

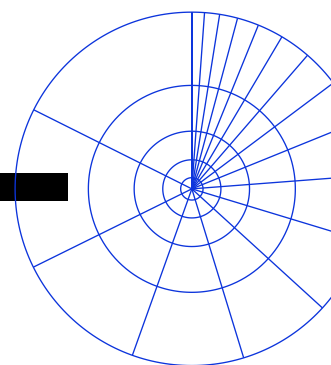
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Defy. Deploy. Run.

## **Tokenized Securities**

Lifecycle, Infrastructure, Opportunities and Challenges

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## Introduction

Tokenized securities are securities where digital records are represented on a distributed ledger technology (DLT) system, which subsequently can be owned and transacted on that system. Theoretically, almost all assets can be tokenized, such as financial assets (stocks and bonds), real assets (real estates and arts), and intangible assets (intellectual properties). This paper focuses on tokenized stocks and bonds since the adoption of their technology is already high and mature, the market size is large, and there are a lot of intermediaries in value chain, hence high potential of tokenization impact.

Tokenized securities present many opportunities such as quicker settlement and processing time in the value chain, and lower transaction cost due to the removal of unnecessary intermediaries, which is one of the core features of the underlying DLT. However, the implementation also poses challenges such as regulatory uncertainties, governance, privacy, and interoperability, which are currently still under discussion. Added to those challenges is the fact that there exists not yet big scale application for tokenized securities on DLT and most of them are still in the early MVP stage, hence there is a lack of benchmark and best practices at production level.

In the market, there have been some proof of concepts of tokenized securities. In January 2021, Vonovia, a residential real estate company, issued a tokenized bond of €20 million to M.M. Warburg Bank as a first investor using the online marketplace firstwire with its partner Bitbond for the technological implementation, which uses Stellar blockchain. In this case, the issuer said that the issuances are transparent and traceable in real time which guarantee a professional transaction standard. The investor said that tokenization will significantly expand the range of financial products and services.

In April 2021, European Investment Bank (EIB) issued a €100 million two-year bond using Ethereum blockchain, with Goldman Sachs, Santander and Societe Generale acting as joint lead managers for the transaction. According to EIB, digital bonds will play a role in giving the bank a quicker and more streamlined access to alternative sources of finance to boost finance for projects across the globe. Also in April 2021, Société Générale issued its very first structured product security token, which represents €5 million of Euro Medium Term Notes (EMTN). From the

bank's perspective, blockchain adds significant capacity for structuring assets with fewer intermediaries in addition to better speed and greater transparency.

In this paper, we present an overview on the lifecycle of tokenized securities, the infrastructure that is needed to bring tokenized securities to market, and the opportunities and challenges that tokenized securities trigger. This provides readers with current knowledge of tokenized securities that support with them navigating the world of tokenized securities for further deeper research.

## Lifecycle of Tokenized Securities

The lifecycle of tokenized securities is analogue to the traditional ones, which is subscription, issuance, custody, trading, settlement, and asset servicing.

The activities in the **initial and subscription phase**, such as distribution of securities specification and terms and conditions, KYC/AML check, and customers' on- and offboarding, are similar for both traditional and tokenized securities.

In the **issuance phase**, traditional securities are registered in centralized systems, while tokenized securities are registered in DLT systems, either public or private, depending on business models. The legal entity which is entitled to register the securities on DLT platforms on the issuers' behalf is responsible for keeping track of the securities' change of ownership and to perform asset servicing during the entire securities lifecycle by developing and executing the securities' smart contract. The issuance of tokenized securities and the entities involved must adhere to regulations which differ across jurisdictions.

The **custody** of traditional securities means the registration and maintenance of securities records in the existing centralized system such as that of the existing (I)CSD. In the tokenized securities world, custody means the safekeeping and management of the private keys of the securities owners. The information about the securities itself is distributed across the DLT nodes. The private keys can be safekept by the owners themselves or by third-party enterprise-grade custodians.

**Secondary market trading** of tokenized securities is made temporarily possible by EU's pilot regime in March 2023. The formation of this market is still in progress. Following the cryptocurrencies market, tokenized securities could be traded on centralized or decentralized exchanges, where the latter fully leverage the disintermediated nature of DLT.

Depending on the required business model, tokenized securities might omit the **clearing phase** entirely since all transactions can be settled immediately without any needs for netting thus save the need for collaterals.

**Settlement** of traditional securities usually takes up to two days, while settlement of tokenized securities can be executed immediately. Since stable coins, which are needed for the payment leg of the DvP settlement of the tokenized securities, are still under discussion by the regulators, fiat money might still be used as a temporary solution until stable coins mature.

**Asset servicing**, such as dividend and coupon payments, are mostly already automated in traditional securities. This is also the case for tokenized securities with the automation logic is now integrated of the smart contract. Efficiency gains might be achieved in some areas, e.g., voluntary corporate actions.

## Infrastructure of Tokenized Securities

The current infrastructure of the securities market is **highly dependent on intermediaries** that connect issuers and investors, and investors with each other, during the securities lifecycle. Each intermediary has a different role, for example: issuing and paying agents, clearing via central counterparty (CCP), brokers/dealers, and multiple layers of custodians. DLT, the platform on which the tokenized securities are running, enables peer-to-peer connection between issuers and investors, and among investors, **without the needs for intermediaries**. The trust to those intermediaries is replaced by a collective trust on the DLT infrastructure such as the auditable smart contract logic and the well-proven consensus mechanism.

Since tokenized securities are regulated, there is a need for a legal entity which is entrusted by securities issuers to **register** the securities on DLT platform on their behalf. In Germany's eWpG (elektronische Wertpapiergesetz), this entity is called registrar. The registrar is also responsible for executing any corporate actions that happen during the securities lifecycle, responding to regulators and auditors' request for report, and redeeming the securities at later point in time. Registrar can codify the logic of these activities in **smart contract** that are transparent and auditable by all participants.

Depending on the intended business model and regulatory compliance, the registrar can issue tokenized securities on either **public or private DLT platforms**. Private DLT is commonly used for enterprise or consortium use cases with known participants and clear legal responsibilities, while public DLT is aimed at generic purpose use cases with full trust on code and platform.



The ideal case for a DLT platform is one with **highest level of decentralization, scalability, and security**. However, the well-known blockchain trilemma states that only two features above can be maximized at the expense of the other one. Consequently, DLT platforms in the market today have a different level of decentralization, scalability, and security that needs to be adapted to suitable business needs. As an example, private DLT achieves higher scalability at the cost of lower decentralization, and public DLT works the other way around.

In public DLT, the infrastructure consists of multiple **validators**, which participate in the transaction verification, consensus and block production, and **node providers**, which store historical data in the shared ledger. Validators verify tokenized securities' transactions by executing the securities smart contract created by the registrar and work together with other validators to achieve consensus to accept the transaction and put it in a block. In addition, there could also be third-party entities that run the **chain forensic** for AML purpose, and third-party **crypto custody**, which takes care of participants' key management and signing process orchestration.

In private DLT, the infrastructure depends on the platform. For example, the infrastructure of R3 Corda consists of **participant nodes**, which store the relevant data that belongs to them, and **notaries**, which timestamp and optionally validate the transactions, and **certificate authorities**, which authenticate each participant node in the network. Whereas the infrastructure of Hyperledger Fabric consists of **peer nodes**, which host copies of ledgers and smart contracts, **orderer nodes**, which guarantee the single global order of transactions in the chain, and **certificate authorities**, which authenticate each node in the network.

From the perspective of regulation that prevails in centralized securities market, it seems that private DLT is more compliant because it has larger centralization degree than its public DLT counterpart, hence more resemblance to the existing centralized system. However nowadays there are more and more securities tokenized on public DLT platform. The regulatory issue on transaction privacy and legally sanctioned validators in public DLT remains open. This lingering regulation uncertainty might **impede market adoption of public DLT**. One approach might be firstly to experiment with private DLT to test the market, while at the same to observe the regulatory development to migrate to public DLT at later point of time.

The EU's pilot regime enables a sandbox for securities exchanges to conduct **secondary market trading** of tokenized securities, which was not allowed before. In the future, the infrastructure might follow the current cryptocurrency exchange, which is either centralized or decentralized. **Centralized exchange** works analogue with the existing stock exchange with order book and multiple order types capabilities. It is an intermediary that allows investors to buy or sell multiple

cryptocurrencies easily without having to deal with the hassles of key management and other DLT specificities, and it takes care of the transactions in the underlying different DLT platforms in the background. On the other hand, **decentralized exchanges** really leverage the distributed nature of DLT where participants trade with each other directly with the help of smart-contract-based liquidity providers such as automated market maker (AMM).

DLT enables direct settlement **without any needs of clearing infrastructure** such as Clearing Counterparty (CCP).

The other infrastructure needed for tokenized securities is the **payment infrastructure** to enable delivery-vs-payment (DvP) settlement. Ideally the money should also be tokenized in the same DLT platform as the tokenized securities in the forms of stable coins, CBDC, or other accepted means so that the settlement can happen in the same execution environment. If the money is tokenized in different DLT platform than the tokenized securities or if the money is not tokenized at all (such as the existing fiat money), then an **interoperability mechanism** should be developed to enable atomic settlement between different DLT platform or between DLT platform and non-DLT payment infrastructure.

In derivatives securities market where the calculation of the derivatives price is dependent on external data that is generated by non-DLT system, an **oracle infrastructure**, either centralized or decentralized, should be developed to ensure the validity of that data and then to fetch it to the DLT platform.

## Opportunities and Challenges

### Opportunities

The underlying DLT platform enables issuers to issue and distribute securities directly to investors in the primary market and enables investors to trade with each other in secondary market **without any unnecessary intermediaries**. This has the potential to **shorten the settlement time** of tokenized securities significantly while **increasing settlement efficiency**, to **accelerate other processing time in the value chain** of tokenized securities, and to **lower their transaction cost**.

The single source of truth of data and transactions of tokenized securities, which is enforced by the DLT platform, **increases transparency** among related participants and **minimizes or eliminates the cost of reconciliation and audit effort** that would typically incur in traditional world with siloed systems.

The business logic and rules of the tokenized securities are codified in a smart contract which are **visible, testable, and auditable** by all participants.

## Challenges

**Regulatory uncertainty related to tokenized securities is probably the largest challenge for mainstream adoption.** In addition, different jurisdiction might have different regulatory framework. Regulation harmonization across different jurisdiction would still take time to happen. Considering this issue, the European Commission introduced the Digital Finance Package, which one of the aims is to foster innovation in DLT area by providing legal framework on MiCA (Market in Crypto Assets), DORA (Digital Operational Resilience Act), and DLT Pilot Regime (a regulatory sandbox to enable regulated experimentation on DLT).

**The transparency feature of DLT might not suit participants' needs of transaction privacy.** One of the mitigation solutions is to use a private DLT solution which is hardened by hardware enclave (secured CPU part), or to use public DLT solution with randomized public key for each transaction receipt to increase the degree of pseudonymity. Another mitigation solution would be using the Zero Knowledge software algorithm; however, its implementation is still computationally expensive for generic use.

**Different implementation of DLT protocols creates different network silos and hinders network effect,** which is contrary to DLT vision of large ecosystem of shared data and infrastructure. Currently, some DLT platforms, either private or public, have larger network than others in terms of applications running on them, developer supports, and the amount of locked asset. But since innovation of DLT is running at a very fast pace, the current landscape might change in the horizon of one to two years. To mitigate this challenge, developers have been developing interoperability mechanism to connect different DLT protocols.

**Fiat money might still be used as a temporary solution until stable coins or other forms of tokenized money is widely adopted by the market.** There are some technical solutions in the market to enable and guarantee atomic settlement between DLT (where the tokenized securities are stored) and the current payment infrastructure (where fiat money is transacted), however they have not yet been battle-tested for large scale use.

**The scalability problem of DLT might be a bottleneck for rapidly traded tokenized securities.** Public DLT mostly suffers from this problem. Various solutions have been developed, for example: the Layer-2 solutions in Ethereum ecosystem. But the solutions are constrained by the famous blockchain trilemma which states that we can only achieve two out of these three objectives: security,



scalability or decentralization. Solution for scalability is part of an overall solution to find the sweet spot among these three objectives.

**Large efforts could be needed to create robust governance of a decentralized ecosystem, especially the public DLT, and to define clear responsibility of each entity involved in the ecosystem.** In a decentralized ecosystem, especially public DLT, different individual and legal entities with different roles and responsibilities work mutually to keep the ecosystem running and there are no single entities that have a single control over the ecosystem. This is a clear departure from the centralized ecosystem where a single entity can delineate the responsibility of each technology and business partner. Therefore, any entity that is accustomed to operating in a centralized ecosystem is faced with the reality that it needs to **release some of its control and places more trust in other network participants.** For example, trusting the validators to execute the transactions. To counterbalance this, the entity needs to create a robust governance. For example, to analyze the legal status of the company developing the DLT platform, to deploy a sound contractual agreement (responsibility and SLA) with network participants (in case it is possible) and to analyze the validators' background to ensure that they are not sanctioned by regulators.

**The dynamics of token price in public DLT are not-yet well understood.** Most public DLT platforms utilize their own token as a means of payment for transaction fee and validators reward. Token price might fluctuate due to internal factors of the platform, for example, a surge ETH price due to large amount of queuing transactions, or external factors, for example, due to market sentiment. Institutions which build applications in tokenized securities must select a highly reputed public DLT platform which has relatively stable token price. If the token price drops in large amounts, validators might exit the ecosystem because it is no longer profitable for them to operate, which might further endanger the functioning of the overall network. On the contrary, if the token price surges, it becomes too expensive for participants to trade the tokenized securities.

Since no big scale application exists for tokenized securities on DLT yet and most of them are still in the early MVP stage, there are **no market benchmarks** on revenue/cost, market appetite, and best practices yet. This lack of information might impede institutional investors from investing large amounts of money to build infrastructure for tokenized securities.

Any entities which aim to develop tokenized securities infrastructure in DLT in this early time must **devise a comprehensive business continuity plan and robust exit strategy** as part of its operational risk management. This is to mitigate various uncertainties that DLT and its surrounding environment pose. For

example the regulation, rapid technology development, and the dynamics of the token price.

## Conclusions

We discussed that the lifecycle of tokenized securities is analogue to the traditional ones. For tokenized securities: (1) Custody refers to the safekeeping and management of private keys of the securities owners. (2) Secondary market trading can be done using centralized or decentralized exchange. (3) Clearing phase might be omitted. (4) Settlement can be executed immediately, and fiat money may still be used as a temporary solution until stable coins are mature. (5) Asset servicing's logic can be integrated into the securities' smart contract.

We also discussed that the infrastructure needed for tokenized securities are: (1) The DLT platform itself, which can be public and private. Different DLT platforms have different degrees of decentralization, scalability, and security. (2) Infrastructure of the registrar, which registers and keeps track of the securities on DLT on the issuers' behalf. (3) Infrastructure for secondary market trading, which can be centralized or decentralized. (4) Connection to existing payment infrastructure for DvP settlement if stable coins or other forms of tokenized money on DLT cannot yet be used. (5) Oracle infrastructure for interoperability between DLT and non-DLT system.

We discussed several opportunities that tokenized securities present such as: (1) Faster settlement time and other processing time in the value chain and lower transaction cost. (2) More transparency, less reconciliation and audit effort. (3) Auditable smart contract by all participants.

Finally, we also discussed several challenges posed by tokenized securities such as: (1) Regulatory uncertainties. (2) Privacy concern. (3) Different silos created by the implementation of different DLT platforms. (4) Connection to existing non-DLT payment provider which necessitates a robust technical solution for interoperability. (5) Scalability of DLT. (6) Large effort to create a robust governance and a clear service level agreement among participants, especially in public DLT ecosystem. (6) The lack of information regarding dynamics of token prices in public DLT. (7) No market benchmark on revenue/cost, market appetite, and best practices yet. (8) Creation of comprehensive business continuity plan and robust exit strategy to accommodate rapid changes and innovations in DLT area.

We conclude that market adoption of tokenized securities will take more time. We see that regulation clarity is the most crucial factor to accelerate this adoption. Robust regulation will create a safe environment for further investment and

participation in this ecosystem. As the ecosystem grows, benchmarks and best practices will emerge, and can be utilized by each participant to optimize their business strategy to bring even more benefits to the ecosystem.

Some positive signs that we see conducive to the market adoption are the introduction EU's Digital Finance Package on the regulatory side, the attempts of several leading financial institutions to issue tokenized securities as their MVP, and the increasing number of institutional-grade entities offering services such as crypto custody and chain forensics.

In the end, we see that in this changing environment, it is important for any institutions to dedicate resources to deal with the regulatory, technology, and business landscape in tokenized securities and DLT area. In case of MVP development, we recommend starting with limited product features to gain practical experiences and developing a comprehensive business continuity plan in parallel to accommodate the uncertainties in this early innovation phase. Moreover, to observe further significant market progress, we see the clear need for some institutions to "lead the way" and not to wait for the (alleged) second mover advantage.

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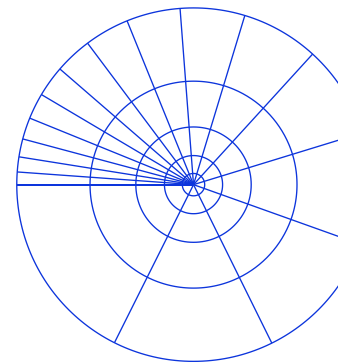
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