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Blochchain-based Real Estate market: one method for applying Blockchain technology in Commercial Real Estate Market

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***Abstract*—Global real estate (RE) investments account more than twice the size of the stock market. Yet the number of investors in RE are much lower, because of the liquidity and global access. Tenants, owners, and investors are barely satisfied in the current system. In this paper, the goal is to try out the employment of blockchain in RE market and represent the facilities it can give to the RE market.The research to date leads to the following conclusions: Blockchain technology and smart contracts can sort out the classical issues that RE is facing with, and they offer much more meaningful tools for a game theoretic stable-priced market.**

***Index Terms*—Blockchain technology, Commercial Real Estate, Algorithm based Stable token**

1. Introduction

RE investment is considered one of the safest options for investing. For that we have: it provides security to investors and is a hedge against inflation (money inflation). It is also a physical asset that is excellent for portfolio diversification, and can be non-volatile and essentially risk-free over a long period of time. RE investment is available to everyone as opposed to for experts only.

1.1. REs markets

The size of the professionally managed global RE investment market increased from USD 7.4 trillion in 2016 to USD 8.5 trillion in 2017 according to the MSCI (which includes 2.97 Trillion from the U.S. market, 0.82 Trillion from China plus Hong Kong, 0.79 Trillion from Japan, 0.72 Trillion from the UK and 0.51 Trillion from Germany), whereas the whole global RE market counts a size of over 200 Trillion USD (see Savills Research Department) [9], [10].

1.2. RE market drawbacks

RE with over 200 trillion USD is the single largest asset class globally. However, the way business with this asset class is carried out is not just complicated, but also costly, non-transparent and highly inefficient [10]. Most importantly, RE investments are even more out of bounds for ordinary people. RE investments are dominated by either institutional investors or by ultra-high-net-worth individuals. This restrictive access prevents ordinary people to profit from growing returns on RE investments. For owners of RE, the value of their RE often serves as a security for unforeseen eventualities. However, it is no liquid wealth. To access the wealth 'trapped' in their RE, owners either have to sell off their equity in it or take recourse to some financial vehicle which secures their equity release [10].

In addition to these drawbacks, Commercial RE (CRE) industry has been slow and problematic to innovate its core business processes. Today, commercial brokers and other middlemen are struggling hard with old-fashioned technology, data sharing mechanism, inefficient cash flow management, real-time performance data, and so forth. These drawbacks lead to collusion and side effects for tenants, owners and investors [17].

In accordance to IBISWorld, the global CRE industry revenue totals $3385 trillion [8] and this indicates how competitive the market is in the fierce condition that CRE is operating within the narrow boundaries of prices, sales comparables, lease rates, and also when previous transactions and valuations that are kept secret by market players.

1.3. Blockchain technology

Blockchain is a shared database technology whose well-known application has been to support Bitcoin digital cryptocurrency. It works with linked databases that update digital record books continuously [1]. Smart contracts are also another concept that means: a work be done and be audited automatically without the existence of middlemen. In smart contracts, codes are laws and two parties in a transaction agreed on its content [20].
Blockchain and smart contracts introduce a new set of tools and framework to create a new generation of markets where supply and demand is equipped with a secure commercial transactions, and also with such various commercial rules

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and without the need for a central mediator sector. Historically, as like as online markets that have just altered many traditional stores and systems, blockchain and smart contracts will lead to a new type of peer-2-peer market that is able to destabilize current running markets [1].

The usage of blockchain can be permissioned or premissionless in that there is a trusted or trustless network respectively. The necessity for using permissioned and permissionless blockchains are shown in Fig. 1 [27]. As this figure shows, blockchain is used when multiple entities write to a shared database. If entities are unknown or want anonymity, then a permissionless blockchain is preferred. Otherwise, when they need trust, they desire a permissioned blockchain [28].

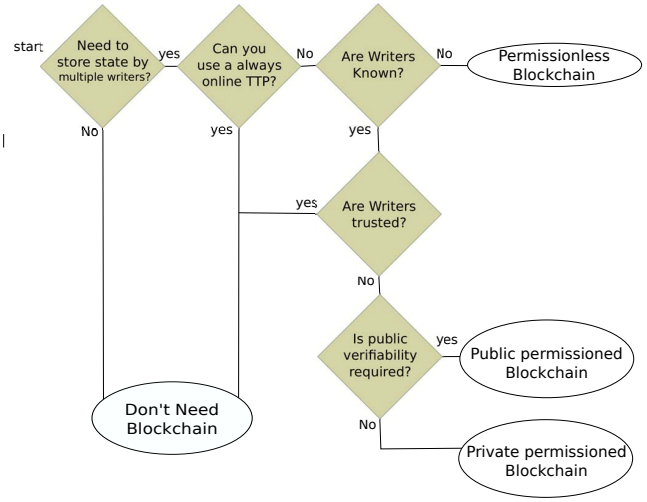

Figure 1. The needs for using blockchain

In a technical view, a blockchain is a public ledger that records chronologically all new transactions requesting a new upload or modification [2]. Figure 2 shows a Ledger and blockchain and their relation [29]. It shows that ledgers can be figured as a history of all transactions that happened up to now. World state, as a database, holds the current values of different fields, and for this manner, blockchain is a transaction log that records all the changes that determine the world state.

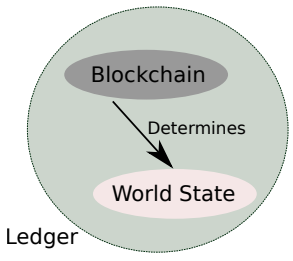

Figure 2. Ledger and its subsections

Due to its nature for storing transaction's log and history, blockchain broadly can be used for asset management (trade processing and settlement) even when there is no trust between seller and buyer or any other members in the network.

2. State of the Art, Literature Review, and Opportunities

In fact like other markets, digitized world enhance mobility, efficiency and transparency for one of the largest global asset categories, namely RE. Due to the drawbacks that centralized databases are facing, the emerge of blockchain technology is able to be present and solve some of these radical issues [3] in RE. Blockchain as a decentralized one offers the following benefits:

- Tokenization: Blockchains make tokenisation business models and economies possible–This is fundamental to tokenizing RE [11]. The liquidity problem has always been the biggest problem of RE. Tokenization democratizes ownership of assets to split assets into tokens that are stored on the blockchain. People in different geographies and tax brackets now have access to attractive investment opportunities that they previously would not [10], [12].
- Transparency and Trust: Blockchain-based applications and businesses are by design transparent in their transactions and building trust. The possibility of frauds and ownership dispute can be almost eliminated with the high degree of transparency. Data and transaction records cannot be manipulated or tampered with. This makes blockchains ideal for trust-free transactions.
- P2P transactions: Blockchains provide P2P transactions a big thrust because by design they eliminate intermediaries.
- Cost reduction: The current process of ownership transfer can take months due to the various parties involved and the need to verify the documentation during various stages, usually with the assistance of a lawyer. The blockchain technology will be able to address this issue by deleting the middle parties [10], [11].
- Smart contracts: A transaction using a smart contract is completed entirely between the buyer and the seller (or renter and landlord) and has no human interaction. Transactions can be done in far less time with far less chance of fraud. Computer protocols check the legitimacy of the transaction and no agreement can be completed until all of the terms are met [13].
- Integrity and Security: The decentralized nature of the Blockchain technology ensures that records stored on it can't be changed or controlled by a single source, thus it provides security against malicious attacks such as hacking.
- Property Title: Title insurance has grown to be up to $15 billion per year by ensuring buyers that

their property is clear of old liens and debts. Every municipality has their own specific method for storing assets' data. With the usage of blockchain, considerable amount of time and money would be saved and, and it could eliminate the need for title insurance. It is also possible to store information about construction, damages and improvements to the title [12].

Applying blockchain in the realm of RE transactions and land/title registries has drawn a considerable attention and support from governments such as North America [4], [21], [24], Europe [5], [25] , Dubai [6], [22] and Japan [7]– all of which are economic giants. This simply means that the CRE world is potential to embrace a faster, better and more affordable way of taking its action. Forbes noted three areas that blockchain has the ability to improve regarding the RE market [9]: multiple listing service (MLS) property data, title records, and transactions.

As such effective projects, aassio [14] is a blockchain-based platform where people will get easy access to easily invest, hold, buy or sell RE with other cryptocurrencies or cryptoassets. Moreover, AgentMile [15] which received FinancesOnline award aims to become the world's first decentralized commercial RE leasing platform powered by artificial intelligence (AI). Properbuz [16] also aims to decentralize a $217 trillion global RE market by developing a blockchain-based decentralized protocol. Besides SMARTRealty [17] intends to employ smart contracts to broaden the traditional contracts.
Today, new companies are having ICOs–initial coin offerings, where one invests in desired market [13]. The graph in Figure 3 shows the top 20 industries in 2018 with the largest average ICO hard cap.

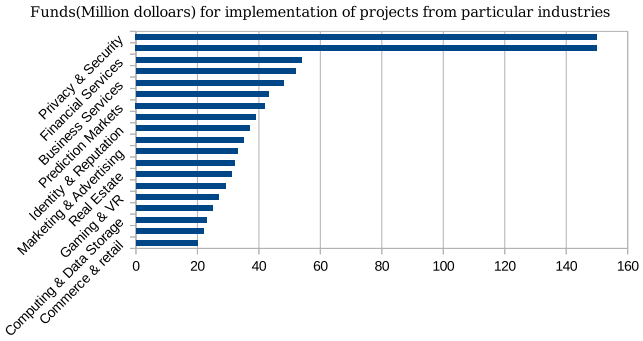

Figure 3. Funds for ICO hard caps for different industries

In addition to ICO, which is not backed by real assets or sometimes does not support voting or owning rights, another concept is going to be legalized in the coming year. This method is called security token offering (STO) which stipulates the blockchain-based projects to be backed by real assets [19]. For this matter, RE can employ STO to offer better solutions for its investors.

The discipline of game theory's breakthrough came with "Theory of games and economic behavior", published in 1944 by Neumann. This was followed by important work by John Nash (1950). Game theory had a major influence on the development of several branches of economics (industrial organization, international trade, etc. Game theory, in fact, provides a formal language for the representation and analysis of interactive situations like market, where several entities–called players–take actions that intend to affect each other [34].

All we do here in this paper is to present a model to benefit all parties involved in the RE and be secure against the mentioned problems. Issues like being resistant to devaluation of investments (inflation and deflation), having a stable price, and gaining interests and revenue are also of paramount importance to demonstrate in this paper.

The rest of the paper is structured as follows: In the next section, literature Review, and opportunities are reviewed and the goal of the present paper is stated. Then we offer a theory that is possible to accept after the emergence of the blockchain and smart contacts. Making this offer leads to giving a discussion in the subsequent section. Additionally, features and facilities that out presented method can provide is explained. In last section, recapping the issue and viewpoint, we come up with a conclusion.

3. Theory development

3.1. Technical issues and solution

As discussed, using blockchain and smart contract can help having a secure and easier investment in RE market. All that said, the technical issues are left unexplained. As a classical issue, when it comes to "supply and demand", it leads the price to fluctuate; it is not a good idea for stable price tokens at all.
Over the centuries, human being used fiat or real assets like gold as means of bartering goods. Both of them are problematic in regards of time [31]: Fiat currency is not trustworthy in long term and, neither is gold in the near term (Fig 4, 5). That means that one can witness the devaluation of fiat or gold in long or near term respectively. As the value of money has an effective connection with "purchasing power" we draw our diagrams in respect with purchasing power [31].

Hence, having a mechanism that keeps the value of its currency stable over time is of high interest. The ideal mechanism in question can be represented in Fig. 6, where in both near and long term this ideal currency is not devalued. In the rest of the section, we discuss this mechanism and its feasibilities and features.

Before we elaborate our ideology, it must be mentioned that the RE sphere along with the new era of blockchain must have the following features:

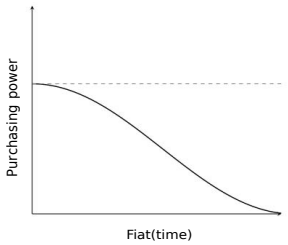

Figure 4. The shortcoming of fiat currency in long term

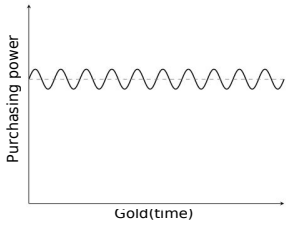

Figure 5. The shortcoming of Gold currency in near term

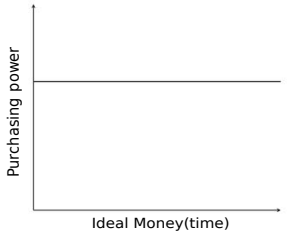

Figure 6. The ideal token(money) as a store of value

Feature 1: having RE tokenization (with T Tokens): for this, a platform is needed to act as an investment 'gateway' in the blockchain economy. It will allow RE investors, tenants, and property sellers to participate in tokenization processes. With this tokenization, the tokens are countable, fungible and divisible. Therefore, these tokens are "unit of account". If people see that one token has these properties, they are willing to specify the value of other assets with this tokens. Also, as the price of T tokens are stable, they can be eligible for being a "medium of exchange". This feature means that both sides in a transaction agree upon the payments with T tokens.

Besides, T tokens must be backed by real assets. Therefore, they are valuable overtime, and they can provide the characteristics of "Store of value". Being the store of value is inherent in RE properties as their values are not perished over the course of time.

Till now, for knowing the main characteristics of the presented tokens see Figure 7 [31]. Fiat money and gold already fulfill these three functions, but they're not able to perform as certain currencies in different times. With the ideal system we discuss later in this subsection, we propose tokens that function as an ideal money every time.

Feature 2: using a crypto exchange (CE): CE is going to

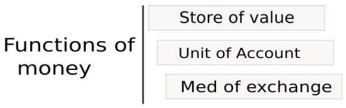

Figure 7. The main characteristics of Token T

be a licensed and regulated crypto exchange, and tokens will be listed on CE and can be traded on it along with other cryptocurrencies or specified fiat money. With the ease of exchanging tokens with fiat and other cryptocurrencies the liquidity problem is met. This easily can state that this system provides a "medium of exchange" for all parties who agreed upon the value of exchanged property or token.

Feature 3: providing open source mechanism: This will provide the system with excellent features to offer innovative solutions promoting efficient and sustainable future-living concepts around RE. Giving an open source platform to user can make them trust the system and see through its performance.

Saying all the features of ideal money (or here ideal stable-priced token), the procedural method to be applied in RE market is as follows:

- Firstly, an ICO is held and investors are welcomed to invest. With the funds that the project receive from the ICO, REs assets are bought.
- Then the RE that are bought are tokenized to tokens T (proportional to its value) and given to investors– 1T=$1. With this, the ICO implicitly is considered as an STO. See the Figure 8. Token T is an ERC20-type token basically created in Ethereum blockchain and can be transfered through the platform between different holders in their very own digital wallets. The term "platform" refers to the system that has investors, buyers, sellers, tenants, owners, and RE assets in overall, and launched with an online web-page or application (Desktop, Mobile) and users can connect to it and do their business work through it.

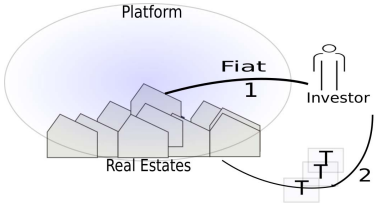

Figure 8. Scheme of platform

Now, we want to show how and why the price of T is stable. Before starting, we must say that RE has some entities: Investors, tenants, Owners, buyers and sellers (see Figure 9).

- Tenants are those who hire houses and give fiat money for their monthly rent payments.
- Owners are the landlords who have their houses and look for tenants.

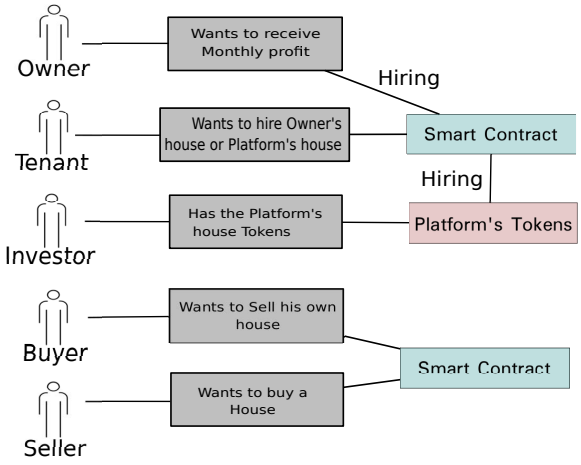

Figure 9. The RE entities

- Investors are the T holders where each of T token has the value equal to 1 dollar.
- Buyers and sellers just want to find each other and buy or sell their desired houses.

RE has its own inflation. Based on the annual inflation, a T holder can have its own T tokens with permitted inflation that is dedicated to the RE market, i.e with having a T token its holder can have T + $\%a$T at the end of each month(this inflation increase in RE is about $\%a$ monthly). Because we pegged T token value to \$1, this inflation rate is considered with regards to 2 percent dollar inflation. The Figure 10 shows that when a house price is \$100 because of inflation of $\%50$ (monthly) its price will be \$150. Therefore, each token part of the house that is tokenized must be effected. As the value of T token is stable to \$1, the rising question is how it is possible to handle this? The answer is simple: If one investor has one token T in hand, his share will be T + $\%50$T at the end of the month.

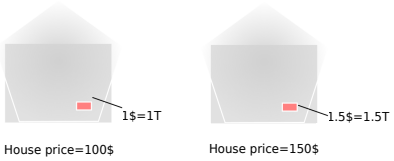

Figure 10. Inflation effect on RE prices and simple solution for this inflation

Moreover, if a RE that is tokenized to T tokens be hired by a tenant, a token can make a profit with rent payments monthly (about $\%b$). In this regard, we can tell that the possible profit of having token T can be represented monthly as: $T + (a + b)\%T$. Notice that this is an ideal situation when token T is hired by a tenant, otherwise, when the token is not hired we can expect $T + a\%T$ (see Figure 11,12).

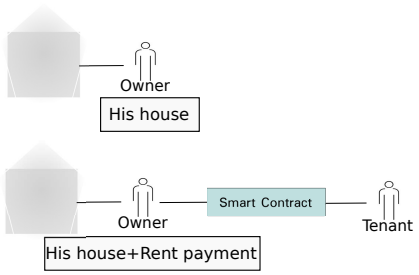

Figure 11. Owner-Tenant connection

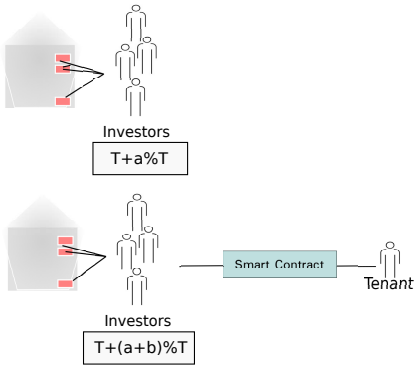

Figure 12. Investor-Tenant connection. In this platform, for instance, sharing the ownership of a house, investors can monthly receive $\%a$T. In case one tenant hires their house they receive more $\%b$T for each of their T tokens.

In fact, for hiring a house, this mechanism is established by a smart contract (See Figure 9). Also, we are to mention that as far as the platform can find tenants, after receiving the rental payment, platform rations this budget proportionally among T holders.

- The existence of tenants can make a change in the price of T tokens(as shown in Figure 13).
  So we have two situations :
  More tenants: When tenants are increased to hire houses: In this case the T price is expected to get higher temporarily.
  Less tenants: When tenants are decreased to hire houses. This will happen when we have tokenized some houses and there is no tenants for hiring the house; this simply means that there are some T tokens that can not make interest monthly.
  As tenants are hiring houses they pay fiat and make the house owner more profit. Besides, these hires, as they make more profit for T holders or owners, makes T tokens more popular in the market. The result of this popularity make the price of T be higher that \$1. To tackle this, the platform needs to mint more T tokens and give them away in the network to regulate the supply proportional to demand; so, the platform will decide to receive the fiat from tenants and buy more RE and equally give T tokens to T holders. With this action, supply will

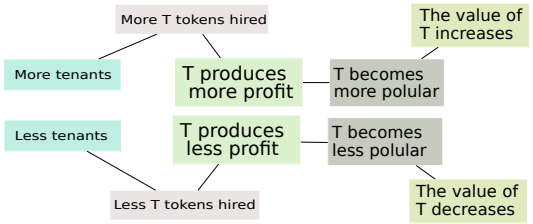

Figure 13. How the T tokens' price are affected, from left to right

be regulated as a proper response to the increased demand.
$A\%$ of the Tokens are distributed to T holders (here the previous investors), and for about $B\%$ are given to the platform owners and developers for further needs.
Accordingly, when tenants are low, the current payments are gathered in fiat and are give to T holders in fiat.
When the tendency of the majority of T holders is to sell their tokens, the value of tokens intends to drop. To face it, the monthly interest is paid in fiat. $A\%$ of the interest are distributed to T holders, and for about $B\%$ are again given to the platform owners and developers. To understand these details see the Figure 14.

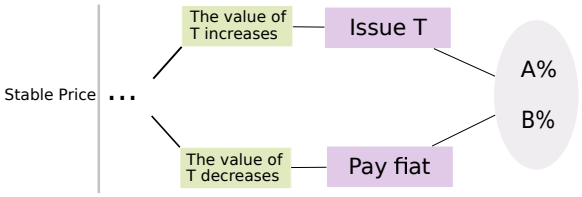

Figure 14. Distribution of rent profit

Therefore, this token is not inflated like fiat (fiat is easy to be injected to the market by the government), and nor it is like gold that is hard to be mined. Therefore, with the aid of this mechanism, T tokens are being able to be responsive in near and long term.

- A small percent of payments' fees prevent malicious transactions that help reduce and control the traffic of platform.

4. Discussion

4.1. Facilities and innovation

In this platform, with blockchain, STO represent fractional ownership of real property. Companies have tried to crowd fund RE before, but the issue was always the liquidity of the ownership. If I buy a house with another person and they want to sell in a year and I don't want to, I either have to buy him out or wait until that person be eager to sell. Depending on the price of the property, I may not be able to buy him out. But, here with having a T token, it allows investors to trade the tokens out for fiat or other properties in the portfolio, offering liquidity with less liability. undoubtedly, investing in RE that needed a large budget in traditional systems are easier in this new system. The inborn features of blockchain, such as security, data verification, the ability to promote disintermediation in CRE, fair rights for participants, low cost, and transparency [9] prompt us to use blockchain facilities in the presented platform to overcome such issues [23].

When it comes to applying blockchain in terms of cryptocurrencies we are to pinpoint that volatility has prevented widespread adoption of cryptocurrencies as payment for RE, though crypto-based RE transactions are continuing to grow. Until cryptocurrencies gain enough stability, it is unlikely that they will become a fully mainstream method of currency in the housing market. Hence, the first step to assure the users of a new innovation in RE is that they must be confident about the value of their tokens–where the proposed method can provide a store of value for T tokens.
As a stable price token, the T tokens are not like algorithm-backed tokens like Ampleforth [31], Kwala [32], or Basis [33]. The difference between T tokens and these algorithmic tokens are that T tokens are backed with RE assets and algorithmic tokens lack any asset-back mechanism– this makes the presented tokens more crucial for having a stable price where it needs a wise plan.
On another hand, as an asset-backed token, T token is not as like as MakerDao [30] that tries to lock up more value than its stable token dai. Moreover, the assets that T tokens are pegging to are producing profits themselves (as of rental payments) and have their own standard inflation market while dai(its stable token) is backed by a fluctuated cryptocurrency like Ether that is not making any profit as a backed cryptocurrency.

4.2. Formal representation and discussion

The innovation method for providing a stable price token T can be formally stated.
To understand the viewpoint, one game theory scheme can be presented: if one applies Nash equilibrium game theory viewpoint [18], it is easy to say that we have only two actors(players) namely $Market$ and $System$. All that $Market$ can do (as strategies) is to take an action that lead to a situation where $Supply > Demand$ or $supply < Demand$ for token T. Strategies designated for the actor $System$ is: $Issue\ T$ or $Give\ Fiat$. By this, the system(our platform) regulate supply with demand.
With considering the payoffs for game between actors $Market$ and $System$ one payoff-strategy scheme can be shown like one in Figure 15. The $(.,.)$ is defined for system's payoff and market's payoff, i.e $(system\ payoff\ ,\ market\ payoff)$ in which $system\ payoff$ represents the

goodness of T token's value (not inflated or deflated), and $market\ payoff$ represents the equilibrium between supply and demand.

System \ Market	Supply>Demand	Supply<=Demand
Issue T	(-1,-1)	(1,1)
Give Fiat	(0.5,1)	(-0.5,-1)

Figure 15. payoff-strategy scheme in a game between market and system

The scores in Figure 15 are given as follows:

- When $Supply > Demand$, the worst case that might happen is to $Issue\ T$; this will mostly devaluate T tokens. We have set the (-1,-1) as both actors, namely $Market$ and $System$, will make loss.
- When $Supply <= Demand$, if $System$ does $Give\ Fiat$ action, investors are not satisfied. We have set the (-0.5,-1) where $Market$ and $System$ will make loss, The impact of this action on $Market$ is more tangible and that is why we set -1 for it.
- When $Supply > Demand$, $Give\ Fiat$ action is a good move. We have set the (0.5,1) where $Market$ and $System$ will both make profit. The situation is not highly ideal for $System$, as its ultimate desire is to engage more investors with issuing T tokens; For that we set 0.5 to show this desire.
- In fact, when $Supply > Demand$, $Issue\ T$ action is the best move for each $Market$ and $System$. We have set the (1,1) since they make profit ultimately. $System$ engages more investors with issuing T tokens, and the need in $Market$ is handled properly.

In this game, Nash equilibrium says that there are two mutual good solutions in this game: (1,1) and (0.5,1), while (1,1) is a preference.

As one might notice, this game in reality is not a simultaneous game. In reality $Market$ takes an action and in a chronological manner the $System$ take a responsive reaction. The game tree for this sequential game (extensive form) is shown in Figure 16. By this figure, the best mutual payoff is when $Supply < Demand$ and $System$ chooses to issue tokens. The subordinate one is when $Supply > Demand$ and $System$ pays fiat to users.

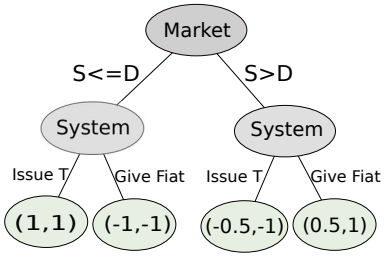

Figure 16. Game tree of the game between market and system

4.3. Implementation

In fact the presented method mostly aims at regulating supply with demand, in regards with applying standard inflation of RE market. All the platform does is running smart contracts verified through transparent codes.

As another fact, today we have a broad spectrum of governmental and regional policies that are different from each other. So we need an RE platform working on its own blockchain and be able to apply different rules according to the country and legislation of the project itself, and sometimes it needs to play with $\%a$ and $\%b$ convenient to that country (These percentages are illustrated earlier).
All said, the best way that can be addressed is to use one network as like as Ethereum letting different policies being applied, tokens be created, and then after raising funds in ICO, allowing us to take them to the customized and proprietary blockchain of our own. Undoubtedly, as users are not known to each other one permissionless blockchain is used to help this trustless network.

Smart contracts that employed by the project do not only define the rules, terms, and penalties of an agreement, they can also automatically enforce those obligations or enforce the agreed upon penalties for failure to perform obligations. Like other business sectors, AI tools (tools like Chatbots with customers, put a price tag on homes [24], price prediction [25], finding potential customers [26]) can also act in an Oracle-based system and benefit the project.
Here in Fig (17) we present an overview of the architecture and its touch-points with the external world. With a market oracle, the current price of token T is given to the system, and with this price the system decides how to manage the functions of actors.

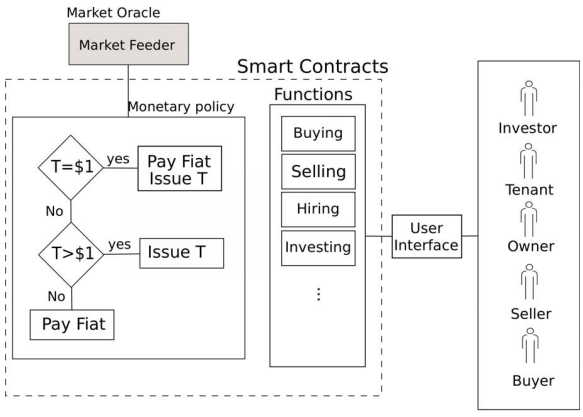

Figure 17. Architecture

5. Conclusion

We discussed that this is possible to provide liquidity to RE market and remove middlemen– classical issues in RE. For this, blockchain technology helps fulfill this plan by harnessing smart contracts.

Also multiple benefits including de-risked asset with a stable price token in RE market is implemented that can be protected against manipulative actions of market bubbles. Other benefits will be process integrity, network reliability and longevity, faster transactions and lower transaction costs. To this matter, the shown system can benefit tenants, owners and investors all in a better way. And also, with an STO-like nature it can assure investors to budget on their future purposes.

References

[1] "(GNC) ICO, Token Sale, 1 ETH 500 GNC", Jan 2019, https://greencointoken.com/.

[2] "Bahiticoin", 2018, https://bahiticoin.com/.

[3] "Global Real Estate Market Outlook" 2 Apr 2019, https://www.cbre.com/research-and-reports/2017-Global-RE-Market-Outlook.

[4] "Council Post: Developments And Adoption Of Blockchain In The U.S. Federal Government. ", Jan 2018, https://www.forbes.com/sites/forbestechcouncil/2018/01/25/developments-and-adoption-of-blockchain-in-the-u-s-federal-government/#427d2b893d99.

[5] "Blockchain in Europe", Feb 2018, https://hackernoon.com/blockchain-in-europe-b914cf1a9ea1.

[6] "Dubai's land registry is world's first to embrace Blockchain", 2017, http://www.property-report.com/detail/-/blogs/dubai-s-land-registry-is-world-s-first-government-entity-to-embrace-blockch-13.

[7] Tech in Asia, "Connecting Asia's startup ecosystem", Oct 2017, http://www.techinasia.com/japan-financial-blockchain-adoption.

[8] IBISWorld, "Industry Market Research, Reports, and Statistics", https://www.ibisworld.com/industry-trends/global-industry-reports/real-estate-renting/commercial-real-estate.html.

[9] Max Crowdfund, "Dominium Whitepaper", 2018, https://dominium.me.

[10] Aassio, "aassio whitepaper", 2018, https://aass.io/.

[11] Iotokens, "iatokens Whitepaper", 2018, https://www.iatokens.com/.

[12] "Three ways blockchain technology will revolutionize real estate in 2019", Nov 2018, https://www.forbes.com/sites/forbesrealestatecouncil/2018/11/15/three-ways-blockchain-technology-will-revolutionize-real-estate-in-2019/.

[13] "Blockchain Technology to Resolve Real Estates Problems", Jul 2018, https://blockchain.wtf/2018/07/industry-impacts/enterprise/real-estate/.

[14] aasio, "aasio Whitepaper", 2018, https://aass.io/.

[15] Agentmile, "Agentmile Whitepaper", 2018, https://www.agentmile.com/.

[16] properbuz, "properbuz Whitepaper", 2018, https://www.properbuz.com/.

[17] Smartreality, 2018, "http://www.smartrealty.io".

[18] Osborne, Martin J.; Rubinstein, Ariel. A Course in Game Theory. Cambridge, MA: MIT. p. 14. ISBN 9780262150415, 1994.

[19] Mobo, "Mobo Whitepaper", 2018, https://www.mobu.io.

[20] Agric, "Agric Whitepaper", 2018,http://agric.online.

[21] Chellecoin, "Chellecoin Whitepaper", 2018, http://www.chellecoin.com.

[22] Habibicoin, "Habibicoin Whitepaper", 2018, https://habibicoin.io.

[23] Brickvest, "The global real estate liquidity platform", 2019 , https://brickvest.com/.

[24] Skyline, "Real Estate Investment Meets Artificial Intelligence", 2018, https://www.skyline.ai/.

[25] proportunity, "New York Creative Marketing Solutions - Upportunity", 2018, https://proportunity.co/.

[26] Rex, "A Smarter Way to Buy and Sell Homes", https://www.rexchange.com/.

[27] Wagenaarm. 2018, Blockchain Decision Tree. steemKR. Accessed March 2019.

[28] James, Febin John, "How to Validate If Your Ideas Need a Blockchain", 2018, https://devopedia.org/types-of-blockchains.

[29] "A Blockchain Platform for the Enterprise hyperledger-fabricdocs master documentation", 2018, https://hyperledger-fabric.readthedocs.io.

[30] makerdao, "Makerdao whitepaper", 2018, https://makerdao.com/.

[31] Ampleforth, "Ampleforth whitepaper", 2018, https://www.ampleforth.org/.

[32] Kowala, "Kowala whitepaper", 2018, https://www.kowala.tech/.

[33] Basis, "Basis whitepaper", 2018, https://www.basis.io/.

[34] Bonanno G, Game Theory (open access textbook with 165 solved exercises). arXiv preprint arXiv:1512.06808, 2015 Dec 21.