Unlocking the Economic Potential of Real Estate Tokenization in Ukraine

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Abstract

The article emphasizes the importance of the adaptive use of theoretical results in computer modeling of economic growth. Computer models prove to be a powerful tool for analyzing and forecasting economic processes, but they have their advantages and limitations. Positive aspects include the inclusion of various factors in the model, the decomposition of the economic system, the consideration of international trade, and the possibility of modification. The limitations include unrealistic assumptions, the absence of some aspects (such as the shadow economy), and the failure to take into account economic cycles. It is concluded that for practical application it is important to get rid of unrealistic assumptions and develop system models based on mathematical validity.

Keywords

Theoretical models of economic growth, their adaptive application, computer modeling of nonlinear evolution of events, digital economy, IT in the economy.

1. Introduction

In the era of technological progress, the convergence of blockchain technology and real estate markets has given rise to a revolutionary financial instrument—real estate tokenization. The Ukrainian real estate and land sector is undergoing dynamic changes and embracing digital innovations, making it pertinent to explore the opportunities and challenges presented by the tokenization of real estate assets. Tokenization, characterized as the process of transforming real assets into digital tokens on the blockchain, has the potential to reshape traditional paradigms of real estate investments. The implementation of tokenization mechanisms based on blockchain offers a pathway to democratize access to real estate investments, enhance liquidity, and introduce a new dimension to the country's economic landscape [1, 2]. Investigating the potential impact on investment models, market dynamics, and economic growth, this research aims to provide stakeholders, policymakers, and investors with information on the possibilities of real estate tokenization in the Ukrainian context. The obtained results will contribute to a broader discussion of financial innovations, offering policymakers, investors, and stakeholders a detailed understanding of the potential and challenges associated with the application of real estate tokenization in Ukraine.

2. Concept and Significance of Real Estate Tokenization

New digital technologies are reshaping markets and offering novel economic instruments for financial and investment interactions. Despite these advancements, financial markets predominantly continue to rely on analog and archaic methods for asset issuance, management, and trading. The financial system is undergoing technological changes, including the emergence of programmable money and tokenized assets, combined with modern digital technologies

such as artificial intelligence, Decentralized Finance (DeFi), decentralized identifiers, Decentralized Autonomous Organizations (DAOs), decentralized gaming, metaverses, and more [3, 4].

One contemporary category within decentralized finance is the concept of tokenizing real-world assets, which combines features and functions of cryptocurrencies with rights to real-world assets. In a broad sense, tokenization refers to the process of converting rights to any assets into digital tokens on the blockchain. It involves transferring information about the properties of real-world assets onto digital tokens in a blockchain network, providing access to virtual asset markets and their utilization within decentralized economic spaces. This process opens new possibilities for financial innovation, offering increased liquidity, accessibility, and efficiency in the management of real estate assets. As we delve into the concept and significance of real estate tokenization, it becomes evident that this transformative approach has the potential to revolutionize traditional investment paradigms and contribute to the evolution of decentralized economies. The overall structure of tokenization is illustrated in Fig. 1.
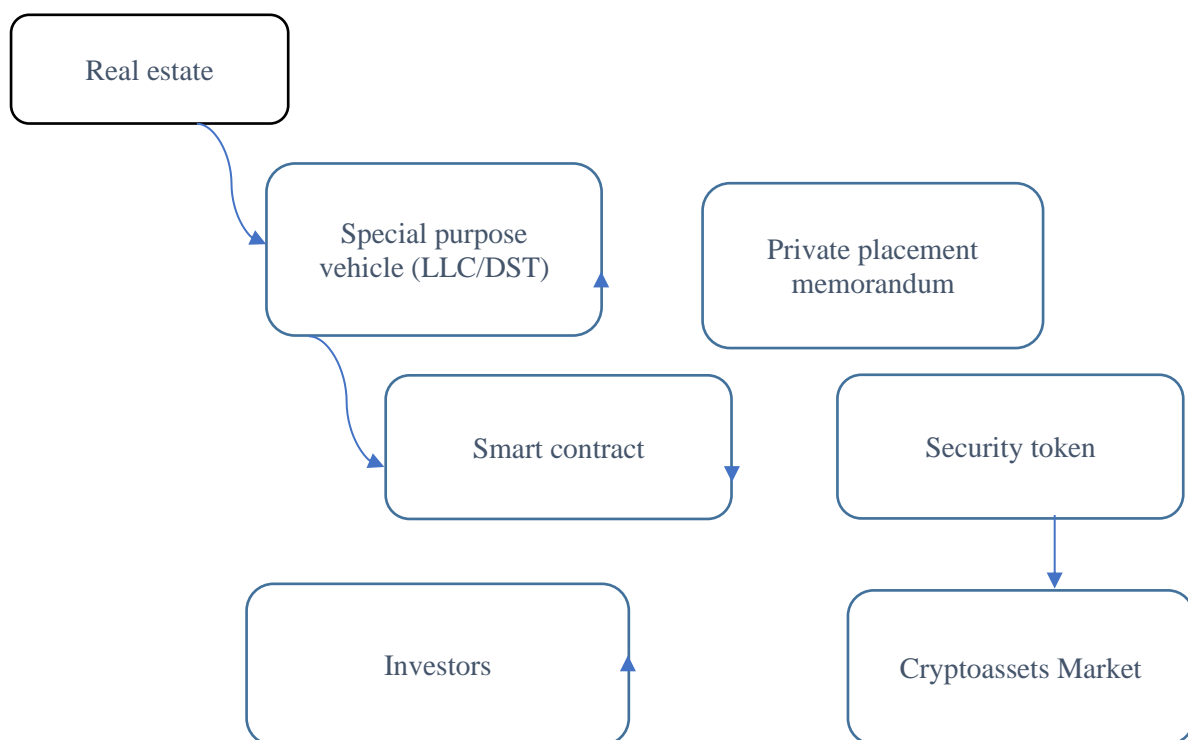

Figure 1: General Anatomy of Real Estate Token Offering (compiled based on the source [5])

The foundation of asset tokenization is blockchain technology, which ensures identity protection during the automation of interactions. Leveraging the secure and immutable characteristics of blockchain technology, tokenization facilitates partial digital ownership of assets through secure transaction records and swift settlement processes. By digitally representing property rights and associated benefits through the use of smart contracts and blockchain technology, liquidity can be enhanced, capital requirements reduced, managerial processes automated, and transparency improved [6]. As a result, issuer costs decrease, and the potential investor pool expands. Tokens represent ownership rights and future incomes of companies owning real estate. These tokens are subsequently used on respective financial markets tailored for trading crypto-assets. In addition to ownership representation, tokens streamline accounting, optimize trading, and facilitate dividend payments by the programmed token strategy.

Tokens representing rights to real estate, created during the issuance process, can be described as fractions of assets that represent the properties of rights and obligations

concerning the underlying asset, offered to investors through crypto asset markets. The characteristics of such tokens are defined in smart contracts located on the blockchain, automatically executed upon meeting specific conditions. Real estate and land markets, which continue to use manual and labor-intensive methods for administering and trading the underlying asset, deal with real-world assets represented by land, real estate objects, and associated rights endowed with specific features. Real-World Assets (RWA) are considered tangible and intangible assets in the physical world (e.g., real estate, bonds, commodities, future benefits, services, etc.). RWA tokenization provides access to virtual asset markets characterized by increased liquidity and easy access for investors. Additionally, the digital nature of property rights tokens allows their use in new, structurally, and formally different models of partnership and cooperation offered by the Web3 economy. Tokenized RWA markets today are represented by centralized (CEX) and decentralized (DEX) exchanges, TFT marketplaces, DeFi platforms, and DAOs, as well as investment opportunities in metaverses.

Models for representing assets in tokenization depend on the infrastructure and necessary tools. For example, the Ethereum network offers several token standards for representing various types of assets. The use of a standard facilitates the tokenization of assets and ensures interaction with network products and tools, providing greater access for investors. Token standards offer a set of functions and attributes for their representation in markets and the implementation of functionality. For instance, some tokens may confer voting rights in strategic decision-making, providing them with additional features. When choosing a token standard, it is recommended to assess the overall project strategy and key characteristics of the asset. Standards propose the following main classes of crypto assets, both interchangeable and non-interchangeable, which can be either alienable or inalienable. Thus, the tokenization of assets allows the modeling of complex systems of financial interaction using various types and classes of crypto assets [7], creating additional opportunities for owners of the underlying

asset and investors. The table below presents the most popular token standards for RWA tokenizations.

Table 1
The most popular token standards for RWA tokenization

Token type	Standards in the Ethereum network	Features and characteristics
Fungible Token (FT)	ERC20, ERC1155, ERC1400, ERC6551, ERC3643, ERC4626, ERC7540	Interchangeable tokens for their use in cryptocurrency markets, depending on the standard, provide opportunities for adaptation to the tools and properties of the underlying asset.
Non-Fungible Token (NFT)	ERC721, ERC5505	Non-fungible tokens, for NFT markets, contain information about the underlying asset and cannot be distributed among investors, but carry information about common ownership.
Governance Token (GT)	ERC20, ERC2767	Interchangeable tokens for use in DAOs and governance and decision-making models.
Soul-Bound Token (SBT)	ERC5516	A non-alienable token with shared ownership accounting and management access capabilities.

Asset tokenization strategies and their implementation in markets can encompass various forms of token issuance, depending on the token's characteristics, its owner, and the token's utilization within the ecosystem. Issuance forms may take the shape of Initial Coin Offerings (ICO), Security Token Offerings (STO), Initial Exchange Offerings (IEO), Initial Decentralized Exchange Offerings (IDO), Digital Tokenized Asset Offerings (TAO), and other token issuance forms. Tokenized assets serve as supplements to traditional assets by expressing digitized asset characteristics in tokens, providing additional opportunities on liquid markets for virtual assets. Consequently, small companies gain access to capital markets. The token issuer, aligned with the issuance purpose, independently determines the number of units and the issuance mode according to the emission plan. If necessary, a set of token functions can be programmed by a smart contract, including conducting additional issuance, locking its transferability, transaction sequencing, and more. Each token represents a legal ownership right to the underlying asset and can be distributed among investors through subscription or on markets in fractional shares, allowing partial ownership of

the underlying asset [8]. A general idea of the stages of tokenization of real estate assets is presented in the table below.

Table 2
Stages of tokenization of real estate assets (compiled based on the source [9])

	Stages	Procedures
1	Asset Selection and Legal Structuring	Selecting a suitable asset for tokenization. Structuring the asset into a token-friendly format, ensuring compliance with relevant regulations, and establishing the legal framework that dictates the rights and responsibilities of token holders.
2	Due Diligence and Valuation	Due diligence to confirm its legitimacy, value, and title. To ascertain the asset's current market value, which will underpin the pricing of the tokens.
3	Token Creation and Issuance	Token design to be compliant with existing standards on the blockchain network, ensuring compatibility with a wide range of wallets and exchanges.
4	Distribution and Trading	Distribution to investors through private sales, auctions, or public offerings, depending on the regulatory framework. Listing on secondary markets allows for trading and providing liquidity to token holders.
5	Regulatory and Compliance Management	Management of ongoing regulatory and compliance requirements, including reporting, maintaining investor relations, and ensuring that tokens comply with the laws of the jurisdictions where they are traded.
6	Asset Management and Servicing	Any necessary maintenance, including rent collection, authenticity verification, and dividend payment. Tracking and reporting to token holders, providing transparency and trust in the investment.
7	Maturity	Receiving of the principals and any additional returns. Token burning.

3. World Trends of Real Estate Tokenization and Opportunities for Ukraine

In the era of technological progress, the fusion of blockchain technology and real estate markets has given rise to a revolutionary financial instrument—real estate tokenization. The Ukrainian real estate and land sector is undergoing dynamic changes, embracing digital innovations. Exploring the potential impact on investment models, market dynamics, and economic growth, this research aims to provide stakeholders, policymakers, and investors with insights into the opportunities and challenges of real estate tokenization in the Ukrainian context. The capitalization of global real estate markets in investments through traditional investment funds has reached nearly $2 trillion today [10].

Real estate has traditionally been one of the most illiquid yet least risky asset classes, requiring substantial capital commitments and extensive, costly operations. As a more liquid way to access the real estate sector, Real Estate Investment Trusts (REITs) have, in the long term, outperformed other major asset classes. In 2023, real estate trust investments in the United States increased by $58.27 billion. According to S&P Global Market Intelligence, the total amount rose by 13.5% compared to $51.36 billion in 2022 [11].

As of May 2023, the market value of tokenized assets on permissionless blockchains is $2.15 billion. Citibank analysts predict that by 2030, tokenized digital securities will reach a value of $4 to $5 trillion, with approximately $1.5 trillion expected in the real estate sector [12]. Blockchain allows experimentation with non-monetary forms of tokenization, such as using Non-Fungible Tokens (NFTs) and forms of Decentralized Autonomous Organizations (DAOs) in projects involving communities and anticipating financial or production partnerships. For instance, LinksDAO has a mechanism that allows any of the 66 million people worldwide interested in golf to invest in fractional ownership of a golf course by purchasing NFTs on marketplaces [13]. Additionally, the decentralized economy enables the integration of real estate finances with other digital technologies, including Augmented Reality (AR) and Virtual Reality (VR), Metaverse, and GameFi. These technologies transform the visualization process of real estate through virtual tours and help project and identify the preferences of future investors.

The expectation is that tokenized real estate assets will evolve not only in capitalization but also in their structure. This will be facilitated by the emergence of more sophisticated token standards that enable interaction with informational and market instruments. The integration into a decentralized economic field of various blockchain networks will contribute to the development of multi-network DeFi markets, devoid of unnecessary bureaucratic procedures. The integration of Internet of Things (IoT) technology with real-time information collection about underlying assets will enhance investor trust in tokenized assets. Projects implemented today in the tokenization of real estate provide insights into

the structure and scale of investments attracted through tokenization, as some of them are presented in the table below.

Trend analysis provides grounds to consider the use of decentralized autonomous organizations (DAOs) instead of the Special Purpose Vehicle (SPV) mechanism for further decentralization of tokenized assets. DAOs may also encompass additional functions, such as voting and rewarding loyalty and activity for token owners. Additionally, each token can be structured to represent ownership rights in a specific company that owns multiple assets, allowing for the structuring of investment private portfolios [14].

Table 3
Examples of real estate asset tokenization projects

Object	Year of tokenization	Raised capital, $ 10^{-6}	Platform	Jurisdiction	Form of issue
Regis Aspen Resort, Colorado	2018	18.0	SolidBlock	USA	TAO, ERC20
Fenton St, Detroit	2022	1.2	RealT	USA	TAO, ERC20
Siam Theme Park, Thailand	2019	50.0	VEWC	USA	STO, ERC20
Lueneburg Old Town, Germany	2020	1.5	TBA	Germany	STO
Hello World, Switzerland	2019	3.2	Blockimmo	Zug	STO, ERC20

Considering the positive trends laying the groundwork for the tokenization of real estate assets in Ukraine, including a high level of crypto literacy among the population, the presence of investment skills in crypto assets, legislative initiatives, and a series of digitalization strategies by the Ministry of Digital Transformation of Ukraine, the Ministry of Finance of Ukraine, and the National Bank, several associations, such as the public union "Virtual Assets of Ukraine" [15], are actively operating in Ukraine. With their support, national projects on tokenization have already been implemented, such as the 4Bill payment service for online payment tokenization and a project for the tokenization of fruit trees. Ukrainian startups, including the Sologenic [16] project, are also involved in these initiatives. The "Art Token" project offers a

solution for the tokenization of art pieces. One of the main obstacles preventing the widespread adoption of asset tokenization technology in Ukraine is attributed to the lack of legal clarity regarding the status and regulation of tokenized assets and related operations. It is believed that by issuing tokenized securities, the investment process in Ukraine [17], could be significantly streamlined for foreign investors, which is crucial for the post-war economic recovery of Ukraine.

The Law of Ukraine dated September 8, 2021, "On Virtual Assets," allows for the creation and utilization of tokenized assets in Ukraine, defining the legal status of virtual assets, providing legal protection to investors, granting access to cryptocurrency markets, and permitting banks to engage with cryptocurrencies. However, as of the article's writing, the law has not come into effect and may be subject to revision. Critics of the law point out several unresolved issues, including the need for a definition of the term "token," the classification of tokens based on the underlying asset, the establishment of types of collateralized tokens, regulation of the tokenization process and circulation, setting emission requirements for tokens, defining the legal status of smart contracts, and issues related to interaction with other jurisdictions [18].

Furthermore, it is suggested to incorporate European regulatory models for the circulation of tokenized assets and to use a consistent conceptual and categorical framework in the law to avoid conflicts [19]. As of the beginning of 2024, the Consultative Council on the Regulation of Virtual Assets is working on a new version of the draft law, taking into account the pan-European requirements for cryptocurrencies under MiCA (Markets in Crypto-assets). Nevertheless, a positive aspect of the mentioned law is that it contemplates the circulation of secured virtual assets, which grant the owner the right to acquire real estate through the execution of a public offer to a specific contract or a notarized receipt. Thus, investors have the opportunity to demand a specific asset by a public offer. It is anticipated that such procedures can be carried out using national tokenization platforms, taking into account the peculiarities of the legislation [20].

4. Benefits and Risks of Real Estate Tokenization

The advantages of tokenization manifest in the characteristics of tokens created using smart contracts that execute automatically upon meeting specified conditions. Within the token ownership infrastructure, tokens provide security, traceability, efficiency, and swift execution of various procedures [21]. The absence of the need for human intervention helps avoid operational errors and reduce transaction costs. Through tokenization, assets acquire new investment qualities, such as ownership fragmentation, the ability to trade on secondary markets, and enhanced liquidity. The absence of barriers and minimal entry thresholds for investors allows a larger number of participants to engage in trading. The digitally structured form of tokens enables the selection of specific ownership characteristics when forming investment portfolios. Providing greater transparency and efficiency, tokenization can be an attractive alternative to existing mechanisms. The integration of real estate tokens into DeFi increases the variety of collateral in the decentralized economic space, preserving digital rights to rental or lease income for token owners. The security and fractional nature of real estate tokens make their inclusion in investment portfolios of investment, pension, and insurance funds working with crypto assets appealing.

Despite the advantages, the tokenization of real-world assets is accompanied by several serious risks and challenges. Regulatory obstacles are a major concern, characterized by their variability and significant differences between jurisdictions. Compliance with securities laws and requirements for virtual asset operations must be ensured. The storage of tokenized assets poses another significant challenge. To prevent theft and fraud, appropriate measures must be taken, and reliable asset storage solutions selected. Smart contracts and blockchain networks can be hacked or have software failures and vulnerabilities. Additionally, they must have legal force in relevant jurisdictions and consider dispute resolution processes. Markets for tokenized asset infrastructure must provide liquidity and price stability with high trading volumes. Determining the adequate value of the underlying asset and dividing it into trading tokens can be subjective and inaccurate. Confidentiality and data security issues must be addressed in the tokenization process.

As of today, there are over thirty platforms offering solutions for asset tokenization, with more than twenty specializing in real estate asset tokenization. The main platforms, identified based on ratings, are presented in the table below with their characteristics. These platforms differ in the solutions and tools they offer for investors and clients, levels of access to DeFi markets, blockchain platforms, standards for smart contracts of tokens, etc.

Table 4
Tokenization platforms with descriptions.

Company developer	Platform	Characteristics
Polymath	Polymath Token Creation Studio	Allows ERC1400-tokes on the Polymesh or the Ethereum blockchain. all operations are paid in POLYX, a native token of the ecosystem. Includes services such as reserving the security token ticker, configuring a security token, Automated distribution of security tokens via simple Security Token Offering, and Automated distribution of security tokens via USD-tiered Security Token Offering.
TokenD	TokenD	Allows to issue, exchange, and transfer real estate assets in the form of tokens with the top level of privacy, security guaranteed by the blockchain immutability, and audibility while strictly following regulations valid in your jurisdiction. Includes services such as web- and mobile wallets, an admin panel, and integrations with external systems. Allows you to configure your identification solution or to integrate third-party services.
AllianceBlock	SolidBlock	The vital link between DeFi and traditional investment by facilitating the tokenization of typically non-bankable assets. Creates custom tokenization solutions for each business based on its needs and vision.
DIBS Capital	Token Suite Platform	Makes it easy to enable the trading of real-world assets in a Web3 environment. Allows to issue, manage, and allocate tokens for trading. Enables all transactions via Web3, including token creation, sale, distribution, and so on.

LenderKit	White-label investment software	Offers an investment infrastructure with third-party connectivity to enable real estate asset tokenization. Allows to build a tokenized real estate investment platform within the shortest time, while being confident that the solution will comply with all the regulations valid in the jurisdiction where the platform will operate.
RealT		Allows investors to invest in fractional ownership of single-family rental properties in the United States, offers investors access to a variety of single-family rental properties, including properties in both urban and rural areas, offers several features that make it easy for investors to manage their investments, such as a user-friendly platform and a team of experienced real estate professionals.
Blockimmo		A regulated real estate tokenization platform with a low investment minimum offers investors access to a diversified portfolio of real estate assets, helps to reduce risk and maximize returns, and provides investors with transparency into the investment process.

The selection of a platform should take into account the characteristics of markets for trading tokenized assets, as well as the qualitative characteristics of the blockchain network and the tokenization platform, along with the capabilities and limitations of the proposed jurisdiction. Below is a model for determining the efficiency of a real estate asset tokenization platform and the proposed criteria for such a model.

$$Y = \beta_0 + \sum_{i=1}^{n} \beta_i \cdot X_i + \varepsilon$$

where Y is the efficiency of the platform (dependent variable), β_0 is the constant, β_i are the regression parameters for each feature, X_i are the individual features (indicators of platform efficiency), and E is the model error.

It is important to determine which signs (Xi) can be considered to be key to determining the effectiveness of the platform. Example:

- X1—Cost of transactions.
- X2—Security.
- X3—Speed of transactions.
- X4—Scalability.
- X5—Selection of standards.
- X6—Availability of tools.
- X7—Platform functionality.
- X8—Effectiveness of jurisdiction.
- Xn—others criteria.

Research into tokenization challenges to achieve maximum impact suggests considering the following advantages provided by tokenization platforms: enhanced liquidity of assets, faster and cheaper transactions, operational transparency, and accessibility for small investors [22]. The most common indicators of tokenized asset markets are the total trading volume and token trading volume relative to the overall volume. The Basel Banking Committee [23] proposes parameters that affect the liquidity of a specific asset. These include tightness (spread between the bid and ask), resilience (time to return to equilibrium price after fluctuations), width (number of rising/falling transactions), depth (how much a transaction increases price movement), and immediacy (time to execute a transaction). There are several well-documented side effects and connections with liquidity, including asset pricing, transparency, and market efficiency. Considering the structure of real estate tokens, measures can be taken to increase liquidity, such as fractionalization and the creation of pools for retail investors, as well as trading on the secondary market. Investors in real estate tokens also have the opportunity to adjust risk [24]. Since real estate through tokenization can now be fractionated and traded on global exchanges, it can directly impact the overall liquidity of real estate.

5. Conclusions

The presented process of real estate asset tokenization in the article holds potential for the Ukrainian economy by improving and simplifying procedures for accessing investments. Analyzing the legal foundations of asset tokenization allows conclusions to be drawn regarding the prospects of utilizing this innovative technology, particularly for small projects in agriculture and construction, seeking cost-effective means of funding. Access to virtual asset markets should be facilitated through both national and foreign tokenization platforms, taking into account national legislation and established regulatory provisions. The proposed recommendations can be considered in the selection of tokenization methods and the structuring of the corresponding investment model.

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