In collaboration with Accenture

WORLD ECONOMIC FORUM

Asset Tokenization in Financial Markets: The Next Generation of Value Exchange

INSIGHT REPORT

MAY 2025

Contents

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Foreword

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Financial markets are evolving to meet growing demands for speed, efficiency and connectivity. Among the forces driving this transformation is the rise of distributed ledger technology (DLT) and tokenization – innovations that have the ability to offer faster transactions, improved efficiency and greater transparency across asset classes. With strong momentum towards regulatory clarity and increasing technological maturity, the tokenization of financial assets is well positioned to support the next generation of value exchange in banking and capital markets.

Global stakeholders are now commonly distinguishing between attention-grabbing cryptocurrencies and the underlying technology, fuelling a renewed era of public–private cooperation focused on scaling tokenization in a safe and compliant manner. Yet progress in financial infrastructure is inherently gradual. History reflects this in the multi-decade transition from paper-based certificates to electronic book entries following the 1960s Paperwork Crisis. While the changes will not be immediate, financial markets may be approaching another major phase in the development of their architecture, powered this time by tokenization.

Today's global financial system relies on fragmented, message-based integrations to reconcile ownership and transfers across independent networks. In contrast, tokenization – enabled by programmable ledgers and smart contracts – offers the potential for unified systems of record, flexible custody models and on-chain governance. These capabilities unlock new possibilities for real-time settlement, fractional ownership, asset composability and more resilient market design.

In this context, the World Economic Forum has collaborated with Accenture to examine the role of asset tokenization in financial markets. The report that follows is the result of this joint effort. Over the past year, we analysed asset classes ranging from equities to alternative investments to develop a taxonomy of tokenization models and the differentiation they provide. While tokenization is expected to scale, realizing its full impact will require sustained public–private coordination and a phased, risk-aware approach. We hope that the insights shared in this report serve as a valuable foundation for informed decision-making and encourage continued collaboration across the financial ecosystem.

Finally, we extend our sincere gratitude to the many experts who contributed to this analysis. Their insights and perspectives, offered through interviews, workshops and written reviews, have been instrumental in shaping the findings of this report.

Executive summary

This report employed a global multistakeholder approach to exploring the potential impacts of asset tokenization on financial markets.

Tokenization presents a transformative digital asset ownership model, fundamentally reshaping global financial markets. When effectively implemented, tokenization can significantly enhance transparency, accessibility, operational and cost efficiency and market flexibility, allowing participants to transact at any time and anywhere. The core advantage of tokenization lies in democratizing financial market access, enabled by trusted infrastructure.

The report examines existing use cases to clearly articulate tokenization's unique value proposition and outlines five distinct differentiators powered by programmable ledgers (DLT/blockchain):

Shared system of record

Unified records that drive information symmetry and provide an unambiguous view of asset ownership

Flexible custodial arrangements

Increased user-centricity through varied custody models, granting end users greater control over their assets

Programmability

Operational efficiency via smart contracts that automate complex financial transactions, embedding logic directly into processes

Asset fractionalization

Expanded market accessibility through micro-units of ownership, significantly reducing administrative burdens and barriers to entry

Composability

Enhanced multi-asset mobility, enabling efficient reuse of collateral across trading and settlement activities

This report assesses current asset tokenization use cases in issuance, securities financing and asset management, highlighting conditions and regional factors that determine successful implementation. Both incumbent and new market structures, along with digitally native service providers, are actively reshaping their services to meet the growing expectations for speed, efficiency and user-centricity in a rapidly evolving landscape.

While the potential of tokenization is clear, barriers to adoption remain, including legacy infrastructure integration, inconsistent global standards, limited cross-chain interoperability, inadequate secondary market liquidity, and privacy and compliance concerns. Addressing these challenges through careful coordination and pragmatic strategies is critical for tokenization to achieve scale and lasting impact in financial markets.

As tokenization develops, there are design choices that need to be considered such as the choice between permissioned and permissionless ledgers, the most suitable settlement asset and the operating hours of future marketplaces. Likewise, there are considerations for deploying tokenized products, including cybersecurity, financial stability and regulatory developments.

Despite its benefits, tokenization adoption remains non-linear, constrained by infrastructure readiness, commercial viability, regulatory fragmentation and insufficient, yet emerging, market coordination. Transitioning financial markets from fixed-trade windows and regional frameworks to continuous, global operations requires a practical, phased approach.

Tokenization has the potential to unlock the next generation of value exchange in financial markets. While barriers remain, momentum continues to build, and financial institutions, policy-makers and technology providers need to coordinate regulation, interoperability and consumer protections to safely usher in this evolution.

Introduction

This report examines the evolution of asset tokenization in financial markets by analysing its distinguishing features and value proposition.

Scope: In the context of recent advancements in tokenization in financial markets, the report evaluates tokenized asset classes and key use cases, examines the barriers to adoption, identifies expected market impacts and outlines strategies for realizing scalable implementation.

The report builds on previous World Economic Forum reports, including Digital Assets, Distributed Ledger Technology and the Future of Capital Markets (2021), Evolution of Non-Fungible Tokens (2023) and Modernizing Financial Markets with Wholesale Central Bank Digital Currency (2024).

These reports have covered the tokenization of payment assets and non-financial assets. This report focuses on financial assets.

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to cycle between texts

This report will

- Focus on regulated financial market activities and instruments
- Define tokenization's key differentiating features and value proposition
- Identify emerging use cases and promising applications of tokenization
- Map the expected impacts on the financial markets value chain
- Share strategies for overcoming identified barriers to adoption
- Outline design choices and considerations for adopting tokenization

This report will not

Research methods:

DESK RESEARCH
that analysed more than 75 industry reports to establish initial assumptions

INTERVIEWS
with more than 60 experts representing public- and private-sector stakeholders

COMMUNITY WORKSHOPS
conducted worldwide, in London, Singapore and San Francisco

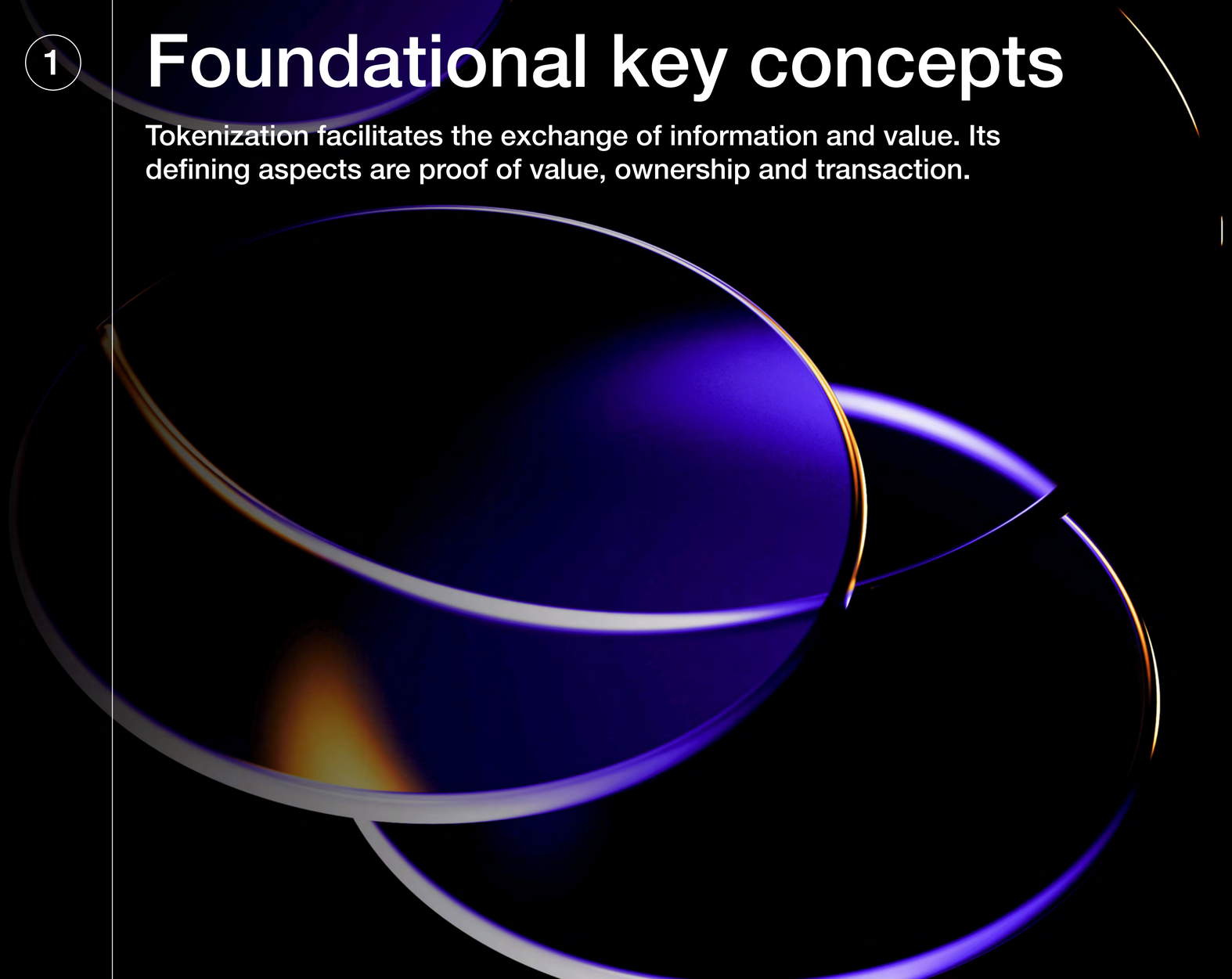
Community:

STEERING COMMITTEE
of 10 leaders from leading financial institutions and technology companies to advise on strategic direction

COMMUNITY
of more than 200 expert members representing more than 100 institutions

1 Foundational key concepts

Tokenization facilitates the exchange of information and value. Its defining aspects are proof of value, ownership and transaction.



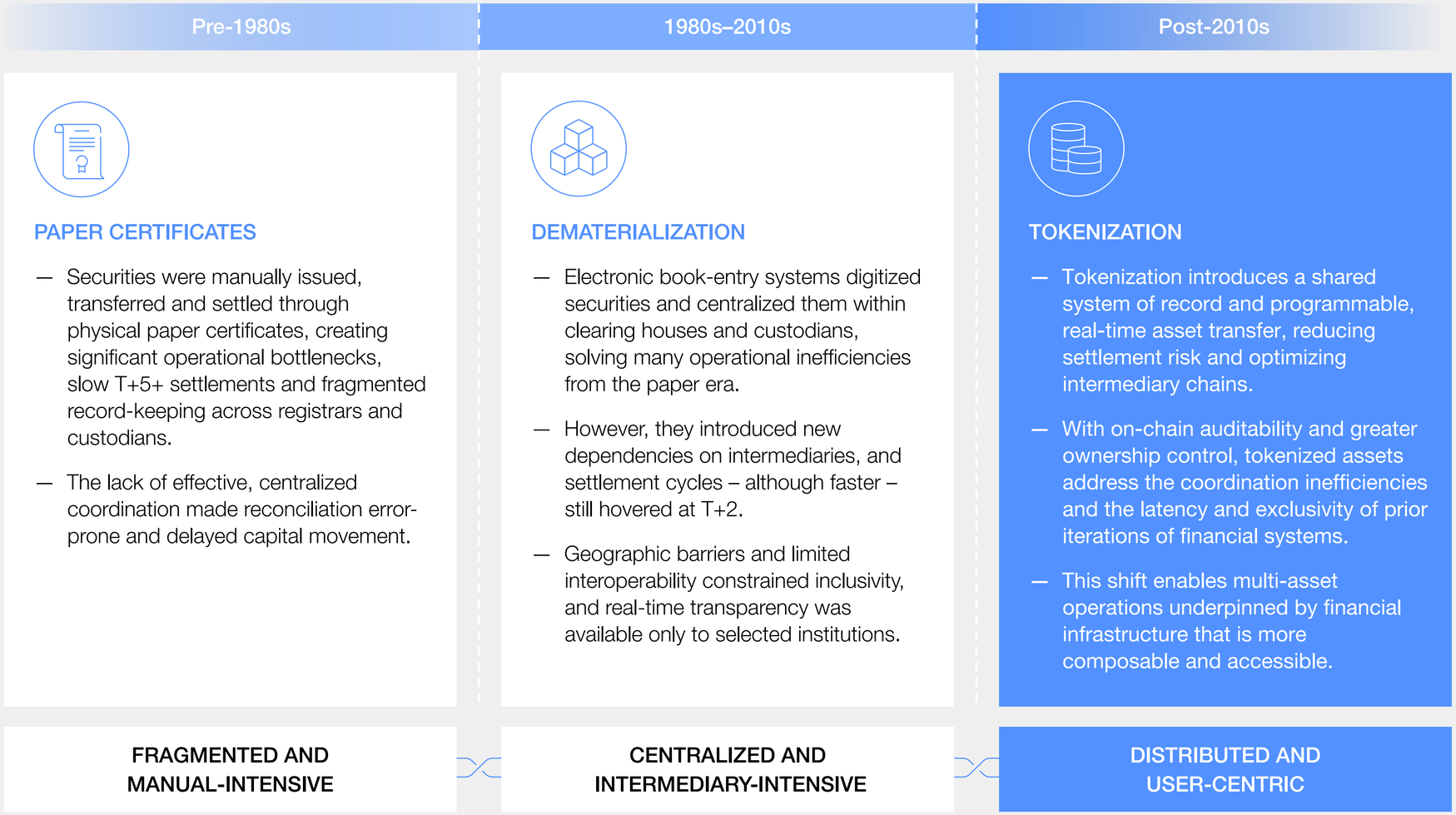
1.1 Tokenization

Tokenization is the process of using a programmable ledger to digitally represent the ownership of an asset – financial or otherwise – in a transferable format. By creating provably unique digital tokens that can be issued, stored and traded on these ledgers, tokenization enables the exchange of information and value.

A "token", in this context, represents something of value (e.g. a claim on or digitized version of a real or financial asset) that can be legally and operationally exchanged on a programmable ledger.[1]

FIGURE 1

The evolution of financial assets



1.2 Programmable ledgers

Programmable ledgers or DLT and blockchain systems support smart contract-based processes. Programmable ledgers may be public or private and permissioned or permissionless, each with varying trade-offs and advantages. These systems allow financial assets to be tokenized by codifying essential data and properties of the asset on the ledger or on-chain.[2]

- **"On-chain"** refers to an asset or activity being operated on a programmable ledger; this term is borrowed from the popularized "blockchain" term, which is a specific type of programmable ledger.
- **"Off-chain"** refers to financial processes or asset life-cycle functions taking place on non-tokenized, or conventional, systems.

1.3 Tokenization models

According to the World Economic Forum, tokenization is differentiated from conventional systems in the following ways:[3]

PROOF OF VALUE

Provides evidence or verification that an asset has a certain value or uniqueness

PROOF OF OWNERSHIP

Establishes unambiguous ownership and assigns agency of the asset to the rightful owner

PROOF OF TRANSACTION

Produces a verifiable record to provide transaction history and evidence of settlement

This report adopts these three viewpoints to identify two tokenization models – backed and native – and analyses their impacts across issuance, value, ownership, transaction or settlement, custody and redemption.[4] Fundamentally, tokenization acts as a capability to enhance settlement operations, underpinned by the asset life cycle functions.

Native token | Backed token

Native tokens represent assets issued on-chain without reference to off-chain counterparts, except for compliance functions or identity management, embedding issuance, trading, custody, settlement and ownership within the token. From a lending and collateral standpoint, this model resembles a "perfect asset" as theoretically no off-chain processes are needed and ownership claims are systematically verifiable. If implemented well, native tokens minimize operational burdens and eliminate liquidity risks; however, technology and governance risks increase as the asset can then have bearer-like characteristics. While this model is currently still in development in regulated markets, trends indicate that it serves as the target-state tokenization model for non-physical or electronic assets.

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FIGURE 2

Tokenization models

MODEL	CONVENTIONAL	BACKED TOKEN		NATIVE TOKEN
Purpose	To allow investors to trade, hold and settle off-chain	To allow investors to trade, hold and settle on-chain, with the ability to redeem the underlying reference asset		To allow investors to trade, hold and settle on-chain
Component(s)	Conventional asset	Reference asset	Token	Token
Issuance	Asset is issued off-chain	Asset is issued off-chain	Token is issued on-chain	Token is issued on-chain
Proof of value	Driven by issuer credibility	Driven by issuer credibility		Driven by issuer credibility
Proof of ownership	Evidenced by off-chain records	Evidenced by on-chain records		Evidenced by on-chain records
Proof of transaction	Recorded off-chain	Recorded on-chain		Recorded on-chain
Custody	Qualified custodian	Qualified custodian	Flexible custodial arrangements	Flexible custodial arrangements
Redemption	No token	Token may be redeemable for the reference asset or its par value		No reference asset
Example	Public equities	Physical gold (commodity)		Sovereign digital bonds

Off-chain On-chain

Legal, operational and market dynamics

These two tokenization models provide the foundation for issuance and settlement driven by programmable ledgers, yet these models are influenced by legal and operational dynamics.

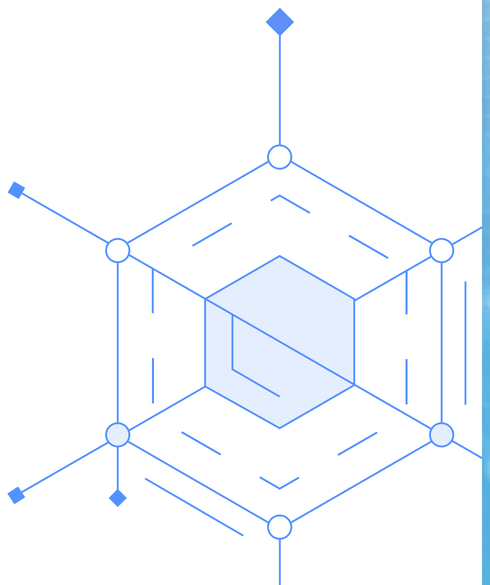
From a legal perspective, the proof of ownership, or a claim, over an asset may technically be evidenced by the programmable ledger. However, two challenges persist:

1. Clear rules must be established regarding the reconciliation and synchronization of counterparties' books and records against the programmable ledger to mitigate discrepancies.

2. The state of ownership must be legally enforceable, such as through a rulebook. Currently, property and ownership rights assigned to assets outside programmable ledgers remain legally uncertain.

Operationally, proof of value and redemption, if applicable, carry some ambiguity. Reliance on a reference asset necessitates off-chain third-party audits and coordination of dual- or tri-liquidity pool management to ensure sufficient backing and proof of value to cover the outstanding tokens and other buffers, such as liquidity coverage ratios. Redemption depends on issuer and custodian operations.

Another operational aspect is bankruptcy-remoteness, which aims to protect customer assets if the issuer or custodian becomes insolvent. Proper segregation of accounts and legal structures ensures underlying reference assets are separated from the issuer's balance sheet, safeguarding investors and reducing counterparty risks.



1.4 Token attributes

Six attributes – asset definition, embedded rights, provenance (history), ownership status, compliance rules and permission controls – make financial asset tokens more transparent, secure and efficient. By embedding key asset information into tokens, financial markets could operate with reduced complexity, stronger investor protections and greater trust.

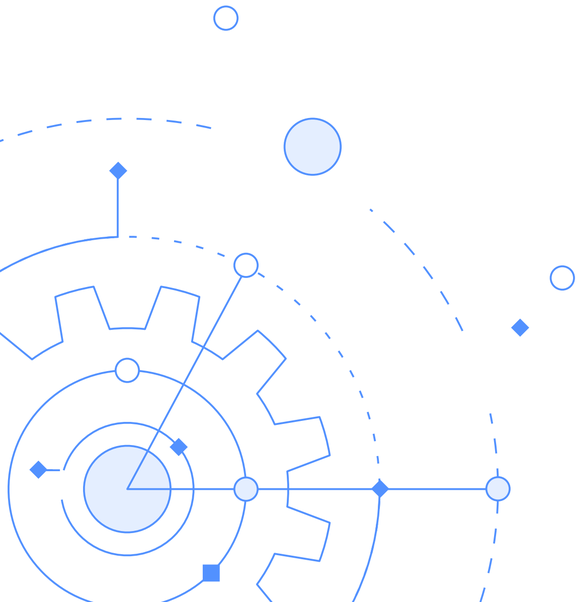


FIGURE 3

Token attributes

ASSET DEFINITION

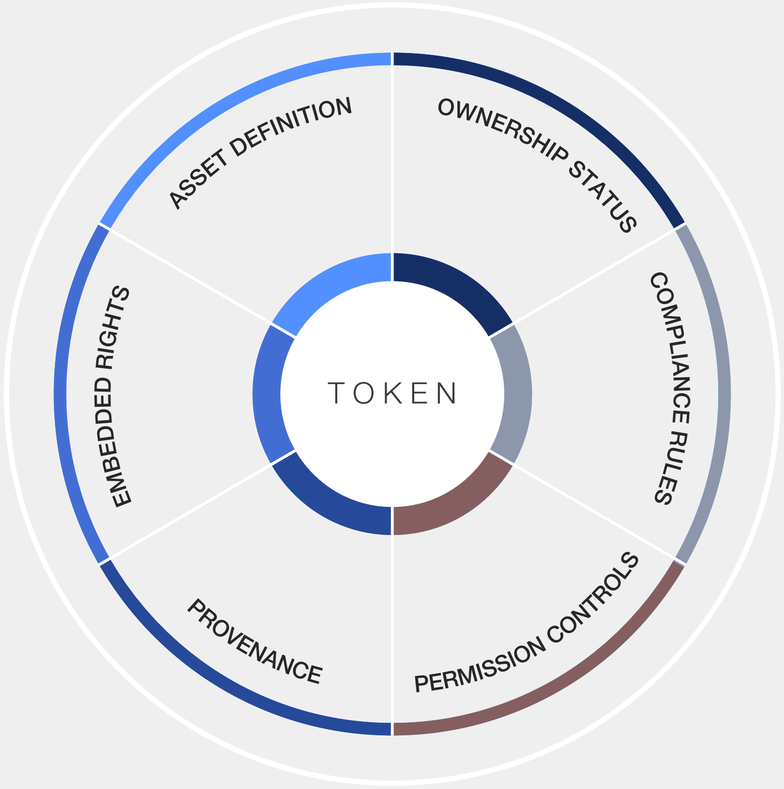
Clearly identifies the underlying asset, specifying its category (e.g. bond, equity), issuer details, unique identifiers, available quantity and characteristics essential for valuation, accounting and trading.

EMBEDDED RIGHTS

Details legal and economic entitlements granted to the token holder, such as dividend payouts, voting participation, redemption capabilities or interest payments.

PROVENANCE (HISTORY)

Provides a transparent, tamper-proof and auditable record of the token's origin, transaction history and previous ownership – all of which can be designated to authorized viewers or publicly viewable.



OWNERSHIP STATUS

Accurately represents current holders or custodians of the token, including explicit claims or encumbrances over the underlying asset.

COMPLIANCE RULES

Encodes compliance requirements, regulatory conditions and jurisdiction-specific rules directly into the token, enforcing rules governing transferability, trading eligibility and legal adherence.

PERMISSION CONTROLS

Implements permissions within smart contracts that specify and control user actions, allowing designated users or restricting actions (e.g. transfers, freezing) based on predefined rules.

1.5 Settlement assets

In a financial transaction, the delivery of an asset (D) typically requires a reciprocated payment leg, whether in cash (the "P" in DvP) or asset (the second "D" in DvD) form. This leg is also referred to as a settlement asset, which is mutually recognized by transacting parties as a final means to discharge obligations. Choosing the right settlement asset involves balancing liquidity and counterparty risks with the speed needed to achieve settlement for the trading scenario.

Settlement assets include fiat-backed stablecoins, reserve-backed digital currencies, deposit tokens and wholesale central bank digital currencies (wCBDC).[5] Crypto-assets, such as Ether, are used as settlement assets in decentralized exchanges (DEXs) or Layer-2 networks.

FIGURE 4

The digital money continuum

	PUBLIC MONEY	PRIVATE MONEY			
	Central bank money	Reserve-backed money	Commercial bank money	Non-bank money	Crypto-assets
Description	A central bank liability can be used for settlement purposes in both physical and digital formats.	A liability of a licensed non-bank FI or commercial bank backed by reserves in an omnibus account held at a central bank.	A commercial bank liability in the form of deposits held at the bank, which can be used for payment purposes.	A liability of a non-bank FI that holds a licence to issue e-money and can be used to settle commercial transactions.	A native digital asset that is usually the utility token of a programmable ledger and is used to pay for transaction fees.
Issuer/operator	Central banks	Commercial banks or non-bank FIs	Commercial banks	Non-bank FIs	Minted via blocks
Risk	Virtually credit risk-free	Bankruptcy-remote	Carries credit and liquidity risk	Carries credit and liquidity risk	Carries settlement risk
Users	— General public — FIs	— Bank customers (commercial and retail) — Financial institutions — Financial market infrastructures (FMIs)	— Bank customers (commercial and retail)	— General public	— General public
Examples	— RTGS systems — Wholesale — CBDC	— Reserves-backed digital currency*	— Deposit token	— Fiat-backed stablecoin	— Ether

Source: World Economic Forum

Note: Reserve-backed money combines elements of both public and private money – while classified here as private due to operation by private entities, it is backed by public funds, namely central bank reserves.

2

Value proposition

Tokenization offers five differentiating features that are driving its value proposition in financial markets.

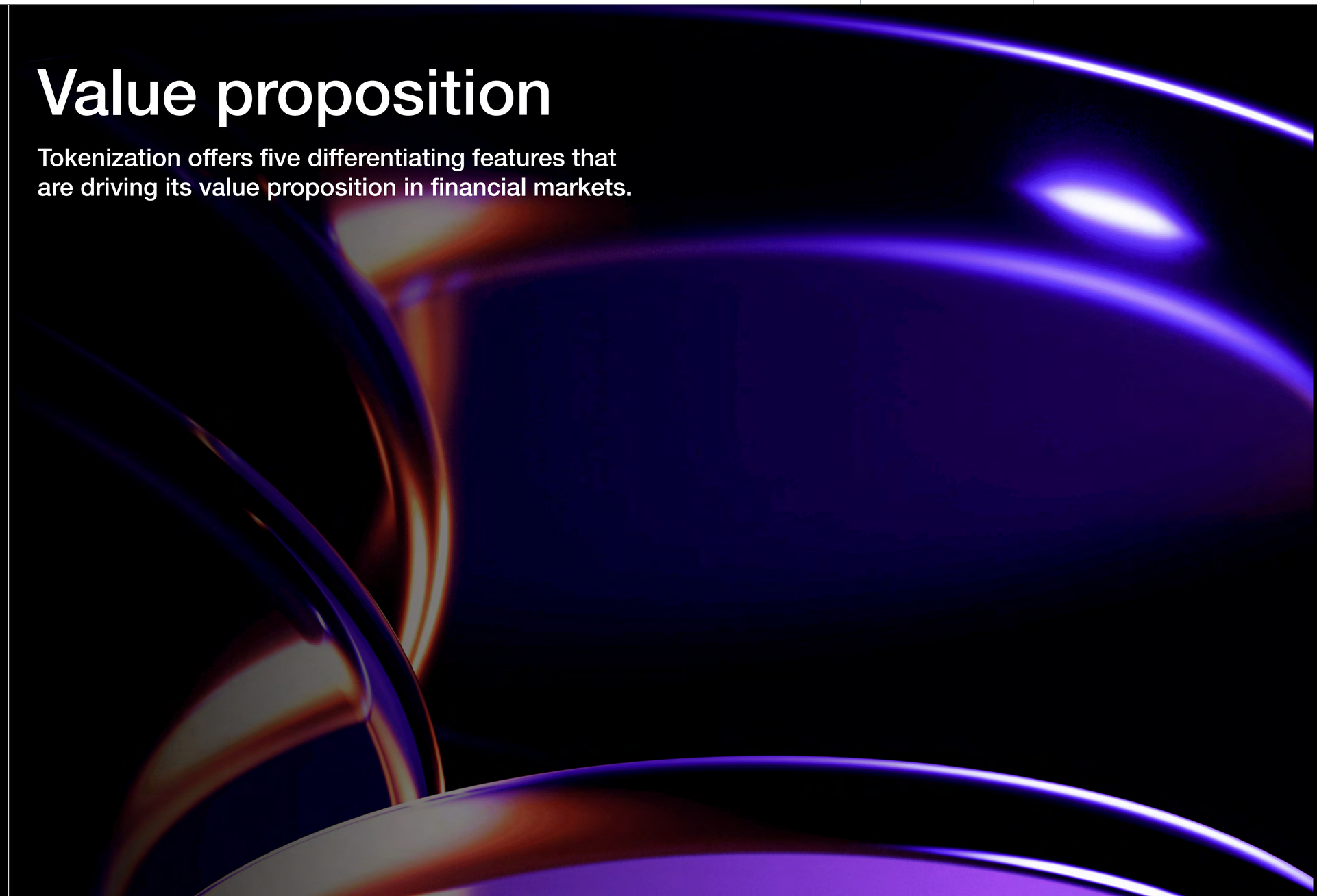
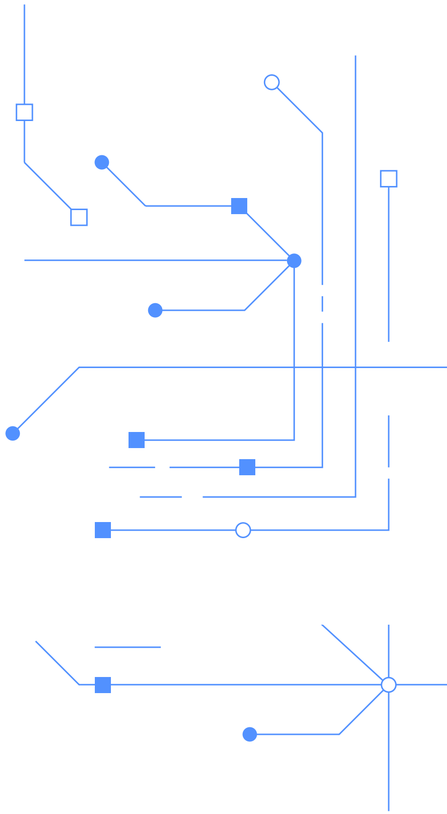


TABLE 1

Differentiated features of tokenization

There are five differentiated technical features of tokenization.

FEATURE	CONVENTIONAL	TOKENIZATION	BENEFITS	RISKS
Shared system of record *Enhances information symmetry*	— Financial institutions use electronic messaging to coordinate transactions and update their own set of books and records based on structured data.[A] — Multiple self-contained databases lead to inefficiencies and manual reconciliations that can lead to errors and delays.	— Establishes unambiguous cryptographic proof of the state of the transaction.[A] — Allows for the automation of key functions, such as corporate actions and asset servicing.[B]	— **Information symmetry** – ensures visibility and auditability, driving the reduction of information asymmetry and a reduction in reconciliations. — **Immutability and auditability** – creates an immutable, tamper-resistant ledger that securely records and verifies asset ownership, history and rights.[C]	— **Off-chain synchronization** – a new system of record can complicate harmonization with existing institutional books and records, possibly resulting in further reconciliations or errors. — **Reversals and clawbacks** – some networks do not natively offer reversibility. — **Data privacy and confidentiality** – the ability to comply with certain measures, such as the EU GDPR's "right to be forgotten".
Flexible custodial arrangements *Enables user-centricity*	— Virtually all financial assets require intermediaries for safekeeping. — Certain markets exhibit centralization risk with few parties dominating market share.	— Enables self-custody through private keys at the most fundamental level. — Offers security options with multisignature and decentralized approaches.	— **Direct user control** – allows individuals to have direct control over their digital assets and data, driving privacy, portability and user autonomy.[D]	— **Cyberattacks** – the risk of third-party providers being attacked with malicious code and bypassing security. — **Lost keys** – the risk of users/institutions misplacing or leaking private keys.



Note: The table continues with additional features on the next page.

FEATURE	CONVENTIONAL	TOKENIZATION	BENEFITS	RISKS
Programmability *Facilitates operational efficiency*	— Disparate systems require external messaging/APIs for coordination, limiting ability to integrate rules and conditions into assets or arrangements. — Processes payments independently and relies on external messaging and APIs.[E]	— Encodes transaction logic and rules directly into smart contracts (self-enforcing code) and the network's operations. — Performs business logic based on predefined conditions, resulting in transfer of value and information across trading scenarios.	— **Process automation** – transforms point-solution automation to broader strategic orchestration[F] by embedding predefined conditions into assets, automating transfers, compliance and event-based logic. — **Reduced operational costs** – efficiencies in administrative processes reduces costs associated with these transactions.	— **"Paradox of programmability"** – trade-off of harnessing smart contract efficiency and constraining the flexibility needed to react to or prevent on-chain issues.[G] — **Off-chain functions** – requirements may require new off-chain processes, thus eroding the operational benefits.[H]
Asset fractionalization *Expands accessibility*	— Administrative burdens often limit asset fractionalization because of additional effort required for functions such as asset servicing. — Legacy systems do not always allow for ownership at the decimal level.	— Enables any asset to be divided into smaller units and made available under various custodial models. — Supports the ownership of micro-units of value.	— **Reduction of administrative burden** – eases the administrative burden of making assets available in divisible, smaller parts, lowering minimum investment thresholds. — **Lower barriers to entry** – lowers barrier to entry for retail investors, particularly in illiquid and secondary markets.	— **Fragmented ownership** – the challenge with coordinating decisions or ensuring fair governance practices. — **Issuer restrictions** – certain issuers may not offer smaller denominations of assets based on regulation.
Composability *Promotes multi-asset mobility*	— Legacy infrastructure requires manual workarounds for composability to ensure sufficient linkage. — Siloed platforms limit asset reusability. — Rehypothecation and collateral reuse are slow and operationally complex.	— Enables multi-asset operations for assets to be integrated, reused and transferred across platforms (e.g. DvD, DvP). — Allows the combination of system components or discrete pieces of programmable code to meet any use case across transaction types, such as liquid staking and wrapped assets.	— **Collateral mobility** – accelerates collateral reuse, extending asset usability across multiple trades. — **Multi-asset coordination** – unlocks multi-asset and multiparty settlement opportunities on a common platform. — **Asset fungibility** – enables greater fungibility across assets and markets, facilitating new economic linkages and businesses.[I]	— **"Limitless composability"** – repackaging assets can lead to an infinite number of yield aggregation and financial vehicle strategies, leading to possible stability risks. — **Interoperability risks** – bridging, mint/burn, etc. not fully developed yet.

Table sources:

A. Citigroup. (2024). Ready Layer 1: *A general-purpose state machine for the financial sector. Citigroup Global Insights*

B. European Central Bank. (2021). *Use of DLT in post-trade processes*

C. Zellweger-Gutknecht, C. (2019): "*Developing the right regulatory regime for cryptocurrencies and other value data*", in S. Green and D. Fox (eds), *Cryptocurrencies in public and private law*, Oxford: Oxford University Press, pp. 57–91

D. Coinbase Institute. (2025). *Why the future of finance calls for a permissionless architecture*

E. MIT Media Lab & J.P. Morgan. (2024). *Application of programmability to commercial banking and payments*

F. Bank for International Settlements. (2024). *Tokenisation in the context of money and other assets: Concepts and implications for central banks.* Committee on Payments and Market Infrastructures

G. World Economic Forum. (2024). *'Code as law': The tokenization of financial assets and the paradox of programmability*

H. FEDS Notes. (2024). *Tokenized assets on public blockchains: How transparent is the blockchain?*

I. State Street. (2024). *Asset tokenization now and in the future*

Shared system of record

The introduction of a shared system of record, underpinned by programmable ledgers and their consensus mechanisms, can drive efficiencies corresponding to the *reduction of information asymmetry*, an aspect crucial to investor awareness. Tokenization can facilitate placing relevant data from financial transactions on-chain. In addition, this allows for additional data to be tracked and enables greater transparency of all information linked to any transaction, including the provenance of the asset.

However, a shared system of record, or a so-called golden record, may yield unexpected challenges for financial institutions that already manage and synchronize with several systems of books and records, internal and external with counterparties. While there are examples of parallel, programmable ledgers and conventional systems operating, there needs to be clarity on the legally enforceable system of record to determine the correct claim status of an asset on-chain. This ambiguity has of led to "shadow records" being put in to record and manage asset ownership.

Flexible custodial arrangements

Tokenization enables flexible custodial arrangements, ranging from full custody to collaborative/shared custody to hosted/embedded custody, all building upon the user-centric self/non-custodial model. This *enables user-centricity* by providing direct control over assets, identity and data through private keys, in many cases removing the reliance on intermediaries such as custodians.[6] However, if private keys are lost or compromised, then the security of these models is undermined, which is why industry efforts such as the DeRec Alliance are driving adoption of private key recoverability. Should keys or users be compromised through phishing or other cyberattacks, on-chain financial products could have freezing functions built into their governing smart contracts to mitigate and deter loss.

Programmability

Programmability is the enabling of smart contract-driven code to govern how tokens are transferred and stored – allows going beyond discrete automation by extending the scope of automation with event-based triggers, conditions and actions on an immutable ledger with embedded data and instructions in the token.[7] Programmable ledgers deliver concurrent, real-time communication to multiple parties, reducing time pressures and aiding deadline compliance.

Putting more of the asset life cycle on-chain *facilitates operational efficiencies* that can be derived using programmable functions to automate actions. Smart contract execution can streamline asset servicing, enable liquidity-saving mechanisms, enhance price discovery and improve settlement.[8] Programmability prevents unilateral changes due to immutability, bolstering trust through standardized operations and ensuring transaction data is integrated within the token rather than relying on external integrations.

However, programmatic structuring could have unintended consequences, including the paradox of programmability – the idea that a smart contract is constrained in its ability to adapt to market events, such as contagion effects, thus introducing systemic risk.[9]

Asset fractionalization

Conventional financial markets offer asset fractionalization, yet this feature is novel under the paradigm of the flexible custodial arrangements. Tokenization also reduces the administrative burden of offering smaller denominations of assets, a key limitation in lowering investment thresholds. This *expands accessibility* because financial institutions can offer smaller denominations to investors while minimizing the operational burden of processing a higher volume of activities, such as disclosures, asset servicing and compliance checks. Fractional ownership, however, can result in challenges when enforcing ownership of off-chain assets, such as real estate or commodities.

Composability

Tokenization introduces composability, or the ability to package and repackage system components and portability, which is the ability to transfer digital assets between different platforms. These features promote *multichain and multi-asset operations*, which allow for improved collateral mobility and a potential increase in liquidity due to the fungibility of assets. While composability contributes to financial innovation, it presents a unique risk in limitless composability where developers could create and recreate a limitless number of derivatives of on-chain products, resulting in potential misuse or non-compliant holding.

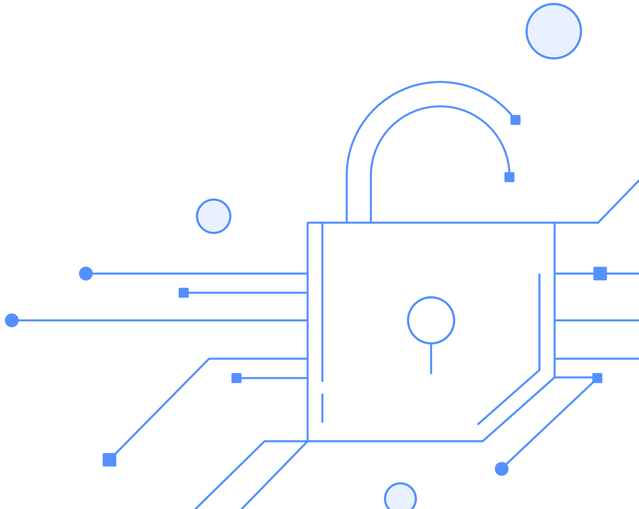


TABLE 2

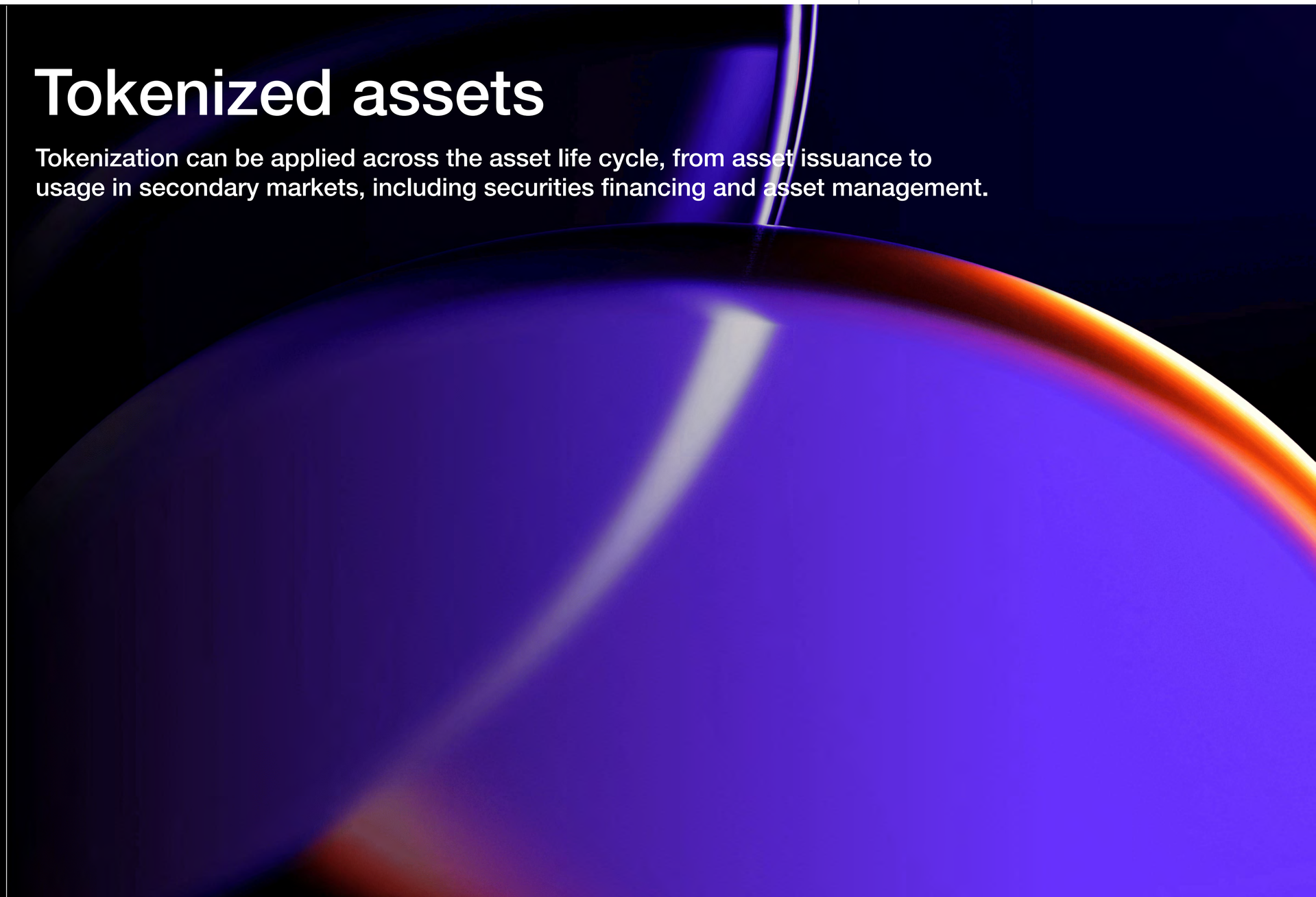
Flexible custodial arrangements

ARRANGEMENT	FULL CUSTODY	COLLABORATIVE/SHARED CUSTODY	HOSTED/EMBEDDED CUSTODY	SELF/NON-CUSTODIAL
Description	A third-party custodian holds and manages private keys on behalf of users or institutions, making this ideal for institutional clients requiring regulatory compliance, security and operational efficiency.	Requires multiple parties to approve transactions by distributing control using multiparty computation (MPC), balancing security and decentralization while reducing reliance on a single entity.	Integrates custody solutions into applications via APIs or SDKs, offering businesses flexible digital asset management while leveraging MPC for enhanced security and granting end users some control.	Users retain full control over their private keys and digital assets without intermediaries, requiring secure key management while ensuring full sovereignty and responsibility.
Private keys	Third-party custodian retains full control	Designated users have shared control	End user has primary control, while the wallet service provider acts as a backup	End user retains full control
Signing patterns	Multisig or MPC	Multisig or MPC	Multisig or MPC	Single signer
Recoverability	Yes	Yes	Yes	No
Account structure	Segregated or omnibus	Segregated	Segregated or individual	Individual
Advantages	Enterprise-level security Reduced operational risk	Reduced risk of key loss No single entity controls keys	Fast, efficient asset transfers Recovery of keys possible	Increased user control Ideal for privacy
Trade-off	Centralization risk: single entity controls assets	Operational complexity: coordinating multiple custodians/signers	Platform risk: possible platform failures	No recovery: no ability to recover lost keys
Applicability	Financial institutions that are transacting or storing a large value of assets	Institutions demanding a degree of distributed security	Retail investors prioritizing ease of access while remaining protected	DeFi users and privacy-focused investors valuing full control
Risk	Low	Moderate	Moderate	High

3

Tokenized assets

Tokenization can be applied across the asset life cycle, from asset issuance to usage in secondary markets, including securities financing and asset management.



3.1 Use case patterns

The sections below examine the impact of tokenization on relevant asset classes.

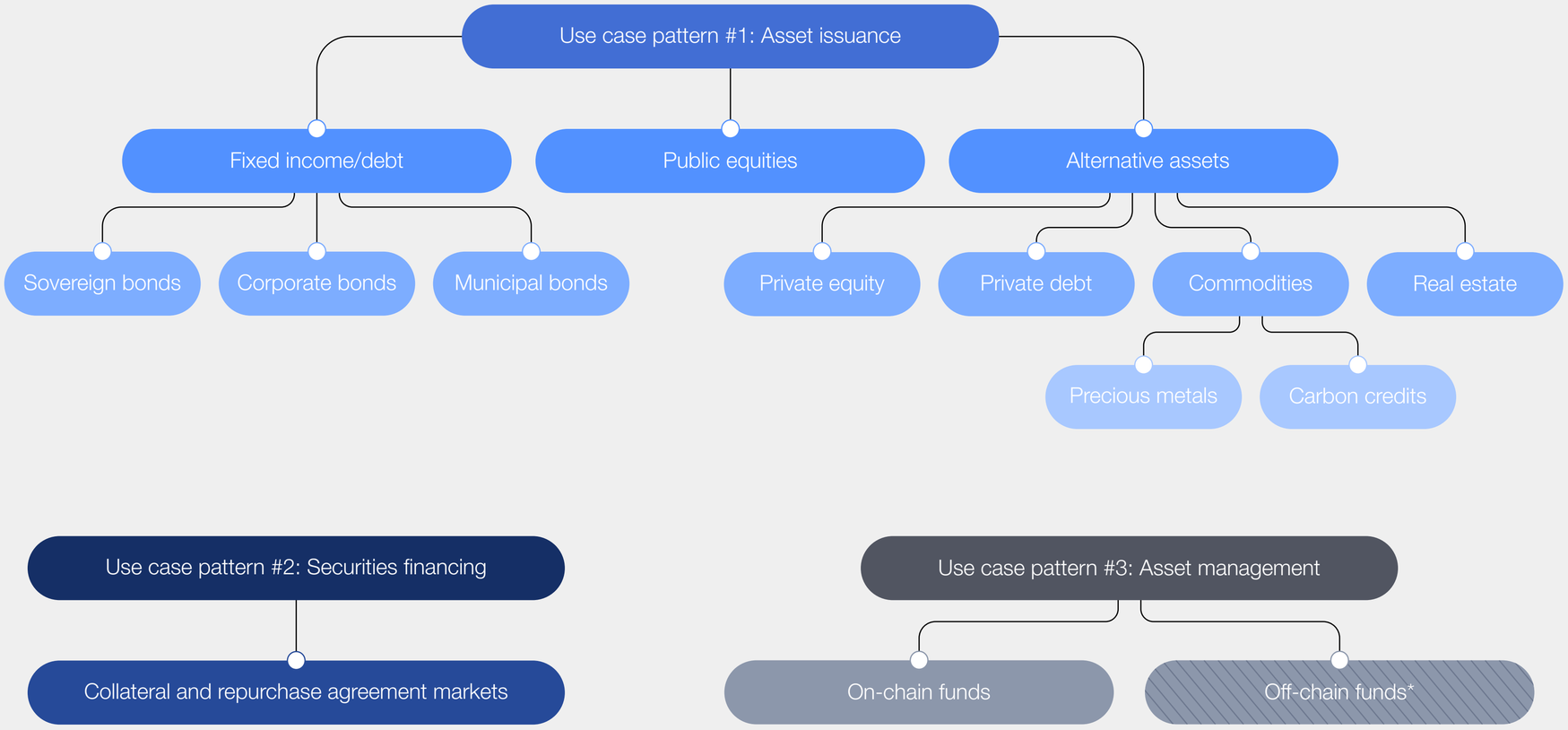
1. **Asset issuance**
   The creation of financial instruments across asset classes including public equities, fixed income (sovereign, corporate, municipal) and alternatives (private equity, private debt, commodities). These assets are issued in support of capital formation and market access.

2. **Securities financing**
   Short-term transactions such as repos and securities lending, where bonds, cash and equities serve as collateral. These markets enable liquidity management, collateral optimization and leverage strategies.

3. **Asset management**
   The assembly of on-chain and off-chain funds, spanning traditional and digital-native vehicles such as tokenized money market funds and treasury funds to provide diversified exposure for investors.

FIGURE 5

Tokenization use case patterns



*Noted as a set of products that bring on-chain assets into off-chain financial markets, such as crypto-asset exchange-traded products.

FIGURE 6

Tokenization-ready traits

There are eight key traits that help determine whether an asset is suitable for tokenization and which asset classes should be prioritized.

PHYSICAL FORM FACTOR

Assets locked in physical form, such as gold, benefit from secure immobilization and tokenization to drive tradability and liquidity.

OPERATIONALLY INTENSIVE

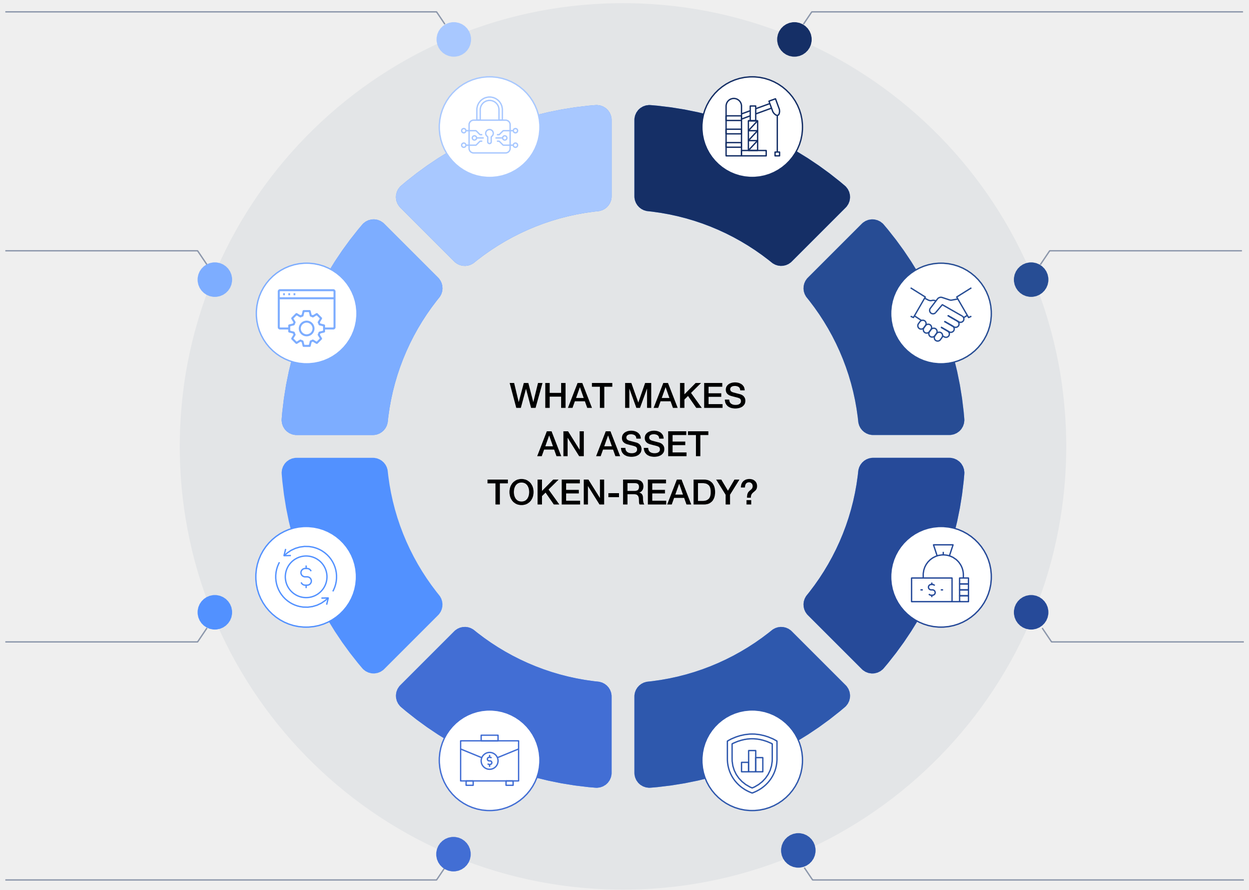
Assets that carry high administrative burdens, such as corporate actions or complex ownership structures, benefit from programmability and a shared system of record.

ASSET REUSABILITY

Assets that can be repurposed or reused across multiple trading steps, such as collateral or liquid staking, benefit from the composable features of tokenization.

INSTITUTIONAL DEMAND

Assets in high demand by institutions and that have familiar structures, such as MMFs and treasuries, benefit from the increased velocity offered by tokenization.



INFRASTRUCTURE MATURITY

Assets with low infrastructure maturity, including custody and exchanges, benefit from the "leap-frog" potential of tokenization.

UNSTRUCTURED OTC MARKETS

Assets traded through unstructured channels and over-the-counter (informal) markets benefit from tokenization's programmability and composability to enable new trading venues.

LIMITED DIVISIBILITY

Assets trading or sold in large-value increments, such as real estate or public placement sovereign bonds, can benefit from fractionalization.

REGULATORY READINESS

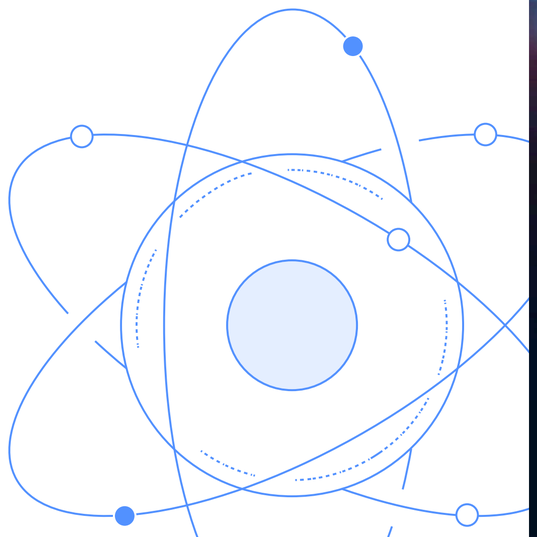
Assets already governed under well-established frameworks (such as ETFs and bonds) are easier to tokenize in a compliant way – these will vary by region.

Regional considerations

Regional differences will shape which asset classes are tokenized first. Equities and bonds already operate rather efficiently in advanced economies (AEs) but could benefit from tokenization through improved access, liquidity and lower costs. In emerging market economies (EMEs), where markets are less liquid, tokenization can democratize access across equities, fixed income and alternatives. In EMEs that have nascent existing financial infrastructure to invest in these products, this could allow for “leap-frogging”. In most markets, real estate, private credit and PE are difficult to access and invest in and tokenization can create increased efficiencies. Meanwhile, commodities such as precious metals and carbon credits show region-specific adoption based on market maturity and regulation.

Current vs. target adoption

Each asset class is following its own adoption path, ranging from tokenizing existing assets to issuing them natively on-chain. While any electronic asset can, in principle, be natively issued, fixed income instruments – such as bonds – have advanced faster due to their simple structures and ability to be issued as a digitally native token. In contrast, real estate and physical commodities are limited by their off-chain nature and cannot be natively issued in the same way. Similarly, off-chain funds often take on-chain assets and wrap them into traditional structures such as exchange-traded funds (ETFs).



3.2 Asset issuance

Equities

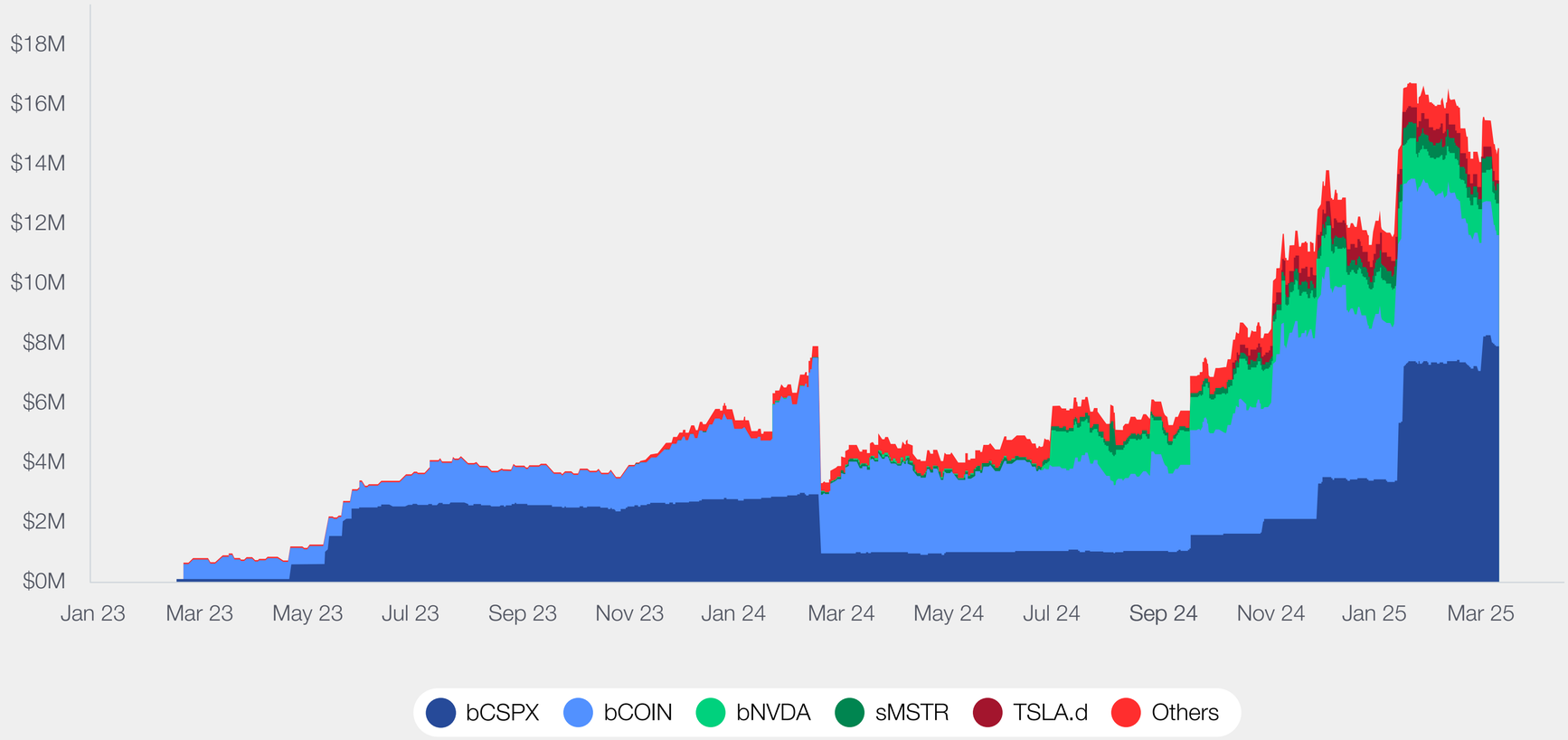
Public equities are shares of publicly traded companies listed on stock exchanges and offered to a broad investor base. The global public equity market was valued at nearly $115 trillion in 2023.[10] The market capitalization of tokenized public stocks was estimated at nearly $16 million by March 2025.[11]

Current public equities markets in AEs are already highly efficient and benefit from decades of technology modernization and proven intermediary chains delivering financial services. Due to existing efficiencies in AEs, tokenizing public equities may not be prioritized over other asset classes.[12] However, opportunities exist, particularly in EMEs, to improve efficiencies and provide access to equity markets.[13]

FIGURE 7

Tokenized stocks

Backed-issued stocks bCSPX, bCOIN and bNVDA represent almost 90% of tokenized stocks in value.



Source: Blockworks Research, RWA.xyz

These are examples of tokenization benefits in public equity markets:

1. **Enhances information symmetry**
   Embedding IPO listing criteria directly into tokens can enhance distribution efficiency and transparency.[14] This could be beneficial as public firms demonstrate faster growth after receiving equity because of superior information efficiency by aggregating known information into the stock price and through robust governance mechanisms, improving the investor experience.[15]

2. **Facilitates operational efficiency**
   Corporate actions represent capital markets' largest unstructured data challenge, with more than 3.7 million event announcements annually in the US alone and costing each participant $3–5 million annually.[16]

3. **Expands accessibility**
   Traditional foreign public equity investments involve costly processes such as immobilizing stocks into depository receipts and incurring administration, custody and FX fees.[17] Tokenization could mitigate these costs by embedding compliance directly into assets and improving secondary market liquidity.[18]

Tokenization is just one enabler for realizing compliance of on- and off-chain data; additional processes are usually also necessary (e.g. identity checks and legal checks). Despite these advantages, tokenizing already-efficient public equity markets, particularly in AEs, faces challenges. Public equities today benefit from robust governance and efficient price discovery.[19] To achieve adoption, tokenization must deliver substantial value and clarify where these assets would be traded in new venues such as DEXs or other digital trading venues.

CASE STUDY 1
Equities
Click to open
case study details

Fixed income

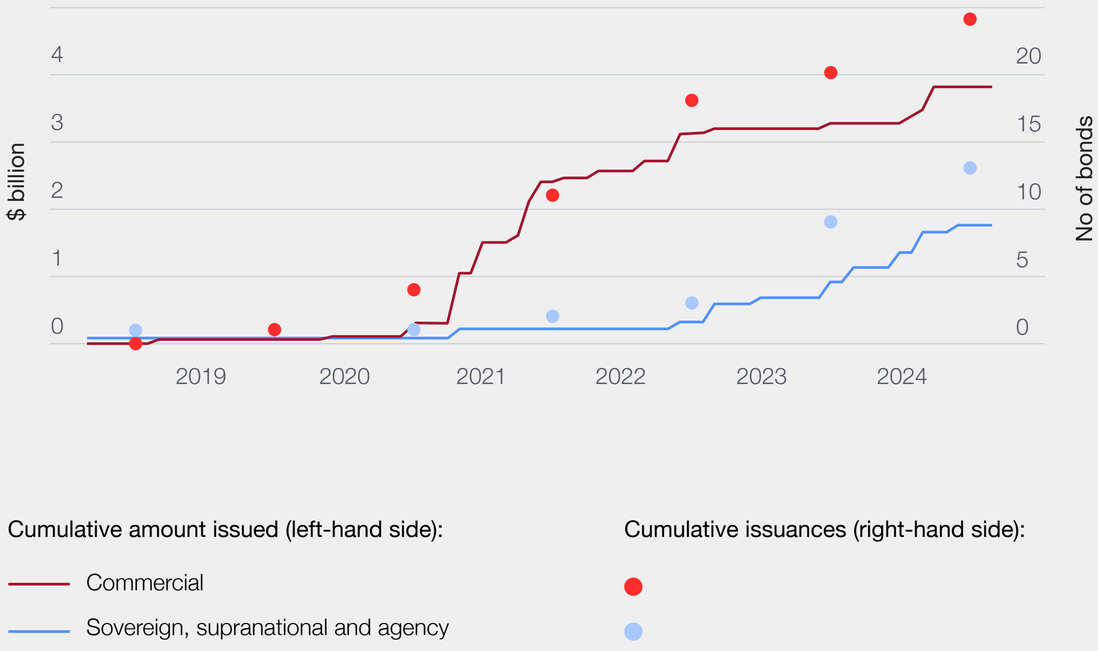
Fixed-income securities are debt instruments issued by a government, corporation or other entity to finance their operations. They provide investors with a return in the form of fixed periodic payments and the eventual return of the principal at maturity.[20] The global fixed-income, or bond, market was valued at approximately $140.7 trillion in 2023.[21] Fixed-income tokenization has seen notable advances in sovereign, corporate and municipal bonds.

According to an Official Monetary and Financial Institutions Forum (OMFIF) survey of 26 financial institutions, 65% believed that bonds were the most likely to be tokenized.[22] For example, the European Investment Bank (EIB) has issued several bonds on-chain, proving the feasibility of tokenization. Since 2021, with its inaugural digital bond issued on Ethereum, the EIB has issued five bonds, most recently using HSBC's Orion platform for issuance and the Banque de France's DL3S platform for settlement.[23]

FIGURE 8

A growing number of issuers are experimenting with tokenized bonds

Commercial vs. sovereign, supranational and agency tokenized bonds



Based on the subset of tokenized bonds with an available International Securities Identification Number (ISIN).

Source: Aldasoro, I., Cornelli, G. Frost, J., Koo Wilkens, P., & Shreeti, V. (2025). *Tokenisation of government bonds*, mimeo

Sovereign bonds

Government or sovereign bonds are debt securities issued by national governments, often considered low-risk investments and used as benchmarks for interest rates. They are critical for funding government operations and old debt or interest. They also play an integral role in institutional portfolios, providing predictable returns and aiding in retirement planning.[24]

Government authorities are gradually endorsing tokenized public debt, evidenced by His Majesty's Treasury's plans for a digital gilts pilot in the UK Finance's comprehensive roadmap,[25] the US Commodity Futures Trading Commission acceptance of tokenized treasuries as non-cash collateral[26] and the US Treasury's acknowledgment of potential operational benefits.[27] In Hong Kong, the government has committed to the issuance of tokenized bonds as standard practice. The Hong Kong Monetary Authority (HKMA) is preparing to issue the third tranche of tokenized bonds, while actively exploring tokenizing existing bonds.[28] Collectively, there is a progressive shift towards adopting tokenization for sovereign securities.

Corporate bonds

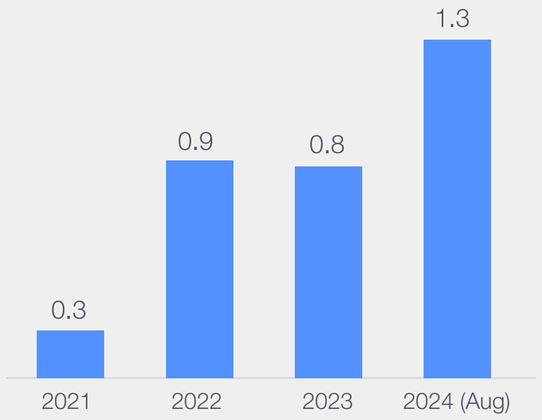
Corporate bonds are issued by companies to raise capital, offering varied yields and risk levels depending on the issuer's creditworthiness. Tokenized corporate bonds represent a form of debt in capital markets, enabling fractional ownership, streamlined settlements and broader investor access.

For example, the Societe Generale FORGE in France has demonstrated how tokenized corporate bonds can comply with regulatory requirements while benefitting from on-chain settlement efficiencies.[29] Nomura's partnership with BOOSTRY in Japan illustrates a growing regulatory acceptance of tokenized corporate bonds, reflecting a global innovation trend in financial assets.[30]

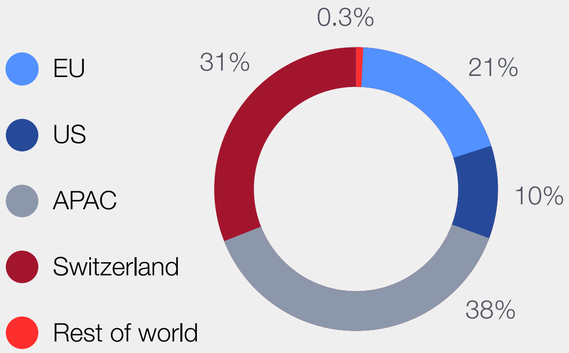
FIGURE 9

Global issuance of DLT-based bonds in billions of euros and by location

Global issuance of DLT-based bonds (in EUR Bn)



% of total issuance volume DLT-based bonds by location (since 2021)



Source: Association for Financial Markets in Europe. (2024). *Use of DLT and tokenisation in financial markets*

Municipal bonds

Municipal bonds are issued by local or regional governments to fund public projects, often providing tax advantages to investors. The Six Digital Exchange (SDX) announced in May 2024 that it had achieved more than 1 billion Swiss francs ($1.2 billion) in assets on its digital asset platform. Part of the success of these digital bond issuances on its platform is due to the availability of atomic settlement (e.g. DvP), using tokenized central bank money as part of the Swiss National Bank's wCBDC limited phase pilot.[31]

Examples of tokenization benefits in fixed-income markets include:

1. **Enhances information symmetry**
   Bonds can be tokenized to create and track metadata across the following parameters: issuance amount, maturity, coupon, features and corporate actions, approved operators and transfer conditions.[32]

2. **Facilitates operational efficiency**
   Tokenized bonds lowered underwriting fees by an average of 0.22% of the bond's par value, reducing 5.3% bid-ask spreads on average and with the efficiencies compounding when including retail.[33] DLT can automate up to 2,000 tasks in the bond issuance process,[34] which can take up to 12 weeks, save 800–1,000 person hours during issuance and reduce book-closing periods by more than 50%.[35]

3. **Expands accessibility**
   Conventional bonds have high minimum buy-in thresholds, limiting investor access. Tokenization can lower this barrier by fractionalizing the assets and easing the operational burden. Low investment thresholds with conventional bonds have operational burdens, including paperwork and resource costs. Lowering thresholds in public markets could increase the likelihood of regulatory limitations.

CASE STUDY 2
Fixed income
Click to open case study details

Alternative assets

Private equity

Private equity (PE) is ownership stakes in companies not listed on public exchanges, typically held by institutional investors and requiring longer investment horizons in exchange for potentially higher returns. The size of the global PE market reached approximately $5.3 trillion in 2023 and shows signs of continued growth.[36] Some projections are for the total PE/venture capital market to grow to $7 trillion by 2030, with roughly 10% being tokenized by that same time.[37]

PE markets are considered less efficient than public markets due to limited information flow and transparency. Investment in private markets relies heavily on intermediaries (fund managers) to source and evaluate deals, resulting in performance disparities.[38]

Tokenization has emerged as a potential solution to these inefficiencies by digitizing ownership in funds or companies. Industry research shows that 73% of European fund managers anticipate that PE will be the first asset class to experience significant tokenization, driven by a need to improve liquidity, transparency and accessibility.[39]

The following benefits could be achieved:

1. **Enhances information symmetry**
   Tokenization can drive increased data sharing and adding disclosures to PE can drive more transparency in the currently opaque private markets.[40]
2. **Facilitates operational efficiency**
   Tokenization, if applied, should reduce frictions associated with operational and technological aspects instead of altering the deal-structuring and relationship-based nature of these markets.
3. **Expands accessibility**
   For example, in 2021, ADDX tokenized units from Partners Group's €5.5 billion ($6.2 billion) PE fund, allowing fractional investments as low as $10,000 (previously $100,000-plus), greatly expanding investor accessibility via lower minimum investment thresholds and complying with regulatory standards.[41]

Several firms have already taken steps to tokenize PE investments. Recently, Aurum Equity Partners launched the world's first combined PE and debt tokenized fund valued at $1 billion on the XRP Ledger, an open-source and decentralized Layer-1, to drive worldwide data centre investment, enabling enhanced investor access and liquidity through secondary markets.[42]

However, private markets derive much of their value from the individual nature of deals, which require research and structuring to deliver investor value. Tokenization may not always be necessary to achieve benefits. For example, EquityZen and Forge Global are two marketplaces offering retail investors a minimum investment threshold of $5,000 and they do not use DLT.[43]

CASE STUDY 3
Private equity
Click to open
case study details

Private debt

The terms “private debt” and “private credit” are used interchangeably and refer to non-bank lending or bonds outside traditional markets used to fund private businesses.[44] The global private credit market has surpassed $3 trillion in assets under management (AUM).[45] This asset class consists of higher-risk loans with higher-interest rates than conventional debt. Unlike public debt, private debt is issued by non-bank entities or individuals to raise funds or form capital.

Private debt can attract investors, offering higher returns and risk. Private-sector leaders believe private debt will be the first asset class to be tokenized and routinely traded.[46] About 70% of private-debt investors are institutional investors or entities investing on behalf of an individual, typically a private credit fund.[47]

Most private loans on-chain are direct loans to institutional crypto investors. These loans mostly appeal to high-net-worth individuals and accredited investors as yields range from 9% to 20%. However, they carry risks in that the collateral posted is limited in diversity.[48] Because crypto-assets such as Ethereum back most loans, significant market corrections of these assets could affect the lending positions of the holders.

Examples of the benefits of tokenization for private debt include:

1. **Enhances information symmetry**
   Transaction flow would be in real time, providing data on underlying assets at all times.[49]

2. **Facilitates operational efficiency**
   Smart contracts reduce and mitigate back-office costs and lower transaction costs and management fees.

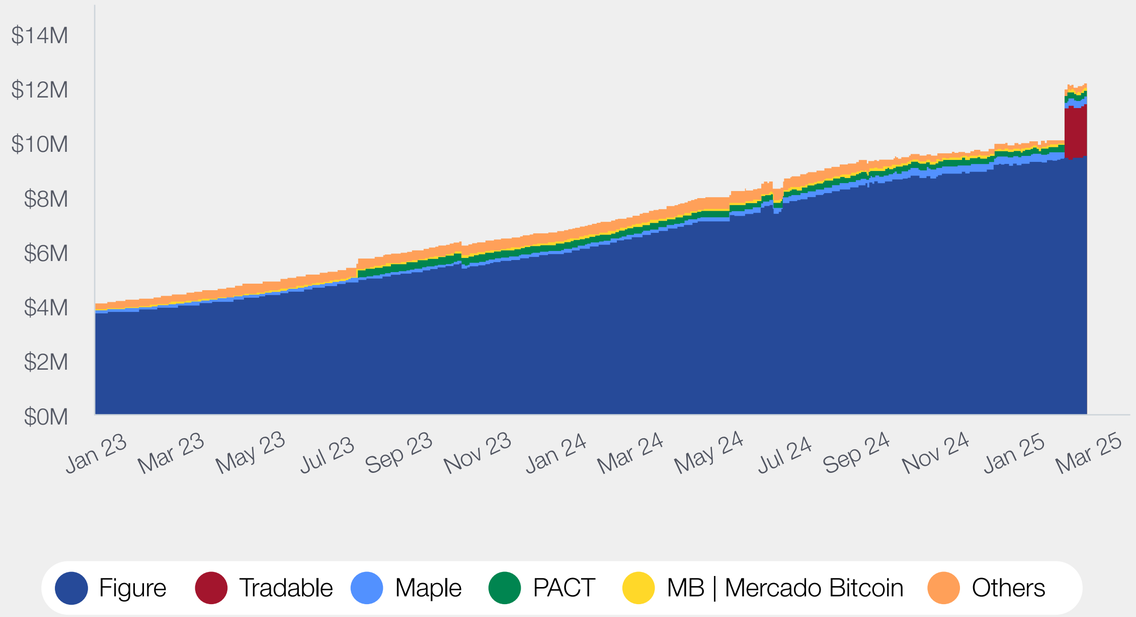
3. **Expands accessibility**
   Easing the process of buying into private credit funds and of trading shares can increase the range of investors. For example, in 2022, KKR collaborated with Securitize to tokenize a segment of its $4 billion healthcare fund on Avalanche, reducing investment minimums and onboarding accredited investors, increasing reach.[50]

On-chain activity for private debt/credit is increasing but is largely limited to crypto-assets and select corporate bond issuances. Protocols such as Maple, Goldfinch and Centrifuge have driven more than $13 billion in on-chain loans in public networks, including Ethereum and Solana.[51]

FIGURE 10

Tokenized private credit by issuer

Figure represents almost 80% of the value of outstanding tokenized private loans



Source: Blockworks Research, *RWA.xyz* (2025)

Real estate

Real estate as an asset class refers to investments in real property and is characterized by its physical nature and potential for both income and capital appreciation.[52] The global real-estate market was valued at approximately $379.7 trillion at the end of 2022, encompassing residential, commercial and agricultural properties.[53]

Tokenizing real estate involves converting property ownership into digital tokens on a programmable ledger, facilitating fractional ownership and potentially enhancing liquidity in this traditionally illiquid market. The total value of real estate brought on-chain is estimated to be between $4 billion and $20 billion, underscoring a large remaining addressable market.

Real estate could benefit from tokenization for these reasons:

1. **Enhances information symmetry**
   Today's real estate markets are isolated and do not have connected systems of record. Tokenization could help with streamlining these records for stronger information symmetry. For example, a district administration in India digitized 700,000 land records dating back to 1950 on the Avalanche blockchain, addressing challenges associated with requests for information regarding records and their verifiability.
2. **Expands accessibility**
   This process can streamline transactions by reducing intermediaries and administrative overhead, making real-estate investment more accessible.[54]

However, regulatory uncertainties between jurisdictions and technological integration issues exist. Outstanding design choices remain related to the impact of tokenizing real estate on the local economy and deed transferability.[55] Existing investment vehicles such as real estate investment trusts (REITs), ETFs and direct funds offer similar benefits, potentially limiting the appeal of tokenization. Despite these hurdles, successful cases demonstrate the potential of this approach to democratize real-estate investment.

CASE STUDY 4
Real estate
Click to open
case study details

Commodities

A commodity is a physical good attributable to a natural resource that is tradable in physical (spot) markets and in future and forward markets.[56] The nominal value in the commodities market is projected to reach $142.85 trillion in 2025.[57]

Precious metals

Precious metals are valued for their scarcity and used as hedges against inflation and economic uncertainty. The tokenization of precious metals, particularly gold, has become a significant use case in financial markets. The total capitalization of the physical gold market, excluding the jewellery market, is estimated at $5 trillion in 2024.[58] While traditional methods of investing in gold, such as physical gold, coins and ETFs, have existed for years, tokenization offers a unique opportunity to broaden access to gold.

Several organizations have introduced gold-backed digital tokens, including Paxos, Tether, WisdomTree and HSBC.

The following opportunities are presented with gold-backed tokens:

1. **Expands accessibility**
   Gold-backed tokens make it possible for investors to purchase fractional amounts, lowering the entry barrier and enabling a wider range of participants – such as retail investors – to gain gold exposure.

2. **Enhances user-centricity**
   Through mobile applications and more flexible custodial arrangements, the ease of holding gold or the exposure to gold improves as compared to investing in gold today.

3. **Promotes multi-asset mobility**
   Tokenization of gold could allow free usage as collateral without traditional limitations such as storage.[59]

As highlighted in the section on backed tokens, gold-backed tokens are not without their hurdles and risks.

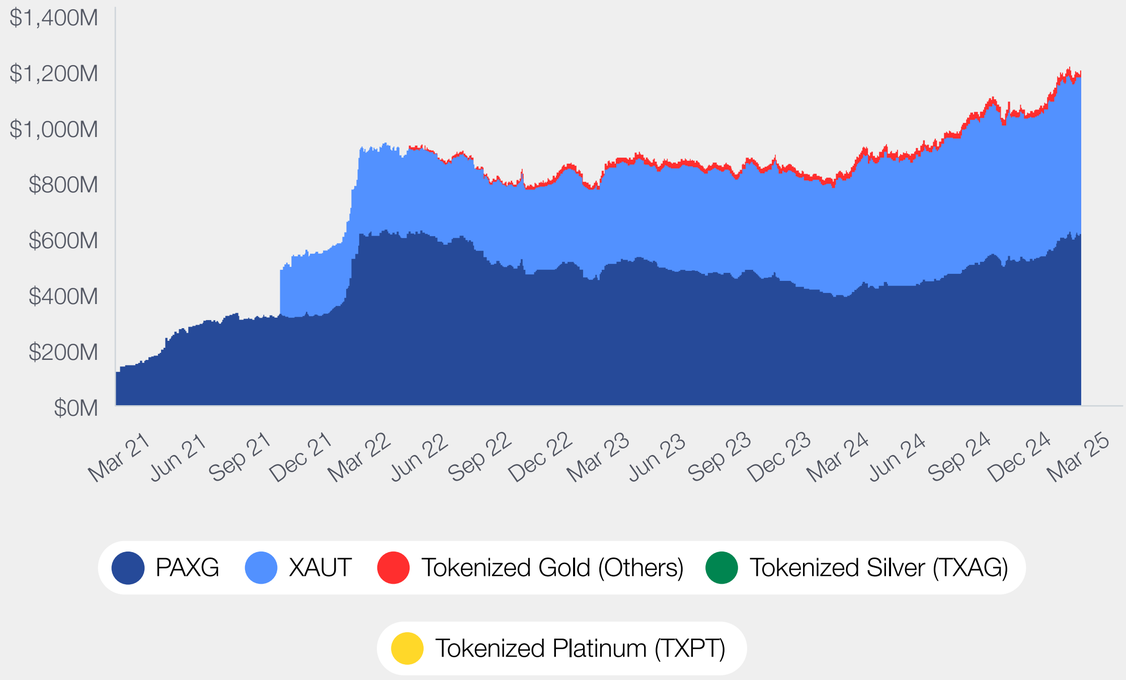
A leading challenge is integrating physical and digital worlds, especially securing and storing metal or stone.[60] Today's model relies heavily on custodians' safekeeping and auditors verifying reserves, potentially creating concentration risk. Due to operational challenges, not all gold-backed token providers offer physical redemption. Fractional ownership is possible, but physical redemption depends on the issuer.

Gold-backed tokens' continuous, 24/7 nature can cause price dislocations when integrated with conventional markets, which operate only Monday through Friday.

FIGURE 11

Tokenized commodities by product

Paxos' PAXG and Tether's XAUT, both tokenized gold products, account for 99% of the tokenized commodity market

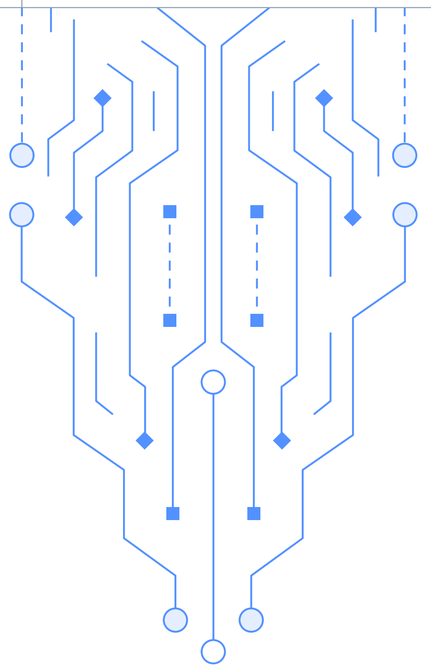


Source: Blockworks Research, *RWA.xyz*. (2025)

TABLE 3

Comparison of gold investment vehicles

MODEL	DESCRIPTION	ADVANTAGES	TRADE-OFFS
Physical bars and coins	Tangible ownership of gold bars or coins purchased from dealers, mints or secondary markets.	— Direct exposure to tangible asset — Minimal to no counterparty risk	— High storage and security costs — Limited liquidity — High spreads
Vaulted physical gold	Investor owns allocated or unallocated gold stored in vaults. They receive a claim/ certificate rather than holding metal.	— Professional storage and security — High liquidity and trading availability	— No direct ownership — High minimum investments — Custody, redemption fees
Gold contracts (futures)	Standardized contracts to buy/sell gold on a set future date, traded on regulated commodity exchanges.	— No storage or security costs — Highly liquid and ease of trading	— No direct exposure — Settlement cycle-dependent
Gold ETFs	ETFs that track the gold price and usually hold physical gold or futures contracts.	— Low transaction costs — Transparent pricing — Enables creative investment strategies, such as leveraging gold exposure through derivatives or use of collateral	— Reliance on custodians — Liquidation depends on exchanges — Inaccessible for those in regions with underdeveloped financial infrastructures — Supply-chain challenges for physical redemption
Gold-backed tokens	Digital tokens on a programmable ledger that represent a claim on physical gold stored by a custodian.	— Fractionalized and easily accessible — Continuous trading availability — Traceability and verifiability — Instant and atomic settlement	— Potential for price dislocation during weekend trading — Platform and custodian risk — Supply-chain challenges for physical redemption



CASE STUDY 5
Precious metals
Click to open case study details

Carbon credits

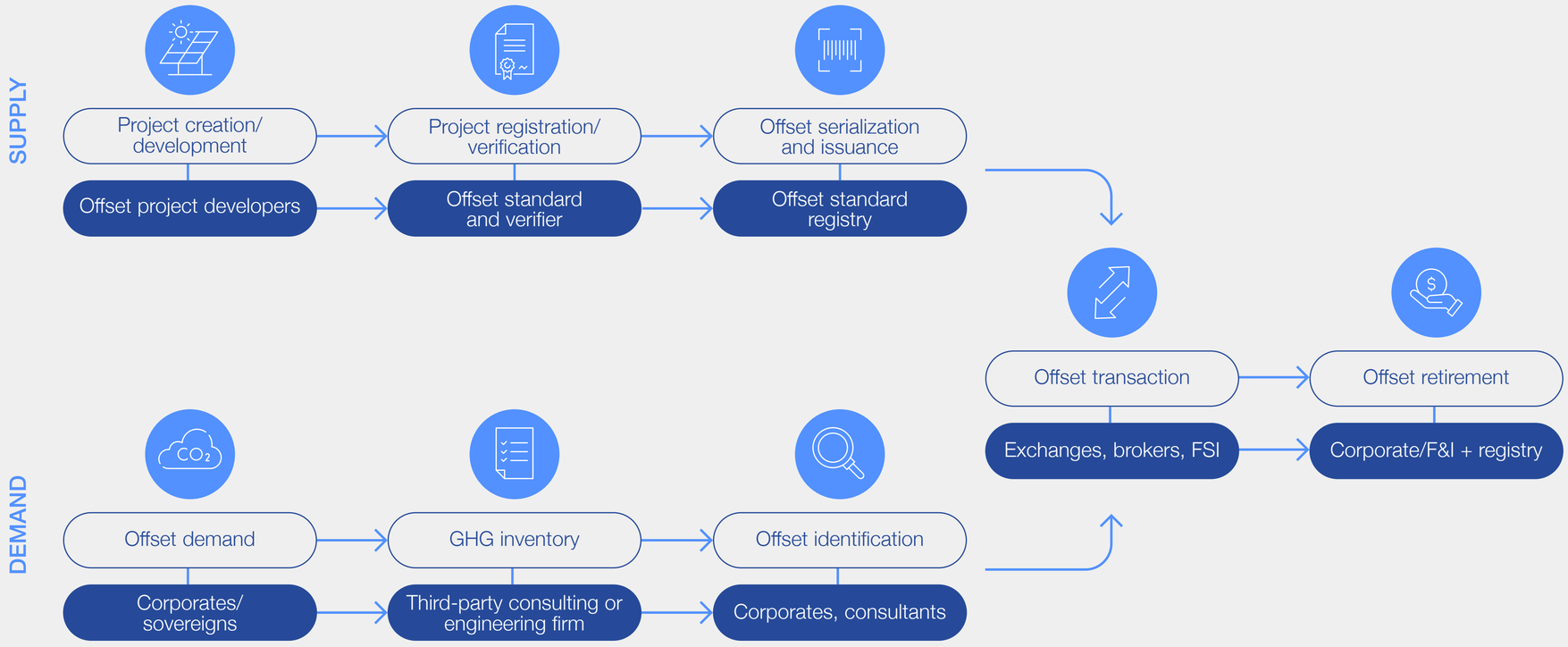
Carbons credits (CCs) are tradable permits that represent the right to emit a specific amount of carbon dioxide (CO_2), supporting global efforts to reduce emissions. The global CC market is valued at around $1.4 billion.[61] A carbon credit is a financial asset that represents ownership of 1 metric ton of CO_2 equivalent and can be traded or sold to meet a mandatory emissions cap or a voluntary emissions reduction target.[62] CCs are integral to both compliance and voluntary carbon markets, enabling entities to offset their greenhouse gas (GHG) emissions.[63]

As a standardized measure for emissions, these credits are used by corporations to counterbalance their GHG emissions stemming from operations.[64] CCs can be tokenized – whether natively issued on a programmable ledger or immobilized off-chain and issued on-chain.

As of 2023, more than 3,400 companies have committed to net-zero emissions, with the VCM valued at approximately $723 million.[65] However, only 188 companies actively invest in carbon dioxide removal (CDR), highlighting a gap between commitments and tangible actions. The market size for VCMs is around $2 billion, with conservative estimates putting it at $50 billion by 2050.[66]

FIGURE 12

The carbon offset life cycle



Source: Accenture (2024)

A leading example is AirCarbon Exchange (ACX), a global platform changing the VCM by providing a transparent, efficient trading system for environmental assets.[67] Another example is the recently successful proof-of-concept pilot of using tokenized deposits to settle carbon credits, led by Standard Chartered, Mox Bank, Mastercard and Libeara.[68]

The CC market could benefit from tokenization for the following reasons:

1. **Enhances information symmetry**
   Tokenizing CCs can enhance transparency, traceability and liquidity in carbon markets. This process streamlines issuance, trading and retirement, reducing administrative costs and minimizing risks such as double-counting and greenwashing.
2. **Facilitates operational efficiency**
   Smart contracts automate transactions, ensuring compliance with regulatory standards and boosting market efficiency.
3. **Expands accessibility**
   Tokenization democratizes access, allowing individuals and smaller organizations to participate in carbon offset initiatives, broadening market reach and impact.

CCs have faced scrutiny due to concerns about overstated emission reductions and the actual impact of offset projects. To address this, the Integrity Council for the VCM (ICVCM) introduced the Core Carbon Principles to enhance buyer confidence by ensuring rigorous baseline fuel determination and usage monitoring. To advance the development of carbon credits using DLT, the InterWork Alliance's Voluntary Ecological Markets set forth principles for further collaboration.[69]

CCs can vary in quality, prompting standards bodies to implement stringent issuance and trading standards to prevent low-quality CCs from entering markets. While tokenization alone cannot fully address these challenges due to operational and human factors, integrating smart contracts with robust governance can standardize and enhance the quality of tokenized CCs.

3.3 Securities financing

Securities financing transactions allow investors and firms to use assets, such as the shares or bonds they own, to secure funding for their activities.[70]

Collateral

This report identifies collateral and repurchase agreements (repos) as a key application of tokenization. The global collateral market is estimated to be worth more than $25 trillion.[71] Collateral refers to what is posted and received – typically a liquid and secure asset – pledged to support a financial transaction, providing default protection. Collateral is fundamental to managing counterparty risk and ensuring the smooth functioning of financial markets by mitigating credit risk. The ideal collateral should be free from credit and liquidity risks, maintain a stable value and not correlate with the provider's credit risk.[72]

Programmable ledger-powered collateral management could unlock more than $100 billion annually in capital that can be redeployed for higher efficiency.[73] This objective of improving collateral mobility is at the heart of emerging tokenized collateral management platforms, such as JP Morgan's Total Collateral Network (TCN), HQLAx and the Canton Global Collateral Network (GCN), which all aim to address the historical challenge of orchestrating complex cross-custodian movements of collateral, or the transfer of ownership countries between custodians through real-time, compliant and interoperable asset mobility between traditional and digital markets.[74] This fragmented custodian landscape tends to be costly and dependent on non-overlapping operating hours. Collateral mobility is measured by a participant's ability to identify the right collateral to be moved to the right party at the right time.[75]

Acceptable collateral frameworks

Current regulatory frameworks and jurisdiction-specific rules limit which investors can hold, pledge or accept collateral, which hinders efforts to trade collateral across borders. Policy-makers and the private sector should clarify the set of eligible tokenized collateral, including potentially expanding the scope of acceptable collateral.

Repurchase agreements

Intraday repo is observed as the primary area of adoption of tokenization. A repo is a short-term loan where one party sells securities to another in exchange for cash, with an agreement to buy them back later at a higher price. Repos are a common way for financial institutions to obtain short-term funding.[76] The global repo market is very large, with an estimated size of more than $15 trillion in outstanding value and a daily turnover of around $3–4 trillion.[77]

Due to their high turnover, repo markets face several inefficiencies and risks. Manual and fragmented workflows rely on outdated and disconnected systems, leading to delays, errors and costs. Additionally, settlement inefficiencies are born from the many intermediaries coordinating complex transactions – rapid buy and sell orders – that have led to longer settlement cycles, liquidity constraints and counterparty risks.

Tokenization offers three benefits for collateral:

1. **Enhances information symmetry**
   Money market funds (MMFs) are not directly used as collateral because of data reconciliation challenges between counterparties driven by their complex ownership structures. Tokenization's shared system of record could bring visibility into the custodial relationship with underlying fund owners, reducing the burden of managing relationships between transfer agents, custodians and counterparties.

2. **Facilitates operational efficiency**
   Enables real-time position tracking and instant transfers of ownership.[78] Programmability can automate asset servicing and maintain a shared record to ease operational burdens associated with maturities, dividends and coupon payments.

3. **Promotes multi-asset mobility**
   Allows participants to extend asset usability through digitally represented collateral across subsequent transactions by using the platform's programmable and composable smart contracts. For example, a pilot on the Canton Network with Euroclear and the World Gold Council found that gold-backed tokens allow freer usage as collateral.[79] SDX and SIX Securities Services are bringing to market the new Digital Collateral Service (DCS), specifically designed to enable the usage of selected crypto-assets as collateral alongside traditional collateral.[80]

CASE STUDY 6
Repurchase agreements
Click to open
case study details

3.4 Asset management

Funds

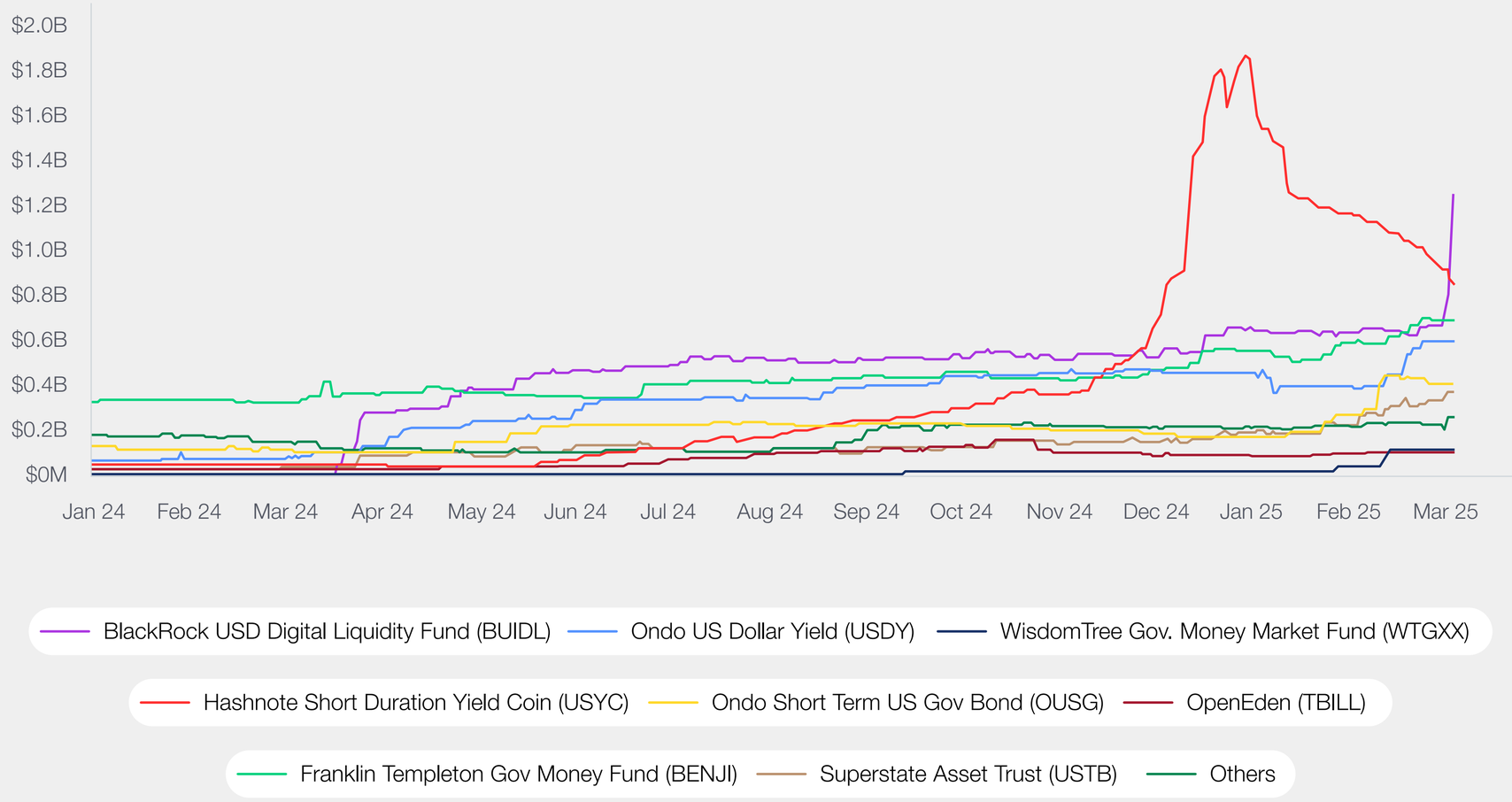
Two primary fund structures are relevant to tokenization: on-chain funds, which tokenize conventional assets, and off-chain funds, such as ETFs, that invest in programmable ledger-native assets.

On-chain funds

On-chain funds represent traditional assets as digital tokens on a programmable ledger, facilitating broader investor access on new digital channels and direct trading without central clearing parties. This approach is intended to reduce operational costs and broaden investor access. On-chain funds today are backed by off-chain reference assets or tokenized versions of traditional securities. Estimates indicate that tokenized treasuries have grown from $104 million to $5 billion in market capitalization since 2023.[82] Examples such as Franklin Templeton's Benji and Ondo Finance's USDY have succeeded in bringing off-chain treasuries and other high-quality liquid assets (HQLA) on-chain.

FIGURE 13

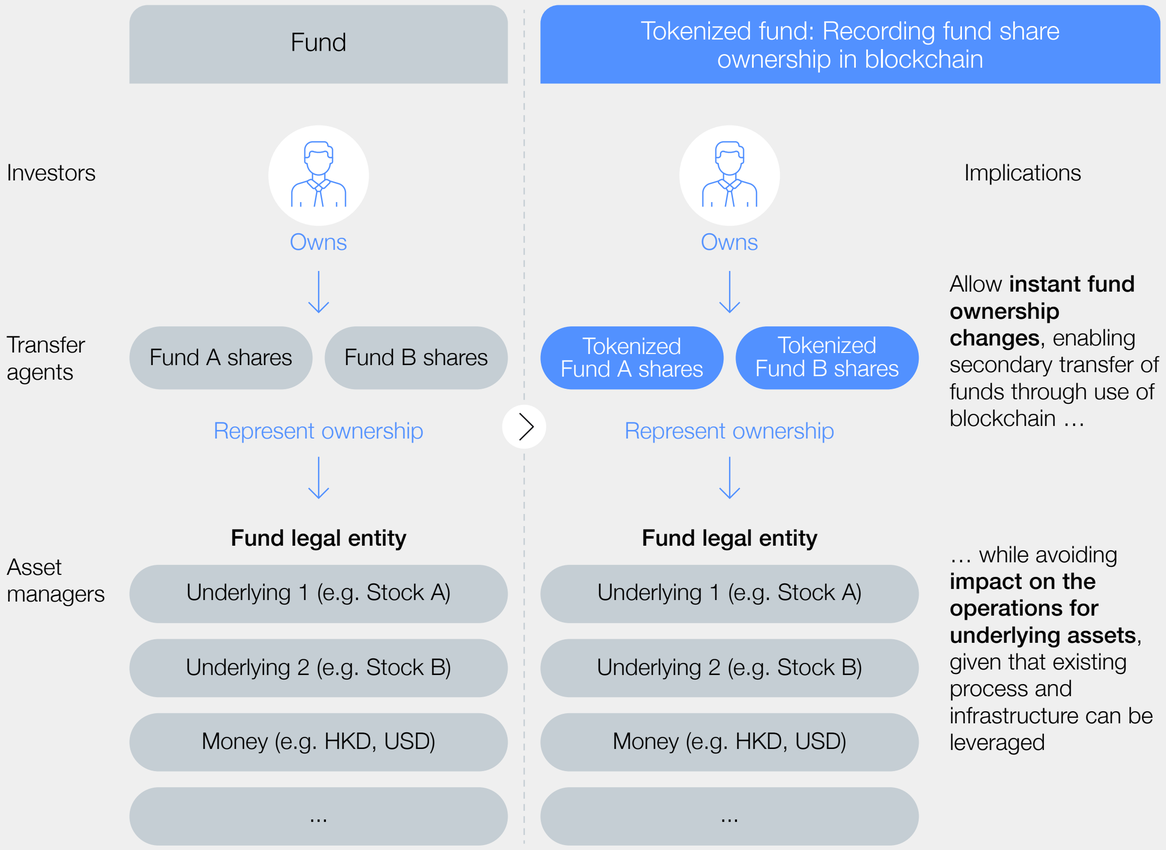
Tokenized US Treasuries by product



Source: Blockworks Research, *RWA.xyz*. (2025)

FIGURE 14

Traditional funds vs. tokenized funds



Source: Boston Consulting Group

However, a future trajectory points towards the development of funds composed of natively issued digital assets. Such a shift could improve transparency in the complex ownership structures of instruments such as MMFs. Greater clarity around ownership claims may enhance the suitability of MMFs for use as collateral, potentially supporting broader adoption.

There is, however, limited evidence so far to suggest these funds significantly reduce costs, such as fund administrator fees, when compared to conventional models. Often, these funds also provide investor returns that are more in line with their conventional counterparts.

Notable examples include:

- In 2021, Franklin Templeton launched the Franklin OnChain US Government Money Fund (FOBXX), the first US-registered mutual fund to use a public programmable ledger for transaction processing and share ownership recording.[83] Initially on the Stellar network, the fund expanded to other programmable ledgers, including Avalanche and Polygon, demonstrating adaptability. BENJI is the user-facing portal for retail investors to buy and hold shares of FOBXX using digital wallets, and BENJI tokens represent ownership in FOBXX and are recorded on-chain.
- In June 2024, Fidelity International tokenized shares of an MMF on Kinexys Digital Assets, piloting a tokenized MMF on the Tokenized Collateral Network (TCN). The fund's transfer agent (JP Morgan) and the TCN coordinated the tokenization, which improved efficiency in delivering margin requirements and reducing transaction costs and operational frictions by serving as collateral in clearing and margining transactions.[84]
- In January 2025, Fasanara Capital introduced its first tokenized MMF, the Fasanara MMF Token (FAST), on the Polygon blockchain in collaboration with Tokeny and others. This fund offers investors enhanced efficiency and transparency in money market investments.[85]

CASE STUDY 7

On-chain fund

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Off-chain funds

Conversely, off-chain funds such as ETFs provide exposure to digital assets without directly holding them on a programmable ledger. The crypto-asset ETFs are not tokenized financial products, though they are covered in this report to capture an expansive view of the integration of tokenized and traditional markets.

By November 2024, the spot crypto-asset ETFs worldwide reached approximately $136 billion in AUM, with the United States accounting for nearly 95% of this total.[86] These funds invest in cryptocurrencies such as Bitcoin (BTC), Ethereum (ETH), offering traditional investors a familiar TradFi vehicle to access the crypto market. For instance, Franklin Templeton filed for an ETF to track the spot price of Solana, indicating a growing interest in diversifying crypto-asset offerings.[87]

4

Barriers to adoption

Tokenization’s success relies on overcoming several barriers that exist in financial markets today.

4.1 Traditional financial infrastructure

One path for driving network effects and liquidity is the integration of tokenized markets with conventional systems. A challenge faced by financial services institutions is the reconciliation between the books and records of tokenized systems and their internal books, resulting in possible discrepancies or disputes on the official claim of the asset. Addressing challenges such as these requires a staged approach to using existing investments in supranational networks to secure transactions between traditional and tokenized systems. This can avoid costly new infrastructure, spur confidence, reduce risk and accelerate adoption.

Financial institutions can incrementally adopt tokenized assets by connecting public programmable ledgers to their existing infrastructure, beginning with non-cash assets and scaling as new forms of on-chain value emerge. For example, Chainlink, Swift and UBS Asset Management enabled tokenized fund transactions via Swift, reducing inefficiencies in the $63 trillion global mutual fund market.[88]

4.2 Global standards

Global tokenization adoption requires robust, harmonized standards. A lack of widespread industry collaboration and fragmented innovation is cited as a major factor in stymying the progress of the adoption of tokenization.[89] Estimates show 74% of DLT projects in 2023 had fewer than six participants, underscoring a need for wider participation.[90] Furthermore, while the legal and technical enablement of tokenization is foundational, only the engagement of market participants will advance adoption.[91]

Five critical areas that would need to align for widespread usage are: roles and responsibilities, token standards, the cash leg and settlement, cross-chain interoperability and reference data.[92] Standardization will require time and deep dedication and will possibly be performed in a staged manner to allow incumbents and digital natives to adapt. For example, the Hong Kong Monetary Authority convened a Programmability Working Group in 2024 to develop a common standard for programmability at scale. The system can realize transformative benefits by uniting around standards and inspiring global efficiency while boosting adoption and trusted market participation.

FIGURE 15

Common token standards (EVM)

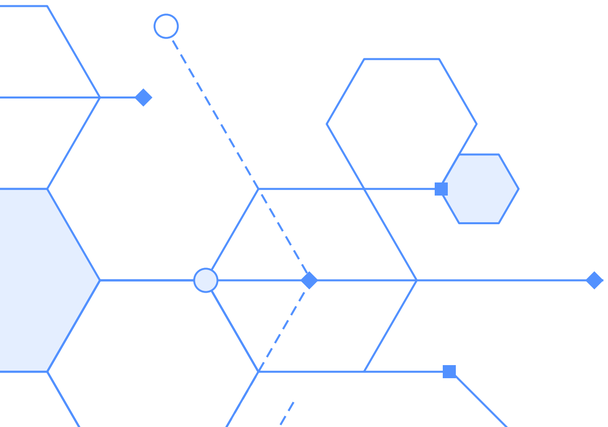
ERC-20 The fungible token standard	**ERC-721** The non-fungible token standard		**ERC-1155** Multi-token standard
	ERC-1400 Security token standard	**ERC-3643** The compliance-aware token standard	
CMTAT Swiss-compliant standard		**ERC-1450** Issuing and trading SEC-compliant securities	**ERC-2980** Swiss compliant asset token

Source: Nethermind & PwC Germany. (2025). *Tokenization Standards: The Missing Link for Institutional Adoption*.

Token standards are an important aspect of this global harmonization. ERC-20 today remains the dominant token standard, yet it lacks built-in compliance features.[93] It is for this reason that compliance-led tokens, such as ERC-1400 and ERC-3643 (T-REX Protocol), are gaining traction:

- **ERC-1400** allows for enhanced document management and investor protection, lending itself more to securities.
- **ERC-3643** embeds identity, know your customer/anti-money laundering (KYC/AML) and transfer conditions, unlocking new approaches to on-chain compliance.

Token standards should continue to evolve towards established regulatory frameworks, such as Markets in Crypto-Assets Regulation (MiCAR) in the Eurozone.



4.3 Cross-chain interoperability

Interoperability across private and public ledgers ensures seamless asset movement. Financial services entities had adopted at least 72 distributed or programmable ledgers as of May 2025 and driven 10 market forces that are accelerating the deployment of individual networks.[94] These networks are not all inherently interoperable and the importance of cross-chain interoperability is underscored to realize inter-network activity.

Emerging techniques reduce concerns regarding cross-chain interoperability, notably "honey-pot attacks", which result from non-canonical bridging. To mitigate this, Chainlink's collaboration with ANZ Bank, which successfully linked a private ledger to a public programmable ledger using the Cross-Chain Interoperability Protocol (CCIP), showed the potential for cross-chain liquidity. LayerZero has created its Omnichain Fungible Token (OFT) standard, which transfers fungible tokens across programmable ledgers without asset wrapping or middle chains.[95]

4.4 Secondary markets

In primary markets, assets are initially issued and purchased. Secondary markets involve trading after initial issuance. Today, there is a lack of sufficient secondary-market liquidity and depth for tokenized assets.[96]

Secondary markets are critical to liquidity, yet tokenized assets struggle to establish market depth.[97] Many tokenized assets could not yet attract sufficient secondary trading volume, leading to illiquidity and difficulty in accurate pricing. In fixed income, more than $15 billion in tokenized assets – bonds, structured products, commercial papers and funds – have been issued, as of 2024. However, nearly half of these initiatives report turnover below $1 million, highlighting a significant gap between expectations and actual activity.[98] Therefore, an implicit illiquidity premium can be applied to tokenized assets in today's markets. However, there is a lack of secondary-market data to fully demonstrate the benefits and drawbacks of the usage of tokenized assets.[99]

Prominent barriers include insufficient incentives for market makers to provide liquidity in predominantly over-the-counter (OTC) markets; high minimum investment thresholds in private placements, with fractionalization offering only partial relief due to administrative costs; regulatory hurdles hindering cross-border trading and collateralization; investor access often restricted to institutions; and listing fees discouraging dual-listing strategies, which traditionally boost liquidity – though UBS notably dual-listed a digital bond on both SDX and the SIX Swiss Exchange in 2022.[100] Enabling this is SIX's bidirectional bridge between traditional and digital central security depositories (CSDs) that enables assets to be issued, custodied or transferred on either venue.

Fragmentation risks emerge when providing liquidity, such as settlement assets, for secondary-market trading. For example, Target 2 is used in the Eurozone to provide security settlement services for all CSDs in the jurisdiction. Furthermore, introducing another on-chain cash system for a distinct secondary market could fragment the unity of cash for settlement.

Market makers require incentives to provide liquidity and inspire capital formation. Dual-listing can benefit issuers who seek to issue in their native jurisdiction, whether because of compliance requirements or allegiance to a target jurisdiction, to drive turnover with a dedicated pool of investors. Lastly, despite programmable ledgers' inherent decentralization goals, liquidity remains fragmented across platforms.

4.5 Privacy and compliance

Fragmented identity verification limits the growth of tokenized financial products. Standardized KYC is estimated to improve onboarding efficiency by up to 90% in fund management.[101] On-chain identities offer potential but raise privacy concerns.

Privacy is the capacity for individuals or organizations to dictate how and when their data is shared and is based on the principle of individuals controlling the degree to which they selectively express themselves digitally, including identifiers such as age, accredited investor status and nationality.[102] On-chain identities can range from fully identifiable to pseudonymous and anonymous. However, fully anonymous identities conflict with Financial Action Task Force (FATF) guidelines, which require due diligence for every financial customer and prohibit untraceable accounts.[103]

Privacy-enhancing technologies (PETs) such as zero-knowledge proofs and fully homomorphic encryption protect sensitive data while enabling compliance. For example, PETs, including pseudonymization and zero-knowledge proofs, are being explored by the BIS under Project Aurum 2.0 to advance retail CBDCs.[104]

Although anonymity provides better privacy safeguards in theory, it poses risks to KYC and AML compliance as it could allow bad actors to obfuscate on-chain illicit activities, which amounted to nearly $25 billion in 2021.[105]

Customer and transaction identification is essential for complying with KYC, AML, sanctions and the Travel Rule, making anonymous transactions unsuitable for regulated markets.[106] To address this, token standards such as ERC-3643 and ERC-5564 are emerging. ERC-3643 enables compliant transfers based on on-chain identity, while ERC-5564 supports privacy through stealth addresses and dynamic address generation.[107] Tokeny's DINO protocol uses ERC-3643 to facilitate compliant DvD transfers across platforms, executing only when both parties are KYC-verified.[108]

On-chain identity enforcement often follows allow- or deny-list models. Allow-lists enhance security but limit inclusivity, while deny-lists are more open but require constant monitoring to mitigate risks from malicious actors.

Achieving privacy on-chain is not without its hurdles and trade-offs. While unlikely, storing personal data on-chain raises concerns about regulations such as the General Data Protection Regulation (GDPR)'s "right to be forgotten".[109] Because public networks have mixer and tumbler decentralized applications that can hide the trail of who sent and received crypto (by blending or shuffling transactions), users can mostly stay anonymous – even though wallet addresses are partly visible. Another hurdle is quantum-safe PETs, as not all PETs are protected against quantum attacks, which can break encryptions and leak sensitive data. Additionally, compliance with the FATF's Travel Rule is heightened when handling tokenized asset transactions, and the number of jurisdictions requiring compliance in the form of tracking originator and beneficiary data in an on-chain setting is growing.[110]

TABLE 4

Advantages and trade-offs of allow- and deny-list models

MODEL	ADVANTAGES	TRADE-OFFS
Allow listing	— Tighter security and control — Simplified compliance checks — Clear accountability and audit trails	— Reduced privacy and anonymity (must disclose information) — High maintenance overhead — Excludes unlisted (possibly legitimate) users
Deny listing	— More open and inclusive — Less friction for onboarding — Default user privacy preserved	— Reactive approach (must constantly update list) — Bad actors can create new identities — Potential for false positives or censorship

5

Impacts of tokenization

Tokenization is catalysing changes across market structures and the financial market value chain.

5.1 Evolving market structures

Tokenization will change intermediary roles, not eliminate or displace them.[111] Reducing intermediaries is often hailed as a value driver for tokenization; however, reducing or eliminating intermediaries is not always beneficial, as incumbents provide valuable services to maintain safety and soundness. For example, Phase 2 of the e-HKD pilot demonstrated that intermediaries could act as dynamic facilitators of liquidity and trust by managing separate liquidity pools for instant retail CBDC-to-fiat conversion to bridge tokenized and traditional systems and ensure adoption where tokenized assets are not yet widely accepted.[112]

Market structures – including the buy/sell side (e.g. wealth managers, asset managers), issuers (e.g. a public government issuing securities or a corporation issuing bonds), exchanges, CCPs, CSDs, custodians and transfer agencies (TAs) – are evolving to adapt to tokenization.

Full disintermediation in regulated financial markets has been demonstrated experimentally. For example, DekaBank issued and sold a digital bearer bond without intermediaries.[113] This should be viewed cautiously as intermediaries thwart harmful market practices and, instead, markets should evaluate the roles of incumbents alongside new entrants.

Regulators are advancing the collective understanding of enhanced market structures through industry initiatives, including the United Kingdom's Digital Securities Sandbox and the European Union (EU) Pilot Regime. Project Guardian led by the Monetary Authority of Singapore also serves as another platform for the collaborative design of a tokenized value chain.

While the asset life cycle will remain unchanged, tokenization reshapes interactions among incumbents and digital-native service providers to meet new demands for speed, efficiency and compliance. Incumbent responsibilities will likely evolve in parallel with the introduction of digital-native market structures and service providers, creating a platform for product innovation.

5.2 Changes to incumbents

Incumbent responsibilities will expand to offer new value propositions.[114] For example, 21X launched a regulated exchange and settlement system on Polygon after being licensed under the EU Pilot Regime's exemptions from CSD Regulations and Markets in Financial Instruments Directive requirements, allowing the integration of a conventional exchange and CSD into one smart contract for trading.[115]

What will remain a constant is the preference for trusted intermediaries, particularly where centralized services, such as custody and regulatory compliance, are critical.

Buy/sell-side (asset managers, wealth managers, brokers/dealers)

The sell-side traditionally handles trade execution and client relationships with the buy-side, while the buy-side manages portfolio strategies and client relationships with end investors. Tokenization expands their role to include reusable digital identity verification, advising on token portfolios, underwriting assistance, automated ordering on digital exchanges, on-chain settlements with on-chain cash, self-custody wallets (e.g. Robinhood's Non-Custodial Wallet) and automated rebalancing/yield strategies using tokenized platforms.

Issuers

Issuers are traditionally tasked with capital raising and corporate actions, issuers are now making use of tokenization for on-chain capital formation, automated corporate actions (e.g. voting) and programmable asset terms, thus enhancing efficiency and transparency. Issuers often incur underwriting, legal, exchange listing and registration fees – all aimed to be reduced by tokenization.

Exchanges

Tokenization modernizes exchanges by enabling programmable trading restrictions via digital identities (e.g. insider trading controls), supporting tokenized listings (e.g. Deutsche Börse's digital exchange) and merging traditional and decentralized models (e.g. AMMs), thereby enhancing compliance and market accessibility.

Central counterparties

CCPs mitigate counterparty risk through collateral management and trade intermediation. In tokenized markets, they may evolve into governance-focused entities, managing tokenized collateral and cross-chain risk via smart contracts.[116]

Liquidity centralization – particularly for tokenized cash and various stablecoins – may become a core function. However, the scope of the CCP's role should be assessed contextually. For example, Australia's Council of Financial Regulators concluded that a CCP delivers net benefit only when participation reaches critical mass to offset its cost structure (e.g. margins, fees).[117]

Central securities depositories

CSDs manage post-trade functions such as record-keeping and corporate actions. Complexity and manual processes persist – 78% of leading financial institutions still process actions manually.[118] CSDs could issue assets using verified digital IDs, manage settlement with on-chain cash, validate ledgers and automate asset servicing.[119] CSDs will also provide regulatory compliance, while supporting asset tokenization, wallet management and interoperability between tokenized and traditional systems.[120] In the Regulated Settlement Network trials, CSDs were also identified as potential immobilization providers for multi-asset DvP settlements.[121]

Custodians

Custodians can evolve into digital asset safekeepers, emphasizing multi-tiered custody, staking and institutional wallet solutions, in addition to acting as a trusted intermediary for on- and off-chain integration. For example, BNY has expanded its Digital Asset Platform to include on-chain data services, beginning with broadcasting fund accounting data for BlackRock's tokenized fund onto the Ethereum network. This example reflects how major institutions are adapting to the commercialization of tokenized products and leveraging data transparency, automation and accessibility across the asset life cycle while also optimizing the user experience for the on-chain native investor.[122]

Further, the expected increase in collateral velocity will designate custodians as key participants in cross-custodial asset movements, thus increasing their speed of operation while remaining KYC/AML-compliant. Digital-native custodians are acquiring trust charters to facilitate payments, access liquidity and bridge traditional and crypto-assets.[123] In the case of physical assets, analogue providers such as gold vault services will become integral to processes like redemption.

Transfer agencies

TAs manage shareholder registries, cap tables and security transfers, often through manual, fragmented processes.[124] Most TAs use ledger software to manage investor data, but these systems rely on manual entry, adjustments and data sharing with fund administrators, alternative trading systems, custodians and brokers.[125] Tokenization could improve their roles by using reusable digital IDs for efficient KYC/AML, automating cap table services, using programmable ledger bookkeeping, conducting direct on-chain transfers and programmatically orchestrating corporate actions, demonstrated by WisdomTree's tokenized funds and Securrency Transfers' integration.[126]

TAs can also benefit from more efficient KYC checks and repurposable digital IDs, as financial institutions spend an average $2,598 per client onboarded, and TAs often verify thousands of investors across dozens of countries.[127] For example, as momentum around tokenized funds builds, the TAs' role could evolve towards a digital transfer agent (DTA) model. In this approach, smart contracts can be used to maintain share registries and automate fund life-cycle activities – such as subscriptions and redemptions – unlocking greater operational efficiency, transparency and interoperability across blockchain networks.

FIGURE 16

Market catalysts driving new custodial capabilities

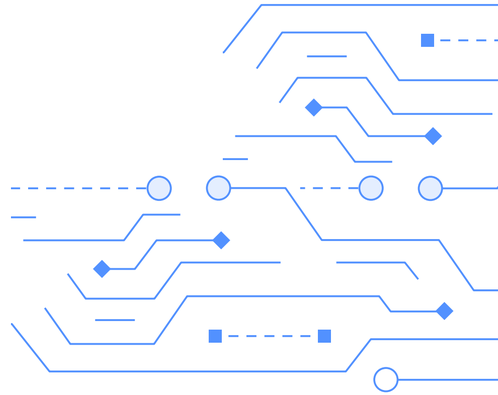
Market catalysts

Trusted custody of native digital assets	Custodians will be viewed as the trusted safekeepers of digital assets, unlocking new products and services
Increased collateral mobility and velocity	More assets can be brought on-chain and used (and reused) as collateral, domestically and cross-border
Pronounced public network adoption	Notable uptick in adoption of public blockchains by financial services entities
Unlocked private market liquidity	New sources of market activity for private assets in primary and secondary markets
Quantum attacks to break encryptions	Risks of network interception, identity impersonation and "harvest now, decrypt later"

Next-gen custodianship

New capabilities

Institutional productization	— Staking rewards management — Tokenized collateral management — Institutional wallet/vault services
Multitiered custody and on-chain functions	— Cold and hot storage — Institutional "vaults" — Retail and segregated wallets — On-chain corporate actions
On-chain identities and KYC/AML	— Reusable credentials — Privacy-enhancing tech — Off-chain ID data storage — GDPR compliance
Network integration and on-chain analytics	— Cross-chain integration — On-chain activity tracking
Quantum-safe systems	— Cryptographic agility — Quantum-resistant signature algorithms — Novel encryption methods



CASE STUDY 8
Integration

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TABLE 5

Potential changes to incumbent responsibilities through tokenization

No major changes anticipated

ENTITY	ONBOARDING	ISSUANCE	TRADING	CLEARING/SETTLEMENT	CUSTODY	ASSET SERVICING
Buy/sell side	— On-chain ID verification via repurposable digital identities (e.g. JPM Project Epic)	— Tokenized Assets Advisory — Underwriting and syndication (e.g. UBS Native Digital Bond on SDX)	— Automated, direct ordering via new digital asset exchanges — Peer-to-peer trading on secondary markets (e.g. DEXs)	— On-chain cash tokens for settlement (e.g. deposit tokens)	— Self-custody brokerage wallets (e.g. Robinhood wallet)	— Automated rebalancing and yield strategies
Issuer (public/private sector)	— Smart contract design (e.g. asset terms)	— Smart contract deployment — On-chain capital raises				— On-chain corporate actions (e.g. voting)
Exchanges	— Re-purposable digital identities to enforce trading restrictions (e.g. insider trading)	— Tokenized asset listings (e.g. Deutsche Börse Digital Exchange)	— Hybrid: Traditional orderbooks and on-chain transactions (e.g. automated market makers)			
CCPs				— Multilateral governance (e.g. Eurex DLT Trials) — Tokenized margin collateral management — Default management and liquidation using on-chain cash		
CSDs	— On-chain ID verification (e.g. SDX's adoption of Digital Token Identifier)	— Tokenized and digitally native issuance replacing book-entry issuance		— On-chain cash for settlement — Node operations and network validation	— Automated ownership records — Updates via distributed ledger — Cross-chain interoperability	— Automated, programmatic corporate actions (e.g. Chainlink, Euroclear, Swift)
Custodians					— Digital asset safekeeping — Digital asset staking — Private key management — Institutional wallets/vaults	— Automated dividend distributions — Staking rewards distribution — Tokenized lending/borrowing (e.g. BTC-backed loans)
Transfer agencies	— On-chain ID verification via repurposable digital identities	— Programmable shareholder registry updates			— Automated cap table services	— Automated bookkeeping via distributed ledger — Direct on-chain asset transfers

5.3 New market roles

New intermediaries will also support the asset life cycle, potentially with more participants than conventional setups.[128] This research found that there may be two new classes of entities to support the capabilities needed to deliver tokenization at scale: new market structures and digital-native service providers. Combined, these two groups plus incumbents would then drive product development forward using tokenization's features.

New market structures

New market structures are expected to play critical roles across the asset life-cycle steps. Token Issuers could provide asset issuance services on-chain, including developing and deploying token contracts. Once the tokenized asset is available, a digital asset exchange could offer compatible trading services, driving liquidity and market depth. Digital securities depositories (DSDs) could be introduced as a native service provider on DLT networks to perform one or more of the actions typically provided by CSDs, including settlement and management of securities.[129]

At least three new digital-native market structures are conceivable:

- **Token asset issuers and developers** will create and structure tokenized assets, ensuring regulatory compliance and embedding programmability to unlock new market efficiencies. These entities will also develop, upgrade and maintain the underlying tokenization platform or DLT and build digital workflows for pre-issuance activities, automating various workflows between parties until deal-closing.[130]
- **Digital asset custodians** will specialize in secure cryptographic key storage and management, enabling institutional-grade custody and access control for tokenized assets. In many cases, incumbents will use digital asset custodians should they decide not to build their own capabilities.
- **Digital asset exchanges** will facilitate the trading and liquidity of tokenized assets, bridging traditional finance with programmable ledger-based assets.

Digital-native service providers

Digital-native service providers will provide solutions for the secure issuance, trading and custody of digital assets. The adoption of these services by financial institutions will require licensing and will vary by region. Often, incumbents or new market structures will employ these services in their delivery of tokenized products.

At least five new digital-native service providers are conceivable:

- **On-chain identity providers** could streamline identity verification, but trust in third-party issuers remains uncertain, so institutions may prefer proprietary KYC processes and certificate authorities are more likely than custodians to become trusted issuers while liability in transferring verified identities remains unresolved.
- **Interoperability providers** could provide interoperability services between programmable ledgers and conventional systems (e.g. ACH, Swift) for settlement.
- **Node operators** could provide resources to verify transactions, produce blocks, facilitate consensus and update the ledger or chain.
- **Key management providers** could offer specialized custodial services to safekeep tokenized assets and help financial firms meet compliance measures, including BitGo and Metaco (acquired by Ripple).
- **Smart contract auditors** could provide auditing and monitoring of smart contracts to ensure the verifiability and safety of the deployed contract.

5.4 New products

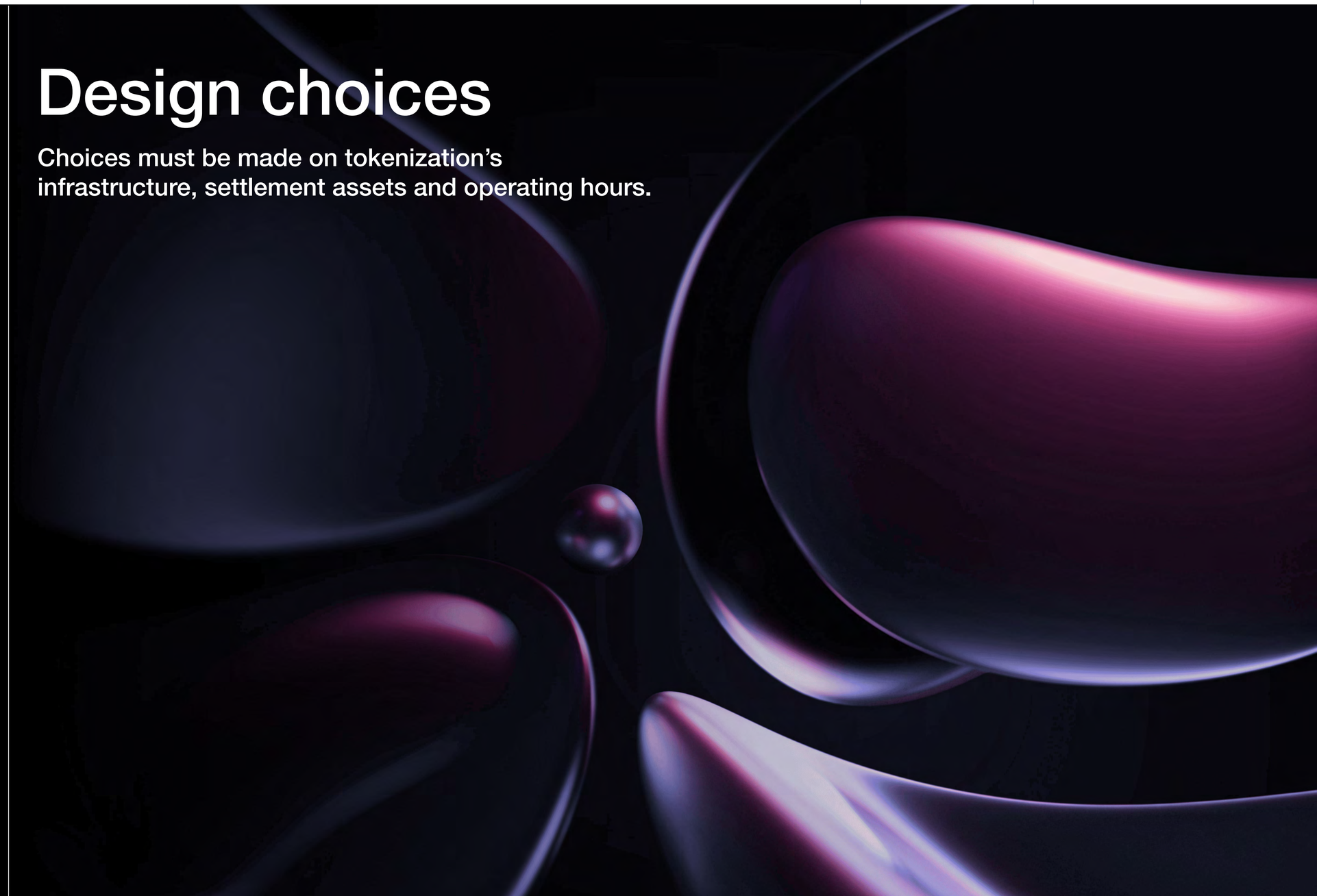
Evolving market structures and the rise of digital-native service providers could enable the creation of innovative financial products by facilitating creativity, largely fuelled by composability and programmability. These advances can unlock new liquidity models, risk-free uncollateralized lending and more efficient capital markets, reshaping traditional finance with programmable, automated and highly composable financial primitives. For example, as the Bank of Canada explored, flash loans native to blockchain ecosystems illustrate how uncollateralized lending with zero default risk transforms liquidity access for sophisticated market participants.[131]

Additionally, new mechanisms, such as using crypto-assets for collateral and smart funding – where assets are aggregated and liquidated based on payment needs, such as converting ETH to fiat-backed stablecoins in real time to facilitate payments – can further accelerate product development.[132]

6

Design choices

Choices must be made on tokenization's infrastructure, settlement assets and operating hours.



6.1 Infrastructure

When different financial institutions adopt tokenization, they need to decide upon the underlying infrastructure. Three models of programmable ledgers are presented, two permissioned and one permissionless, with varying benefits.

Permissioned ledgers

Financial markets have historically used private- and public-permissioned programmable ledgers because of the native functions of control and oversight, which can mitigate AML, KYC, legal and fraud risks and enable dispute resolution. This environment allows for efficient data sharing and secure record-keeping, bolstering trust, as only approved entities can read or write transactions. At the same time, in a permissioned setup, broader participation is possible but still governed by strict rules of entry. For example, JP Morgan's Kinexys platform has processed more than $1.5 trillion in notional value since its inception in 2021 by offering DLT-based payments, intraday repo and collateral services.[133] Another example is Citi's Integrated Digital Assets Platform (CIDAP), which offers an array of use cases across tokenized deposits, trade processing, bond exchange and private fund tokenization.[134]

TABLE 6

Key programmable ledger models

CATEGORY	PUBLIC-PERMISSIONLESS	PUBLIC-PERMISSIONED	PRIVATE-PERMISSIONED
Description	— Open, decentralized networks where anyone can join, transact and validate transactions without prior approval — Ideal for broad participation and innovation but with variable performance and limited default privacy	— Networks open to selected, vetted participants, typically regulated entities — Blend decentralization with controlled governance, providing viewability, high performance and regulatory alignment	— Fully controlled and centralized networks with restricted access to pre-approved participants — Optimized for high performance, confidentiality, regulatory compliance and internal institutional use cases
Transaction permissions	**Open access**: No entry barriers and any user with internet access can submit transactions	**Restricted access**: Participants vetted and approved by trusted authorities can submit transactions	**Closed and selective entry**: Typically, enterprises and known counterparties can submit transactions
Data viewability	**Fully transparent by default**: Privacy achievable through additional tools (e.g. ZK proofs)	**Controlled transparency**: Targeted privacy measures feasible (e.g. selective disclosure)	**Strict confidentiality**: Default confidentiality with complete control over data exposure
Governance model	**Highly decentralized**: Consensus among independent nodes (e.g. proof-of-stake)	**Moderately centralized**: Governance through permissioned entities who validate the network	**Highly centralized**: Even narrower onboarding of permissioned entities to validate the network
Scalability and performance	**Varies significantly**: Dependent on consensus algorithms (e.g. proof-of-work is not natively scalable, while proof-of-stake is scalable)	**High throughput**: Optimized for regulatory compliance and institutional transactions	**High throughput**: Purpose-built for enterprise-level volume and with predictable performance
Compliance and regulatory alignment	**Minimal by default**: Compliance possible but requires additional processes or layers	**Strong compliance**: Designed for regulated activities and integration with legacy infrastructure	**Highest compliance**: Explicitly designed for internal regulatory adherence, auditability and granular control
Liquidity and market access	**High liquidity**: Driven by network effects, global participation and interoperability; suitable for broadly traded assets and digital currencies	**Moderate liquidity**: Dependent on size and influence of the managing consortium, targeted towards institutional-grade asset pools	**Variable liquidity**: Access tightly controlled but can be engineered for high internal liquidity within members, suitable for discrete trading
Infrastructure requirements	**Low barrier to entry**: Moderate–high operational and transaction costs based on network fees	**Moderate barrier to entry**: Stable, predictable operational costs aligned with enterprise standards	**High barrier to entry**: Lowest marginal transaction costs; ideal for large, structured transactions

The main challenges associated with permissioned ledgers are scalability and adoption, although they are likely to succeed when financial institutions with strong network effects operate the platform. However, the permissioned or private construct can hinder adoption for smaller players.

Permissionless ledgers

Financial institutions have historically approached permissionless networks with caution due to regulatory and operational concerns. Nevertheless, a clear trend towards exploration and adoption is emerging.

Permissionless networks – open systems where anyone can join, access data and validate transactions – are increasingly being tested and integrated into institutional strategies.[135] At their core, permissioned and permissionless systems differ in governance and access.

There are five distinct drivers for the exploration of permissionless networks:

1. **Economic efficiency**
   Deploying and operating Layer-1s is increasingly cost-effective. Avalanche's 9000 upgrade, for instance, cut Layer-1 deployment costs by 99%.[136]
2. **Developer ecosystems**
   Open-source networks such as Ethereum and Solana host more than 24,000 active developers, accelerating innovation and tool development.[137]
3. **Network effects**
   Public ledgers promote broader participation and distribution, reducing single points of failure and aligning with user-centric financial models.[138]
4. **Transparency and real-time settlement**
   Open ledgers allow for continuous asset verification, streamlining operations and reducing intermediary reliance.
5. **Enhanced transaction performance**
   Innovations such as Ethereum's Proto-Danksharding (EIP-4844) and Solana's speed enhancements have improved transaction throughput and costs.[139]

As of May 2025, financial services entities are actively using at least 30 permissionless programmable ledgers.[140] Their adoption is expected to grow as various market forces drive further use of programmable ledgers. Public networks such as Ethereum now average 1–1.5 million daily transactions.[141]

Deutsche Bank is planning a permissioned ZK-proof Layer-2 on Ethereum to meet compliance requirements, demonstrating that compliance on permissionless networks does not require platform-wide gatekeeping functionalities and this can be enabled at the application or asset level.[142]

Notable institutional deployments include:

- Franklin Templeton expanded its tokenized US Government Money Fund (FOBXX) to Avalanche, marking the first US-registered mutual fund using a public ledger for recordkeeping and transactions.[143]
- BlackRock launched its BUIDL fund across Ethereum and six other public networks: Aptos, Arbitrum, Avalanche, Optimism, Polygon and Solana.[144]

These on-chain products operate without central clearing parties, signalling a structural shift in market infrastructure.

Environmental concerns have diminished. The shift from energy-intensive proof-of-work (PoW) to efficient proof-of-stake (PoS) consensus mechanisms – now the dominant model for public-permissionless – has made programmable ledgers far more sustainable and scalable than in prior cycles.[145] The longstanding concern of network scalability has been put to rest.[146]

However, there can be challenges associated with permissionless ledgers. From a financial stability perspective, the transparency of permissionless programmable ledgers can amplify liquidity risks for banks by enabling visible transaction flows that may trigger withdrawals during stress events. Network congestion, low throughput and variable fees further delay settlements and can undermine liquidity.[147]

Permissionless networks also face the privacy–transparency conundrum – balancing open data access with confidentiality.[148] Lacking built-in identity verification, they require external solutions to meet KYC/AML requirements, often involving off-chain data storage and compliance processes.

Lastly, while programmable ledgers enable distributed governance, financial institutions must ensure that these systems align with their mandate to establish clear lines of responsibility and business continuity, such as reversals and maintenance upgrades.[149]

6.2 Settlement assets

Without reliable on-chain settlement assets, using tokenized assets at scale will be challenging.[150] According to a 2024 survey, 79% of respondents indicated regulatory clarity as the critical dependency for on-chain cash.[151] The lack of riskless settlement assets is a roadblock when considering the BIS Committee on Payment and Settlement Systems (CPSS)–International Organization of Securities Commissions (IOSCO) Principles for Financial Market Infrastructures, which state that an FMI should conduct its money settlements in central bank money where practical and available.[152] The existence of assets and on-chain cash is instrumental to achieving operational efficiency concerning ancillary functions, including coupon payments, dividends and interest.[153] Institutions and customers risk delays, higher costs and compliance uncertainties without on-chain cash.

While wCBDCs have undergone lengthy development cycles that have slowed adoption, a recent OMFIF survey demonstrated that 59% of market participants prefer wCBDC as the settlement asset for DLT-based debt issuances.[154] Responding to market calls from financial institutions for central bank money for DLT-based settlement, the ECB shared its goal of enabling a short-term solution for this "in months, not years", indicating an acknowledgement of the importance of delivering settlement in central bank money natively for on-chain transactions.[155]

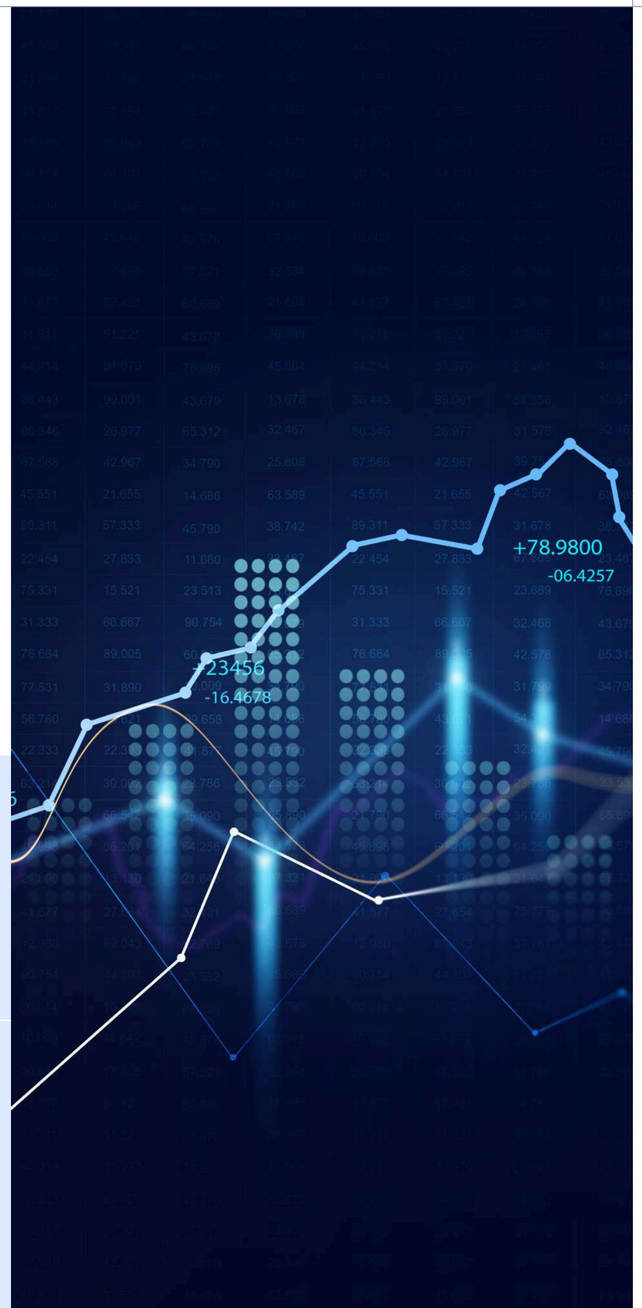
In addition to central bank money, several forms of on-chain cash could be used, including fiat-backed stablecoins, reserves-backed digital currency (RBDC) or deposit tokens. For example, to enhance its platform, Broadridge successfully integrated with Fnality's Payment System (FnPS) – an RBDC platform – paving the way for real-time DvP of intraday repos with digitally represented funds held at central banks.[156] By making cash accessible and trustworthy, financial markets can accelerate the responsible adoption of tokenized assets.

79%

say **regulatory clarity** is the key dependency for on-chain cash to scale

59%

prefer **wCBDC** for DLT-based debt-issuances



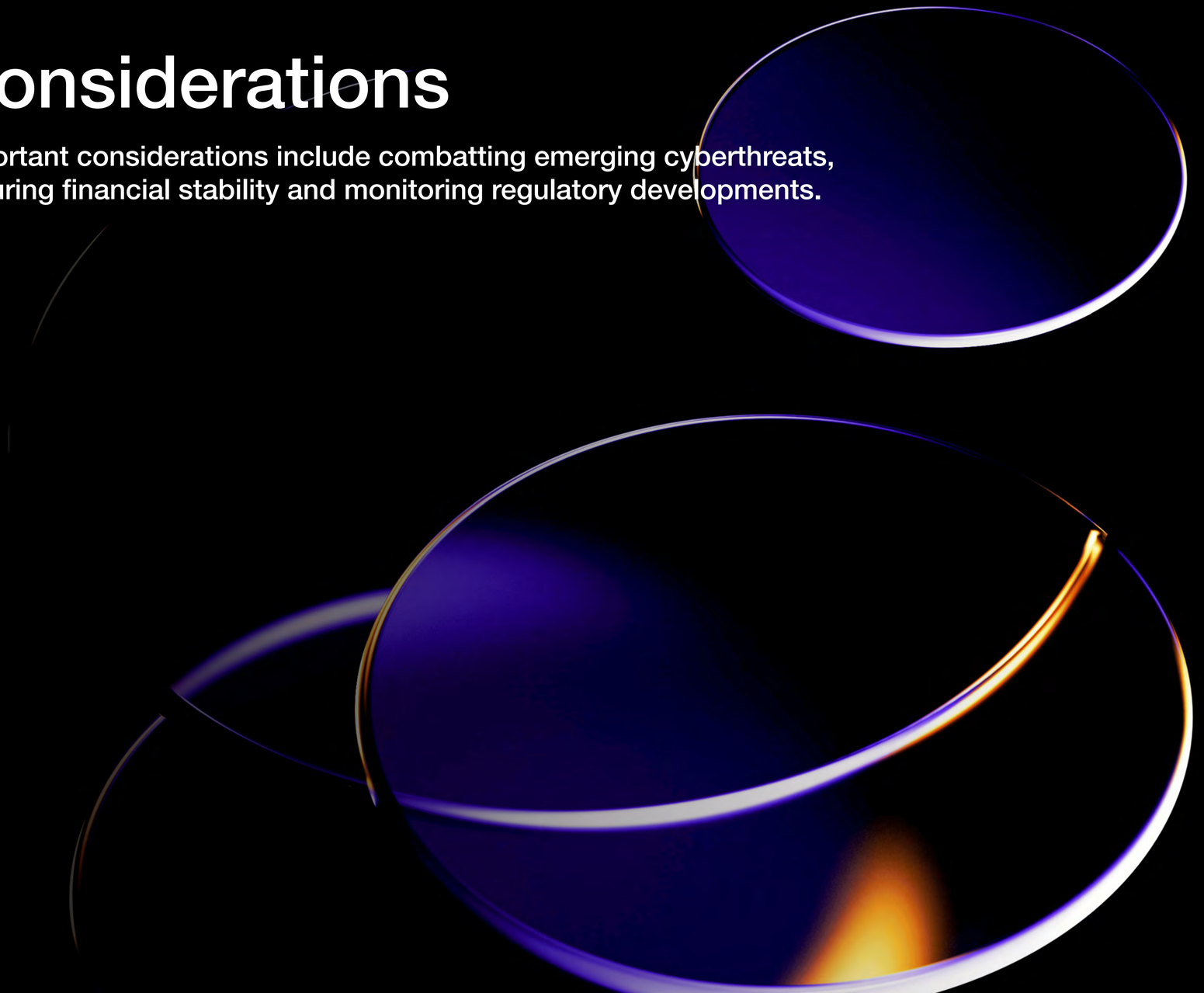
6.3 Operating hours

An "always-on" infrastructure is a design choice dependent on market demand, risk tolerance and technology. Not all markets should or could operate on a true 24/7 basis. For example, the New York Stock Exchange (NYSE) received approval by its regulator to expand its operating hours from 16 to 22 hours, citing a need for a two-hour break for system maintenance, central clearing and asset servicing functions (coupon payments, etc.).[157] Expansion of operating hours is a technical matter, but also a people, business and policy choice that will be dependent on time zones, trade matching, liquidity management and other functions that enable safe trading. Tokenization does offer functionality to operate 24/7, as demonstrated by the always-on feature of DeFi; however, regulated markets operate in a more rigid operational construct and will vary on a case-by-case basis.

7

Considerations

Important considerations include combatting emerging cyberthreats, ensuring financial stability and monitoring regulatory developments.



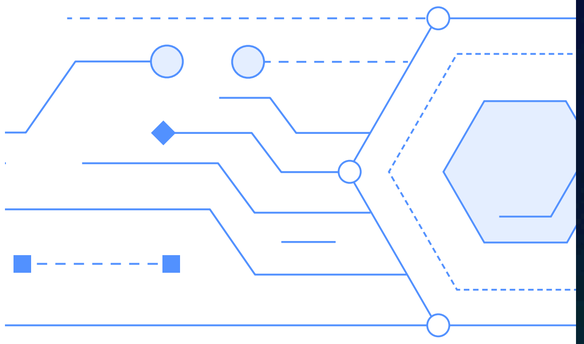
7.1 Cybersecurity

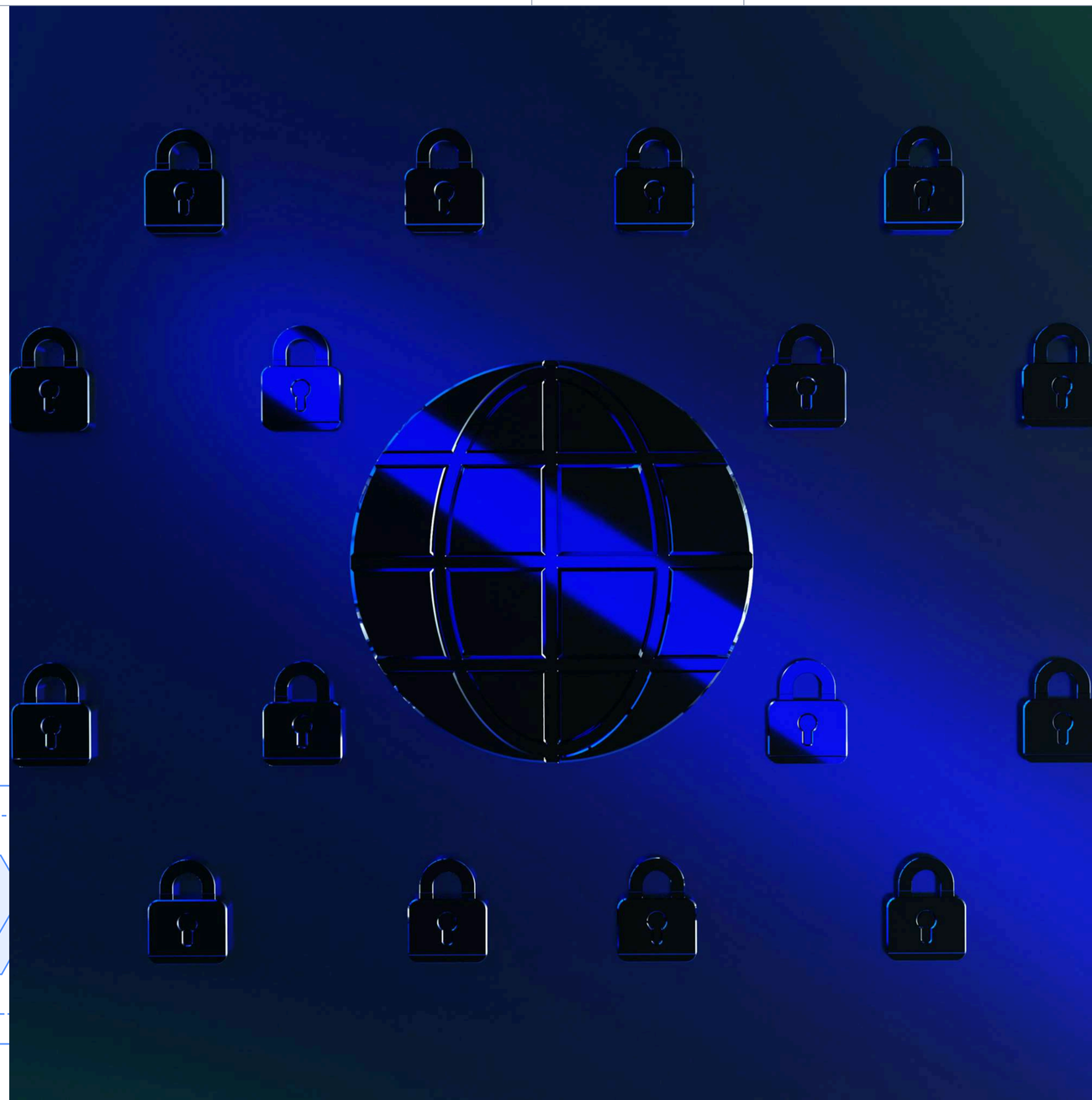
Cybersecurity is paramount in safeguarding digital assets, as many crypto-related breaches still arise from conventional threats rather than lost or compromised private keys. Recent high-profile incidents demonstrate that phishing, malware and insider attacks remain the most prevalent risks.

For example, in 2025 the Dubai-based crypto-exchange Bybit was hacked, leading to a loss of nearly $1.5 billion in ETH – it is regarded as the largest crypto-asset theft to date.[158] This attack showed that even industry-accepted security measures such as multi-signature wallets and cold storage are susceptible when linked to operational processes and third-party services. While specific to crypto-assets, this highlights that regulated digital assets using the same technology must thwart cybersecurity risks by harmonizing cybersecurity measures in congruence with traditional financial markets.

Although institutional private key security has improved through advanced methods such as multi-party computation (MPC) and hardware security modules (HSM), robust threat modelling and protection strategies remain vital. Effective private key management practices, including secure storage and strict access controls, can mitigate fallout even when other defences fail. Addressing traditional vulnerabilities and novel cryptographic threats is essential to protect users and institutions.

Quantum computers represents a key threat to financial systems, and the risk increases with tokenized assets as quantum computing can render widely used encryption methods insecure. Many programmable ledgers are prioritizing quantum-resistance on their roadmaps; however, a trade-off is introduced with the efficiency of encryptions versus their quantum resistance. There are three types of quantum attacks: network interception, identity impersonation and “harvest now, decrypt later”.[159] Design choices can thwart this risk, such as cross-chain protocol security, secure token transfer mechanisms and cryptographic agility.[160]





7.2 Financial stability

Due to its limited scale, tokenization currently poses a minimal risk to financial stability. However, as adoption grows, the Financial Stability Board (FSB) warns of vulnerabilities, including liquidity and maturity mismatches, leveraged rehypothecation, price and quality obscurity from smart contract composability, systemic concentration risks and operational fragilities stemming from multi-party collaboration.[161]

The FSB highlights several strategies to encourage safe adoption:

EXPLORING NATIVELY ISSUED TOKENS

Explore using natively issued tokenized assets compared to reference asset models to minimize challenges associated with liquidity and maturity mismatch, driven by managing dual liquidity pools (token and underlying asset). Firms should embrace cash on-chain to mitigate maturity mismatch and ensure standard settlement windows.

MITIGATING CONCENTRATION AND CONTAGION RISKS

Promote competition by making markets accessible to smaller players and carefully distributing market powers, balance sheets and liquidity.

CONTROLLING THE LIMITLESS NATURE OF COMPOSABILITY

Use composability in a manner congruent with safety and soundness and embed controls to prevent the limitless creation of wrapped assets per the asset's risk profile and the risk tolerance of relevant parties, such as with the application in increasing the velocity of collateral through reuse across multiple trading steps.

EMBEDDING SMART CONTRACT AUDIT PROCEDURES

Apply rigorous testing procedures associated with smart contract development using open-source frameworks and testing tools to minimize risks associated with asset composability.

GOVERNING MULTISTAKEHOLDER PROCESSES

Coordinate rules and governance frameworks across all participating parties while relying on a neutral third party to mediate disputes or challenges.

7.3 Regulatory developments

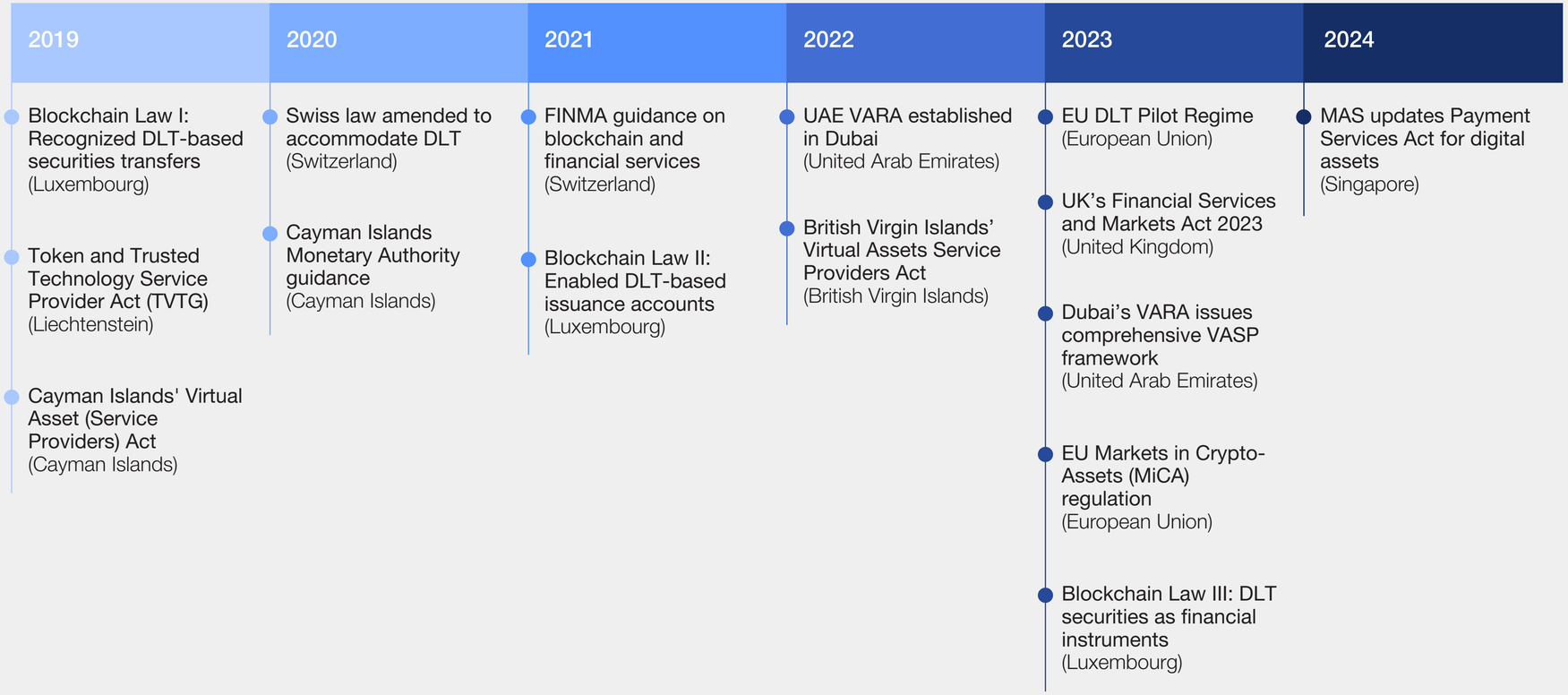
A major barrier to large-scale tokenization remains the lack of regulatory clarity in digital asset markets. However, recent political and regulatory shifts suggest growing momentum towards a more defined framework. Institutional digital asset projects have often stalled due to uncertainty regarding the permissibility of on-chain products.[162]

One of the first regulatory frameworks that clarified the role of tokens and tokenization was in Luxembourg. Blockchain Law I (2019) recognized DLT as a valid system for securities registration and enforceable book transfers. Blockchain Law II (2021) permitted DLT-based securities issuance accounts. Blockchain Law III (2023) confirmed that DLT-held securities qualify as financial assets under collateral regulations, aligning with the EU's DLT Pilot Regime.

Liechtenstein enacted the Token and Trusted Technology Service Provider Act (TVTG) in 2020. This legislation provides a comprehensive and technology-neutral approach to regulating the token economy, addressing civil and supervisory aspects. By defining tokens as containers of rights, the TVTG enhances regulatory clarity.[163]

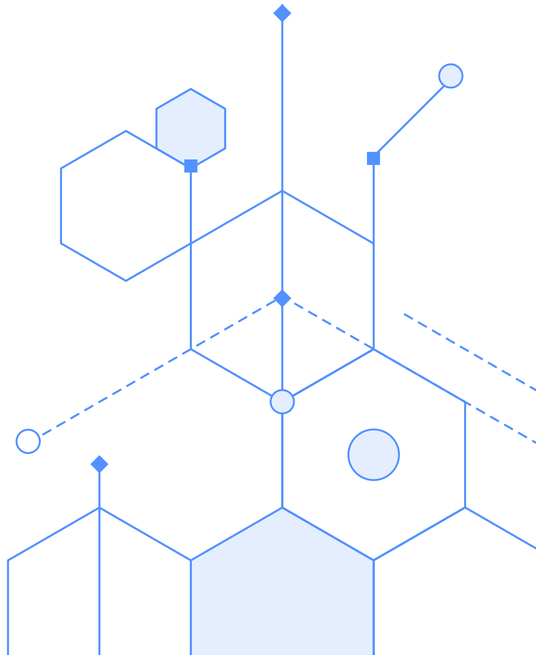
FIGURE 17

Policy and digital asset regulatory developments (2019–2024)



Source: World Economic Forum

The newly elected US administration has signalled a pro-digital assets stance, which indicates progress towards integrating digital assets into traditional finance.[164] Hong Kong is advancing bond market tokenization, with the SFC and HKMA forming a task force to develop a roadmap for bond and FX market infrastructure, including tokenized issuance and trading – marking a key step towards institutional adoption of digital assets.[165] Lastly, in the UK, the Financial Conduct Authority has recently pledged to support fund tokenization as part of its 2025–2030 goals.[166]



Conclusion

Tokenization can benefit financial markets by establishing transparency, allowing greater ownership control, promoting operational efficiency, granting greater accessibility to investors and enabling multi-asset operations.

The differentiators of this technology application can help to realize cost and time savings for financial markets and broaden access to investors in capital markets. However, achieving these benefits will not come without deep public–private collaboration on consistent regulations and standards, adaptation of market structures and value chains, enhanced collateral frameworks and safe and sound usage of open networks.

Market structures need to evolve to harness tokenization's advantages. Today's financial infrastructure is based on centralized intermediaries and predefined settlement cycles, whereas tokenized markets introduce programmability, atomic settlement and the potential for "always-on" markets. However, despite technological advances, certain financial operations – including risk management, clearing and corporate actions – require controlled execution windows to maintain stability and mitigate volatility. Technological innovation alone does not eliminate the operational and regulatory realities that underpin market integrity. There needs to be a balance between incumbent institutions and new industry players from a regulatory and market power perspective. Ensuring fair market access, open interoperability and balanced regulatory influence is critical to preventing any undue concentration of power while inspiring sustainable growth.

Lack of global standards and regulatory fragmentation for tokenization remain a leading challenge and policy-makers should update financial regulations based on the principle of technology neutrality to accommodate tokenized assets while ensuring enforceability, investor protection and risk management. The lack of legal clarity around on-chain ownership rights and settlement finality can stifle the value proposition of tokenization as observed in potential discrepancies associated with a shared system of record and unified consensus on the state of an asset.

By implementing new technologies in the market infrastructure, it is necessary to ensure interoperability, particularly in defining common transaction protocols, asset classification frameworks and reference data models. However, complex financial processes – such as corporate actions – may require a phased approach to standardization to adapt to jurisdictional differences and evolving industry practices.

For tokenized markets to function effectively, liquidity providers and market makers should be encouraged to participate. Without sufficient secondary market depth, tokenized assets risk remaining illiquid, limiting their utility despite technical advances. Policy-makers and financial institutions should explore mechanisms to encourage market-making activities, such as tailored liquidity programmes, capital treatment incentives and expanding regulatory sandboxes that spur institutional participation.

Several stakeholders should make strides to facilitate the use of tokenization including policy-makers, technology providers and financial institutions.

By addressing regulatory uncertainty, adapting market structures and encouraging competitive, liquid markets, tokenization can enable an improved global financial infrastructure. Achieving this vision requires a balanced, pragmatic approach that spurs innovation while upholding market integrity, competition and operational resilience.

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Endnotes

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