real estate market on the basis of use of the blockchain technologies: Opportunities and problems. MATEC Web Conf. 2018, 212, 06004.

Karamitsos, I., Papadaki, M., & Al Barghuthi, N. B. (2018). Design of the blockchain smart contract: A use case for real estate. *Journal of information security*, *9*(3), 177–190.

Konashevych, O. (2020). General concept of real estate tokenisation on blockchain: The right to choose. *European property law journal, 9*(1), 21–66.

Konashevych, O. (2020a) Constraints and Benefits of the Blockchain Use for Real Estate and Property Rights. Available at:https://papers.ssrn.com/sol3/papers.cfm?
abstract_id= 3520270 (Accessed: 26 February 2020).

Laarabi, M., Chegri, B., Mohammadia, A. M., & Lafriouni, K. (2022, March). Smart contracts applications in real estate: a systematic mapping study. In *2022 2nd international conference on innovative research in applied science, engineering and technology (IRASET)* (pp. 1–8). IEEE.

Latifi, S., Zhang, Y., Cheng, L.-C. Blockchain-Based Real Estate Market: One Method for Applying Blockchain Technology in Commercial Real Estate Market. In Proceedings of the 2019 IEEE International Conference on Blockchain (Blockchain), Atlanta, GA, USA, 14–17 May 2019; pp. 528–535.

Li Z., Wang W. M., Liu G., Liu L., He J., Huang G. Q. (2018). Toward open manufacturing: A crossenterprises knowledge and services exchange framework based on blockchain and edge computing. *Industrial Management & Data Systems*, 2018 118, 303–320.

Loukil F., Abed M., Boukadi K. Blockchain adoption in education: A systematic literature review. *Education and information technologies*, 2021 26, 5779–5797.

Morrow, M. J., Zarrebini, M. Blockchain and the Tokenisation of the Individual: Societal Implications. Future Internet 2019, 11, 220.

Mottaghi, S. F., Steininger, B. I., & Yanagawa, N. (2024). Real Estate Insights: The current state and the new future of tokenisation in real estate. *Journal of Property Investment & Finance*, *42*(6), 614–620.

Nakamoto, S. (2008). Bitcoin: A Peer-to-Peer Electronic Cash System.

Naz, L. F., Qamar, R., Asif, R., Ahmed, S., & Imran, M. (2024). Block Estate: Revolutionising real estate transactions through hyperledger-based blockchain technology. *Engineering, Technology & Applied Science Research*, *14*(3), 14458-14464.

Park. A study on the utilisation of real estate blockchain to the real estate transaction - focusing on the propy case of international real estate transaction in the United States, J. Korea Real Estate Manag. Rev. 21 (2020) 115–152, https:// doi.org/10.37642/jkremr.2020.21.6.

Redekar, S., Bhagwat, S., Upasani, K., Jha, S., & Thorat, V. (2024, June). Real Estate Management System using Blockchain. In *2024 3rd International Conference on Applied Artificial Intelligence and Computing (ICAAIC)* (pp. 1455-1460). IEEE.

Rogers, M., & Dutta, S. K. (2020). Tokenisation of the japanese real estate market. In The Definitive Guide to Blockchain for Accounting and Business: Understanding the Revolutionary Technology (pp. 177-207). Emerald Publishing Limited.

Saari, A., Vimpari, J., & Junnila, S. (2022). Blockchain in real estate: Recent developments and empirical applications. Land use policy, 121, 106334.

Schmid P., Schaffha user A., Kashef R. IoTBChain: Adopting Blockchain Technology to Increase PLC Resilience in an IoT Environment. *Information*, 2023 14 437.

Shankar, R. Potential of Blockchain Based Tokenised Securities for Green Real Estate Bonds. In Infrastructure Development–Theory, Practice and Policy; Routledge: Oxfordshire, UK, 2022; pp. 88–99.

Sheikh, A., Bqa, R., & Qureshi, S. A. (2023). Blockyards: a blockchain-powered system for secure real estate transactions. *Int. J. Emerg. Eng. Technol*, *2*(1), 30–34.

Smith, J., Vora, M., Benedetti, D.H., Yoshida, K.; Vogel, Z. Tokenized Securities & Commercial Real Estate. MIT Digital Currency Initiative: Cambridge, MA, USA, 2019, p. 46.

Spielman, A. (2016). *Blockchain: digitally rebuilding the real estate industry* (Doctoral dissertation, Massachusetts Institute of Technology).

Tapscott, D., & Tapscott, A. (2016). Blockchain Revolution. Penguin.

Treynor, J. L. (1972). *The Economics of the Dealer Function. Financial Analysts Journal*.

Ullah, F., & Al-Turjman, F. (2023). A conceptual framework for blockchain smart contract adoption to manage real estate deals in smart cities. *Neural Computing and Applications*, *35*(7), 5033-5054.

Uzair, M. M., Karim, E., Sultan, P., & Ahmed, S. S. (2018). The impact of blockchain technology on the real estate sector using smart contracts.

Witzig, P., & Salomon, V. (2019). Cutting out the middleman: A case study of blockchain technology induced reconfigurations in the Swiss financial services industry. In Blockchains, Smart Contracts, Decentralised Autonomous Organisations and the Law (pp. 18-48). Edward Elgar Publishing.

World Bank. (2021). Pakistan Digital Economy Diagnostic.

Wouda H. P. Opdenakker R. Blockchain technology in commercial real estate transactions. *Journal of property investment & Finance*, 2019 37, 570–579.

Wright, A. and De Filippi, P. (2015) 'Decentralised Blockchain Technology and the Rise of Lex Cryptographia', Social Science Research Network, 62, pp. 4–22. doi: 10.2139/ ssrn.2580664.

Yang, H., Zhang, Z., Jian, C., & Ahmad, N. (2025). Exploring real estate blockchain adoption: An empirical study based on an integrated task-technology fit and technology acceptance model. PloS one, 20(1), e0317993.

Yang, H., Zhang, Z., Jian, C., & Ahmad, N. (2025). Exploring real estate blockchain adoption: An empirical study based on an integrated task-technology fit and technology acceptance model. *PloS one*, *20*(1), e0317993.

Yeoh, W., Lee, A. S. H., Ng, C., Popovic, A., & Han, Y. (2024). Examining the acceptance of blockchain by real estate buyers and sellers. Information Systems Frontiers, 26(3), 1121–1137.

Yermack, D. (2017). Corporate Governance and Blockchains. Review of Finance.

APPENDIX

2. Key Mathematical Formulas and Their Application

2.1 Price Volatility Reduction

Price volatility measures fluctuations in property prices over time. The reduction in price volatility with block-chain adoption is calculated as:

Price Volatility Reduction = $\sigma_{before} - \sigma_{after}/(\sigma_{before}) \times 100$

Where:

• σ_{before} = Standard deviation of property prices before block-chain adoption.

• σ_{after} = Standard deviation after blockchain adoption.

2.2 Price Certainty Index (PCI)

PCI quantifies the improvement in price stability due to block-chain adoption:

$PCI = (1 - (\sigma_{after}/\sigma_{before}) \times 100$

Higher PCI values indicate more stable prices and reduced speculation.

2.3 Transaction Risk Reduction

Transaction risk is assessed based on fraud cases, transaction costs, and time delays. The weighted reduction formula is:

$$\text{Transaction Risk Reduction} = W_1 \times ((T_b - T_a/T_b) + W_2 \times ((C_b - C_a)/C_b) + W_2 \times ((F_b - F_a/F_b)$$

Where:

• T_b, C_b, F_b= Transaction time, cost, and fraud cases before block-chain.

• T_a, C_a, F_a= Transaction time, cost, and fraud cases after block-chain.

• W_1, W_2, W_3= Weights assigned (e.g., transaction cost = 70%, others = 15% each).

2.4 Liquidity Improvement

Liquidity measures how quickly assets are converted into cash. Block-chain adoption reduces selling time:

$\text{Liquidity Improvement} = ((S_b - S_a)/S_b) \times 100$

Where:

• S_b = Average selling time before blockchain.

• S_a = Average selling time after blockchain.

2.5 Speculative Reduction Index

Block-chain adoption reduces speculation by increasing market transparency:

$\text{Speculative Reduction} = ((P_b - P_a)/P_b) \times 100$

Where:

• P_b = Price fluctuation before block-chain.

• P_a = Price fluctuation after block-chain.

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