TECHNOLOGY

An Investment Perspective on Tokenization

Part I: A Primer on the Use of Distributed Ledger Technology (DLT) to Tokenize Real-World and Financial Assets

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BACKGROUND TO THE RESEARCH ON DIGITAL FINANCE BY CFA INSTITUTE

A recent CFA Institute research report titled "Future State of the Investment Industry" (Preece, Munson, Urwin, Vinelli, Cao, and Doyle 2023) identified digital transformation as one of the four key scenarios that will significantly affect capital markets in general and investment management in particular during the next 5–10 years.

Digital assets and tokenization are related to tech-driven investment solutions that will only become more ubiquitous, propelling opportunities for personalization and customization. Technology promises to revolutionize the modes of accessing possible investments, the range of investment opportunities made available, and the construction of portfolios tailored to investors' needs, whether short term or long term. This technological transformation is not without risk, with a new generation of investors exposed to hype generated by social media, as regulatory frameworks grapple with the need to adapt to a changing environment.

CFA Institute has approached the development of digital finance progressively, taking an investor perspective. The following is a retrospective of the research we have built on the subject during the last two years:

- "Cryptoassets: Beyond the Hype," published in January 2023, presented a general assessment of the cryptoasset sector and delved into three of the most critical issues we had identified at the time: valuation, fiduciary duty, and custody (Fines and Deane 2023).
- "CFA Institute Global Survey on Central Bank Digital Currencies," published in July 2023, analyzed the development of central bank digital currencies and expressed the views of the CFA Institute membership on key considerations related to these instruments' risks and design features (Deane and Fines 2023).
- "Valuation of Cryptoassets: A Guide for Investment Professionals," published in November 2023, provided a deep-dive analysis of the most prevalent quantitative methods for valuing digital instruments and processes based on distributed ledger technology (Soni and Preece 2023).

This new report, focused on the concept of tokenization, aims to shed light on the crucial development of distributed ledger technology as it pertains to generating digital forms of assets.

EXECUTIVE SUMMARY

This report is the first publication in a two-part series that covers the topic of tokenization from an investment management perspective. We believe this material will be of particular interest for general investment management practitioners interested in the impact digital finance is having on real-world and financial assets, as well as the regulatory and policy implications of such developments in key jurisdictions around the world.

This first part of the series serves as an introduction to tokenization, in which we explain distributed ledger technology, various models of tokenization, and the process involved, including an overview on investment fund tokenization from an asset management perspective. We consider the benefits and limitations of tokenization regarding clearing and settlement, transparency and compliance, and fractionalization and market access. The limitations and challenges we highlight include security risks, regulatory challenges, market infrastructure, and limited retail investor access to private markets.

Finally, we conducted interviews with firms and digital finance professionals to gauge the real impact of tokenizing investment products on asset managers and investors. The results of those conversations are rendered here as case studies and include such assets and processes as art and collectibles, commodities, equity funds, private funds, interbank transfer activities, and repo (repurchase agreement) financing. Within these case studies, we provide a brief overview of the business, the investment process, the regulatory framework, the process of tokenization, and the benefits and limitations for the users or clients of the platforms.

Part II of the series, which will appear in a separate report, focuses on the regulatory and policy issues surrounding tokenization and digital assets. It will compare and contrast policy developments in key jurisdictions around the world and expose the risks related to lack of harmonization and definitional divergence.

In this report, we find that the immediate benefit of tokenization is represented in an increase in operational efficiency with either cost or time savings for end clients and investors. We endeavored to focus particular attention on the private market sector. In this area of investments, tokenization has shown the potential for operational gains related to the management of or even a reduction in lockup periods, the tradability of tokenized units on secondary markets, and a wider spectrum of minimum investment requirements, all of which can help in managing portfolios more efficiently.

At this time, regulation remains inconsistent in key jurisdictions, with choices usually made along a spectrum of policy opposites: at one end, integrating digital assets within existing securities laws; and at the other, creating an entirely new framework. Tokenization requires a balanced and holistic approach

that fosters innovation and experimentation while ensuring consumer protection, financial stability, and market integrity. Such an approach entails developing clear and consistent rules and standards, promoting interoperability and compatibility, enhancing education and awareness, and fostering dialogue and cooperation among all stakeholders.

Key Takeaways

- Tokenization is the act of creating a digital representation of various assets using distributed ledger technology. There are different types of decentralized ledgers with varying degrees of centralization and other elements. Key characteristics of decentralized ledgers include whether they are "permissioned" or permissionless, public or private, nonhierarchical or hierarchical, and open source or closed source.
- Tokenization has a variety of hybrid models depending on the processes and parts of an asset's value chain that are tokenized. These range from an asset that is completely off-chain, such as stocks listed on a regulated exchange, to a digital asset such as bitcoin, which resides entirely on a digital ledger. Hybrid models include certain types of investment funds, which are accessible through digital tokens yet are themselves invested in traditional assets not represented on a blockchain.
- The value proposition of tokenization revolves around three key areas where tokenization purports to improve upon existing processes: clearing and settlement, transparency and compliance, and fractionalization and market access.
- Limitations and challenges include cybersecurity risks, regulatory uncertainties, a still-fledgling market infrastructure, and the issue of whether it makes sense to grant easier access to private market investments for retail investors.

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1. INTRODUCTION

In the past few years, increased interest in cryptoassets has highlighted the use of the underlying distributed ledger technology, which promises quicker settlement of transactions, less operational friction, a transparent ledger, and automation. This development raises the question of whether blockchain technology can be applied to traditional or real-world assets to improve on the current processes that traditional assets use. The opportunities include increasing operational efficiencies, with the potential to pass on these benefits to end users, and introducing retail investors to investments in private or alternative markets.[1]

The recent CFA Institute publication "Future State of the Investment Industry" (Preece et al. 2023) highlighted the potential of tokenization under the digital transformation scenario, which anticipates more investors having access to investment in alternative assets that were previously not available to them. Also in 2023, "Cryptoassets: Beyond the Hype" (Fines and Deane 2023) discussed the potential use case of tokenizing real-world assets and highlights that "in large part, the future of cryptoassets and their acceptance by the public as part of the mainstream economy will depend on the reality of these processes finding an efficient usage and distribution channel through tokenization" (p. 39).

We reiterate the point made in "Cryptoassets: Beyond the Hype" on digital finance: It has the potential to transform the traditional mechanisms of commercial transaction intermediation by financial institutions, and it will continue to change as it stabilizes and as rules that govern the sector are clarified. Thus, our two-part series on tokenization provides a point-in-time assessment of a burgeoning industry that is changing fast, and our assessment made in this report should help investment practitioners learn about and understand the value proposition of tokenization.

We begin with an explanation of distributed ledger technology, which serves as the foundational mechanism for tokenization, and continue by explaining the process of tokenization and highlighting its merits, use cases, and limitations.

We conducted interviews with industry practitioners who have applied the process of tokenization to various financial assets or transactional processes, including equities; commodities, such as gold; art and collectibles; repurchase agreements; and private market assets, such as private equity, venture capital, and private credit. From these interviews, we present five case studies that explain the investment and tokenization process and aim to determine whether there are realized benefits to tokenizing the various assets mentioned relative to traditional practices.

[1]*Private markets* and *alternative investments* refer to nontraditional financial markets and investment instruments—typically, hedge funds, private equity, private debt, infrastructure, and real estate. These strategies are generally not available for retail investors.

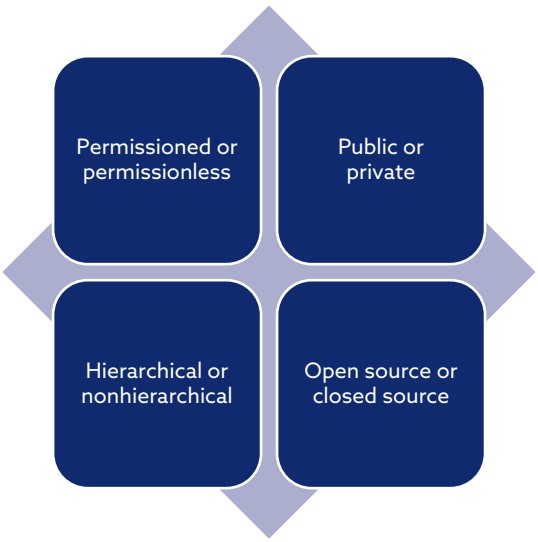
1.1. Distributed Ledger Technology

In the United States, FINRA (the regulatory organization that oversees brokerage firms) describes distributed ledger technology (DLT) as "involv[ing] a distributed database maintained over a network of computers connected on a peer-to-peer basis, such that the network participants can share and retain identical, cryptographically secured records in a decentralized manner" (FINRA 2017, p. 2). A popular use of DLT has been to record transactions and ownership of cryptoassets. The ledger serves as a digital database, without any central authority approving transactions. Instead, transactions and updates to the ledger are made through the consensus mechanism that characterizes the cryptography process underpinning digital finance.[2] A confirmed transaction on the ledger is permanently recorded, with records being time stamped and displayed in a sequence to parties involved in the network.

There are different types of distributed ledgers. Key varying elements among different DLTs can be depicted on a spectrum of four dimensions (see **Exhibit 1**).

Note that the features presented in Exhibit 1 are not always mutually exclusive. Specific technological choices will naturally condition other choices. For example, private blockchains tend to operate within existing systems of an enterprise. Such networks thus prioritize providing privacy for their participants and are created to be permissioned. Similarly, private blockchains are also

Exhibit 1. A Spectrum of Key Characteristics That Define the Nature of a Distributed Ledger



[2]For more information on consensus mechanisms, visit https://usa.visa.com/solutions/crypto/consensus-mechanisms.html.

Exhibit 2. Key Features of Distributed Ledgers

Permissionless	Any node[a] can download the ledger and validate transactions.
Permissioned	Permission is required to download the ledger and validate transactions.
Public	Any node can read and initiate transactions on the ledger.
Private	Only a selected group of nodes can read and initiate transactions.
Nonhierarchical	Each node has a full copy of the ledger.
Hierarchical	Only designated nodes have a full copy of the ledger.
Open source	Anyone can suggest changes to the code underpinning the ledger platform.
Closed source	Only trusted entities can see and make improvements to the code underpinning the ledger platform.

[a]Nodes refer to computers running the blockchain software and maintaining the state of the distributed ledger.

Source: Wadsworth (2018).

generally found to be closed source and hierarchical. In contrast, a public ledger would need participation from various individuals and entities for its consensus mechanism and development—hence the preference in this case for open-source, permissionless, and nonhierarchical models.

Exhibit 2 illustrates the key differences among these features.

We will refer to the characteristics shown in Exhibit 2 throughout this report to describe the parameters that pertain to the various networks and systems we present, including in the case studies discussed in Chapter 4.

1.1.1. Permissioned vs. Permissionless

The characteristic feature of permissioned networks is to decide who can download the ledger and validate transactions. Such cryptoassets as ether and bitcoin are permissionless, allowing interested participants to participate in their validation mechanism if the user fulfills certain requirements. A permissioned ledger would limit validation of transactions to certain trusted parties. Such ledgers allow for easier know-your-customer (KYC) and anti-money-laundering (AML) checks as well as higher security resulting from the presence of a trusted central party.

In a permissionless setting, there is far greater decentralization and realization of the benefits of using distributed ledger technology. However, a permissionless network also makes it more difficult to implement compliance with regulation and legal requirements.

1.1.2. Public vs. Private

Public networks are open and accessible to any member of the public. Everyone is allowed to have access to data and initiate transactions on the ledger.

Despite being available to the public, the data cannot be altered. Privacy is maintained through the use of cryptography to secure the network, which includes the encryption of data and use of a consensus mechanism to verify transactions. Furthermore, as transactions take place on the network, it becomes increasingly difficult to change historical transactions. Bitcoin and Ethereum are examples of public networks where anyone can gain access to transaction data on the network. In contrast, private networks are limited to participants who have been granted access to join the network, with only certain nodes allowed to read and initiate transactions on the ledger. Access on private networks can be tiered, with varying levels of authority to transact and view data for different participants, thus creating a hierarchical ledger.

1.1.3. Nonhierarchical vs. Hierarchical

A node refers to the computer participating in the operations of the distributed ledger. A nonhierarchical ledger secures transactions without requiring trust between the nodes, accomplished through the use of a consensus mechanism, such as proof of work or proof of stake.[3] Here, all the nodes can see the transactions on the ledger. In contrast, a hierarchical ledger implies that access on the network can be tiered, with varying levels of authority to transact and view data for different participants. For example, a trusted third party may have access to a full copy of the ledger and can see and approve all transactions, while other participants in the network are able to see and authorize only their own transactions or activity on the network.

The hierarchical feature removes the requirement to have a consensus mechanism and a validation role for the participants in the network because there is a trusted third party to approve transactions, increasing privacy for all participants. Referring to the earlier point that these features are closely related, permissionless ledgers would generally not be hierarchical, because access to the complete ledger would be required for the consensus mechanism.

1.1.4. Open Source vs. Closed Source

The main difference between open-source and closed-source networks lies in who can see and edit the source code of the ledger platform. Open source generally means that anyone can see and make improvements to the code, whereas closed source means only a limited number of parties are entrusted to do so. For the time being, blockchains used for various cryptoassets, such as

[3]Proof of work and proof of stake are two popular consensus mechanisms used to process transactions in blockchains. In proof of work, transactions are verified through a competition among miners to solve cryptographic puzzles. In a proof-of-stake system, validators are randomly chosen to process the transaction.

bitcoin or ether, are public, permissionless, nonhierarchical, and open-source distributed ledgers.

A tokenized investment product can use either a public or a private blockchain based on the evaluation of the benefits and limitations. However, the use of a hierarchical, permissioned, and private ledger is considered faster and cheaper to maintain (Wadsworth 2018) because validation of transactions occurs through a trusted third party. The third party acts as a central node and validates payments given it has complete access to the ledger balances and transaction history, improving the speed of the payment processes. Hierarchical, private, permissioned, and closed-source ledgers can be similar to that of traditional processes, depending on the overall design in terms of operational hours, transparency, dependency on a central party (creating a single point of failure), and scalability. They would differ from traditional systems only by providing faster authorization and settlement. Please refer to Exhibit 1 for a presentation and explanation of the various characteristics that distinguish the different types of blockchain networks.

1.1.5. Overview of Possible Arrangements for DLT Solutions

Various configurations of the aforementioned characteristics are possible, as presented in **Exhibit 3**, using an analytical framework built by the Bank for International Settlements (BIS) as a basis.[4] Exhibit 3 shows how these arrangements condition the features that can be applied to a distributed ledger, depending on the objectives sought for the network. All the case studies we discuss in Chapter 4 present networks that can be described using Exhibit 3.

Exhibit 3. Potential DLT Configurations Based on Key Network Features

Description of the Arrangement	One entity maintains and updates the ledger	Only approved entities can use the service; entities can be assigned distinct restricted roles	Only approved entities can use the service; entities can play any role	Any entity can use the service and play any role
Operational Responsibility	Single entity	Multiple entities		
Access	Restricted			Unrestricted
Technical Roles of Nodes	Differentiated		Not differentiated	
Validation and Consensus	Within a single entity	Within a single entity or across multiple entities	Across multiple entities	

[4]See Table 1 in BIS (2017, p. 8).

1.2. Tokenization

Over the years, a variety of international institutions and researchers have defined the process or concept of tokenization. Here, we provide three such definitions:

- "The process of linking reference assets to crypto tokens via design features that link the token's price to the value of the token's reference asset" (Carapella, Chuan, Gerszten, Hunter, and Swem 2023)
- "The act of creating a digital representation of traditional assets using distributed ledger technology" (Financial Stability Board 2019)
- "The process of recording claims on real or financial assets that exist on a traditional ledger onto a programmable platform" (Aldasoro, Doerr, Gambacorta, Garratt, and Koo Wilkens 2023)

Tokens both define assets and specify what can be done with them. Depending on the status of legislation and regulation pertaining to digital assets in a particular jurisdiction, this technically means that the token holder has a claim over the underlying asset. They integrate the records of the underlying asset with the rules and logic governing the transfer process of the asset.

In contrast to traditional systems, where intermediaries are entrusted to maintain and update the record of ownership, in a tokenized system, the money or assets become "executable objects" that are maintained on programmable platforms. Compared with traditional systems, the programmability feature removes the need for an account manager and changes the role of the intermediary. As such, the intermediary serves "in a governance role as the rule book's curator, rather than as a bookkeeper who records individual transactions on behalf of account holders" (BIS 2023, p. 88).

1.2.1. Two Approaches for the Tokenization of an Asset

There are two approaches to consider for the tokenization of an asset:

- *Tokenizing an existing tangible asset or financial asset* involves representing an existing security or asset digitally on the blockchain. The token is a mirror of the value and ownership rights that are associated with the asset and acts as a link between the blockchain and the real world, allowing the token to be tradable and transferable within the blockchain ecosystem.
- *Tokens native to the blockchain or digital assets* are directly issued on the blockchain and are generally not backed by a traditional real-world asset. Most cryptoassets, such as bitcoin, are native tokens that are used as a means of exchange, as a store of value, to execute contracts, or to participate in the governance of the protocol.

1.2.2. Asset Types and the Market for Tokenization

In theory, any type of traditional asset, in either a public or private market, can be tokenized and digitally represented on a blockchain. This includes tangible assets, such as commodities, real estate, and art; financial assets, such as equities and bonds; and other forms of intangible assets, such as intellectual property. **Exhibit 4** shows examples of the types of assets that can be tokenized and are currently available in the market, some of which we cover later in the report.

The market for tokenization in 2024 involves a mix of players, including traditional financial institutions, fintech startups, and international organizations (development banks).

When referring to tokenized products in this context, we exclude unbacked tokens native to the blockchain (e.g., cryptocurrencies) and instead focus on tokens representing financial assets and other types of tangible and intangible assets, as shown in Exhibit 4.

Exhibit 4. Tokenizable Assets in Various Markets

General Asset Class	Subcategory
Traditional investments	Equities
	Bonds
Alternative investments	Private equity
	Private debt
	Venture capital
	Commodities
	Real estate
	Infrastructure
	Art
	Collectibles
Cash and equivalents	Stablecoins
Money markets	Money market funds
	Repurchase agreements
Intangible assets	Intellectual property

One asset class that has seen significant attention and growth as a tokenized product is fixed income—in particular, US Treasuries, government bonds, and cash equivalents, which reached an estimated value of approximately USD2.51 billion in November 2024, according to RWA.xyz. An example in the commodities sector is tokenized gold,[5] which had a total market capitalization of USD1.62 billion as of November 2024, according to CoinGecko.

1.2.3. A Spectrum of Five Models for Tokenization, Based on Degrees of Digitalization

Tokenization can involve a variety of hybrid models, in which certain processes and parts of the asset's characteristics may be tokenized while others run through existing processes or infrastructures. RWA.xyz's report "The Spectrum of Tokenization" highlights five models that fall within the range of completely off-chain to completely on-chain (Erickson, Naggar, and Chong 2023). *On-chain* refers to "activities, data, or processes that occur within a blockchain or are directly recorded on a blockchain," whereas *off-chain* refers to "activity, data, or processes that occur using traditional systems or on traditional databases" (Erickson et al. 2023).

We describe the five models, mostly focusing on the important differences and where they sit on the broader spectrum of digitalization, as follows:

- Model 1 is an asset that is represented and whose ownership is enforced using the legal and regulatory processes that the financial industry uses currently, meaning it is completely off-chain and does not use distributed ledger technology. An example presented by Erickson et al. (2023) is the buying or selling of stocks through centralized exchanges (such as the NYSE, the NASDAQ, the London Stock Exchange, and the Tokyo Stock Exchange), where the transaction takes place through a brokerage firm and the stock is held with a custodian.
- Models 2, 3, and 4 propose varying degrees of digitalization of the asset's representation, enforcement of ownership rights, and value transfer[6] mechanisms, including the currency used to effectuate the transaction, whether fiat or digital.
- Model 5 proposes a fully on-chain process and captures essentially cryptoassets, for which ownership and value transfer occur on the blockchain. Examples include ether, bitcoin, and Solana.

Broadly speaking, an asset can therefore be defined according to a series of key characteristics that will be treated or processed differently depending on

[5]Each tokenized gold token represents ownership and claim over one fine troy ounce of physical gold.

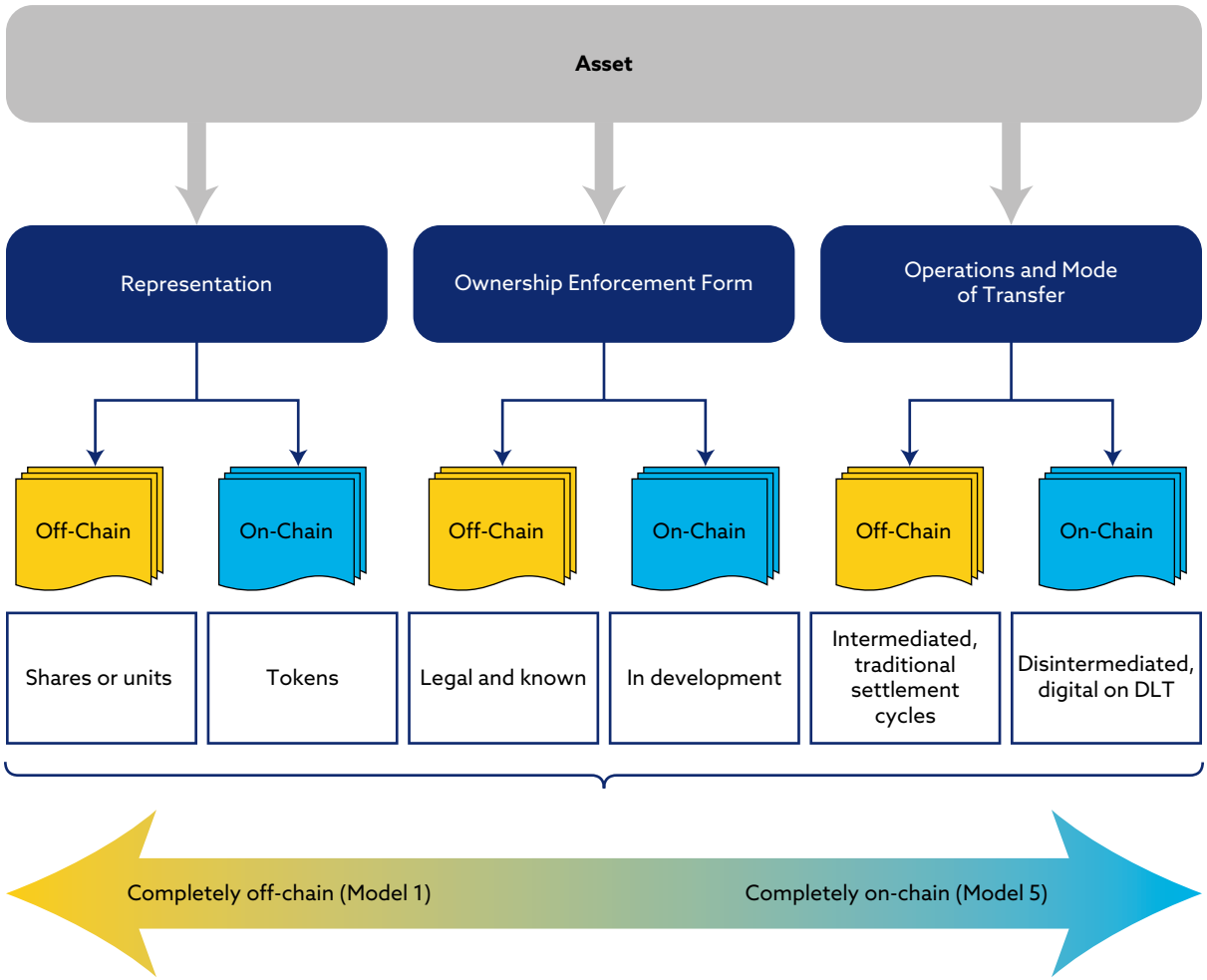
[6]*Value transfer* refers to the use of either fiat or digital currency in the purchase, transfer, or redemption of the asset. In Models 1 and 2, value transfer is off-chain because it occurs in fiat, using traditional infrastructure and in compliance with existing regulations. Models 3 and 4 require the use of both off-chain and on-chain capabilities, including the use of traditional infrastructure. On-chain value transfer requires the use of cryptoassets, whereas off-chain does not. In Model 5, value transfer occurs completely through on-chain means.

the model chosen and the degree of digitalization entailed by the approach (i.e., on-chain or off-chain):

- Representation of the asset (what form the title to the asset takes)
- Ownership enforcement form (the legal framework that establishes and recognizes ownership)
- Operations and mode of transfer (the mechanism used to transfer the asset from the existing owner to a new owner)

Exhibit 5 offers a graphical representation of this spectrum of hybrid models for asset tokenization.[7]

Exhibit 5. Models for Asset Tokenization



[7]Policy and regulatory developments applicable to digital finance are following an uneven path around the world. In particular, the approach to recognizing and enforcing ownership rights is still largely country dependent—in some areas, it has not yet been defined in legislation. As we discuss later and also in Part II of this series, some jurisdictions are more advanced than others on this particular question (e.g., Switzerland and Singapore).

The Unresolved Problem with the Enforcement of Ownership Rights

As observed in previous research on cryptoassets (Fines and Deane 2023, Section 7.4.5), property or ownership rights assigned to tokens for assets located outside the blockchain remain an uncertain process or legal territory. In general, property law and contract law in most jurisdictions have not yet adapted to a digital setting. As a result, although determining ownership for fully on-chain processes and tokens can be easily automated, hybrid models will run into issues pertaining to validating and enforcing the rights conferred by such tokens to their owners.

This issue is made more complicated by the intricate interconnection between law (or legislation), regulation, and business practices, which do not always progress at the same pace. This issue is discussed and presented as part of certain case studies found in Chapter 4, for illustrative purposes.

More generally, Part II of this research series will address the problem in further detail and compare approaches in different jurisdictions.

2. TECHNICAL OVERVIEW

This chapter highlights the design features to be factored into the process of tokenization and presents the standard four-step process generally used for tokenization. We further focus on investment funds and how the traditional asset management value chain may be impacted through tokenization. Finally, we make a comparison between tokenization and exchange-traded funds and present theoretical benefits from tokenized exchange-traded funds.

2.1. The General Process Involved in Asset Tokenization

There are five main design features of tokenized assets (Carapella et al. 2023):

- A blockchain
- A reference asset
- A mechanism to assess the value of the reference asset
- A means to provide custody for the reference asset
- A mechanism to facilitate purchases and redemptions of the token and reference asset

As discussed previously, the distributed ledger has various characteristics, including public or private, hierarchical or nonhierarchical, permissioned or permissionless, and open source or closed source. These characteristics have their own strengths and limitations, and token issuers can determine whether they prefer to develop a private blockchain to issue their tokens or use existing public blockchains, depending on their preferred levels of security, restrictions, and centralization. The token issuer also must determine how to approach custody and redemption processes, which depend on the underlying asset. For example, redemption for a tokenized money market fund would likely differ from a private equity fund because of the large differences between the respective underlying assets, including their liquidity and lock-in periods.

These key design features are considered further as part of the four-step process of tokenizing an asset (World Bank 2023):

- The first step, origination, involves pricing and auditing the underlying asset and structuring the deal, including determining fee structures, capital commitment requirements, understanding relevant regulations, and tax implications, all of which can be encoded on-chain.
- The second step involves selecting the token issuance service provider, the KYC/AML[8] vendor, the custodian or private trust company, and the secondary market provider.
- Once these steps occur, the asset can be tokenized, including choosing a token standard,[9] choosing a public or private network, writing the smart contract[10] according to the specifications of the deal structure, and satisfying compliance and regulatory requirements. Certain actions, such as interest payments or dividend distributions, can be automated, and the number of tokens the asset is fractionalized into is chosen.
- Finally, the tokens can be issued directly to investors or listed on a market. Investors must set up their wallets to receive the tokens, with the underlying asset remaining with the custodian. The issuer may choose to create a secondary market for the tokens depending on the underlying asset, in order to facilitate access and tradability.[11] The use of smart contracts automates a number of activities, including sending distributions directly to the wallet, issuing token holder communications, voting activity, and tax activity.

The Unresolved Problem with Identifying the Issuer or Issuing Entity

As digital finance develops and matures, the finance industry, along with legislators and regulators, will have to come to terms with the imperfect match between existing financial regulation, which focuses on specific entities or activities, and the proposition made by digital finance, which is largely based on the notion of decentralization and disintermediation, to various degrees.

[8]This vendor provides KYC/AML controls, including counter-terrorism financing.

[9]Token standards define the functionalities and properties of a blockchain (a set of rules the blockchain abides by). The use of a token standard allows for interoperability among products developed using the standard and makes the monitoring of the tokens easier through the standard features across all products on the same token standard.

[10]BIS (2023) defines smart contracts as "self-executing applications of programmable platforms that can trigger an action if some pre-specified conditions are met" (p. 118).

[11]Depending on the capital structure chosen, whether open or closed, there are related risks in terms of liquidity mismatch, which we discuss later in this report.

A particularly thorny issue relates to identifying the issuer of a token or the issuing entity. Existing rules pertaining to securities markets are based on the existence of a single party legally assuming responsibility for the issuance of a particular security and compliance with regulation. In turn, other similar rules may apply to commodities and derivatives, depending on circumstances and jurisdictions.

The question of the fundamental nature of cryptoassets, however, has not yet been resolved definitively or in a cohesive manner across jurisdictions. Therefore, digital finance remains a sector with variable geometry when it comes to determining which rulebook applies to specific tokens or digital processes. Depending on the form a cryptoasset or token takes, it may or may not feature an identifiable issuer. Currently, the main regulatory frameworks in the world address the problem in different ways, without necessarily providing clear guidance to the industry on expectations.

Part II of this research series delves into this issue in more detail, delineating how jurisdictions have been treating the problem of identifying the issuing entity.

2.2. Investment Fund Tokenization: A Value Chain Perspective

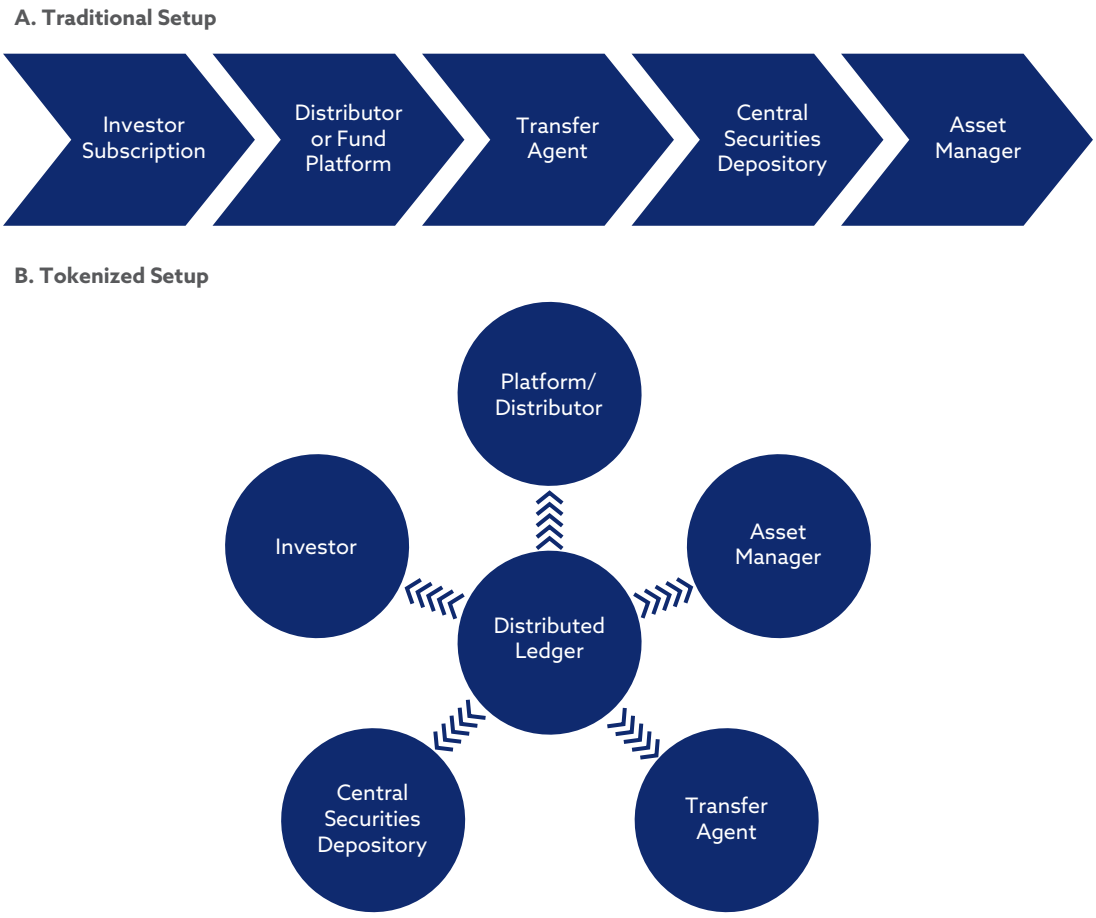
Tokenization could significantly impact the investment fund industry by streamlining the various functions involved in its operational chain. In this section, we provide a comparison between a traditional fund and a tokenized fund and illustrate how tokenization would change the value chain the industry currently uses throughout a fund's life cycle.

2.2.1. Overview

An investment fund, or mutual fund, is an investment vehicle that pools money from multiple investors to invest in a portfolio of assets, such as securities or other forms of financial instrument. A tokenized fund is a fund for which shares or units are digitally represented and can be traded and recorded on a distributed ledger. The overarching differences between a tokenized fund and a traditional fund are that the use of the distributed ledger replaces and automates the traditional fund administration operations and shares or units are replaced with tokens.

Exhibit 6 presents a comparative analysis of the sequencing of processes and entities of an investment fund's normal operations, under a traditional setup and a tokenized framework. Different types of entities serve operational functions

Exhibit 6. Difference in Investment Fund Operations: Traditional Setup vs. Tokenized Setup



Note: Exhibit 6 is a stylized representation. The specific elements may vary, depending on the fund structure and the jurisdiction where the fund is domiciled.

along this chain in addition to the investor and the actual asset manager, including the following:

- *Distributor:* A distributor is a third-party institution that sells or distributes funds to investors on behalf of fund management companies.
- *Transfer agent:* Transfer agents are responsible for recording changes in ownership, maintaining the issuer's security holder records, canceling and issuing certificates, and distributing dividends.[12]
- *Custodian banks, depositories, and central securities depositories:* This series of institutions is in charge of holding and safekeeping financial instruments and assets (in physical or electronic form) on behalf of the

[12]This definition is from the SEC: www.sec.gov/divisions/marketreg/mrtransfer.

actual owners. They allow transfer of the instruments' ownership by maintaining an electronic record often known as a book-entry record (Financial Conduct Authority 2023).

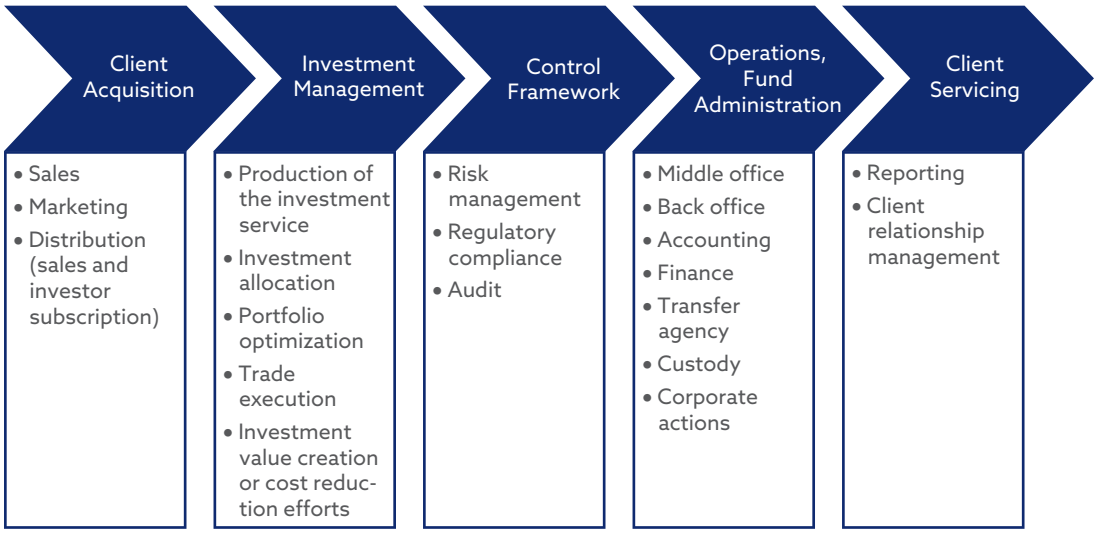
The valuation of the fund is typically determined by its net asset value (NAV), calculated as the value of the portfolio assets less fund liabilities (such as accrued management expenses) divided by the number of shares outstanding or, in the case of a tokenized fund, the number of tokens. In the latter case, the distributed ledger maintains and updates the record of the tokens as transactions occur on the network.

The operational setup of the various parties and intermediaries depicted in Exhibit 6, whether linear or distributed on a blockchain, may also be understood in terms of the value chain of the broader asset management economic activity. The value chain consists of all the operational steps that are part of a product's or service's life cycle, which collectively constitute the sum of all processes adding value for the client. Literature abounds on this concept and how it has changed over the years (see, e.g., EFAMA 2023; Doshi, Kwek, and Lai 2019). The asset management value chain can be summarized and simplified as shown in **Exhibit 7**.

We focus next on the segments of the value chain that we believe are most directly affected by the tokenization process:

- Distribution (sales and investor subscriptions)
- Investment management
- Fund administration (including corporate actions)
- Client servicing and relationship management

Exhibit 7. The Asset Management Value Chain



Tokenization can take place for any or all of these segments, which makes it a very modular approach. We delve into the benefits and challenges of tokenization in each of these cases.

2.2.2. Distribution

Marketing and distribution are key components of the client acquisition phase. Such clients become investors or beneficial owners of the funds or investment vehicles they have chosen. In turn, a register of investors must be put together and maintained at all times. Various functions share the responsibility to maintain this register (distribution, fund administration, registrar, transfer agency), and in practice, the model used may vary in different jurisdictions. For example, a large number of mutual funds in the United States and collective investment schemes in the United Kingdom are distributed either by fund companies directly to investors (such as Vanguard and BlackRock) or via a retail brokerage platform (such as Charles Schwab and Hargreaves Lansdown)—a model shaped by an open architecture approach. By contrast, distribution models in continental Europe and China tend to be based on large retail banking networks and their associated wealth and asset management functions—a model characterized by vertical integration.

Regardless of the distribution model, most funds offered to retail customers today transact only in the primary markets. When investors purchase or redeem their holdings, they are exchanging their shares directly with the fund manager or via an intermediary. For traditionally pooled investment funds, excluding exchange-traded fund (ETFs), there is by definition no active secondary market available for transacting in fund shares because the fund's capital is variable and subject to subscription and redemption orders instructed by investors. In the case of closed-end investment funds—for example, investment trusts and limited partnership structures—secondary markets vary and depend largely on market liquidity, market access, or regulation.

In addition, multiple intermediaries are involved in the clearing and settlement process, such as transfer agencies, custodians, distribution platforms, and brokers. As a result, most funds do not offer instant settlement and generally take two to three days to complete a subscription or redemption order from their investors.

2.2.3. Investment Management

On the investment management side, fund managers need to create and manage investment portfolios that align with a fund's defined financial goals, risk profile, and investment objectives. In particular, they maintain a ledger of assets making up the fund's portfolio, such as stocks, bonds, and other investable securities or assets. This ledger is regularly reconciled with the ledger maintained by the depository and custodian (or central securities depository) of the fund, as legal guarantors of the assets' safety.

Fund managers consider investment management to be their core capability. They are responsible for making investment decisions, managing and mitigating risk, monitoring fund performance, and ensuring that the fund aligns with its defined investment strategy. Fund houses are therefore naturally exploring ways to reduce the ancillary administrative costs and operational burden related to their investment management activities; for this reason, tokenizing the asset ledger is considered an attractive proposition if it can simplify the operational chain.

According to BIS (2023), smart contracts are "self-executing applications of programmable platforms that can trigger an action if some pre-specified conditions are met" (p. 118). The details of investment terms; portfolio rebalancing; corporate actions, such as dividend distributions; and even regulatory compliance (e.g., portfolio investment limits, breaches) can be coded into the smart contract, deployed to a blockchain, and automatically executed through investment transactions when predefined criteria are met (such as when market conditions change). This approach has the potential to significantly reduce manual intervention and therefore would enhance operational efficiency in the investment management process.

In practice, we have not yet seen many public examples of tokenization at the level of a fund's asset ledger. For asset ledger tokenization to happen, the assets in which a fund has invested need to be represented on the blockchain. Except for the cryptocurrency ETFs that have invested in digital native on-chain assets (e.g., bitcoin), most mutual funds are invested in traditional off-chain assets (i.e., outside the blockchain), such as stocks and bonds, which means smart contact automation cannot be deployed at the asset level.

Exhibit 8 describes the layered logic of the tokenization of investment management activities.

2.2.4. How Can Tokenization Be Used for Fund Administration?

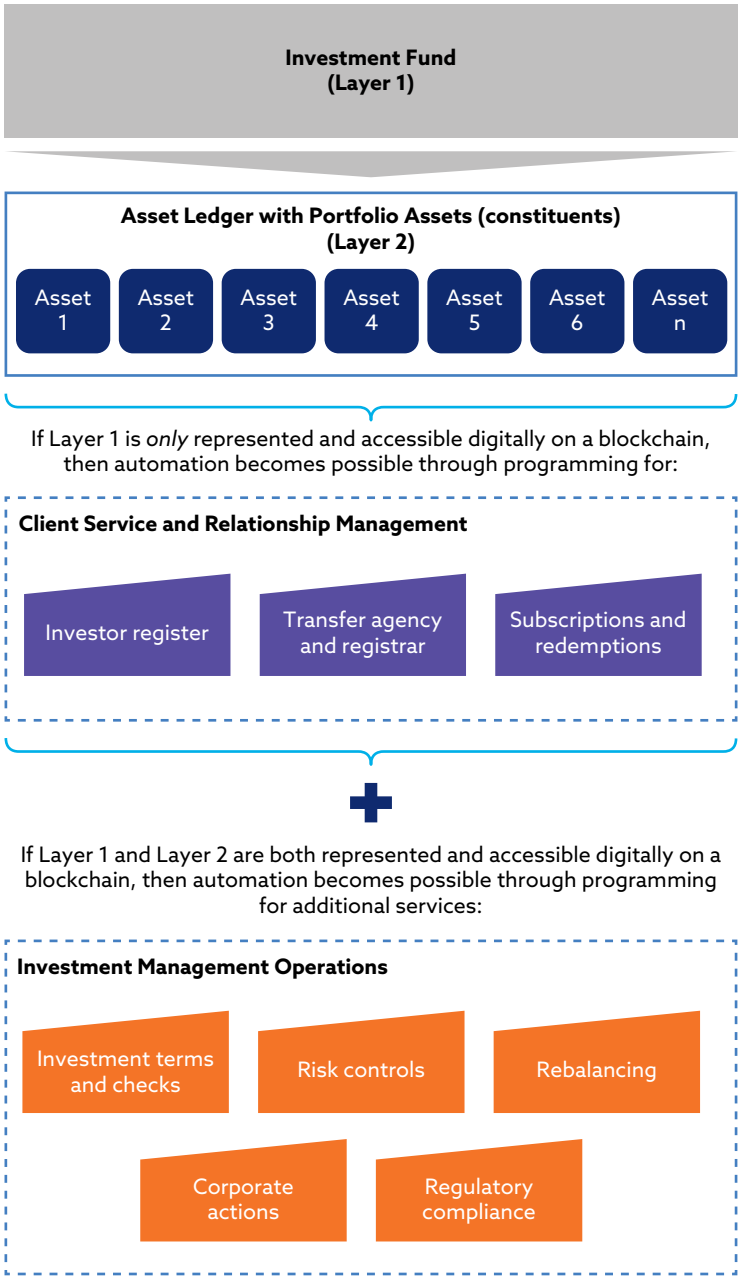
Tokenization involves transforming the investor's holdings of the fund into a digital representation—that is, a token on the blockchain.

Two key characteristics of blockchain technology could be used to transform or facilitate the current client servicing process:

- *Blockchain technology not only is a record-keeping mechanism but also provides a platform for transactions.*
- Investors holding fund tokens could initiate a transaction with each other, follow the protocol to confirm the trade, and update the new investor holding information in the new block. Tokenization would enable the *facilitation of secondary markets* for mutual fund holders without a fund company in the center to manage the purchase and redemption process, which would reduce the administrative (e.g., record-keeping)

and client servicing (e.g., cash management) burdens for fund managers and offer better market access and efficiency to the investor. *Blockchain uses cryptographic techniques to secure transactions and consensus mechanisms to achieve agreement among network participants on the validity of transactions*.

Exhibit 8. Tokenization of Investment Management Activities



Once data are added to the blockchain, each block contains a reference to the previous block, creating a chain of blocks, and any change in a block would require altering subsequent blocks (Crooks 2024), which is computationally and economically extremely difficult. In theory, the speed of a fund's corporate actions and settlement process could match that of the blockchain being used, potentially taking only a few minutes to complete. Use of the blockchain would lead to improvements in the *clearing and settlement process* because accuracy and certainty of the outcome would also improve given the lower number of intermediaries involved in typical clearing and settlement steps. The client's purchase or redemption request can be automatically updated on the ledger (blockchain) for all parties involved in the operational chain. In theory, the use of blockchain allows for continuous trading of an asset because of automation and the use of smart contracts. Inherent limitations, however, should be considered because of the very nature of the underlying asset, which generates friction in the form of liquidity restrictions or transaction costs.

2.2.5. Client Servicing and Relationship Management

On the client servicing and relationship management side, fund managers focus on building and maintaining strong relationships with clients or investors, understanding their financial needs, and providing pertinent advice and services. Most importantly, because each investor in the fund owns a portion of the fund holdings, it is essential to maintain a register of beneficial owners (i.e., investors) for each fund. Several firms are currently exploring tokenizing the investor register, such as Hamilton Lane, Franklin Templeton, and Generali Group. As a first step, these firms are experimenting with tokenizing a subset of the investor ledger while performing daily reconciliations to their traditional off-chain register to meet the current client record regulatory requirements. Depending on the jurisdiction and its respective legal or regulatory frameworks, legal uncertainties remain as to whether digital records on a decentralized platform (i.e., blockchain) are considered appropriate to maintain the client record. We will explore these legal and regulatory limitations in Part II of this series.

The current addressable market for fund tokenization can be seen as a spectrum, which depends on both industry adoption of a new technological framework and the availability of traditional mechanisms in a digital format. Time will tell the extent to which technological capacity, service providers' adoption, and clients' interests will converge. Potential benefits may include better transparency, further automation and streamlining of traditional asset management operations, and greater scope for increased personalization of investment solutions. In their report on the future state of the investment industry, Preece et al. (2023) identified digital transformation as a key industry trend that could increase demand for personalized products, offer opportunities to reconnect with clients, and result in an expandable investment universe.

2.3. A Comparative Analysis with Exchange-Traded Funds

An exchange-traded fund is an investment vehicle that invests in stocks, bonds, or other assets, whether directly (physical replication) or indirectly (synthetic replication). According to the SEC, "Unlike mutual funds … ETF shares are traded on a national stock exchange and at market prices" (SEC Office of Investor Education and Advocacy 2012, p. 1). ETF shares are not sold or redeemed directly by the retail investor but rather are sold or redeemed through the involvement of authorized market participants. These authorized participants make markets in the ETF and transact in both the primary and secondary markets, whereas ETF investors transact only in the secondary market. Consequently, a number of the administrative processes associated with mutual funds are removed, because the asset manager must deal with only the authorized participant in the primary market.

We elaborate further on this market structure in this section. For the sake of facilitating comparison with tokenization, we focus here on ETFs applying a physical replication approach.

In general, ETFs are open-ended investment schemes, similar in this respect to mutual funds. This means their capital structure is open and allows the issuance of theoretically unlimited shares. The fund manager or sponsor is responsible for managing the differential between the liquidity of shares offered to fund subscribers and that of the underlying assets.

As noted previously, the operational process of ETFs can be broken down into the primary market and the secondary market. The primary market is where the in-kind creation and redemption process[13] for ETFs takes place, and the secondary market is where the ETF shares are traded on exchanges.

In the primary market, the ETF sponsor enters into a contractual agreement with an authorized participant (typically a broker/dealer), who is permitted to purchase and redeem shares from the ETF sponsor. The authorized participant delivers a specified basket of securities in exchange for shares of the ETF, which it can sell in the secondary market to retail investors or institutions.

In the secondary market, the ETF shares are traded on exchanges on an intraday basis and the NAV is calculated on an end-of-day basis. The authorized participant transacts in the primary market to rebalance its inventory. When there is excess demand for the ETF shares in the secondary market, associated with a shortfall in the authorized participant's inventory and rising ETF prices that may exceed the NAV, the authorized participant transacts with the ETF sponsor to create shares (in-kind subscription), balancing supply with demand and keeping ETF prices in line with NAV. Conversely, where there is selling

[13]"In-kind" refers to the exchange of fund shares for the underlying securities.

pressure in the market and an excess supply of ETF shares causing their price to fall below NAV, the authorized participant redeems shares with the ETF sponsor (in-kind redemption), again bringing supply back into equilibrium with demand and keeping prices in line with the NAV.[14]

In certain jurisdictions, such as the United States, the in-kind creation and redemption structure of ETFs permits tax efficiency gains for investors. ETFs also do not generally levy sales charges/loads or redemption fees. Overall, the costs are generally much lower for ETFs as a result of their market structure, whereby the ETF sponsor must only deal with the authorized participant in the primary market, which simplifies the operational processes and bookkeeping, eliminating the need for intermediaries, such as a registrar and transfer agent in a traditional investment fund structure. ETF shares are book-entry securities that eliminate the need for transfer agent services, an expensive component of operating traditional funds.

The ETF structure brought clear innovation to the fund industry through the streamlining of the operational chain and led to benefits for both issuers and investors. It is also noteworthy that ETFs are naturally structured for index strategies rather than active investment strategies, given their focus on operational leanness. Although index-tracking ETFs constitute the vast majority of the ETF market, we are seeing the emergence of actively managed ETFs.

The question that arises is whether tokenization can bring further operational benefits to the ETF structure.

We consider here possible theoretical benefits and enhancements to ETFs from tokenization:

- *Increased speed and lower settlement complexity:* The ETF structure would potentially benefit from the atomic settlement[15] that tokenization would introduce, leading to increased speeds in trading and settlement of ETF tokens.

  We note that current efforts to tokenize ETFs are focused on the fund layer (refer to Layer 1 in Exhibit 8), which means the underlying assets are not tokenized and remain with the custodian; the typical creation/redemption process involved in the operations of ETFs between investors and market participants remains in its traditional form. Should regulation permit and recognize the tokenization of securities, these underlying assets may reside on a distributed ledger and form part of the smart contract, which can result in the optimization of the process aiming at minimizing the discrepancy between the market price of the ETF and that of the underlying constituents.

[14]For further detail on the creation and redemption process, refer to Hill, Nadig, and Hougan (2015).

[15]Atomic settlement is defined as the conditional settlement that occurs if both delivery and payment are received at the same time (DTCC 2022).

Furthermore, a tokenized structure would facilitate the direct trading of ETF tokens themselves as the need for intermediary steps and cash exchanges is removed. Specifically, tokenization could allow exchanging ETFs without the need to sell one type of ETF for cash and purchase another type through cash.

- *Automation of operational tasks:* The use of smart contracts would automate various tasks that are part of the administration and management of an ETF structure, including dividend distributions and reconciliation operations, by embedding predefined rules and conditions into the smart contract. This approach would further reduce operational costs for fund sponsors through workflow automation.
- *Facilitate operational access to ETFs for clients based in other countries:* In theory, investors will be able to access tokenized funds in various countries because of the public and borderless nature of the blockchain, with the reservation that legislation and regulation would need to be adapted.

We elaborate on several of these operational efficiencies in Chapter 6.

Chapter 2 provided a technical overview of the tokenization process and how it may be applied to key parts of the typical asset management value chain and operations. In Chapter 3, we evaluate the value proposition of tokenization by focusing on the processes we have identified as presenting the greatest benefits in terms of operational efficiency.

3. VALUE PROPOSITION AND USES

In this chapter, we discuss the value proposition of tokenization and how it proposes to improve on the current systems used in the investment industry. Our own research and the case studies that follow in Chapter 4 led us to identify three main areas where tokenization may yield the strongest possible benefits in terms of operational efficiency:

- Clearing and settlement
- Transparency and compliance controls
- Fractionalization and market access

Under these three overarching themes, we discuss the impact of tokenization on operational efficiency, the automation of specific tasks or processes, and market liquidity.

3.1. Clearing and Settlement

In general terms, clearing and settlement involve a complex series of tasks that take place between the various entities and intermediaries that are part of a financial transaction, aimed at ensuring the proper handling and recognition of the transaction by all parties involved. Specifically, clearing can be defined as "the process of transmitting, reconciling and, in some cases, confirming transactions prior to settlement, potentially including the netting of transactions and the establishment of final positions for settlement."[16] The European Central Bank (2009) defines settlement as "the completion of a transaction or of processing with the aim of discharging participants' obligations through the transfer of funds and/or securities. A settlement may be final or provisional." These tasks are performed by back- and middle-office operations.

The main potential benefit of tokenization for clearing and settlement comes from efficiency gains through automation and the reduction in the number of intermediary entities involved in these processes. As previously mentioned, multiple intermediaries form part of the investment management value chain. A multi-step process takes place among those entities so as to ensure that every node in the system accurately records and reflects transactions and the changes in asset ownership that ensue. To highlight the complexity of this operational system, we provide a summary overview of the tasks assigned to each of its key components:

- The investment manager or asset manager acts as a fiduciary for the clients or investors, which can mean individual accounts or pooled accounts, such as investment funds. In this capacity, they may instruct and execute trades on behalf of the client accounts they have authority over.

[16]Source: https://www.bis.org/cpmi/publ/d00b.htm?selection=11.

- A trading venue is a regulated and authorized facility or platform that allows for securities to be bought and sold among various parties (e.g., a stock exchange).
- A clearinghouse is a financial market infrastructure institution that generally stands between market participants as a central counterparty and is responsible for finalizing trades, settling trade accounts, and reporting trade data. The effect of such institutions is to reduce market risk and facilitate the exchanges of assets or derivative positions between participants.
- Custodian banks and depositories, including central securities depositories, generally hold the assets (in physical or electronic form) and maintain a record of client ownership. They provide segregation and safekeeping of client assets, while arranging for the transfer of these assets when instructed by the owners or asset managers acting as fiduciary.

The inefficiency in the current process arises from the need for all intermediaries to maintain their own records, which can lead to inconsistencies in data and the use of significant resources for reconciliation. Each stakeholder's dataset has to be reconciled at each step of the clearing and settlement process.

With the use of a distributed ledger, information is shared in a common format and all involved parties have instant access to the same information. Rather than each party maintaining its own private ledger, the distributed ledger acts as a single source of information for all parties, available across locations in real time. Therefore, information becomes available to all parties of a transaction in full synchronization, which would eliminate the need to implement transfer and reconciliation processes. As such, the validity of a transaction would take place at the point of transaction itself rather than at later stages in the clearing and settlement process.

Verification of the ownership, trade matching, and recording of transactions would take place continuously and be automatic, transparent, immutable, and nearly immediate.[17] The efficiency gains from the reduction in operational complexities (e.g., middle- and back-office costs, data discrepancies and reconciliation, risk controls, and compliance) resulting from the ability of smart contracts to facilitate, execute, and enforce certain parts of an agreement will lead to almost real-time settlement for transactions (depending on the underlying blockchain),[18] in contrast to the current settlement cycle of $T + 1$

[17]Examples of process automation made possible with smart contracts include "reaching a certain date and executing a principal and interest payment on a loan contract" and using certain data feeds as an input with a threshold to trigger event-driven actions, including corporate actions, fees, and charges (BIS 2017).

[18]Among the various smart contract platforms, the speed of conducting transactions—and consequently the transaction fees they charge—depends on the scalability of the platform and the network demand on the platform. In periods of high demand, transactions may take longer to process, and fees will be much higher relative to the average transaction fee. In addition, the ability of the platform to process transactions also depends on its consensus mechanism. The most popular mechanisms are proof of work and proof of stake, with proof of stake providing much higher speeds relative to proof-of-work platforms.

or *T* + 2 in most jurisdictions. An important point, however, is that same-day settlement does not require that a blockchain be used and can be achieved through traditional processes.[19]

3.2. Transparency and Compliance Controls

Blockchains allow interested parties to have access to real-time information about asset ownership, holdings, and transactions. In the case of tokenization, the use of a transparent blockchain provides a few major benefits.

The programmability, immutability, and real-time availability-of-information features of a distributed ledger would allow regulators and auditors access to transaction-level or aggregate-level data. The use of smart contracts also facilitates compliance procedures through automation, whereby trade execution may take place only after pretrade compliance checks have been verified, for example.

The level of access an institution (auditor or regulator) would have to a firm's distributed ledger can be determined and set up through the smart contract with relevant access rights. Data privacy requirements for client information could be maintained by using cryptography on a per-transaction basis. Obvious efficiency gains can be realized by directly linking regulators or auditors to the firm's distributed ledger, removing the need for the firm to compile and deliver data.

The use of smart contracts would allow automatic calculation and verification of information, such as end-of-reporting-period compliance, calculation of risk exposures, and sensitivity analysis of balance sheet exposures to market fluctuations (Auer 2022). The smart contract would also automatically enforce specific conditions or covenants related to any compliance or regulatory requirements. For example, a limit to the number of investors allowed to participate in an offering can be programmed into the smart contract, which would automatically stop any further investors from participating in an offering once a threshold is reached. A firm choosing to limit the number of investors allowed could either be for its own purposes or to comply with regulation. For example, in the United States, a traditional 3(c)(1) fund is allowed up to 100 accredited investors to qualify for exclusion from the definition of an investment company. Another example would be verifying the eligibility of an investor against a set of predefined criteria. Regulators would also be alerted if the restrictions are modified or switched off (OECD 2020).

Overall, the use of smart contracts to address regulatory requirements and compliance would lead to simpler processes and cost savings for the institutions in charge of supervision, as well as the firm itself.

[19]Some countries, such as China and India, have begun testing for same-day settlement.

3.3. Fractionalization and Market Access

One of the main value propositions tokenization provides is fractionalization, which could broaden or facilitate the scope of access for investors in public and private markets. Fractionalization refers to the process of dividing an asset into smaller, tradable units that represent an ownership stake in the asset, allowing an investor to buy a part of an asset rather than the whole asset.

In public equity markets, specialized financial service providers and brokers already offer fractions of shares as a service through their traditional operations.[20] Tokenization of assets through a digital process, however, can become more efficient and also more direct because it enables division of the asset into much smaller claims compared with the fractionalization currently seen in markets for financial instruments, such as structured products and securitization. Furthermore, fractionalization through tokenization will lead to cost savings and operational gains relative to the management of fractional assets through traditional processes. Lastly, lower minimum investment requirements and smaller claims will lead to portfolio diversification benefits because investors who may generally not be able to access highly priced assets will be able to do so with smaller claims.

Access to private markets and illiquid assets is generally limited to institutional investors and high-net-worth individuals because of high minimum capital requirements, high purchase prices of assets, or high levels of risk. For example, in the United States, private funds require investors to meet accredited investor requirements (annual income of at least USD200,000 for the two previous years, with expectations of the same earnings for the current year or a net worth of USD1 million).[21] In terms of high purchase prices for illiquid assets, the average global sale price of fine art in 2022, for example, was USD43,473 (Artnet News and Morgan Stanley 2023).[22] Another structural limitation is the closed nature of private funds after the initial capital raise, which limits the capacity for shares of these funds to trade on open secondary markets, as retail-oriented investment funds do.

Fractionalization of private funds and alternative investments more generally through tokenization could, in principle, facilitate access for retail investors, similar to some market solutions that have already emerged for alternative assets, such as real estate investment trusts (REITs) and commodity ETFs. The benefit of a digital process to tokenize alternative assets would stem from the highly scalable nature and operational efficiency gains of DLT-based solutions, as previously discussed. We recognize, however, that this perspective raises

[20]A fractional share is a situation in which an investor owns less than one full share of a stock or other security. A number of brokers provide the option to invest in fractional shares for a minimum value of USD1.

[21]See the SEC's "Accredited Investors" webpage: www.sec.gov/education/capitalraising/building-blocks/accredited-investor.

[22]Contemporary art and all art have an annualized price appreciation of 14% and 9%, respectively, over a 25-year period (Parsons 2021).

policy issues related to investor protection and fiduciary duty, which we discuss later in this report.

Finally, tokenization would allow direct access for investors to both primary and secondary markets. One example is initial coin offerings, which are digitally native tokens (not backed by a real asset or financial asset) issued directly to investors to raise capital (OECD 2020). The tradability of these tokens on secondary markets would create the potential for liquidity to gradually build in these markets, depending on a number of factors, including but not limited to sufficient volumes to trade and the emergence of a market making function. If there are sufficient secondary market volumes for illiquid assets, it may lead to increased price discovery of these assets, which could be informative for the fair value measurement of the underlying assets.

Depending on the conditions offered, the emergence of a secondary market for tokenized private market investments and other alternative assets, with fractionalization and wider investor access, could provide investors greater liquidity, increased price information for price discovery, and the ability for the assets to be transacted on a daily basis assuming that there are sufficient volumes in the secondary market.

Chapter 3 evaluated the processes for which we believe tokenization may lead to the greatest benefits in terms of operational efficiency. In Chapter 4, we present a series of case studies based on interviews conducted with professionals in various segments of the financial services industry who are already making use of tokenization in different ways, in order to provide real examples of the concepts we discussed in previous chapters.

4. CASE STUDIES

This chapter presents five case studies resulting from individual interviews we conducted from February to April 2024.

The structure of these case studies is harmonized as much as possible along the following considerations:

- Brief business overview
- Regulatory framework
- Case for tokenization
- Tokenization process
- Choice of blockchain
- Investment and administration process
- Benefits and limitations

Note that the information presented in this chapter reflects the status of the firms at the time of the interviews, which took place throughout the first and second quarters of 2024. Subsequent updates or changes to these firms and their status are not reflected in the chapter. The inclusion of these firms and the investment products or services they provide does not constitute a recommendation, endorsement, or promotion by the authors or CFA Institute. These case studies are provided solely as illustrative examples to evaluate the implications of tokenization through real-life scenarios.

4.1. A Platform for Issuing and Managing Tokenized Shares of Small and Medium-Sized Enterprises

Firm: Aktionariat AG

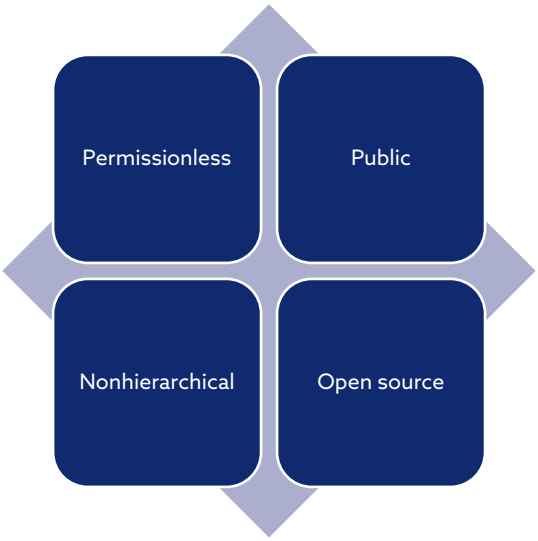
Web address: www.aktionariat.com

Established: 2020

Headquarters: Zurich

Asset subject of tokenization: Equity

Key Network Characteristics



Brief Business Overview

Aktionariat AG offers a software solution that allows corporations to issue tokenized equity shares using an ERC-20[23] contract on the Ethereum blockchain or on Layer 2 blockchain platforms (Optimism and Polygon) and make them tradable on the issuer's website. Aktionariat's software facilitates shareholder management with a digital and automated shareholder registry, dividend distributions, digital general assembly, and other corporate actions.

[23]According to the Blockchain Council (2024), ERC-20 is a technical standard used for smart contracts on the Ethereum blockchain. It defines a set of rules that developers can follow to create their own tokens on Ethereum, making it easier for developers to create and deploy tokens because it provides a common set of interfaces and functions that can be used by different token contracts. It also allows tokens built on the ERC-20 standard to be compatible with each other.

Regulatory Framework

Aktionariat AG is a technology company incorporated in Switzerland. Regarding the regulatory framework governing the provision of financial services and securities markets, the company is not considered a financial intermediary and therefore is not regulated or supervised by the Swiss Financial Market Supervisory Authority (FINMA).

Interestingly, Switzerland is among the first jurisdictions to have begun adapting its body of law to the new frameworks allowed by cryptoassets and digital finance. In September 2020, the Swiss Parliament adopted the Federal Act on the Adaptation of Federal Law to Developments in Distributed Ledger Technology (DLT Act). As part of this legislative process, a series of federal laws were adapted to recognize the introduction and effects of ledger-based securities represented on a blockchain, including the Code of Obligations (effective as of February 2021), which regulates corporations and contract law. In practice, this means that the issuance of tokenized securities is recognized by the law. The introduced Article 973d of the Swiss Code of Obligations therefore recognizes the rights attached to the tokenized securities, how these rights can be transferred only via the securities ledger, and how the integrity of the ledger must be secured through adequate technical and organizational measures, which is the service rendered by Aktionariat.

It is worth noting that Aktionariat is not regulated as a DLT Trading Facility, a new type of license introduced by the DLT Act, amending the Financial Market Infrastructure Act (FMIA), because it does not provide custody, clearing, and settlement services for DLT securities. Aktionariat need not provide custodial services, because investors open their own Ethereum-based wallets when they purchase tokens or are custodied with their bank. As such, the services provided by Aktionariat are purely technological and do not involve financial intermediation.

Tokenization Process

The first step for tokenization is laying the legal foundation, starting with changing the articles of association, which is carried out by a partner law firm. The change is required to allow the board of the issuing company to issue its shares as DLT securities according to Article 973d of the Swiss Code of Obligations, the federal body of law regulating contract law and corporations.

The second step involves the client issuing the shares in a tokenized format. The process used by Aktionariat stands in contrast to the traditional method of capital raising, where shares are created, then notarized, and finally issued. Aktionariat's tokenization process uses the creation of treasury shares by the issuing company (the client), which are then tokenized, as we will discuss later. As part of the process, an existing owner of the company decides to sell his or her shares back to the company at nominal value, or the book value of these shares. The company creates treasury shares with these purchases, which can

then be tokenized and eventually sold to investors at market value. In practice, the resulting tokens represent a claim on these treasury shares.

In the third step, an external partner conducts due diligence on the company issuing the shares (the issuer). The external partner examines the management team, the company's claims, revenue, and third-party agreements among other things, to ensure the quality of the issuers onboarded on the Aktionariat platform. The process also involves a review of the company's proposed valuation.

The final step involves tokenizing the treasury shares and technical setup, which is conducted through the platform. This process includes structuring the exit mechanism and parameters for investors to sell back their shares and setting up a draggable smart contract for the enforcement of drag-along rights.[24] Subsequently, an investor page website is set up and linked to the issuing company's website, where investors can find relevant details and buy share tokens of the company.

If investors want to sell or exit a position, they have two options: using a liquidity pool created by the issuing company or selling to another investor through a P2P transaction. A secondary market for the shares can be created because the firm provides the option for the issuer to have an automated market maker (AMM) smart contract.[25] The issuer acts as a noncommercial market maker and is the counterparty to the trade, providing liquidity through share tokens to raise capital and currency tokens to buy back shares, allowing the issuer to create a price discovery mechanism and mitigate liquidity issues to a certain extent. The issuer provides a liquidity pool using a part of the funds collected from the issuance of shares.[26] The second option for buyers is to transfer their shares to another investor through a P2P transaction,[27] wherein the shares are transferred to another investor's Ethereum wallet. A level of complexity must be dealt with at this stage, however, because the transfer of a share token transfers only the ownership rights over the share token and not the actual shareholder rights (voting rights and receiving dividends). In order for shareholder rights to be recognized and enforced, the investor must register the transfer of the share token with the issuing company and ask to be included in the shareholder registry.

[24]According to Ropes & Gray (2023), "'Drag-along rights' allow the majority shareholders to procure an exit [e.g., agreeing to an acquisition] by forcing the remaining minority shareholders to sell their shares on the same terms as have been negotiated by the majority shareholders for the sale of their own shares."

[25]The AMM model functions as follows: There are two sides of liquidity, with one being the tokenized shares and the other being a Swiss franc stablecoin. The starting price per token is set by a linear function that increases with an increase in demand and decreases when shares are sold back the company, which allows for price discovery. For more information on Aktionariat's automated market making mechanism, refer to Aktionariat (2021).

[26]Should the investors wish to sell the tokens back to the issuer, the liquidity pool serves as an automatically adjusted mechanism to align the market price with the liquidity demand.

[27]Aktionariat allows for the issuer to create a secondary market for the shares wherein investors directly trade among themselves. In this process, the seller creates an offer at a desired price point, with buyers able to match the offer either entirely or partially. Finally, the issuer approves the match, and the trade is executed on-chain.

Choice of Blockchain

For Aktionariat, using a public blockchain was a philosophical decision based on the transparency and inclusion it offers. The reasons for choosing Ethereum over other public blockchains are ecosystem integration, popularity, development of applications on the platform, and the development of Layer 2 platforms that address the high transaction costs that Ethereum faces. The issue that arises with the use of private blockchains is centralization and reliance on one party. There are advantages to using a private blockchain, but the reliance on a central party leads to security risks, risk of malicious intent, and lack of transparency.

Investment and Administration Process

The corporation (issuer) defines its own minimum requirements in terms of ticket size, KYC checks, and whitelisting[28] the smart contract. The process takes place directly on the issuer's website. The custody of the tokens can take place through two options: (1) self-custody through an Ethereum wallet or (2) custody at a Swiss bank (currently, Hypothekarbank Lenzburg).

If an investor chooses a bank for custody, the firm sends the tokens to the bank's wallet along with an encrypted email that includes client details. To sell or transfer their tokens, investors can contact the bank either through its interface or by telephone or email to execute these actions on their behalf. Doing so would also require onboarding with the bank itself to discuss the custody service provided. This process would be relatively slower than self-custody of the tokens through a blockchain wallet; however, it would be beneficial to investors with limited knowledge of operating crypto wallets.

Obligations related to KYC/AML controls are governed according to a combination of several bodies of law, rulebooks, and regulatory guidance. This combination includes the FMIA, which determines whether tokens represent securities according to the law; the Code of Obligations, which covers general contract law; the Stock Exchange Act, which provides the framework for the functioning of securities markets; the Anti-Money Laundering Act, which establishes the required controls on the identification of beneficiaries to financial transactions; and a series of guidance provided by FINMA (2018). Arguably, this setup is not yet perfectly clear and depends on an interpretation of the service offered by the platform and the role played by the issuer of the tokenized securities. Depending on the decentralized nature of the trading platform, AML obligations may not apply, because the platform is not considered a financial intermediary (see Federal Council 2018, Section 7) and the service performed does not constitute a financial intermediary activity. In the case of the service performed by Aktionariat, the resulting initial coin offering concerns the issuance of asset tokens, per FINMA guidance, which is not

[28]A whitelist is a list of approved participants for a particular event, such as an initial offering, that allows the limiting of access by creating certain criteria, such as minimum fund requirements or transfer restrictions, for the token.

subject to AML obligations, because the direct placement of securities does not constitute a financial intermediary activity.

If the client wishes to conduct active marketing outside Switzerland, the relevant prospectus rules and regulations of each country will apply. If more than CHF8 million is raised within a calendar year, Swiss law requires a prospectus to be filed. For the time being, the platform limits access to investors based in the European Economic Area to prevent the risk of the client being unaware of the public offering law in other countries.

Benefits and Limitations

Two benefits of issuing tokens for SMEs compared with the traditional alternative are the reduced time and effort involved. A traditional approach would involve financing rounds, raising the money, collecting commitments, and finally, notarization. The advantage of the platform is that the shares are tokenized prior to commitments being received, which distinguishes the process from a typical IPO for which there is generally a time limit. When a commitment is made, the investor can directly buy the shares (tokens) on the company's website and the settlement occurs instantaneously. Later, the investor can sell the tokens back to the company through a buyback mechanism or trade them to another investor. Moreover, because the token represents the rights to the assets as well, it reduces the legal procedures through the use of smart contracts compared with traditional methods.

The firm currently faces a usability challenge for investors resulting from the necessity of paying transaction costs ("gas fees") using ether, which creates a learning curve and is time consuming. Gas fees are incurred when selling share tokens back to the company or when sending them to another investor's wallet in a P2P transaction. Transaction costs are not incurred when initially buying the shares, with 95% of the transactions being paid using fiat currency. Aktionariat requires investors to have or acquire knowledge on how to use the platform, manage their self-custody wallet, store their private keys, and conduct transactions. To address this issue, the firm is developing a solution based on "permits,"[29] which would eliminate the need for the end user to pay transaction fees. Instead, the permit would authorize Aktionariat to initiate transactions on behalf of the user, pay the transaction fee, and then charge the cost back to the user.

Another issue is the high gas fees on the Ethereum platform, which tend to spike during periods of high network demand. To keep costs manageable, the firm plans to deploy future token smart contracts on the Polygon chain.

[29]Permits, a feature of the Ethereum blockchain, allow a user to grant token approvals to a third party by signing a message off-chain to transfer a specific amount of tokens. The third party uses the off-chain signature to verify and execute on-chain transactions in a single transaction that also executes the transfer. The feature is beneficial in terms of reducing gas costs because it removes the need for an on-chain approval of the transaction while also making the process more straightforward for users new to transacting on the blockchain.

Another limitation of the tokenized product, relative to traditional counterparts, is custody of shares, especially for investors with transaction sizes greater than EUR100,000. Most institutional investors do not have custody infrastructure set up for tokenized assets. This situation is further exemplified by the lack of widespread adoption of a fiat stablecoin in Switzerland.

4.2. Tokenization of Art and Collectibles

Firm: Artory Inc.

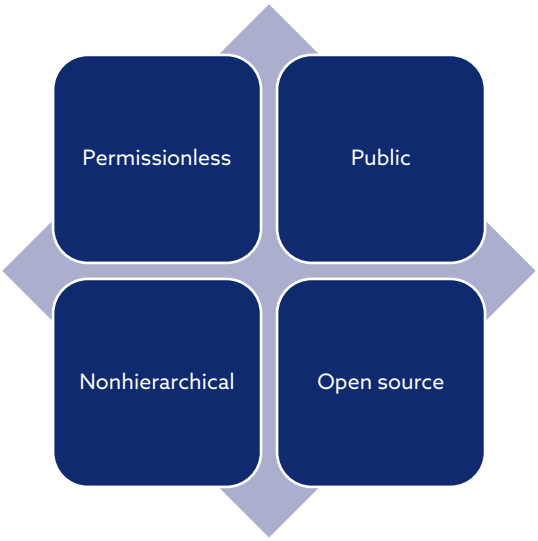
Web address: www.artory.com

Established: 2016

Headquarters: New York City

Assets subject of tokenization: Art and collectibles

Key Network Characteristics



Brief Business Overview

Artory Inc. is a digital platform that facilitates the management of such assets as fine art and collectibles. The firm uses tokenization techniques to secure artwork information and ultimately package such assets into traditional and investable financial products. Artory uses the services of Winston Art Group as an independent art appraisal and advisory firm, with a turnover between USD10 billion and USD12 billion of art evaluation in a year.

Artory/Winston is an asset management joint venture between Artory Inc. and Winston Art Group that provides access to artwork and collectibles through two closed-end equity funds. The first fund, Artory/Winston Art Fund (launched in 2023), allows accredited investors to gain access to a portfolio of between 100 and 200 works of art. The second fund, Cask100 Wine & Whiskey Fund, includes

a diversified portfolio of wine, whiskey, and casks. Launched in September 2023, it aims to raise USD25 million. As of February 2024, the assets under management for the art fund and the wine and whiskey fund were, respectively, USD20 million and USD2 million.

Regulatory Framework

Domiciled and registered in Bermuda, the investment funds are regulated by the Bermuda Monetary Authority as private funds under the Investment Funds Act 2006. The funds are offered to accredited investors as private placements in the United States under Regulation D, which governs private placement exemptions. As such, Artory/Winston is exempt from registering with the SEC as an investment adviser, because the funds and their shares are not registered with the SEC as securities. Tokens representative of the funds are listed for sale to Asian investors on the Singapore Digital Asset Exchange (SDAX) platform, which is regulated by the Monetary Authority of Singapore. Artory/Winston advises the fund to acquire artwork and collectibles. A separate board approves acquisitions, and a fund administrator handles the fund's accounting, limited partner reporting, capital calls, and capital distributions.

Brief Introduction to SDAX and Its Regulatory Framework

SDAX is a multi-asset investment platform based in Singapore focused on private markets. It provides investors with access to such assets as private debt, private equity, art, and real estate. The platform has two parts: capital markets services and a digital exchange. Tokenized assets are traded on the exchange, which uses blockchain technology for clearing and settlement of trades and recording ownership interests of investors' transactions. The platform had around SGD1.1 billion in asset value listed on the exchange as of March 2024.

SDAX Group consists of two corporate entities registered in Singapore and regulated by the Monetary Authority of Singapore (MAS).

MAS has issued general guidance on digital token offerings, and security tokens are regulated in the same way as traditional securities. Under the Securities and Futures Act (Cap. 289), an offer or issue of a digital token that constitutes a capital market product,[30] a security, or a unit in a collective investment

[30]According to MAS (2020), "Capital market products refer to any securities (which includes shares, debentures and units in a business trust), units in a collective investment scheme. Derivatives contracts (which includes derivatives of shares, debentures and units in a business trust), spot foreign exchange contracts for the purposes of leveraged foreign exchange trading, and such other products as MAS may prescribe as capital markets products as capital market products" (p. 2).

scheme under the securities law administered by MAS must comply with the same regulatory regime of products offered through traditional means. MAS regulation requires a business that facilitates offers or issues of digital tokens to carry a Capital Markets Services (CMS) license.

A legal person who operates a trading platform related to digital tokens must be approved by MAS as a regulated exchange or a recognized market operator (RMO). For the time being, Singapore has opted to apply existing securities laws to tokenized assets that are within scope. The rationale is to prevent mismatching and confusion if two different sets of laws were created—one for traditional securities and one for DLT-issued tokenized products.

Case for Tokenization

There are several reasons for the tokenization of art and collectibles. The first is the general state of the art market, which is typically unorganized, with limited information about the artwork because of the market's fragmented state or even, perhaps surprisingly, the loss of paperwork by participants over time. Information on the credibility of the artwork is required when engaging with a third party, such as insurance companies, at the time of sale or when using art as collateral with a bank. Consequently, distributed ledger technology is able to provide security and transferability of information with instantaneous settlement. Furthermore, because all trustee information is stored on the blockchain and can be verified easily at the time of sale or when borrowing against the artwork, these artworks are easier to sell compared to their non-tokenized counterparts.

The second reason is diversification, which is comparatively easier to implement through the tokenization of art in combination with an investment fund scheme. Another benefit that arises through a tokenized pool of art assets is that an asset manager can provide a proxy level of valuation of the collection, in contrast to situations where there is a single piece of artwork and a buyer or a lender (using the art as collateral) must value the artwork through the buyer's or lender's own means. Lastly, art as an investment class has been opaque with respect to valuation and generally is priced or appraised only once a year. Tokenization of art, combined with an investment fund format, will allow art to be priced more regularly.

Tokenization Process

The first step of Artory/Winston's approach involves acquiring the art and collaborating with independent specialists on conducting research, establishing provenance, and collating literature references to capture all the information

required to either transfer the title or sell the artwork. If the artwork is being acquired through a single owner, KYC/AML checks are conducted on whomever the art was acquired from through the art appraisal firm. The due diligence on the artwork is performed by the Winston Art Group and independent third-party appraisers.

The second step involves the process of tokenization per se. Both the fund and the underlying assets (art) are tokenized. The Artory/Winston platform allows it to capture all the due diligence information (research, provenance, and literature references) to be recorded into the smart contract and immutably linked to the token. Once audits are conducted, the information can be checked by token holders to verify details and to see the entity responsible for conducting the audit and the time it was conducted. The due diligence statements or certificates are also periodically updated with such information as annual valuations and insurance updates. This process leads to the creation of a set of digital information elements that can be captured in the smart contract and the tokens.

Lastly, investors can gain access to these funds either through the traditional method or through tokenized shares of the fund available on SDAX, a digital exchange based in Singapore.

Choice of Blockchain

Artory has been using Ethereum and its Layer 2 platform, Polygon, to be compatible with its secondary market provider and fund administrator. The firm chooses to be blockchain agnostic, however, and has also tested with other Layer 1 platforms, including Algorand. Although Artory has also considered private blockchains, this choice could create an additional silo, and the firm believes enough protections are provided by using public blockchains.

Investment and Administration Process

The Artory/Winston Art Fund and the Cask100 Wine & Whiskey Fund have two classes of shares.[31] The first class corresponds to a traditional share class that is investable using conventional methods. The second share class is tokenized, accessible through security tokens on SDAX, where the token represents the number of shares that are bought in the fund. The setup of a tokenized share class for the Cask100 Wine & Whiskey Fund is in progress. Investment through the tokens is limited mainly to Europe and Asia, and the provider does not offer access to US investors. Stringent KYC and AML checks are conducted according to the regulations of the Monetary Authority of Singapore. Approved investors can buy the tokens, which represent shares of the funds through SDAX.

[31]Both share classes represent equal ownership rights over the fund relative to the amount invested.

For the art fund, the physical custody of the artwork is handled by a third party and the artwork is inspected regularly, with inspection updates added to the smart contract so investors can remain informed. For the wine and whiskey fund, the casks of whiskey remain at the distillery for regulatory and quality purposes, and the whiskey and wine bottles are stored in temperature-controlled warehouses.

For the art fund, the minimum investment requirement is USD10,000 for the tokenized share class and USD1 million for the traditional share class. The Cask100 Wine & Whiskey Fund does not currently have a tokenized share class, and its setup is still in progress. When acquired through traditional means—that is, non-tokenized shares of the fund—a minimum lockup period of five years applies. If tokens are acquired through the secondary market provider, a one-year holding period applies before secondary trading of the tokens is permitted.

Benefits and Limitations

Two benefits of using tokenization are increases in operational efficiencies and cost savings. The efficiency and cost savings result from the ability to capture all the information digitally with the smart contract and the addition of more information with time and updates. On the audit side, there is time efficiency because the auditor does not have to go through paperwork and can have continuous access to information stored on the blockchain. The firm has also seen benefits for its investors resulting from their access to continually updated information on artwork inspection, updates on any value increase by the secondary appraiser, and information on the acquisition price of the underlying artwork. The art market generally has a lack of transparency, which is addressed, in this case, through the blockchain and by providing investors security and reassurance in an automated manner by allowing them to manage and secure their artwork on a digital ledger.

A limitation that has been highlighted by the firm is investors' general lack of awareness and understanding of the technology. The firm engages in regular educational exercises with investors on the technology and digital operations. A second limitation is the novelty of the market, which currently offers limited avenues for tokenized assets to be traded. The presence of a secondary market has no impact on the fund offering, but there would be an increase in investor demand for the tokenized product if there were a larger trading market for the token.

4.3. Digital Platform for Collateralization, Interbank Payment Operations, and Repurchase Agreements

Firm: Kinexys by J.P. Morgan

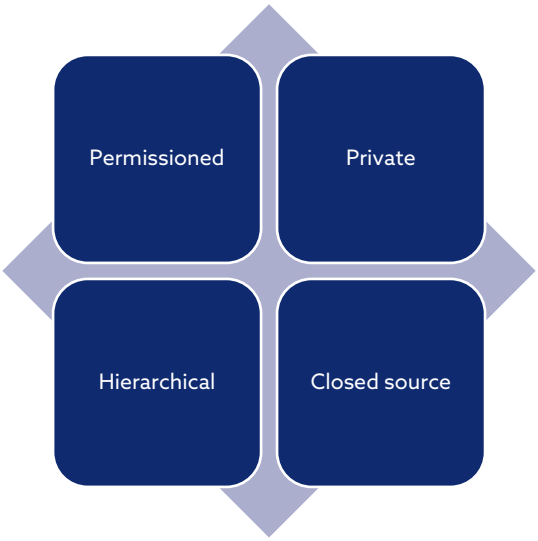
Web address: jpmorgan.com/kinexys

Established: 2020

Headquarters: New York City

Asset or instrument subject of tokenization: Repurchase agreements (repos)

Key Network Characteristics



Brief Business Overview

Kinexys is a blockchain-based business unit focused on building and commercializing blockchain-based products, solutions, and infrastructure for J.P. Morgan's clients. It consists of three in-production blockchain-based networks that provide solutions in the areas of payments, data sharing, and multi-asset settlements:

- *Kinexys Link*, a network for payment-related data sharing between banks
- *Kinexys Digital Payments*, a blockchain-based payment rail for institutional clients

- *Kinexys Digital Assets*, an asset tokenization platform that has three applications: Digital Financing (settlement of repo transactions), Tokenized Collateral Network (tokenizing assets to use as collateral), and Digital Debt Service (issuance, settlement, and life-cycle management of debt instruments)
- *Kinexys Labs*, an incubator for new blockchain-based solutions

Digital Financing is a web-based application on the Kinexys Digital Assets platform that enables J.P. Morgan and clients of the firm's Markets business to negotiate, execute, and settle repos and reverse repos with trades settled through
"delivery versus payment." The application currently processes approximately USD2 billion on average in transaction volume on a daily basis in its repo markets and has surpassed USD1.75 trillion in total volume since its launch in December 2020.

Regulatory Framework

Kinexys' services involving activities related to payment systems, repos, collateral mobility, and debt issuance/settlement are regulated at various levels by the Securities and Exchange Commission (SEC), the Office of the Comptroller of the Currency (OCC), the Federal Reserve Board, and other regulatory bodies.

In November 2021, the OCC issued Interpretive Letter 1179, which states that "the activities addressed in those interpretive letters[32] are legally permissible for a bank to engage in, *provided* the bank can demonstrate, to the satisfaction of its supervisory office, that it has controls in place to conduct the activity in a safe and sound manner" (OCC 2021, p. 1). These controls include having an established risk management and measurement process for the proposed activities on an ongoing basis, and the bank should specifically address risks associated with cryptocurrency activities, such as operational risk, liquidity risk, strategic risk, and compliance risk.

Case for Tokenization

Traditionally, repo financing was not an intraday financing option, because of settlement risk (manual trade entry errors or inventory mismanagement), data transmission errors, and suboptimal capital management (uncertainty around settlement timing and delays in capital deployment). Digital Financing enables a client to tokenize treasuries or high-quality liquid assets, allowing banks to lend against these securities. The use of tokenization enables a unique combination of execution and settlement in the same venue and more broadly allows for further programmability.

[32]The OCC issued Interpretive Letters 1170, 1172, and 1174, which address whether it is permissible for national banks and federal savings associations to engage in certain cryptocurrency, distributed ledger, and stablecoin activities.

The platform enables pretrade inventory checks to prevent settlement delays and lets the trading partners include a settlement time and maturity time set on the same day in the terms of the trade. This process is possible because the cash and collateral balances are recorded on the same blockchain ledger, which also allows them to be almost simultaneously exchanged (atomic settlement).[33] Furthermore, the solution, when used on an intraday basis, should not require repo participants to incur overnight capital charges or commit their balance sheet. The interest costs can be closely monitored, with interest accruing on a minute-by-minute basis.

Tokenization Process and Trade Life Cycle

The process of tokenization and conducting the transaction using the Digital Financing service can be broken down into four main steps. The first step involves the segregation of the collateral to be used in the trade. The broker/dealer has a custodian, referred to herein as the "triparty custodian," that holds the assets—in this case, the treasuries. A separate custodian serving as the subcustodian is linked to the Kinexys platform, referred to as a "collateral token agent." The triparty custodian moves the assets from the regular account of the broker/dealer to an account of the collateral token agent, which is created for the purpose of immobilizing the securities or treasuries and creating the tokens. When the assets are moved to the collateral token agent account, they are tokenized using the Kinexys platform, which essentially means that the books and records vis-à-vis those assets are maintained using the blockchain ledger. Kinexys verifies the collateral before the trade is offered and establishes a right to the ownership of the collateral. The collateral token agent uses the Kinexys platform to track entitlements and automatically instructs the recording of the securities balances on-chain upon receipt of securities.

The second step is the lender's pre-trade requirement. The lender must fund its blockchain deposit account (BDA) via Kinexys Digital Payments through a transfer of cash from its demand deposit account (DDA). BDA balances are equivalent to balances in traditional DDAs from a legal and regulatory perspective, but they enable additional functionality in the blockchain ecosystem. Both parties are now prepared for trade execution and settlement.

In the next step, the lender and buyer negotiate terms and cryptographically sign the terms of the trade, which includes encoding into the smart contact the agreed-upon settlement and maturity timing. The cash and entitlement to ownership of the collateral are atomically settled at the designated settlement time. The borrower withdraws its cash from the blockchain deposit account to its demand deposit account to satisfy regular-way payment obligations, but the lender maintains entitlement to the collateral in tokenized form.

[33]As stated previously, atomic settlement is the conditional settlement that occurs if both delivery and payment are received at the same time (DTCC 2022).

Finally, in anticipation of maturity, the platform initiates a transfer of the cash plus interest from the borrower's demand deposit account to the blockchain deposit account, followed by the smart contract triggering the maturity of the trade. Digital Financing exchanges the principal plus interest for the collateral. The involved parties can choose to remove their assets or leave them on the platform.

J.P. Morgan currently serves as the counterparty for all repo trades that can be denominated in US dollars and euros. Digital Financing enables third parties to act as a borrower or a lender for intraday, overnight, or term repo trades.

Choice of Blockchain

In 2016, J.P. Morgan open-sourced a private, permissioned blockchain protocol called Quorum, derived from the Ethereum blockchain with a focus on institutional-grade performance, privacy, and security requirements. Ultimately, the firm has made the choice of a private, permissioned blockchain for reasons pertaining to its own preferences regarding security, regulation, and efficiency. Solidity[34] is used to implement the smart contracts.

Quorum is available to use for third-party vetting and validation purposes, and other financial institutions and corporations are allowed to develop applications using Quorum's technology. In 2020, J.P. Morgan sold Quorum to ConsenSys.[35] The firm has a strategic investment in ConsenSys, and Kinexys' products continue to be developed on the Quorum protocol.

Benefits and Limitations

According to the firm's own assessment, one of its participants using its Digital Financing platform experienced a reduction in its intraday financing costs of 50%–60% compared with its traditional intraday credit funding solution.[36]

Overall, there are four main benefits for repo participants:

- It eliminates duplicative processes and reduces the need for reconciliations traditionally required to identify manual trade entry errors.
- Risks stemming from collateral inventory mismanagement are mitigated by requiring institutions to tokenize their collateral prior to submitting requests for funding and near-real-time delivery versus payment of cash in exchange for collateral, which both reduce the likelihood of delays in settlement.

[34]Solidity is a programming language designed for developing smart contracts that run on Ethereum.
[35]ConsenSys is a blockchain software technology company that builds blockchain-based financial infrastructure and applications.
[36]See the case study at www.jpmorgan.com/kinexys/content-hub/digital-financing#results.

- Transacting on the blockchain provides transparency across the trade life cycle, with the application enabling the feeding of trade details and confirmations directly into participants' systems, thereby ensuring full transparency.
- Programming settlement and maturity timings of cash movements allow for precise planning of liquidity requirements, precise interest calculations, and optimization of capital deployment.

One limitation of Digital Financing relates to the use of a private blockchain. If tokenization aims to address most assets on public infrastructure, there will be an issue with complete interoperability by having multiple private blockchain networks. J.P. Morgan, however, has committed to opening up its network by allowing third parties to deploy their applications on Kinexys Digital Assets and exploring interoperability solutions with public blockchains, such as Avalanche and Provenance. It has also allowed for application-level interoperability in repo, meaning that clients can have assets in non-J.P. Morgan triparty custodians while using J.P. Morgan's repo product.

4.4. Tokenization of Equities, Money Market Funds, Bonds, and Gold

Firm: WisdomTree

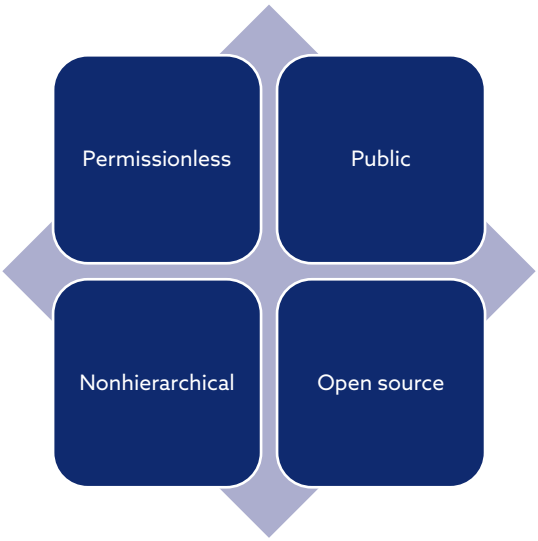
Web address: wisdomtree.com, wisdomtreeprime.com

Established: 1985 (tokenization business in 2021)

Headquarters: New York City

Assets subject of tokenization: Equity funds, bond funds, money market funds, and commodities (gold)

Key Network Characteristics



Brief Business Overview

WisdomTree is an investment management firm and a sponsor of exchange-traded products, including ETFs, with 300 employees globally. WisdomTree Prime is a personal finance application from WisdomTree's digital asset and blockchain focused subsidiaries, providing access to digital assets and 13 digital funds on a blockchain-integrated platform. The application allows investors to invest in tokenized equity funds; fixed-income funds; money market funds; asset allocation strategy funds; cryptoassets, such as bitcoin and ether; and a gold token. Examples of the products offered include the WisdomTree Government

Money Market Digital Fund (WTGXX), WisdomTree 500 Digital Fund (SPXUX), WisdomTree Floating Rate Treasury Digital Fund (FLTXX), and WisdomTree Gold Token.

Regulatory Framework

For their digital assets, WisdomTree Digital Movement, Inc. (WDM) and WisdomTree Digital Trust Company, LLC (WDTC) provide applicable products and services in select US jurisdictions. WDM is registered with the Financial Crimes Enforcement Network as a Money Services Business and engages in money transmission (or similar activities) in applicable US states. WDTC is chartered as a limited purpose trust company by the New York State Department of Financial Services to engage in virtual currency business (WDM and WDTC are referred to as "WisdomTree Digital" as the context requires).

The gold token, as a digital asset, and the movement of digital assets are regulated under the money transmission laws of various states, as well as virtual currency licenses in certain states, which requires WisdomTree Digital to apply for licenses or otherwise rely on exemptions or no-action relief in each state with differing requirements for approval or relief. Currently, WisdomTree Digital has been approved or otherwise relies on relief in 43 states in the United States for this activity. For example, the state of New York requires companies conducting virtual currency business activity to apply for a money transmission license and either a BitLicense[37] or a charter under the New York Banking Law as a limited purpose trust company or a bank.[38] When applying as a limited purpose trust company, the firm is allowed to engage in money transmission in New York without obtaining a separate money transmission license. WDTC received its trust company charter in March 2024 and commenced operations in May 2024. Comparatively, Connecticut includes virtual currency under the definition of money transmission and requires a business to gain a money transmission license.

For its digital funds, WisdomTree Digital Management, Inc., is registered as an investment adviser with the SEC. The underlying funds are open-end '40 Act funds[39] and are regulated by the SEC under the Investment Company Act of 1940 in combination with the Securities Act of 1933 and the Securities Exchange Act of 1934. In effect, the digital funds maintain a traditional structure, in addition to their digital representation through tokens.

[37]BitLicense is a term used for a business license of virtual currency activities issued by the New York State Department of Financial Services.

[38]A virtual currency business, as defined by the New York State Department of Financial Services in virtual currency regulation 23 NYCRR Part 200, means the conduct of activities involving New York or a New York resident, including "receiving virtual currency for transmission or transmitting virtual currency, storing, holding, or maintaining custody or control of virtual currency on behalf of others, buying and selling virtual currency as a customer business, performing exchange services as a customer business, or controlling, administering or issuing a virtual currency" (www.dfs.ny.gov/virtual_currency_businesses).

[39]According to Citi Prime Finance (2013), "A '40 Act fund is a pooled investment vehicle offered by a registered investment company as defined in the 1940 Investment Companies Act."

Tokenization Process

The digital funds vary across asset classes, including equities, bonds, and money markets. In terms of the type of tokenization (see Exhibit 8), although the funds' shares are tokenized, the underlying portfolio assets (equities, bonds, US Treasuries) are not. The tokens serve as a representation of ownership of the digital fund.

The digital fund tokens can be minted on either the Stellar or Ethereum blockchain. The process can be broken down into two main parts: the funding mechanism and the record of ownership issuance. The funding mechanism follows the traditional process of a fund launch and subsequent investor subscription operations.

Digital Funds

Token issuance for digital funds occurs in the following steps:

- When customers fund their account at WisdomTree, through WDM or WDTC, it is converted to a US dollar stablecoin issued by WDTC (the issuer), which is held inside their wallets on the platform.
- If customers purchase any of the digital funds, WisdomTree mints a token that represents a share of the fund after the stablecoin is burned and converted into US dollars to purchase the digital fund. The token representing ownership of the digital fund is minted and deposited into the user's wallet and linked to the user's blockchain address, with the record of ownership maintained by the transfer agent through an integrated blockchain recordkeeping system.
- Similarly, with respect to a digital fund redemption, when the token recording ownership of the digital fund is burned, US dollars are delivered by the digital fund, with the customer instructing US dollars to be converted into the dollar stablecoin, which is then issued and deposited into the investor's wallet.

Gold Tokens

Gold tokens can be minted using either the Ethereum ERC-20 or the Stellar SEP-8 token standard, with a 1:1 unlevered representation of the gold token to a certificate of title to physical gold. This gold is physically held in a secured external vault (i.e., custody account) with HSBC, which secures allocated physical gold storage for WDTC as bailee for a gold token holder. The tokenization process involves WDTC purchasing gold bars on the market, which are settled into the secured external vault (custody account) to ensure that physical gold held in storage is at least equal to the gold tokens outstanding.

The last step involves the usability of the digital funds and gold tokens once purchased through the application. The gold token can be exchanged for

physical gold or US dollars, or the investor can hold it as an investment. Furthermore, the digital funds and the gold tokens can be used to trade for other tokenized assets available on the WisdomTree platform. Only transactions from authorized customers and registered blockchain wallets can take place on the platform. The blockchain gas fees of buying, selling, or trading the tokens are borne by WisdomTree and are part of the running cost of the infrastructure.

Choice of Blockchain

The reason Stellar was chosen for WisdomTree Prime is that it has a lot of characteristics that are compelling in terms of settlement times, lower operational costs, and in-built features to support tokenization. Another feature is that Stellar has tokenization capabilities natively built into its protocol. Additionally, the Stellar blockchain was well tested and well established and it had the infrastructure to support an application for financial services.

WisdomTree intentionally chose to do its tokenization efforts on public blockchains, such as Stellar and Ethereum, as opposed to a private permissioned blockchain. The reason to choose a public blockchain is interoperability. Public blockchains provide a way in which different entities can interact with one another on a common standard, allowing the facilitation of economic activity among participants on the network.

Ethereum has two main strengths. The first is the Ethereum Virtual Machine, which allows any code written into this standard to be compatible across several blockchains even though these blockchains do not "speak with" each other. The second is Ethereum's network effects, which provide the advantage of its expanding user base for the platform.

There are, however, drawbacks to using Ethereum, including lower throughput of transactions in order to ensure that the nodes that run the network are sufficiently decentralized, along with a higher cost of transactions based on the willingness of users to pay the transaction fees. Public blockchain networks allow more frictionless interactions for those using the network. Private blockchains may provide greater privacy but come at the cost of interoperability. WisdomTree believes public blockchains—with interoperability and their open-source nature—offer greater promise and utility for fund tokenization.

Investment and Administration Process

Investors who sign up for WisdomTree Prime must complete a KYC and onboarding process on the platform itself prior to being allowed to invest in any of the products available. The application is currently available for most US retail investors. The minimum investment requirement is USD2 in the application for the gold token, USD1 for the money market fund, and USD25 for the bond, equity, and asset allocation funds. Investors using the application receive a Stellar-based wallet, but WisdomTree Digital manages the wallets on behalf of the customers and abstracts away any technical requirements (private

key management, for example), so the interface looks similar to a traditional brokerage or banking account.

The gold token represents ownership of a 1 troy ounce portion of a London Bullion Market Association (LBMA) gold bar and functions as a certificate of title to the underlying gold meeting the LBMA's good delivery standards. HSBC, through its vault facilities in London, acts as an independent custodian and maintains a segregation process where gold bars associated with the token are segregated with a serial number (serialized allocated storage). Audits of the physical gold held by HSBC are conducted twice a year by an independent audit firm. WisdomTree receives a daily serialized number bar list for its physical gold holdings, which is made public.

The official records of share ownership for the digital funds are maintained through the transfer agent (WisdomTree Transfers) in book-entry form, with the record of share ownership also being digitized on either the Stellar or Ethereum blockchains, creating an integrated record of ownership. Therefore, for regulatory compliance purposes, the transfer agent reconciles the blockchain transactions and the official record for the digital funds on a daily basis, including the number of shares in circulation, ownership of shares, and the transactions between parties involving the shares. State Street serves as the fund administrator and custodian for the funds and is responsible for the custody of the underlying assets while also providing administrative, legal, tax, and financial reporting services for the maintenance and operations of the funds.

Benefits and Limitations

Compared with traditional investment funds, including ETFs, tokenized funds enable investors to directly initiate transfers and redemptions and conduct other processes using blockchain infrastructure, with potentially less need for the involvement of typical intermediaries, while offering the possibility to monitor the execution of these operations. One of the main benefits is in addressing the issue of share transfers and the typically laborious processes involved. A comparable example is the transfer of cryptoassets around different platforms, which can be conducted quite easily and within minutes, whereas a traditional stock transfer is a multi-step process that takes days to complete through normal banking infrastructure.

Furthermore, because the application handles the storage of private keys and addresses on behalf of the investors, investors can more easily invest in and trade the assets available on the platform. This structure benefits investors who do not know how to navigate blockchain-specific tasks, such as handling wallets and keys or purchasing lumens[40] to conduct transactions, while also increasing security and reducing the risk of malicious activity.

[40]Lumens are the native cryptocurrency of the Stellar Lumens smart contract platform.

The business choices made by WisdomTree, however, lead to a natural tradeoff for investors. The simplicity of the graphical user interface and the application itself create an environment where users do not have to learn the technical specifications involved in navigating the blockchain. In effect, the company balances the technical and operational benefits of using the blockchain with the need to protect investors from misinformed use of the technology, especially at such an early stage of digital finance development. For the time being, customers may buy, sell, or trade tokens only through WisdomTree Prime, which is built on the Stellar network.

4.5. Digital Platform for the Issuance and Trading of Private Funds

Firm: Securitize

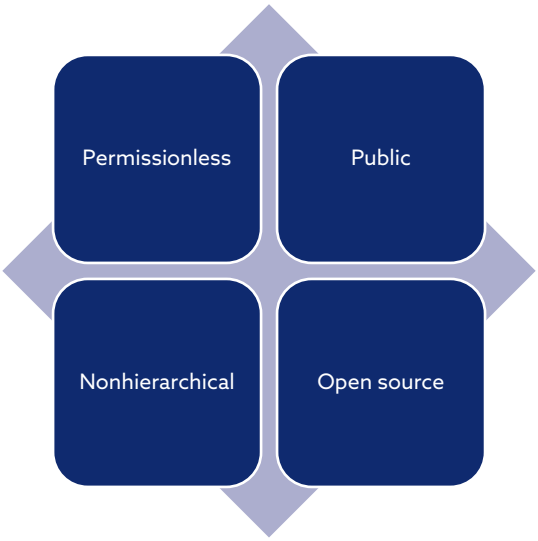
Web address: https://securitize.io

Established: 2017

Headquarters: Miami

Assets subject of tokenization: Private equity, private credit, venture capital

Key Network Characteristics



Brief Business Overview

Securitize is a digital securities issuance platform. It enables issuers to raise capital and allows investors to access tokenized investment schemes in various asset classes, such as private equity, private credit, venture capital, treasury funds, and real estate investment trusts (REITs). Examples from various asset classes include the KKR Health Care Growth II Feeder Fund (private equity), the Hamilton Lane Senior Credit Opportunities Feeder Fund (private credit), Science Blockchain (venture capital), and the BlackRock USD Institutional Digital Liquidity Fund (money markets). As of April 2024, USD800 million has been invested through the platform by around 125,000 individuals or entities.

Regulatory Framework

Securitize Inc. is the group parent company that oversees three subsidiary entities. Securitize Capital LLC is registered as an exempt investment adviser with the SEC. Securitize Markets is registered as a broker/dealer and is a member of FINRA/SIPC. Securitize LLC is registered as a transfer agent, also regulated by the SEC.

Securitize is also working on expanding into Europe. The company has applied to be a broker/dealer in the EU with the Spanish securities markets regulator (CMNV) under the EU's DLT Pilot Regime (a component of the EU digital finance package)[41] for market infrastructure operations based on DLT.

Tokenization Process

Securitize conducts two types of tokenization with funds onboarded on the platform:

- The full fund is unitized and then tokenized, where every share is represented as a token on the blockchain.
- A portion of a feeder fund is unitized and tokenized, while the rest of the fund remains managed according to traditional operations.

The platform's technical approach is to tokenize the fund layer (fund shares) but not the underlying portfolio assets (see Exhibit 8 in section 2.2.3). The process involves Securitize taking up a certain allocation of a fund and issuing it to investors on its platform. In both types of tokenization mentioned previously, the funds have to first be unitized and then tokenized. This is the process that ultimately differentiates the platform's value proposition from traditional mechanisms for investments in private funds, which involve a direct and customized interaction between the general partners and the limited partners for them to agree to the terms and logistics of an investment. In practice, Securitize automates and streamlines the process through tokenized units maintained on a digital ledger.

In the case of private funds, the number of tokens remains consistent with the number of units issued, whereas the net asset value is updated either monthly (private credit) or quarterly (private equity).

Beyond the commercial discussions involved in agreeing to host a particular fund on the platform, technical decisions relate to:

- fund specifications (regulatory compliance details, minimum investment requirements, lockup period, investor types allowed),

[41]For more information, visit https://finance.ec.europa.eu/publications/digital-finance-package_en.

- the choice of a blockchain (either permissioned or permissionless), and
- the number of tokens (units) to be created.

Creating the tokens involves programming by developers to turn the asset into a blockchain representation as a fraction or unit of the fund, followed by writing self-executing smart contracts with the terms of agreement in the code. The creation of tokens includes automating processes, such as dividend distributions, governance updates, and ownership transfers. Finally, a primary distribution is conducted for investors to buy the tokens of the fund through the Securitize platform.

Once investors are in possession of their tokens, they can either sell them on the secondary market or conduct a peer-to-peer swap with another investor. The secondary market works as a three-step alternative trading system (ATS)[42] with a limit order book system for investors to buy or sell their shares in any of the funds.

Choice of Blockchain

Securitize does not use one specific blockchain, nor does it operate its own. Instead, it made a strategic choice to support a variety of private and public blockchains, including Ethereum, Aptos, Arbitrum, Optimism, ZKsync, Avalanche, Polygon, and XDC. Different issuers have different requirements and may want to be a part of different digital ecosystems, which Securitize strategically chose to accommodate.

The choice of a blockchain infrastructure is made by Securitize's clients and is rooted in a variety of considerations. For example, clients have different reasons for choosing various blockchains. Some choose Ethereum because it is considered the most well-established and secure blockchain. Some choose Avalanche for its low transaction fees, in addition to its parent company (Ava Labs) being registered as a company in the United States. Others choose Polygon for its advanced wallet features and increased accessibility.

[42]An ATS is an SEC-regulated trading venue in which a computerized system matches buy and sell orders of securities. Securitize conducts business and is filed with the SEC under the name "Securitize Markets ATS." See the SEC's list of ATSs at www.sec.gov/foia/docs/atslist.

Investment and Administration Process

There are three categories of investor on the Securitize platform: qualified purchasers,[43] accredited investors,[44] and retail investors. Issuers define their own minimum investment requirements and the type of investor that can invest in the product. Private equity and private credit offerings are limited to qualified purchasers and accredited investors. The lockup period for most private market products is 12 months.

In contrast to traditional private market practices, the platform collects the total investment commitment up front, instead of requiring capital calls through a fund life cycle, with unused funds being placed in a money market account. Investors also experience shorter lockup periods and are able to sell their tokens on a secondary market after the 12-month lockup period. Distributions are either automatically reinvested into the fund or deposited into the investor's Securitize account.

Investors who wish to be on the Securitize platform and invest in any products there have to go through a systematic KYC/AML process as part of the account opening. Custody of the tokens is ensured and operated through the transfer agent (Securitize) and done within the Securitize account itself, and investors have the option to transfer their tokens to a registered secondary wallet, depending on the fund the investor has invested in, because each of them may use different blockchains.

The platform charges a 0.5% fee (per annum) on assets under management issued by Securitize Capital in a feeder fund structure, in addition to the regular fee structure charged by the fund itself. Funds that are not originated by Securitize have no additional fees paid by the investor to the platform. Securitize charges placement and transaction fees via its broker/dealer (Securitize Markets) and additionally charges the fund issuer as a transfer agent (Securitize LLC) for any transfer agent services provided.

Benefits and Limitations

The main benefit offered by the platform is the removal of a series of intermediaries involved in the typical operations and administration chain that is required in a traditional approach to investing in a private fund. Time and cost

[43]A qualified purchaser is an individual or entity that can invest in securities or investment products based on specific requirements set by the Investment Company Act of 1940. To be considered a qualified purchaser, the individual or entity has to be an individual with more than USD5 million in investments, a family or estate planning entity with more than USD5 million in investments, an investment manager with more than USD25 million in investments, or a qualified institutional buyer under Rule 144A with more than USD100 million in investments.

[44]Financial criteria include net worth of more than USD1 million, excluding primary residence (individually or with spouse or partner), or annual income of more than USD200,000 (individually) or USD300,000 (with spouse or partner) in each of the prior two years. There are four other professional criteria that can make individuals qualify as an accredited investor. See the SEC's "Accredited Investors" webpage: www.sec.gov/education/capitalraising/building-blocks/accredited-investor.

savings are realized through reducing the investor onboarding process from about three months to one week, according to Securitize.

In terms of KYC obligations, the platform facilitates the process, and an investor has to go through the onboarding and verification sequence only once to gain access to multiple funds. The information is saved on the ledger and is therefore portable. The process becomes homogeneous and streamlined across funds. Cost savings arise from simplifying the operational chain and related fees.

One limitation is the low levels of liquidity in the secondary market, largely attributed to the nature of the investments, which have longer investment cycles relative to traditional public securities. In addition, the use of public blockchains implies the absence of a single and central party responsible in case of a disruption event or attack on the public network. This issue, however, is remedied by having an off-chain duplicate record of all necessary information, which is also a factor relevant to ensure regulatory compliance.

Chapter 4 presented a series of five case studies on tokenization processes applied to an array of real and financial assets, types of transaction, or financial instruments. In Chapter 5, we summarize the main and most important limitations we have observed from these case studies and which we think are important for investors and regulators to consider.

5. LIMITATIONS

In this chapter, we highlight from the previous case studies four limitations to the development of tokenization, including risks related to security, regulatory challenges, market infrastructure, and access to private markets.

5.1. Security Risks

Among the main limitations that arise with the use of new technologies are the security risks that inevitably emerge. Multiple technological and security challenges are involved with the use of blockchains, which must be assessed prior to the technology's implementation in a tokenized product.

As such, specific security risks pertain to blockchain technology:

- Malicious actors can target a blockchain through multiple methods, including a "51% attack,"[45] "Sybil attack," "DDoS attack" (transaction flooding or poorly designed smart contracts), or phishing attack.
- Tokenization creates more opportunities for fraud and deception because clients are less familiar with handling wallets and keys and performing transactions on the blockchain.
- The use of private keys also enhances the risk of complete inaccessibility to the asset token in case of fraud or even if the user improperly stores the key.

These forms of vulnerability have been observed even on popular smart contract platforms, such as Solana and Layer 2 platforms of Ethereum.

Risks related to malicious attacks on individuals (for example, by gaining access to their private keys[46] or digital wallets) can be mitigated by simplifying the user interface that the investor or client interacts with. Such simplification may, however, come at the cost of limiting the use cases of blockchain-enabled investment products.

Preventive measures must be taken to ensure that the blockchain in use is sufficiently secure. The following considerations are important:

- Regular security assessments and smart contract audits should be mandated through an independent third party.

[45]A 51% attack refers to a malicious actor controlling more than 50% of a network, giving the actor the ability to manipulate the transactions on a blockchain, including reversing transactions, using double-spend coins, or preventing other nodes from validating blocks. The cost to conduct such an attack depends on the size of the network, because the amount of computational power committed to the network increases with growth in the network.

[46]Investopedia defines a private key as "an alphanumeric code generated by a cryptocurrency wallet. It is used to authorize transactions and prove ownership of a blockchain asset." A public key, in turn, refers to "a cryptographic code used to generate cryptocurrency addresses that allow a user to receive cryptocurrencies." Sources: https://www.investopedia.com/terms/p/private-key.asp and https://www.investopedia.com/terms/p/public-key.asp.

- Security also depends on the technical nature of the blockchain, whether private or public. As discussed earlier, a private blockchain is naturally centralized because the nodes are either owned by a single entity or restricted to certain approved individuals or firms. We must also consider, however, that the centralization of a private blockchain creates the single-point-of-failure factor compared to the decentralized nature of public blockchains. The question of security is multifaceted and depends on business and product choices.
- When assessing various smart contract platforms, it is also important to realize the benefits offered by large and mature blockchains, such as Ethereum, in terms of ongoing development and continuous improvement, with a focus on enhancing the security of the platform. More widely used and decentralized networks are also costly to attack, because the economic resources required to attack these platforms are much greater. For example, the total cost to execute a 51% attack, as of 31 December 2023, has been estimated at USD31 billion for Ethereum and between USD5 billion and USD20 billion for bitcoin (Nuzzi, Waters, and Andrade 2024).

5.2. Regulatory Challenges

Regulation on blockchain and tokenized products remains misaligned across regions and key jurisdictions, with no recognized international standard emerging as of yet, which naturally acts as a limiting factor in the expansion of tokenized products. The borderless nature of digital finance processes calls for a progressive alignment of regulatory frameworks; otherwise, the risk of regulatory arbitrage and market failures will rise. Part II of this research series will delve more precisely into these inconsistencies across the major jurisdictions involved in the development of digital finance.

As discussed in previous chapters, regulatory development, for the time being, occurs on a spectrum of the perceived risks of digital assets and how they currently fit within existing securities market laws. Jurisdictions are currently approaching this issue from varying perspectives and are trying to effectively balance the need to protect markets and investors from misconduct while facilitating the establishment of an industrial ecosystem favoring innovation and conducive to flourishing entrepreneurship. This conundrum is not easy to resolve.

The key jurisdictions considered in Part II of the series are the EU, the United States, the United Kingdom, Switzerland, Hong Kong SAR, and Singapore.

In general, inconsistencies among regulations are related to the following:

- The definition of digital assets and when they are considered securities or financial instruments for the sake of securities market laws
- The centralized or decentralized nature of the network

- The nature or identification of the responsible corporate entity or individual
- The recognition and enforcement of ownership rights
- The regulatory jurisdiction and scope of application
- Whether existing rules are sufficient or an entirely new body of rules is required
- The debate around technological neutrality

5.3. Market Infrastructure

A wider deployment of tokenization will require a market infrastructure that is both flexible and robust enough to support the various assets, asset managers, and clients that will interact with the various blockchains. Tokenization is fragmented among various public and private blockchains, which adds potential hurdles for a seamless experience in navigating various tokenized assets. Furthermore, a smart contract is, by definition, limited to on-chain data, and it needs to be connected to activities that may take place either on-chain or off-chain.

As more and more assets are tokenized using public and private blockchains, we may see a cycle of consolidation taking place among these networks, whether public or private. Working toward higher levels of interoperability is another possible avenue.

Having a separate private blockchain for each firm may not be economically sustainable and could lead to further market fragmentation, with assets being isolated within each blockchain and thus providing little benefit in terms of increasing liquidity. This issue could be addressed by forming a consortium among similar types of asset managers. For example, a few banks could have one shared ledger among them to conduct transactions for repurchase agreements.

It is possible to envision a situation where private and public networks end up having their own specific use cases and are deployed according to the nature of the tokenized assets or the form of regulatory oversight.

The use of public blockchains also may lead to governance risk and jurisdictional risk, because it could become difficult to identify an operator responsible for the entire network and hold an entity responsible in case of failure of the blockchain. This situation could result in regulatory arbitrage or some difficulty in determining and managing the compliance rules that would apply to the blockchain, with its nodes spread out across various jurisdictions.

Finally, although tokenization proposes to enhance liquidity in private markets, it could also lead to potential liquidity risk, stemming from the typical liquidity mismatch that may arise between the asset and liability sides of investment schemes. In this regard, it is important to remember that tokenization does

not necessarily create liquidity; rather, it facilitates access, tradability, and operational simplicity, which may result in higher overall market liquidity. However, it will face equivalent risks in case of market dislocation situations.

A report from the Federal Reserve considers the financial stability implications of tokenization (Carapella et al. 2023). The report points to the existing empirical evidence on ETFs (considered the closest financial instrument to tokenized assets). A strong positive correlation exists between the liquidity, price discovery, and volatility of ETFs and those of their underlying securities. In effect, additional trading activity for ETFs results in higher information efficiency for the underlying securities composing the ETF. Although greater liquidity in the crypto markets could improve liquidity in the underlying assets, it could also transmit volatility from the crypto markets to the underlying assets' markets. The cause for a liquidity or price mismatch has historically been attributed to the microstructure of the financial ecosystem, which has gradually disintermediated from the typically predominant role played by large banking groups.

The following are important considerations for tokenized funds or digital assets:

- First, there can be a timing mismatch in trading hours. Digital assets are traded 24/7, whereas traditional markets have fixed trading times.
- Second, not all tokenized asset providers are traditional institutions; many new companies form part of the developing decentralized finance ecosystem. These market participants integrate their products with other cryptoassets and allow cross features, such as trading cryptoassets for tokenized assets and borrowing against tokenized assets for cryptoassets—which can all be classified within the broader decentralized finance category.
- Third, tokenized funds or digital assets will face the same potential liquidity mismatch as their traditional counterparts, depending on the open or closed (fixed) nature of their capital structure. This fact explains why several providers we interviewed as part of the case studies naturally continue to apply liquidity and investment restrictions appropriate to the potential liquidity mismatch under consideration.

These considerations bring to mind the notion of system fragility developed by Nassim Nicholas Taleb (2012) in his seminal book *Antifragile*. We do not yet fully understand how digital assets and their interconnections with the wider capital market infrastructure may propagate risk and cause disruption across the system. In essence, we do not know with clarity where the fragility resides. To paraphrase Taleb, we do not have a clear understanding of how the system of capital markets will react to the "disorder" or the "destructive uncertainty" that digital finance and tokenized processes may generate.

Therefore, in terms of systemic risk potential, the three previously described considerations could allow for shocks and volatility to reverberate from the cryptoasset markets to traditional markets. This could occur through a run on the issuer of the tokenized assets (which is itself a concept not yet definitively

settled by regulation) or by disguising riskier assets via tokenization, which could obfuscate a typical asset–liability liquidity mismatch.

5.4. Access to Private Markets

In theory, tokenization is a technological development that could provide additional benefits in terms of access to investments traditionally out of reach for regular retail investors, such as private equity, venture capital, and private credit.

Fractionalization and unitization of such investment products are the mechanisms by which this result could be achieved. In turn, the operational efficiency gains discussed earlier could make it possible to reduce minimum investment requirements, thanks to automation across the value chain. Our case studies provide evidence that firms have been able to provide lower minimum investment requirements for certain products.

It is important to remember, however, that technology-induced or technology-facilitated access does not change the situation regarding the regulation that applies to marketing, distribution, fiduciary duty, and client categorization. Nor does it alter the reasoning or process for determining why an investment would be appropriate or suitable for a particular investor. CFA Institute continues to believe that facilitating access to private investments for retail investors, whether directly or indirectly, is a contentious proposition that requires careful consideration of possible risks (Rosov 2020). Private market investments usually involve high levels of qualitative and quantitative sophistication regarding their approach to investment strategy, liquidity restrictions, time horizon, fee structure, or performance measurement, which should not be underestimated.[47]

Chapter 5 presented a compendium of the limitations raised in the analysis of the case studies we have considered in this research, notably security risks, regulatory challenges, market infrastructure issues, and access to private markets. In Chapter 6, we offer overall implications of our work for investors and regulators to consider, whether they relate to the nature of the market, technological developments, or regulatory coherence across jurisdictions.

[47]The Asset Management Advisory Committee at the SEC established a subcommittee to review retail investors' access to private investments. It concluded that "the SEC should consider permitting retail investors access to a wider range of private investment. … Wider access could initially be considered within a set of 'Design Principles' that balance the potential benefits to retail investors from wider access to private investments with sufficient investor protection, and the current RIC framework could serve as the basis on which to achieve the balance sought by the Design Principles outlined" (SEC Asset Management Advisory Committee 2021).

6. IMPLICATIONS

The implications we discuss in this chapter are based on the case studies in Chapter 4. The variety of situations, types of firms, business models, regulatory frameworks, and processes used provide valuable information regarding the important notions to keep in mind as the digital finance sector develops.

- **Nascency of the market**

  The market for tokenized products is still nascent, implying that the infrastructure required to sustain and facilitate integration with traditional finance is still under development. However, several firms providing supplementary services, such as custody and settlement services, banking, and information and infrastructure security, have been established and are working toward addressing these limitations.

- **Compliance with anti-money-laundering and know-your-customer obligations**

  In all of our case studies, the entity in charge of the platform or the tokenized product requires prospective investors to undergo KYC and AML checks before granting them access to invest in any of their offerings. These checks are conducted in line with the regulatory requirements of the country in which the platform operates.

- **Limited understanding among investors and the link with cryptoassets**

  The people we interviewed are aware that investors may have a limited understanding of tokenized products, the technology, and navigating processes, such as learning about token-specific characteristics, managing wallets, storage of private keys, and usability. In some instances, providers have simplified the processes and take responsibility for managing blockchain-specific tasks, such as maintaining wallets and keys, so that potential investors do not have to engage in these processes. This situation leads to a tradeoff, however, whereby investors may be unable to use the full capabilities of the blockchain. Furthermore, tokenization is often associated with cryptoassets, and the tumultuous events that transpired in the cryptoasset industry in recent years have made investors wary of tokenized products.

- **The importance of choosing the type of blockchain**

  We observed throughout our sample of case studies a mixed distribution between the use of private and public blockchains. There are two reasons underlying the support of public blockchains: (1) an ideological decision based on the foundational ideas of decentralization, accessibility, and contributing to the development of the ecosystem and (2) an assessment that the safety provided by public blockchains is sufficient compared with the safety provided by a private blockchain, the latter adding extra layers

of operational complexity. In turn, there are two main and interconnected arguments in favor of private blockchains: (1) their features, including the provision of additional security with controlled user restrictions and a central party in charge who can be held responsible, and (2) regulatory restrictions imposing certain technological choices.

- **Benefits**

  Improvements in operational chain efficiency through a combination of cost and time savings are the main benefit we can identify for asset tokenization. These improvements arise from the ability to store information in the smart contract, which is accessible to all service providers and investors, while removing or reducing the number of intermediaries generally involved in traditional financial mechanisms.

- **Access to private markets**

  Tokenization, in theory, could facilitate access to private markets for a wider range of investors, including retail investors, through fractionalization and unitization, which is made much more practical by the technology involved in tokenization. In effect, we have observed how this approach may permit lower minimum investment requirements, reduces lockup periods, and facilitates trading on secondary markets. On their own, however, tokenized assets do not change how regulation currently applies to marketing and distribution of private market investment products. Nor do they change the determination of whether such a decision is suitable and appropriate for any given investor, which is where CFA Institute believes investment advice continues to play a key role.

- **Imperfect alignment and harmonization of regulatory frameworks around the world**

  As we have discussed throughout this report, current regulatory frameworks in application or in development for digital finance differ greatly across key jurisdictions. The differentiation is observed on a spectrum—that is, whether to insert digital finance and digital products within existing securities market laws or whether to create an entirely new set of rules that apply only to certain digital products. Regulation remains inconsistent, which for the time being may give rise to regulatory arbitrage or limit the potential development of an industry that is inherently borderless.

7. CONCLUSION

This report highlights and analyzes the concept of tokenization, including the underlying distributed ledger technology, the process of tokenization, and its technical overview, value proposition, and limitations.

The use of distributed ledger technology in finance and tokenization shows interesting potential in terms of operational chain efficiency gains through simplification, automation, and streamlining, made possible by technology and resulting in cost and time savings. It can also be argued that such operational gains in theory may facilitate access to a wider range of investment products for investors, through fractionalization and unitization, made practical by these technological developments.

The case studies we presented in this report identified meaningful benefits in the ability to

- provide repo facilities or interbank financing operations through tokenized collateral;
- facilitate access to traditionally difficult asset classes, such as private markets, art, and collectibles;
- organize the trading of tokenized assets on secondary markets; and
- systematize and broaden the collection, storage, and portability of information and disclosures for a variety of assets.

The digital finance industry is expected to gradually mature through the following series of developments that will need to take place:

- Widening of the ecosystem through the entrance of new firms and providers will collectively stabilize the development of tokenization techniques.
- Market infrastructure should develop alongside the work done by individual firms and align practices and business standards.
- Operational resilience will benefit from a gradual juxtaposition, harmonization, and reasonable consolidation of the ecosystem of private and public blockchains.
- Interoperability of competing blockchains will be necessary, however, to ensure that efficiency gains are realized. General market liquidity will naturally benefit from interoperable networks.

Significant challenges and risks pertaining to this development remain, related to technical complexity barriers, security issues, and natural investor protection considerations. Both regulators and industry participants will need to address these issues.

As with any new technology, DLT-specific risks have a potentially aggravated effect on a general population that may lack the required technical knowledge to properly appreciate the risks involved, such as fraud or malicious attacks. Consequently, we expect regulators to focus significantly on the promotion of financial education on DLT and tokenization to support general objectives and outcomes sought in the realm of investor protection and market integrity.

Further challenges include inconsistency across jurisdictions and the approach of regulators in addressing tokenized assets. The borderless nature of blockchains may allow investors to invest in assets outside of their jurisdiction of reference, posing another challenge for regulators. Addressing this issue will require some form of standardization of policy frameworks that requires collaboration between various jurisdictions and across several layers of the regulatory and policy apparatus.

The CFA Institute perspective is that a successful implementation of tokenization will require a balanced tradeoff between favoring useful innovation, on the one hand, and ensuring enough consumer protection measures, on the other. Our forthcoming report on the regulatory and policy implications of tokenization will cover the development of regulatory structures around tokenized assets in various jurisdictions, including the United States, the United Kingdom, the EU, Singapore, and Hong Kong SAR.

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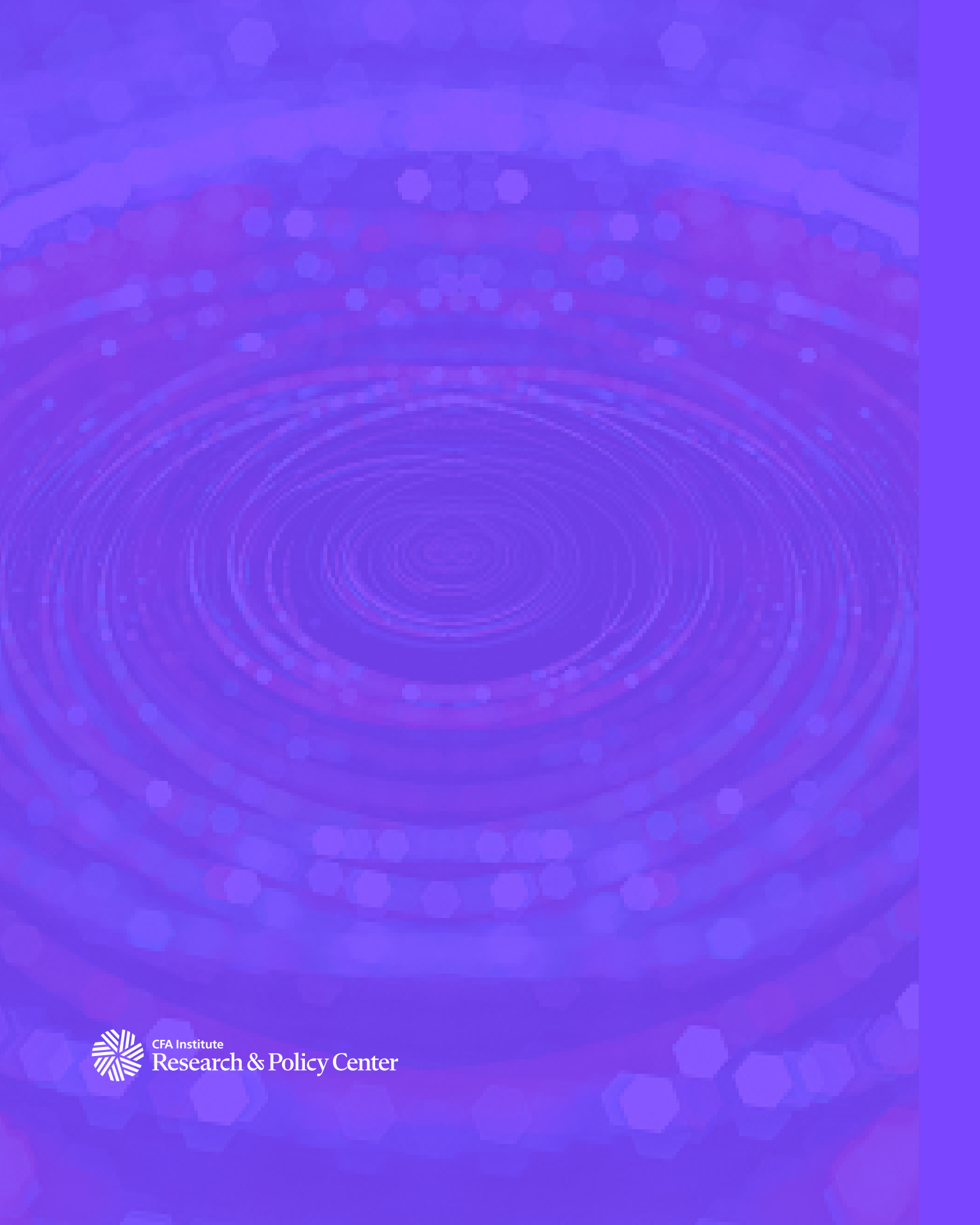
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