APPLICATION OF ASSET TOKENIZATION, SMART CONTRACTS AND DECENTRALIZED FINANCE IN AGRICULTURE

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Abstract
This is a study for applying Decentralized Finance (DeFi) operations in a real life Agricultural finance application focusing on how assets tokenization in general and crop insurance in particular may take advantage of fundraising, global capital markets, atomic swap operations over blockchain and finally peer-to-peer trading without intermediaries under standardized regulations and revolutionary custodial services. Descriptive statistical data presentations such as graphs and tables are used to do the analysis and evaluate the development of the sector. The paper is exploring the boundaries and the depth of Decentralized Finance while focusing on Asset Tokenization Application that are being deployed mainly in different agri-businesses starting with crop insurance and ending up with tokenizing the products over blockchain. In conclusion, asset tokenization as a representational digital asset for a traditional financial instrument is becoming an increasingly important part of modern finance and "blockchainization" of the real world. This paper addresses how agriculture sector as production sector can use asset tokenization in securing the crops by smart contracts and issuing digital tokens to fundraising for micro-insurance. Also, using blockchain to tokenize the crops for future contracts while in the same time boosting the efficiency of the agribusiness finance, crop insurance, trading in primary and secondary markets as well as exploring new markets without intermediaries, are aspects that are found in the present research.

Keywords
Tokenization, decentralized finance, smart contract, crop insurance, blockchain, decentralized ledger.

JEL Classification
O330.

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Introduction

Tokenization is a process in progression that stems from securitization embedded in Blockchain technology that allows for sharper transparency, aggressive transactional efficiency, improve risk management than ever before.

Today tokenization is about enabling robust accessibility to illiquid assets without increasing systematic risks and by paving the way to fundraising for micro-projects as well as large-scale startups. To digitally convert an asset from its analog nature is a new representational way of ownership for the class asset itself – a digitized version and more importantly a democratization of the asset itself "wrapped".

Digital dollars, stablecoins, or even gold traded in the secondary market are all virtual assets that are having representational nature (Berentsen and Fabian, 2019). Tokenization of assets is the new "sliced-ownership" that evolves around DeFi (Decentralized Finance) and Blockchain networks. Many examples are floating nowadays about tokenization of carbon credits and how companies are being able to buy and sell these credits in slices known as "tokens" over a secondary market that is accessible by anonymous buyers and sellers that are being paid in digital money usually known as cryptocurrencies.

The problem is usually approached from two perspectives:

a) In terms of demand: Smallholder farmers and the problem of mistrust, long period claim cycle and the limitation of coverages.

b) In terms of supply, Di Marcantonio and Kayitakire (2017) argue that "the most common restraints are lack of quality data, start-up costs and related economic support by the government, and difficulty in shifting covariate risk to the international reinsurance market." Additional limitations are represented by the fact that policies are developed and distributed by mediators who lack the substructure to scale the product at low cost and effectively track real-time weather data linked to multiple policies.

1. Literature review

Blockchain, as the main technology behind DeFi, is a decentralized system of distributed ledgers. Each system contains several ledgers for events, instances, conditions, and other data-driven inputs that are stored, sorted, protected and secured by computational power that is equivariant to quasi-quantum levels which makes them impossible for breaking, using nowadays technologies. The properties of the blockchain processes that concerns DeFi in agriculture and asset tokenization is aiming to:

- Reduce claim cycles
    - The claim cycles are usually long and frustrating especially when the tokenization of assets is about converting insurance to smart contracts. In many cases the financial frictional risks are related to the time-stamps of the claiming "phases" where the time period taken to trigger the payments for coverage is usually slow due to implications that are seeded in the process itself – for example the time taken for payee to apply for insurance will be extended depending on the nature of the insurance policy and how that specific policy is having ramifications into diverse variables and parameters that cannot be easily executed promptly without wasting time.

- Reduce transaction costs
    - Reduction in transaction cost is a reduction in the number of the transactions as well as a reduction in the time taken to conduct the operation (taking into account the opportunity costs, frictional time taken, exposure to exchange rate risks as well as time value of money with changing discount and interest rates).
- Increase standardization
    - Standardization in finance and accounting is a critical element that defines the nature of the relation among different users and stakeholders, on the one hand a smart contract living on a permissioned or a permission-less blockchain will be following by a systematic form to perform and execute the code, on the other hand, as well as the nature of the blockchain as an distributed ledger will be following by itself a standard format to make it easier for interoperability and decentralization on different levels.

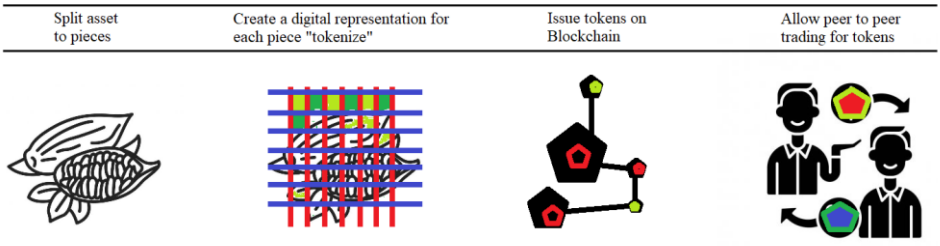

Figure no. 1: Correlation graph between mathematics score and average annual expenditure per pupil between 2012-2017
Source: Authors' own contribution

The features of asset tokenization (figure no. 1) over a blockchain are characterized by modernity, speed of operations, cost effectiveness and operability without time limitations or restrictions. The figure is clarifying how the process of tokenization is taking place over the distributed ledger:

- Step 1 – The farmer may recreate the crops in the form of asset splits to make them tradable, easier to move, instantaneous and fungible if requested. The digitization happening in the next stage relies on how the asset will be represented. Farmers may use crops as tokens or may use their lands, equipment, or machinery as tradable tokenized assets to recover costs and reduce depreciation expenses.
- Step 2 – Conversion to a digital representation for each token means a creation of a token that is backed by the selected asset – it could be crops for farmers or pooled insurance services or even source of funds for future investments and a form of micro-payments to support small farmers that may have access to a global finance plat form via DeFi and smart contracts.

- Step 3 – Issue token on blockchain, the token may get embedded at any public blockchain such as Bitcoin, Ethereum or Stellar. Each token will have its unique address and unique identification code to make it immutable, tamper-proof and tradable on various platforms.
- Step 4 – Peer-to-peer (P2P) trading - the tokens will be traded even after being issued in the secondary market to add value for investors and intensify network effect which may also add value for token issuers by increasing the value for the original asset itself.

Lin, Liu and Jie (2017) are defining the blockchain technology as one Trust Machine that is expected to organized and facilitate the shared information of the chains in the Hyperledger (it does not matter if the blockchain network is public or private). According to Lin, Liu and Jie (2017) blockchain impact on the supply chain (including agriculture) is reflected by comparing two states: Centralized and Decentralized formations.

Centralized: At the core of the centralized blockchain formation comes the Food and Drug Administration (or any government body/agent) in a food industry typical supply chain network. Food and Drug Administration must be watching closely the other entities in the network topology.

Origination, delivery, government, warehouse and sales market are all economic agents that must be integrally monitored to make sure that the operations are seamless and emphasize hygiene and safety of consumers.

The other auxiliary activities within the centralized network are more functioning as catalysts and supporters to make sure that the central core of the network is having access to information, data and other inputs.

The problem with the centralized system is the time wasting factor because too much operations (thousands of daily operations) will require a large number of monitoring personnel and that will increase pressure on the authorities and on the other hand the quality of monitoring will be consistence since the operations are manually driven with the inconsistency of human error (the natural level human error).

Decentralized: The decentralized formation of the distributed network of blockchain is clearly shown as juxtaposing entities in a frictionless way without overlapping one central entity over others. The nature of the decentralized network for food chain is similar to the central one but the main difference is the consensus by which the voting by nodes will create the "Trust Machine" and eventually the network will decide who is honest and who is dishonest considering the upstream and the downstream parts of the supply chain network (Lin et al.. 2017).

Blockchain's decentralization main problem is the nature of the consensus protocol used: at the code level the problem is not major, but at the hardware and energy consumption level is a serious challenge especially if the protocol is relying on consensus that are proof of work (such as Bitcoin network).

Contractual farmers, producers, wholesalers, manufacturers, distributers and retails are forming the main network in a given supply chain. Smart contracts built on blockchain will help these partners and entities to create a contractual state that is based on autonomous decentralization of incidents layered with financial services (integrated financial technology). From a technical point of view retailers such as bakeries and

supermarkets are being able to use Smart Contracts (e.g Walmart) to create a fluent and agile supply chain network with just in time strategies and near real time tracing for events anytime during the life span of the smart contract. (Buterin, 2013)

The blockchain system records the information of every links in food supply chain and integrates all the details using blockchain, which realizes the traceability management for quality and safety food supply. As proof of concept, we are starting with the basic method of food traceability system using blockchain technology. In further studies, we would like to build up a complete food traceability system after we study the practicality and limit of the system in the future.

Pre-Defined Contract: Terms are agreed by all counterparties, hard-coded into the smart contract and cannot be changed without all parties knowing, at this very first stage the smart contract is a classical agreement before being converted into an application (decentralized application) that will be nested inside the blockchain network (Sawtooth Blockchain or other blockchains). The pre-definition will include all the terms, conditions, limitations, penalties and legitimate and/or legal obligations and rights of the counterparties within the supply chain network.

Events: Event triggers contract execution by hard coding, the application will respond to defined events in the smart contract by taking inputs from the network (broadband), wireless sensor networks, IoTs (internet of things), RFIDs and other smart devices, once the event is occurring the smart contract will open the chain effects of other conditions and executable lines to be followed.

Execute and value transfer: The smart contract is automatically executed based on the pre-agreed terms – because it's a decentralized application that acts as an algorithm of artificial intelligence (independent entity) the smart contract will be executing without the ability of reversing it back since all the counterparties agreed on every single detail mentioned.

Settlement: Payout and other settlement is completed instantly and efficiently – payments to be done with any native cryptocurrency – without the hassle of going back to traditional banking operations (without applying to traditional credit lines and paying orders).

Smart contracts are proving that efficiency and effectiveness cannot be achieved in the virtual universe of business digitization without really applying a safe and secure blockchain network and limiting the use of centralized databases that are easily breached and reversed.

2. Smart contract algorithm

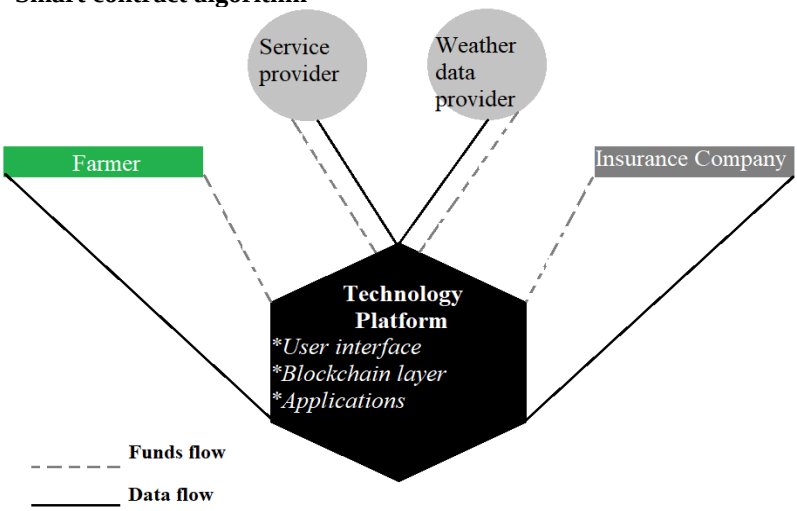

Figure no. 2. Smart contract algorithm
Source: Authors' own contribution

The algorithm in (figure no.2) is a skeleton for relational scheme showing the "interior" of the smart contract of crop insurance done using tokenization of assets over a blockchain – the agents are:

- Insurance company: This is the main service provider for the insurance. Its duty is about securing a pool of funds that should be available at any time the contract automatically executes using the smart contract atomic and instantaneous swaps.
- Farmer: Is the user-agent that is expecting compensations in return for a payment installed to hold a digital asset (usually cryptocurrencies or other DeFi-based tokens), the compensations are automated when the smart contract executes following deployment routines and command-code. The terms inside the smart contract are defined and programmed to foresee the automation of the process and reduce discrepancies.
- Service provider: Is the main provider of the smart contract services (blockchain-as-a-service: BAAS) and they usually play an important role in designing the architecture of the smart contract for agriculture digital assets and for crop insurance companies at once.
- Weather data provider: It is a data center that is integrated into smart contract as an agent to provide biased, transparent, valid and traceable data that can be replying upon (consistency and integrity) – usually weather data providers could be contributing altogether for the same smart contract for comparative and optimization reasons.
- Technology platform: The core of the smart contract, according to Wang et al, (2019) "smart contracts are computer digital-based protocols that are initiated

and facilitated to verify, negotiate, implement and transact on blockchain distributed ledger without a central authority that may interfere in the deployment/ execution part of the process" (Wang et al., 2019), the main challenge for smart contracts is the systematic risk originated from the idea of self-triggered automations that are exposing contractors to technical difficulties that are embedded at code level and that means a privacy and a security threat as well.

- One of the main features (selected from many) for a typical smart contract is peer-to-peer interactions (P2P) and that is a revolutionary part of any smart contract since its removing barriers to access a pool of funds that is locked by code, agreed by payee and payer with the terms printed into the "code" using special smart-contract programming language (i.e Solidity) (Szabo, 1997)

A classical crop insurance plan is covering the following:

- Damage due to climate change and sudden chances in weather, soil and irrigation difficulties caused by natural disasters.
- Risks related to planting such as unavailability of organic remedies, tools, machinery damage
- Loss of standing crop
- Damage or harm caused to post-harvest crop

A typical crop insurance contract is usually built on Application, production reporting, acreage reporting, claims, and contract changes.

- Application: The payee and payer will be agreeing on the terms regarding time, conditions, exemptions, obligations, and commitments by accepting and validating the cases covered by claims.
- Production reporting: The reporting system that reflects and validates the quantities of actual production compared to the area average and weather conditions.
- Acreage reporting: The acreage is reporting for the land and area used for agricultural purposes for a given period.
- Claims: A request for a compensation to cover loss initiated by insurance policyholder for insurance company.
- Contract changes: These are the changes that should be considered anytime when renewing insurances or when initializing premium insurance levels and reassessing the insurance risks.

Smart contracts are self-regulatory and they follow standards and regulations (can also be adjusted and formulated to consider nuances of domestic market regulations without complicating its purpose).

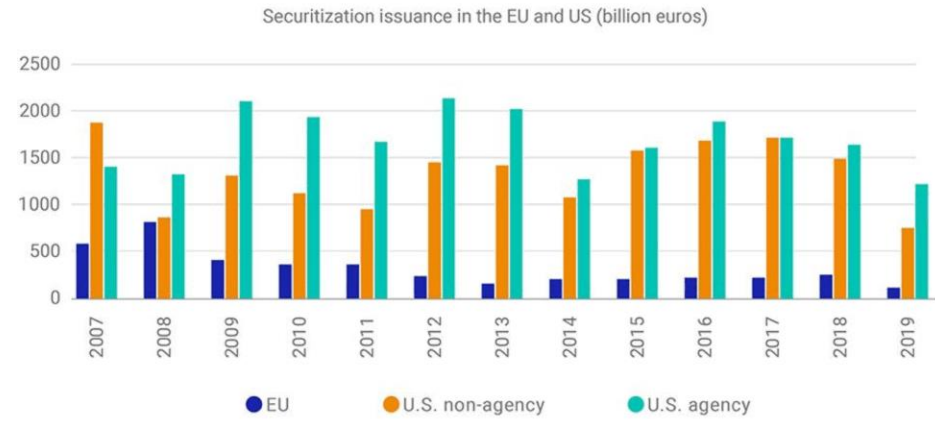

Figure no. 3. Securitization 2007 – 2019

Source: SIFMA, AFME, The 2019 numbers are annualized Q1 numbers – billion euros

Figure no.3 is showing how the securitization over time (between 2007 and 2019) is decreasing globally especially when comparing 2012 with 2019 the reduction in securitization is almost 50% decrease and that shows how securitization as a tool is changing recently giving more way for digital assets and asset tokenization to take place.

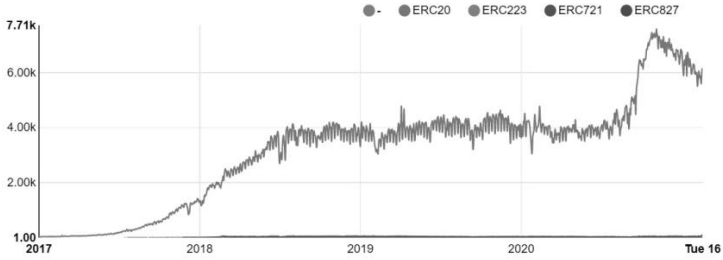

Figure no. 4. Ethereum tokens 2017 – 2020

Source: https://stat.bloxy.info/superset/dashboard/tokens/?standalone=true

Figure no.4 is showing how tokenization of the second largest blockchain "Ethereum" is witnessing a dramatic increase in the number of tokens printed over the blockchain over time period (2017-2020) and that also explains how the reduction in securitization is paving the way for asset tokenization while the former is plummeting and the other one is booming. Figure no.5 is showing a composition of ERC20 tokens compared to other Ethereum based tokens.

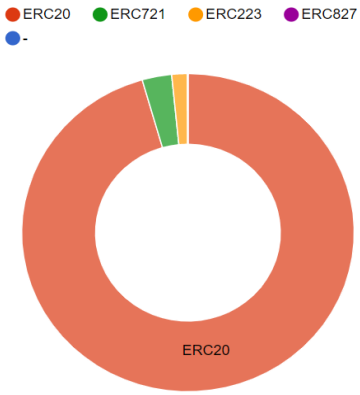

Figure no. 5. Transfers by token type
Source: https://stat.bloxy.info/superset/dashboard/defivalue/

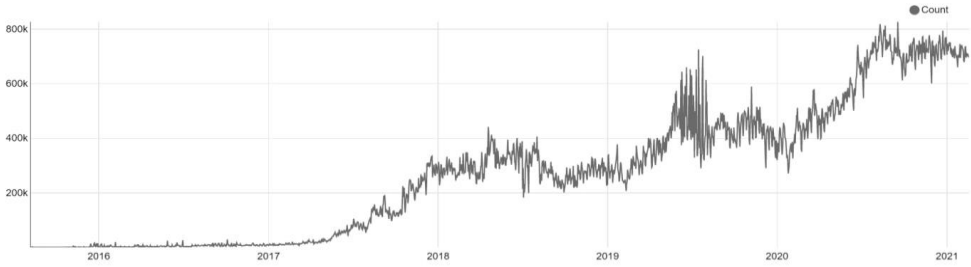

Figure no. 6. Dynamics of smart contracts 2016 – 2021
Source: https://stat.bloxy.info/superset/dashboard/tokens/?standalone=true

Figure no.6 is showing how smart contracts and their use expanded between 2016 and 2021 – while this is considered very promising but it's also challenging as seen from a regulatory perspective.

Table no.1. DeFi ranking by asset

	Name	Chain	Category	Locked ($)	1Day%
1	Maker	Ethereum	Lending	$6.96B	1.82%
2	Aave	Ethereum	Lending	$5.59B	-1.06%
3	Compound	Ethereum	Lending	$5.19B	1.78%
4	Curve Finance	Ethereum	DEXes	$4.31B	0.10%
5	Uniswap	Ethereum	DEXes	$4.27B	0.17%
6	SushiSwap	Ethereum	DEXes	$3.66B	-2.08%
7	Synthetix	Ethereum	Derivatives	$2.55B	-5.43%
8	Badger DAO	Ethereum	Assets	$1.98B	-3.37%

9	Balancer	Ethereum	DEXes	$1.47B	-0.69%
10	RenVM	Ethereum	Assets	$1.17B	3.91%

Source: Defi Pulse https://defipulse.com

Table no.1 is a top 10 list of the latest and most used DeFi assets and as its being observed that do belong Ethereum decentralized network but with different categories such as exchanges, tokens, derivatives and lending networks.

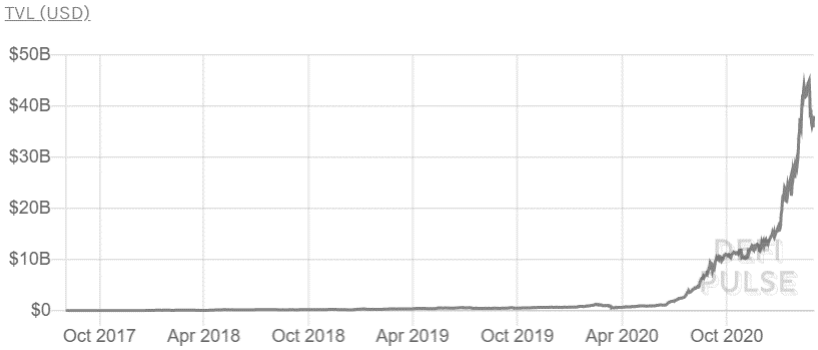

Figure no. 7. DeFi time-series 2017 – 2020
Source: https://defipulse.com/

Figure no.7 is reflecting the time-series development for the new DeFi solutions and as a general observation its clearly shown here how 2020 witnessed a gigantic jump in DeFi services globally with a promising market that is becoming an important aspect of the revolutionary new blockchain technology – the monetization of the network is becoming a reality.

Conclusions

There are challenging addresses when discussing asset tokenization and how agriculture sector may take advantage of technological advancement to find new opportunities and grow beyond domestic market, not just for their final goods but also for capital markets:

- Low demand and awareness (government may subsidize) – especially when it comes in farming at global south where awareness about the latest disruptive technologies is still negligible compared to conventional ways, the farmers should be fully equipped with at least 3G network access (using primitive SMS – Short Messaging) to access funds.
- Technology should be close to farming areas for effective data collection, initiating processes that are robust and sustainable, ensuring accuracy and not covering larger radii at a time to improve reliability and validity.
- Use public blockchain algorithms that are having lowest carbon footprint and emissions- optimizing is a key (Statista, 2018) that also means high visibility and tamper- proof protection against malfunctional activities or malpractices.

Benefits for asset tokenization

- Transparent automatization since the tokenized assed is publicly traded in a global blockchain network that is giving accessibility for investors and beneficiaries to track, inspect, validate and even study at a code-based level. This is one of the most useful features in asset tokenization where transparency, integrity and safety are not adding to the overall costs – to create a resilient solution for agents involved.
- Ease of transaction is another important feature because with the directness of the trading, the effective use of technology and the immediate nature of tokenization paves the way for faster "atomic" transactions that can facilitate the movement between tokenized assets to stablecoins, to fiat money and back to tokens, in a speed that cannot be matched by classical financial instruments.
- Increased access to investors and ease of fundraising is an inherent feature for asset tokenization since it gives start-ups in different business (and agri-business) sectors the opportunity to gain capital from a global market, that same global market that was once functioning as securitization market (limited by many restrictions) is now open to international faster money network that will give investors as well as projects a boost of strength and can easily make what was not possible yesterday a great opportunity for tomorrow with the full engagement of blockchains, fog-computing and cloud computing.
- Liquidity is a natural dominant aspect for asset tokenization and the main purpose for tokenizing the assets is about their speed convertibility to liquidation at spot prices defined by market dynamics (supply and demand) at any given time (Roth, Schär and Schöpfer, 2019)
- Fractional ownership is by itself a functional feature that will allow business start-ups and investors to decide the degree of investment into the tokens and how they would prefer to manage these tokenized assets – especially if the tokenization subject is lands, crops or agricultural products (or unfinished products) more easily while they can also transfer that ownership with lower fees and faster time frame.

It must be noted that the democratization of the capital markets under asset tokenization is a new world that converts limited capitals for participants into open and global capital markets with a large base of participants that may contribute to the start-ups in a given sector or industry and that revolutionizes the way business is conducted on a global scale since the market itself is reachable without adding to the costs, especially registration costs and the complications of intermediaries.

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