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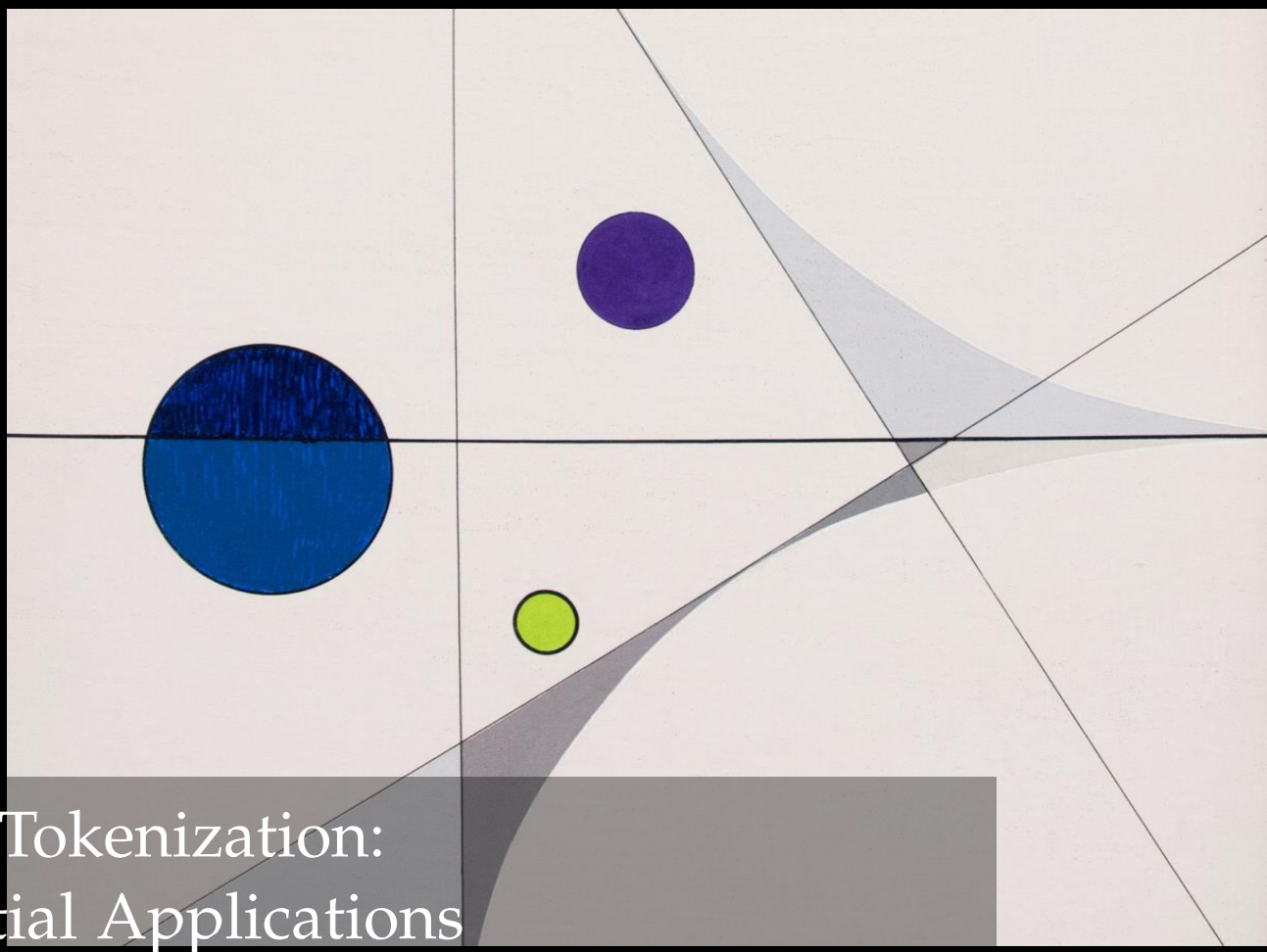

# Asset Tokenization: Potential Applications

**Valerio Ciminelli**

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# Executive Summary

The growing interconnections between markets and technologies are fostering radical changes in traditional business paradigms supporting potential groundbreaking shifts in various industries. This research aims to uncover the disruptive potential embedded in asset tokenization within this evolving landscape. Explaining first the features and the characteristics of both its operative environment and its regulatory landscape. The paper proceeds in the analysis of two key markets where asset tokenization could boost the growth and bring transformative shifts. In summary, the main object of the research is to provide both a technical and applicative vision of the evolution of the market on asset tokenization, providing a brief but solid knowledge of the potential of these technologies.

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*This document was prepared in collaboration with Nicola Mazzoni who at the time was working for Iason Consulting.*

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## *Lending and Real Estate Markets*

Valerio Ciminelli Nicola Mazzoni Giuseppe Morisani

In the dynamic and fast-changing digital and financial landscape, the rise of asset tokenization stands out as one of the most impactful technology applications in markets which will probably reshape the traditional view of asset ownership and trading. The growing interest in this technology is strictly related to the widespread of the DeFi, a decentralized financial environment that relies on DLTs, within the markets and the potential changes that these could bring in the future economic landscape. The core focus of the research is firstly to uncover the technology foundations on which DeFi, and so asset tokenization, rely and proceed with an explanatory view of the main phases of the asset tokenization process unrevealing the most important benefits that this technology could bring across several markets. Secondly, the work focuses on the playing field where different market participants can apply this new technology in their respective business areas. To this end, the state of the art of the international regulatory framework is analyzed, considering the latest efforts by International Financial Authorities, as well as national and supranational regulations. Furthermore, the analysis will rely on two pivotal applications of asset tokenization, lending and real estate markets examining also some of the most relevant asset tokenization leveraged projects in these markets.

## 1. DeFi Key Concepts and Components

This first chapter aims to explain all the core concepts which will be crucial to understanding how the asset tokenization works. We will provide the reader with an overview of the main "new" Technologies that are cornerstones of the Digital Assets environment. A reader who is already comfortable with terms and concepts such as DLT, Blockchain, and tokens could consider reading the chapter as a "refresher". After that, we will describe the token anatomy, focusing on the main token typologies and their characteristics.

### 1.1 The Environment

The core of any introduction to tokenized environments has to be the explanation of the already famous Distributed Ledger Technologies. DLTs are the most important technologies that have made the expansion and growth of Digital Asset transactions possible. With DLT we are referring to a database distributed in identical copies among the nodes that compose the environments. The peculiarity of DLTs is that the ledgers among the nodes chain are simultaneously updated through a consensus mechanism. The node's network is in charge of the maintenance of the ledgers implying the continuous update of the information stored in the registries. However, the ledgers are not simultaneously updated at all the node levels implying a floating time to synchronize the information in all of them.

One of the most notable differences between a traditional centralized ledger and DLTs is the application of a consensus algorithm that requires accordance between every node of the network in order to proceed with the update of the ledgers. The most diffuse Consensus Mechanism is the well-known "Mining Process" that requires the network components to solve high-level

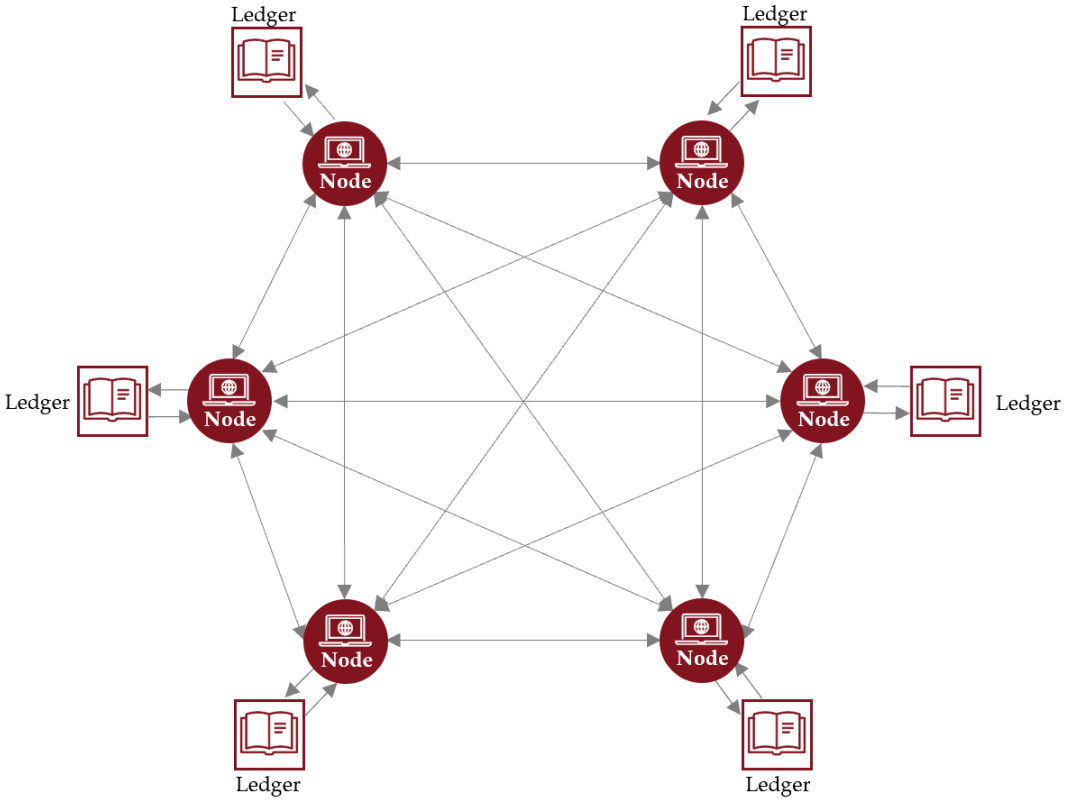


*FIGURE 1: DLT Structure*

computational problems to validate the information and update the ledgers. The high computational and energetical cost of the PoW (Proof of Work) "Mining mechanism" has opened the way to another kind of consensus algorithm among which one of the most famous is PoS (Proof of Stake) that requires participants to hold and prove the ownership of a certain amount of digital assets to validate transactions and secure the network. Another key role in ensuring transactions and information stored in the ledgers is played by cryptography algorithms that are used to authenticate the transaction's participants, guarantee the integrity of the messages and avoid breaches in the network by third parties. The most famous ones are asymmetric cryptography, which consists of the use of a public key to encrypt a message that can only be read by using a private key, and hash function, which consists of mathematical functions that map the input data into a fixed-size string of known hashes. The DLTs could be classified according to the access control profile in Permissioned and Permissionless. Permissioned DLTs are characterized by a restricted group of participants that could participate in the consensus mechanism and act as trusted validators within the network. We could distinguish inside this type of DLT between Private Permissioned DLTs and Consortium Permissioned DLTs, the first is characterized by the presence of only one validator that is typically the owner of the network while the second presents a restricted predefined number of trusted validators. Permissionless Public DLTs are the purest form of decentralized ledgers; without a centralized authority that manages the network, anyone can join it. These types of DLTs rely on consensus mechanisms to ensure the validation of the information stored in the ledgers. The absence of a Central Authority grants the complete transparency of the transactions that are performed within the network. Furthermore, some networks are experimenting a hybrid version of the upper configurations, these are known as hybrid DLTs that present, for instance, the open participation and transparency of public DLTs and let the validator role at a defined group of participants as the Private DLTs. We should punctuate that there is not a preferred configuration, the wider plethora of participants, and the absence of a central control of the public DLTs are counterbalanced by the loss in terms of speed and performance that a minor number of validators as of private DLTs could improve.

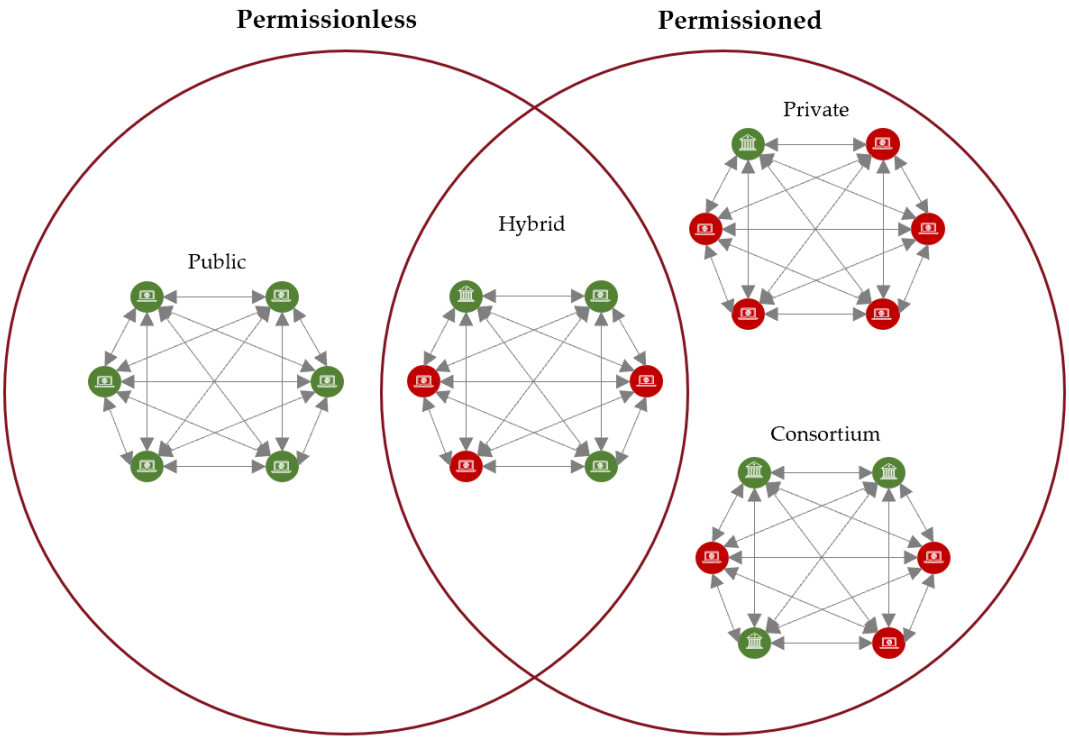


*FIGURE 2: Types of DLTs*

It is indeed clear that DLTs could bring several advantages in a wide range of markets. First, this kind of network could boost both the transparency of the transactions, as all the network participants have access to the same ledger, and the security of the information, as the presence of a cryptographic algorithm ensures the system from data breaches. Secondly, one of the focal points of the DLTs is the reduction of intermediation, bypassing the needs of central authorities, improving efficiency, and reducing intermediation costs. On the other hand, DLTs still suffer difficulties in the scalability of transactions, struggling to handle a large number of transactions simultaneously without a speed reduction within the network. Moreover, there is still uncertainty surrounding the regulatory environment of DLTs that could obstacle and slow the adoption of these technologies in some markets.

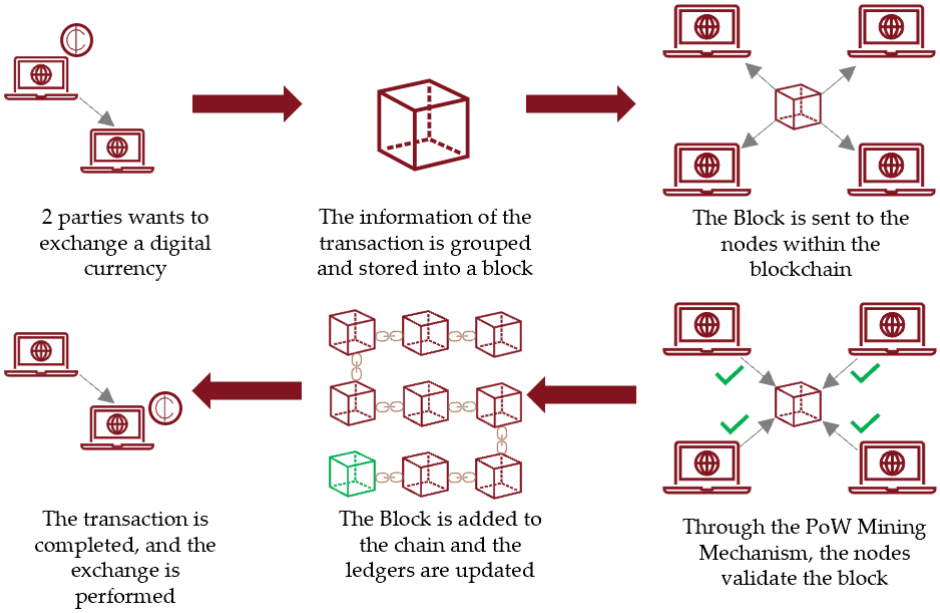


*FIGURE 3: Blockchain process*

### 1.2 Blockchain

Blockchain is a particular Permissionless Public DLT, the most famous and notable one, characterized by the usage of blocks of data. Specifically, the Blockchain network records transaction information and groups them inside "blocks" that contain a cryptographic hash of the previous block's header. Each block is then broadcasted to all the nodes of the network that, through a "Mining Process", validate or deny it. If it is validated the block is added to the previous ones forming the so-called "chain" and is distributed through the network. Once added, the blocks are immutable and the information stored inside is permanent.

### 1.3 Smart Contracts

Smart contracts are computer protocols with pre-determinate conditions that ensure the automatic execution of an agreement, with no need for a central authority, where the conditions are met. smart contracts rely on DLTs, where their transactions are stored and registered, and are designed to facilitate and automate the exchange of digital assets, information, or services. Their function could be seen as a simple if/then condition directly imprinted, for instance, in a block of the chain. When the smart contract conditions are met and verified, a computer network will automatically execute the actions, such as issuing a ticket, moving funds between parties, or unlocking functionalities within the platform. In summary, smart contracts are the vault of the conditions that rule the interactions inside the platform, so network participants have to determine all the conditions and the possible outcomes that have to be programmed inside the smart contract in order to avoid any possible dispute. The Flight Delay assurance of Etherisc[1] could be an easy-to-understand example of the functioning of smart contracts. In this case, if the smart contracts are linked to several APIs that monitors the take-off and the landing time of the flight, and if the subscriber's flight is delayed or canceled the smart contract underlying the assurance will automatically pay the payout of the assurance.

The insurance market is not the only one that could benefit from the automatisms that smart contracts bring, in fact, generally financial markets could benefit probably more than other sectors from the innovation of smart contracts. For instance, the coupon payment schedule of a bond could be encoded into a smart contract that at every payment could quickly execute the settlement of the payment without the need of any intermediary. It is clear from these short examples that the

[1]Etherisc is a Deutsche firm that offers decentralized insurance services.

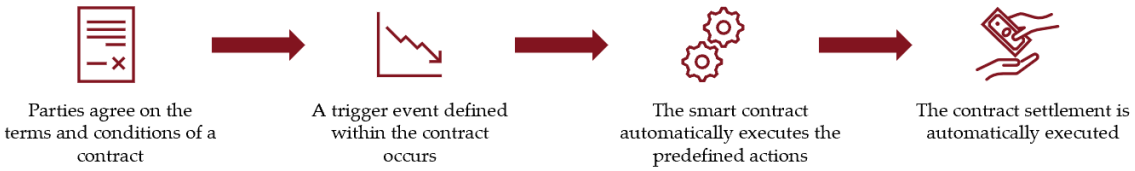


*FIGURE 4: Smart Contract synthetical execution process*

potential usage of this technology could be advantageous to all business areas that may benefit from the improvement of the transaction speed and efficiency, in fact, once the conditions of the smart contract are met the algorithm embedded in it will immediately be executed avoiding any kind of payment delay or reconciliation error. The automatisms underlying the function of the smart contract will also reduce the transaction costs as no third party or intermediaries are needed to execute the transaction. Considering also that smart contracts run on the chain, they inherit other improvements in transparency as the transaction immutability within the network and the transaction visibility among the network participants.

### 1.4 Tokens

A central role within the DLT environments is played by tokens, which usually act as the exchange goods among network participants. Simplifying, tokens are native digital assets registered on top of decentralized ledgers that allow their exchange within the network while their creation, issuing, and management happen thanks to the support of smart contracts. The origin of a token could be anything from a real-world asset, such as a piece of art or a real estate asset, to a right to vote within the governance system of the network and they could serve for several purposes, for example, payment services. Despite the wide applications and services that a token could aim for, we can find five intrinsic characteristics that are common to every type of token: they are "valuable, representative, digital, distinct, and authentic"[20]. As described in the "Token Taxonomy" by Dan Tapscott, a token is valuable because we can always determine its value, for instance, we can express a token value into a fiat currency amount as USD. A token holder will always have the claims or the rights represented by the token. As we already said, tokens are native to DLTs so consequentially they are "digital" by definition. Considering the updating process that occurs among the ledgers of the network we can always know the discretional amount of tokens that are circulating within the network and distinguish one from another. A token's authenticity is also ensured by the intrinsic characteristic of DLTs that use a consensus mechanism to validate the transactions. Going a little deeper in the explanation, tokens incorporate two main "layers": a "Core Layer" that embeds the specific features of the token, such as ownership rights and proof of authenticity, and a "Service Layer" that specifies the logic underlying the token used within the Platform (e.g., the interoperability and Cross-Chain Functions or the token regulatory conditions). Tokens, as stated before, serve various purposes depending on their specific design and reference Platform. For instance, DeFi Tokens are a specific type of tokens designed to provide functionality, governance, or economic incentives within the DeFi environment. Below are some examples of the most popular typologies of tokens[15]:

- Cryptocurrencies;
- Stable Coins;
- Security Tokens;
- Non-Fungible Tokens (NFT);
- Commodity Tokens;
- Utility Tokens;
- Collateral Tokens.

**Cryptocurrencies** are decentralized digital currencies that rely on cryptographic algorithms in order to secure transactions [18]. These kinds of tokens, which the most famous are Bitcoin and Ether, due to their intrinsic nature are not issued by a central authority, and the transactions performed between parties are validated thanks to a peer-to-peer system.

**Stable Coins** are cryptocurrencies that have their value anchored to an underlying asset, such as a fiat currency (e.g. US Dollar, Euro) or a commodity, ensuring a stable value related to a near 1:1 ratio to the underlying asset. They provide stability and serve as a medium of exchange and store of value (e.g., USDC). Examples of Stable Coins are Tether USD (USDT), Paxos Standard (PAX), which are backed to the US dollar, or Stasis Euro (EURS) which is anchored to the Euro.

**Security Tokens** represent traditional financial assets, as shares or bonds but are traded without the need of a broker. A particular type of these tokens are the real estate tokens that represent an investment in real estate assets and permit leverage on DLTs to provide fractional ownership, increased liquidity, and potential access to a wide range of investors in the real estate market (e.g., SwissRealCoin).

**NFTs** incorporate the ownership rights of a unique digital or real-world asset. NFTs can be exploited to foster copyrights (e.g., prevent digital creations from being copied) and (continuous) value creation and distribution through rights selling and/or royalties embedded in the token. Famous examples of NFTs could be Top Shots tokens, which represent NBA tokenized unique moments, or "Everydays: the First 5000 Days", a digital art masterpiece sold as an NFT by Christie's Auction House for 69,3USD million.

**Commodity Tokens** are tokens linked to a specific commodity, like gold, copper, or oat. These kinds of tokens aim to increase accessibility to commodities as an investment asset class by permitting small investors to acquire fractional parts of a commodity (and not requiring any physical settlement). Relevant examples are KAG Silver or Meld Gold. Utility Tokens are designed to be used for different purposes as part of the internal economy on a specific platform or for fundraising vehicles.

**Utility Tokens** are used to allow access for users to features within the reference environment, such as data storage, computational power, and identity verification. As an example, we could look at Chainlink which aims to "enable smart contracts on any Blockchain to leverage extensive off-chain resources, such as tamper-proof price data, verifiable randomness, automation functions, external APIs, and much more".

**Collateral Loan Tokens** are a specific kind of token that represents a loan secured by collateral within a DeFi environment. These tokens enable borrowers to access funds without selling their underlying assets, providing a mechanism for leveraging their digital holdings within the DeFi ecosystem. Examples of this typology of tokens are Compound and Collateral.

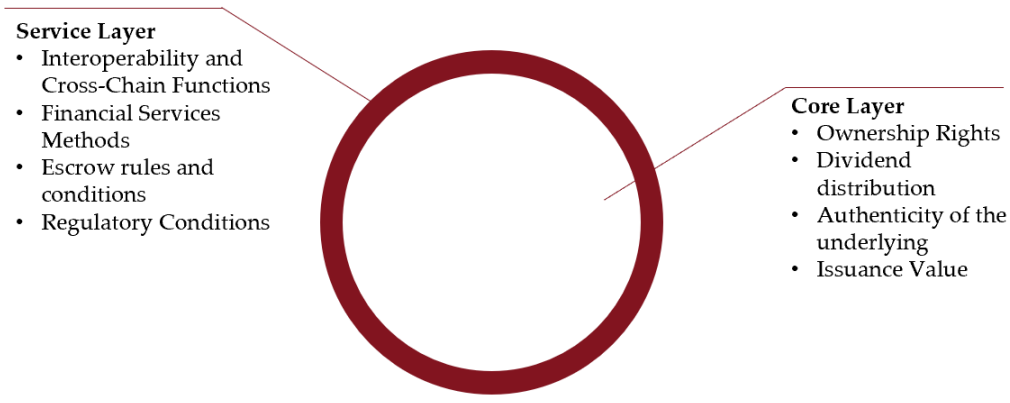


*FIGURE 5: Token Anatomy: Service Layer, Core Layer*

### 1.5 Decentralized Finance (DeFi)

Decentralized Finance represents one of the fastest-growing applications that has been unlocked by the wide-spreading diffusion of DLTs. By DeFi we can refer to DLT-based environments that aim to make available several financial services without relying on any kind of Central Authority. In practice, DeFi environments consist of "Financial Protocols" that guarantee the execution of specific tasks in order to deploy different financial transactions and services. The Protocols are implemented on smart contracts that define the rules within the environment and rely on the DLT as the base system to be executed. The underlying DLTs and the smart contracts built on DeFi ecosystems ensure that no Central Authority is needed to complete and validate the transactions. Smart contracts, performing predefined and specific-purpose tasks, replace the intermediary within the transactions and users can therefore interact directly with smart contracts, instead of another user. To describe the fundamental composition and the core functionality of a DeFi environment, we will introduce the DeFi Stack Reference Model (DSRM) [2], which was first explained in the "BIS Working Papers No 1066 - The Technology of Decentralized Finance (DeFi)".

According to this model, we can distinguish three different core subsequential layers that compose a DeFi environment:

- **Settlement Layer**, which represents the base of the DeFi;
- **DLT Application Layer**, that comprehends:
  - **Crypto Assets;**
  - **DeFi Protocols;**
  - **DeFi Compositions.**
- **Interface Layer**, which represents the top of the pyramid and conceptually is just the end-user interface of the environment.

**The Settlement Layer** is the base on which the DeFi is built, and essentially, it is the Decentralized Ledger Technology at the base. The DLT guarantees the execution of financial transactions and, through the consensus mechanism built into the DLT itself, ensures the update of the ledgers across the network. The most diffused DLT in the DeFi space is Ethereum, with Solana, Polygon, and Cardano as other diffuse DeFi Blockchains. In the **DLT Application Layer**, all the specific features are embodied through smart contracts within the DeFi environment. **Crypto Assets** represent the "value" that is usually exchanged within the DeFi. They are expressed as tokens which, as we have shown in the previous paragraphs, could serve several different purposes. Thus, as the foundation of the value that is the base of the transactions within the network, we could easily understand the core importance that tokens cover inside a DeFi environment. Following the model, we find the **DeFi Protocols Layer**, where are linked all the DeFi Protocols that define the Financial Functionalities of the environment. "The Technology of Decentralized Finance (DeFi)"[2] distinguishes three main kinds of DeFi Protocols:

- Decentralized Exchanges (DEXs);
- Lending Protocols;
- Derivatives Protocols.

**Decentralized Exchanges** are protocols that aim to ease the exchange within the DeFi environment. In the Automated Market Makers (AMM) configuration, the traders execute the transaction against a liquidity pool, which could be defined as a smart contract that stores a reserve of the token supply. **Lending Protocols** are peer-to-pool DeFi protocols that enable the match between lenders and borrowers within the environment. Borrowers could access funds by interacting against a smart contract that pools the supplies that have been deposited by the lenders. These protocols use the pool size or the intrinsic demand of the environment to set the interest rates automatically. **Derivatives Protocols** enable the issuing and the exchange of decentralized crypto derivatives. These digital assets act as traditional derivatives instruments with the difference that are native

to the DeFi environment. In practice, they take their value following the value of the underlying instrument/rights movements, which could be any kind of real-world asset or even another crypto asset. **DeFi Composition**, as the final part of the DLT Application Layer, is one the most innovative features of a DeFi environment. "A DeFi protocol composition occurs when an account leverages one or more accounts belonging to at least another DeFi protocol within a single transaction to provide a novel financial service"[12]. An example of DeFi Composition Protocols is Yield Aggregators that aim to maximize the profits of the investors. In practice, users allocate their assets into a pool of smart contracts (the Yield Aggregator) that invest them following a predefined strategy of portfolio optimization. At the peak of the DSR Model, we found the **Interface Layer** which is nothing less than the interface that users utilize to interact with the DeFi environment.

Analyzing the features that characterize DeFi, it is clear how this kind of environment could lead to a potential revolution in the classic financial ecosystems. These environments, which are for their nature decentralized and open, could boost transactions and accessibility to financial services that normally are precluded to many market participants reducing the intermediatory fees as well. Other than enabling the tokenization of a variety of off-chain assets, DeFi could also push the born of new financial instruments. On the other hand, the lack of a central authority leads to regulatory uncertainty with several possible frictions between market participants due to unclear legal treatment of assets exchanged in the environment as well as the lack of a framework that ensures protection against frauds.

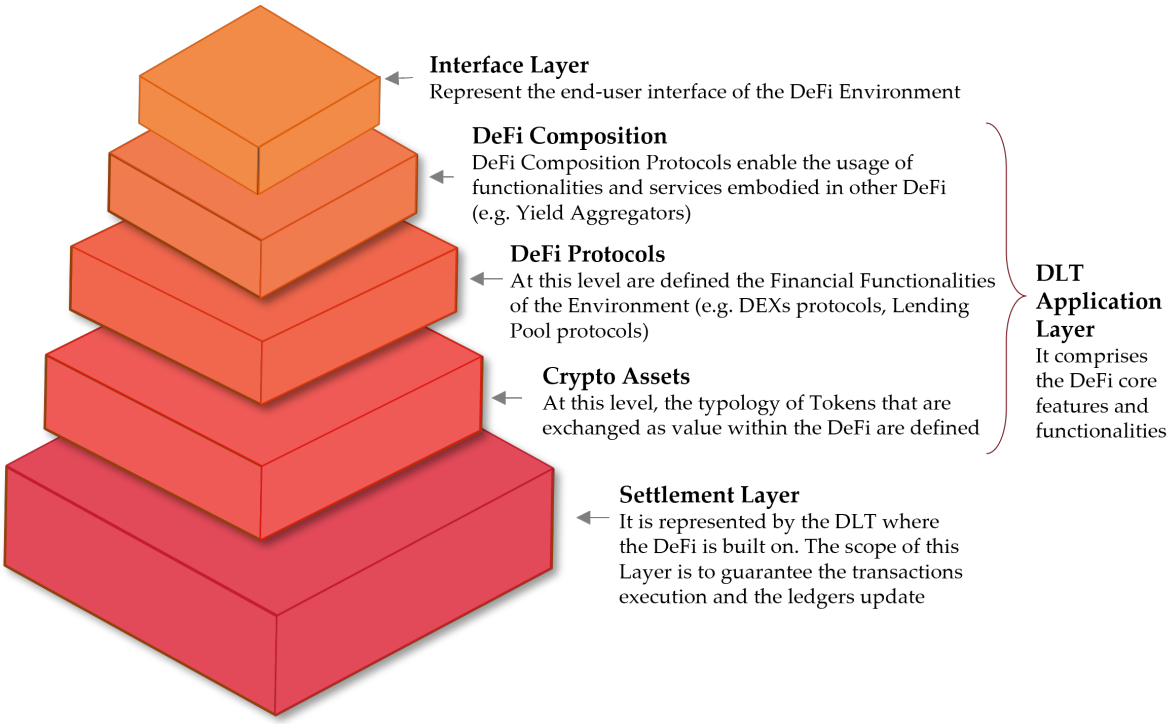


*FIGURE 6: DeFi Stack Reference Model*

# 2. Asset Tokenization: What Is It?

Asset tokenization represents the process of registering a physical asset on a distributed ledger by incorporating the economic rights and claims of the real-world asset, such as a real estate asset, into a token. The potential benefits of moving the intrinsic rights of an asset from the real world to a DLT range from increasing market liquidity to improving transaction efficiency. This section will first delve into the characteristics of the tokenization process, from asset selection to token issuance, and end by explaining the potential benefits the process could bring to markets.

## 2.1 The Process

Tokens cover, as seen before, a crucial part of the DeFi environments being the main subject of every transaction among the market participants. They can be defined as the digital representation of real-world assets or rights, and we can delineate the asset tokenization process as the flow that allows to recording real-world assets from traditional ledgers to DLTs. The technical process that permits the transfer from the traditional to the digital ledger requires a "ramp" that locks assets in their platform of origin as collateral for the tokens, which are then issued on the programmable platform[1]. The real-world asset, or claim, continues to exist off-the-chain but its rights are transferred on-the-chain through the token issuance. The process involves six main phases:

1. **Asset Selection;**
2. **Asset Evaluation;**
3. **Regulatory Analysis;**
4. **Platform Selection;**
5. **Smart Contracts Development;**
6. **Token Creation and Issue.**

The first step involves the selection of the real-world asset that must be tokenized. This phase covers a crucial part of the process and will affect all the following stages. In fact, the asset class of reference of the chosen real-world asset will affect the evaluation methodologies that will determine its tokenized value, the reference regulatory framework, and potentially even the platform selection. For example, tokenizing a real estate asset or security is a different process from both the respective reference regulatory framework and the evaluation methods of the asset. The Asset Evaluation phase aims to define the value of the asset to which the token will be backed. The evaluation won't stop at the economic value of the assets but will include the analysis necessary to ensure the ownership rights of the assets, gauging the potential market demand, and assessing the potential future revenue and the token feasibility as well. The right choice of evaluation methodologies for the chosen asset type is crucial to avoid discrepancies between the real-world asset value and its representation on the DLTs. In concomitance with the Asset Evaluation, occurs the Regulatory Analysis which aims to identify the reference regulatory framework for the asset to be tokenized and to inquire the legal implications of its tokenization. In this phase, it is crucial to investigate the asset classification in force within the country of reference; for instance, securities, debt instruments, and real estate assets are subject to different regulatory requirements and constraints. Other than that, is important to understand the AML (Anti-Money Laundering), the KYC (Kwon Your Customer), and the data protection regulations to ensure the appropriateness of the future transactions of the token. Also, it is important to state that cross-border transactions will be influenced by both jurisdiction and framework. The selection of the technology and platform to rely on, and which the tokenized asset will be placed on, involves, for instance, decisions related to whether the network will be permissionless or permissioned, or whether the token will rely on the Blockchain or a different kind of DLT. Choosing the right native platform for the tokenized asset will cover a crucial part of the token's life, influencing deeply the course of its future transactions. In fact, the platform will influence first the scalability of the transaction's volume, and it will also affect the transaction costs (e.g., in terms of gas fees, or the possibility to perform cross-platform and cross-border

interoperability). Obviously, these are only a few factors that will be affected by the choice of the platform: others could range from security implications to regulatory boundaries. Defined the platform, it's important to state the rules that will govern the token and the token behavior within the platform environment. That is possible through the development of smart contracts which, as stated before, could embed the automatic clauses and actions that will rule the interactions and the transactions of the tokens. This step concerns the definition of how the tokens are created, their ownership clauses, and their transferability. The possibilities enclosed in smart contacts could also enable the development of rules and clauses such as regulatory restrictions, voting rights, and dividends or coupon payment mechanisms. At this level of the process, it is also decided which standard (e.g., ERC 20, ERC-3643) will be used for the token implementation. The token creation phase involves the modeling of the digital asset on the on-chain environment and the contextual lock of the real-world asset. As already said, this process relies on a "ramp" to technically ensure both the transfer of the value from a traditional ledger to a DLT and the consequential lock of the off-chain asset. In some cases, for instance for art pieces, it is also required to support a trusted custodian to segregate the asset and guarantee its safeness. The decisions regarding the tokenization model are also taken in this step, involving the consideration of the possibility of opting for fractional ownership, and the related number of tokens that will be issued, or for the individual ownership of the digital asset. The conclusion of the process will require the definition of the offering structure of the token issuance, implying to choose between public offering (ICO) or private placement.

### 2.2 Potential Benefits

The tokenization process, thanks to its nature that allows the on-chain transformation of a physical asset, could valorize the latent potential of the traditional real-world assets by bringing new lymph in some markets, generating economic value that otherwise would be unexploited. Following there will be reported some of the major benefits that could be related to the asset tokenization:

- **Markets Accessibility and Liquidity Boost:** Asset tokenization, through the fractionalization of the ownership, could widen the plethora of potential investors, opening markets that are usually presided over by institutional investors to retail investors. Also, the possibility of trading these fractional assets directly in an on-chain platform could be another very important factor in boosting markets' liquidity. For instance, a market historically characterized by high entry barriers and illiquidity of assets such as the real estate market that thanks to the ownership fragmentation could benefit from a much larger investor pool that could easily trade real estate tokens sidely boosting the market liquid. Solidblock and RealT are two interesting examples of the potential application of asset tokenization and the related benefits on the real estate market.

- **Transaction Efficiency:** Through the automation embedded in smart contracts features, asset tokenization could enforce faster, and potentially frictionless transactions. For instance, the settlement processes could take advantage of the smart contracts' conditions to speed up the elapsed time needed to complete a trade. A representative case of these possible improvements is the atomic settlement condition that could be coded into a smart contract that will permit an instantaneous exchange between two tokens once both parties submit their transaction.

- **Transaction Transparency Enhancement:** Tokenization guarantees the immutability of records and the safeness of transactions that is ensured by the consensus process typical of the DLTs exchanges.

- **Costs Reduction:** Relying to a DeFi environment the asset tokenization could benefit from the absence of central intermediaries leading to a reduction of transaction costs and of administrative expenses of the asset.

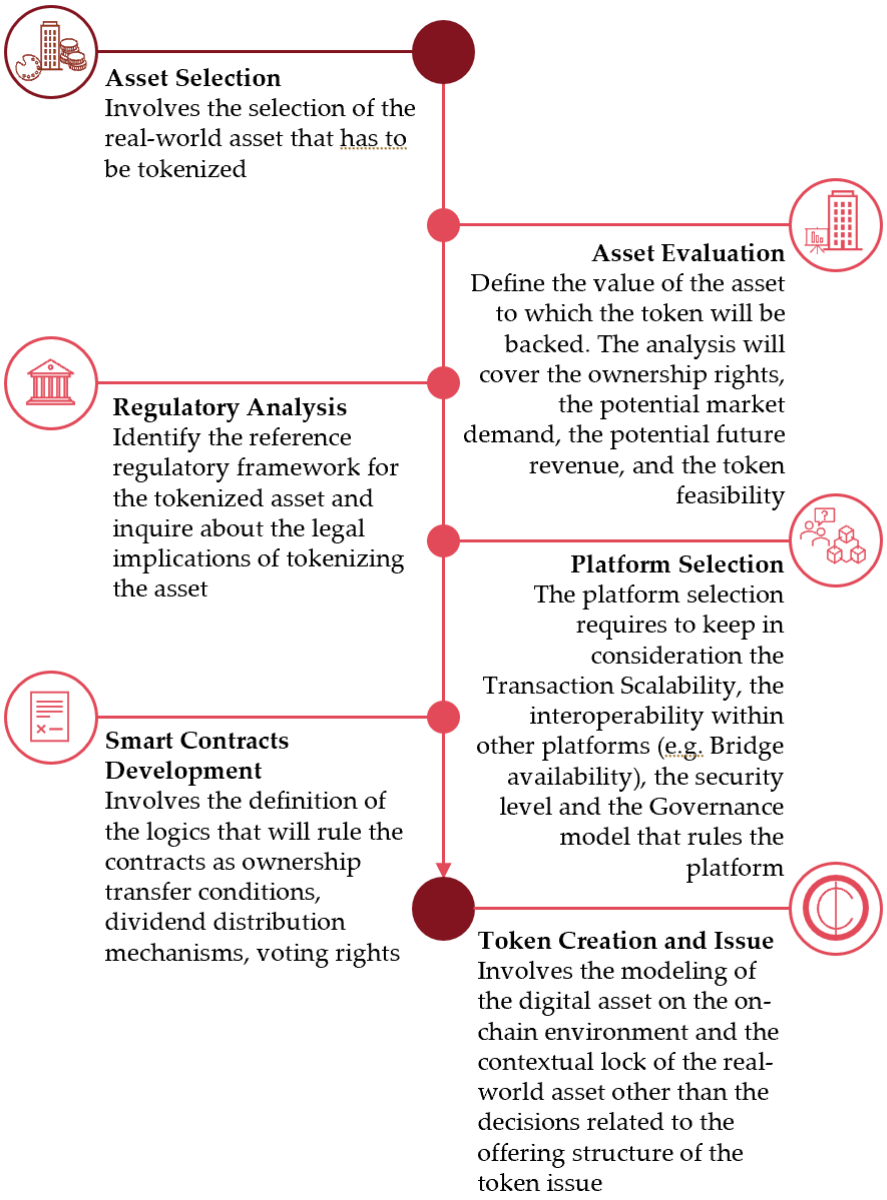


*FIGURE 7: Asset Tokenization Process*

# 3. Digital Assets Regulatory Overview

## 3.1 An Open Issue

As stated, asset tokenization is one of the most notable potential applications of DLTs in financial markets with several potential benefits that could boost both the economic growth and the development of markets. Despite that, leveraging on new technologies (as the ones described in the previous chapters) to do business opens up critical challenges, hardly accounted also due to the lack of robust and shared regulatory frameworks among different legislations. The growing impacts and interconnections that digital assets are having on traditional financial systems, combined both with the high volatility period that cryptos have been facing and the recent bankruptcies of important exchanges and market players (e.g. FTX, Three Arrow Capital), have enlightened the attention on the sector from several International Financial Authorities. These, in order to assure market integrity and risk mitigation, have begun to propose guidelines and recommendations to help National Authorities set a fair regulatory environment. Among others, the most notable works carried on by the International Financial Authorities are:

- The **"FSB Global Regulatory Framework for Crypto Asset Activities"**[11] published by the Financial Stability Board aims to promote the consistency between the international regulatory frameworks and to define a shared approach among the different supervisors. The framework proposes a set of recommendations to help in the definition of a shared regulatory framework over the regulation of crypto assets and global stable coins founded on a set of three guide principles:

  1. **Same Activity, Same Risk, Same Regulation**
     This principle wants to ensure that the regulatory frameworks will take into consideration the risks to the financial market's stability that could be related to crypto assets and stablecoins. In particular, Regulators should apply the same, or equivalent, regulation to crypto activities that are similar to traditional financial assets.
  2. **High-Level and Flexible**
     The framework is designed to suggest high-level recommendations to Regulators leaving them enough free of movement to implement new frameworks and to be flexible in reacting to market changes.
  3. **Technology Neutral**
     A technology-neutral approach focuses on defining regulatory guidelines without relying on a specific platform or technology. This means that Regulators should concentrate on defining frameworks that assess the economic functions or the risk related to the crypto activities rather than the technology on which they rely on.

- The **"Prudential Treatment of Crypto Asset Exposures"**[4], published by the Basel Committee on Banking Supervision (BCBS), has defined a harmonized standard for the treatment of the crypto assets "banks" exposure which requires banks to classify crypto assets in two distinct groups:

  - **Group 1:** composed of traditional tokenized assets with a risk level similar to their non-tokenized counterpart and crypto assets with effective stabilization mechanisms (stablecoins). The capital requirements for these cases are based on the risk weights of the underlying exposures.
  - **Group 2:** the bank exposures for all the crypto assets that don't fall under the group 1 must not exceed 2% of the TIER1 Capital and should fall near the 1%.

- The **"Updated Guidance for a Risk-Based Approach to Virtual Assets and Virtual Asset Service Providers"**[10] incorporates the guidelines of the Financial Action Task Force (FATF) in a matter of Anti-Money Laundering and Countering Financial Terrorism for Digital Assets and Digital Assets Providers promoting, as the FSB guidelines, a risk-based and technological neutral approach imposing also the adoption of specific AML and CTF requirements (e.g."VASP Travel Rule").

Other than the International Financial Authorities, some countries have shown growing attention to the necessity to develop a strong body of legislation regarding digital assets [16], which we can cite as notable examples:

- The Swiss **"DLT ACT"** recognizes the issuance and transfer of rights on the Blockchain, allowing the segregation of digital assets in case of custodian bankruptcy and introducing a special license for financial digital services providing.
- The Liechtenstein **"Blockchain Act"**, that allows the tokenization of any kind of assets and rights, foreseeing also the introduction of "Physical Validator", a mediator that ensures that the real-world assets or rights underlying the token can be verified and enforced.
- The Japan 2020 recognition of the digital asset in its regulatory framework through the amend of:
    1. **Payment Service Act (PSA)** which now include under its regulation digital currencies, utility tokens and crypto asset exchange services.
    2. **Financial Instruments and Exchange Act (FIEA)** which now covers the regulation of security tokens which represent shares, bonds, or fund interests in tokens.

Despite these initiatives of the International Authorities and the efforts of some countries, the regulatory landscape across the world is still suffering from a lack of consistency and harmonization within the countries. One of the most cited problems of the existing framework regards, in particular, the absence of a shared taxonomy and body of definition for digital assets.

### 3.2 MiCAR and The European Approach

The fragmentation in the legal treatment of digital assets among the Union Members has led the EU to plan a strategic program to minimize market fragmentation and boost the financial innovation of the European financial market. In order to obtain this notable result, the EU published in September 2020 the "Digital Finance Package"[8] which comprehended the strategies and the legislative proposals on crypto-activities and other digital initiatives. The Union, with this publication, has posed the goals of both being an example for other countries in the matter of digital asset regulation, and developing a much more innovative intensive, and competitive European financial market. The proposals inherent in the "Digital Finance Package" are set in two main categories:

1. The **"Renewed strategy for modern and safe retail payments"**, which wants to ensure the development of instant payments and create an innovative and competitive retail payments market.
2. The **"Digital Finance Strategy"**, which aims to develop a less fragmented digital European market and to promote a regulatory framework that can permit the growth of digital markets ensuring the digital operational resilience of the financial system.

Focusing on the latest part of the package, we can zoom in on four milestones (one is not part of the "Digital Finance Package" but follows its principles) that will define the harmonization of definitions and the regulatory field of digital assets within the Union:

- **(EU) 2018/843 5th EU Anti-Money Laundering Directive (5AMLD);**
- **(EU) 2022/858 Digital Ledger Technologies Regulation (DLTR);**
- **(EU) 2019/1937 MiCAR First Proposal;**
- **(EU) 2023/1114 Markets in Crypto Asset Regulation (MiCAR).**

With the **"5th EU Anti-Money Laundering Directive" (5AMLD)**, the first crypto-focused regulatory amendment made by the Union coming into effect in September 2020, the EU has amended the previous laws in the matter of AML/CFT including on its perimeter cryptocurrency exchanges and wallet providers. With the implementation of the 5AMLD, all the "providers engaged in exchange

services between virtual currencies and fiat currencies"[6] (cryptocurrency exchange) and the custodian wallet providers, defined as "entity that provides services to safeguard private cryptographic keys on behalf of its customers, to hold, store and transfer virtual currencies[6], will fall under the European regulation for AML/CFT requiring them to verify the identity of their customers reducing both the risk of money washing and the anonymity related with crypto transactions. Besides that, the 5AMLD has introduced mandatory checks and reporting obligations to identify and counter suspicious transactions. It is clear that the EU, with these interventions, has put the lens on improving the transparency within the digital asset market.

The **"(EU) 2022/858 Digital Ledger Technologies Regulation" (DLTR)** (in force since June 2022 and applicable starting from May 2023) has put another brick on the goal of identifying a shared regulatory framework among union members. The DLTR, brings a temporary six-year exemption on the current EU financial regulation for investment firms, central securities depositories (CSDs), market operators, and new market players, to allow the creation of financial market exchanges and settlements based on distributed ledger technologies. The DLTR aims at the development of a much more technology-integrated EU financial market following the principle of promoting the growth of the European financial system. The DLTR not only permits access to the markets to new players, but also extends the exemption on existing multilateral trading facilities (MTFs), organized trading facilities (OTFs), central securities depositories (CSDs), and central counterparties permitting them to potentially extend or replace their current infrastructure with a DLT based one. Always in the scope of harmonizing the new definitions involved with the crypto-focused technologies usage expansion, the DLTR has identified three categories of DLTs involved in the financial markets:

- **DLT Multilateral Trading Facilities ("DLT MTFs")** that are "multilateral trading facility that only admits to trading DLT financial instruments"[7].
- **DLT Settlement Systems ("DLT SS")** are "settlement system that settles transactions in DLT financial instruments against payment or against delivery, irrespective of whether that settlement system has been designated and notified in accordance with Directive 98/26/EC, and that allows the initial recording of DLT financial instruments or allows the provision of safekeeping services in relation to DLT financial instruments"[7].
- **DLT Trading and Settlement Systems ("DLT TSS")** that combines the services provided by DLT MFs and DLT SS.

At the end of the third year since the entry into force of the Pilot regime, ESMA will deploy a report regarding the impact on the European financial system of the introduction of DLTs and future proposals for the DLTR and the integration of DLTs in the EU market.

The **MiCAR (2023/1114)** represents much more than a regulatory framework, in fact, we can define it as the first cross-jurisdictional regulatory and supervisory framework for crypto assets. The EU, with MiCAR, aimed to create an ambitious shared framework, among all the Members, harmonizing both legal treatment and the taxonomy of digital assets that are not currently under any existing EU legislation. The framework will enter in force by the end of 2024 (30/12/2024) replacing all the existing rules at the national level. The MiCAR establishes the rules in matters of crypto assets issuance and trading admission focusing also on both the relative transparency and disclosure requirements. The crypto assets, "digital representation of value or rights which may be transferred and stored electronically, using distributed ledger technology or similar technology"[9], are the focal point of the framework which distinguishes three main categories of not regulated by current financial UE regulation crypto assets:

- **Utility Token:** "a type of crypto asset that is only intended to provide access to a good or a service supplied by its issuer"[9].
- **Asset Referenced Token (ART):** "a type of crypto asset that is not an electronic money token and that purports to maintain a stable value by referencing another value or right or a combination thereof, including one or more official currencies"[9].
- **Electronic Money Token (EMT):** "a type of crypto asset that purports to maintain a stable value "by referencing the value of one official currency"[9].

For the utility tokens, the MiCAR defines the requirements to proceed with their public offer, including that the proponent must be a legal person, and has to draft a paper that specifies the main details of the offer[9] and the communication standard which has to be satisfied.

The issuing of ART and EMT demands much more stringent requirements. In particular, for ART are expected some capital constraints: the issuer has to dispose at least of the maximum of EUR 350.000, 2% of the average amount of the reserve, a quarter of the fixed overheads of the preceding year. Instead, the EMT issuer must be an authorized credit institution or electronic money institution and the issued EMT must be at par value and on the receipt of funds. Other than that, the EMT should not grant any kind of interest and the issuer must invest the proceeds of the EMT issuing only in low-risk activities.

The MiCAR also identifies two sub-categories of the upon tokens:

1. **The significant asset-referenced tokens (SART);**

2. **The significant e-money tokens (SEMT).**

According to some specific dimensional thresholds, such as the tokens total value, the number of transactions, or the interconnections with the traditional financial system.

It is clear that the work done by the EU with the MiCAR represents an important step for the digital market's growth, but it does not cover all the aspects involved in the crypto environment. In fact, it is important to highlight that other well-known digital assets fall out of the MiCAR scope, in particular, we can point out Central Bank Digital Currencies (CBDC), NFTs, and DeFi protocols. It is important to note that the ECB, in its plan to promote financial innovation within the Union, has concluded in October 2023 the Digital Euro Investigation Phase that has detailed the possible characteristics and architecture that the European CBDC should rely on. The Digital Euro project is currently facing the, so-called, preparatory phase where are going to be consolidated and tested the features and the business processes defined during the previous phases (for a total view on the Digital Euro Project see "Digital Euro: Now and Beyond"[17]).

# 4. Asset Tokenization: Lending Perspectives

## 4.1 DeFi Lending and Over-Collateralization Issues

By looking at DeFi's history, given its goal to redefine traditional financial services (also TradFi), lending was one of the first applications that gained popularity, thanks to the promised offer of a transparent, permissionless, and open-source financial service environment. Traditional lending processes involve financial institutions acting as intermediaries between borrowers and lenders, introducing complexities such as credit checks, collateral requirements, and various fees. DeFi lending challenges this status quo by establishing decentralized platforms that enable individuals to lend and borrow directly without the need for intermediaries thanks to smart contracts, that automate the lending processes, ensuring trust and transparency through their open and verifiable nature. Starting from the "DeFi Summer" of 2020, Total Value Locked (TVL) in DeFi lending protocols peaked at $50 billion in early 2022, up from nearly zero in end-2020, but in June 2022 there was a major drop due to the Terra Luna crash[3] as shown in Figure 8. This event, together with the macroeconomic framework of late 2022 represents a turning point in the DeFi lending industry, thus creating a growth opportunity for tokenization of assets on lending protocols.

Before 2022 the crucial feature of DeFi lending was that it relied heavily on crypto collateral. The most common lending protocols focused on offering crypto loans with a trustless approach. This means that the users could easily lock their crypto assets on the DeFi lending platform without worrying about intermediaries. The borrowers could directly opt for loans from the decentralized platform with the help of P2P lending. This is a focal point: the total absence of the trust element represents the deepest difference from the traditional lending process perpetuated over centuries by Banks.

In addition to it, the DeFi lending protocol helps lenders to earn interest on crypto assets. As compared to the conventional loan processing system of banks, DeFi lending enables individuals to become a lender just like a bank. An individual could easily lend their assets to others and

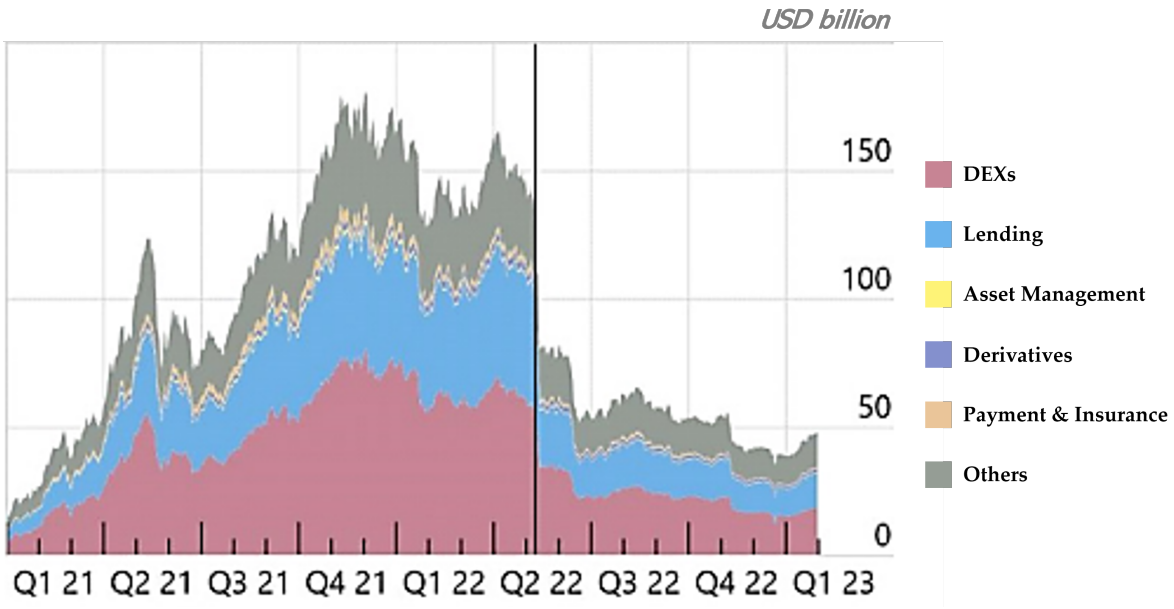


*FIGURE 8: Daily Total Value Locked in DeFi by type of Activity (2021-2023), Financial Stability Board*

accrue interest on that loan. Traditional financial intermediaries often impose various fees, including application fees, processing fees, and origination fees while DeFi lending minimizes these costs by directly connecting borrowers and lenders, bringing more favorable terms for both parties. The typical DeFi loan was disbursed in stablecoins, while the collateral consists of a riskier unbacked crypto asset, making the whole process self-referential. As already stated, stablecoins are a type of cryptocurrency whose value is tied to another asset class to keep a stable, steady value and typically are pegged to fiat currencies in a one-to-one ratio, but, if the peg breaks during adverse market conditions, the whole system might collapse. The figure 9 gives an outline of what happens when the peg breaks. This is particularly true for algorithmic stablecoins, like TerraUSD (UST) or Ampleforth (AMPL) which, unlike asset-backed stablecoins, employ smart contracts and algorithms that automatically re-balance supply to maintain their value relative to the target currency.

A business case that has been already well documented is the one regarding the Terra Luna crash of May 2022[3]. UST was supposed to keep a one-for-one peg to the US dollar by being convertible into one dollar's worth of LUNA (a native crypto on Terra Blockchain), and vice versa. To ensure sufficient demand for UST, the lending protocol Anchor offered a deposit rate of around 20% on UST. Attracted by high returns, new users bought LUNA to mint UST, leading to a steady increase in the value of LUNA. As soon as UST dropped below its peg, due to a $2 billion withdrawal on the Anchor lending platform, a classic run dynamic took place among investors in the hope of selling LUNA and making a profit. Therefore, given the size and speed of the shock, there were not enough parties willing to buy all the newly minted LUNA coins and, consequently, the price of LUNA crashed too. When the LUNA crypto network collapsed, it's estimated that $60 billion was wiped out of the digital currency space.

These kinds of lending platforms are a key part of the decentralized finance (DeFi) ecosystem, but their institutional features mostly facilitate speculation in crypto assets rather than real economy lending. In this sense, the Terra Luna crash teaches us two important lessons that need to be assessed in DeFi lending near future:

- **Absence of Trust:** in TradFi, the credit origination process starts with the assessment of the borrower's creditworthiness that relies on the collection of documents and information such as credit scores and financial statements in order to mitigate credit risk; in DeFi lending protocols, on the other hand, this kind of assessment is simply not feasible due to the anonymity of borrowers, anyone can be a creditor, even non-human agents: they simply need to have funds to borrow, a valid address, and a way to send and receive valid information from a protocol. Furthermore, in traditional finance, a loan can be flexible and the contractual terms may be modified by banks according to the latest hard and soft information collected; in DeFi there's

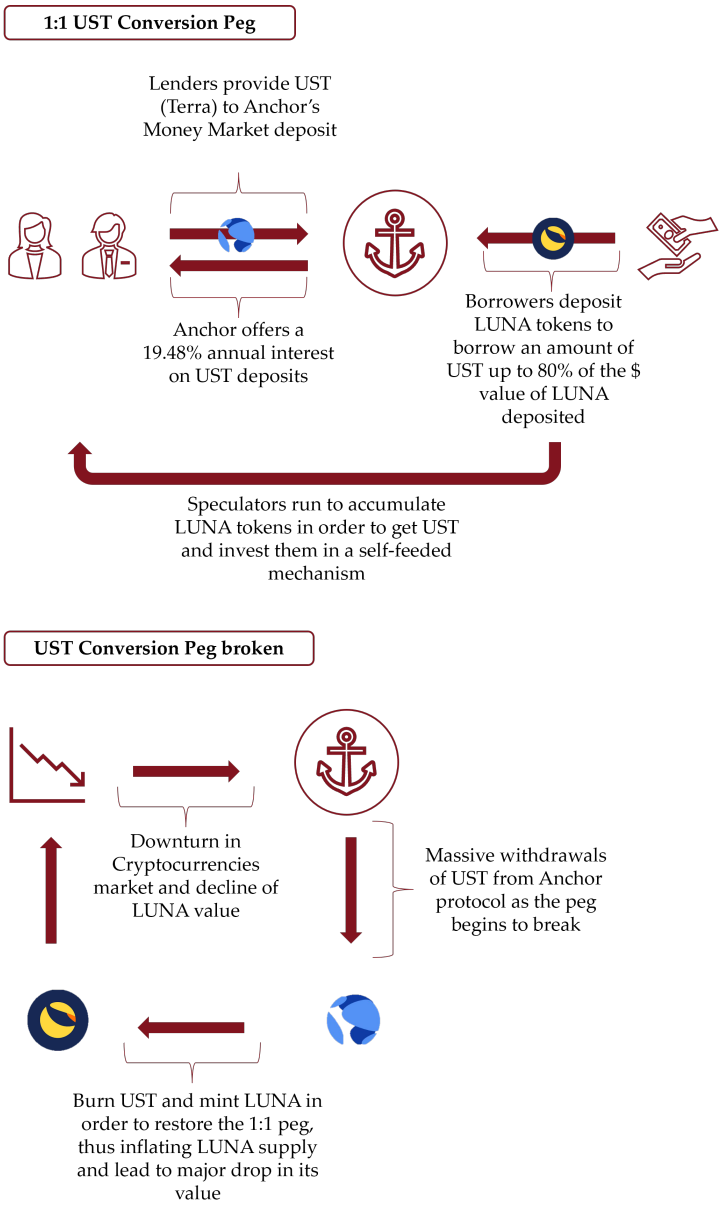


***FIGURE 9:*** *Anchor Protocol lending process and Terra/LUNA collapse*

no space for such flexibility, contractual terms are pre-programmed and cannot rely on soft information if we take, for example, loan and deposit rates, they are determined only by the level of supply and demand in the pool, according to formulas specified in the smart contract. For instance, in AAVE's protocol borrow interest rates are derived from the Utilisation Rate (U), the interest rate curve is split in two parts around an optimal Utilisation Rate and the interest rate R_t follows the model below[5]:

- If U $\leq U_{Optimal}$: $R_t = R_0 + (U_t / U_{Optimal}) R_{Slope1}$
- If U> $U_{Optimal}$: $R_t = R_0 + R_{Slope1} + (U_t - U_{Optimal} / 1 - U_{Optimal}) R_{Slope2}$

Given these assumptions, the only way to ensure the repayment of the loan is by posting some amount of collateral.

- **Overcollateralization:** to obtain the loan from a lending pool, the borrowers are requested to pledge any collateral accepted by the protocol through a borrowing smart contract, typically crypto assets. The Blockchain native crypto assets so far, tend to have a very high price volatility. Taking a closer look at lending platform protocols, we can see that smart contracts assign each

collateral type a haircut, or margin, that determines the minimum collateral borrowers must pledge to receive a loan of a given amount; minimum collateralization rates typically range between 120% and 150%[14] on major lending platforms, leading to over-collateralization. Together with collateralization rates, almost every protocol defines a liquidation threshold (also named, in AAVE protocol, "health factor") as the percentage at which a position is considered undercollateralized. If the collateral price falls below this threshold, anyone with sufficient liquidity can act as a liquidator, repay the lender, and keep a share of residual collateral. The posting of collateral does not eliminate credit risk for lenders, indeed and commonly, the underlying assets of liquidity pools are mostly stablecoins such as USDC and USDT, however, tokens used as collateral are volatile cryptos (e.g. ETH, BTC, YFI, YNX). The difference between assets and liabilities used in DeFi lending leads to high procyclicality: the amount of lending that can take place depends on the total value of assets eligible as collateral, thus creating boom-bust cycles. It can be seen very clearly studying the evolution of AAVE V2 TVL over the last few years: when collateral prices increase (BTC and ETH, fig.1), collateralization ratios fall, easing the borrowing constraints and expanding loan volumes (April-November 2021); on the other hand, when crypto prices fall, like in the 2022 "crypto winter", lenders run to pull out their deposits from lending protocols and by doing so exacerbate even more the procyclicality effect; from December 2021 to June 2022 decentralized exchanges trading volumes dropped 40%, in the same period TVL for DeFi protocols experienced a 67% drop.

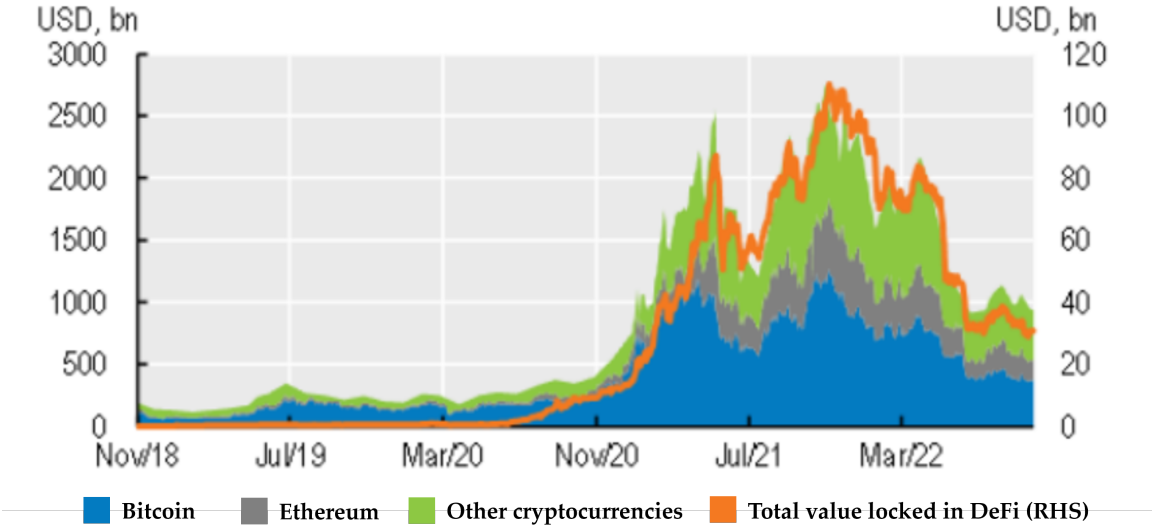


*FIGURE 10: Market Value of Major Crypto Assets (Source: CoinMarketCap)*

### 4.2 Introducing Real-World Assets on DeFi Lending Platforms

Despite the inherent fragilities described before, DeFi Lending might still fulfill its potential and try to fill the gap with Traditional Finance; the Total Value Locked (TVL)[2] in Lending protocols, in August 2023, was $10.300 billion meaning that currently, the scale of DeFi is quite small compared to the trillions of dollars outstanding of traditional finance debt. The turning point that could boost Defi lending might be the engagement in its protocols of large-scale tokenization of real-world assets to break out of the vicious circle of over-collateralization and cease to be a self-referential system dominated by speculation. Real-world assets could also act as a connection point with the centralized financial system, tapping into real-world business capital and from institutional investors. The self-referentiality experienced by the decentralized lending systems so far leads also to a great contradiction even in terms of the DeFi Manifesto: the collateral posting requirement results in a very high entry barrier for the debt market, meaning that only individuals who have already a great amount of deposits could become borrowers; If DeFi wants to fulfill its promise of making financial services more accessible, it must be able to reach the vast audience of small and medium-sized enterprises that struggle to access traditional financial channels. Finally, real-world assets tokenization, such as stocks, commodities, government bonds, and real estate might introduce much more stability into lending protocols and by doing so reduce credit risk. To study the state of the art of asset tokenization in on-chain lending processes, we will analyze three business cases of the current key players in this emerging market. We will see how they are incorporating elements of institutional finance with the goal of reducing credit risk.

#### 4.2.1 Maple Finance

Maple Finance, launched in 2021, is a capital market built on Ethereum and Solana Blockchains, designed to give users access to different lending pools where they can put their assets and earn interest. Anyone who has tokens hosted on Ethereum or Solana Blockchains could become a lender, but not everyone could be a borrower. Indeed, Maple aims to be an alternative to the traditional debt market for institutional borrowers, and on September 2023 had a TVL of $65.383.953. The minimal loan amount is $1.000.000 and to gain access to a loan from a specific lending pool, some identifying information must be provided and the Delegate of the pool, which is typically a fund or a credit professional, must conduct due diligence, including KYC and AML checks. There are several lending pools in which investors can deposit the pool's liquidity asset (e.g., USDC, wETH) and each one of them is managed by a single Pool Delegate who is responsible for negotiating loan terms with borrowers, performing due diligence, and liquidating collateral in the event of a default. Considering the operational model of individual lending pools, we can already assume that the Maple protocol has sacrificed a degree of decentralization in exchange for greater credit stability. Beyond the well-known lending pools secured only by digital assets, Maple has recently launched liquidity pools backed by real-world assets: Cash Management Pool and AQRU Real World Receivables Pool.

- **Cash Management Pool:** with an outstanding loan value of $25.847.358 is a cash management solution for stablecoin holders backed by U.S. Treasury Bills or reverse repurchase agreements fully collateralized by U.S. Treasury Bills. The pool lends USDC to a standalone SPV established by the borrower, which generates yield by investing the proceeds on permitted U.S. government instruments. The weighted average maturity of the borrower portfolio must remain no more than 30 days and the target APY is that of the 1-month U.S. T-bill rate, less fees and expenses.
- **AQRU:** is a digital asset investing platform with an outstanding loan value of $16.164.482[3]. The overall strategy of AQRU Real World Receivables pool is to provide liquidity to U.S. businesses by purchasing their receivables, with a focus on tax credits provided by the U.S. Treasury. The market that backs AQRU liquidity pool is the IRS Receivables marketplace; the U.S. government's revenue service periodically undertakes schemes to supply liquidity to targeted sectors of the economy, recently in the form of Employee Retention Credit (ERC)

[2]Total Value Locked represents the amounts of assets deposited by the liquidity providers in the lending protocols, source DeFiLlama.

[3]Source: AQRU receivables monthly pool update September 2023.

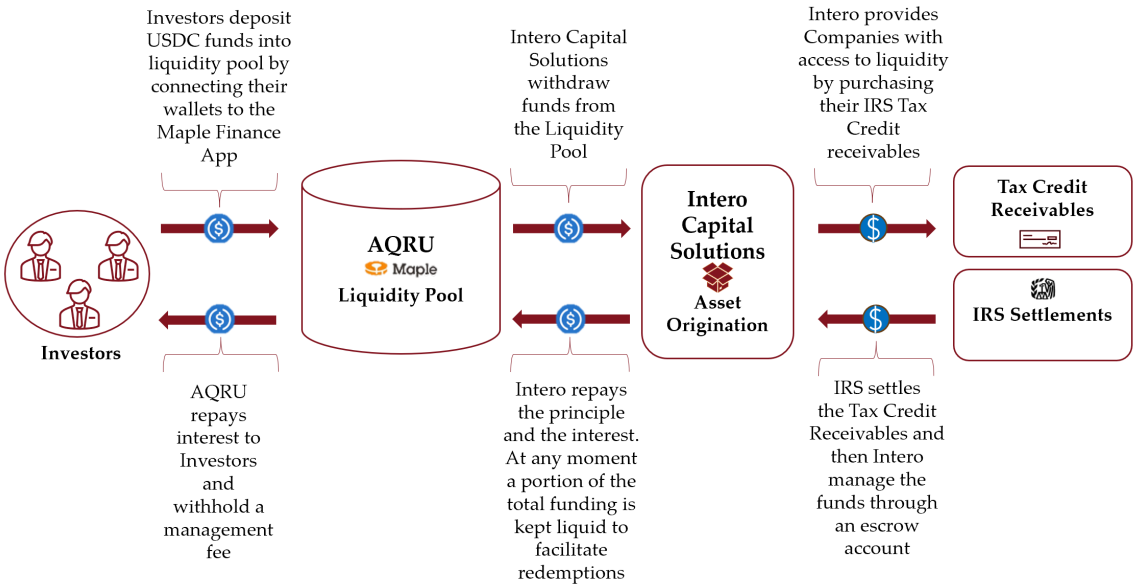


*FIGURE 11: AQRU Operational Flow*

that consists of a fully refundable tax credit for employers that paid qualified wages during the Covid pandemic. The sole borrower of the pool is Intero Capital Solutions which acts as a facilitator by purchasing tax credits owed to U.S. businesses and providing them liquidity thanks to AQRU funds; once the IRS settles the receivables, the disbursement of funds is then managed by Intero through an escrow account ensuring that all parties with interest are settled before any proceeds are returned to the original tax credit recipient. The pool offered, in August 2023, a yield of 16,2% and is available only to accredited investors who have passed the KYC check, the minimum deposit size is $50.000 USDC.

### 4.2.2 Goldfinch

Founded in 2020, Goldfinch is a decentralized lending platform built on the Ethereum Blockchain that allows collateralization of on-chain loans using off-chain assets and income. On-chain loans are issued in USDC provided by investors to the protocol, borrowers (mostly off-chain lending businesses) propose deal terms in order to gain access to credit lines and create a Borrower Pool. Borrower Pools are specific to individual borrowers and represent the credit lines from which borrowers draw capital to fund their real-world lending. The assessment of individual Borrower Pools is done by a specific category of investors called Backers who eventually invest directly with first-loss capital earning in return the protocol's highest yield (in August 2023 Borrowing Pools on Emerging Markets targeted a 17% USDC APY). Goldfinch protocol, on the other hand, allows investors to choose a lower-risk strategy, by providing USDC not to any specific individual Borrower Pool, but in the Senior Pool of the platform with a second-loss capital that optimizes diversification by automatically allocating its funds across all Borrower Pools according to the assessment of Backers. The distinctive feature of the Goldfinch platform is the "Trust through Consensus" mechanism, used to determine how to allocate capital from the Senior Pool: where more Backers supply to a specific Borrower Pool, the Senior Pool increases the ratio with which it adds leverage. The Trust through Consensus mechanism implies that in order to count individual Backers the protocol must ensure they are represented by different individuals; therefore, all Backers require a unique entity check to participate in a pool and KYC check for U.S. investors. The process that goes through the consensus of Backers aims to replace the over-collateralization issue with the borrower proposals screening in order to reduce credit risk. Prospective borrowers submit a term sheet to the network's Backers, who evaluate individual deals, including off-chain collaterals that are legally enforceable, and covenants. Furthermore, borrowers are required to launch a data room for due diligence that should include some minimum information such as an overview speaking to

the borrower's historical performance, transaction structure for the Borrower Pool, and a security overview document explaining how collateral will work in the instance of default. In addition, borrowers also set up a two-way communication channel for potential investors where they can ask questions, find clarification on due diligence documentation, or request additional information. By taking a closer look into Goldfinch protocol architecture, it can be seen that Borrower Pool's smart contracts have both a junior and a senior tranche: Backers supply first-loss capital to the Pool's junior tranches, while Senior Pool investors supply capital to the Pool's senior tranches. As soon as a Borrower makes repayments to its Borrower Pool, the pool applies the payment first to any interest and notional owed to the senior tranche and then to the junior tranche. This structure is meant to incentivize Backers who actively assess the creditworthiness of individual Borrower Pools and define the lending terms; indeed, they will be the first to experience loss in case of default. There's also a more explicit incentive the protocol grants to Backers: in order to compensate them for evaluating Borrower pool terms and providing first-loss capital, 20% of the Senior Pool's nominal interest ($i_n$) is reallocated to Backers, according to the following formulas:

- $i_{Senior}=i_n*(1-p-j)$
- $i_{Junior}=i_n*(1-p+r*j)$

This means that Senior Pool earns an effective interest rate that is the 70% of the nominal interest rate, considering a 10% of protocol reserve allocation (p) and the 20% of junior reallocation (j). The junior pool, instead, gains an effective interest rate that is higher than the nominal interest rate of the Borrower Pool, due to the incremental effect of leverage ratio (r)[4] and junior reallocation (j). On September 2023 there were 11 active deals on the Goldfinch platform accounting for a total loan amount of $90.435.000; the average borrowers are Credit Funds Fintech Companies that finance small and medium-sized businesses in developing markets, that usually experience serious constraints in raising funds in their domestic financial systems.

[4]According to Goldfinch Whitepaper the leverage ratio increases linearly from Bmin, the minimum number of Backers necessary for leverage, to Bmax, the maximum number of Backers necessary to achieve the maximum potential leverage, Lmax.

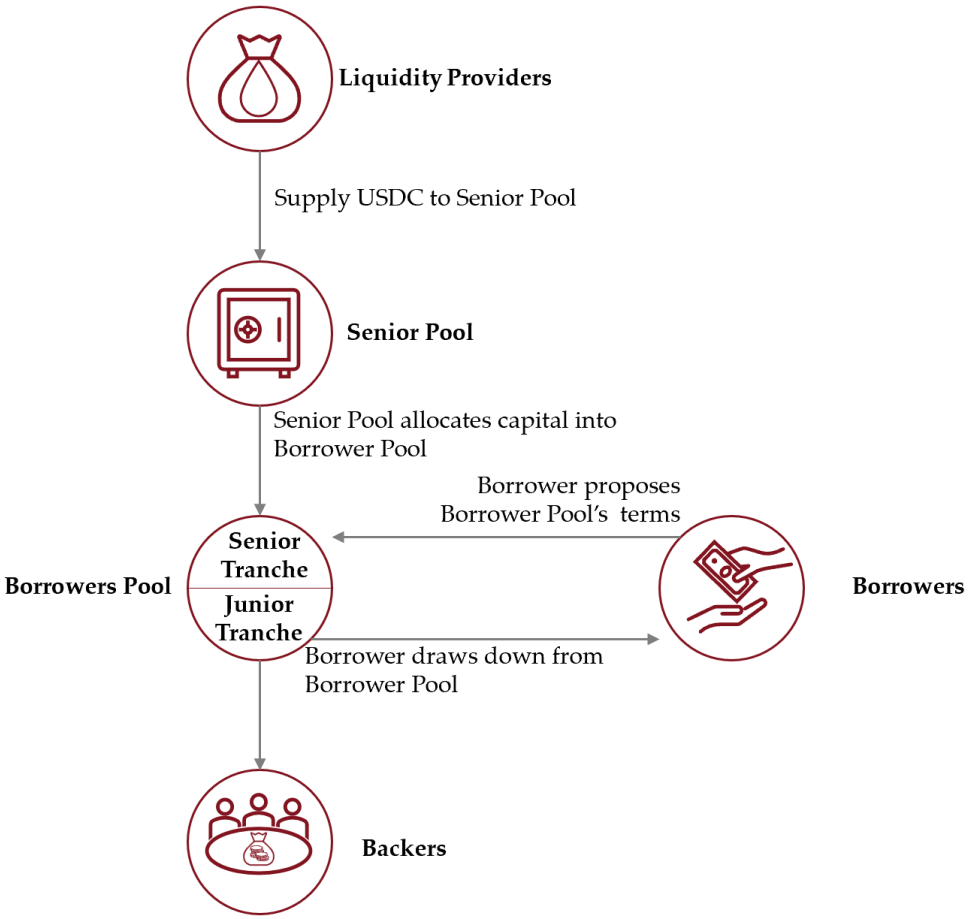


*FIGURE 12: Goldfinch Protocol Mechanics*

### 4.2.3 Centrifuge

Centrifuge launched Tinlake in 2019 as an open marketplace and investment dApp[5] built on the Ethereum Blockchain that uses a DAO (Decentralized Autonomous Organization) to govern the protocol. Tinlake allows businesses to borrow against their real-world assets such as invoices, real estate, machinery, mortgages, and royalties. In order to create an on-chain representation of the off-chain real-world assets, borrowers need to tokenize their financial assets into NFT and use them as collaterals in Tinlake pools to draw funding. The main feature of Tinlake NFT is that it contains the relevant information required for pricing, financing, and valuation. Centrifuge protocol aims, just like other protocols at least in their public statements and documentation, to increase the liquidity of real-world assets, that are often illiquid in order to help small and medium enterprises access financial services. On the other hand, Centrifuge enables investors to participate in asset-backed loans within the DeFi ecosystem mostly uncorrelated with crypto market volatility. Centrifuge, once a single asset has been tokenized, uses a well-established instrument of traditional financial markets to improve the asset liquidity profile: asset securitization. The protocol governance system pools together multiple assets into a liquidity pool that collects investors'funds. Any asset in the pool is priced and then the issuer borrows liquidity from the pool, over time, accruing debt per asset is repaid by the issuer including interest payments and principal repayments. One of the major obstacles to real-world asset tokenization is the enforcement of asset legal structure on-chain. Centrifuge tries to assess this issue by tying a Special Purpose Vehicle (SPV) to each pool. The SPV the asset originator's business separated from the financing activity underlying the pool in order to minimize default correlation, furthermore, just like in TradFi, to securitize assets, its legal ownership is transferred by the asset originator to the SPV. The legal framework for each pool closely mirrors the structure of Centrifuge's smart contracts and the real-world relationships among the involved parties. The design of this framework is guided by two primary objectives:

1. The primary aim is to provide investors in the pool with the highest level of protection possible, offering them avenues for recourse concerning the real-world assets used as collateral in the pool. The ultimate source of truth is maintained on the Blockchain. All responsibilities and obligations are meticulously encoded within on-chain smart contracts, ensuring a transparent and secure environment for investors.

2. Secondly, SPV serves a crucial role by maintaining the integrity and independence of the financing process.

Similarly, to other DeFi protocols, Centrifuge allows investors to choose among different risk exposures and yield on the same asset class by structuring a pool in senior, mezzanine, and junior tranches, each one represented by a specific token. The senior token also called the yield token, is protected against defaults by the junior token which receives the proceeds after all other tranches have been served in a typical waterfall structure. To mitigate the risk for senior and mezzanine investors, each tranche, except the junior one, is set with a subordination ratio that determines the protection level of upper tranches. More in detail, the subordination ratio is the percentage of the Asset Pool that must be covered by the losses of subordinated tranches below in the waterfall. For example, a subordination ratio of 10% for the senior tranche means that the senior tranche should in any case be protected by a combined mezzanine and junior tranche accounting for at least 10% of the total asset pool. The waterfall structure carries, furthermore, a trade-off between risk and return: all the tranches above the junior one grant a fixed return, while the junior "first-loss" tranche relies on a variable rate due to the possibility of capturing the excess returns greater than the fixed rates of the tranches above.

[5]Decentralized Application are distributed applications that rely on a DLT or a Blockchain, instead of a single computer, and operate autonomously thanks to smart contracts.

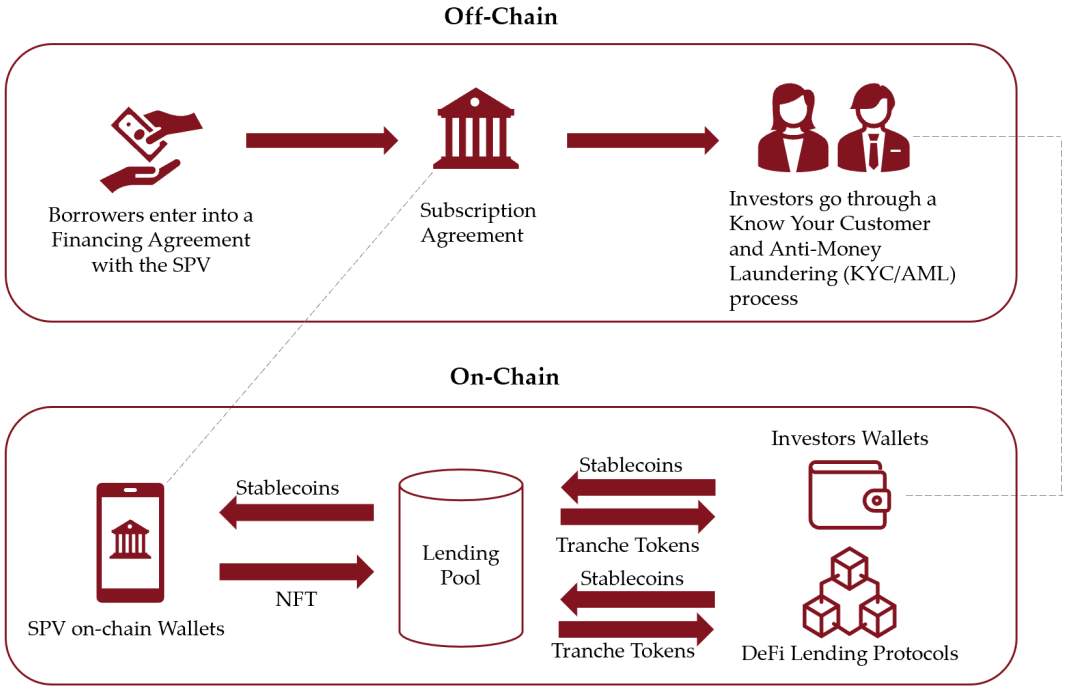


*FIGURE 13: Centrifuge Pool structure and relationship with off-chain world*

### 4.3 Market Perspectives

The use of real-world assets in DeFi lending platforms could be one of the crucial steps to bridge the gap between decentralized finance and traditional finance. Currently, many DeFi platforms primarily focus on crypto assets like Ethereum and cryptocurrency derivatives. However, the introduction of real-world assets presents new opportunities and challenges. The case studies mentioned here are currently the largest in terms of TVL, but they are not the only ones in the market: the real game is being played on the ability to make as many types of financial assets legally valid on the Blockchain as possible. According to some sector studies, the asset tokenization market is expected to reach an estimated value between 10 trillion USD[19] and 16 trillion USD[13] by 2030. A significant portion of this growth will come from private debt, which will be brought on the chain, approximately 2.8 trillion USD. These estimates are based on observing the market values of major off-chain asset classes (Debt, Private Equity, Real Estate, Investment Funds, Public Equity), which are projected into the future with a growth rate consistent with the macroeconomic context (ranging from 2% to 8% annually). It is estimated that a portion of this growth (a conservative estimate of 1%) can be brought on the chain, increasing the Total Value Locked in DeFi protocols. If we start from these assumptions, it is reasonable to think that a significant portion of the growth in tokenized assets will be absorbed by DeFi lending platforms since potentially any asset class, once brought on-chain, can be used as collateral for a loan. The macroeconomic context of rising inflation and interest rates could push more and more companies and individuals to seek alternative and faster sources of liquidity in Decentralized Finance protocols, especially if DeFi operators will prove their ability to provide solutions to the intrinsic illiquidity of certain off-chain assets. We have seen how in the recent past, the DeFi lending industry has attempted to address these issues by enhancing certain features of the utilized protocols:

- **Affordability:** Many potential real-world investors are deterred by the high minimum amount, which ranges from $250.000 to $5 million, depending on the asset type such as real estate, bonds, or hedge funds. Concerning this specific point, as we have seen in the previous paragraphs, the trend in lending pools is to further reduce the minimum threshold required for investors, for example The minimum investment to participate in a Tinlake pool is currently 5.000 USD equivalent, and as stated in Centrifuge FAQ section: "Centrifuge is working hard to

decrease this. This minimum is in place due to the operational efforts required to onboard an investor to a pool."

- **Fractionalization:** Some assets, like real estate or industrial properties, cannot be easily divided among investors, making it hard to create smaller, accessible investment opportunities. Although fractionalization is a common practice in traditional financial markets, Blockchain technology and smart contracts ensure that the fractionalized asset is divided and distributed according to predefined rules, protecting the rights of token holders.
- **Institutional Adoption:** Institutional investors, such as banks, asset management firms, and pension funds, are increasingly delving into tokenized assets to diversify their portfolios and enhance liquidity. The involvement of these major players is anticipated to infuse substantial capital into the market. As we have seen in the previous paragraphs, the shift away from overcollateralized lending models based on crypto assets and the introduction of real-world assets has significantly reduced the underlying volatility and the overall credit risk, making them attractive to institutional players.
- **Diversification:** The continuous advancement of Blockchain technology is enhancing scalability, security, and efficiency. With an increasingly robust Blockchain infrastructure, a wider array of asset classes can be supported, and a higher volume of transactions is accommodated, making it increasingly appealing to investors. On this target, various initiatives by major market players are underway. Recently, Centrifuge launched Prime, a suite aimed at large investors that allows the building of highly diversified portfolios based on the risk profile sought by the investor. Solutions range from those ensuring high liquidity, consisting of Treasury Bills and Money Market Funds, to allocations targeting a yield of over 13%, comprising ESG, receivables, real estate, and trade financing.

In conclusion, the actual realization of market perspectives for asset tokenization and the probability of reaching trillion-dollar growth scenarios depends on the market participants'ability to enhance all the aspects mentioned above and on an additional factor that influences all the previous ones: regulatory evolution. As we have seen in paragraph 3.2, the European Union is moving in the right direction in terms of regulatory harmonization with the MICAR regulation. If other supranational institutions follow suit, DeFi lending platforms, and decentralized finance in general, could truly bridge the gap with traditional financial markets and become a viable alternative for investors worldwide.

## 5. Real Estate Market: a Tokenization Opportunity

The empirical evidence suggests that both residential and commercial real estate markets are typically characterized by low liquidity, especially during "cold" periods (Krainer, 2001) high transaction costs (Bian, Waller, and Wentland 2016), elevated search costs (Ling et al.,2018) and high entry barriers due to the considerable minimum capital requirements. These specific features and the related risks have undoubtedly influenced the investment returns of the entire real estate market, discouraging business activities within the sector. Real Estate Investment Trusts (REITs) and other private equity investment vehicles with real properties as underlying assets have contributed to overcoming some of the challenges caused by the intrinsic characteristics of the real estate market that we have already mentioned. For instance, REITs allow to profit from properties without the need to manage and carry out physical property maintenance. REITs are also tradable on the secondary markets; hence these types of assets are more liquid than direct real estate investments and they are also accessible with a low level of initial capital. In addition, REIT investments are supported by a strong and consolidated regulatory environment. We can cite as an example the case of the United States, where REITs need to be registered with the U.S. Securities and Exchange Commission (SEC). Nevertheless, REITs do not allow investing in individual properties, but only into property portfolios. Therefore, investors cannot specifically select their investment vehicles according to their preferences. Moreover, investors usually need to pay up-front fees and management fees in exchange for REIT funds administration and governance. The advent of tokenization and Blockchain technology could have a positive effect on the entire real estate market, as it has been already

established by the last research based on real-life data and examples. However, there are also some negative features related to the use of these technologies, whose use is clearly limited by the lack of a fully reliable regulatory environment, that is still under development in most countries. In this paragraph, we set aside the regulatory context focusing instead on the main characteristics of real estate tokens pointing out some advantages and disadvantages related to these types of digital assets and then we analyze the empirical evidence already available on this argument.

### 5.1 The main features of Real Estate Tokens

Real estate tokens can be described as fractions of assets representing properties incorporating the related rights and obligations, that are offered to the public through Security Token Offerings (STOs). The characteristics of these investments are defined within smart contracts located in the Blockchain that are executed automatically when determined conditions are met, allowing security, traceability, efficiency, and speediness of the various procedures, eliminating the need for human interventions, and avoiding operating errors. Transaction costs can be reduced since there is no need for intermediaries. Properties fragmentation as well as the possibility to trade real estate tokens in the secondary markets make these types of assets more liquid than traditional real estate ones, which might need several years to be sold at a fair price and require maintenance to avoid their decay. Moreover, there are no entry barriers for small-scale investors, who can access this market with small sums of money with the aim of diversifying their portfolios. Another advantage provided by these digital assets compared to REITs is represented by the possibility to individually select each single property that investors want to include in their digital wallets. On the other hand, omitting the lack of a complete and integrated regulatory environment and a well-defined taxation system, real estate tokens have many other limitations. If we want to mention one of them, smart contracts are continually threatened by hackers. After a cyber-attack, the money embedded in the contracts may become impossible to trace. Furthermore, the process necessary to obtain the authorization to launch a platform for a STO is long and tortuous and this element can disadvantage entrepreneurs who want to embark on new ventures.

### 5.2 Evidence from the Market

Most of the studies available from the literature are based on the analysis of various samples of US real estate tokens available for trading in a digital platform owned by RealT, a pioneering firm in this market niche. Despite the similarity of the selected samples, which are primarily composed of properties located in Detroit (MI) and Chicago (IL), each study differs from the others regarding the research methodology and investigation topic. We propose an accurate selection of these papers to summarize the main evidence available to date on the argument. Swinkels (2022) published a detailed analysis of a sample of 58 residential properties tokenized by the company RealT between October 2019 and February 2021, which represents the total number of tokens issued by the enterprise during the analyzed period. All the properties within this sample are located in the US: in particular, 52 of them are positioned in Detroit (MI). In RealT's business model, token holders receive the rent (after subtracting costs) for each specific property according to the number of tokens owned. With regard to this specific sample, the investments have been executed through the Ethereum Blockchain. Summarizing the results, the median value of the properties is USD 65.211, token prices mostly fall in the range of USD 45-60, while rents used to be close to USD 6. Most of the properties have between 150 and 400 holders and the number of owners increases in accordance with the value of the underlying property. However, the authors consider this sample too small to provide valid conclusions about the performance of these token assets, even if prices seem to be correlated to economic fundamentals. Steininger, B. I. (2023) analyzes the return-risk pattern of 180 tokenized properties located in the US and finds that this variable does not have a strong correlation with any other asset classes, highlighting the opportunity to use real estate tokens as portfolio diversifiers. Kreppmeier et al. (2023) examine a sample of 173 US tokenized properties available in the RealT platform and find that investors prefer to buy tokens during Security Token Offering (STO) processes instead of investing in this type of assets through the secondary markets. Another important finding is that investors try to evade transaction costs when they buy or sell tokens and they are influenced by crypto market-specific sentiment when

purchasing tokenized property fractions. Kull, F., & Naumann, T. (2022) analyzed the performance of a token index constructed on the returns of a sample of tokenized properties issued within the RealT platform against various benchmarks, such as the S&P Case-Shiller MI-Detroit (DetroitHI) home price index and S&P Case-Shiller IL-Chicago (ChicagoHI) home price index (FederalReserve Bank, 2022), arguing that token indices do not outperform the benchmarks during the selected period. Furthermore, this research paper provides an articulated point of view on the effect of the liquidity increase generated by the advent of real estate tokens. Specifically, there are both positive and negative possible consequences of liquidity soaring within this market. Starting with the first category, some of the effects may be improved transparency, market efficiency, and more accurate asset valuation. Regarding the second class, price changes have the potential to negatively affect some investors and intermediaries that generate their gains thanks to the information asymmetries that characterize the real estate market.

## 5.3 Real Estate Tokenization Projects

### 5.3.1 SolidBlock

SolidBlock was the first company to enter the real estate tokenization industry in 2019 with the digitalization of the St. Regis Hotel in Aspen (CO), which probably represents the most famous case of real estate tokenization that has been also realized in compliance with the SEC regulation. This company is an example of Tokenization as a Service (TaaS) which interconnects Blockchain and Web3 technologies. SolidBlock allows people to buy, sell, raise money, or collateralize properties and manage them in a user-friendly platform, that includes Customer Service with live chats and on-demand reports. Even though it is not easy to find information about the fees for the services offered, the firm supports owners and investors in all the phases of real estate tokenization, from security issuance to secondary market trading. SolidBlock uses Ethereum-standard (ERC20) real estate tokens to represent property shares.

The SolidBlock model from DIBS (Distributed Brokerage System) implies a two-stage process:

- The first step involves asset securitization, which for DIBS requires the tokenization of a share of the asset that is less than 50% of its value.
- Thanks to Web3-enabled digital platforms the asset is issued and traded within the market. At this stage, DIBS will perform all compliance checks according to US and Global regulations.

A peculiarity of DIBS platform is that the Web3 platform links different independent brokers that could distribute any asset listed on DIBS while paying them commission every time they connect investors to listed deals.

### 5.3.2 SwissRealCoin

SwissRealCoin is a security token linked to a portfolio of Swiss commercial real estate managed through a Blockchain software named "MIA". This project is currently set on hold. The Swiss RE market has been historically characterized by low volatility and high stability. The SRC business model aims for a constant growth of the invested Portfolio thanks to the reinvestment of 80% of the received rents on new properties. In order to sustain the token's liquidity, the SRC will be traded on licensed exchanges. Additionally, the program will ensure the right of all the token-holders to participate in a portfolio liquidation vote. Tokens can be purchased through FIAT, Bitcoin (BTC), or Ethereum (ETH).

### 5.3.3 RealT

RealT represents the most famous real estate token platform in the US as we have already mentioned in the previous paragraph. The company has been able to tokenize hundreds of properties in this country, especially in the areas of Detroit and Chicago. On the technology side, RealT tokens can be purchased or sold through both the Ethereum Blockchain and the Gnosis chains. RealT platform allows investors to buy, sell, and collateralize real estate. The collateralization processes take place on the RMM platform, where users can contract for loans by placing RealT tokens as collateral.

Users can borrow stablecoins and when a default event occurs, real estate tokens are used to repay the loans. The possibility to borrow stablecoins on the RMM platform allows people to get liquidity without the need to sell their real estate tokens and it does permit them to continue to benefit from the income generated by the rents. The collateralization rate is typically set at 50% so that investors can borrow up to half of their property tokens'value. Collateralization allows also to increase the profitability of the operations thanks to the leverage effect, which is obtainable through the reinvestment of the borrowed stablecoins. We underline that the use of leverage does increase the risk profile of the portfolio and might generate major losses.

### 5.4 Italian Real Estate Tokenization Market Perspective: The BlockInvest Case

Tokenization could represent a valid investment alternative to the traditional real estate investment vehicles already available in the Italian market, thanks to its intrinsic characteristics: efficiency, transparency, innovation, and accessibility. The Italian Fintech startup RealHouse SRL and the platform they own named BlockInvest represent a perfectly fitting example of an entrepreneurial initiative that aims at the development of this specific market niche. As evidence of this, in December 2021 the bank Credit Agricole Italia, aware of the potential of this startup, finalized its first investment in an Italian startup and has also included the startup in the acceleration program of Le Village by CA Milano, which is a Credit Agricole open innovation Hub. Regarding tokenization, in January 2020 RealHouse SRL together with InvestiRe SGR SPA and Immobiliare Casati SRL concluded the first real estate Security Token Offering (STO) in Italy, tokenizing two properties located in Rome through the Ethereum Blockchain. The agreement is based on a Non-Performing Loan (NPL) originated by Unicredit which is guaranteed by those two properties. In particular, RealHouse SRL has created and stored in the Blockchain the "digital portfolio" and the documentation related to the entire operation. Immobiliare Casati SRL has issued an equity token called RHC1 with its own intrinsic value and then a new Special Purpose Vehicle (SPV) has been created in order to manage the credit and the property development, also allowing a successful fundraising stage: around EUR 3 million have been collected among private accredited investors. Although the BlockInvest example related to the NPL market highlights the potential of the application of tokenization to the Italian real estate sector, there are still several obstacles to the full realization of an efficient real estate token marketplace in Italy. The first of them is undoubtedly the current legislation: there has been no significant development over the few last years regarding the introduction of real estate tokenization into the Italian legislative landscape. The lack of clear and complete legislation on this matter slows down the development of this market niche, delaying the entry of the most ambitious investors within the sector as well as the realization of an efficient real estate token marketplace.

## 6. Conclusions

In conclusion, the analysis delves through the transformative potential that real estate and lending asset tokenization could bring to the markets in the coming years. However, the insights that emerged in the paper scratch only the surface of the impact that asset tokenization could have on the traditional financial landscape. First, the fractional ownership and decentralization that characterize asset tokenization have the power to diminish and break traditional markets entry barriers, fostering market liquidity and widening the plethora of possible investors. Additionally, the absence of centralized authorities could enhance the exchange possibility thanks to the reduction of costs and bureaucracy ensured by the overtaking of middle intermediaries. As we have seen, the regulatory environment could be a critical factor in the development of digital assets. As witnessed in the paper some international regulators and the European Union, with the MiCAR are moving forward in the right way but globally the work on the regulatory playfield for digital assets is far away from being done, and Regulators, market players, and emerging FinTech start-ups must collaborate in order to promote and develop the future architecture of the digital asset's environment. In conclusion, real estate and lending asset tokenization represents more than a technological advancement; it embodies a paradigm shift in how we conceive and interact with financial instruments. In particular, the possibilities of using real-world tokenized assets as collateral in the DeFi lending environment could bring new lymph in these markets being a propellor to the mark growth. On the other hand,

the possibility of ownership fragmentations could make investments in real estate assets much easier also for retail investors that are historically a not significant share of this market. Looking forward, it becomes evident that the applications of asset tokenization extend beyond real estate and DeFi lending, which are not the only one that could play a key role in reaching the full potential of asset tokenization; there are, indeed some other potential applications that deserve in-depth analysis, for instance, supply-chain management, asset management and insurance market which could be the subjects of dedicated future papers.

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