The Impact of Distributed Ledger Technology in Capital Markets

Ready for Adoption, Time to Act

gfma afme/ asifma sifma IIF Institute of International Finance ISDA Safe, Efficient Markets Celebrating 40 Years GDF Global Digital Finance GBBC Global Blockchain Business Council FIA bpi Bank Policy Institute Financial Services Forum

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Foreword

Across each evolution of global capital markets, trust has been the cornerstone upon which efficient and robust capital markets rest. Regulatory frameworks play an essential role in maintaining this trust, setting clear, consistent rules that protect stakeholders and meet the objectives of policymakers worldwide. Effective regulation balances growth and innovation with market integrity, consumer protection, systemic stability, and overall safety.

The emergence and rapid maturation of distributed ledger technology ("**DLT**") and digital assets are driving a transformational shift in capital markets – demanding proactive collaboration from market participants and regulators to ensure these assets and their infrastructure build on the existing protections of traditional financial instruments.

This report provides a comprehensive analysis of the practical applications, opportunities, and challenges posed by DLT and tokenization in global capital markets. It evaluates the implications of digital securities across the entire securities lifecycle, offering insights into at-scale use cases such as collateral management, fixed-income issuance, and fund tokenization. The analysis further addresses critical operational risks, such as cybersecurity, smart contract reliability, and settlement finality, and outlines clear risk mitigation strategies, affirming that institutional-grade risk management frameworks are both robust and adaptable to these innovations.

The use of DLT in capital markets may provide material benefits such as substantial operational efficiencies, reduced settlement times, and increased transparency throughout the trade lifecycle. Precision settlement, automated asset servicing, and enhanced regulatory reporting capabilities are just a few tangible benefits that tokenization can unlock, addressing longstanding inefficiencies in existing securities workflows, making the system safer and more secure for all.

Since the publication of the 2023 report titled *The Impact of Distributed Ledger Technology in Capital Markets*, institutional adoption of DLT has accelerated significantly across the world. Key building blocks—robust technology platforms, evolving regulatory clarity, and sustained institutional engagement—have converged to create the conditions for rapid expansion of tokenized assets. The central question is no longer whether real-world assets will be tokenized at scale, but when and how DLT will become embedded in market operations. Signals from both market activity and policy frameworks indicate that a structural turning point is near.

Major financial institutions have moved beyond experimentation to large-scale implementation, demonstrated by notable milestones such as J.P. Morgan's Kinexys digital asset network, which has processed over $1.5 trillion in tokenized transactions. Similarly, prominent bond issuances on DLT platforms, including those by the European Investment Bank, illustrate the growing acceptance and viability of digital securities. Tokenized money market funds have also witnessed substantial growth, reflecting increasing institutional demand for DLT-based financial instruments that streamline liquidity management and collateral optimization. Likewise, the proliferation of regulated and sound DLT-based Payment Instruments has enabled these use cases to scale. We highlight that these institutions have been able to deploy these use cases and satisfy the controls and standards required of traditional financial institutions – demonstrating that it is possible to ensure risks are appropriately managed, with issuer, market, and investor protections in place.

Our analysis indicates that the selection of DLT network architecture continues to be fundamentally driven by specific use-case considerations. Network architecture and technological choices vary significantly depending on the business requirements and operational needs of each use case. Importantly, our research demonstrates that institutional-grade controls and robust risk management frameworks can be effectively implemented across diverse network types—private-permissioned, public-permissioned, and public-permissionless networks. For public permissionless networks, additional solutions such as Layer 2 technologies and asset-specific smart contracts have demonstrated the capability to provide many of the necessary controls, scalability, and compliance mechanisms required by institutional market participants. These solutions can help manage privacy, operational resilience, and governance concerns within a public blockchain environment.

Hence, we advocate for a technology-neutral regulatory approach. Prudential and regulatory treatments should focus on the underlying financial activities and associated risks rather than on the specific technology being utilized. This approach will enable market participants to responsibly leverage innovative DLT solutions, ensuring robust controls and efficient risk management tailored precisely to the complexity, scope, and scale of each distinct use case.

Institutional adoption of DLT is accelerating, backed by client demand, measurable efficiency savings, and growing use as a key operational tool in high-priority asset classes. The impetus for progress will continue to be defined by how effectively institutions, regulators, and policymakers can work together to solve open challenges around legal certainty, share infrastructure, risk frameworks, and liquidity formation to scale in a safe and sound manner. This report presents six priority areas of focus: legal clarity, interoperability, collaboration to develop high-priority asset classes, operational resilience, enabling stable payment for settlement, and public-private coordination. We re-emphasize the importance of coordination between market participants, be it banks, non-bank financial institutions, or digital natives, prudential authorities, and policymakers – a fragmented approach risks reinforcing the very inefficiencies we hope to overcome. Ultimately, this report aims to support policymakers, regulators, and industry participants in aligning on practical risk management tools and supervisory practices that balance market safety and innovation.

The stage for mass adoption of tokenization in capital markets is set, driven by clearer regulatory pathways, mature technology platforms, and committed institutional participation. Now is the time for coordinated action to harness the benefits of DLT, modernize financial infrastructure, and support sustainable economic growth.

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This report serves as an update to the 2023 publication *The Impact of Distributer Ledger Technology In Capital Market* and seeks to provide an updated assessment of the opportunities and risks posed by distributed ledger technology – including DLT-based Securities (both tokenized securities and DLT-native security tokens) – and associated activities across the end-to-end securities lifecycle. Co-developed with members of a broad set of trade associations (see **Foreword**, hereafter referred to as the "**Joint Trades**"), the report represents the perspectives of industry practitioners who are pioneering research and real-world applications of DLT use cases across the world.

SCOPE OF THIS REPORT

Implementation Models: This report explores two different implementation models of DLT for use across the securities lifecycle by regulated financial institutions: "Books and Records", and "Tokenization". These are defined as follows:

- **"Books and Records":** Existing internal recordkeeping, accounting, reporting, and other back-office functions centrally administered by a financial institution(s), which can be supported by DLT-based infrastructure; and

- **"Tokenization":** Digital representation of securities and payment instruments on a distributed ledger, reflecting an ownership right of the underlying asset, and its transfer between entities using the ledger. The report assumes that DLT is the enabling technology and catalyst for Tokenization. Although some features of Tokenization can be achieved without DLT (e.g., precision settlement and fractionalization), this is out of scope for this report given market adoption of DLT.

Asset Classes and Types: The core asset classes in scope are the DLT-based forms of traditional equity and fixed income securities (including asset-backed securities), including securities collateral held in relation to derivative transactions.[2] These assets can exist on a distributed ledger in two formats:

1. **"Tokenized Securities"**, which are issued and custodied traditionally, but also represented on a distributed ledger through a digital twin token that represents the underlying traditional security; and

2. **"Security Tokens"**, which are issued and custodied natively on a distributed ledger only and therefore do not have a traditional security as an underlying basis.

It is important to distinguish between the two because they pose significantly different implications across the securities lifecycle. Where a distinction is not required, they are collectively referred to as **"DLT-based Securities"**.

Prudential Classification: These in-scope asset classes and types either meet the classification conditions for **Group 1a** digital assets as set out by the Basel Committee on Banking Supervision ("**BCBS**") under its revised "SCO60: Cryptoasset exposures" standard in the Basel Framework[3], whether recorded on permissioned ledgers or, where robust token-level governance and compliance controls exist, on permissionless networks, or are acknowledged as out of scope for this framework.[4]

Payment Instruments: In addition to the core scope of this report, payment instruments that are represented on a distributed ledger through Tokenization or otherwise are also considered as they relate to capital markets activities.[5] These are defined as **tokenized commercial bank monies; tokenized deposits** (where the ownership of commercial bank deposits is reflected natively on a distributed ledger); use of DLT by central banks, financial institutions, and payment institutions to facilitate payments among wholesale market participants; and/or regulated **Stablecoin** instruments.[6]

They will be collectively referred to as "**DLT-based Payment Instruments**". Members underline the importance of DLT-based Payment Instruments to realize the benefits of Delivery-versus-Payment ("**DvP**") settlement for DLT-based Securities transactions, the distribution of coupons, dividends and other proceeds on a distributed ledger.[7]

2. Tokenization also includes the representation of other tangible assets (e.g., commodities) and intangible assets (e.g., copyrights and patents) on a distributed ledger, but this is out of scope for this report. Additional use cases for Tokenization also exist but are out of scope for this report.
3. The Basel Framework is the full set of standards of the BCBS, which is the primary global standard setter for the prudential regulation of banks.
4. BCBS, "Prudential treatment of cryptoasset exposures," November 27, 2024; see SCO60.3 for specific detail on CBDCs etc.
5. The use of money and deposits as an asset class in this report does not include Foreign Exchange. With respect to DLT platforms designed primarily to facilitate payments, this report does not address these systems generally, but instead focuses on considerations that may be applicable to the use of these platforms in connection with capital markets activities.
6. For a detailed description of these DLT-Based Payment instruments, we direct readers to Chapter 1.3.1 – DLT-Based Payment Instruments.
7. ASIFMA, "Tokenized Securities: A Roadmap for Market Participants and Regulators", 2019.

USE CASES IN FOCUS:

The market has matured from predominantly experimental pilots to live use cases, with scaling institutional adoption. DLT has become meaningful in reshaping collateral management, improving fixed income issuance, and accelerating fund tokenization, delivering operational improvements and setting the stage for broader market transformation.

- **Collateral management has benefited from DLT-enabled intraday repos**, addressing inefficiencies related to delayed settlement, fragmented systems, and limited liquidity reuse. Platforms such as J.P. Morgan's Kinexys and Broadridge's Distributed Ledger Repo (DLR) have demonstrated value. J.P. Morgan's Kinexys, for example, tokenizes cash and collateral to execute intraday repos within minutes, integrating seamlessly into traditional banking systems. Similarly, Broadridge's DLR utilized smart contracts to automate bilateral repo processing. The results are notable:
  - Settlement times reduced from several hours to mere seconds.
  - Dramatically lowered operational risks and funding costs.
  - Increased efficiency in collateral reuse and liquidity management.
  - Improved regulatory transparency and reporting capabilities.

- **DLT also reshaped fixed income markets through digital bond issuance**, transforming a historically manual process characterized by delayed settlements and significant reconciliation burdens. Real-world applications include UBS's CHF 375 million bond issuance on the SIX Digital Exchange (SDX), achieving immediate settlement while preserving interoperability with traditional investor channels. Another milestone was the Asian Infrastructure Investment Bank's (AIIB) $500 million digital bond, issued via Euroclear's D-FMI platform, combining DLT-based settlement with traditional infrastructure integration. This innovation led to tangible benefits:
  - More efficient settlement cycles.
  - Lowered issuance and reconciliation costs.
  - Expanded investor accessibility through dual listing and seamless cross-platform interoperability.

- **Fund management has seen substantial progress via tokenization**, particularly with digital money market funds, addressing settlement delays and inefficient cash management practices. Franklin Templeton's FOBXX, a money market fund operating entirely on a public blockchain, has reached assets under management exceeding $740 million, enabling real-time tracking and instant peer-to-peer transferability. Similarly, BlackRock's tokenized liquidity fund BUIDL, managing more than $2 billion through multi-chain issuance, has demonstrated significant adoption. Spiko's tokenized EU Treasury Bills UCITS fund offers 24/7 access and immediate redemptions through public blockchain platforms, highlighting transformative impacts:
  - Instant settlement and real-time net asset valuation (NAV) calculation.
  - Improved collateral utility and liquidity.
  - Simplified compliance and enhanced investor onboarding efficiency.

These successful implementations indicate DLT's potential to become foundational in capital markets, signaling a hybrid future where digital and traditional infrastructures coexist, mutually reinforcing their strengths and paving the way for continued market modernization. To fully realize this hybrid vision and scale the initial successes into industry-wide transformation, market participants must now address specific foundational requirements.

CALL TO ACTION: RECOMMENDATIONS TO BUILD MOMENTUM

The findings in this report highlight several critical steps needed to support the next phase of adoption in capital markets. While early implementations have gained traction, particularly across specific asset classes in both primary and secondary markets, broader ecosystem development remains in a transitional stage. At this juncture, it is essential for all market participants, including financial institutions, infrastructure providers, regulators, and technology vendors, to collaborate in shaping the core components of a resilient and scalable DLT ecosystem.

To accelerate ecosystem maturity, the following **calls to action** are directed at mobilizing public and private stakeholders towards meaningful and sustainable progress. Governments establishing a pro-innovation mandate to foster growth and competition, and market integrity, while protecting clients, investors and end users, sends the necessary signal for the private sector to unlock investment to deliver enhancements for the ecosystem. **While public policy and regulatory clarity remain crucial enablers, this roadmap prioritizes actions that can be taken now, unilaterally or in collaboration with peers, to build sustainable momentum and unlock value:**

1 | Accelerate Market Development in High-Potential Asset Classes: To accelerate tokenization, the industry is currently prioritizing high-impact asset classes such as private credit, and money market funds. Building scalable infrastructure, enabling broad investor access, and embedding programmability into design will drive market depth. Regulatory enablement and support for innovation, including tokenized instruments in existing frameworks and public-sector issuance can catalyze cross-border adoption and unlock institutional-grade liquidity at scale.

2 | Clarify Legal Foundations and Align Regulatory Treatment: To unlock the full potential of tokenized capital markets globally, further timely action is needed to establish clear, consistent legal frameworks. With coordinated regulatory reform and industry coordination, tokenized instruments can achieve legal certainty, enabling cross-border adoption, improving market confidence, and accelerating institutional-scale deployment.

3 | Establish Interoperability to Prevent Market Fragmentation: To realize the full benefits of tokenization, interoperability must be prioritized. Industry, in collaboration with regulators, should align on common data models, smart contract standards, and messaging protocols. By embedding interoperability into infrastructure design and regulatory frameworks, we can reduce fragmentation, lower integration costs, and unlock scalable, cross-platform market connectivity. The building blocks for this coordination already exist, now is the time to act.

4 | Address Technical and Operational Integration Gaps: To enable institutional adoption, DLT platforms must meet high operational and security standards. Industry should identify minimum requirements for wallet custody, smart contract governance, and system integration in a manner consistent with appropriate regulatory standards. With robust frameworks, auditability, and standardized APIs, institutions can safely scale tokenization while aligning with existing operational and regulatory practices. Coordination and investment now will ensure secure and seamless future deployment.

5 | Enable Scalable Settlement with Tokenized Money and Stable Payment Instruments: To unlock the full benefits of tokenized markets, scalable on-chain settlement with DLT-based Payment Instruments is essential. Industry should integrate tokenized deposits and stablecoins into settlement workflows, enabling atomic DvP and programmable payments. Regulatory clarity and interoperability with central bank systems will ensure secure, efficient, and continuous settlement across digital and traditional rails.

6 | Foster Public-Private Coordination: To scale tokenized markets, public and private sectors must align on institutional use of DLT infrastructure in such cases of custody, identity, compliance, and settlement. Industry should adopt open, collaborative models and support joint pilots. Policymakers can accelerate progress by harmonizing cross-border legal standards to foster funding of critical infrastructure.

REPORT OVERVIEW

The full report that follows provides a granular, bottom-up analysis across the topics explored in the Executive Summary. This includes a detailed overview of DLT, including the infrastructure and the digital assets represented on this infrastructure, a phase-by-phase impact assessment across the securities lifecycle, an exploration of live use cases, legal and regulatory considerations and recommendations, and barriers to adoption. To close the report, joint trades and members present critical calls to action from market participants to drive progress towards network effects, working in dialogue across key areas. For regulators, it could help inform efforts around emerging legal and regulatory frameworks, with a view to protecting markets and promoting innovation. For industry, it provides detailed potential areas for further dialogue to accelerate ongoing research and development.

As an overarching guiding principle, legal and regulatory frameworks should be designed in line with the "same activity, same risk, same regulatory outcome" and "technology-neutral" risk-based guiding principles that support, rather than deter, industry innovation and adoption. Joint trades and members underline the importance for all market participants to contribute toward ongoing research and development of DLT, and the representation of securities and payment instruments on this infrastructure. Punitive penalties for the use of a particular technology, without clearly defined risk-based justification, could be detrimental to innovation in the market and have unintended consequences on the evolution of a future DLT-based market structure within the regulatory perimeter.

Significant contributions have been made by a wide selection of joint trade members and non-members across the financial services ecosystem, together with industrial and legal advisers. Engagement has also been held with regulatory bodies across jurisdictions to ensure central areas of concern are addressed. We hope this provides a value-added perspective that drives public-private dialogue and advances progress on the topic.

For further details, please see the following chapters of this report:

- **Chapter 1: DLT Technology and Tokenization |** Providing a clear and unambiguous definition of the key terms and concepts required with the goal of providing a consistent cross-industry framework for discussions of DLT, Tokenization, technology, and infrastructure.
- **Chapter 2: Opportunities and Risks:** Impact Across the Securities Lifecycle | Examining the impact across the end-to-end securities lifecycle on roles and responsibilities, workflows and activities, technology and infrastructure, financials, and existing levels of risk.
- **Chapter 3: Towards a Future-DLT-Based Ecosystem |** Outlining what a potential future-state DLT-based ecosystem may look like, barriers to adoptions and the role of regulated institutions in a DLT-based future.
- **Chapter 4: Legal and Regulatory Landscape |** Demonstrating where existing regulation sufficiently addresses DLT-enabled operations and Tokenized Securities and highlighting gaps in legal and regulatory frameworks based on the "same risk, same regulatory outcome" principal
- **Chapter 5: Conclusion and Call to Action |** A set of six, pragmatic next steps for industry participants to work towards a desirable future. Prioritizes focus areas that require cross-industry collaboration and public-private dialogue to unblock and drive progress.
- **Deep Dives: Assessing Select Examples of Scaled Adoption |** Exploring real-world use cases, developed with joint trades and members, to provide insights and best practices on how existing risk-management approaches are being used to drive decisions around technology and governance.

The Joint Trades on behalf of their members recognize the growing relevance of DLT to global capital markets and the extensive research backing its adoption. We believe this report will prove a valuable asset to policymakers, regulators, and governmental authorities, fostering deeper collaboration on DLT's potential to reshape global capital markets.

Executive Summary

THE STAGE FOR MASS ADOPTION IS SET – USE CASES ARE SCALING

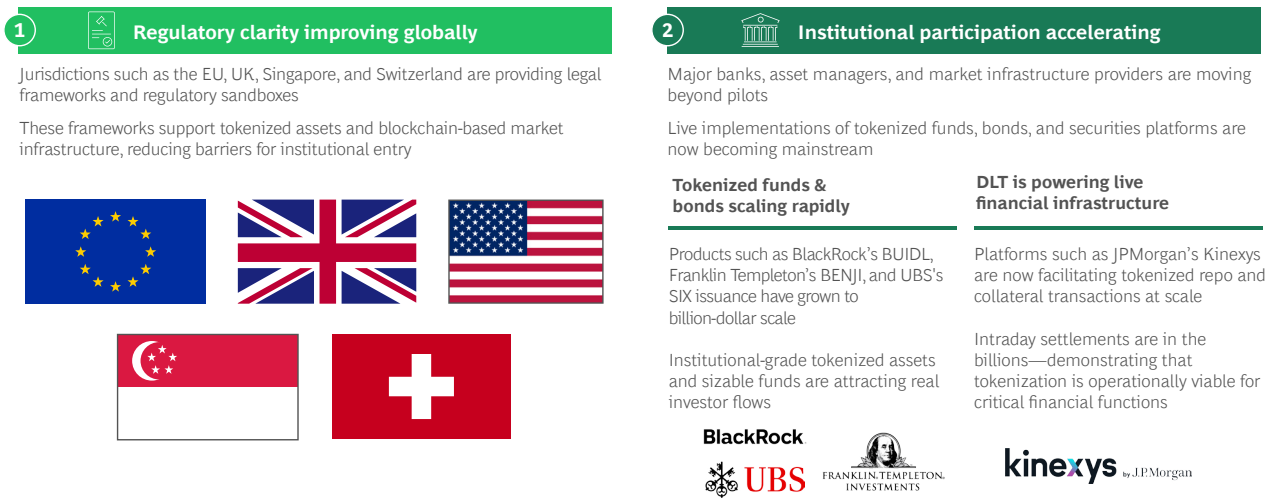
Global capital markets are entering a new phase where **tokenization** – the representation of financial assets on distributed ledgers – is poised for mass adoption. Key building blocks that were nascent a few years ago have matured. **Market infrastructure** is increasingly robust and interconnected: major banks and market utilities have launched live distributed ledger platforms, and settlement networks are achieving significant scale. For example, J.P. Morgan's Kinexys digital assets network has processed over $1.5 **trillion** in transactions (averaging $2 billion daily) for tokenized deposits and collateral transfers, demonstrating that institutional-grade blockchain systems can handle real volumes.[8] Likewise, central bank and regulatory experiments are validating the technology, from cross-border payment pilots to on-chain bond issuances, demonstrating that distributed ledgers may be able to operate within existing market ecosystems.

Crucially, **regulatory clarity** has improved in multiple jurisdictions, lowering a key barrier to institutional adoption. Policymakers are establishing frameworks that recognize tokenized assets and provide guardrails for their use, and wider DLT implementation across financial services.

In the U.S., developments and updated policy guidance from the White House, the Securities and Exchange Commission ("**SEC**"), federal banking regulators, and Congress have accelerated a more supportive regulatory environment. On July 30th, the President's Working Group on Digital Asset Markets released a report outlining the administration's stances on various aspects of digital asset regulation and legislation, while calling for regulatory agencies and Congress to work together and create a pro-innovation regulatory regime for digital assets. The SEC has established a dedicated Crypto Task Force and published guidance to clarify the agency's stance on the registration, issuance, custody and trading of crypto-assets. The Federal Reserve Board ("**FRB**"), Office of the Comptroller of the Currency ("**OCC**") and the Federal Deposit Insurance Corporation ("**FDIC**") have all withdrawn prior restrictions on crypto-asset activities and issued new guidance to better align crypto-asset oversight with comparable traditional products. Congress has recently made significant strides towards establishing a supervisory framework for crypto-assets and digital markets, demonstrating a commitment to fostering innovation in financial markets. The Guiding and Establishing National Innovation in U.S. Stablecoins ("**GENIUS**") Act was signed into law, marking a pivotal moment in establishing a supervisory framework for payment stablecoins. Beyond the GENIUS Act, market structure legislation, including the Digital Asset Market Clarity ("**CLARITY**") Act in the House of Representatives and parallel legislation in the Senate, aim to establish a comprehensive federal framework for digital asset markets offerings and trading activity, further underscoring ongoing efforts to create a legal framework.

EXHIBIT ES.1

Key Developments Driving Institutional Adoption of DLT And Tokenization



8. J.P. Morgan, 2024

In the EU, the landmark **MiCA** regulation was enacted in 2023, creating a comprehensive licensing and oversight regime for crypto-assets, including stablecoins, while the **European DLT Pilot Regime** now allows market infrastructure trials for digital securities within a controlled environment. The UK has launched a **Digital Securities Sandbox (DSS)** in 2024 to facilitate the issuance, trading, and settlement of digital securities on blockchain under close regulatory supervision, reflecting authorities' willingness to accommodate innovation in a safe setting. The UK's Financial Conduct Authority ("**FCA**") is also consulting on stablecoin legislation as well as market structure rules via CP25/14: Stablecoin issuance and cryptoasset custody, and DP25/1: Regulating cryptoasset activities. In parallel, major jurisdictions such as Switzerland have authorized tokenization projects within their securities and payments systems. This convergence of clearer rules and supportive regulators has given institutional players the confidence to move from proofs-of-concept toward full-scale implementations.

In Asia-Pacific, regulators are advancing fast-paced reforms to support digital asset innovation within structured, compliant frameworks. Singapore has emerged as a leader, with the Monetary Authority of Singapore (MAS) spearheading Project Guardian—a collaborative initiative with major banks to test tokenized securities and DeFi applications under regulated conditions. Hong Kong has also made significant strides, with the Hong Kong Monetary Authority (HKMA) playing a central role in enabling the issuance of tokenized green bonds under the Government Green Bond Programme and integrating blockchain into the operations of its Central Moneymarkets Unit (CMU). The HKMA has also set out clear licensing expectations for virtual asset trading platforms, reinforcing its commitment to responsible innovation. Most recently, tthe HKMA's Stablecoins Ordinance has been enacted and will come into effect in August of 2025, establishing a licensing regime for fiat referenced stablecoin issuers in Hong Kong.[9] Japan amended its Payment Services Act and Financial Instruments and Exchange Act to recognize stablecoins and digital securities, while also establishing dedicated frameworks for Security Token Offerings. Australia is consulting on digital asset custody and exchange licensing, and Korea is piloting wholesale CBDC infrastructure for capital market applications. This wave of regulatory clarity and structured experimentation across APAC has created a fertile environment for institutional adoption and positioned the region as a key hub for next-generation financial market infrastructure.

Institutional participation is therefore at an all-time high. Many of the world's largest asset managers, banks, and market infrastructure firms have either gone live with tokenized offerings or are on the cusp of doing so.

Notably, tokenized U.S. Treasuries are now being used in intraday repurchase agreements among banks, with daily volume in some networks measured in the billions. JPMorgan's Kinexys platform, for example, conducted one of the first such tokenized collateral transfers in 2022 and has since scaled to routinely process large bilateral repos within minutes on-chain. Prudential authorities, like the Bank for International Settlements ("**BIS**") have also weighed in on these benefits highlighting that tokenizing government bonds has the potential to enhance market efficiency and drive financial innovation.[10] These tangible use cases across funds, bonds, and repos underscore that the technological and operational stage for tokenization at scale is effectively set.

DLT has significantly reshaped fixed income markets by enabling digital bond issuance: prominent examples of this transformation include UBS's CHF 375 million bond issuance on SDX, which delivered precise settlement while preserving full interoperability with traditional investor access points. Similarly, AIIB issued a $500 million digital bond through Euroclear's D-FMI, combining blockchain-based settlement with legacy infrastructure compatibility. These real-world implementations highlight the practical benefits of DLT in capital markets—namely, reduced friction, operational efficiency, and stronger integration between emerging technologies and established systems.

Tokenized money market funds are reaching critical mass: BlackRock's tokenized U.S. Treasury fund (ticker **BUIDL**) has grown to over $2 billion in market value – now accounting for more than 30% of the tokenized Treasury market – while Franklin Templeton's on-chain government money fund (**BENJI**) has amassed well over half a billion in assets.[11] These are no longer experimental pilot programs but sizable funds attracting real investors.

This report will assess these use cases in detail across standard dimensions such as: *Overview of the Use Case, Settlement Asset and Legal Structure, Interoperability and Network*, and *Conclusion*. Seeking to provide practical examples of benefits espoused here, these deep dives serve as a sample of the transformation underway.

The past two years have seen significantly increased readiness for digital assets in mainstream finance. The foundational pieces, mature technology platforms, clearer regulations, and committed institutional players, have aligned to create an environment where tokenized assets can expand rapidly. The question is no longer if real-world assets will be tokenized at scale, but when these assets will be represented on DLT and how participants will interact with them. Market momentum, supported by regulatory green lights, suggests the inflection point is imminent. As we stand today, the conditions are in place for tokenization to move from early-stage live projects to a critical component of market infrastructure in the coming years. The stage for mass adoption is set.

9. HKMA, "Robust and Sustainable Development of Stablecoins", June 2025.
10. BIS, "Tokenization of Government Bonds: Assessment and Roadmap, BIS Bulletin No. 107", July 2025.
11. RWA.xyz, May 2025.

THE CASE FOR VALUE REMAINS CLEAR ACROSS THE TRADE LIFECYCLE

The fundamental value proposition of tokenization – efficiency and automation across the entire trade lifecycle – remains clear demonstrated by live use cases today. Tokenization directly addresses longstanding pain points in securities markets by leveraging smart contracts and distributed ledgers to streamline issuance, trading, settlement, and asset servicing. At the issuance stage, digital tokens can simplify syndication, enabling faster time-to-market and broader investor reach. For example, issuing financial instruments as tokens can cut out numerous intermediaries and manual processes. According to analysis by Ripple and BCG, tokenizing an investment-grade bond can reduce operating costs by 40–60% compared to traditional issuance, largely by automating workflow and reducing paperwork.[12] Settlement of such tokenized bonds can occur nearly instantly (T+0 or T+1), versus several days in the conventional system, improving capital efficiency and reducing counterparty risk.[13] An issuer handling $1 billion in bonds annually could save on the order of $2–3 million in costs by issuing on-chain, thanks to efficiency gains in book-building, compliance processing, and distribution.[14] These savings directly enhance issuance profitability and can lower financing costs for issuers.

During trading and settlement, the benefits are equally compelling. Transactions recorded on a distributed ledger settle *delivery-versus-payment* automatically through smart contracts, significantly reducing settlement times and reducing the likelihood of fails or reconciliation breaks. Providing the option for precision (such as on a real-time or near-real-time basis) may allow market participants to benefit from improved liquidity and faster collateral mobility. Participants no longer need to maintain large buffers for operational delays. In the **collateral management and securities financing** context, these efficiencies translate into material financial gains. A recent industry study estimated that a global bank managing around $100 billion in daily repo transactions could realize **$150–300 million in annual cost savings** by using tokenized collateral and instantaneous settlement, due to reduced idle collateral, faster trade cycles, and the ability to settle repo trades on a 24/7 basis.[15] Early deployments in the repo market (such as JPMorgan's collateral tokenization for intraday liquidity) have already demonstrated reduced friction – collateral can be mobilized and re-used multiple times a day when represented as tokens, something not feasible under traditional intraday cutoff constraints.

EXHIBIT ES.4

Market and Efficiency Potential Across Key Use Cases

INVESTMENT-GRADE BONDS	REAL ESTATE	COLLATERAL & LIQUIDITY MANAGEMENT	TRADE FINANCE & WORKING CAPITAL	TREASURY & CASH MANAGEMENT
Savings of **USD 40M–60M**	Savings of **USD 100M–150M**	Savings of **USD 150M–300M**	Savings of **USD 2B–4B**	Savings of **USD 55M–140M**
Annually, for USD 100B in issuance, by reducing intermediaries and automating issuance, settlement, and compliance through smart contracts.	Over 5 years, for a real estate fund with USD 5B in AUM, by reducing admin costs through automation. Additional USD 500M–1B in new capital possible via fractional ownership and broader investor access.	Annually, for a global bank with USD 100B in daily repo volume, by reducing idle collateral and accelerating settlement cycles.	Annually, for a firm processing USD 50B in trade volume, by accelerating invoice settlement and programmable payments. Additional reduction of financing costs by USD 20M–50M achievable through tokenized receivables.	Annually, for a multinational company managing USD 1B in idle cash and 10B in payments, by boosting yield, reducing FX and processing costs, and improving liquidity through tokenized money.

12. BCG, Ripple, "Approaching the Tokenization Tipping Point", April 2025.
13. Ibid.
14. Ibid.
15. BCG, Ripple, "Approaching the Tokenization Tipping Point", April 2025.

Cost-benefit analysis

Implementing DLT often means overhauling or integrating with core banking systems, which can be expensive and technically challenging. Early adopters have encountered hurdles around scalability, integration, and security.[16] Major banks have also made sizable internal investments: JPMorgan's Kinexys division (its dedicated DLT unit) grew from a small team in 2014 to over 100 full-time staff by 2020 underscoring a multi-year, multi-million-dollar commitment to DLT innovation.[17]

Deploying DLT at an institutional scale is typically a multi-year journey. Some high-profile projects have incurred large costs with mixed results. A cautionary example is the Australian Securities Exchange (ASX), which spent an estimated $165–$170 million USD attempting to replace its clearing and settlement system with a blockchain platform.[18] After several years of development, that project was paused due to technical challenges, illustrating the risk and complexity involved in reinventing core market infrastructure. Lessons from such cases underscore the need for rigorous planning, phased implementation, and stakeholder alignment to achieve success.

Recognizing these costs and complexity, institutions have collaborated to develop DLT solutions. R3, for example, is a banking-led consortium that at one point included over 100 banks, regulators, and trade associations developing a dedicated DLT platform (Corda) for finance.[19] Similarly, the Linux Foundation's Hyperledger project attracted 170+ participating organizations ranging from tech firms to exchanges.[20] SDX trading, which has recently merged with SIX, offers a strong example of how DLT can be effectively applied, integrating seamlessly with existing market infrastructure rather than replacing it, while emphasizing confidentiality, settlement finality, and adherence to regulatory standards in its design.[21] DLT adoption is a strategic commitment that requires long-term investment, cross-functional coordination, and sustained executive support. Given the scale of integration, regulatory complexity, and capital at stake, successful implementation depends on careful planning, phased deployment, and strong risk management from the outset.

Further, costs are falling and are increasingly strategic. Recent research has identified that launching a focused tokenization use case can cost USD $2M or less. However, a full integration (i.e., across custody, trading, compliance and multiple asset types) may require an investment of USD $15M-20M for a mid-size bank and up to USD $100M for a Tier 1 Financial Institution or GSIB.[22] These are not solely "R&D" or experimental budgets, but rather strategic investments in infrastructure that will support new business models and deliver on efficiencies for the financial system and franchise to expand products and services benefiting clients globally.

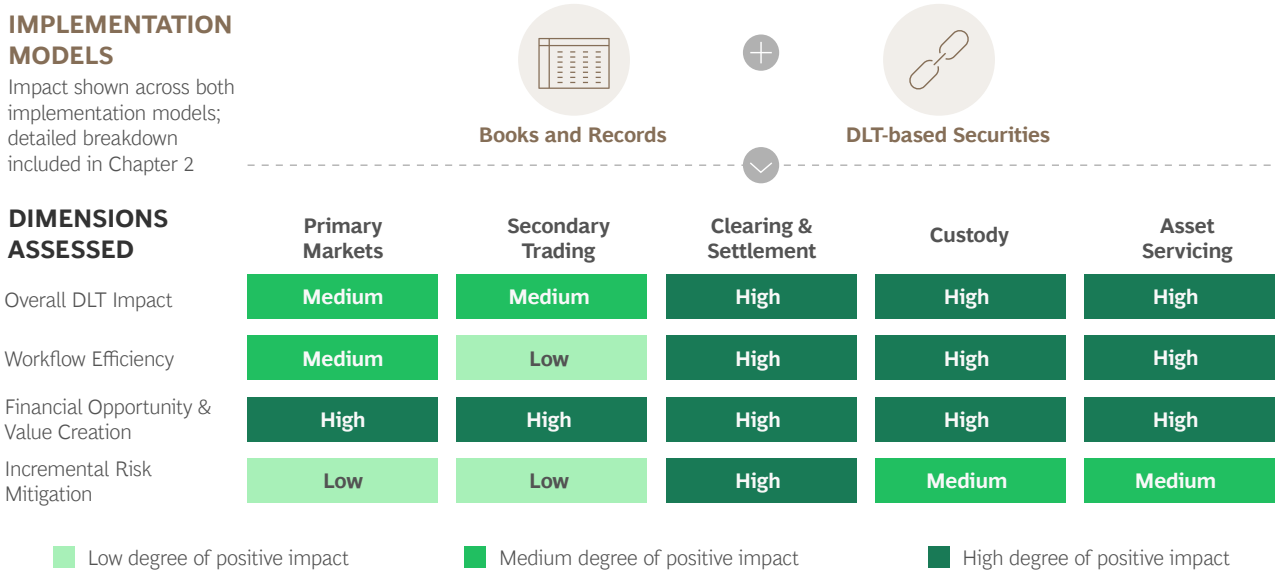
Global banks and market players have poured substantial capital into DLT projects and consortia over the past decade, and these investments are now maturing to the point where they can produce substantial industry-wide benefits. Over time, these economics are likely to reverse as tokenization platforms become the default choice and may one day cost less to run than legacy systems, especially as liquidity forms and scale accelerates.

Perhaps the most underestimated gains are in **asset servicing and lifecycle management**. Processes such as coupon payments, corporate actions (e.g., dividends, splits), and investor communications can be automated via smart contracts embedded in the tokenized asset. This analysis finds that **DLT-based asset servicing** offers **high impact** potential. For instance, smart contracts can automatically credit entitlements to holders or handle tax withholding and reporting, drastically reducing manual workloads and errors in back-office operations. In a tokenized environment, an equity token could automatically execute a shareholder vote or distribute a dividend to token holders without the complex chain of custody and custodians that exists today. These improvements not only cut costs but also enhance transparency and accuracy across the lifecycle of a security.

16. Secfin Solutions, "Blockchain and Distributed Ledger Technology in the Repo Market: A Comprehensive Analysis", 2025.
17. CNBC, "JPMorgan creates new unit for blockchain projects, says the technology is close to making money", 2020.
18. Reuters, "Australian stock exchange's blockchain failure burns market trust", 2022
19. World Bank Group, "Distributed Ledger Technology (DLT) and Blockchain", 2017.
20. Ibid.
21. SDX, "SDX announces the consolidation of trading for digital assets into SIX Swiss Exchange", May 2025.
22. BCG, Ripple, "Approaching the Tokenization Tipping Point", April 2025.

EXHIBIT ES.5

Impact of DLT-based Securities on Workflow Efficiency, Financials and Value Creation, and Risk Mitigation Across the Securities Lifecycle



Source: BCG analysis.

The **operational resilience** benefits are notable as well – with an authoritative ledger, all parties share a single source of truth, simplifying reconciliations and audits. Our comprehensive lifecycle assessment confirms that tokenization can drive value at each stage: from **faster issuance and settlement to more efficient servicing and reporting**. In aggregate, these efficiencies can free up significant capital and reduce the frictional costs that have historically burdened capital markets. One study estimates that by 2030, widespread tokenization could unlock **tens of billions of dollars** in savings industry-wide through reduced operational overhead and improved liquidity management.[23]

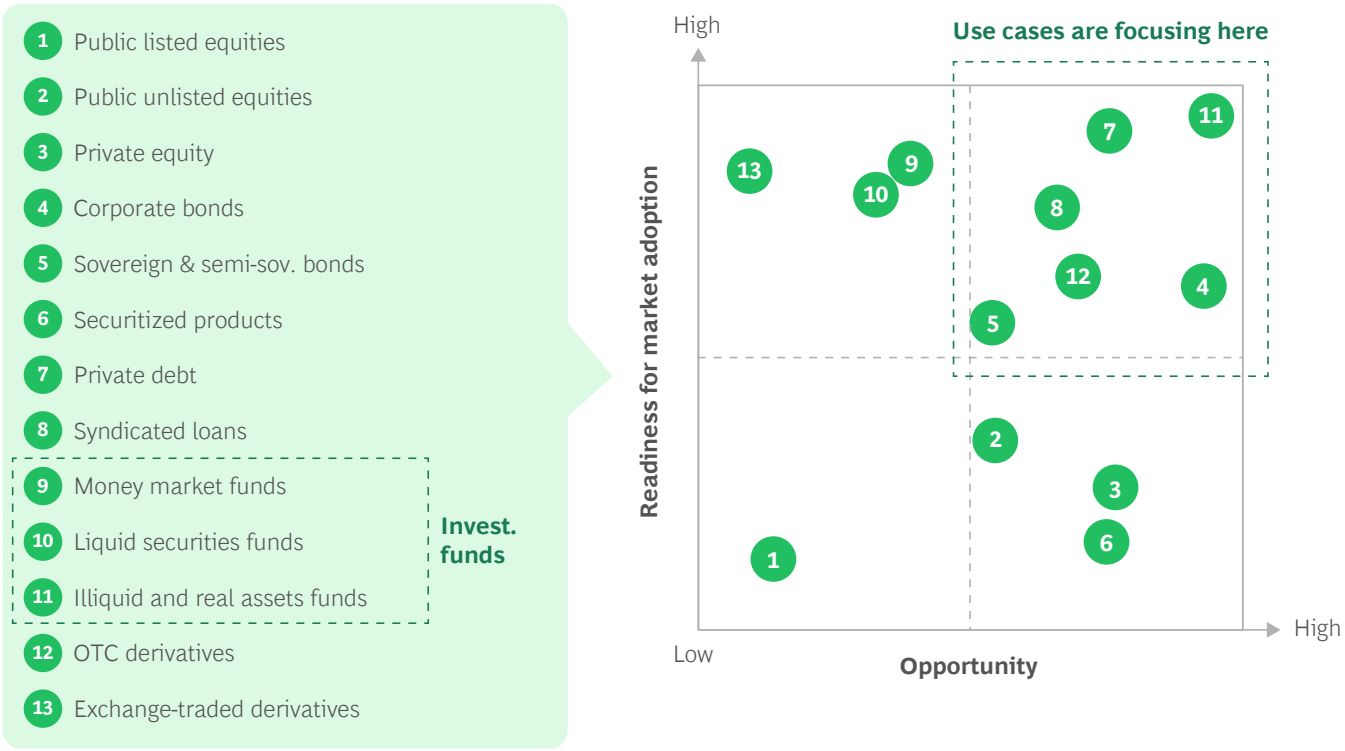
The case for these economic benefits has only grown stronger as pilot projects have quantified the time and cost reductions in practice. For many participants the economic rationale for tokenization is compelling as it begins to deliver tangible improvements in speed, cost, and risk mitigation across the entire trade lifecycle. Prudential authorities such as the Bank of England have highlighted that tokenization provides a route to innovation that supports financial stability while preserving public trust and confidence in the monetary system.[24] Market participants and observers now widely recognize that tokenization is not just a technological experiment, but a means to enhance market infrastructure and operational processes.

Adoption of DLT-based Securities will not progress equally across asset classes. As demonstrated by the use cases profiled later in this report (see **Deep Dive | Use Cases)** adoption is informed by two common drivers: (1) a clear financial opportunity from efficiency gains or innovation; and (2) market readiness for innovation and adoption around specific market structure attributes. The BIS offers a similar perspective in the *Tokenization Continuum* citing that "Tokenization could bring benefits" to assets and the way transactions and transfers occur, but adoption will occur on a "continuum and highlight a trade-off: where Tokenization is easiest, per-unit gains are likely to be modest" and conversely "where Tokenization is difficult the potential benefits are the largest".[25] As a result, the authors suggest Tokenization efforts to "focus on identifying assets that are suitable for Tokenization" and have enough volume for a sizeable impact.[26]

23. BCG, Ripple, "Approaching the Tokenization Tipping Point", April 2025.
24. Sasha Mills, Bank of England, "Keynote Address at City Week 2025", July 2025.
25. Aldasoro, Doerr, Gambacorta, Garratt, Wilkens, BIS Bulletin No 72 "The Tokenization continuum", April 2023.
26. Aldasoro, Doerr, Gambacorta, Garratt, Wilkens, BIS Bulletin No 72 "The Tokenization continuum", April 2023.

EXHIBIT ES.6

Asset-Classes Show Varying Suitability for Adoption onto DLT



Sources: BCG analysis; Adapted from JP Morgan and BCG, 'The Future of Distributed Ledger Technology in Capital Markets', November 2022.

THE FUTURE STATE WILL BE A COMBINATION OF DIGITAL NATIVES, NON-BANK FINANCIAL INSTITUTIONS, AND BANKS

The emerging tokenization ecosystem is characterized by a **hybrid market structure** in which diverse types of institutions – from digital natives to non-bank financial institutions ("NBFIs") to banks – all play complementary roles and co-exist within the regulatory perimeter. **Collaboration between traditional and new players** may define the future state.

Digital-native firms (including DLT-native FinTechs, tokenization platforms, stablecoin issuers and exchanges) have provided much of the early innovation, developing technology and business models for tokenized assets. They bring technical expertise and a willingness to experiment with decentralized finance protocols. **NBFIs**, such as asset managers, broker-dealers, and market makers, have also been quick to embrace tokenization where it enhances their services – for example, asset managers launching tokenized funds or nonbank lenders arranging tokenized private credit. These NBFIs serve as a bridge, applying institutional standards to new digital asset products while not being subject to bank-specific constraints. **Banks**, for their part, have moved more deliberately but are now entering the space in force, especially where tokenized assets intersect with their core businesses (such as payments, custody, and lending). Large global banks are focusing on tokenized versions of traditional assets (bonds, deposits, money market funds) that can be brought under existing regulatory and risk frameworks.

While there were early concerns that stablecoins may not fully meet the core monetary system criteria of singleness[27], elasticity, and integrity,[28] as regulatory frameworks continue to evolve for stablecoins, they show meaningful potential in supporting tokenization, and the aforementioned risks should be weighed thoughtfully against the potential benefits that stablecoins can offer. Stablecoins, alongside other forms of DLT-based Payment Instruments like Tokenized Deposits, can play a valuable role, particularly in enabling 24/7, programmable settlement and supporting innovation in tokenized markets. With appropriate regulation, transparency, and interoperability, many of the risks around singleness, elasticity, and integrity may be able to be managed.

A next-generation financial system built on DLT-based Payment Instruments and DLT-based Securities offers the potential to significantly enhance efficiency, programmability, and cross-border functionality. At the core of this system is the integration of central bank reserves, commercial bank money, and government securities into unified, programmable platforms. In this ecosystem, central banks provide the foundation of trust and monetary stability, while commercial banks play a critical role in distribution, customer access, and credit intermediation. As private innovations such as stablecoins continue to evolve, the active involvement of both central and commercial banks is essential to ensuring that future financial infrastructure operates safely. Regulated institutions, working in partnership with regulators are uniquely positioned to provide the compliance, risk management, and technological integration capabilities needed to support the safe scaling of digital asset ecosystem.[29]

Notably, industry stakeholders are actively urging regulators to refine their rules to better integrate public blockchain innovation into the mainstream. Overly restrictive bank capital rules, such as blanket penalties on assets issued on public, permissionless blockchains, could push digital asset activity outside the regulated financial services sector, leading to market fragmentation and new systemic risks. The industry has called for re-integrating permissioned and permissionless public networks into the ambit of allowable infrastructure for banks, provided appropriate risk mitigants (such as smart contract controls, vetted code, and on-chain analytics) are in place, and for a case-by-case, risk-based treatment of tokenized assets. Regulated institutions bring their expertise in risk management and may help prevent system of significant scale from growing completely outside prudential oversight. The future market structure will therefore be a blend of various participants: we will see regulated banks, digital native innovators, FinTechs, and non-bank intermediaries coexisting and interacting within tokenized markets. Each type of player will occupy the roles best suited to their strengths, together working to support a healthy financial system.

27. Single-minded? Rethinking our approach to the 'singleness of money' could help to reap the benefits of stablecoins: **https://www.kcl.ac.uk/news/stablecoin-regulation-and-the-singleness-of-money**.
28. Bank for International Settlements, "Blueprint for the Future Monetary System: Improving the Old, Enabling the New. Annual Economic Report 2025, Chapter III", June 2025.
29. Ibid.

Over time a pluralistic market structure is a likely end state. Achieving this will require continued dialogue between the private and public sectors. Regulators are already beginning to acknowledge that an inclusive approach, one that welcomes banks, NBFIs and digital natives into the digital asset space under appropriate safeguards, is preferable to forcing all activity into unregulated corners. In summary, the tokenization ecosystem of the future will not belong to any single class of institutions; instead, it will be an integrated network of banks, non-banks, and FinTech firms, each playing critical roles to ensure both innovation and stability. Innovation must evolve within the traditional financial system, requiring regulatory frameworks that enable both legacy and emerging technologies to coexist and interoperate within a unified market infrastructure.[30] This hybrid model will help embed tokenization into the fabric of finance in an orderly, resilient way, combining the best attributes of traditional finance (reliability, compliance, scale) with the efficiencies and inclusiveness of decentralized technologies.

Looking ahead, the evolution of this ecosystem is likely to be a phased development, supported by advancements in technical capabilities, clarity around legal and regulatory frameworks and taking learnings from lessons of live use cases. As risk mitigants continue to mature towards the standard needed for institutional activity, progress could significantly accelerate.

The path toward widespread adoption of tokenization is expected to unfold in three key phases:

Phase 1 | Institutional Readiness: This is the current stage, where institutions are moving beyond isolated pilot programs and beginning to develop the operational capabilities and regulatory frameworks needed to support real product launches. Activity is likely to remain concentrated in asset classes with more established regulatory clarity—such as money market funds, collateral, especially fixed income instruments. The focus at this stage is less about scale and more about building foundational experience, infrastructure, and risk frameworks.

Phase 2 | Commercial Expansion: As market liquidity deepens and early use cases demonstrate consistent value, adoption is expected to broaden across asset classes and investor segments. This phase is defined by more widespread issuance and trading of DLT-based Securities, especially in secondary markets. Institutions may begin to standardize issuance and settlement practices, and interoperability between platforms could become more critical. The emergence of shared infrastructure and common protocols will help accelerate adoption.

Phase 3 | Market Transformation: The final phase marks the shift to a fully integrated digital market infrastructure. At this point, tokenization spans the entire securities lifecycle, from primary issuance through post-trade servicing. End-to-end automation and programmability become embedded features of the system, delivering structural efficiencies and enabling new financial products. Regulatory frameworks will have been tested and finalized, investor trust established, and institutional workflows reconfigured to support the operational and legal standards of a tokenized environment.

30. Sasha Mills, Bank of England, “Keynote Address at City Week 2025”, July 2025.

EXHIBIT ES.7

Phased Adoption of Tokenized Capital Markets

	TODAY PHASE 1: INSTITUTIONAL READINESS 1–3 years	MEDIUM TERM PHASE 2: COMMECIAL EXPANSION 3–5 years	LONG TERM PHASE 3: MARKET TRANSFORMATION 5–10+ years
	Partnered experimentation to validate technical capabilities & pilots move to production (e.g., repos, bond issuance). Public-private partnerships on legal ambiguities, regulation and best practice risk mitigants.	**Commercial viability** driven by rising issuer and investor demand in selected asset classes, as liquidity establishes. Legal and regulatory frameworks crystallize as benefits proven across jurisdictions.	**Large-scale growth** in issuer and investor demand across primary and secondary markets in selected asset classes. Robust and globally harmonized legal and regulatory frameworks established as DLT-ecosystem matures.
Key Enablers	**Limited demand for DLT-based securities; experimental issuances** • Mix of tokenized security and native security token issuance • Majority of process (e.g., structuring, syndication, book build) performed traditionally, no cost savings • Limited innovation around fractionalization and bespoke products	**Demand emerges in selected asset classes** • Native security token issuances outstrips tokenized securities • Native security issuance process party enabled on DLT, driving speed to market and lower issuance costs • Fractionalized issuance on select DLT platforms; issuers test new products	**Demand overtakes traditional issuance in selected asset classes** • Native security tokens is default format over tokenized securities • Native security issuance process fully enabled on DLT, driving further market responsiveness & savings • Scaled (retail) investor adoption of fractional issues and products tailored to investor needs
Secondary Trading	**Few secondary markets for DLT-based securities; liquidity is low** • Majority of trading venues (exchanges, OTC networks, MDPs) do not offer DLT-based securities • Where trading is possible, participants leverage non-FMI, purpose-built DLT-trading platforms	**Growth in DLT-based secondary market liquidity** • Trading of DLT-based securities emerges in selected trading venues for selected asset classes (e.g., illiquids) • DLT Platforms are integrated with traditional, non-DLT, FMI (e.g., FedNow for payment settlement)	**Majority of liquidity and trading in selected asset classes is via DLT** • Interoperable DLT market allows aggregation of liquidity across OTC markets and greater velocity • DLT-specific FMI matures (e.g., post-trade) • Fractionalization allows precise hedging and risk management
Clearing & Settlement (C&S)	**Testing of DLT-based C&S operational processes** • PoCs demonstrate instant DvP with traditional payment rails (e.g., RTGS) • Instant DvP in live production across repos, enabling intra-day use cases • DvP driven by tokenized commercial bank money, deposits and/or other forms of DLT-based Payment instruments	**DLT-based C&S emerges as alternative DvP channel in selected asset classes** • Instant DvP in live production across selected asset classes • Traditional settlement continue to dominate markets • DvP driven primarily by tokenized commercial bank money, deposits	**Automated, continuous DLT-based C&S is the default in selected asset classes** • Settlement choices driven by needs of market participants • DLT-based C&S enables Opex & capital efficiencies, and mitigates risk • DvP driven by either tokenized commercial bank money or deposits depending on use case
Custody	**Digital custody solutions are limited, propositions focused on cryptoassets** • Custodians focused on custody of cryptoassets to meet near-term market demand • Limited adoption of DLT-based books and records and post-trade operations • Emergence of DLT-based collateral mobility platforms in repos and OTC derivatives	**Growth in digital custody solutions, with move away from cryptoassets** • Custodians build or buy solutions for DLT-based security custody (recordkeeping and automation in post-trade operations) • DLT-based collateral mobility platforms become default option • Clarity on role of national CSDs across major markets	**Digital custody solutions offer DLT-based and traditional custody** • Custodians provide seamless interoperability between DLT-based and traditional securities • DLT simplifies post-trade operations reducing Opex and mitigating risk • Harmonization on roles of CSD across markets
Asset Servicing	**Limited ecosystem around smart contracts (standards, regulation etc.)** • Proof-of-concept testing for smart contracts supporting DLT-based income payments (e.g., coupons, dividends) • Partnerships to build capabilities but open questions remain (e.g., legal, regulatory, risk and governance, standards)	**Growth in piloting of DLT-based asset servicing** • Standardization of smart contracts drives traction in DLT-based income payments (e.g., coupons, dividends) • Functionality to support tax and regulatory reporting processes piloted • Clarity across legal, regulatory, risk and governance frameworks	**DLT-based asset servicing becomes default in selected asset classes** • Corporate actions embedded in smart contracts tied to securities at issuance • Dividends, coupons, and tax withholding processes automated and settled with DLT-based payments • Targeted 'embedded supervision' introduced for real-time regulatory visibility and monitoring
Key Enablers	Cross-industry, public-private partnerships Regulated, accepted, DLT-based money Industry-aligned taxonomy and educative materials Updated fund and investment mandates Global legal and regulatory framework Interoperable networks and markets DLT-specific FMI		

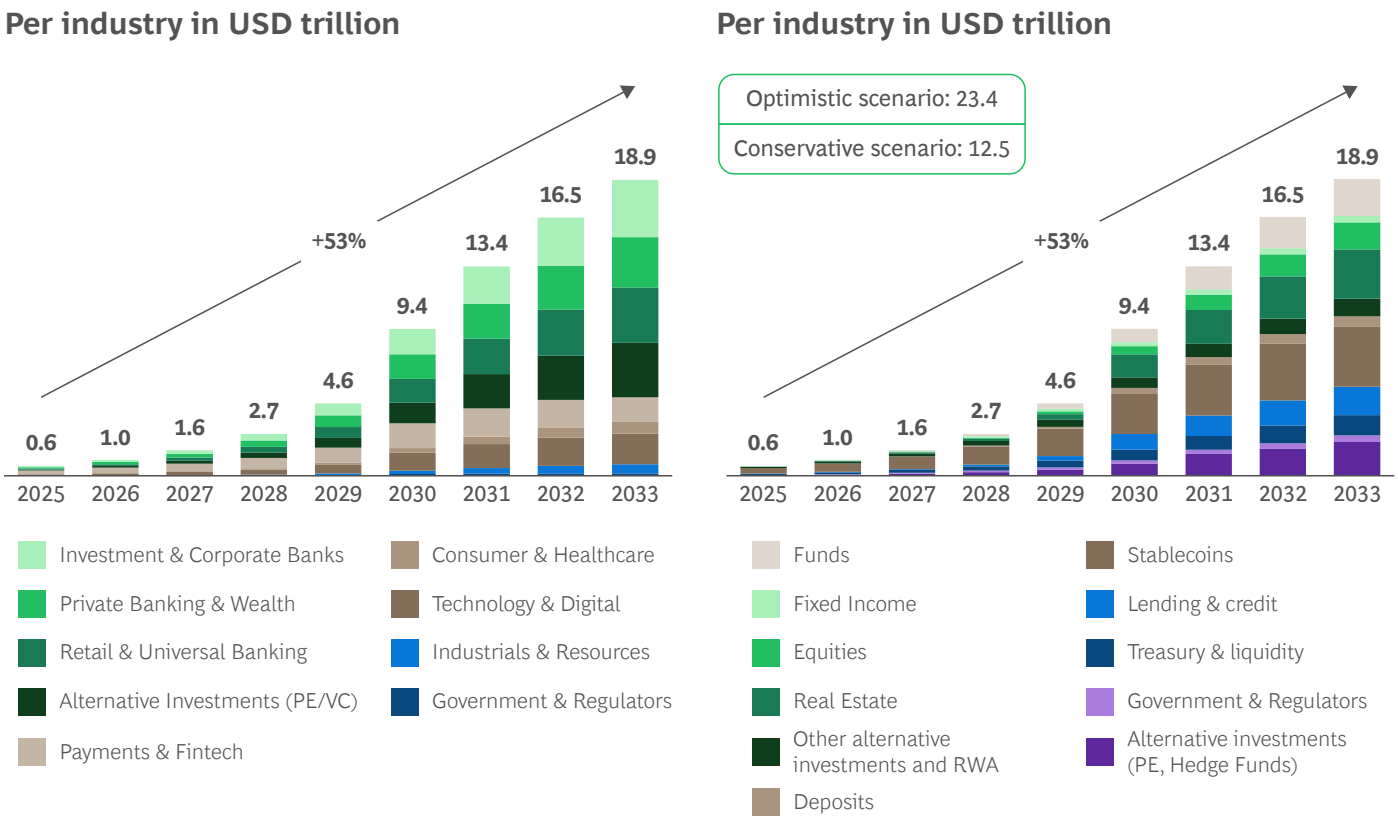
Sources: BCG analysis, GFMA Member Interviews.

As adoption expands, liquidity improves, and investor demand materializes, the growth of tokenization will likely be a **self-reinforcing flywheel** as organic growth naturally accelerates. Tokenization supports long-term product trends such as accessibility and fractionalization that institutions are already beginning to offer via non-DLT-based solutions. The tokenization of capital markets is expected to scale materially through 2033. Market analysis projects tokenized real-world assets will grow from approximately $0.6 trillion in 2025 to $18.9 trillion by 2033, a compound annual growth rate of over 50%.[31] This transition reflects both a technological shift and a strategic reorientation within institutions.

As this market matures – the differentiating factors between market participants will not be technological, but like today, their ability to meet client demand, deliver innovative services, offer safe, sound, and compliant access to global capital markets.

EXHIBIT ES.8

Estimated Growth in Tokenization Through 2033[32]



Source: Ripple and BCG.

31. BCG, Ripple, "Approaching the Tokenization Tipping Point", April 2025.
32. BCG, Ripple, "Approaching the Tokenization Tipping Point", April 2025.

RISK MITIGATION MEASURES HAVE EVOLVED TO MEET INSTITUTIONAL STANDARDS

As tokenization moves from the periphery to the mainstream of capital markets, **risk management and governance frameworks** have likewise evolved to meet the high standards of institutional finance.

This report serves as a comprehensive update to the existing "Risk and Mitigants" chapter articulated in the 2023 GFMA Report *The Impact of DLT in Capital Markets*, integrating the latest insights from seminal industry publications, including the GFMA-GDF Smart Contract Primer (October 2024), the Guardian Fixed Income Framework (November 2024), and the ISDA Digital Asset Derivatives Definitions (January 2023) and ISDA Tokenized Collateral Model Provisions (May 2024). It further supplements this analysis with current guidance and frameworks from leading international standard-setting bodies and national regulators such as the Bank for International Settlements ("BIS"), the Financial Stability Board ("FSB"), the International Organization of Securities Commissions ("IOSCO"), the Basel Committee for Banking Supervision ("BCBS"), the MAS, SEC, the FCA, and the European Securities and Markets Authority ("ESMA"). The primary objective is to provide a consolidated view of how DLT-specific risks are being systematically addressed and managed. For a full view of the identified risks and mitigants, please refer to **Chapter 1.4 | Risk Mitigants Across Network Types**.

The focus remains steadfast on the robust mitigation of identified risks. The operational procedures and control enhancements detailed herein convey a strong sense of confidence that current and evolving risk management frameworks are increasingly sufficient and appropriate for institutional controls, thereby fostering responsible innovation and ensuring the continued integrity and stability of capital markets.

Holistic Understanding of DLT-Specific Risk

Joint Trades and members consistently advocate for DLT implementation that aligns with the stringent standards of regulated capital markets, thereby safeguarding market participants and the broader financial system. This approach is built upon established principles from organizations such as the IOSCO[33,34] BCBS[35], and FSB[36], with the explicit goal of identifying and mitigating DLT-specific risks to ensure safe and secure development.

A guiding principle for regulatory approaches emphasizes technology-neutrality. This means that regulatory requirements should be determined by the specific use cases or activity taking place, rather than by the technology's characteristics alone. This perspective is crucial for avoiding broad, undifferentiated regulatory mandates that could inadvertently hinder responsible innovation. The current DLT ecosystem is still in its formative stages, with primary and secondary markets yet to achieve widespread adoption. This foundational phase necessitates ongoing dialogue and collaboration between the public and private sectors to address technical challenges and work towards global harmonization in regulatory and operational frameworks.

The understanding of DLT's impact has matured from viewing it as a revolutionary technology introducing entirely new risks to recognizing it as an enhancement or alternative infrastructure. Discussions now frequently refer to "new considerations" or "novel applications of existing risks," rather than solely "new risks." This evolution in perspective suggests that regulatory bodies are increasingly integrating DLT into their established oversight mechanisms, which helps reduce regulatory uncertainty and encourages the scaling of DLT within existing prudential boundaries.

Updated principles for DLT risk assessment and mitigation underscore the need for adaptability. Risk assessments which must be undertaken for each DLT platform in light of the platform's specific characteristics, must evolve based on three critical factors: **the implementation model** (e.g., 'Books and Records' versus 'DLT-based Securities'), the **lifecycle activity** (e.g., Primary Markets, Secondary Markets, or post-trade operations), and the **specific DLT network archetype** employed (Private-Permissioned, Public-Permissioned, or Public-Permissionless). Regulated financial institutions possess a well-established history of responsible innovation, leveraging their high standards in institutional-grade technology, operational risk management, operational resilience, cybersecurity, data protection, client suitability frameworks, and robust Know Your Customer ("KYC"), Anti-Money Laundering ("AML"), and Combating the Financing of Terrorism ("CFT") procedures. These existing frameworks form the bedrock for managing risks associated with DLT adoption.

33. BIS-IOSCO, "Principles for Financial Market Infrastructure", 2012.
34. IOSCO, "Principles on Outsourcing" October 2021, and "Operational resilience of trading venues and market intermediaries during the COVID-19 pandemic", January 2022.
35. BCBS, "Principles for Operational Resilience", March 2021, and "Principles for Sound Management of Operational Risk", March 2021.
36. FSB, "Recommendations to Achieve Greater Convergence in Cyber Incident Reporting", and Format for Incident Reporting Exchange (FIRE), April 2023; and the FSB's Guidance on "Operational Continuity while in Resolution", August 2016.

DLT-based Books and Records

DLT-based Books and Records systems, primarily used for internal recordkeeping, accounting, and reporting on private-permissioned networks, are managed with risk management practices that are analogous to traditional systems. The BCBS has indicated that such systems, where the legal nature of the service remains unchanged, fall outside the scope of additional prudential treatment.

For internal DLT-based systems, regulatory oversight remains focused on ensuring that the system fulfills the financial institution's existing obligations to maintain efficient and effective systems and controls in a safe and sound manner. Key criteria for maintaining analogous risk management include: operating within a private-permissioned and internal control environment; ensuring security is properly ringfenced within the regulated institution's technology and security controls; limiting direct read/write access exclusively to the institution; recording debits, credits, and other asset transfers consistent with existing approved traditional book entries; requiring the approval and vetting of instructions by the regulated financial institution for any third-party changes; providing permissioned reporting to customers without direct third-party access; and establishing mechanisms for reconciliation and unilateral correction of mistakes in line with internal governance protocols.

The explicit policy stance that the mere introduction of DLT protocols for Books and Records, akin to traditional banking activities, should not in itself lead to additional regulation or capital charges, is a significant development. This position indicates that internal, permissioned DLT applications are largely perceived as operational enhancements within existing regulatory boundaries, rather than new regulated activities. This clarity reduces regulatory uncertainty and the potential for punitive capital treatment, thereby incentivizing financial institutions to invest in DLT for internal efficiencies and accelerating its adoption in back-office functions.

Perspective on Public-Permissioned and Public-Permissionless Networks as a Form of Books and Records Use Cases

DLT enables a reimagining of traditional books and records systems through digital infrastructure that allows greater transparency, programmability, and resilience. While private-permissioned networks have long been viewed as best suited for internal recordkeeping due to their control and security, emerging perspectives suggest that public-permissioned, public-permissionless, and hybrid networks can serve comparable books and records functions under appropriate conditions.

In essence, the core functionality required for books and records—control over who can read and write data, validation of transactions, and auditability—can be achieved on public networks when deployed with permissioning mechanisms. In such configurations, control over the token and protocol remains with the issuing institution. Access to the wallet may be distributed, but only authenticated actors can initiate or view transactions. The institution retains ultimate authority to read and write data relevant to ownership records and obligations.

This architectural model redefines the concept of a wallet. Rather than serving as a direct custodian of bearer assets (as is default for many public network architectures), the wallet becomes a method of issuing or coordinating the issuance of instructions. Access credentials (such as private keys or digital certificates) act as gatekeepers to instruct a transaction, but not to alter the official record unilaterally. The actual recording—what the institution owes to the client and what the client owns—is governed centrally, even if the infrastructure to record said record is distributed.

Critically, such a model should not alter the legal nature of the asset or the risk profile of the activity. A token representing a deposit or security should remain subject to the same regulatory outcome as its traditional counterpart if it is merely a new format for existing records. This aligns with the principle of "same activity, same risk, same regulatory outcome." Institutions should maintain their obligations under existing regulatory frameworks—including KYC, AML, and transaction monitoring—even when deploying on public infrastructure.

A recent example of this approach is J.P. Morgan launch of a blockchain-based deposit token (JPMD) that represents insured U.S. dollar deposits held at the bank, offering a regulated and interest-bearing alternative to stablecoins.[37] Built on Coinbase's Base Layer-2 network, the token enables instant, low-cost transfers and 24/7 settlement between institutional clients. The initiative supports cross-border payments, tokenized asset transactions, and interoperability between public blockchains and J.P. Morgan's internal infrastructure.

37. Ledger Insights, "JP Morgan's blockchain bank account used to settle Ondo public chain transactions", May 2025.

As institutions evaluate implementation models, the decision is less about whether the infrastructure is public or private, and more about how control, access, and validation are architected. When built with institutional-grade security and oversight, public-permissioned, public-permissionless, and hybrid networks that utilize Layer 2 scaling solutions can support books and records use cases in a manner consistent with regulatory and operational standards.

Refreshing a Principles-Based Approach to Assessing Risk Implications of Each DLT Network Type

As the ecosystem evolves, it is vital that regulatory frameworks remain technology-neutral, proportionate to actual risk related to the asset class and use case. Regulatory expectations should focus on outcomes, such as financial stability, financial integrity, investor protection and competition, rather than prescribing specific architectural choices. While permissioned networks and institutional controls offer clear benefits in certain contexts, decentralized networks can also offer robust alternatives through emerging tools like programmable compliance, decentralized identity, and zero-knowledge proofs. Maintaining a diverse and open infrastructure landscape is essential to preserving competition and enabling innovation for all market participants to serve clients. Both permissioned and permissionless systems can coexist within a responsible and well-supervised ecosystem, provided the right safeguards are applied—and crucially at the appropriate layer of the stack.

EXHIBIT ES.9

Comparison of Defining Characteristics Across Distributed Ledger Network Archetypes

		Private-permissioned	Public-permissioned	Public-permissionless
Defining characteristics	Governance	Centralized	Centralized (for the relevant application)	Decentralized*
	Accessibility to users	Role-Based Access	Role-Based Access	Role-Based Access
	Control over privileges	Can be defined as required	Users authenticated for specific roles	Defaults to open, but fully configurable (RBAC)
	Identification Requirements	All users known	All users known (for the relevant application)	Defaults to open, but fully configurable
	User base	Limited (by design)	Limited (for the relevant application)	Broad
	Interoperability	Can be developed as req'd but lower ease of implementation. In practice – limited.	Can be designed as required (for the relevant application). In practice – limited.	Higher interoperability given existing DLT-based ecosystem. "composability" as standard
Technology and infrastructure	Default data confidentiality	Can be defined as required	Can be defined as required (for the relevant application)	All users can view all transactions (without bespoke approaches)
	Overall operational resilience	Lower common fault tolerance but highest cyberattack resilience	Provides lower common fault tolerance and cyberattack resilience vs permissionless	Higher common fault tolerance; most exposed to cyberattacks but proven resilience in leading networks
	Scalability	Higher scale and performance in core network given fewer nodes	Higher scale and performance in core network given fewer nodes	Lower scale and performance in core network (layer 1) given many nodes; higher scale and performance at layer[2]
	Interoperability	Can be developed as required but lower ease of implementation. In practice – limited.	Can be designed as required (for the relevant application). In practice – limited.	Higher interoperability given existing DLT-based ecosystem. "composability" as standard
Regulatory and Compliance Factors	1 | Cyberattacks (application layer)	Strongest mitigation as network closed and centrally controlled Vulnerable to human errors/misconfigurations and phishing	Permissioning reduces risks of cyberattacks and hacks but still vulnerable to human errors/misconfigurations and phishing	Unique risks of cyberattacks and hacks (e.g., bridges)
	2 | KYC/AML compliance	All participants are verified by default	Authentication enables KYC/AML, but some participants (e.g., node validators) unverified although verified validators can be an option	Participants are unverified, so bespoke solutions are required (e.g., application whitelisting)
	3 | Group 1b & Group 2a/b asset exposure[1]	No Group 1b/2 assets are used	Can be designed to ensure no Group 1b/2 assets are used	Workarounds required to avoid Group 1b/2 assets
	4 | Settlement finality	Can demonstrate precise moment of settlement finality in network-wide rules (subject to rules/regs)	Can be designed to define moment of settlement finality similar to private-permissioned networks	Probabilistic settlement due to validation by consensus; some networks defined "finality" step where reorg probability is very low
	Examples	HYPERLEDGER FABRIC, r3 corda	POLYMESH, corda	bitcoin, ethereum

Sources: GFMA member input; BCG analysis.
[1]As defined in the Basel Framework, set out by BCBS in the "Prudential treatment of cryptoasset exposures", 2022.
*technical, legal, economic, logical and governance measures of decentralization.

For a more detailed discussion, including the advantages and resilience of public networks, we refer readers to **Chapter 1.2 | DLT Architectural Attributes and Networks.**

Layer 2 solutions for Public-Permissionless blockchains allow Institutional Control

Regulated financial institutions are exploring public **Layer 1** blockchains (such as Ethereum) to leverage their decentralization, transparency, and broad liquidity. However, some public **permissionless** networks pose challenges around governance, privacy, and compliance. **Layer 2** technologies – including rollups, state channels, and app-specific chains – are emerging as a potential solution to address these challenges and may enabling institutional **operational controls** (such as permissioning, KYC/AML compliance, access control, and privacy) on top of public L1 infrastructure.

Layer 2 (L2) solutions inherit technological architecture from a Layer 1 chain but operate with custom rules, allowing banks and other firms to enforce controls. They can be permissioned at the L2 level – meaning only authorized participants (with verified identities) can transact or validate, even though the L1 architecture may be more open in nature. This may help address the trade-off institutions face: permissionless chains offer wide transparency and liquidity, but raise compliance and security risks, whereas fully permissioned blockchains offer control but isolate assets from broader market. For example, **rollups** (either optimistic or zero-knowledge) batch many transactions off-chain and post proofs to L1, enabling high throughput and custom logic. Banks can run an L2 with a known set of validators, enforce whitelisting of addresses, and incorporate **KYC** checks at onboarding. One real-world example is Deutsche Bank's planned Ethereum L2 using zk-rollup tech: it is described as a "public and permissioned" network where anyone can observe the ledger but only authorized parties can participate. The goal is to **know all counterparties** (satisfying KYC/AML rules that are hard to meet on a fully open network) and to improve speed and privacy, all while settling on Ethereum's robust base layer. Indeed, the bank's prototype will let them choose permitted validators and even give regulators special "super auditor" access to monitor fund flows on the L2.

Other pilots show how L2 or analogous structures meet institutional needs. In Singapore's **Project Guardian** (2022), major banks (JPMorgan, DBS, SBI) traded tokenized forex and government bonds on a modified DeFi platform. They used a permissioned liquidity pool on a public chain (Polygon) with "**trust anchors**" issuing verifiable credentials to users – essentially embedding KYC verification into the DeFi process. All wallet addresses in the pool were verified, allowing trading to occur only among known, vetted participants in that **permissioned market**. This ensured compliance (no anonymous or blacklisted actors) while still using automated smart contracts for settlement. **State channels** offer another tool: two parties (or a consortium) can lock funds in a smart contract and transact off-chain with each other rapidly; only final state is settled on L1, giving privacy and speed for, say, interbank payment flows while relying on L1 for final **settlement assurance**. In all cases, the L1 blockchain serves as an immutable anchor for finality and dispute resolution, while the L2 or off-chain layer provides the *operational envelope* where institutional rules (permissions, limits, checks) are enforced.

Despite their advantages, L2 solutions bring unique challenges. Operational complexity increases due to managing off-chain transactions and their settlement on-chain, potentially complicating governance and oversight. Ensuring robust security in L2 mechanisms, especially around cryptographic proofs and validator accountability, may introduce new vulnerabilities to be managed. Additionally, interoperability between different L2 solutions, essential for seamless asset movement and market integration, remains an evolving technical and regulatory challenge. While not a panacea, L2 solutions represent promising emerging technologies that can broaden institutional participation, enabling greater market reach and regulatory compliance.

Risks and Governance

This executive summary reflects a synthesis of the broader analyses conducted across the DLT ecosystem to identify practical and forward-looking risk mitigants. It consolidates industry-wide perspectives on risk exposures associated with various DLT architectures—ranging from private-permissioned to public-permissionless networks—and highlights consensus-driven strategies for managing these risks effectively. The insights presented here are the result of extensive industry collaboration, aiming to support both market participants and regulators in navigating DLT adoption with greater confidence and resilience.

Operational risks are a key focus area, including cybersecurity threats and smart contract vulnerabilities, and settlement finality concerns. Cybersecurity risks vary significantly across DLT architectures. Permissioned networks typically utilize strict access controls, centralized monitoring, and traditional cybersecurity measures, while permissionless networks rely on decentralization, cryptographic safeguards, and open-source scrutiny. Smart contract risks, arising from code vulnerabilities or malicious designs, are mitigated by rigorous audits, formal verification, and built-in emergency intervention capabilities, differing considerably between centralized private networks and decentralized public ones.

Settlement finality remains a critical concern, particularly in public-permissionless environments, where finality can be probabilistic rather than deterministic. Effective mitigation combines technical solutions, such as economic penalties and sufficient confirmation depths, with emerging legal frameworks providing clarity and assurance.

Interoperability among diverse DLT networks introduces additional complexity and vulnerabilities, especially at cross-network bridges. Mitigations emphasize standardizing interoperability protocols, using secure gateway nodes, and employing multi-party validation schemes to minimize systemic risks. Industry efforts, such as DTCC's ComposerX platform, showcase growing interoperability maturity, integrating DLT seamlessly with traditional financial systems.

Common mode failures, due to shared vulnerabilities across nodes or infrastructure dependencies, represent significant operational risks. Strategies such as deploying nodes across multiple clouds or regions, diverse validator implementations, and continuous disaster recovery exercises significantly bolster network resilience.

Scalability remains critical as institutions require high transaction throughput and predictable costs. Layer-2 solutions, sharding, and optimized consensus mechanisms are recommended for scaling effectively across network types. Mitigations increasingly focus on integrating off-chain processes and innovative fee stabilization strategies to maintain performance during peak usage.

Quantum computing poses long-term existential threats, with potential capabilities to compromise existing cryptographic algorithms. Mitigation involves transitioning proactively to quantum-resistant cryptography through layered encryption, crypto-agility, and community consensus for algorithm upgrades. Regulatory bodies advocate preparatory adoption of post-quantum cryptography to safeguard future network integrity.

Finally, compliance risks, particularly KYC/AML/CFT obligations, data privacy, and regulatory uncertainties, demand embedded compliance controls and active engagement with regulators. Public-permissioned networks often implement embedded controls like token-level permissioning, while public-permissionless networks increasingly utilize advanced analytics and decentralized identity solutions to manage illicit finance risks. Cross-network compliance solutions are maturing through automated smart contract checks and holistic analytics.

For a full review of identified risks, mitigants, categorized by network type, please refer to **Chapter 1.4 | Risk Mitigants.**

The integration of DLT and smart contracts into global capital markets represents a significant evolution, offering substantial opportunities for enhanced efficiency, transparency, and liquidity. This report demonstrates that while DLT introduces new considerations for risk management, the financial industry and global regulators are proactively developing and implementing robust mitigation strategies. The prevailing approach emphasizes the application and adaptation of existing, well-established regulatory frameworks for operational resilience, cybersecurity, and financial crime compliance, rather than the creation of entirely new regimes. This technology-agnostic stance fosters responsible innovation by providing a clearer pathway for regulated entities to adopt DLT.

A key theme emerging from this analysis is the critical role of interoperability and standardization in scaling DLT adoption. Efforts to bridge traditional and DLT-based systems, alongside the development and implementation of common technical and legal standards for smart contracts and data, such as the FINOS Common Domain Model ("CDM"), are essential to prevent market fragmentation and unlock the full benefits of tokenization. Furthermore, the detailed examination of smart contract risks highlights the industry's commitment to rigorous pre-deployment testing, independent auditing, and the integration of human oversight mechanisms ("human-in-the-loop" governance), ensuring that the self-executing nature of smart contracts is balanced with necessary controls and recourse.

The ongoing dialogue and collaboration between public and private sectors, as evidenced by initiatives such as Project Guardian, are vital for harmonizing approaches and ensuring that DLT development in global capital markets continues to meet the high standards of safety and soundness required for financial stability. The continuous evolution of regulatory guidance and industry best practices provides a strong foundation for managing the risks associated with DLT, instilling confidence that these technologies can be safely and effectively integrated into the future of global capital markets.

LEGAL AND REGULATORY CHANGE: GO FURTHER AND FASTER

Chapter 4: Legal and Regulatory Landscape demonstrates where existing regulation sufficiently addresses DLT-enabled operations and Tokenized Securities and highlighting gaps in legal and regulatory frameworks based on the "same risk, same regulation, same regulatory outcome" principle.

Joint Trades urge regulators and legislators (amongst other things) to:

i. increase their focus and resourcing to ensure legal and regulatory certainty; and

ii. continue engaging in ongoing dialogue with the private sector to work towards solutions to those issues.

Legal and regulatory clarity is an essential element of a well-functioning and thriving financial services sector. The established rights and obligations in traditional finance (TradFi) have developed over many decades. The same concepts do not, or cannot, always provide a good fit when applied to DLT-based financial instruments and markets. In some cases, pending legislative and rule-making developments, participants have taken an incremental and pragmatic/risk-based view (for example, the issue of whether cryptoassets are classified as securities or not under US law).

As we noted in 2023, both regulators and legislators have been aware of this situation, and since then there has been ongoing work around the world. It is important to recognize that these developments involve engaging with difficult policy choices, require significant public sector resource, and necessitate balancing consumer protections.

We should emphasize that having a transparent 'roadmap' of legal and regulatory modifications/clarifications is as important to the growth and facilitation of market activity in DLT as the implementing measures themselves. Therefore, to take an example, we have seen the EU Digital Finance package performing a vital role in attracting business innovation to the EU market.

Uncertain and/or overly restrictive DLT-related laws and regulation pose numerous challenges, including:

- limitation on scaling in markets and practices outside the scope of existing regulated financial services regimes; and
- substantial delay in the evolution of transparent, disciplined, and effective development of markets and infrastructure.

In this Executive Summary, we summarize the extent of legislative and regulatory progress in major financial centers. We then provide our updated recommendations.

EU Update

The European Commission adopted on 24 September 2020 a digital finance package, including a digital finance strategy and legislative proposals on cryptoassets, for a competitive EU financial sector that gives consumers access to innovative financial products, while ensuring consumer protection and financial stability.

This led to two major regulations on cryptoassets and the use of DLT in financial market operations: Regulation (EU) No. 2023/1114 of 31 May 2023 ("**MiCA**") and Regulation (EU) 2022/858 of 30 May 2022 ("**EU Pilot Regime**").

Furthermore, on 28 June 2023, the European Commission published its proposals for a digital euro as part of a 'Single Currency Package' comprising proposals for a Regulation establishing the legal framework for a possible digital euro, a Regulation on the provision of digital euro services by payment services providers incorporated in EU Member States whose currency is not the euro and a Regulation on the legal tender of euro coins and banknotes ("**Digital Euro Proposal**").

MiCA: MiCA fully entered into application on 30 December 2024 and establishes a comprehensive and harmonized regulatory framework for cryptoassets and related services across the EU.

MiCA applies to persons involved in the issuance, offer to the public and admission to trading of cryptoassets or that provide services related to cryptoassets in the European Union, imposing a series of obligations on them. It specifically excludes from its scope cryptoassets that are already regulated by existing EU financial services legislation, such as cryptoassets qualifying as financial instruments under Directive 2014/65/EU of 15 May 2014 ("**MiFID II**"), deposits, funds (with the exception of e-money tokens), securitization positions, pension products, and central bank digital currencies.

MiCA classifies cryptoassets into three main categories: 'e-money tokens', which are stablecoins referencing the value of a single official currency; 'asset-referenced tokens', which are stablecoins other than e-money tokens and referencing another value or right or a combination thereof, including one or more official currencies; and 'other cryptoassets', which include utility tokens and other forms of cryptoassets not covered by the previous categories.

EU Pilot Regime: The EU Pilot Regime fully entered into application on 23 March 2023 and provides a legal framework for trading and settlement of financial instruments (as defined under MiFID II) issued, recorded, transferred and stored using DLT. The EU Pilot Regime addresses regulatory barriers that hinder the use of DLT in financial market infrastructures by allowing certain DLT market infrastructures to apply for temporary exemptions from certain requirements of existing EU financial services legislation, namely Regulation (EU) No. 909/2014 of 23 July 2014 ("**CSDR**"), MIFID II, Regulation (EU) No. 600/2014 of 15 May 2014 ("**MiFIR**") and Directive 98/26/EC of 19 May 1998 ("**Finality Directive**").

The EU Pilot Regime applies to DLT multilateral trading facilities (DLT MTFs), DLT settlement systems (DLT SS), and DLT Trading and Settlement Systems (DLT TSS). The DLT TSS is an innovation that allows a single player to provide both the services of a multilateral trading facility and those of a settlement system.

Only shares issued by issuers with a market capitalization of less than EUR 500 million, bonds or securitized debt with an issue size of less than EUR 1 billion, and certain units in collective investment undertakings, the market value of the assets under management of which is less than EUR 500 million are eligible for inclusion in the EU Pilot Regime. Additional value thresholds are imposed: in particular, the aggregate market value of DLT financial instruments admitted to a DLT market infrastructure must not exceed EUR 6 billion.

In principle, the EU Pilot Regime will run for a period of 3 years, renewable or extendable to 6 years total. However, in a letter to ESMA dated May 2024, the European Commission publicly stated that the regime would not have an expiry date[38].

In a joint paper published on 9 April 2025, the French *Autorité des marchés financiers* and the Italian *Commissione Nazionale per le Società e la Borsa* highlight the low number of players authorized under the EU Pilot Regime and suggest amendments to enhance the competitiveness of this regime[39].

In a report "on the functioning and review of the DLT Pilot Regime" published on 25 June 2025, the ESMA presents strategic recommendations to the European Commission about (i) how to make the E.U. Pilot Regime more attractive to the market, and (ii) suggested amendments to the E.U. Pilot Regime to make it permanent and allow for more flexibility in the regulatory thresholds or eligible assets depending on the risks of each business model.[40]

38. **https://www.esma.europa.eu/sites/default/files/2024-05/3056562_030524_Reply_Verena_Ross_on_DLT_Pilot_Regime_Implementation.pdf.**
39. AMF, "Towards a More Competitive European Pilot Regime: A Proposal for Fostering Experimentation by Blockchain-Based Market Infrastructures", Accessed 2025.
40. **https://www.esma.europa.eu/sites/default/files/2025-06/ESMA75-117376770-460_Report_on_the_functioning_and_review_of_the_DLTR_-_Art.14.pdf.**

Digital Euro Proposal: The Digital Euro Proposal would give a digital euro legal tender status in euro area EU Member States, entailing its mandatory acceptance by payees, subject to certain exemptions. The digital euro would be a direct liability of the European Central Bank or of the national central banks of the EU Member States whose currency is the euro towards digital euro users.

Based on the Digital Euro Proposal, the digital euro would support a variety of use cases of retail payments, excluding its use for wholesale payments.

Hong Kong Update

Since the Hong Kong Government's first "Policy Statement on Development of Virtual Assets in Hong Kong" in 2022, there have been significant developments in Hong Kong's exploration and adoption of DLT in the financial sector.[41] This includes financial institutions exploring DLT applications in traditional financial market operations, changes in Hong Kong law and regulation both responding to market developments and which are intended to facilitate change,[42] and interventions by regulators[43]. The latter included the Hong Kong Monetary Authority (HKMA)'s Supervisory Incubator for Distributed Ledger Technology launched in January 2025, intended to enable banks to explore the adoption of DLT, and with a particular focus on addressing risks that may arise as banks move to develop services (e.g. deposits and loans) that cut across DLT-based and legacy banking infrastructures.[44]

The Hong Kong Government issued a second policy statement on digital assets on 26 June 2025 ("Policy Statement 2.0 on the Development of Digital Assets in Hong Kong"), reiterating the Government's commitment to establishing Hong Kong as premier global hub for digital assets.[45] This second policy statement builds on the 2022 policy statement and sets out a series of strategic policy directions to be implemented through a number of corresponding initiatives. These efforts are designed to be technology agnostic, to ensure adaptability to future digital assets innovations while embedding them into the real economy and financial systems for sustainable growth. The initiatives are structured under the "*LEAP*" framework, an acronym for: "Legal and regulatory streamlining; "Expanding the suite of tokenised products' "Advancing use cases and crosssectoral collaboration; and "People and partnership development.

Key developments in recent years have included the amendment of the Anti-Money Laundering and Counter-Terrorist Financing Ordinance ("**AMLO**") to introduce a licensing regime, with effect from 1 June 2023, for Virtual Assets Trading Platforms and Virtual Asset Service Providers engaging in different specific virtual asset operations. The amendments to the AMLO also introduced a definition of "*virtual assets*" which is now being referenced across subsequent legislation and in regulatory guidance, with the effect that the Hong Kong regulatory landscape is increasingly joined up in the context of the regulatory characterization of asset classes which had previously fallen between the existing patchwork of regulations and remits of regulatory authorities. Coordinated with Policy Statement 2.0, consultations were launched on 27 June 2025 jointly by Hong Kong's Financial Services and Treasury Bureau and SFC to expand Hong Kong's regulatory regime for virtual assets to include (i) dealing in virtual assets and (ii) virtual assets custodian services.

In the context of the traditional securities markets the **HKMA** has engaged in a number of pilot projects, including through the issuance of two rounds of digital bonds as part of the HKMA's Project Evergreen (in February 2023, and in February 2024), which were in part intended to act as proof-of-concept for bond tokenization[46]. The second of these issuances saw the **Hong Kong Government** issue a multi-currency "digitally native" green bond, denominated in HK dollars (HKD2 billion tranche), Renminbi (RMB-1.5 billion tranche), US dollars (USD-200 million tranche) and euro (EUR80 million tranche) under the Government Green Bond Programme. This used a private blockchain network (HSBC's Orion platform as part of the HKMA's Central Money Markets Unit ("**CMU**")), and the bonds were constituted on-chain without first being issued in a traditional central securities depositary, and with direct participants in the platform holding legal (rather than beneficial) title and with their on-chain records again **legally recognized as the definitive record of ownership**. The bonds were also listed on the Hong Kong Stock Exchange. This was followed in November 2024, with the launch by the HKMA of the Digital Bond Grant Scheme, aiming to promote the development of the digital securities market and to encourage broader adoption of tokenization technology in capital market transactions[47]. Subject to the satisfaction of relevant eligibility requirements under the scheme, a maximum grant of HKD2.5 million is available to each eligible digital bond issuance in Hong Kong[48].

41. Financial Services and Treasury Bureau. 2024. Policy Statement on Development of Virtual Assets in Hong Kong", Accessed 2025.
42. HKMA, "Distributed Ledger Technology in the Financial Sector: A Study on the Opportunities and Challenges", March 2025.
43. Ibid.
44. HKMA press release, "launches Supervisory Incubator to foster responsible adoption of distributed ledger technology", January 2025.
45. Financial Services and Treasury Bureau. 2025. "Policy Statement 2.0 on the Development of Digital Assets in Hong Kong".
46. HKMA inSight Article," Project Evergreen: From concept to application", November 2024.
47. HKMA press release, "HKMA launches Digital Bond Grant Scheme", November 2024.
48. Ibid.

Most recently a new Stablecoins Ordinance has been enacted and will come into effect on 1 August 2025, establishing a licensing regime for fiat referenced stablecoin issuers in Hong Kong. This follows on from the HKMA's Stablecoin Issuer Sandbox (launched in March 2024) for the purposes of testing proposed business models[49]. The development of the stablecoins regime has taken place in parallel with the Hong Kong Government's exploration of a central bank digital currency (CBDC). This includes Project Ensemble, which was launched in March 2024 to explore innovative financial market infrastructure that facilitates interbank settlement of tokenized money through wholesale CBDC and involves a sandbox to test tokenization use cases that include, among other various use cases, settlement of tokenized real world assets.[50] This also includes exploring utilizing CBDC for wholesale cross-border payments. As part of Project mBridge, in which the HKMA has been working with the Bank for International Settlements Innovation Hub Hong Kong Centre, the Bank of Thailand, the Digital Currency Institute of the People's Bank of China, the Central Bank of the United Arab Emirates and the Saudi Central Bank, to develop a multi-central bank digital currency platform shared among participating central banks and commercial banks, built on DLT to enable instant cross-border payments and settlement. The first issuance announced under this scheme was in December 2024 by Zhuhai Huafa Group, an issuer incorporated in Greater China, which issued a 3-year 1.4 billion RMB-denominated digital bond.

In its March 2025 research paper on DLT in the financial sector, the HKMA communicated its intention to work closely with industry stakeholders and to provide clear supervisory guidance with the purpose of positioning Hong Kong "to lead the responsible integration of DLT within global capital markets"[51].

Japan Update

A regulatory framework for transactions in respect of DLT-based Securities has been implemented in Japan.

For securities tokens, the Financial Instrument and Exchange Act of Japan ("**FIEA**") was amended in 2019 to regulate transactions of tokens representing securities in an attempt to facilitate capital formation in this manner while protecting investors. The amendment came into force in May 2020. Under the amendment to the FIEA, tokens representing (i) a conventional class of financial assets listed as “Type I Securities” under the FIEA (such as shares and bonds) or (ii) an interest in a collective investment scheme, would be deemed to be "securities".

For stablecoins, an amendment to the Japanese Payment Services Act, which aims to regulate digital money to be used for fund transfers and payments, including stablecoins, was made in June 2022 ("**2022 Amendment**"). The 2022 Amendment enables the use of legislatively permitted stablecoins in Japan. Permission to issue stablecoins in Japan is only granted to licensed banks, fund transfer agents, and trust companies. Immediately after the 2022 Amendment, only the issuance of stablecoins was regulated, and secondary market activities such as trading and exchanging issued stablecoins were not regulated. However, with the further amendment to the Japanese Payment Services Act, which was made in 2023 ("**2023 Amendment**"), the sale and purchase, exchange, intermediation of sale and purchase or exchange, and custody of stablecoins have also become subject to regulation under the Japanese Payment Services Act. In other words, with the 2023 Amendment, not only the issuance of stablecoins but also the secondary market activities of stablecoins has become regulated.

Furthermore, the revision of the Japanese Payment Services Act made in June 2025 ("**2025 Amendment**") has made three major changes regarding crypto-assets and stablecoins. These are: (i) giving the regulator the authority to order stablecoin operators and crypto-asset operators (collectively, "**Operators**") to hold assets in Japan in the event of their bankruptcy, (ii) relaxing of the administration and management of the underlying assets of trust-type stablecoins, and (iii) creation of intermediary services for cryptoasset and stablecoin transactions.

In relation to (i) above, it has become possible to prevent the outflow of assets overseas in order to ensure the return of assets to domestic users of the service of the Operators in the event of their bankruptcy. It was previously impossible to issue an order that required retention of assets in Japan in the event of the bankruptcy of the Operators, and this was criticized as a shortcoming of the law in protecting the interests of Japanese investors. It is now possible to issue such an order to the Operators at the time of their bankruptcy.

The 2025 Amendment is scheduled to take effect within one year from its enactment in June 2025.

49. HKMA inSight Article, "Stablecoin Issuer Sandbox", July 2024.
50. HKMA press release "HKMA unveils Project Ensemble to support the development of the Hong Kong tokenization market", March 2024.
51. Ms Carmen Chu, Executive Director (Banking Supervision) of the HKMA, quoted on page 5 of "Distributed Ledger Technology in the Financial Sector: A Study on the Opportunities and Challenges", March 2025.

Singapore Update

Singapore continues to spearhead as a leading jurisdiction for the adoption and regulation of DLT in capital markets. The Monetary Authority of Singapore ("MAS") has taken a proactive approach, fostering innovation while maintaining robust regulatory standards to ensure market integrity and investor protection. Key initiatives include Project Guardian and Project Orchid, which explore asset tokenization and DeFi applications within a regulated framework, and possible use cases of a digital Singapore Dollar, respectively.

On digital money, MAS's position is "Yes to digital asset innovation, No to cryptocurrency speculation". MAS takes the view that "stablecoins – if well regulated – can potentially play a useful role as digital money alongside Central Bank Digital Currencies and tokenized bank liabilities." In August 2023, MAS announced key features of its new regulatory framework[52] for Singapore stablecoin issuance.[53] MAS's stablecoin regime will apply to single currency stablecoins ("**SCS**") pegged to the Singapore dollar (or any G10 currency) that are issued in Singapore. Whilst detailed regulations for its stablecoin regime have not taken effect, MAS encourages SCS issuers who would like their stablecoins recognized as "MAS regulated stablecoins" to make early preparations for compliance. During the Singapore FinTech Festival 2023, MAS announced in-principle approval under Singapore's Payment Services Act ("**PSA**") to three entities that already demonstrate compliance with MAS's upcoming detailed regulations.

MAS has also implemented AML/CFT requirements[54] and customer protection measures aimed specifically at digital payment token service providers, such as customer assets segregation and custody[55], prohibition over lending and staking retail customers' assets, business conduct measures, consumer eligibility controls and risk management of technology and cyber security issues.[56]

Following Project Orchid, MAS published the Orchid Blueprint[57] which sets out 4 key infrastructure components for introducing digital money infrastructure in Singapore: (i) settlement systems to facilitate transfer of value and ensure settlement finality; (ii) tokenization bridges to connect existing market infrastructure with token-based systems; (iii) programmability protocols to specify the conditions for the use of digital money and; (iv) a name service to translate complex wallet addresses to name identifiers that are easier for the average user to verify.

The publication of the Orchid Blueprint also came with the announcement that the Project Orchid digital money trials would be expanded, and that MAS would commence the development of CBDC for wholesale settlement, although updates on the latter have not been forthcoming.[58] MAS' position remains that it does not currently see a compelling case for retail CBDCs in Singapore.

MAS's Project Guardian explores the potential applications of asset tokenization and decentralized finance (DeFi)[59], focusing on how tokenization could be integrated into existing, conventional financial systems. The main benefits of DeFi identified in the project report include enhancing efficiency and transparency in the financial system as well as reducing operational complexity and costs. Project Guardian identified a three-stage evolution of tokenization, beginning with the tokenization of conventional funds, then of underlying assets in bespoke portfolios, finally culminating in tokenization of value flows using smart contracts for self-executing financial products. In January 2025 MAS launched the Global-Asia Digital Bond Grant Scheme to promote digital bonds issued using DLT by companies and non-bank financial institutions with an Asian nexus[60]. The bonds must be issued on a designated digital asset platform in Singapore and denominated in an Asian local or G3 currency, and the scheme will run until the end of 2029.

Singapore takes a technology agnostic approach to regulate DLT within the existing legislation framework. Most notably, the PSA regulates digital payment tokens used as forms of payment, the Securities and Futures Act ("**FSA**") regulates tokens that share the same features as securities or other capital markets products, and the Financial Services and Markets Act regulates virtual asset service providers established in Singapore that provide virtual asset services outside of Singapore to address regulatory gaps that are not otherwise regulated under the SFA or the PSA.

52. MAS Finalises Stablecoin Regulatory Framework.
53. Response to Public Consultation on Proposed Regulatory Approach for Stablecoin-related Activities, 15 August 2023.
54. Prevention of Money Laundering and Countering the Financing Of Terrorism – Holders Of Payment Services Licence (Digital Payment Token Service), 2 April 2024: **https://www.mas.gov.sg/-/media/mas-media-library/regulation/notices/amld/psn02-aml-cft-notice---digital-payment-token-service/notice-psn02-dated-2-april-2024.pdf**.
55. Response to Public Consultation on Proposed Regulatory Measures for Digital Payment Token Services (Part 1), 3 July 2023: **https://www.mas.gov.sg/-/media/mas/news-and-publications/consultation-papers/2023-consultation-paper-on-proposed-measures-on-market-integrity-in-dpt-services/consultation-paper-on-proposed-measures-on-market-integrity-in-dpt-services.pdf**.
56. Response to Public Consultation on Proposed Regulatory Measures for Digital Payment Token Services (Part 2), 23 November 2023: **https://www.mas.gov.sg/-/media/mas/news-and-publications/consultation-papers/2022-proposed-regulatory-measures-for-dpt-services/response-to-public-consultation-on-proposed-regulatory-measures-for-dpt-services-part-2-v2.pdf**.
57. Orchid Blueprint, November 2023: **https://www.mas.gov.sg/-/media/mas-media-library/development/fintech/project-orchid/orchid-blueprint-final.pdf**.
58. MAS Press Release, "MAS Lays Foundation for Safe and Innovative Use of Digital Money in Singapore", 16 November 2023: MAS Lays Foundation for Safe and Innovative Use of Digital Money in Singapore.
59. Project Guardian Funds Framework, November 2024, **https://www.mas.gov.sg/-/media/mas-media-library/development/fintech/guardian/guardian-funds-framework.pdf**.
60. Global-Asia Digital Bond Grant Scheme (G-ADBGS), 15 January 2025, **https://www.mas.gov.sg/schemes-and-initiatives/global-asia-digital-bond-grant-scheme**.

Singapore's regulatory landscape for the implementation of DLT in capital markets is characterized by a progressive, risk-based approach that balances innovation with robust investor protection and anti-money laundering safeguards, positioning the jurisdiction as a leading global hub for digital asset development and adoption

UK Update

The UK Government has recognized the potential of digital assets and cryptoassets to contribute to economic growth, innovation and the UK's position as a global financial center. It has set the financial services sector, including DLT, at the heart of its plan for economic growth. The UK Government wants to see the UK become a global center for digital assets. There are many UK initiatives in train. As part of the UK Government's recent Mansion House 2025 announcements, it has reiterated and updated a number of the initiatives as well as adding new ones. For example, the package included announcing a Wholesale Financial Markets Digital Strategy[61].

UK regulatory approach: there has been a regulatory reset for UK financial services regulators. The UK Government's view is that post-financial crisis financial regulation went too far by seeking to eliminate risk-taking. The balance is now being reset, with a regulatory focus on growth, innovation and proportionate regulation. In addition, UK regulators have been given a secondary objective to facilitate international competitiveness and economic growth where they recognize the importance to creating an environment where innovation can flourish safely and where households, business and markets can reap the benefits[62].

Digital Securities Sandbox (DSS): the DSS is a live regulated environment created to explore how developing technologies can be used by firms in the financial sector. For example, the DSS will facilitate the issuance, trading and settlement of digital securities in the UK on distributed, programmable ledgers. There are proportionate guardrails and DSS activities will need to comply with UK regulation by the Financial Conduct Authority and the Bank of England. The DSS aims to facilitate innovation, protect financial stability and protect market integrity. The DSS is generally acknowledged as a progressive move by UK authorities. It has been designed so that participants can scale their businesses as they demonstrate regulatory compliance, and there will be the opportunity to transition to a new permanent regime if the technology is successful.

Digitally native UK sovereign gilt (DIGIT): the UK Government intends to launch a pilot digitally native sovereign gilt using Distributed Ledger Technology. Issuing a digitally native UK sovereign gilt is intended to complement existing DLT initiatives and support private sector innovation in digital asset platforms and securities. DIGIT will be issued on a platform within the DSS. It will be a real short-dated transferable security instrument, albeit experimental and separate from the UK's standard debt issuance processes. The Government wants DIGIT to encompass key-DLT features, for example on-chain settlement (including the cash leg) and interoperability. The Government is expected to select suppliers in relation to the DIGIT project in late summer 2025.

Central Bank Digital Currency (CBDC): CBDCs are digital currency backed by the full faith and credit of a central bank. In other words, a digital form of a country's fiat currency. The UK Government and the Bank of England are continuing their work exploring the possibility of a digital British Pound.

Regulation: the UK Government and UK regulators have published detailed proposals for creating a UK regulatory regime for cryptoassets and are in the process of implementing this plan. For example, cryptoassets are now within the UK's financial promotion regime. A detailed discussion and consultation process is underway, including cryptoasset admission and disclosure; market abuse rules; trading platform rules; and intermediation, lending and staking rules. In addition, a consultation and discussion process concerning a UK stablecoin regime is underway, encompassing rules in relation to backing assets, record-keeping, redemption, custody, segregation of assets and prudential rules. There will also be new UK regulated activities in relation to cryptoassets, including conduct rules, a complaints regime and the application of the consumer duty. The final rules are expected to be published, and the full framework to go live, in 2026. In addition to the ongoing FCA consultation on stablecoins, the Bank of England is expected to release a consultation on systemic stablecoins in the coming months. The Bank of England has provided an update on its plans for synchronised settlement and programme of experiments in wholesale payments[63]. The Bank of England has also recently clearly signaled its support for digitalization, saying that "[i]t is time to move away from talking about potential and one-off demonstrations of the technology, and for all of us to start working together to deliver a new generation of the financial system that is befitting of London's place as the heart of the global financial system[64]".

61. **Wholesale Financial Markets Digital Strategy - GOV.UK**.
62. **Innovation and regulation—striking the balance**, David Bailey (June 2025).
63. **https://www.bankofengland.co.uk/speech/2025/july/victoria-cleland-keynote-address-at-city-week-2025**.
64. **https://www.bankofengland.co.uk/speech/2025/july/sasha-mills-keynote-address-at-city-week-2025**.

There are shortcomings with the proposed regimes, for example the "qualifying cryptoasset" definition is not technology neutral, creates uncertainty and regulatory duplication. Finally, the Prudential Regulation Authority ("PRA") is expected to consult on the implementation of the BCBS's SCO60 in 2026.

Reforming the law: the Law Commission of England & Wales continues its work in relation to digital assets. For example, it recommended and drafted the Property (Digital Assets etc.) Bill, which is currently in the legislative process. If enacted the Bill would permit an additional third category of personal property rights. This would be in line with current English judicial thinking and overrule 19th Century case law which restricted English law to two categories. Recognizing the challenges that DLT poses for private international law (for example which jurisdiction's laws apply, and in which courts to litigate), the Law Commission is currently consulting on private international law reform in the context of digital assets and electronic trade documents. The UK Government has committed to providing legal clarity where it is needed, while acknowledging that English and Welsh law should broadly be able to accommodate DLT already.

UK Jurisdiction Taskforce of LawtechUK (UKJT): the UKJT aims to provide market confidence and legal certainty in the digital space by issuing Legal Statements (although they are not legally binding). A Second Legal Statement in 2023, amongst other things, concluded that blockchain or DLT could facilitate the issue and transfer of digital bonds in a variety of forms (bearer, registered and indirect). LawtechUK has also established the International Jurisdiction Taskforce (IJT). The IJT is an independent panel bringing together legal experts from the most widely used private law systems worldwide (including the UK, USA, France, Singapore, the EU, Australia, and Japan). Its objective is to present proposals to reduce the international legal barriers to the use and development of novel digital asset technology, including blockchain and smart contracts.

US Update

During 2025, the U.S. has made significant progress towards fostering a regulatory environment that supports banks, broker-dealers, investment advisers and other financial institutions seeking to engage with crypto-assets and DLT. The combined effect of agency guidance, rule rescissions, targeted proposals, executive orders,[65] and congressional bills suggests the beginning of a more navigable environment for institutions seeking to engage in crypto-asset related activities and increased clarity around key activities, from custody and trading to tokenization of securities and payment stablecoins.

Most recently, on July 30, the President's Working Group on Digital Assets released a report entitled "Strengthening American Leadership in Digital Financial Technology."[66] The report provides an overview of, and makes policy recommendations concerning, a myriad of topics including, but not limited to: (i) digital asset market structure, (ii) banking and digital assets, (iii) stablecoins and payments, (iv) countering illicit finance, and (v) taxation.

In early 2025, the three federal banking regulators each took steps to clarify their position on permissible crypto-asset activities. In January, the FDIC stated that insured institutions do not need to seek prior FDIC approval to engage in crypto-related services, but as with other activities, must be able to demonstrate sound risk management across market, liquidity, operational, and compliance dimensions.[67] In March, the Office of the Comptroller of the Currency ("OCC") issued guidance reaffirming that national banks and federal savings associations may custody and transfer digital assets under existing statutes without new prohibitions.[68,69] The Federal Reserve followed suit, issuing guidance signaling that supervision will now occur through its routine processes as opposed to a specialized supervisory regime.[70]

Regulatory accounting treatment, previously a major deterrent to banks' engagement in cryptoasset activities, has also undergone a momentous change. SAB 121, which had forced banks and broker-dealers to record client crypto-assets as a liability on their balance sheets at fair value with an offsetting asset in the same amount, was rescinded by the SEC and replaced with SAB 122 in January 2025.[71] This change removed a substantial capital-management obstacle for banks subject to BCBS capital requirements and aligned crypto-asset accounting more closely with practices for traditional custody assets. Meanwhile the SEC withdrew its 2023 proposal to expand the custody rule for investment advisers, stating that the Commission may revisit the issue via a new proposal at a later date.[72]

65. See **https://www.whitehouse.gov/presidential-actions/2025/01/strengthening-american-leadership-in-digital-financial-technology/**.
66. See **https://www.whitehouse.gov/wp-content/uploads/2025/07/Digital-Assets-Report-EO14178.pdf**.
67. This replaced prior restrictive guidance issued by the FDIC. See **https://www.fdic.gov/news/financial-institution-letters/2025/fdic-clarifies-process-banks-engage-crypto-related**.
68. This guidance replaced earlier OCC bulletins as well as two interagency statements on crypto risks published jointly by the OCC, FDIC and FRB. *See* **https://www.occ.gov/topics/charters-and-licensing/interpretations-and-actions/2025/int1183.pdf**.
69. This guidance has spurred activity in this space, with several market participants, including Ripple and Circle, applying for OCC trust charters. See **https://www.reuters.com/business/finance/ripple-applies-us-national-bank-charter-crypto-eyes-next-frontier-2025-07-02/**, and **https://www.reuters.com/sustainability/boards-policy-regulation/circle-applies-us-trust-bank-license-after-bumper-ipo-2025-06-30/**.
70. The FRB also withdrew previous guidance to the contrary. See **https://www.federalreserve.gov/newsevents/pressreleases/bcreg20250424a.htm**.
71. See **https://www.sec.gov/rules-regulations/staff-guidance/staff-accounting-bulletins/staff-accounting-bulletin-122**.
72. See, Commissioner Mark T. Uyeda, Remarks at the Crypto Task Force Roundtable on Custody (Apr. 25, 2025), *available at* **https://www.sec.gov/newsroom/speeches-statements/uyeda-remarks-crypto-task-force-roundtable-custody-042525**.

The SEC has been active on multiple other fronts. In April 2025, the SEC's Division of Corporation Finance issued a statement on disclosure requirements for crypto-asset offerings and registrations, emphasizing that all filings must be tailored, clear, and consistent with public materials, addressing business stage, risk factors, and token characteristics.[73] The SEC's Division of Trading and Markets released a May 2025 FAQ making explicit that registered transfer agents may use a permissioned distributed ledger as their official master securityholder file, without duplicate off-chain records, so long as they meet all Exchange Act recordkeeping and operational standards and providing additional guidance on the treatment of digital assets for broker-dealer net capital and customer protection rule purposes.[74] We discuss relevant updates to SEC guidance, in more detail below.

Relatedly, the SEC established a Crypto Task Force, which, among other actions, has requested input on changes to the current regulatory framework and proposed a new exemptive "sandbox" order under Section 36 of the Exchange Act. Commissioners have indicated the SEC is considering rulemaking to create a bespoke trading-venue category for tokenized securities, while the conditional exemptive order would grant limited relief from broker-dealer, exchange, and clearing-agency registration in order to pilot DLT market infrastructure in real-world settings.[75]

There has been substantial activity on Capitol Hill with respect to major digital asset regulation. The GENIUS Act[76] has been signed into law, establishing federal licensing and prudential requirements, capital, liquidity, governance, and reserve standards, for payment stablecoins, with slight differences on treatment of foreign issuers, transition timelines, and bank capital backstops. Legislative attention has shifted to digital asset market structure following the passage of the GENIUS Act, with two draft bills currently under consideration. On July 17, 2025, the CLARITY Act[77] was passed in the House by a vote of 294-134. The CLARITY Act would establish a regulatory framework for digital asset market structures and delineate between the Commodity Futures Trading Commission ("**CFTC**") and the SEC as it relates to regulatory authority over digital assets. On July 22, 2025, Senate Banking Chairman Tim Scott and Senators Cynthia Lummis, Bill Hagerty and Bernie Moreno released a discussion draft of digital asset market structure legislation, building upon the concepts established in the CLARITY Act along with a request for information.

While significant progress is being made to support DLT more generally, that support does not extend to retail CBDCs. The proposed CBDC Anti-Surveillance State Act of 2024,[78] which recently in the U.S. House during the previous legislative session, would prohibit the Federal Reserve from issuing a retail digital dollar absent congressional authority or using a retail CBDC to implement monetary policy.[79,80]

Securitization and bond tokenization have also moved into production. DTCC and Digital Assets have launched a pilot of tokenized U.S. Treasury collateral,[81] while private-sector players, including INX, have completed SEC-registered offerings of security tokens.[82] Meanwhile, Franklin Templeton's OnChain U.S. Government Money Fund (FOBXX) and UBS's uMINT money-market fund on Ethereum and Polygon represent advancements in money market and mutual funds offerings.

Together, these developments constitute a sea-change in the U.S. regulatory approach: from categorical prohibitions and punitive accounting rules to nuanced, risk-based frameworks that encourage banks and intermediaries to innovate responsibly. While some further legislative action remains pending, agencies have demonstrated a clear willingness to update longstanding rules, provide targeted relief, and explore interim approaches, all laying the groundwork for broader adoption of tokenization, crypto custody, and DLT-enabled financial services within the existing legal perimeter.

73. See, SEC Division of Corporate Finance, Offerings and Registrations of Securities in the Crypto Asset Markets (April 10, 2025), *available at* **https://www.sec.gov/newsroom/speeches-statements/cf-crypto-securities-041025**.
74. See, SEC, Division of Trading and Markets: Frequently Asked Questions Relating to Crypto Asset Activities and Distributed Ledger Technology, *available at* **https://www.sec.gov/rules-regulations/staff-guidance/trading-markets-frequently-asked-questions/frequently-asked-questions-relating-crypto-asset-activities-distributed-ledger-technology**.
75. More recently, on June 12, 2025, included as part of a larger withdrawal of fourteen proposals, the SEC withdrew several rule proposals related to crypto-assets and DLT issued by the prior administration, confirming that any future rulemaking on these topics will begin with a new rule proposal and a fresh opportunity for public comment. See, SEC Commissioner Hester M. Peirce, A Creative and Cooperative Balancing Act (May 8, 2025), *available at* https://**www.sec.gov/newsroom/speeches-statements/peirce-iismgd-050825**; see also SEC Chairman Paul S. Atkins, Remarks at the Crypto Task Force Roundtable on Decentralized Finance (Jun. 9, 2025), *available at* **https://www.sec.gov/newsroom/speeches-statements/atkins-remarks-defi-roundtable-060925**.
76. See **https://www.congress.gov/bill/119th-congress/senate-bill/1582**.
77. See **https://www.congress.gov/bill/119th-congress/house-bill/3633**.
78. See **https://financialservices.house.gov/news/documentsingle.aspx?DocumentID=409278&**.
79. The Executive Order issued by the Trump Administration also discusses the potential risks posed by CBDCs. Supra note 65.
80. The report published by the Presidential Working Group on Digital Assets also recommends that no CBDC be established, issued or promoted in the United States or abroad. Supra note 66 at page 151.
81. See **https://www.prnewswire.com/news-releases/dtcc-and-digital-asset-complete-successful-pilot-to-test-collateral-and-margin-optimization-through-tokenization-302255589.html**.
82. See Inx Limited, Prospectus Supplement, *available at* **https://www.sec.gov/Archives/edgar/data/1725882/000121390020023202/ea125858-424b1_inxlimited.htm**.

Legal and Regulatory Recommendations: Progress, But More to be Done Soon

Development of DLT-based finance continues apace. Reform of legislation and regulation needs to catch up, and keep the pace, with these market developments.

(**1**) **Legislative and Regulatory Constraints:** The law and regulation of TradFi has developed over hundreds of years and may operate in a way which is incompatible with DLT technology. Legislation and regulation should be technology agnostic based on "same activity, same risk, same regulatory outcome".

For example:

a. A clear advantage of a DLT blockchain is its ability to keep immutable and dematerialized records. Under EU law (the Central Securities Depositories Regulation (**CSDR**)) it is a requirement that for a security to be traded on a trading venue (an exchange or a multilateral system) it must be recorded in book-entry form in a centralized securities depository (**CSD**)[83]. Whilst these obligations do not actually *prohibit* the issuance of DLT-based financial instruments they are a fetter on DLT's development and the ability to harness its many advantages including the development of a secondary market.

b. The BCBS's rule SCO60 -(cryptoasset exposures) is fundamentally inconsistent with the principle of technology neutrality. Amongst other things, there is a disproportionate prudential charge for certain cryptoasset exposures and it does not take into account the growing adoption, customer demand or the true underlying risk associated with many digital assets.

c. The UK has set up its own digital securities regulatory 'sandbox' to encourage DLT development. The UK Government is using the UK's digital securities sandbox for its much-anticipated sovereign digital gilt (known as 'DIGIT').

d. The EU Pilot Regime addresses regulatory barriers that hinder the use of DLT in financial market infrastructures by allowing certain DLT market infrastructures to apply for temporary exemptions from certain requirements of existing EU financial services legislation.

e. Regulators in Hong Kong have established various sandboxes to encourage the adoption of DLT, including in September 2016, the Hong Kong Monetary Authority's "FinTech Supervisory Sandbox", and in January 2025, its “Supervisory Incubator for Distributed Ledger Technology”, with the purpose of helping banks responsibly unlock the transformative potential of DLT.[84]

f. The Hong Kong Government has specifically committed to adopting the “same activity, same risk, same regulatory outcome” principle in the context of virtual assets with the intention that virtual asset innovations can thrive in Hong Kong.[85]

g. In the context of its path-finding digital bond issuance, the Hong Kong Monetary Authority has acknowledged that digitalizing paper processes currently used in bond issuances can enhance efficiency gains, but it also acknowledges that it may take time for the industry to replace existing market practices and conventions which have been in place for decades, and that the legal and regulatory framework may also need to be fine-tuned to fully digitalize these processes.[86]

Act Now: There should be a technology-neutral level playing field for financial services based on "same activity, same risk, same regulatory outcome". Where this is not the case and/or there are unintended consequences of existing TradFi legislation, this should be addressed as a matter of priority. We welcome the initiatives taken by governments to promote DLT development and lead by example.

(**2**) **Legal Uncertainty:** DLT-based financial services manifest novel concepts which in many cases do not have a developed legal interpretation.

83. For further information, see AFME's June 2025 submission to the European Commission's Consultation document: Targeted consultation on integration of EU capital markets.
84. **https://www.hkma.gov.hk/eng/news-and-media/press-releases/2025/01/20250108-3/**.
85. See paragraph 4 of **https://gia.info.gov.hk/general/202210/31/P2022103000454_404805_1_1667173469522.pdf**.
86. See paragraph 68 of **https://www.hkma.gov.hk/media/eng/doc/key-information/press-release/2023/20230824e3a1.pdf**.

For example:

a. Ownership rights are the most basic, and yet most fundamental, attribute of a financial asset. Until very recently there was legal uncertainty in some jurisdictions about whether assets manifested on blockchain could constitute personal property. It now seems to be beyond doubt that most of the major common law jurisdictions recognize blockchain assets as personal property rights[87].

b. As a related point, in England the Property (Digital Assets etc) Bill is currently in the legislative process. If enacted it will permit a 'third category' of personal property rights, confirming current judicial thinking on cryptoasset ownership and overruling 19th Century English case law, which has historically recognized two categories.

c. Parts of EU legislation (for example the EU's Settlement Finality Directive, Financial Collateral Directive and CSDR) do not contemplate DLT-based concepts and/ or fetter the use of DLT. These points are explained in more detail in AFME's June 2025 submission and ISDA's June 2025 submission[88] to the European Commission's Consultation document: Targeted consultation on integration of EU capital markets.[89]

d. The Hong Kong Government has similarly acknowledged that virtual assets "h*ave unique characteristics different from traditional assets, and their features may not fit squarely into the current private property law categories or definitions in Hong Kong*". In response, the Government has indicated an openness to a future review on property rights for tokenized assets and the legality of smart contracts, in order to provide a legal foundation for their development.[90]

Cross-functional Collaboration: We invite legislators and regulators to engage in a dialogue with each other and market participants to find appropriate and workable fixes for these legislative and regulatory issues so that the full social and economic benefits of DLT can be realized.

(**3**) **Remove Legal Frictions & Reduce Regulatory Arbitrage:** DLT is by its nature "everywhere and nowhere" and in many respects knows no borders. For this reason some participants may seek to minimize their compliance obligations using regulatory arbitrage and/ or by establishing in jurisdictions with less (or no) regulation. We believe that an international level playing field for DLT has many advantages. Ideally there would be coordinated and broadly equivalent international legislation and regulation.

For example, as currently drafted, we do not believe that the BCBS's SCO60 (prudential treatment of cryptoasset exposures) achieves a level playing field because it discourages the use of permissioned public and permissionless public blockchains by large traditional financial institutions. This will also have the effect of hampering the crucial development of DLT interoperability. In contrast, for example, the EU's MiCA is DLT technology agnostic. And the UK's Financial Conduct Authority recent consultation paper (**CP25/14**) is also DLT technology agnostic provided that the DLT risks are adequately addressed.

Growing Risk of Market Fragmentation: we Joint Trades emphasize that a level playing for DLT legislation and regulation will reduce legal frictions and regulatory arbitrage. We encourage the G20 and G7, global standard setters and regional legislators and regulators to ensure coordinated and broadly equivalent international legislation and regulation to support financial stability, resilience in the global ecosystem, as well as growth and competition to serve end users globally.

We strongly advocate:

i. that finance ministers, legislators and regulators globally to go **further and faster** to harness the social and economic benefits of DLT; and

ii. for international cooperation and consensus to ensure as much as possible a level playing field and to reduce regulatory arbitrage which could force participants offshore and/or encourage unregulated participants.

87. See for example England, Singapore, Hong Kong and Australia.
88. ISDA Response to European Commission Consultation on Integration of EU Capital Markets – International Swaps and Derivatives Association.
89. ISDA Response to European Commission Consultation on Integration of EU Capital Markets – International Swaps and Derivatives Association.
90. See paragraph 8 of **https://gia.info.gov.hk/general/202210/31/P2022103000454_404805_1_1667173469522.pdf**.

TOKENIZATION IS READY TO SCALE – THE TIME TO ACT IS NOW

The value proposition of tokenization in global capital markets – efficiency, transparency, and new market opportunities across the trade lifecycle – has been validated through concrete use cases and quantifiable benefits, dispelling doubts about whether the gains are real. A vision of the future market structure is coming into focus, one that marries the strengths of traditional finance (banks and regulated entities) with the innovation of digital natives and FinTechs, creating a richer and more resilient ecosystem than either could achieve alone. And critically, the risk question – often cited as the chief barrier – is being answered: through advanced technology safeguards and thoughtful regulation, tokenized markets are meeting the high bar of safety, soundness, and compliance required for broad institutional trust.

To accelerate ecosystem maturity, the following **calls to action** are directed at mobilizing public and private stakeholders towards meaningful and sustainable progress. Governments establishing a pro-innovation mandate to foster growth and competition, and market integrity, while protecting clients, investors and end users, sends the necessary signal for the private sector to unlock investment to deliver enhancements for the ecosystem. **While public policy and regulatory clarity remain crucial enablers, this roadmap prioritizes actions that can be taken now, unilaterally or in collaboration with peers, to build sustainable momentum and unlock value:**

1 | Accelerate Market Development in High-Potential Asset Classes: To accelerate tokenization, the industry is currently prioritizing high-impact asset classes such as private credit, and money market funds. Building scalable infrastructure, enabling broad investor access, and embedding programmability into design will drive market depth. Regulatory enablement and support for innovation, including tokenized instruments in existing frameworks and public-sector issuance can catalyze cross-border adoption and unlock institutional-grade liquidity at scale.

2 | Clarify Legal Foundations and Align Regulatory Treatment: To unlock the full potential of tokenized capital markets globally, further timely action is needed to establish clear, consistent legal frameworks. With coordinated regulatory reform and industry coordination, tokenized instruments can achieve legal certainty, enabling cross-border adoption, improving market confidence, and accelerating institutional-scale deployment.

3 | Establish Interoperability to Prevent Market Fragmentation: To realize the full benefits of tokenization, interoperability must be prioritized. Industry, in collaboration with regulators, should align on common data models, smart contract standards, and messaging protocols. By embedding interoperability into infrastructure design and regulatory frameworks, we can reduce fragmentation, lower integration costs, and unlock scalable, cross-platform market connectivity. The building blocks for this coordination already exist, now is the time to act.

4 | Address Technical and Operational Integration Gaps: To enable institutional adoption, DLT platforms must meet high operational and security standards. Industry should identify minimum requirements for wallet custody, smart contract governance, and system integration in a manner consistent with appropriate regulatory standards. With robust frameworks, auditability, and standardized APIs, institutions can safely scale tokenization while aligning with existing operational and regulatory practices. Investment now will ensure secure and seamless future deployment.

5 | Enable Scalable Settlement with Tokenized Money and Stable Payment Instruments: To unlock the full benefits of tokenized markets, scalable on-chain settlement with DLT-based Payment Instruments is essential. Industry should integrate tokenized deposits and stablecoins into settlement workflows, enabling atomic DvP and programmable payments. Regulatory clarity and interoperability with central bank systems will ensure secure, efficient, and continuous settlement across digital and traditional rails.

6 | Foster Public-Private Coordination: To scale tokenized markets, public and private sectors must align on institutional use of DLT infrastructure in such cases of custody, identity, compliance, and settlement. Industry should adopt open, collaborative models and support joint pilots. Policymakers can accelerate progress by harmonizing cross-border legal standards to foster funding of critical infrastructure.

It is now incumbent upon leaders in both the public and private sectors to **act**, to update the rules, modernize the operations, and embrace the opportunities of tokenization, thereby ushering in a new era of finance that is fit for the digital age.

Report Overview: The full report that follows provides a granular, bottom-up analysis across the topics explored in the Executive Summary. This includes a detailed overview of DLT, including the infrastructure and the digital assets represented on this infrastructure, a phase-by-phase impact assessment across the securities lifecycle, an exploration of live use cases, legal and regulatory considerations and recommendations, and barriers to adoption. To close the report, joint trades and members present critical calls to action from market participants to drive progress towards network effects, working in dialogue across key areas. For regulators, it could help inform efforts around emerging legal and regulatory frameworks, with a view to protecting markets and promoting innovation. For industry, it provides detailed potential areas for further dialogue to accelerate ongoing research and development.

As an overarching guiding principle, legal and regulatory frameworks should be designed in line with the "same activity, same risk, same regulatory outcome" and "technology-neutral" risk-based guiding principles that support, rather than deter, industry innovation and adoption. Joint trades and members underline the importance for all market participants to contribute toward ongoing research and development of DLT, and the representation of regulated financial instruments and payment instruments on this infrastructure. Punitive penalties for the use of a particular technology, without clearly defined risk-based justification, could be detrimental to innovation in the market and have unintended consequences on the evolution of a future DLT-based market structure within the regulatory perimeter.

As shown through this report, there are critical enabling steps required to drive the next stage of development toward a DLT ecosystem in capital markets. The current DLT-based ecosystem is primed for future growth. Primary and secondary markets are beginning to reach critical mass in select asset classes and product types. **At this transitional stage, all market stakeholders should come together and proactively shape the ecosystem across the core components as identified in this report.**

The recommendations are designed to mobilize the full spectrum of market participants toward the successful scaling of a DLT ecosystem in capital markets. While public policy and regulatory clarity remain crucial enablers, this roadmap prioritizes clear industry commitments—actions that can be taken now, unilaterally or in collaboration with peers, to build momentum and unlock value.

In **Chapter 5**, each recommendation outlines:

- **Industry Actions:** Specific steps that market participants can commit to, including suggested timelines, partnerships, and shared infrastructure initiatives.
- **Policy Enablers:** Legislative, regulatory, or supervisory adjustments that could accelerate or amplify the effectiveness of planned industry actions but are not prerequisites for industry progress.

This structure ensures that each recommendation begins with the industry's path forward, and identifies where public sector alignment can reduce friction, improve coordination, or enhance scalability.

The Joint Trades and their members stand ready to work closely with policymakers globally.

Chapter 1 | Distributed Ledger Technology (DLT) and Tokenization

This chapter explores the two foundational concepts of this report: DLT[91] and the digital representation of assets on this infrastructure, known as Tokenization.[92]

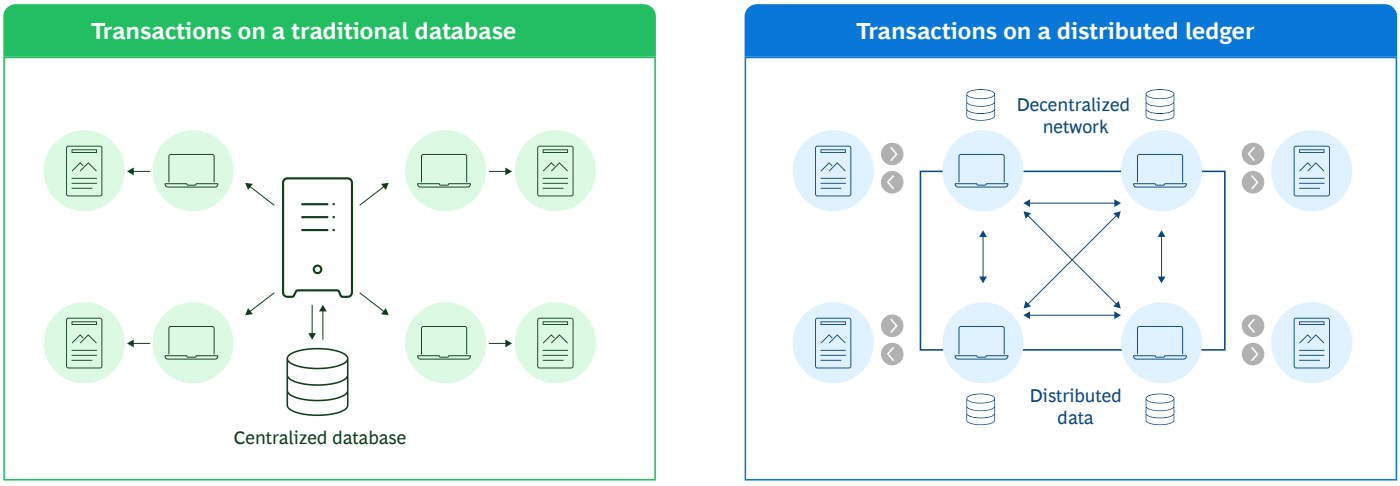
1.1 DEFINITION OF DLT

DLT is a database construct that brings together existing approaches around distributed computing networks and data encryption. It enables a novel way to record state updates and transactions of assets between participants on a network.[93] A leading technology provider notes: "DLT enables everyone involved in a transaction to know with certainty what happened, when it happened, and confirm other parties are seeing the same thing without the need for an intermediary providing assurance, and without a need to reconcile data afterwards."[94] Separate participants in different locations, known as nodes,[95] each maintain a copy of a common ledger, proposing new transactions and verifying proposed transactions to be appended onto the ledger.[96] The verification of transactions requires the consensus of participating nodes. Verified transactions form a record that is protected by cryptography so historical transactions cannot be altered,[97] known as immutability.[98]

If properly operated and maintained, the main advantages of a distributed ledger over traditional databases used by financial institutions are the potential for near-instant settlement, reduced operating costs, data integrity, enhanced automation, and operational resilience.[99] DLT is enabled by an underlying computing network, protocols, services, and interfaces – which can

EXHIBIT 1.1

Comparison Between Traditional and Distributed Ledgers



Source: BCG analysis.

91. While often used interchangeably, a blockchain and a distributed ledger are distinct technologies. A blockchain is a way to implement distributed ledger technology, but not all distributed ledgers employ blockchains. In this report, we will reference distributed ledgers and DLT, rather than blockchain. Refer to "Blockchain Byte: R3 Research" by Emily Rutland for a discussion on the distinction between blockchains and distributed ledgers.
92. OECD, "The Tokenization of Assets and Potential Implications for Financial Markets", 2020.
93. See, for example, the BIS discussion of distributed ledgers: "…as a collection of states and transactions that describe the transition from one state to another" – BIS, "Cryptocurrencies and Decentralized Finance", 2022. This report will refer to both state updates and transactions collectively as transactions for ease of reference.
94. R3, "Blockchain 101", 2023.
95. See Blockchain Council's overview: "Nodes are network stakeholders, and their devices are authorized to keep track of the distributed ledger and serve as communication hubs for various network tasks." Taken from "What Are Blockchain Nodes? Detailed Guide," 2022.
96. Bank of International Settlements, "What is distributed ledger technology?", 2017.
97. Blockchain Byte: R3 Research, Emily Rutland.
98. The term immutability refers to a state that cannot be changed or altered after it has been created. In capital markets, immutability can enable consensus and trust across the network but will also require mitigants to ensure errors and remediations can occur.
99. HSBC, "Distributed Ledger Technology in the Capital Markets – Game Changers – Future Trends in Securities Services", 2019.

have varying degrees of centralization or decentralization (explored in **Chapter 1.2**). A distributed ledger is accessible either through a private network (where access is permissioned to predefined users, similar to infrastructure used today in capital markets), or a public network (which includes either permissionless access or permissioned access). These concepts are explained in this chapter.

DLT consists of two foundational concepts that work together. First, a **distributed database architecture** across participants provides a novel infrastructure and method to capture and update data on a near real-time and shared basis. Second, this architecture enables the digital representation of assets (or other forms of value) as data on this infrastructure, which is referred to as **Tokenization**. Although Tokenization on DLT infrastructure was pioneered by public, permissionless distributed ledger networks with native cryptocurrency tokens (e.g., Bitcoin and Ethereum), the same concepts can be applied to a broad range of asset classes on other public or private networks. This includes regulated financial instruments that are frequently traded (e.g., equities, fixed income including asset-backed securities, and derivatives), additional financial instruments (e.g., private debt and unlisted securities), and cash.

1.2 DLT ARCHITECTURAL ATTRIBUTES AND NETWORKS

A distributed ledger uses a unique architecture for capturing, appending, and verifying transaction data, which typically has four key attributes:

1 | Distributed peer-to-peer ("P2P") network: A single database architecture ("ledger") is replicated by multiple participants ("nodes") in a network of connected computers. The network is governed by predefined rules regarding the management of data on the ledger ("protocol"). This distribution across participants is the central feature of DLT, providing enhanced operational resilience compared with centralized databases as there is no single-point-of-failure.[100] While it is often conflated with the concept of decentralization, it is entirely distinct. Decentralization refers to the degree of central control and governance (or lack thereof) over the operation and administration of the infrastructure. Distributed ledgers can have varying degrees of decentralization (or none at all), which can be considered across the three sub-attributes shown in the sidebar.[101]

Decentralization

i. Computing network: Control over the computational infrastructure, called nodes, replicating the ledger to power the network. Decentralized computing networks provide operational resilience against technical faults and cyberattacks by reducing central points of failure.[102] This is a defining advantage of distributed ledgers when compared to centralized databases.[103]

ii. Ledger architecture: Control over the overall interface and structure of the ledger database replicated by nodes. Counterintuitively, DLTs have a centralized ledger design that enables the provision of a uniform structure to be replicated by nodes (the distributed ledger itself). This ensures the ledger is the same for all nodes and resists change.

iii. Governance: Control over the decision-making authority (e.g., accessibility and permissioning) and operations across the network. With greater decentralization of governance, decision-making and operations can be increasingly shared by network participants. Governance can also be centralized in totality or with regard to specific functions — ultimately, this is a design option that can be defined and optimized for the activities being conducted. It is important to distinguish between decision-making and operations of the network. Though both can be combined, they can also be separated (e.g., when there is a central governance entity, but the operations are performed by specific actors). The consensus mechanism for a network is also fundamental to governance. The central governance entity can design how this consensus mechanism works for a given application. For example, in capital markets, permissioning (either for a private network or for one or more permissioned nodes on a public network) may define which market participants are entitled to have governance roles, which may vary as they are defined, for the network. These concepts are elaborated upon in the review of distributed ledger network archetypes (see page 38).

100. Distribution is not unique to DLT–many databases and systems can be managed across locations, but typically they are connected to a central database or system with updates pushed out at a point in time. DLTs are differentiated because there is no central database–instead, copies of the ledger exist across the network.
101. Adapted from Vitalik Buterin, "The Meaning of Decentralization", 2017.
102. This is a generalized rule, though "common mode" failures can exist where, for example, all nodes are running the same software.
103. This concept already exists across mission-critical infrastructure and software systems, for example, in the use of backup systems in cloud computing provision, aircraft engines, and power generation.

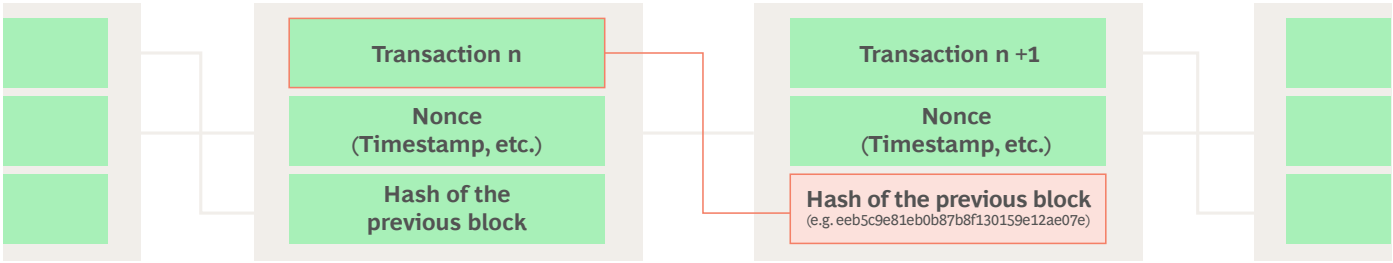
2 | Validation of transaction integrity through consensus: New transactions are added to a distributed ledger only after they are verified through a predefined protocol known as a consensus mechanism. This is an important source of trust in the accuracy of the database and prevents double-spends.[104] Depending on the chosen approach and scale of adoption, both the network scalability (defined as the number of transactions processed per second) and energy consumption can vary drastically.[105] Many different consensus mechanisms are used in distributed ledgers, but the most common are Proof of Work and Proof of Stake.[106,107] These consensus mechanisms are designed for public networks, where nodes are unverified and therefore not assumed to be trusted actors. Private networks can specify rules that guide how consensus is achieved, including consensus mechanisms can build on these approaches or take different forms based on the specific needs of the activities (for example the PBFT method).

3 | Immutability of data: Prevents data tampering or reversal of transactions on the ledger. Many distributed ledgers (but not all) choose to achieve this using the blockchain approach. Although this approach was pioneered by the Bitcoin ledger, a blockchain approach is not intrinsically linked to cryptocurrencies or other digital assets defined as out of scope for this report.

A unique identifier known as a hash signature, or just "hash," is typically assigned to a bundle of transactions to be added to the ledger. This is known as a block. The next block added to the ledger is chained to the preceding block using the preceding block's hash signature, creating a mathematical linkage between the two. If an attempt is made to alter a previously agreed upon block, this mathematical relationship is broken as later blocks now refer to an incorrect hash signature. In such cases, the altered block is rejected and discarded by the network to restore the mathematical linkage through the consensus mechanism. Any block added to the ledger is therefore irreversibly recorded in this way and cannot practically be changed after it has reached cryptographic consensus. This concept is called "immutability."

EXHIBIT 1.2

DLT Prevents Tampering of Data by Using Encrypted Unique Identifiers (hash signatures) Between Transaction Data



Source: BCG analysis.

104. With fiat currencies, for example, there are structural safeguards against the double-spending of money (i.e., using the same money more than once): (1) double-entry bookkeeping to ensure the balance of debits and credits; (2) authentication, clearing, and verification processes that reconcile transactions and check for money laundering and fraud; and (3) the use of physical cash as a means of exchange to make sure it cannot be used by the same party again unless a theft is committed. Distributed ledgers provide an alternative to prevent double-spending primarily by recording transactions immutably across a shared, decentralized network where a consensus mechanism ensures that each unit of value is only spent once, although they can also work in tandem with (1) and (2).
105. Boston Consulting Group, "Thinking Outside the Blocks: A Strategic Perspective on Blockchain and Digital Tokens", 2016.
106. Proof-of-Stake: Proof-of-stake (PoS) is a consensus mechanism used in DLT that relies on validators staking cryptoassets (the native token of the network) to validate transactions and create new blocks. Validators are chosen based on the amount of cryptoassets they hold and are willing to stake as collateral, with the higher the amount staked, the higher the chances of being selected as a validator. Validators earn rewards for their work, which typically come in the form of additional cryptoassets, but can also be penalized (e.g., lose their staked funds) for malicious behavior (e.g., double-signing transactions, which risks forking the DLT).
107. Proof-of-Work: Proof-of-work (PoW) is a consensus mechanism used in DLT networks that relies on computational power to validate transactions and create new blocks. In PoW, validators (also called "miners") compete to solve complex mathematical puzzles to create a new block, and the first validator to solve the puzzle gets to add the block to the DLT and earn rewards in the form of newly minted cryptoassets (the native token of the network). The difficulty of the puzzle is adjusted based on the total computational power of the network, and validators are incentivized to use more computational power to increase their chances of solving the puzzle and earning rewards.

4 | Programmability: Ability to build an ecosystem of applications that are interoperable because they have back-end integrations with a common distributed ledger and a means of exchange to transact on the ledger. The back end delivers services by using software code known as smart contracts. Smart contracts are developed on a distributed ledger to self-execute "if…then"–style logic, based on predefined criteria, and applied to a user's assets on the ledger. This programming of smart contracts is known as programmability, resulting in asset-level automation. The front end can be accessed through web or mobile applications, providing functionality to end users, such as financial products and services (see **exhibit 1.2**).

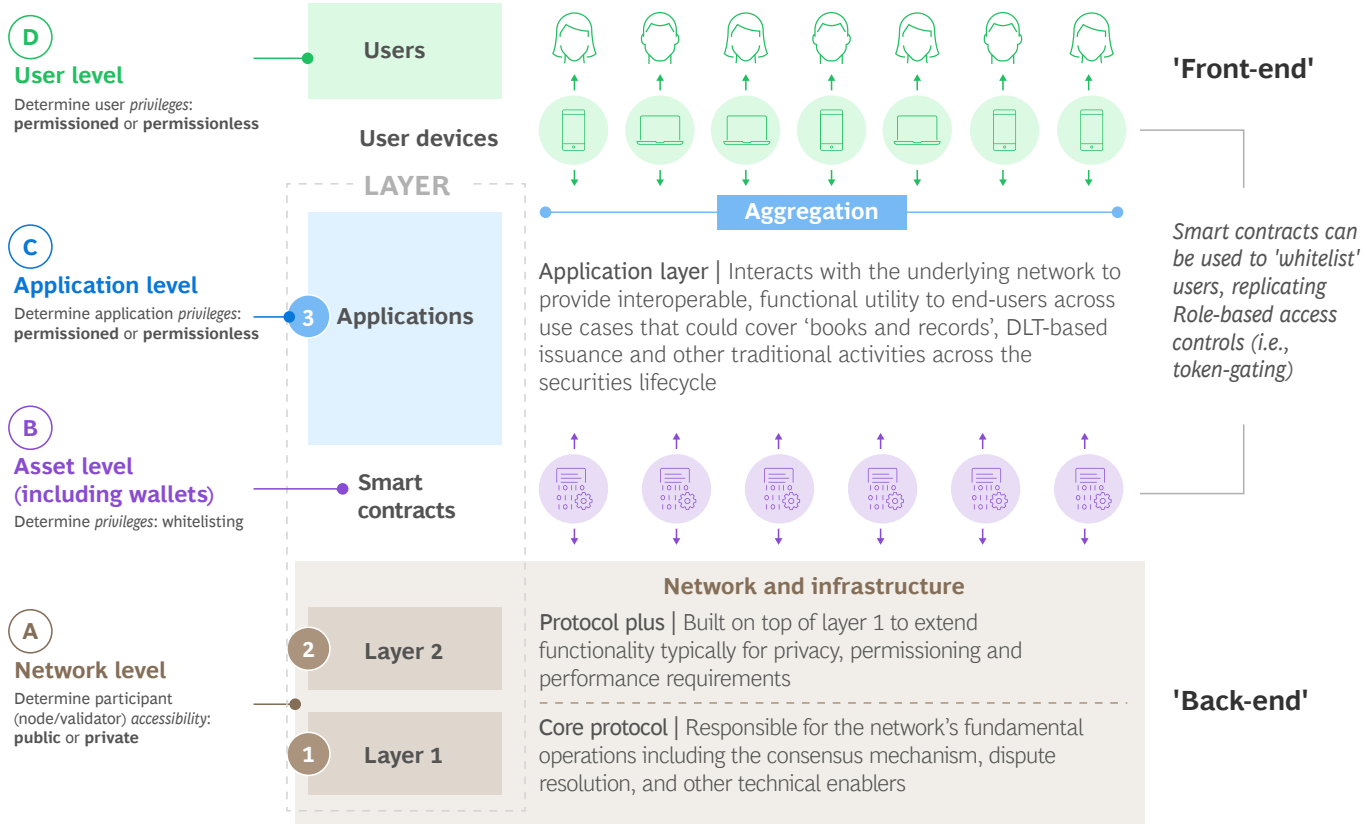
Composability through smart contracts (i.e. one smart contract calling another for additional functionalities) is providing a conceptual basis that participants in capital markets are exploring to fulfill books and records back-office use cases, and experimentation with traditional services across the securities lifecycle provided to issuers and investors through distributed ledgers. This is driven by the potential to realize the benefits enabled by the four attributes highlighted above. **A series of choices exist around these attributes.** The distributed ledger network is one of the most critical, directly driving the ability to influence all other attributes. The level of central control over the distributed ledger network can also influence how data verification through consensus and immutability is achieved, and the extent of ecosystem interoperability enabled by composability.

Distributed Ledger Network Archetypes

Given its central importance to a DLT-based ecosystem, recent debate in the industry has focused on the different archetypes of distributed ledger networks. Distributed ledger archetypes are differentiated along two dimensions: (i) the **accessibility** of the network, which can be private (closed, invitation-only) or public (open to all); and (ii) the **privileges** set for users to perform specific actions, such as transfer to, which can be permissionless (users are unauthenticated) or permissioned (users are authenticated). **Accessibility is determined at the network level (layer 1), while privileges can be set at the asset (through smart contracts), application (through user rights) and/or user levels in the blockchain (through digital identities).**

EXHIBIT 1.3

Accessibility and Privileges in a Composable, DLT-based Ecosystem



Sources: Phemex; Blockchain Council, "A Beginner's Guide to Understanding the Layers of Blockchain Technology," 2022; BCG analysis.

This has given rise to three archetypes of distributed ledgers which is synthesized in the **exhibit** and supporting text below:

EXHIBIT 1.4

Comparison between distributed ledger archetypes

		Private-permissioned	Public-permissioned	Public-permissionless
Defining characteristics	Governance	Centralized	Centralized (for the relevant application)	Decentralized*
	Accessibility to users	Role-Based Access	Role-Based Access	Role-Based Access
	Control over privileges	Can be defined as required	Users authenticated for specific roles	Defaults to open, but fully configurable (RBAC)
	Identification Requirements	All users known	All users known (for the relevant application)	Defaults to open, but fully configurable
	User base	Limited (by design)	Limited (for the relevant application)	Broad
	Interoperability	Can be developed as req'd but lower ease of implementation. In practice – limited.	Can be designed as required (for the relevant application). In practice – limited.	Higher interoperability given existing DLT-based ecosystem. "composability" as standard
Technology and infrastructure	Default data confidentiality	Can be defined as required	Can be defined as required (for the relevant application)	All users can view all transactions (without bespoke approaches)
	Overall operational resilience	Lower common fault tolerance but highest cyberattack resilience	Provides lower common fault tolerance and cyberattack resilience vs permissionless	Higher common fault tolerance; most exposed to cyberattacks but proven resilience in leading networks
	Scalability	Higher scale and performance in core network given fewer nodes	Higher scale and performance in core network given fewer nodes	Lower scale and performance in core network (layer 1) given many nodes; higher scale and performance at layer[2]
	Interoperability	Can be developed as required but lower ease of implementation. In practice – limited.	Can be designed as required (for the relevant application). In practice – limited.	Higher interoperability given existing DLT-based ecosystem. "composability" as standard
Regulatory and Compliance Factors	1 | Cyberattacks (application layer)	Strongest mitigation as network closed and centrally controlled Vulnerable to human errors/misconfigurations and phishing	Permissioning reduces risks of cyberattacks and hacks but still vulnerable to human errors/misconfigurations and phishing	Unique risks of cyberattacks and hacks (e.g., bridges)
	2 | KYC/AML compliance	All participants are verified by default	Authentication enables KYC/AML, but some participants (e.g., node validators) unverified although verified validators can be an option	Participants are unverified, so bespoke solutions are required (e.g., application whitelisting)
	3 | Group 1b & Group 2a/b asset exposure[1]	No Group 1b/2 assets are used	Can be designed to ensure no Group 1b/2 assets are used	Workarounds required to avoid Group 1b/2 assets
	4 | Settlement finality	Can demonstrate precise moment of settlement finality in network-wide rules (subject to rules/regs)	Can be designed to define moment of settlement finality similar to private-permissioned networks	Probabilistic settlement due to validation by consensus; some networks defined "finality" step where reorg probability is very low
	Examples	HYPERLEDGER FABRIC, r3 corda	POLYMESH, corda	bitcoin, ethereum

Sources: GFMA member input; BCG analysis.
[1]As defined in the Basel Framework, set out by BCBS in the "Prudential treatment of cryptoasset exposures", 2022.
*technical, legal, economic, logical and governance measures of decentralization.

As joint trades and industry members, we recognize that clear definitions of distributed ledger network archetypes are a useful reference point for regulators and policymakers. This has been reinforced by the BIS's recent inclusion of our categorization—private-permissioned, public-permissioned, and public-permissionless networks—as a foundational framework in its analysis of novel DLT risks[108]. The summary table cited from our 2023 report highlights key distinctions across governance, access, role privileges, and identity requirements, offering a structured lens through which emerging platforms can be assessed.[109]

In this update, we aim to build on that foundation by reflecting on how the landscape has evolved. We incorporate recent developments that blur the boundaries between archetypes—such as selectively permissioned applications built on public chains—and identify where new patterns of implementation are emerging across the capital markets ecosystem.

Following this discussion, we apply the same archetypes to structure our assessment of risk and mitigation strategies. This alignment ensures that our analysis remains grounded in a consistent vocabulary while remaining flexible enough to accommodate innovation. We believe this approach will support both industry participants and regulators in evaluating where and how DLT networks can responsibly scale in financial markets.

Private-permissioned: Private networks enable a comparable model to existing infrastructure used by capital markets today, with control over all network layers. These defining characteristics mean existing legal, regulatory, and institutional risk management frameworks (such as operational and cyber resilience frameworks) can apply with relatively minimal adaptations. The primary limitation of these networks is interoperability, which is typically not a key design feature though can be achieved through API information flows or alternative solutions. Some industry participants have chosen private-permissioned networks as a starting infrastructure for use case development on Distributed Ledger Technology.

Public-permissioned: Though public-permissioned distributed networks mark a step away from the tight central control of private networks, they also operate as closed networks (at Layer 2 if it is a Layer 1-2 architecture) or closed application (if permissioning is at the smart contract/asset lever) with centralization retained over key attributes. For example, a centralized sequencer in layer 2. Therefore, like private networks, similar legal, regulatory, and institutional risk-management frameworks can also help to govern these networks with relatively fewer adaptations, including novel considerations around cybersecurity and impacts on operational resilience, and the emerging development of tools to better enable KYC/AML/CFT compliance. In these instances, the permissioning of activities and participants can play an important role to mitigate these risks. As the DLT ecosystem matures, joint trades and members identified the suitability of these networks for capital market use cases where interoperability and wider end-client access are key requirements (e.g., facilitating broker-dealer access), along with a degree of central control that can also be configured based on needs. Regulators interviewed for this publication have also expressed interest in public-permissioned networks for these reasons.

Public-permissionless: These publicly available distributed ledger networks have defining characteristics, such as consensus decentralization, cryptographic pseudonymity, and large-scale user bases, which are significantly different to private-permissioned and somewhat different to public-permissioned networks. Joint trades on behalf of their members have identified advantages this could provide for use cases in a more developed DLT ecosystem. Similarly, prudential authorities like the European Comision have highlighted their "[suitability] for a wide range of financial protocols".[110] This includes interoperability and driving adoption, including the proven operational resilience of leading public networks and reduced infrastructure costs they enable.[111] Public networks are continuously battle-tested due to their permanent public accessibility, which requires them to demonstrate their security robustness in real time. They are purpose-built to operate securely in open environments, rather than relying on the protection of a surrounding network perimeter. Supply-side injection attacks have shown that simply placing a database within a corporate firewall does not make it immune to exploitation. Such attacks are often easier to execute than compromising the extensive, decentralized security infrastructure of a large-scale public blockchain.[112]

108. BIS, Novel Risks, Mitigants and Uncertainties with Permissionless Distributed Ledger Technologies, August 2024.
109. We note that the BIS, Novel Risks, Mitigants and Uncertainties with Permissionless Distributed Ledger Technologies, highlights that the archetype "Private-Permissionless" was not discussed as this model is not practically applicable to use cases.
110. EU Commission, Enhancing Financial Services with Permissionless Blockchains, October 2024.
111. Ibid.
112. Ibid.

Layer 2: Layer 2 solutions are built on top of other public DLT archetypes to address scalability and transaction cost limitations without compromising foundational security and decentralization features on the associated Layer 1. These networks use cryptographic proofs and off-chain processing to bundle transactions, which significantly increases throughput and reduces fees. This alleviates network congestion, making L2 technologies suitable for high-volume applications. The modularity of Layer 2s allows for flexible design choices and improved interoperability of solutions with different permissioning practices, creating additional flexibility for institutions to implement permissioning and KYC/AML/CFT controls at the application layer across jurisdictions that may have different regulatory requirements. This ensures compliance with applicable regulatory requirements while still benefiting from the transparency and global reach of public blockchains. L2s are a crucial pathway to scale institutional use cases, unlock new market functionalities, and help to foster broader adoption of DLT in capital markets. While Layer 2 solutions present clear benefits, they also introduce a distinct set of challenges. Operational complexity can grow substantially, particularly when coordinating off-chain activity with on-chain settlement, which may complicate governance, reconciliation, and oversight. Security considerations are heightened as institutions must rely on the integrity of cryptographic proofs and the trustworthiness of L2 validators, which may differ in accountability models from those of the underlying Layer 1. As institutions expand across multiple platforms, fragmentation and a lack of interoperability between L2s can hinder seamless asset movement and cross-platform integration. These hurdles underscore that L2s are not a universal solution. Still, they remain a promising technological path for enabling more controlled, scalable, and compliant participation in public blockchain environments.

The Internet as an "analogy"

Financial institutions and regulatory bodies exploring DLT can examine parallels with decisions made around the adoption of the internet. Like a distributed ledger, the internet is a network of connected computers. It is accessible to any user with a service connection to interact with it, and there are generally no default limitations on privileges to interact with and develop webpages, email, and other applications (in line with publicly available rules, known as permissionless protocols).[113] The internet can therefore be described as a **public network** with **permissionless access**.

Applications developed on the internet deliver security through approaches including encryption and authentication to identify users and websites.[114] Mainstream web browsers search for certification from a website to confirm the website's identity and then encrypt all communication between the browser and the website.[115] The user can also be authenticated, such as for email access and online banking. Signing up for online banking or other financial services requires users to undergo KYC checks. This can be described as the use of a **permissioned application** on a **public network** with **permissionless access**. Most financial services are delivered through permissioned applications on the public internet to ensure end-user security while maximizing market accessibility.

There are also restricted, closed-loop networks of connected computers known as intranets. Intranets limit or block external connectivity to the public internet as a cybersecurity defense, typically chosen by corporations and governments. Users interacting with intranets are authenticated to gain access to the network. These can be described as **private networks** with **permissioned access**. They are not typically used to provide financial services to end users, but rather to store internal intellectual property, knowledge bases, and other internally focused content.

As is the case with any new technology, financial institutions and regulators are evaluating these archetypes with a heavy focus on legal, regulatory, and risk management considerations for use cases in capital markets. Joint trades and members have worked to better understand the defining attributes of these networks, the technical features, and the crucial implications on institutional-grade risk management frameworks.

113. For example, Transmission Control Protocol/Internet Protocol (TCP/IP), Hypertext Transfer Protocol (HTTP), and Simple Mail Transfer Protocol (SMTP).
114. For example, Secure Sockets Layer/Transport Layer Security (SSL/TLS) protocols.
115. Coin Center, "What does 'permissionless' mean?", 2017.

Choosing the Appropriate Network: Aligning Infrastructure to Use Cases

Choosing the appropriate blockchain network for institutional use requires a clear understanding of the specific requirements and constraints presented by each unique use case. Institutions must consider factors including compliance mandates, regulatory oversight, transaction privacy, scalability needs, and the desired balance between transparency and control. The chosen infrastructure should align closely with strategic business objectives and regulatory frameworks, enabling effective management of operational and compliance risks.

Public permissionless networks, public permissioned networks, and private permissioned networks each provide distinctive capabilities and limitations. Rather than viewing one category as inherently superior, institutions should analyze their specific context—such as the level of decentralization necessary, the nature of counterparties involved, required transparency for audit purposes, and anticipated regulatory scrutiny—to identify the optimal infrastructure.

For instance, use cases that prioritize broad market engagement, high liquidity, and interoperability might lean towards public networks. Conversely, highly regulated activities requiring stringent compliance controls, privacy guarantees, and limited participant interactions may benefit more from permissioned networks.

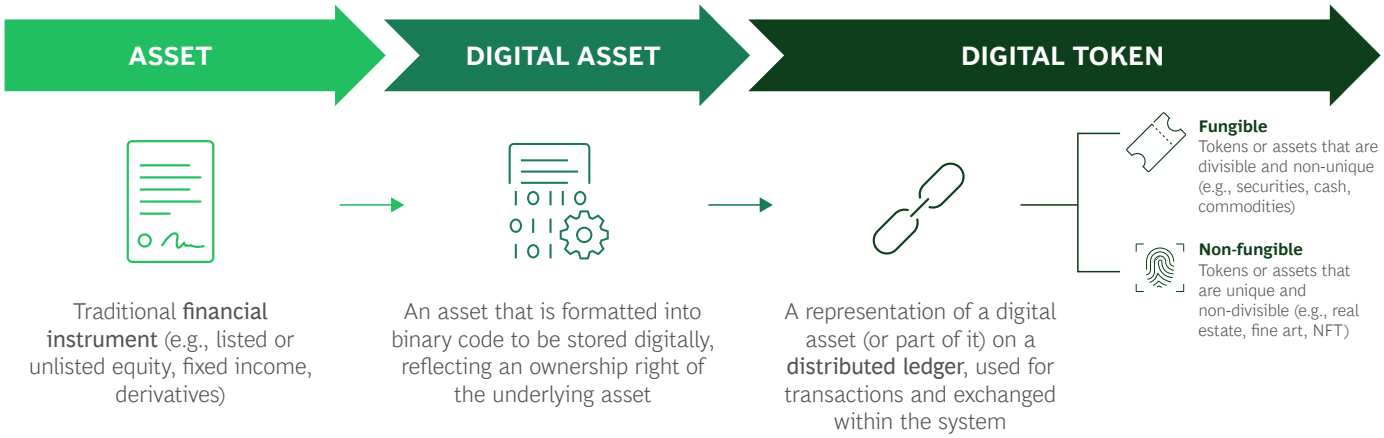
Importantly, the evolution of technology has introduced more nuanced infrastructure solutions. Hybrid models and Layer 2 technologies have emerged to bridge gaps between these traditional network types, enabling institutions to customize solutions precisely matched to their nuanced requirements. This ongoing evolution allows institutions greater flexibility and precision when choosing blockchain infrastructure, ensuring alignment with both strategic objectives and regulatory expectations.

1.3 DIGITAL ASSETS

Since the advent of paper certificates to represent real-world assets, such as banknotes, Tokenization has existed across various form factors in finance. This report defines Tokenization as the digital representation of securities and payment instruments on a distributed ledger, reflecting an ownership right of the underlying asset (e.g., securities, cash).[116] Assets tokenized on a distributed ledger are commonly referred to as digital assets.[117] For Tokenization to occur, units representing a digital asset, known as tokens, are added to the distributed ledger, and exchanged through transactions. This initial process is known as minting. Minted tokens can either be fungible (interchangeable and divisible – like securities, cash, or commodities) or non-fungible (unique and indivisible — like real estate, fine art, and other nonfinancial assets). The ledger can be used in primary issuance, secondary trading, Custody, and other back-office activities.[118]

EXHIBIT 1.5

Tokenization of Assets on a Distributed Ledger



Source: BCG analysis.

116. Tokenization includes the representation of other tangible assets (e.g., commodities) and intangible assets (e.g., copyrights and patents) on a distributed ledger, but these are out of scope for this report. Additional use cases for Tokenization also exist but are out of scope for this report.
117. European Union, "Article 3(2) of the 'E.U. Project Proposal for a Regulation on Markets in Crypto-assets (MiCA).", 2022.
118. The technical difference should be noted between native coins issued by a layer 1 distributed ledger (e.g., ETH) and tokens, which are composed on a layer 2 distributed ledger protocol through smart contracts. Layer 2 refers to a secondary protocol built on top of an existing distributed ledger (Layer 1) to enhance its scalability and efficiency. For simplicity, this report refers to any unit representing a digital asset on a distributed ledger as a token, in line with common usage by practitioners.

"Digital assets" is a broad umbrella term. For the purpose of this report, tokens that lack intrinsic value or are issued without backing by an asset with intrinsic value, like cryptocurrencies, are out of scope. Tokenized representations of securities and payment instruments, however, have firmly emerged in the regulated financial services ecosystem today.

With regard to digital taxonomy, the joint trades and members re-emphasize that use of the term *cryptoassets* to refer to securities and payment instruments fails to meaningfully differentiate between types of digital assets (for example those that are classified as Group 1 and Group 2 as per the BCBS standard) despite the significantly different economic structures, regulatory status, and risk profiles outlined above. Consensus around terminology and classification is critical to prevent this conflation, enabling all industry stakeholders to work from a consistent baseline and globally harmonized definitions. The CFTC's Global Markets Advisory Committee Digital Asset Markets Subcommittee *Approach for the Classification and Understanding of Digital Assets* aims to address these challenges, providing a clear, consensus-driven approach to classifying assets and the functions they serve. and is based on inputs from market participants across banks, financial market infrastructure and other leading digitally-native institutions.[119] It also incorporates the views of joint trades and members, representing the perspectives of global capital markets. It is intended as a starting point for consensus-building across the financial services ecosystem. The relevant sections for this report have been highlighted below.

A. DLT-based Securities

Type of assets	Traditional securities including, but not limited to, equities, fund interests[120], fixed income, derivatives, and asset-backed securities that satisfy existing legal definitions of securities and financial instruments.
Purpose	Issued as a means of generating additional capital and income through primary issuance and secondary trading on a distributed ledger.
Characteristics	Equivalent to the securities they are representing outside of a distributed ledger or DLT ecosystem.
Examples[121]	**Tokenized Security:** a Digital Twin token that represents an underlying security issued on a different platform (e.g., a traditional central securities depository ("CSD") or registrar), where such representation itself satisfies the definition of a security under local law. **Security Token:** a Digital Native token that satisfies the applicable regulatory definition of a security under local law.

EXHIBIT 1.6

DLT Payment Instruments

	Stablecoins	Tokenized Deposits	Wholesale Tokenized Central Bank Money
	DLT-based asset that aims to maintain a stable value relative to a reserve asset, such as fiat currency	DLT-based digital representation of existing bank deposits (M1) held by depository institutions	Digital representation of central bank money (M0) intended to serve alongside banknotes and reserves
Issuer (and liability of)	Commercial bank or Non-bank	Commercial bank	Central bank
Backing assets	100% backed by cash and HQLA[1] held in reserve	Fractionally backed by cash, assets/HQLA[1] (like bank deposits)	N/A: Claim on the central bank (like banknotes and reserves)

119. GFMA, "GFMA Response to FSB Crypto-Asset Consult", 2022.
120. Note: for the purposes of this report, references to tokenized fund interests refer to money market funds, private credit or private equity funds.
121. CFTC, Global Markets Advisory Council Digital Asset Markets Subcommittee, "Digital Assets Classification Approach and Taxonomy", 2024.

B. DLT-based Payment Instruments:

Type of assets	Stablecoins, commercial bank money or, as may become applicable, central bank money.
Purpose	Issued as a means of exchange on a distributed ledger.
Characteristics	Holds a reliable value due to the nature of the issuance structure.
Examples[122]	**Tokenized Deposits:** digital tokens that represent an existing record of a traditional ownership claim for a bank deposit on the token-issuing bank or depository institution, for a fixed amount of commercial bank money denominated in a single currency. **Deposit Tokens:** transferable digital tokens issued by a licensed depository institution which evidence a deposit claim against the token-issuing bank or depository institution, for fixed amount of commercial bank money or fiat cash denominated in a single currency. **"Wholesale" tokenized central bank money:** tokenized central bank money that enables the settlement of wholesale transactions by regulated financial institutions and could be used in the facilitation of regular capital markets functions (e.g., settlement of securities transactions).[123] **Stablecoins:** privately issued, money-like, digital token that functions as a medium of exchange, such as payments and aims to maintain a stable value relative to a peg specified by a reference asset or a collection of reference assets and designed to minimize value fluctuations relative to these reference assets(s). They are not issued by a central bank.

DLT-Based Payment Instruments and Atomic DvP Settlement[124]

The settlement of securities transactions on a distributed ledger is dependent on integration with the payments infrastructure. Depending on the maturity of jurisdictions, central banks, and other public authorities may contemplate the pros and cons between existing real-time payment infrastructure or DLT-based payment infrastructure. DLT-based Payment Instruments have the potential to enable new benefits that are distinct to the nature of the technology itself, such as the ability to integrate programmability into the infrastructure on which they run. DLT-based workflows can also be developed that link DLT-based Payment Instrument proxies with existing payments infrastructure, such as Real-Time Gross Settlement Systems ("RTGS").

Existing Payment Infrastructure

Advanced payments infrastructure is being rolled out across global markets, including RTGS for wholesale and other real-time payments systems such as FedNow, FPS, SCT Inst. Distributed ledgers used in capital markets could be integrated with these systems to enable the settlement of domestic securities transactions using existing forms of commercial bank and central bank money, building on investments already made in financial market infrastructure across the U.S., U.K., E.U., Middle East, and Asia Pacific. The Bank of England has introduced an omnibus account model to enable its RTGS service to interface with a wider range of payment systems, including those using DLT.[125] This account model is being used by Fnality.[126]

In contrast, longer-term adaptability could also be limited through existing forms of money and infrastructure, with trade-offs on payment automation (e.g., no smart contract–style programmability and potentially higher transaction costs) and without the benefit of reducing settlement risk by means of full DvP settlement. For example, capital markets are globally interconnected, yet real-time payment improvements to date have had a limited impact in cross-border transactions, which rely on correspondent banking. To this end, recently SWIFT and others have been exploring the use of DLT-based infrastructure and interoperability solutions for cross-border payments.[127] The BIS together with seven central banks and the IIF, in collaboration with over 40 private sector financial firms, in Project Agorá is currently investigating how tokenized commercial bank deposits can be integrated with tokenized wholesale central bank money in a public-private programmable financial platform to enhance the functioning of cross-border payments while maintaining the monetary system's two-tier structure.[128]

122. Ibid.
123. Note: in some jurisdictions authorities may use an omnibus account model to facilitate such transactions, and in other authorities may pursue this type of DLT-based settlement in the form of a central bank digital currency ("**CBDC**").
124. DLT-based Payment Instruments and related platforms are discussed in this report as they relate to capital markets activities, not in connection with their use to facilitate other types of payments or payments generally.
125. Bank of England, "Bank of England publishes policy for omnibus accounts in RTGS", 2021.
126. Fnality is jointly funded by leading financial institutions across the U.K., E.U., Asia and US. See here for more details: "Fnality Global Payments & Multi-CBDC", 2021.
127. Swift, "New experiments pave way for international payments using CBDCs", 2022.
128. Bank for International Settlements, "**Private sector partners join Project Agorá**", 2024.

DLT-based Payment Instruments are foundational to enabling atomic DvP in tokenized capital markets. These instruments represent fiat-denominated value directly on a distributed ledger, allowing for programmable, simultaneous exchange of cash and securities. DLT-based Payment Instruments play a key role in enabling **atomic DvP** settlement on DLT-based platforms. They facilitate the **simultaneous exchange of securities and cash** on a shared ledger without settlement delay. Unlike traditional settlement processes, where the cash and asset legs are typically coordinated via multiple intermediaries and systems, DLT-based Payment Instruments enable **on-ledger finality**, which reduces the risk of trade failure and settlement mismatch.

A further analysis of the role that **Banks** play in DLT-based Payment Instruments, is included in **Chapter 3.3.1 | Role of Banks in Scaling DLT-based Payment Instruments**.

DLT-based Payment Instruments may offer a wide range of benefits across client segments by addressing specific pain points related to payments, liquidity, and settlement. For institutional and capital markets participants, DLT-based payment instruments may also help address inefficiencies in traditional post-trade operations by allowing the option for near-instant (T+0) settlement[129], real-time collateral transfers, and automated reconciliation through shared ledgers. These capabilities may reduce counterparty risk, improve liquidity usage, and streamline complex operations.

A further analysis of the role that Banks play in DLT-based Payment Instruments, is included in **Chapter 3.3.1 | Role of Banks in Scaling DLT-based Payment Instruments**.

The following three forms of DLT-based Payment Instruments are emerging to support this capability:

Tokenized Commercial Bank Money and Deposits: Joint trades on behalf of their members are exploring the use of DLT-based Commercial Bank Money and deposits for the settlement of securities transactions. This is in line with principle nine of the CPSS-IOSCO Principles for Financial Market Infrastructure. Deposits can be tokenized, account-based, with ownership reflected on a DLT, or otherwise linked to commercial bank accounts to allow for transfer of balances on DLT. This approach has been demonstrated with JPM's blockchain deposit accounts, used in the J.P. Morgan repo use case example described in this report. The Regulated Settlement Network ("RSN"), initiated by several commercial banks, payment platforms and the Federal Reserve Bank of New York Innovation Center participating as a technical observer, also explores the interoperability of tokenized commercial bank money as a payment method with other Group 1a digital assets.[130] Tokenized commercial bank money and deposits have typically been based on private-permissioned networks to date, as these environments readily offered control over access, compliance, and operational risk—key priorities during early experimentation and regulatory uncertainty. As of 17 June 2025, J.P. Morgan introduced its USD Deposit Token on Coinbase's Layer 2 base blockchain, marking a notable development toward public-permissioned network deployment.

Wholesale Tokenized Central Bank Money: Wholesale tokenized central bank money is currently the closest proxy to central bank reserves in a DLT-based ecosystem – though central banks are also exploring simply tokenizing reserves themselves – representing a form of settlement free of credit and default risk, and limited to wholesale market participants who have central bank account access. Though many are under research and development, no form of fully launched wholesale tokenized central bank money exists today.

EXHIBIT 1.7

What DLT-based Payment Instruments Can Solve

Non-exhaustive

Client segment	Key pain points addressed	How DLT-Based Payment Instruments can solve them
Institutional & capital markets	• Slow, **multi-day settlement** and **counterparty risks** • **Inefficient** DvP[1]/PvP[2] **processes** • **Collateral inefficiency** and manual FX netting • **Complex post-trade ops** with high reconciliation efforts	• Near-instant (**T+0**) **settlement** • **Programmable**, instant settlement • Automated, **real-time collateral transfers** • **Simplified reconciliation** via shared ledgers

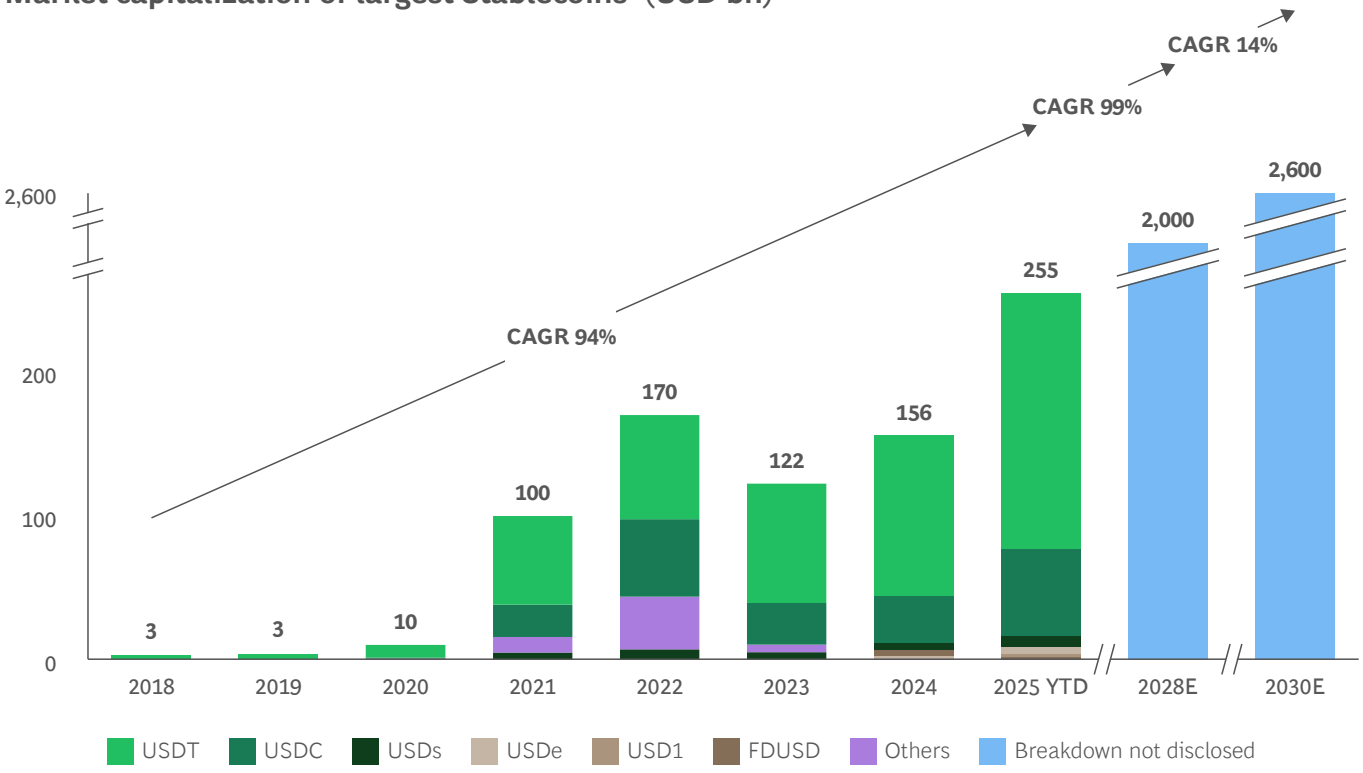
Source: BCG analysis.

129. We note that T+0 settlement, particularly on the payment-leg of an DvP transaction, may not always be the most optimal outcome for market participants, as it may impact pre-funding or liquidity requirements currently mitigated by "netting". This consideration is addressed in more detail in Chapter 2.1.3 | Clearing and Settlement.
130. SIFMA, "Members of the U.S. Financial Sector Demonstrate Feasibility of Multi-Asset and Cross-Network Settlement Using Shared Ledger Technology", December 2024.

EXHIBIT 1.8

Market Capitalization of Largest Stablecoins 2018 to 2030E

Market capitalization of largest Stablecoins[1] (USD bn)



Sources: Market data by CoinMarketCap, retrieved 02.06.2025; Standard Chartered; BCG analysis.
[1]All Stablecoins shown exceed market capitalization of USD 1bn in 2025.

Stablecoins are gaining traction in live institutional applications today. For example, stablecoins are already being used as payment instruments and as a cash equivalent settlement tool into and out of tokenized funds. Unlike other forms of tokenized money still in development or operating within a walled-garden infrastructure, stablecoins are already in active use across a range of real-world financial applications.

While initially developed for digital native ecosystems, institutional grade stablecoins, such as **USDC, EURC, PYUSD, RLUSD, USDG, USDCV** and **EURCV**, are increasingly being adopted by regulated financial institutions and integrated into capital market workflows. This evolution is already visible in large-scale use cases. BlackRock's **BUIDL fund** is a tokenized short-term U.S. treasury fund, in which stablecoins operate outside the fund and play a critical role in enabling its broader ecosystem. In this context, stablecoins support full-cycle digital asset workflows, including **automated settlement, intraday liquidity optimization, and cross-chain interoperability.**[131]

Projects such as the **"Global Layer 1"** and **Project Guardian** have also demonstrated that stablecoins and tokenized securities can be exchanged atomically on public blockchains such as Ethereum using smart contracts that embed compliance logic. Notably, **Société Générale** issued its first **digital green bond** on a public blockchain in November 2023, using **EUR CoinVertible ("EURCV")**—a euro-denominated stablecoin issued by SG-FORGE—to settle the transaction atomically on-chain. This marked a significant milestone in demonstrating how regulated stablecoins can function as a cash leg in real-world DvP settlement. Similarly, **Circle Payments Network ("CPN")**, may help enable this shift by, according to Circle's description of CPN, enabling financial institutions to securely exchange information accompanying the near-instant settlement of stablecoin on public blockchains while meeting regulatory requirements through permissioned smart contracts and whitelisting protocols.[132]

131. Circle, "Circle Announces USDC Smart Contract for Transfers by BlackRock's BUIDL Fund Investors", April 2024.
132. Finovate, "Circle Goves Live with the Circle Payments Network", May 2025.

According to **Citi**, the market for payment stablecoins could grow to **$1.6 trillion by 2030**, driven by demand for programmable, 24/7 money from institutions and corporates.[133] The **BIS** also acknowledges that fiat-referenced stablecoins, if regulated and interoperable, can complement existing payment rails and support capital market innovation, especially when used in DLT-based settlement systems that require real-time or conditional settlement.[134]

Major banks across the Americas, Europe, and Asia-Pacific are actively pursuing or have launched stablecoin-related projects. In the Americas, firms such as Citi, JPMorgan, and State Street are exploring stablecoins. European banks display similarly broad engagement, with Société Générale and Standard Chartered issuing their own stablecoins and others like Santander and Barclays backing shared settlement networks. In Asia-Pacific, banks including Mizuho, MUFG, and ANZ are advancing national currency-backed stablecoins, such as the AUDC and proposed yen-based tokens. Overall, the landscape indicates a clear strategic shift toward tokenized money, with stablecoins positioned as a key innovation across regions. To fully realize these benefits, regulatory clarity, reserve transparency, and network interoperability are essential. Nonetheless, stablecoins, particularly when embedded in permissioned applications on public or hybrid blockchains, are emerging as a **possible settlement asset** within institutional capital markets infrastructure.

Authorities such as the FATF have noted potential risks, particularly around identity verification, sanctions compliance, and AML/KYC safeguards.[135] Stablecoin issuers are exploring new ways to support compliance without compromising the open architecture of blockchain networks, such as transaction proximity and Easily Attainable Identities ("**EAIs**").[136]

Recent efforts by INTERPOL, including through initiatives such as Silver Notice[137], Operation HAECHI and Global Rapid Intervention of Payments (I-GRIP) stop payment mechanism, demonstrate a growing willingness to coordinate with stablecoin issuers to freeze suspicious accounts linked to criminal activity, though success depends heavily on the issuer's jurisdiction and whether the account is primary or secondary market-facing. These initiatives highlight both the potential for cross-border enforcement partnerships and the limitations of stablecoin controls, especially when issuers lack direct KYC relationships with end users.

133. Citi, "Digital Dollars: Banks and Public Sector Drive Blockchain Adoption", April 2025.
134. Bank for International Settlements, "Stablecoins: Regulatory Responses to Their Promise of Stability", April 2024.
135. Financial Action Task Force (FATF), "Targeted Update on Implementation of the FATF Standards on Virtual Assets and Virtual Asset Service Providers", June 2025.
136. Gordon Liao, Ziming Zeng, Mira Belenkiy, and Jacob Hirshman, "Transaction Proximity: A Graph-Based Approach to Blockchain Fraud Prevention", May 2025.
137. **https://www.interpol.int/News-and-Events/News/2025/INTERPOL-publishes-first-Silver-Notice-targeting-criminal-assets**.

1.4 RISK MITIGANTS ACROSS NETWORK TYPES

Refreshing a Principles-Based Approach to Assessing Risk Implications of Each DLT Network Type

As the ecosystem evolves, it is vital that regulatory frameworks remain technology-neutral, proportionate to actual risk related to the asset class and use case. Regulatory expectations should focus on outcomes, such as financial stability, financial integrity, investor protection and competition, rather than prescribing specific architectural choices. While permissioned networks and institutional controls offer clear benefits in certain contexts, decentralized networks can also offer robust alternatives through emerging tools like programmable compliance, decentralized identity, and zero-knowledge proofs. Maintaining a diverse and open infrastructure landscape is essential to preserving competition and enabling innovation for all market participants to serve clients. Both permissioned and permissionless systems can coexist within a responsible and well-supervised ecosystem, provided the right safeguards are applied—and crucially at the appropriate layer of the stack.

The following risk mitigation tables provide a structured comparison of risk management strategies across different DLT network types: Private-Permissioned, Public-Permissioned, Public-Permissionless, and Cross-Network. Cross-Network refers to risks that arise from the interaction and interdependence between distinct DLT networks, rather than multi-chain operations of a single asset such as Tokenized MMFs, which operate across chains but are not inherently subject to the same interoperability risk dynamics. Each table clearly outlines specific practices designed to mitigate key risk domains, detailing both a highlighted mitigation title and an explanatory description. These tables aim to facilitate understanding of how distinct DLT architectures approach risk mitigation differently, enabling decision-makers and institutional stakeholders to identify relevant strategies tailored to their specific network type and operational requirements.

1. Operational Risk

Operational risks stem from failures in technology, security, or processes in distributed ledger systems. These risks can manifest as cyber-attacks or software bugs that disrupt network operations, undermine integrity, or cause loss. Effective management of operational risk is critical to maintain trust in the system's resilience and performance.

1.1 Cybersecurity Risk

Cybersecurity risk refers to the threat of malicious actors compromising the confidentiality, integrity, or availability of a blockchain network. In public blockchain networks, any participant can join and potentially attempt attacks, such as a *Sybil* or **51% attack**, where an attacker gains control of a majority of network power to manipulate the ledger.[138] Major networks such as Bitcoin and Ethereum have so far proven resilient.[139] Traditional cybersecurity threats such as **Distributed Denial of Service (DDoS)** or node intrusion also apply, targeting critical nodes (e.g. mining pools, exchanges) to disrupt service.[140] Furthermore, compromise of private keys or credentials at a node can be another source of risk – if an attacker obtains a node's private key, may have the ability to impersonate that node and manipulate transactions.[141] Even permissioned and private networks are not immune: misconfigured infrastructure or insider threats can create vulnerabilities behind a firewall. The **attack surface** and incentive structures differ by network type, influencing how this risk is mitigated.

Mitigating cybersecurity risk in DLT requires layered security controls, but approaches vary by network design. For example, permissioned networks inherently limit access to known entities, reducing exposure to Sybil attacks and rogue nodes.[142] Public permissionless networks rely more on robust cryptographic consensus and decentralization to make attacks economically infeasible, though safeguards are still evolving. In all cases, regular security audits, network monitoring, and incident response plans are vital. The following table compares mitigation strategies for cybersecurity risk across different network types:

138. Bank of International Settlements, "Novel risks, mitigants and uncertainties with permissionless distributed ledger technologies", August 2024.
139. Bank of International Settlements, "Novel risks, mitigants and uncertainties with permissionless distributed ledger technologies", August 2024.
140. Rish Crew, "Enhancing Cyber Security in Blockchain", Accessed 2025.
141. Rish Crew, "Enhancing Cyber Security in Blockchain", Accessed 2025.
142. Ibid.

TABLE 1.1

Cybersecurity Risk – Mitigation Strategies by Network Type

NETWORK TYPE	MITIGATION STRATEGIES
Private-Permissioned	**Strict access controls and node vetting:** Limit network participation to vetted entities with strong authentication to prevent unauthorized access and Sybil attacks. Each node operates under defined security policies, reducing unknown actors on the network.[143] **Centralized security monitoring:** A designated operator or consortium monitors network traffic and node behavior in real-time, enabling rapid detection and isolation of anomalies or breaches. Incidents can be addressed through governance processes (e.g. halting the network to patch critical vulnerabilities **Enterprise IT security integration:** Leverage traditional cybersecurity measures (firewalls, intrusion detection systems, secure enclaves) and regular penetration testing. Since the infrastructure is known, organizations can enforce uniform security standards (e.g. mandatory hardware security modules for key management) across all nodes.
Public-Permissioned	**Known validator set with legal agreements:** Only approved validators produce blocks, each often subject to legal/compliance requirements. This deters many attacks, as validators risk penalties for misbehavior. It also simplifies accountability if an incident occurs (identified parties).[144] **DDoS and Sybil resistance by design:** By having a limited set of permissioned nodes, the network can implement defensive measures such as failover nodes or bandwidth constraints. The consortium may maintain backup nodes and coordinate incident responses (e.g. restarting a halted chain) without relying on an open community vote. **Regular audits and updates:** The governing consortium can require periodic security audits of the node software and enforce timely updates or patches across all validators. This uniform governance helps close vulnerabilities faster than in permissionless settings, though it relies on trust in the governing body.
Public-Permissionless	**Decentralization and economic incentives:** A large, distributed network of miners/validators makes it *cost-prohibitive* to achieve majority control in major blockchains (attackers would devalue their own holdings through a successful attack). Incentive-aligning mechanisms (e.g. staking penalties for misbehavior in proof-of-stake) help secure the network.[145] **Open-source scrutiny and bug bounties:** Code is open to the global community, and many projects offer bug bounty programs to encourage ethical hacking and early vulnerability disclosure. While community testing is extensive, the lack of formal validation means some exploits go undetected. Mitigants such as formal verification are beginning to supplement this process for critical protocols.[146] **Redundancy and resilience measures:** Nodes are distributed globally; even if some nodes are attacked or go offline, the ledger copies on other nodes maintain continuity. High-value systems often require a certain number of confirmation blocks before trust (to mitigate short forks or reorganizations). However, current practices for mitigating novel attacks in permissionless systems *remain largely untested under stress scenarios* – a gap indicating ongoing need for improved safeguards.[147] **Key management best practices:** Encourage the use of hardware wallets, multi-signature schemes, and custody solutions for private keys to reduce theft risk. While not enforced by the network protocol, ecosystem participants (exchanges, custodians) provide these controls to users as an essential risk mitigant.
Cross-Network	**Segmentation and secure gateways:** When bridging between networks, use secure gateway nodes or bridge smart contracts that are thoroughly audited and, where possible, *isolated* from core network consensus. The principle of least privilege is applied: the bridge only handles the minimal necessary assets/data to limit impact if compromised **Multi-party validation for bridges:** Require cross-network transactions to be validated by multiple independent parties or oracles. For example, *multi-signature or MPC (multi-party computation) schemes* can ensure no single compromised entity can hijack a cross-chain transfer. Decentralized bridge designs distribute trust, albeit at the cost of added complexity **Continuous monitoring and kill-switches:** Monitor cross-chain transaction flows for anomalies (sudden large movements, unusual patterns) using analytics tools. Some bridge implementations include emergency "pause" features or circuit breakers to freeze activity if a suspected exploit is detected – though activating these relies on governance decisions. Notably, cross-network integrations are still a major security challenge and mitigations are *still maturing* and must be strengthened.[148]

143. Ibid.
144. Ibid.
145. Bank of International Settlements, "Novel risks, mitigants and uncertainties with permissionless distributed ledger technologies", August 2024.
146. Ibid.
147. Ibid.
148. Chainanalysis, "Vulnerabilities in Cross-chain Bridge Protocols Emerge as Top Security Risk", August 2022.

1.2 Smart Contract Risk

Smart contract risk[149] refers to the possibility that a self-executing code on the blockchain can behave unexpectedly or be exploited due to bugs, logical errors, or malicious design. Smart contracts automate transactions and business logic without human intervention.[150] This means smart contract failures can lead to loss of funds, frozen assets, or systemic shocks unless contingency measures are built in.

Mitigation of smart contract risk centers on improving code quality and having safeguards for failure. Legal and regulatory frameworks, designed for traditional operational and technology risk, can be adapted effectively to mitigate smart contract risks.[151] Best practices include rigorous code audits, formal verification methods, and thorough testing (often in testnets or sandboxes) before deployment. Some contracts incorporate upgradeable proxies or emergency pause mechanisms to allow human intervention in extreme cases, though these introduce centralization. Mitigation strategies also differ by network type – for instance, a private enterprise chain can impose strict controls on contract deployment, whereas public chains rely on community-driven measures. Below is a comparative summary of how smart contract risk is mitigated across network types:

TABLE 1.2

Smart Contract Risk – Mitigation Strategies by Network Type

NETWORK TYPE	MITIGATION STRATEGIES
 Private-Permissioned	**Controlled deployment and code review:** Only authorized developers can deploy smart contracts, often subject to internal code audits and quality checks. Organizations typically establish coding standards and use formal testing (or even formal verification) for contracts before approval. This reduces the chance of unvetted or malicious code entering the system. **Upgrade and kill-switch provisions:** Smart contracts on private networks often include administrator privileges or governance mechanisms that allow patching bugs or pausing a contract in emergencies. A designated entity (or multi-party governance group) can reverse fraudulent transactions or amend contract code if a flaw is discovered. For example, an enterprise token contract might empower an administrator to freeze or correct balances in case of a critical error – a trade-off accepted in permissioned contexts to enhance safety.[152] **Sandbox and gradual rollout:** New smart contract functionalities may be deployed in a test environment or with restricted access (pilot nodes) before full network-wide activation. This phased approach, feasible in a permissioned setting, helps catch bugs early. Additionally, extensive training is provided to developers on secure coding practices specific to the platform.
 Public-Permissioned	**Consortium governance over contracts:** The governing body or consortium may curate and whitelist certain smart contracts or applications that meet security and compliance standards. For instance, only audited smart contracts might be allowed for use in critical network functions. The consortium could also require **third-party code audits** for any contract intended to be widely used on the platform. **Emergency intervention capabilities:** Like private networks, many consortium-led chains retain some emergency controls. For example, validators (or a super-majority of them) might collectively agree to halt or fork the chain to disable a malfunctioning smart contract. While not a first resort, the known identity of validators and legal agreements make coordinated intervention possible if needed to protect the network or users. **Ongoing monitoring and updates:** The network's operators continuously monitor contract activity for anomalies (e.g., detecting an exploit in progress via abnormal fund movements). There is often a protocol for quickly alerting all validators and users if a vulnerability is identified, with recommended actions (such as updating client software or interacting with a replacement contract). The permissioned nature facilitates rapid dissemination of such critical updates.

149. Smart contract Risk as discussed here generally refers to non-issuer smart contracts, i.e., those that are built by institutions other than the issuer of a DLT-based security to incorporate the asset into an application. Issuer-deployed smart contracts are an important control in achieving KYC/AML/CFT controls on public DLT networks, however they may also benefit from the risk mitigation strategies discussed here.
150. Bank of International Settlements, "Novel risks, mitigants and uncertainties with permissionless distributed ledger technologies", August 2024.
151. GFMA and GDF, "The Smart Contract Primer: An Initial Overview of Smart Contract Implementation within Financial Services & Regulatory Solutions for Risk Management", October 2024.
152. Ibid.

NETWORK TYPE	MITIGATION STRATEGIES
 Public-Permissionless	**Community audits and bug bounties:** In the absence of gatekeepers, the community relies on crowdsourced security. Many projects undergo one or more independent security audits (by firms such as Trail of Bits, OpenZeppelin, etc.) and then publish the results. Additionally, bug bounty programs incentivize security researchers to find and responsibly disclose vulnerabilities. However, **no formal or mandatory code review exists** – ultimately, unsafe contracts can still be deployed by anyone, so users and investors must exercise caution (e.g., prefer audited projects).[153] **Immutable-by-choice vs upgradeable designs:** Developers mitigate risk by carefully choosing contract designs. Critical contracts (such as governance or large vaults) sometimes use upgradeable proxies or multi-signature admin controls to allow fixes if needed, accepting some centralization for safety. Conversely, truly immutable contracts are kept simpler to minimize attack surface. Some DeFi protocols also build in circuit breakers (e.g. transaction rate limits or pause triggers) that activate if abnormal behavior is detected, containing potential damage. **Formal verification and simulation:** An emerging mitigant is the use of formal verification tools to mathematically prove certain properties of smart contracts (e.g., "no more than X tokens can be drained per hour"). While still not widespread, high-value protocols have started employing these methods alongside traditional testing. Simulation platforms are also used to model various attack scenarios on economic logic (for example, testing a DeFi protocol against price manipulation attacks in a controlled environment).[154] **Diverse user safeguards:** End-users and interfaces add another layer of mitigation. Wallets and blockchain explorers may flag contracts with known issues or without verifications. Insurance products have also emerged (provided by decentralized insurance protocols or traditional insurers) to compensate losses from contract exploits – though these don't prevent hacks, they incentivize better security and offer partial risk transfer for users.
 Cross-Network	**Standardized cross-chain protocols:** When smart contracts on different networks interoperate (e.g., a contract on Chain A triggers action on Chain B), standardized protocols such as *hash time-locked contracts* ("*HTLCs*") or frameworks such as the Inter-Blockchain Communication (IBC) protocol are used to ensure atomicity and reduce complexity. Standardization helps avoid ad-hoc code that may introduce errors; these protocols are scrutinized by a broader community and often formally verified. **Multiple layers of audit and testing:** Cross-network contracts (such as bridge contracts or oracle contracts) undergo intensive security audits because they compound risk (an exploit could affect multiple chains). Each connected chain's community may conduct tests. For example, a cross-chain bridge might be tested on testnets of all involved networks and subject to joint code reviews by developers from each project. Despite this, bridge contracts have been frequent targets, meaning the industry is learning and hardening designs iteratively. **Risk isolation mechanisms:** Design the interoperability such that a failure in one chain or contract does not propagate uncontrollably. This can involve setting strict limits on how much value can flow through a bridge at once or requiring human confirmation for large transfers. Some cross-chain systems maintain *circuit breakers* that, if a breach is suspected, automatically halt cross-network functionality. Because cross-network smart contract frameworks are relatively new, **mitigants here are still emerging** – robust governance frameworks and possibly new regulatory oversight for cross-chain service providers are being explored to fill the gap.

1.3 Settlement Finality Risk

Settlement finality risk refers to the uncertainty about when a transaction can be considered irrevocably final on a blockchain, especially in a legal sense. In conventional payment and settlement systems, finality may be clearly defined – once a payment is settled, it cannot be unwound, and legal frameworks (such as the EU Settlement Finality Directive) protect that finality.[155] To the extent these frameworks or similar measures do not apply to a DLT platform, a ledger might only achieve **probabilistic finality** – the probability of reversal decreases over time but never truly reaches zero.

Mitigating settlement finality risk involves both technical and legal measures. Networks can be designed for deterministic finality, and legal agreements can clarify finality points. The strategies differ by network type, as summarized below:

153. Ibid.
154. Ibid.
155. Ibid.

TABLE 1.3

Settlement Finality Risk – Mitigation Strategies by Network Type

NETWORK TYPE	MITIGATION STRATEGIES
 Private-Permissioned	**Deterministic consensus algorithms:** Private chains often use consensus protocols that provide immediate finality (e.g., Practical Byzantine Fault Tolerance ("PBFT"), Reliable, Replicated, Redundant, and Fault-tolerant ("RAFT"), or Istanbul Byzantine Fault Tolerance ("IBFT") algorithms). Once a block is agreed upon by the validators, it is final and will not be forked away. This eliminates probabilistic confirmation wait times. Each transaction commit comes with certainty, satisfying technical finality requirements akin to traditional systems. **Legal finality by rulebook:** The network's governance establishes a legal rulebook among participants that defines the moment of finality for transactions (often at block confirmation) and binds participants to honor it. Because all members are known and under contract, this rulebook can be enforceable. For example, participants agree that if a network fault requires a rollback, any transactions after a certain checkpoint may be nullified and/or manually restored according to prior state – a process defined in advance to handle the exceptional case. **Designation as settlement system under law:** Private DLT networks that handle significant financial transactions may seek recognition under relevant laws (for instance, being designated as a recognized settlement system by a central bank or regulator). This provides statutory protection: transactions on the network are afforded the same finality status as those in non-DLT systems, reducing legal uncertainty. Achieving this typically requires meeting oversight standards, but it greatly mitigates the risk that a court will refuse to acknowledge on-chain settlement as final.
 Public-Permissioned	**Finality built into protocol:** Some public-permissioned networks (such as certain consortium blockchains open to public use) use **hybrid consensus** that gives finality guarantees. For example, a network might use proof-of-stake with a finality gadget (such as Ethereum's Casper/Checkpointing mechanism) so that after a checkpoint, blocks are practically immutable unless a super-majority of validators collude (which is very unlikely under their legal obligations). Thus, users can treat checkpointed blocks as final. **Checkpointing and fallbacks:** The consortium might run a parallel permissioned service that snapshots the state of the public chain at intervals (say every hour) and notarizes it (potentially even in a legal document or another system). In the event of a major fork or dispute on the public chain, those notarized checkpoints can serve as a reference of truth for dispute resolution among governed participants. Essentially, it's an added layer of finality insurance provided by the consortium's oversight. **Regulatory and contractual clarity:** Like private networks, public-permissioned networks can proactively define finality in their terms of service for users. For example, a stablecoin issued on a public chain might specify that a transfer is final after X blocks and that the issuer treats it as such for all purposes. If a deeper reorg happens, the issuer might have a policy (backed by reserves or insurance) to honor the first-seen final transaction. By contract, they absorb the reversal risk beyond X blocks, giving users confidence in effective finality.
 Public-Permissionless	**Confirmation depth and probabilistic assurance:** The common practice is to wait for a sufficient number of block confirmations before considering a transaction final. Exchanges, for example, often require 6 confirmations on Bitcoin or 12 on Ethereum before crediting a deposit to mitigate the risk of reorg. This is a de-facto mitigant providing a high probability of irreversibility. However, it's not foolproof – it just lowers risk to an acceptable level for most cases. **Economic finality mechanisms:** Newer blockchains implement economic penalties to discourage reverting finalized blocks. For example, Ethereum's Proof-of-Stake finality (through Casper FFG) means if validators attempt to revert a finalized block, they stand to lose a large bond (slashable event). This "economic finality" makes reversion extremely costly, thus *practically* ensuring finality after checkpoints. While not absolute, it's a strong deterrent – the idea being no rational actor would incur that cost, therefore finality holds with near certainty. **External finality insurance or derivatives:** An emerging concept is third-party finality insurance – a service where an insurer or fund will compensate losses if a supposedly final transaction is reversed. This doesn't prevent reversal but mitigates the impact. For example, for critical transactions (such as DVP settlements on-chain), parties could purchase insurance that pays out if a chain reorg invalidates the transaction after a set time. Similarly, futures or derivatives could hedge the risk of a large value transfer being undone. These financial mitigants are not widely available yet, but they reflect market-driven solutions to finality uncertainty. **Ultimately, legal adaptation:** In the long term, achieving true settlement finality on public chains may require legal frameworks to adapt. Courts and regulators might define at what point a transaction gains *irreversibility* in the eyes of the law (for example, treating an Ethereum block finalized by its protocol as legally final). Efforts by bodies such as the Committee on Payments and market Infrastructure ("CPMI") and -IOSCO are underway to reconcile these definitions. Until then, users of public chains may have to accept a small residual risk. For critical use cases, many opt to use layered solutions (such as processing provisional transactions on a faster chain but settling on a permissioned or layer-2 network with finality guarantees).

NETWORK TYPE	MITIGATION STRATEGIES
 Cross-Network	**Atomic swap protocols:** To ensure cross-chain transactions finalize properly, atomic protocols are used where either *both* legs of a cross-chain exchange finalize or *neither does*. Mechanisms such as HTLCs enforce that if Chain A transfer doesn't finalize in a given timeframe, the Chain B transfer is automatically canceled (and vice versa). This prevents scenarios where one side is final on one chain while the other fails on another. However, timing parameters must be set cautiously considering different finality speeds. **Synchronous settlement frameworks:** Emerging cross-network models (such as interlinked networks proposed by projects such as **Project Guardian's Interlinked Network Model**) aim for synchronous settlement across chains. In practice, this might mean using an intermediary or a unified protocol layer that coordinates the finality of transactions on multiple networks. For example, a "network of networks" could use a common ledger or mediator that only confirms a cross-chain transaction when all involved ledgers have reached their respective finality, thereby delivering an all-or-nothing guarantee.[156] **Unified legal approach (contracts for cross-chain):** Parties engaging in cross-network transactions can mitigate finality risk by entering into legal agreements governing their exchange. For instance, two trading firms doing DvP across two chains may have a fallback agreement: if one chain's leg fails to finalize by a deadline, they agree off-chain to unwind the other leg or compensate accordingly. Essentially, a smart contract might be backed by a real contract. Industry groups are also working on standardized terms for such scenarios. While this introduces a traditional layer to a decentralized process, it provides a safety net for finality issues that technology alone can't cover yet.

1.4 Interoperability and Cross-Network Risk

Interoperability risk is the risk that the proliferation of disparate blockchain networks leads to fragmentation, or that the mechanisms to interconnect these networks introduce vulnerabilities[157]. As the digital asset ecosystem grows, dozens of blockchains (public and private) could operate in silos, each with their own protocols and tokens. This fragmentation would reduce efficiency and liquidity (assets locked on one network can't be used on another).[158] To bridge these gaps, **cross-network bridges** and **interoperability protocols** have been developed – but these themselves have become points of failure. The complexity of coordinating state between different ledgers means any flaw can be catastrophic, potentially affecting multiple networks. Additionally, inconsistent standards can result in **transaction failures** or misinterpretation when moving data across chains. There is also a **concentration risk** if one interoperability solution or hub becomes widely used – an issue there could cascade across many connected platforms (a "single point of failure" for an otherwise decentralized ecosystem). On the flip side, *lack* of interoperability is itself a risk: it could leave markets segmented and reduce the network benefits that make blockchain valuable. Thus, the industry is pushing for solutions, but they must be approached cautiously to avoid creating new systemic risks. Since the last publication of this report, many industry solutions to solving these challenges have matured. Firms now build with interoperability as a guiding feature when launching new use cases, for example, DTCC's **ComposerX** platform which is "DLT-agnostic" to enable flexibility and transparency to integrate with DLT-based and legacy systems.[159] Work has also been done to explore the integration of DLT with traditional financial systems. For example, leveraging the open-source FIX Trading Community and the FinP2P Tokenization interoperability protocol, the joint GDF x FIX Trading Community working group successfully demonstrated[160] interoperability between traditional financial systems and blockchain-based platforms. Mitigations for interoperability risks have seen significant progress.

Mitigation strategies focus on developing secure, standardized interoperability protocols and governance frameworks for cross-network operations. The approach varies with context, as summarized below:

156. Abishek Majumdar, "Project Guardian and the Interlinked Network Model - Transforming Singapore's Financial Landscape Model", December 2023.
157. As the digital asset ecosystem continues to evolve, market participants have and will continue to launch products on multiple DLT networks; operators of tokenized MMFs, a key use case that has achieved scale often deploy these products on multiple networks which may require reconciliation across separate books and records system. However, the interoperability risks defined here are specifically addressing the transfer or connectivity of assets between networks, which to date is not a key feature of these products.
158. Abishek Majumdar, "Project Guardian and the Interlinked Network Model - Transforming Singapore's Financial Landscape Model", December 2023.
159. DTCC, DTCC Announces ComposerX, Feb 2025.
160. FIX <> FINP2P Protocol Interoperability Alliance White Paper: **https://www.gdf.io/wp-content/uploads/2020/12/GDFFIX_WhitePaperFV_030225.pdf**.

TABLE 1.4

Interoperability & Cross-Network Risk – Mitigation Strategies by Network Type

NETWORK TYPE	MITIGATION STRATEGIES
 Private-Permissioned	**Standardization and consortia:** Private networks often adopt common technical standards (e.g., using Ethereum-compatible platforms or Application Programming Interfaces ("APIs") to ease interoperability with other networks. Industry consortia and standards bodies (e.g., the International Organization for Standardization ("ISO"), Enterprise Ethereum Alliance, etc.) provide guidelines so that different private DLT systems can understand each other's data formats and transactions. By aligning on standards, when two private networks need to connect (for instance, a trade finance network with a supply chain network), the integration is smoother and less error-prone. **Trusted gateways and APIs:** If direct ledger-to-ledger interoperability is complex, private networks use *gateway nodes* or API middleware to interchange data with other systems. These gateways are run by trusted entities that translate and relay information between networks securely. For example, a bank might operate a node on two permissioned networks and act as a bridge under strict security controls and legal agreements. While this reintroduces a trusted intermediary, it confines risk to that known party and can be governed through contracts. **Inter-network governance agreements:** Private networks that interoperate often establish mutual governance frameworks – essentially extending the consortium model across networks. They agree on liability, error handling, and data sharing rules when transactions span both ledgers. For instance, if Network A and Network B link, the consortium operators might sign a Memorandum of Understanding ("MoU") outlining how to resolve discrepancies (e.g. if Network A says a delivery happened and Network B did not register it, who arbitrates?). This mitigates the risk of inconsistencies by having a predetermined conflict resolution path.
 Public-Permissioned	**Hub-and-spoke models:** A common approach is to use a well-audited *hub network* to interconnect multiple permissioned chains. For example, a consortium of public-permissioned networks might all connect to a central interoperability hub that handles transfers and messages among them. The hub is governed jointly by the participating networks. This centralizes the interoperability function in a controlled environment, reducing the chances of ad-hoc insecure bridges between every pair of networks. **Cross-certification of validators:** If two public-permissioned networks want to trust each other, they may allow a subset of validators from each side to serve as observers or proxy validators on the other network. Essentially, known entities are "ambassadors" on the foreign network, easing trust. These cross-certified nodes verify that operations on one chain meet the agreed conditions before triggering on the other. Because the entities are permissioned and legally bound, the risk of foul play is lowered relative to anonymous cross-chain bridging. **Regulated interoperability frameworks:** Public-permissioned networks often operate in regulated contexts (e.g. digital securities platforms). Regulators and industry groups are developing frameworks for interoperability that ensure market integrity.[161] This might involve common protocols for delivery-vs-payment across networks or messaging standards for cross-chain corporate actions. By following these frameworks, networks reduce the risk that their interconnection will cause legal or operational issues – the flows are designed to meet compliance needs and have fail-safes (such as manual override if something goes wrong in the cross-network process).
 Public-Permissionless	**Decentralized interoperability protocols:** In the permissionless realm, projects such as **Cosmos** (**IBC**) and **Polkadot** have built-in interoperability features. The Inter-Blockchain Communication (IBC) protocol, for instance, provides a standardized way for independent blockchains to securely talk to each other and transfer assets.[162] These protocols are open-source and undergo rigorous security testing and formal verification, aiming to become as trust-minimized as the underlying blockchains themselves. Using such proven frameworks mitigates the need for custom bridges that might have undiscovered bugs. **Multi-signature and MPC bridges:** Many cross-chain bridges implement a multi-sig design where a group of reputable nodes (or a threshold of independent oracles) must sign off to validate a cross-chain transaction. While not as trustless as IBC, this federation of signers ensures no single point of failure. The risk is spread among multiple parties who ideally are economically or reputationally incentivized to act honestly. Ongoing efforts are improving this model with MPC, where the private key controlling assets is never reconstructed in one place, making it harder for attackers to compromise. **Economic incentives and insurance for bridges:** Some interoperability solutions create their own tokens or fee mechanisms that can be slashed or seized if something goes wrong. For example, a bridge might require validators to stake funds, which are forfeit if they attest to a fraudulent transfer. Additionally, a portion of bridge fees might go into an insurance fund to reimburse users in case of a hack. These market-based mitigants seek to align the bridge operators' interests with security and to provide a backstop if an exploit occurs. While not preventing incidents outright, they can lessen the impact and likelihood.

161. Abishek Majumdar, "Project Guardian and the Interlinked Network Model - Transforming Singapore's Financial Landscape Model", December 2023.
162. Ibid.

NETWORK TYPE	MITIGATION STRATEGIES
	Continuous audits and rapid upgradeability: Given the high stakes, many interoperability projects employ multiple security auditors and even formal verification of smart contracts. They also build in the ability to pause the bridge or rapidly push emergency updates if a vulnerability is found (with community approval when possible). The culture in the DeFi community after several exploits is now to prioritize interoperability code audits and to adopt a "*slow rollout*"—starting with small transaction limits and gradually increasing them as confidence grows. This phased approach limits damage from any single flaw.
 Cross-Network	**Global interoperability standards:** Recognizing the double-edged sword of interoperability, international bodies and central banks are working on standards to make networks interoperable *safely*. One example is the vision of **interlinked networks** under MAS's Project Guardian, which calls for common protocols and governance across diverse networks.[163] Adopting global standards (for messaging, identity, transaction formats) across networks ensures that when networks connect, they do so under a shared understanding, reducing miscommunication risk. This is akin to how Internet protocols standardized data exchange – similarly, financial networks are pursuing ISO 20022 and other standards for digital asset transfers. **Segmentation and risk limits**: A prudent mitigant is not to enable interoperability without restriction. Networks can be selective about what they interoperate with and set limits on cross-network exposure. For instance, a network might only connect directly with central bank or regulated networks and cap the total value flowing through a cross-network link per day. By containing the scope, any interoperability-related issue can be quarantined without systemic failure. Essentially, *do not put all eggs in one bridge* – use multiple smaller bridges, different routes, and clear circuit breakers that isolate a problem chain if needed. **Layer 0 or intermediary networks:** Some propose a dedicated "interoperability layer" (Layer 0) that sits beneath blockchains and handles connectivity. This could be a specialized blockchain or service that acts as a translator and escrow for cross-chain deals. All chains plug into it rather than directly to each other. The mitigant here is that this Layer 0 can be heavily secured and governed (perhaps even by a consortium of major stakeholders or international institutions), concentrating security effort on one system that protects inter-chain interactions. If successful, individual chains wouldn't need dozens of bespoke bridges – they rely on the robust intermediary. The risk is of course that this layer becomes a critical piece of infrastructure that itself must be failure-proof.

1.5 Common Mode Failure

Common mode failure refers to situations in which multiple components within a blockchain or distributed ledger network simultaneously fail due to shared underlying vulnerabilities or dependencies.[164] This can stem from reliance on identical infrastructure, such as a single cloud provider or data center region, software monoculture with widespread use of the same validator implementation, or shared vulnerabilities within consensus algorithms or network protocols.[165] Common mode failures represent significant operational risks, potentially undermining the redundancy and resilience that decentralized systems are designed to achieve, thereby creating systemic disruption across multiple participants and applications within a single event.[166]

TABLE 1.5

Common Mode Failure - Mitigation Strategies by Network Type

NETWORK TYPE	MITIGATION STRATEGIES
 Private-Permissioned	**Multi-cloud and Region Deployment:** Deploy nodes across multiple cloud providers and regions to eliminate single points of infrastructure failure. Using diversified cloud providers and geographic redundancy ensures continuity if one provider or location experiences outages or disruptions.[167] **Diverse Validator Software Implementations:** Require network participants to use multiple independent software clients or validator implementations, reducing the risk that a single software vulnerability could compromise all validators simultaneously.[168]

163. Ibid.
164. Common Mode Failure: A Critical Challenge in Redundant Systems, Accessed 2025.
165. Brayden Lindrea, "3 cloud providers accounting for over two-thirds of Ethereum nodes: Data", August 2022.
166. Ibid.
167. Ibid.
168. Ethereum, Client Diversity, Accessed 2025.

NETWORK TYPE	MITIGATION STRATEGIES
	Regular Stress Testing and Failover Drills: Conduct routine exercises to simulate common mode failures, such as cloud outages or software crashes, allowing proactive identification and remediation of correlated risks. Regular stress testing ensures participants are well-prepared for actual incidents.[169] **Robust Disaster Recovery and Backup Procedures:** Maintain off-chain backups and detailed disaster recovery plans to restore network states rapidly in the event of correlated failures, minimizing downtime and disruption to critical operations.[170]
 Public-Permissioned	**Validator Infrastructure Diversity:** Mandate validators to distribute nodes across multiple infrastructure providers and regions. Consortium agreements may require diversification to prevent systemic failures from centralized dependencies. **Consortium-Enforced Software Diversity:** Utilize governance policies to enforce multiple validator software implementations across validators, mitigating software monoculture risks inherent in a single software stack. **Consortium-led Disaster Recovery Exercises:** Conduct collaborative stress tests and disaster recovery scenarios regularly among consortium participants to ensure network-wide preparedness and effective coordination during common mode failure incidents. **Notarized Checkpoints and State Snapshots:** Periodically store notarized state checkpoints off-chain, allowing quick restoration or reconciliation of the network state in case of significant correlated failures or network disruptions.
 Public-Permissionless	**Decentralized Node and Infrastructure Diversity:** Promote geographic and infrastructural decentralization of validator nodes through community incentives, thereby reducing reliance on single cloud providers or data centers.[171] **Multiple Independent Client Implementations:** Encourage a diverse set of software clients (e.g., Ethereum's multi-client approach) among validators and participants to prevent widespread network disruption due to a single client vulnerability. The open-source nature of public blockchains enables extensive peer review, engaging a broad and diverse community of developers. This transparency significantly enhances software quality—improving security, performance, reliability, and maintainability beyond what is typically achievable in proprietary environments. **Community-Sponsored Chaos Testing:** Support community-driven programs (such as bug bounties and chaos engineering tests) that proactively identify and remediate systemic risks before they can impact the network. **Community-Based Disaster Recovery and Protocol Updates:** Leverage decentralized governance processes (e.g., emergency hard forks or community-led upgrades) to swiftly address systemic issues and recover from network-wide disruptions or vulnerabilities.
 Cross-Network	**Modular and Isolated Interoperability Components:** Ensure cross-chain bridges and interoperability solutions are modular, isolated, and independently secured to prevent faults or vulnerabilities from cascading across interconnected networks. **Multi-Party Validation and Threshold Schemes:** Adopt MPC or threshold validation schemes for cross-chain transactions, ensuring no single point of failure or compromise can propagate across networks. **Interoperability Standards and Diversified Implementation:** Use standardized interoperability protocols (such as IBC or CCIP) and encourage multiple independent implementations to prevent common vulnerabilities from affecting all network participants simultaneously. **Risk Isolation and Containment Protocols:** Establish predefined procedures and circuit breakers for isolating faulty cross-chain components, ensuring that common mode failures in one network or component do not propagate widely across interconnected systems.

1.6 Scalability

Scalability risk relates to a blockchain's capacity to reliably handle growing volumes of transactions, user activity, and data while maintaining acceptable performance, cost predictability, and low latency. Institutional use of blockchain technology often demands significant transaction throughput, rapid finality, and stable transaction fees—conditions that can quickly become constrained under high network loads.[172] Scalability limitations may manifest as transaction congestion, rising fees, longer processing times, and degradation of overall network performance, undermining the viability of blockchain networks for large-scale financial and enterprise use cases.[173]

169. Bank of International Settlements, "Novel risks, mitigants and uncertainties with permissionless distributed ledger technologies", August 2024.
170. Ibid.
171. Ethereum, Client Diversity, Accessed 2025.
172. Bank of International Settlements, "III. The future monetary system", June 2022.
173. European Central Bank, "Paradise lost? How crypto failed to deliver on its promises and what to do about it", June 2023.

TABLE 1.6

Scalability - Mitigation Strategies by Network Type

NETWORK TYPE	MITIGATION STRATEGIES
Private-Permissioned	**Horizontal Infrastructure Scaling:** Expand network throughput by adding additional validator nodes or computing resources horizontally as demand grows. Private networks often leverage enterprise-grade infrastructure allowing scalable performance without compromising control. **Optimized Consensus Algorithms:** Implement high-performance consensus mechanisms (e.g., PBFT or Raft) specifically designed to maximize throughput and minimize latency, enabling predictable transaction processing times. **Parallel Transaction Channels or Shards:** Deploy parallel transaction channels or network shards within private-permissioned networks to distribute transaction processing effectively, significantly increasing the overall network throughput. **Private Transaction Pools and Priority Queues:** Use private pools or priority transaction queues to maintain stable transaction fees and ensure critical transactions are processed reliably, even during peak usage periods.
Public-Permissioned	**Consortium-Managed Protocol Upgrades:** Leverage governance structures to swiftly implement protocol upgrades (e.g., enhanced consensus algorithms or sharding) to improve scalability in response to evolving institutional demand. Layer-2 Solutions Integration: Integrate Layer-2 scaling solutions (e.g., rollups, state channels) to offload high-volume transactions from the primary ledger, substantially improving throughput without compromising decentralization. **Hybrid On-Chain/Off-Chain Processing Models:** Adopt hybrid approaches combining off-chain or traditional processing for high-frequency transactions with final settlement on-chain, allowing public-permissioned networks to maintain high scalability and throughput. **Geo-Partitioning and Regional Subnets:** Utilize regional subnetworks or validator clusters to distribute transaction loads geographically, ensuring stable throughput and low latency across global use cases.
Public-Permissionless	**Layer-2 Rollups and Payment Channels:** Promote extensive use of Layer-2 solutions (e.g., Optimistic rollups, ZK-rollups, state channels) that dramatically enhance transaction throughput and reduce costs, effectively overcoming Layer-1 bottlenecks.[174] **Sharding and Parallelization Techniques:** Implement base-layer protocol innovations such as sharding, parallel execution engines, and stateless client architectures to significantly boost on-chain throughput and reduce transaction latency.[175] **Fee-Stabilizing Mechanisms (e.g. Gas Price Risk Hedging and Management):** Deploy mechanisms (such as Ethereum's EIP-1559 fee model and Flashbots' transaction ordering) designed to reduce fee volatility and ensure transaction cost predictability during periods of congestion.176 Gas price risk hedging and management provides pricing certainty during network stress. Emerging solutions like gas price hedging markets, private mempool agreements, and on-chain derivatives allow participants to manage or lock in transaction costs in advance. These tools reduce exposure to sudden fee spikes during congestion, supporting more predictable and stable use of DLT systems—especially for institutional users.[177] **Community-Driven Protocol Optimization:** Continuously evolve public-permissionless protocols through community-supported upgrades (e.g., Ethereum's roadmap and community-driven improvements) that systematically address scaling challenges.[178] **Maximal Extractable Value ("MEV") Resistance:** A valuable risk mitigant that can enhance trust and fairness in DLT networks, supporting broader institutional adoption. By preventing harmful transaction manipulation, MEV-resistant solutions address a key concern for regulated entities. Mechanisms such as self-validation, known counterparty validation, or block builder agreements can ensure secure and predictable transaction flows in permissioned environments. Additionally, innovative approaches on permissionless chains—such as CowSwap, which uses presigned transaction batching to neutralize MEV opportunities—demonstrate that such protections are technically feasible and effective. By reducing the risk of value leakage and maintaining equitable access, MEV resistance strengthens the case for DLT in critical capital market infrastructure and enhances confidence among institutional participants.[179]

174. Gemini, "Layer-2 Scaling: zk-Rollups and Optimistic Rollups", February 2025.
175. Avax Network, "Avalanche (AVAX)", May 2025.
176. Medium, "Flashbots Auction: A Paradigm Shift in Ethereum Transaction Processing | by Bounce Brand", Accessed 2025.
177. AFME, "Annex – Risk Mitigants for Permissionless Blockchains", Accessed 2025.
178. Emre Gunen, "How Polkadot 2.0 refines blockchain scalability and interoperability", April 2024.
179. AFME, "Annex – Risk Mitigants for Permissionless Blockchains", Accessed 2025.

NETWORK TYPE	MITIGATION STRATEGIES
 Cross-Network	**Interoperability Layer Optimizations:** Develop specialized interoperability layers (Layer-0) designed explicitly for high-performance and efficient cross-chain transaction processing, handling complex cross-network workflows at scale. **Atomic Cross-Chain Transactions:** Use atomic transaction protocols (e.g., HTLCs) to ensure reliable and efficient cross-chain settlements, minimizing transaction latency and complexity during cross-network interactions. **Workload Distribution Across Networks:** Partition or distribute workloads strategically across multiple interconnected networks, each optimized for specific transaction types, thereby increasing overall scalability through specialization.[180] **Hierarchical Interoperability:** Establish hierarchical interoperability frameworks (e.g., network-of-networks designs) to distribute transaction volume efficiently, mitigating single points of congestion and enhancing cross-network transaction scalability.

1.7 Quantum Computing Risk

Quantum computing risk is the threat that future quantum computers could break the cryptographic primitives underpinning blockchain security. Most blockchain systems (Bitcoin, Ethereum, etc.) rely on public-key cryptography (e.g., Elliptic Curve Digital Signature Algorithm ("ECDSA") signatures) and hash functions that are currently secure against classical computers. However, a conceptual powerful quantum computer running Shor's algorithm could **factor RSA keys or compute discrete logarithms** exponentially faster than classical machines, effectively enabling it to derive private keys from public keys.[181] In blockchain context, that means an attacker with a sufficiently advanced quantum computer could potentially *forge signatures* and thus steal funds from any address where the public key is known (for example, any address that has made a transaction reveals its public key).[182] This is a long-term risk – quantum computers today are not yet at the scale needed to break 256-bit elliptic curve keys, but progress in the field continues. Estimates vary on when this might be feasible (some say a decade or more, others are more optimistic). The impact would be severe: an adversary could undermine trust in the blockchain by double-spending, stealing assets en masse, or impersonating validators/miners. Even the fundamental hash-based proof-of-work could be affected by Grover's algorithm (though that poses a lower risk, effectively speeding up mining rather than breaking it entirely). **Quantum risk extends to all digital security**, but blockchains are particularly exposed because of the irreversibility of transactions – if keys are compromised, the losses would be irreversible and confidence in the system could collapse.

Mitigating quantum risk entails transitioning to **quantum-resistant (post-quantum) cryptography** well before quantum computers become a practical threat. This is a multi-faceted effort, involving algorithmic upgrades, network governance, and possibly overlapping cryptographic techniques during the transition. A number of global regulatory bodies have already published guidance on how the financial sector should approach this migration.[183] These strategies differ by network type in terms of how swiftly and easily they can adapt:

TABLE 1.7

Quantum Computing Risk – Mitigation Strategies by Network Type

NETWORK TYPE	MITIGATION STRATEGIES
 Private-Permissioned	**Planned cryptographic agility:** Private networks can be designed to be *crypto-agile*, meaning the cryptographic algorithms can be swapped out with minimal disruption. The operators maintain control over the protocol, so they can mandate an upgrade to post-quantum cryptography ("PQC") algorithms in a coordinated fashion.[184] For instance, node software might support both current ECDSA and a PQC signature scheme;[185] at a predetermined time (or upon detection of quantum progress), the network flips to requiring PQC signatures for all transactions. These algorithms have not yet been formally adopted or accepted by industry, and adoption remains in an early, preparatory phase. Regular internal drills or tests of this switch could be part of the network's resilience strategy. **Layered encryption and key rotation:** In anticipation of quantum threats, a private network can add an extra layer of protection. One approach is using hybrid encryption – transactions are signed with classical algorithms *and* a backup post-quantum scheme. This dual signature means even if one gets broken, the other still secures the transaction. Additionally, permissioned systems often enforce frequent key rotation (e.g. validators must update their keys every few months) and use longer key lengths than public systems. Frequent rotation limits the time available for a quantum attacker to target a specific key.

180. Polkadot Wiki, "Polkadot 1.0", Accessed 2025.
181. Deloitte, "Quantum risk to the Ethereum blockchain", Accessed 2025.
182. Ibid.
183. World Economic Forum, "Quantum Security for the Financial Sector: Informing Global Regulatory Approaches", January 2024.
184. National Institute of Standards and Technology (NIST), "Crypto Agility", April 2025.
185. National Institute of Standards and Technology (NIST), "Considerations for Achieving Crypto Agility", April 2023.

NETWORK TYPE	MITIGATION STRATEGIES
	Controlled environment for updates: The advantage in permissioned systems is that all participants can be instructed to update their cryptographic libraries in unison. The network governance can set a policy that, say, by 202X all nodes must support quantum-safe algorithms X, Y, Z. Compliance is enforceable. Should a breakthrough in quantum computing occur, the network could even pause operations and resume only after all nodes have implemented the cryptographic patch. This ensures a unified defense: there won't be straggler nodes using outdated cryptography. While a temporary halt is disruptive, it's preferable to continuing with broken security.
 Public-Permissioned	**Consortium-led upgrades:** In public-permissioned networks, the validators or governing council can agree on a roadmap for quantum migration. Similar to private networks, they can introduce post-quantum algorithms via a network fork or upgrade that all validators adopt. The difference is that because the network serves public users, they also need to ensure user-level changes (e.g. wallet software) are deployed. The consortium can coordinate industry-wide announcements and support to get users onto quantum-safe wallets in time. Their semi-centralized governance aids in decision-making and execution of such a large-scale change. **Early adoption and testing:** These networks may start testing quantum-resistant algorithms in parallel with existing ones. For example, a network might allow accounts to optionally use a quantum-resistant address format (with larger keys from a lattice-based scheme) even before it's strictly required. This opt-in approach lets the ecosystem slowly gain experience with PQC. The consortium can encourage high-value users (such as institutions) to begin migrating to quantum-safe addresses well in advance. This way, when the switch eventually flips to mandatory PQC, a significant portion of the network is already comfortable with it. **Partnerships with quantum research bodies:** Public-permissioned systems often have ties to enterprises and governments, so they are likely to collaborate with standard bodies (such as the National Institute of Standards and Technology ("NIST")) and academic researchers on implementing the best PQC. They might run dedicated nodes in quantum research testbeds, or integrate hardware quantum random number generators for added security. By staying at the forefront of quantum-resistant tech, these networks mitigate the risk of being caught off-guard. Essentially, they leverage their institutional backing to ensure they are quantum-ready as soon as practical.
 Public-Permissionless	**Community consensus for algorithm change:** Transitioning a fully decentralized network to new cryptography is challenging – it requires broad community agreement (miners/validators, developers, exchanges, users). Mitigation here involves extensive outreach and the development of improvement proposals well in advance. For instance, Bitcoin or Ethereum would likely go through a lengthy process of proposing a move to a PQC signature scheme, with test networks and bounty programs to prove the new scheme's security and performance. Achieving consensus is slow, but the open-source community is already aware of the need – groundwork is being laid in research forums and trial implementations. The key is starting early so that by the time quantum machines are potent, the network has an agreed path forward. **Dual-key or hybrid addresses:** One incremental strategy is to introduce the option for users to secure their assets with quantum-resistant keys now, before a full network switch. For example, Ethereum could allow accounts that use a combination of an ECDSA key and a PQC key, both of which must sign to move funds. This kind of dual-key requirement (one classical, one post-quantum) ensures that an attacker needs to break both cryptosystems. Users who are especially concerned (say, holding large amounts) could opt into this, effectively *future-proofing* their holdings at the cost of some convenience. This voluntary adoption helps mitigate risk for the most vulnerable funds even if the entire network hasn't upgraded. **Encouraging best practices ("quantum hygiene"):** Until full PQC is in place, public networks can at least advise users on steps to reduce exposure to quantum attacks. A known practice is **address reuse avoidance** – if you never reuse an address after spending from it, your public key is never seen on-chain, and thus cannot be attacked by a quantum computer.[186] Many wallets now default to generating a new address for each receiving transaction (HD wallets). Educating users and reinforcing this practice means a large fraction of funds might reside in addresses whose public keys have not been revealed, buying time even in a post-quantum scenario (the attacker could only target addresses that have made outgoing transactions). This isn't foolproof, but it's a simple mitigant to reduce risk in the interim. **Global coordination and pressure:** Given the borderless nature of public chains, mitigation also comes from global regulatory or community pressure. If quantum computing advances faster than expected, we might see emergency actions such as social consensus to freeze certain activities or create a hard fork that nullifies quantum-exploited thefts (as an extreme measure). Knowing this possibility, the community can signal deterrence: i.e., "if someone uses a quantum computer to steal coins, we collectively will not honor those transactions and will fork them out." This game-theoretic stance could disincentivize attackers, though it challenges the notion of blockchain immutability. It underscores that, in the end, the community's collective agreement is the ultimate backstop for protocol changes in face of existential threats.

186. Ibid.

NETWORK TYPE	MITIGATION STRATEGIES
 Cross-Network	**Uniform upgrade protocols:** In an interconnected environment, the weakest link is a problem – if one network remains quantum-vulnerable, it could compromise assets bridged from stronger networks. Therefore, cross-network mitigation involves aligning quantum-resistance efforts. Industry coalitions might establish a **quantum-safe certification** for networks, and only quantum-safe networks are allowed to connect via certain bridges after a cutoff date. Essentially, making interoperability contingent on meeting a quantum-secure standard ensures that one network's laxity doesn't endanger others. **Diversified cryptography across networks:** As an interim risk reduction, different networks might use different cryptographic schemes. An attacker with a quantum computer might break one type of algorithm, but if each network uses a variety, it can't breach all simultaneously without multiple quantum capabilities. For example, one network may adopt a lattice-based signature scheme, another uses a hash-based one; a cross-chain transaction might then require breaking two types of PQC to fully compromise. This diversity is akin to biodiversifying – it avoids a monoculture where one exploit kills everything. Coordination would be needed so that crossing from one system to another doesn't create gaps, but done right, it adds resilience. **Post-quantum interoperability layers:** The protocols that handle cross-network communication should themselves employ quantum-resistant encryption/signatures as soon as possible. Even if underlying networks haven't completely switched, the *bridges* or *oracles* facilitating interop can use PQC to authenticate messages (ensuring an attacker can't forge cross-chain commands). This way, the connectivity layer is secured ahead of time. It mitigates the risk that an attacker could, for instance, forge a message in a bridge system to steal assets across networks. By upgrading the interop layer early (which is often easier as it's more centralized or upgradable), we protect the multi-network operations from quantum threats, buying time for individual chains to follow suit.

2. Compliance and Financial Crime Risk

Blockchain networks introduce unique challenges for regulatory compliance and financial crime prevention. Key concerns include compliance with **KYC**, **AML** and **CFT** obligations, sanctions enforcement, **fraud detection**, and **data privacy** regulations. Pseudonymity (or anonymity) on many distributed ledgers means participants are identified only by cryptographic addresses, making it difficult to ascertain real-world identities and screen transactions against blacklists. Likewise, the immutability and global reach of blockchain transactions complicate traditional compliance mechanisms (for example, the "*right to be forgotten*" under data protection law clashes with an immutable ledger). Below we discuss major compliance risk categories – **Illicit Finance (KYC/AML/CFT and Sanctions) Risk** and **Data Privacy Risk** – and provide comparative mitigation tables for each. (Other aspects such as consumer/investor protection and market integrity are also pertinent but are addressed in separate sections.)

2.1 KYC/AML/CFT and Sanctions Risk

Illicit finance risk is the danger that criminals or sanctioned entities exploit the blockchain network to launder money, finance terrorism, or evade financial sanctions. In permissionless blockchain networks, users can often transact without undergoing any KYC checks – wallets are pseudonymous, identified only by alphanumeric addresses. This pseudo-anonymity complicates compliance with KYC/AML laws and sanctions regimes, since authorities cannot easily link on-chain addresses to real identities.[187] For example, a bank transacting on a public cryptocurrency network risks unknowingly dealing with an address controlled by a sanctioned actor. Further, many public networks allow or even promote privacy-enhancing features (privacy coins such as Monero or the use of mixers), which obscure transaction flows and ownership, making traditional tracing extremely challenging.[188] The **lack of intermediaries** in peer-to-peer networks means there is no single entity responsible for conducting AML checks on-chain. As a result, regulators and institutions have highlighted the risk of sanctions evasion using digital assets across jurisdictions.

Mitigating AML/CFT and sanctions risk may require embedding compliance controls within the service layer of the ecosystem, including regulated intermediaries and interfaces, while preserving the neutrality and general-purpose nature of the underlying protocol. While some DLT systems support token- or contract-level permissioning, regulatory compliance can also be achieved through alternative mechanisms, including modular compliance layers and decentralized identity frameworks. No single architecture should be viewed as prescriptively necessary for regulatory approval. Approaches range from enforcing participant identity requirements (in permissioned systems) to using advanced blockchain analytics and smart contract-based controls (in public systems). Below, we compare mitigation strategies across network types:

187. Bank of International Settlements, "Novel risks, mitigants and uncertainties with permissionless distributed ledger technologies", August 2024.
188. Ibid.

TABLE 2.1

Illicit Finance (AML/CFT & Sanctions) Risk – Mitigation Strategies by Network Type

NETWORK TYPE	MITIGATION STRATEGIES
Private-Permissioned	**Closed-loop KYC enforcement:** All participants (nodes and users) are known and vetted by the network operator or consortium. Account opening requires full KYC/AML checks off-chain, and only approved entities can transact. By design, this eliminates anonymous actors – the network operates as a walled garden of identified members, greatly reducing AML risk exposure.[189] **Transaction monitoring & reporting:** The operator integrates traditional AML monitoring tools to flag unusual patterns even within the permissioned network. Because identities are known, any suspicious activity (e.g. large transfers inconsistent with a user's profile) can be investigated and reported to authorities under applicable regulations. Essentially, the network treats on-chain transfers similar to bank internal transfers, subject to oversight. **Blacklist/whitelist integration:** The network can programmatically prevent transactions involving barred entities. For instance, if a member entity becomes sanctioned or high risk, the operator can revoke its access or freeze its on-chain assets. Since governance is centralized, updates to sanctions lists or risk rules can be quickly propagated and enforced network-wide.
Public-Permissioned	**On-chain address controls (smart compliance):** Networks that are public but permissioned (having known validators or issuers) often implement **denylists/allowlists at the token or protocol level**. For example, a token issuer on such a network can embed logic to **denylist specific addresses** – preventing blacklisted entities from transacting that asset.[190] Conversely, "allowlisting" restricts asset transfers only to pre-approved addresses.[191] These controls are enforced by the smart contract, directly blocking illicit addresses (e.g. Office of Foreign Assets Control ("OFAC")-sanctioned wallets) from sending or receiving value. **Regulated intermediaries and portals:** While the base network may be publicly accessible for read or even transact, entry and exit often occur through regulated gateways (such as exchanges or custodial wallets) that perform KYC/AML. The consortium behind the network typically works closely with these intermediaries to ensure compliance data flows (travel rule information, etc.) accompany transactions as required. **Real-time screening and freezes:** The governing body can leverage analytics to watch transactions in real time and has authority to prompt validators or contract owners to freeze assets if illicit activity is detected. A notable example is the ability of some stablecoin issuers (operating on public chains) to blackball addresses – freezing funds associated with crime or sanctions as soon as they are identified. Such actions have been used to interdict stolen funds on public networks, demonstrating an effective (if centralized) mitigant within a permissioned-public context.
Public-Permissionless	**Blockchain analytics and surveillance:** In an open network with pseudonymous users, mitigation falls largely to advanced analytics. Firms and regulators deploy blockchain tracing tools (Chainalysis, Elliptic, etc.) to de-anonymize patterns and link addresses to illicit activity. These tools use heuristics and sometimes external data (e.g. clustering addresses by exchange usage) to flag high-risk addresses. Compliance teams monitor these and can refuse service (banking, exchange conversion) to tainted funds. While this doesn't stop illicit use on-chain, it *discourages misuse* by threatening the ability to cash out.[192] **Privacy-preserving compliance tech:** Emerging solutions attempt to reconcile public blockchains with privacy and AML. One approach is **zero-knowledge proof-based identity** checks – e.g. a user can prove they are not a sanctioned party or have passed KYC, *without revealing their full identity on-chain*. Such techniques allow a smart contract to validate that a user's attributes meet compliance criteria in a privacy-preserving way. These technologies are still nascent and not widely deployed, but pilot programs (often with regulatory sandboxes) are testing their viability.[193] **Network-level risk controls (nascent):** Some public networks explore protocol changes to facilitate compliance – for instance, Ethereum's community has discussed address "*sanction tags*" or optional KYC segments. Another concept is **permissioned mining/validation** subsets: a group of compliant validators that only process "clean" transactions, effectively creating a compliant partition within the network. These ideas are controversial and technically complex, and thus remain largely theoretical or in early stages.[194] **Off-chain enforcement and chokepoints:** Ultimately, regulators mitigate residual risk by regulating the touchpoints: exchanges, payment processors, and other off-ramps must implement the Financial Action Task Force ("FATF") *Travel Rule* (sharing sender/receiver identity for crypto transfers) and refuse dealings with non-compliant services. If a public blockchain address is known to be illicit, regulated entities will freeze or reject associated transactions. This doesn't stop peer-to-peer illicit transfers on the blockchain, but it limits where those funds can go (e.g. converting to fiat or interfacing with regulated economies), indirectly discouraging abuse.

189. Ibid.
190. Ibid.
191. Ibid.
192. Elliptic, "$7 billion in crypto laundered through cross-chain services", October 2023.
193. Bank of International Settlements, "Novel risks, mitigants and uncertainties with permissionless distributed ledger technologies", August 2024.
194. Ibid.

NETWORK TYPE	MITIGATION STRATEGIES
 Cross-Network	**KYC on cross-chain bridges and mixers:** Enhanced monitoring and compliance frameworks for cross-chain bridges may be appropriate, particularly where such bridges are operated by identifiable entities. However, KYC requirements should be proportionate to the level of control and risk, and not automatically applied to non-custodial or decentralized protocols. **Automated compliance checks in smart contracts:** Cross-network transactions can embed compliance rules. A real example is MAS's Project Guardian pilot, where a cross-currency swap smart contract automatically performed an AML screening before execution.[195] Such *programmable compliance* ensures that multi-network workflows halt if any party fails a sanction or risk check, without manual intervention. **Holistic cross-chain analytics:** To mitigate illicit transfers that hop across several networks (often to shake off tracing), law enforcement and analytics companies increasingly use *cross-chain analytics*. These tools correlate activity across Bitcoin, Ethereum, and many alt-chains and layering protocols to follow the money trail through obfuscation layers.[196] By improving visibility end-to-end, they reduce the "blind spots" criminals seek when they move value from one ledger to another. This field is evolving quickly, supported by international cooperation (e.g. the International Anti-Money Laundering regulators focusing on cryptoasset tracing). However, technology and standards for cross-chain AML are still catching up to the sophisticated tactics observed, marking this as a partially mitigated risk at best.

2.2 Data Privacy Risk

Data privacy risk in blockchain arises from the tension between an immutable, transparent ledger and laws or expectations around personal data protection. On-chain transactions can inadvertently include personal identifiable information (PII) or allow inferences about individuals' behavior, which is problematic under regimes such as the EU's General Data Protection Regulation (GDPR). A fundamental property of blockchains is **immutability** – once data is recorded, it cannot be altered or erased. This is great for integrity, but it conflicts with the GDPR's requirement that individuals have the right to correct or delete their personal data. Additionally, many blockchain ledgers are **publicly transparent** (all transactions visible to anyone), which can expose sensitive financial information or relationships that would normally be private. Even in permissioned networks, multiple parties share a common database, raising concerns about how confidential information is controlled and who can access it. Privacy risks include scenarios such as: embedding personal data (names, account details) into an indelible transaction record; inability to retract data that was posted in error; and analysis of transaction histories revealing personal habits or business secrets.

Mitigation strategies focus on minimizing on-chain personal data and using cryptographic techniques to protect confidentiality. There is a spectrum: from private networks that simply avoid putting any customer data on the ledger, to advanced cryptographic solutions on public chains that try to obfuscate or encrypt data. Below we compare approaches by network type:

TABLE 2.2

Data Privacy Risk – Mitigation Strategies by Network Type

NETWORK TYPE	MITIGATION STRATEGIES
 Private-Permissioned	**Off-chain storage of personal data:** Design systems such that any PII or sensitive data is kept off-chain in traditional databases under the control of the permissioned network operator. The blockchain records only references or hashes of the data. For example, a trade finance DLT might record a hash of a document on-chain to prove it hasn't been altered, while the actual document (containing names/addresses) resides in a secure off-chain repository. This way, if data must be modified or deleted to comply with law, it can be handled off-chain without disturbing the ledger **Permissioned access and data partitioning:** Even within a private blockchain, not all participants may need to see all data. Techniques such as channelization or sub-ledgers (as in Hyperledger Fabric's private channels) ensure that only authorized parties can view certain transaction details. By segmenting data, privacy is preserved among consortia members (e.g. competitors on the same network won't see each other's client details). All participants sign confidentiality agreements extending traditional data protection commitments to the consortium setting. **Data lifecycle management policies:** The consortium can implement policies aligned with data protection laws – for instance, agreeing on procedures if a participant requests deletion of their data reference. While the blockchain record itself isn't deleted, the network might support *logical deletion* where data is rendered inaccessible (e.g. encryption key destruction). Regular audits are conducted to ensure no excessive personal data is creeping into on-chain records. These governance measures mitigate legal risks by showing a proactive stance on privacy compliance.

195. Leong Sing Chiong, "Tokenization in financial services - pathways to scale", Accessed 2025.
196. Elliptic, "The state of cross-chain crime", Accessed 2025.

NETWORK TYPE	MITIGATION STRATEGIES
 Public-Permissioned	**Encryption and hashing on-chain:** When public participation is allowed (read or transactional), any personal data that must be referenced is stored in encrypted form or as a one-way hash. For example, a public-permissioned identity blockchain might put only a hash of a user's ID document on-chain; verification happens by comparing hashes, without revealing the actual document. Only entities with the decryption key (often the permissioned validators) can access the raw data if needed. This ensures that to an outside observer, the ledger doesn't leak private details. **Selective disclosure via smart contracts:** Implement smart contracts that allow users to share proof of certain data attributes *without exposing the data itself*. A real-world implementation is using zero-knowledge proofs for identity – e.g. proving "I am over 18" or "I reside in Country X" to a service, by providing a zk-Proof that validators can confirm, instead of sharing your full date of birth or address.[197] Public-permissioned networks, with a governing authority, can standardize these privacy-preserving credential schemes so that users can interact with on-chain services anonymously but still meet any necessary regulatory checks. **Compliance by design:** The network's rules incorporate data protection principles. For instance, the network might require that any smart contract proposing to handle personal data undergo a privacy impact assessment and include an "expiration" mechanism (if feasible) for personal data. The governance body can refuse to approve or can revoke contracts that are found to be violating privacy standards. Furthermore, if jurisdictions demand it, the consortium can implement processes to selectively fork or modify the ledger (highly exceptional) to remove unlawful personal data – effectively an administrative erasure with consent of validators, used only under legal compulsion.
 Public-Permissionless	**Avoidance and minimization of personal data:** The primary mitigant is simply to never put plaintext personal data on a public blockchain unless absolutely necessary. Business applications built on public chains use techniques such as pseudonymous identifiers, tokens, or references. If personal data is involved (e.g. a diploma certificate on a blockchain credential system), typically only an index or hash goes on-chain, with the actual PII stored off-chain by the issuer. This minimizes direct privacy exposure on the immutable ledger. **Privacy-enhancing overlays:** Various layer-2 solutions or encryption techniques are employed to add privacy to public chains. Examples include **privacy layers/sidechains** (such as Aztec network on Ethereum, which uses zk-SNARKs to enable confidential transactions) and coin mixers/tumblers for transaction privacy. While these can protect user privacy by obscuring amounts or participants, they raise compliance issues if abused, and some have been subject to regulatory sanctions themselves (e.g. Tornado Cash). Nonetheless, as mitigants, they show that technically it is possible to have confidentiality on a public chain, at the cost of complexity and sometimes transparency. **Self-sovereign identity ("SSI") frameworks:** Emerging SSI systems allow individuals to control their identity credentials and share validated proofs on public networks without exposing underlying data. For instance, a user could store their ID with a trusted issuer and then present a blockchain-verifiable proof of ID ownership when transacting. The public chain sees only a cryptographic proof, not the personal data. These frameworks (e.g. DID – Decentralized Identifiers and Verifiable Credentials standards) are gaining support as a way to marry privacy with public blockchain utility. They are still in early phases of adoption. **Legal and regulatory adaptations:** From a non-technical angle, some jurisdictions are creating sandbox exemptions or refining interpretations of laws such as GDPR to accommodate blockchain's nature. For example, if data on a blockchain is irreversibly encrypted or hashed (no one can derive personal info from it), regulators may consider it sufficiently anonymized and thus outside GDPR's scope. Users and businesses mitigating privacy risk on public chains often seek such legal guidance to ensure compliance (e.g. using GDPR's concept of pseudonymization). In summary, a combination of technical anonymization and evolving legal standards is used to manage this risk on open networks, but full compliance remains challenging and case-specific.
 Cross-Network	**Consistent data governance across chains:** When data or assets move between networks, the strictest privacy standard among those networks should be applied end-to-end. For example, if a private chain transfers an asset to a public chain via a bridge, the bridge service must enforce that no personal data leaks in the process (perhaps by tokenizing the asset in a way that carries no personal info). Cross-network agreements or contracts can specify data handling requirements so that privacy isn't lost in translation between systems. **Federated identity and trust frameworks:** In a multi-network environment, one mitigation is to rely on federated identity systems that work across platforms. A user could have a digital identity issued on a permissioned network, and when interacting on a public network, they use an attestation from that identity rather than new personal data. Essentially, trust and KYC checks done in one network (with stronger privacy controls) are re-used in another via cryptographic attestation. Efforts such as the World Wide Web Consortium's ("W3C") Verifiable Credentials and various national digital ID initiatives aim to enable such interoperability, reducing the need to expose raw personal data when crossing networks

197. Bank of International Settlements, "Novel risks, mitigants and uncertainties with permissionless distributed ledger technologies", August 2024.

NETWORK TYPE	MITIGATION STRATEGIES
	Privacy-focused interoperability protocols: New interoperability solutions are being developed with privacy in mind. These include cross-chain communication protocols that transmit proofs or shielded data instead of raw data. For instance, a cross-chain transaction could send a zero-knowledge proof that a condition is met on Chain A to Chain B, instead of sending the underlying private data from A to B. By architecting the interoperability layer to carry *credentials or proofs* rather than personal info, we preserve privacy as assets or information flow across networks. This area is still emerging, and gaps exist – notably, many current cross-chain tools do not fully address privacy, focusing more on functionality. Over time, we expect privacy considerations to be baked into interlinked network models.

2.3 Regulatory and Legal Uncertainty Risk

Regulatory and legal uncertainty risk is the risk arising from unclear, inconsistent, or rapidly evolving laws and regulations concerning blockchain and digital assets. This includes uncertainty about the legal status of crypto-assets, uncertainty about which regulations apply to novel decentralized protocols, and the danger that new laws or policies could *suddenly render a previously acceptable activity non-compliant*. Because blockchain technology often doesn't fit neatly into existing regulatory frameworks, participants face a patchwork of approaches globally. For example, a cryptocurrency might be legal tender in one country, tolerated as a commodity in another, and banned entirely in a third. A network that spans jurisdictions could be in a constant state of legal risk. Moreover, regulators are continually updating rules – what's legal today (e.g., unhosted wallets, certain DeFi operations) might be restricted tomorrow. There's also **counterparty regulatory risk**: if a major jurisdiction enacts a strict law (say banning a type of node operation), it might force a hard fork or shutdown of part of the network, affecting everyone. An example highlighted by the BIS is that a change in policy could abruptly change validator behavior or network stability, making the blockchain **operationally unstable**.[198] This was seen when China banned cryptocurrency mining; it instantly knocked out a huge portion of Bitcoin's network until it relocated. Legal uncertainty also complicates dispute resolution – if something goes wrong, parties may not know what laws apply or which court has jurisdiction (especially in cross-border, decentralized setups).

Mitigating regulatory uncertainty involves proactive engagement, adaptable design, and sometimes deliberately limiting certain activities until rules are clearer. The strategies differ across network types as follows:

TABLE 2.3

Regulatory & Legal Uncertainty Risk – Mitigation Strategies by Network Type

NETWORK TYPE	MITIGATION STRATEGIES
 Private-Permissioned	**Regulatory sandbox and collaboration:** Private network operators often work closely with regulators through sandboxes or pilot programs. By engaging regulators early (e.g. a central bank observing a blockchain settlement system test), they gain clarity on how laws will be applied or may even get specific exemptions during trial phases. This collaborative approach reduces uncertainty – the network evolves in tandem with regulatory guidance, and adjustments can be made before full launch. Successful sandbox experiences can lead to more permanent licenses or regulatory frameworks that the network can then operate under confidently. **Jurisdictional structuring:** A private network can be structured (legally) in favorable jurisdictions to mitigate uncertainty. For example, if one country has clear DLT legislation (recognizing digital records, offering legal finality, etc.), the consortium might incorporate there and ensure that their legal agreements choose that country's law to govern operations. Important contracts (among members or with users) will include choice-of-law and arbitration clauses to avoid ambiguity. Essentially, the network opts into a legal environment that's predictable, thus sidestepping some uncertainty from less defined jurisdictions. **Flexibility in system rules:** The governance of permissioned networks typically retains the ability to modify network rules or business logic to comply with new regulations. If a law change requires all transactions above a certain size to record additional data, a private network can implement that requirement relatively quickly via a governance vote. Having an agile governance framework (with emergency change provisions) means the network can pivot to maintain compliance, rather than being caught in a rigid protocol that might become illegal. Participants also usually agree that if a law or regulator demands certain action (e.g. blocking an account), the network will comply – this is codified in membership agreements, ensuring everyone is on the same page and legal risk is collectively managed.

198. Bank of International Settlements, "Novel risks, mitigants and uncertainties with permissionless distributed ledger technologies", August 2024.

NETWORK TYPE	MITIGATION STRATEGIES
 Public-Permissioned	**Transparent rulebook and regulatory liaison:** Public-permissioned networks mitigate uncertainty by publishing clear rulebooks for participants that align with current regulatory expectations. They might, for instance, voluntarily enforce KYC on all users even if not strictly required yet, anticipating that regulators will eventually mandate it. Additionally, these networks often establish advisory boards that include legal and compliance experts who keep an eye on regulatory trends and liaise with authorities. By self-policing to a degree and maintaining an open dialogue with regulators, they reduce the chance of nasty surprises (such as a sudden injunction). **Geo-fencing and adaptive access:** To handle differing laws, networks can geo-fence certain features. For example, if derivatives trading on DLT is legal in Country A but not in Country B, the network can restrict access to that module based on user jurisdiction (often via front-end controls or identity checks). Similarly, if a particular asset is deemed a security in one jurisdiction, the network could prevent users from that region from transacting it. These programmatic compliance measures allow the network to stay operational globally while tailoring compliance locally, thus mitigating legal risk by *not breaking local laws* where they differ. **Insurance or legal risk pooling:** Some consortium-led networks establish insurance or contingency funds to cover legal risks, such as potential fines or required user compensation if a regulatory action occurs. While this doesn't remove uncertainty, it provides a financial buffer and reassurance to participants. For instance, the consortium agreement might include a provision that if a member is penalized due to actions taken on the network that were later deemed non-compliant, the consortium fund will help cover costs. This encourages participation despite uncertainties and shares the risk of a regulatory shift among the group.
 Public-Permissionless	**Open-source legal advocacy and self-regulation:** Communities often band together to form industry groups or alliances (such as the Blockchain Association, DeFi Education Fund, etc.) to engage with policymakers. They produce best-practice guidelines (for example, voluntary AML standards for DeFi or technical standards for auditability) to show good faith and influence sensible regulation. These efforts mitigate uncertainty by preemptively addressing regulators' concerns and pushing for clarity. In essence, the community attempts to self-regulate where possible, hoping to reduce the likelihood of broad-brush heavy-handed laws. **Modular approaches to compliance:** Some projects are building optional compliance modules that can plug into permissionless protocols. For instance, a DeFi platform might have an *optional KYC module* that jurisdictions or institutions can require when they interact with it, while leaving the base protocol permissionless. This flexible architecture means the network can be all things to all people – compliant in regulated contexts, but open elsewhere. While this doesn't eliminate legal uncertainty (and some regulators may reject the optional nature), it mitigates risk by making the protocol adaptable: if a law demands KYC, the module can be activated in that context without redesigning the whole system. **Exodus and contingency planning:** Participants in permissionless systems often maintain contingency plans to relocate or fork the network if a legal regime becomes too hostile. For example, miners might move operations out of a country that bans mining, or developers might shift a project's base to a crypto-friendly jurisdiction. In extreme cases, a network can even hard-fork to exclude a jurisdiction's influence (for instance, changing rules so that nodes in Country X are ignored if Country X tries to censor the chain). These are last-resort mitigations – essentially routing around regulation – and come with costs. They underscore that in a worst-case scenario, the community can choose to sacrifice a market or region to keep the project alive elsewhere, thereby mitigating *global* impact of local legal risks.
 Cross-Network	**Legal harmonization efforts:** Cross-network activities often fall into gaps between jurisdictions (whose law applies when assets move chain to chain?). To mitigate this, industry groups and international organizations (such as the Financial Stability Board, IOSCO, BIS, etc.) are working on harmonized regulatory frameworks for crypto-assets and networks. Compliance with such standards acts as a proxy for compliance in multiple jurisdictions. **Network-specific legal entities:** In some cross-chain collaborations (say between a public and a private network), participants set up a special legal entity or agreement to oversee the bridge or interaction. This entity can be the focal point for regulatory compliance – e.g., it gets licensed as a money transmitter or exchange if value is moving across networks. By having a responsible legal entity "in the middle," the arrangement provides regulators someone to hold accountable, which can make them more comfortable and give legal certainty to the process. Essentially, it compartmentalizes the cross-network activity into a legally recognized framework. **Choice-of-law and dispute resolution clauses in protocols:** It's novel, but some smart contract systems are starting to incorporate by reference certain legal clauses – for example, a smart contract for a cross-chain swap might include text or a hash referencing an arbitration agreement under a specific jurisdiction's laws. This way, if something goes wrong (such one side claiming breach), there is clarity on how it will be resolved legally (perhaps via off-chain arbitration in a neutral forum). While the transactions are automated, having this legal *backstop* written in mitigates the uncertainty of "what court handles a dispute that spans blockchains?" Parties can agree upfront on governance of their cross-chain interactions, blending code and law. **Adaptive compliance routing:** In a scenario where multiple networks interconnect, transactions can be routed in a way that optimizes compliance. For instance, if transferring an asset from Chain A to Chain C directly is legally uncertain, but doing so via Chain B (which has a clear regulatory status, perhaps a regulated intermediary network) provides legal clarity, then design the interoperability to always pass through B. By routing cross-network transactions through legally sturdy networks or layers, the overall legal risk is mitigated at the expense of some efficiency.

Chapter 2 | Opportunities and Risks: Impact of Tokenization Across the Securities Lifecycle

This chapter provides an overview of the current capital markets ecosystem and a detailed impact assessment of DLT and DLT-based Securities. Subsections are dedicated to Primary Markets and Issuance, Secondary Trading, Clearing and Settlement, Custody, and Asset Servicing to ensure that this assessment is exhaustive across every stage of the securities lifecycle. The chapter concludes with a detailed analysis of the regulatory reporting and KYC/AML requirements across major jurisdictions globally with an assessment of the impact DLT could have.

2.1 SECURITIES LIFECYCLE: CURRENT STATE AND IMPACT ASSESSMENT

Each sub-chapter within **Chapter 2.1** provides a description of the current state and key inefficiencies experienced by participants in each stage of the securities lifecycle—these can span across participants and processes or be found concentrated within a certain workflow. The **joint trades on behalf of members, through detailed assessment, evaluates whether DLT can address, mitigate, or eliminate these barriers.**

Each sub-chapter provides detailed impact assessment for each stage of the securities lifecycle – ranked HIGH, MEDIUM, or LOW based on the degree of positive DLT when assessing its impact across five key attributes of the security lifecycle:

- Models of Implementation
- Activities
- Evolved Roles and Responsibilities
- Financial Impact and Opportunities
- Risk Impact

EXHIBIT 2.1.1

Stages of the Security Lifecycle

Primary Market	Secondary Market	Post-trade	Life-cycle management	
Issuance	**Trading**	**Clearing and Settlement**	**Custody**	**Asset Servicing**
Banks, underwriters and other intermediaries support the creation of new securities on behalf of an issuer, and distribute them for sale to investors	Investors trade securities that have already been issued, with market makers providing liquidity that supports price formation	Financial Market infrastructure organizations and market participants process trades and legally transfer ownership of securities and funds	Custodians provide safe-keeping and record-keeping for the security throughout the client's holding period	Custodians service the security by recording corporate actions and providing compliance and regulatory reporting, and supporting issuer disclosure

Source: BCG analysis.

Important to note, the Risk Impact assessed here refers **specifically to existing risk in the traditional markets and does not address DLT-specific risk**; this is covered in detail in **Chapter 1.4 | Risk Mitigants**.

Capital markets have specific nuance across asset classes that drive the level of risk impact. Where applicable within this chapter, asset-class sidebars, subsections, and other callouts provide these details.

KYC/AML and regulatory reporting are critical components of the securities lifecycle and span across many stages of the securities lifecycle – as a result they are treated completely and separately in **Chapter 2.2 | Regulatory Reporting and KYC**, with specific detail by the applicable global geographies including the U.S., U.K./EU, Hong Kong, Japan, and Singapore.

Primary Market Issuance

This chapter provides an overview of participants, key activities, and critical inefficiencies that exist today. This provides a baseline for an impact assessment of DLT, considering **different models of implementation** and **impact on activities, roles and responsibilities, opportunities,** and **risk.**

SUMMARY OF IMPACT ASSESSMENT **MEDIUM**

The primary issuance phase (in isolation) is not deemed a major area of disruption by DLT, given existing processes are broadly expected to persist in a DLT ecosystem. Issuance though would act as a necessary on-ramp for the creation of Security Tokens, driving new workflows to support this activity.

Three possible implementation models of DLT-based issuance are considered: 1) Books and Records only; 2) Tokenized Securities; and 3) Security Tokens.

- Books and Records (e.g., documents and administration etc.), which support pre-issuance workflows, could provide a starting point for getting institutions and regulators familiar with the technology.
- Tokenized Securities allow greater utility of securities as collateral and enable some post-trade efficiency benefits, though these could be limited in primary issuance and are better suited to secondary markets.
- Security Tokens enable the realization of the broadest benefits case, including significantly lower cost and time to issue and broader security innovation. However, legal and regulatory ambiguity and absence of liquidity are major hurdles.

Activities and roles: Existing activities performed by market participants **to originate, structure, and distribute securities will persist.**

- **Existing issuance workflows are generally highly bespoke and manual:** This adds time and cost to the issuance workflow but allows for effective formation of primary markets liquidity.
- **Structurally, there have been challenges in standardizing and creating standardized electronic issuance workflows.** This is driven by:
  a. Bespoke processes perceived as necessary and value-adding;
  b. Transaction Manager disincentives to support platform intermediation;
  c. Behavioral changes that are challenging to implement. DLT is not required to achieve this evolution, but the technical requirement to have a DLT-based asset lifecycle management platform on-ramp could likely embed electronification.

Opportunities: DLT-lifecycle platforms and certain asset classes with the highest benefit case (e.g., corporate paper, medium-term-notes) will see the greatest impact. Other areas, where existing processes persist (e.g., those of Transaction Managers) will see less impact, respectively.

- **The rise of DLT-based asset lifecycle management platforms** could present the most significant market structure change. These platforms are a critical on-ramp to issue Security Tokens; adoption may drive standardization and interoperability, integrating with traditional systems and workflow and achieving automation benefits.
- **Transaction managers have a low risk of disintermediation.** Their work could evolve to require less operational involvement, but their role in underwriting new issues and forming primary markets liquidity could remain. Intermediaries in the primary issuance value chain predominantly focused on operational execution are at a higher risk of disintermediation.
- **Asset classes have highly heterogenous issuance workflows** and thus have differing likelihoods of adopting Security Token issuance. This report presents a likelihood framework by asset class and recommends the market focus on specific use cases to prove meaningful adoption and validate viability. The greatest opportunity exists in transitioning recurring, frequent issuance securities (corporate paper, medium-term-notes), repo, and establishing new markets (DLT-based funds, private assets).

Current State and Inefficiencies

Existing workflows allow issuers to tailor securities to the needs of investors, typically involve specialist input from advisors, and support proven processes to form Primary Markets liquidity. Workflows generally follow the three stages below:

A) Origination

Issuers (or their representatives), Transaction Managers, and Advisors work together to set a capital strategy, drawing data from both primary and secondary markets. Many issuance decisions are time-dependent, relying on disclosure windows or market conditions, and highly sensitive to the market environment, including interest rates and monetary policy, economic conditions, investor risk appetite, and market liquidity.

Inefficiencies exist in the cost and time to issue new securities. Issuance lead time is driven by cumbersome processes (e.g., issuing a bond takes six weeks, and requires around one hundred individuals working on nearly two hundred tasks) and extended settlement (e.g., up to T+5 for some asset classes and geographies).[199] To date, electronic primary issuance platforms have struggled to meaningfully impact workflows.[200]

B) Structuring

Security issuance is documented (drafted, negotiated, and executed) through legal documents and regulatory filings that are specific to the asset class and issuance type. Production of legal and marketing documentation are highly manual, bespoke to the issuance, and multi-party (including the Transaction Manager(s)[201], Advisor(s), Issuer, and Investors) allowing each issuance to be tailored to investors' needs.

Security document preparation is complex, adding considerable cost, time delay, and operational risk to the issuance process. Presence of numerous—often opposed—legal counsels introduce sequential document workflows, which must be reconciled across organizations, creating inefficiencies in document management. In some cases, inefficient document management could cause delays and lead to transactions being withdrawn from the market. However, some asset classes and issuers have developed solutions for these inefficiencies. For example, the Euro Medium-Term Note ("EMTN") program allows issuers to access the market at short-notice (e.g., one or two days), and with very standardized documentation for vanilla senior unsecured transactions.

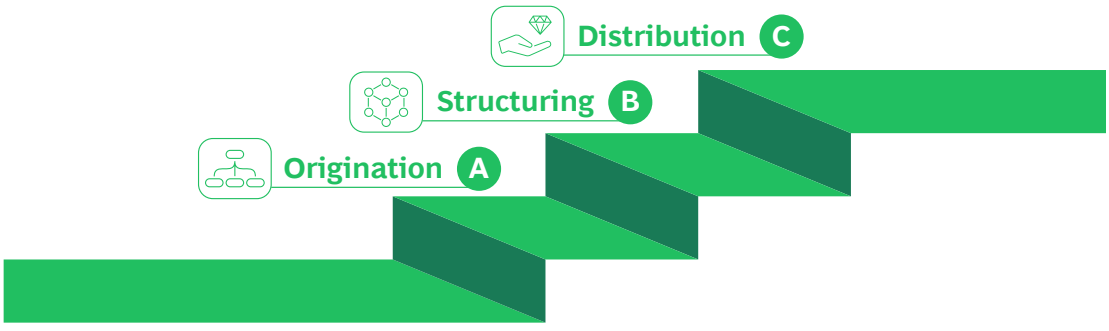
C) Distribution

Transaction Managers form primary markets liquidity through soft-sounding, formal roadshow, and/or broad notification of issuances. Heterogeneous workflows exist for various asset classes. For example, an issuer may request its commercial paper placement agent to distribute securities to investors at set terms (amount, rate, and maturity). Underwritten issuance processes have the benefit of pricing certainty, with underwriters taking pricing risks. The majority of deals are arranged on a best-effort basis, with pricing uncertainty mitigated by banks.

Existing market structure allows for limited systematic buyside influence on the supply of securities. Instead, Transaction Managers gauge investor sentiment and structure issuances in response.

EXHIBIT 2.1.2

Primary Issuance – Key Workflows



199. Complications such as security registration and cross-border payments lead to long settlement time which can be up to T+5 for some asset classes.
200. Dealogic Connect, Origin Markets, IPREO, Agora, and Nivaura are examples of platforms seeking to automate primary issuance workflows. DirectBooks is gaining traction on a significantly reduced functionality scope.
201. "Transaction Manager" is used in this report to generalize across asset classes and subfunctions: it covers a subset of roles including Coordinator, Bookrunner, Joint Lead Manager, Arranger, Underwriter, and Placement Agent.

Impact Assessment: Medium

The overall impact of DLT and Tokenization on Primary Market Issuance is **Medium.**

EXHIBIT 2.1.3

Primary Issuance Impact Assessment

Issuance	Issuer	Transaction Manager	Investor
A Origination	Low	Low	Low
B Structuring	Low	Medium	Low
C Distribution	Low	Medium	Low

Source: BCG analysis.

Primary issuance workflows are unlikely to fundamentally change; however, adoption of Tokenization platforms would support standardization and electronification.

The main change in market structure may be the emergence of Tokenization platforms. There would be considerable short-to-medium-term cost to build required systems; establish legal comfort; and educate participants. Jurisdictions may realize competitive advantages in supporting early adoption. Market participants are urged to focus their investment on high-impact, clearly defined use cases where tokenization can deliver measurable value.

The main areas of impact from DLT on Primary Issuance are:

Lower cost and time to issue. Lower-cost DLT-based issuance can be used more frequently and faster. Securities can be minted at time of distribution (similar to any shelf-based issuance such as an MTN program). Impacts routine/repeated issuances.

Innovation in Primary Market Issuance offers new types of instruments (e.g., bespoke instruments with automation of income flows and ability to streamline Asset Servicing and Lifecycle Management events, ESG tracking); tailors these instruments to investor needs (recurring revenue-based financing, bespoke frequencies etc.); and takes advantage of market conditions more precisely and effectively.

Buyside collaboration can take a more active role, including more informed matching of supply/demand, tailoring to fit portfolio/fund strategies of buyers, and shared research.

Fractionalization potentially broadens distribution of illiquid private assets (unlisted equities, real estate, funds, commodities); may enable greater usability & liquidity; and lower ticket sizes offers potential for increased access to investors and could aid more effective risk diversification.

Reduced settlement time. Settlement time is considerably longer in primary markets when compared with secondary markets, saving time for all parties, and limiting market risk (and the potential need for, and cost of, risk management transactions) during the settlement period.

Adoption will be heterogenous. Asset-class issuance workflows that are recurring, frequent, and offer benefits from improved operational efficiency and/or product innovations are likely to adopt issuance of Security Tokens first.

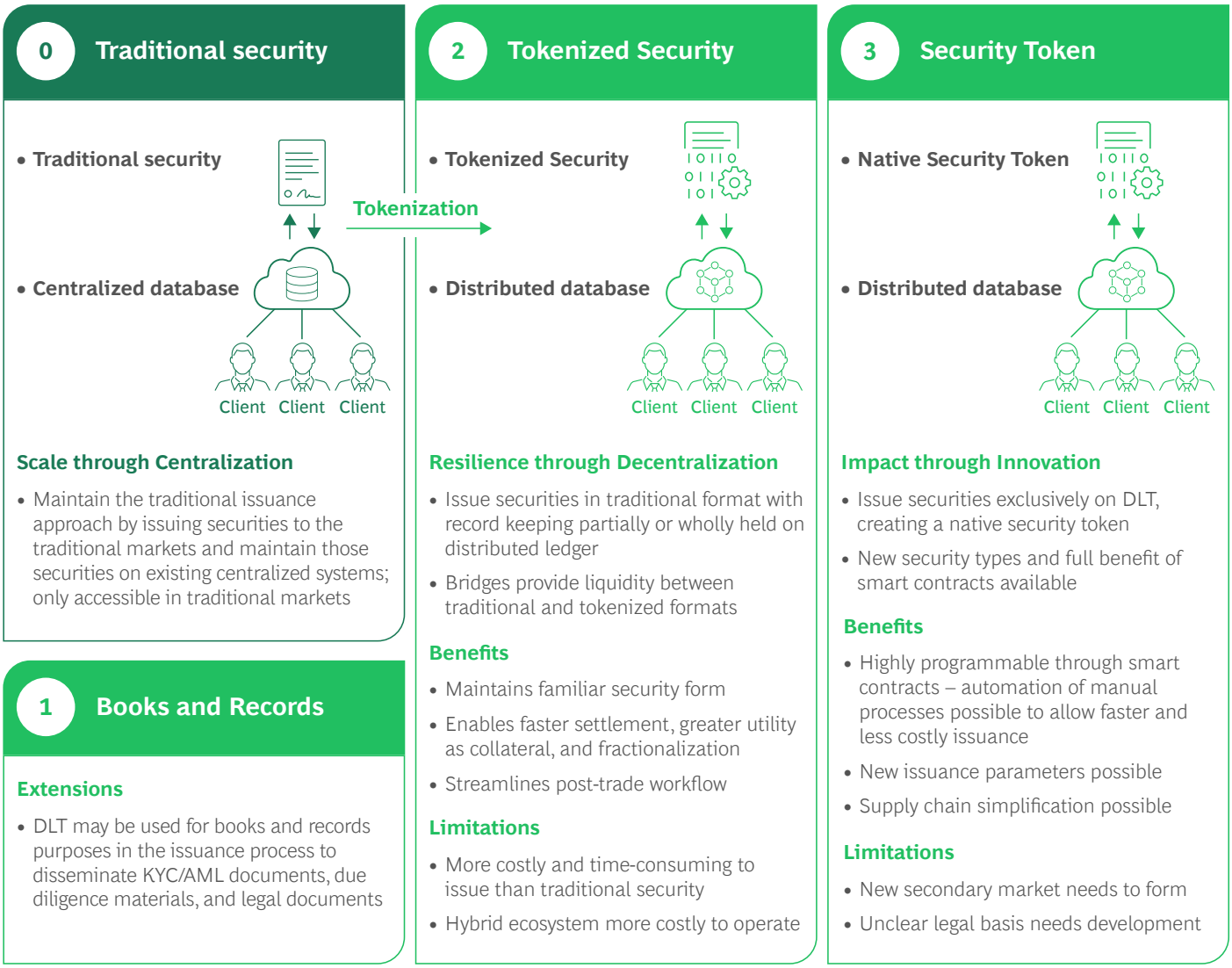
The main change in market structure may be the emergence of Tokenization platforms. There would be considerable short-to-medium-term cost to build required systems; establish legal comfort; and educate participants. Jurisdictions may realize competitive advantages in supporting early adoption. Market participants are urged to focus their investment on high-impact, clearly defined use cases where tokenization can deliver measurable value.

Models of Implementation

There are three formats of security issuance available to Issuers and Transaction Managers in a future state: 1) Books and Records; 2) Tokenized Securities; and 3) Security Tokens:

EXHIBIT 2.1.4

Format of Security Issuance Under DLT



Source: BCG analysis.

In the section below, the report focuses on impact from issuance of Security Tokens.

Evolved Roles and Responsibilities

The core workflow of Origination, Structuring, and Distribution could remain; however, there could be scope for faster iteration and response to market conditions through streamlined processes.

Investors could have the opportunity to become systematically involved in the issuance process once the deal is public.

Transaction Managers have a low risk of full disintermediation; however, they could reduce their operational workload in the issuance process. Their role of security structuring, underwriting, and distribution is likely to remain critical.

Issuance Platforms: standardized electronic issuance platforms are nascent and may likely be superseded by Tokenization platforms that could be used to create and offer tokens. As market adoption increases, there is likely to be a sharp increase in the number of Tokenization platforms available on the market. It is unclear which party is best suited to operate these platforms (Transaction Managers vs. market operators vs. specialist data platforms). In the long term, there could likely be consolidation of platforms and aggregation of deal flow as the tokenization of assets grows.

It is unclear which platforms will succeed. In the near term, integration is critical between tokenized and traditional markets. In the longer term, interoperability between DLTs, issuance platforms, and other market systems (such as Order and Execution Management Systems ("OEMS")) may become a greater focus for market participants.

Tokenization Platforms

Tokenization platforms—with integration across existing infrastructure—are emerging to simplify and automate the issuance workflow. Transaction Managers could likely be the key decision-makers on which platform to use due to their role structuring and distributing the tokens. A lengthy procurement process will likely be required, covering auditing, selection, and testing.

These platforms may play a critical role in developing Security Token structuring capabilities with workflow automation tooling and broad systems integration.

EXHIBIT 2.1.5

Tokenization Platform Provider Archetypes

Provider type	Commentary	Examples
Transaction Manager (HSBC, Goldman Sachs)	Transaction Managers are developing proprietary tokenization platforms as a method of enhancing relationships and building competitive advantage.	• HSBC Orion • GS DAP • DBS FIX
Security Lifecycle services provider (Nasdaq, LSEG)	Providers with involvement across the securities lifecycle (e.g., exchange groups). This is an area where securities service providers could play a key role in the future.	• NASDAQ Primary • LSEG DCM Flow
Specialist platform (S&P, Bloomberg)	Specialists are developing transaction manager and exchange neutral platforms.	• S&P Issuer Services (IssueNet etc.) • New entrants like PrimaryBid, Origin Markets, Nivaura (acquired by NowCM)
Digitally-native providers	Digitally-native providers are emerging to support banks and NBFIs in their secondary trade process including tokenization platforms (e.g., to issue tokens, decentralized exchanges) to enable liquidity formulation in primary issuance	• Securitize • Uniswap

Source: BCG analysis.

Financial Impact and Opportunities

- A recent study estimated that tokenizing investment-grade bonds could generate annual savings of USD 40–60 million per $100 billion in issuance by reducing intermediaries and automating processes through smart contracts.[202] An issuer handling $1 billion in annual volume could realize $2–3 million in cost savings.[203]

Introduction of DLT into the Primary Market Issuance workflow may provide the following benefits:

Cost and time benefits

The technical design of Security Tokens would likely be digitized around industry-adopted standards (such as ERC-3643 and ERC-1400).[204] Decoupling from traditional convention and documentation—where existing workflow has evolved from manual processes toward digitized (e.g., syndicate desk collecting bids and issuing updates via email, and lengthy security documentation)—may support the step-change in issuance efficiency in relevant areas where issuance inefficiencies are particularly focused.

In these selected instances, reduced issuance cost may increase Primary Market Issuance volume by reducing issuance friction and enabling access to capital markets for (small-medium-enterprises ("SMEs") and other currently underrepresented issuers. Bespoke securities may be issued directly to investors to meet individual needs.

Issuance innovation

Security Tokens may unlock new ways to deliver existing features or drive innovations, such as:

- *Smart contracts:* embedded governance over cash flow waterfall, covenants, types of security (assets as collateral and guarantees), and investor entitlements (liquidation preference, drag-along clauses).

- *Bespoke distinction by investor:* For example, initial public offering ("IPO") investors can earn bonus special incentives if they hold on to their allocation for a certain duration, promoting the interests of the Issuer. These could be programmed on a more customizable basis, with the execution of these incentive payments automated through smart contracts. Similarly, lock-up clauses may be programmed into the token to ensure adherence to issuance contract. For example, stock held by management and employees could offer additional benefits (e.g., use as collateral) while the investor is affiliated with the Issuer.

- *New characteristics:* daily coupons, non-standard reference rates, revenue-based finance, and green-bond securities could be available and achievable to Issuers and Investors at a lower cost.

These innovations build on existing investor products and propositions and could additionally make it easier to trade different entitlements separately from the underlying security through DLT.

Buyside collaboration

The introduction of tokenization platforms may allow investors (once deals are publicly announced and in line with existing mandatory market pre-trade transparency requirements) greater a) systematic influence over security supply and design; b) the ability to participate in private placements or share risk through cornerstone investments; and c) the ability to collaborate with other investors through the issuance process.

Fractionalization

Fractionalization offers the potential to enable broader access to liquidity by allowing investors to purchase smaller tickets, diversifying the investor base, and supporting secondary liquidity. Investors may be able to further diversify idiosyncratic risk by holding a wider range of securities. It should be noted that the functionality described above can be preserved, even when the original Security Token has been subdivided multiple times.

202. BCG, Ripple, "Approaching the Tokenization Tipping Point, April 2025
203. Ibid.
204. ERC-3643 is a token standard for the management and transfer of security tokens, while remaining compliant with rules and regulations. ERC-1400 is a proposed standard for security tokens that incorporates many of the features (e.g., error signalling, issuance semantics) in traditional securities).

Additional opportunities:

- **Cost to the ecosystem:** In the near term, participants in the issuance process would require significant capital and operational expenditure to build the underlying technological architecture, smart contract platforms, and test-nets central to DLT-based issuance processes. Participants would also need to consider the operational expenses of hiring the appropriate resources, additional workflows required to drive trust in the system, and general switching costs that underly any technological transition.

- **Introduction of DLT-based asset lifecycle management platforms:** Many participants in capital markets would see strategic benefit in developing a DLT-based asset lifecycle management platform to service and attempt to influence the market structure of primary market issuance workflows. These platforms are seen as attractive market positioning; however, fragmentation arising from differing platforms offered by multiple participants in this space may instead increase the cost to market participants and challenge goals of standardization.

- **Focused asset class use cases:** To drive significant market adoption, highly targeted use cases are recommended. Focusing on a very clearly defined target market could help product development, build secondary liquidity, and be seen as a credible primary issuance option.

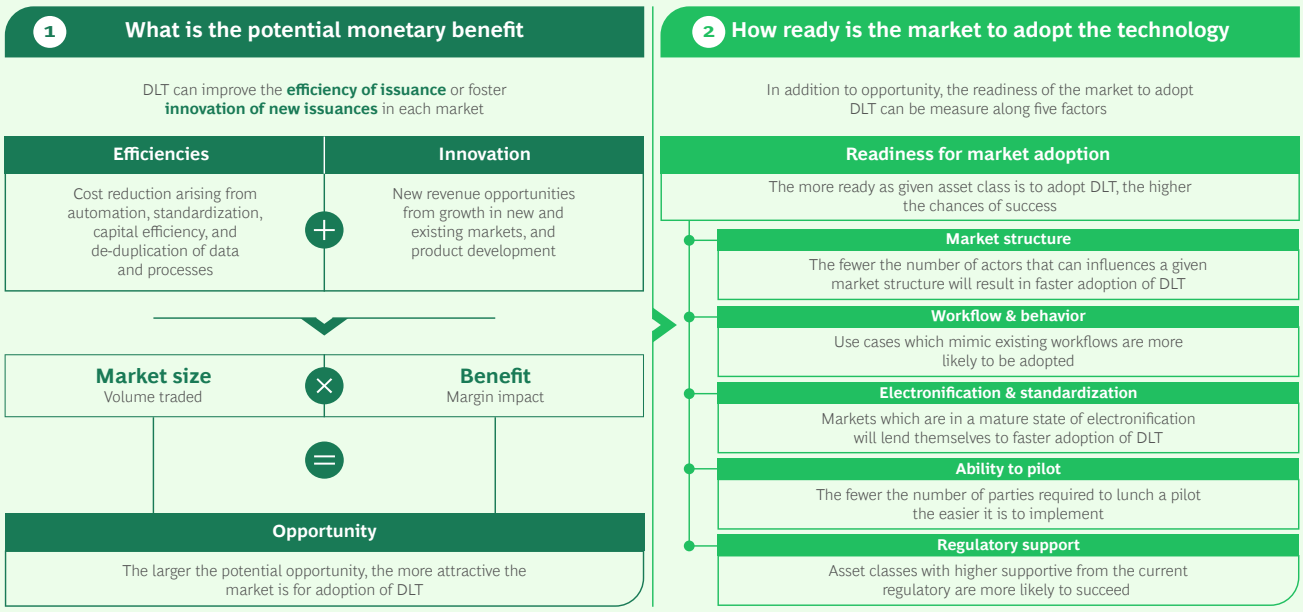
Transitioning existing markets to Security Token primary issuance by asset-class and workflow

Issuance workflows by asset-class are highly heterogenous. The following framework is proposed to inform analysis of market adoption to consider both the a) opportunity, and b) readiness of a market to adopt Security Token issuance.

As presented in the Executive Summary, we find there is significant distribution on a global asset-class level in the opportunity and readiness for market adoption of Security Token issuance. Issuance workflows that are recurring, frequent, and offer benefits from improved operational efficiency and/or product innovations are likely to adopt issuance of Security Tokens first. Looking ahead, market participants could align on specific use cases to build meaningful adoption, pooling Secondary Market liquidity, and proving the viability of Security Tokens (i.e., D2D intraday repo or five-year unsecured fixed-rate investment-grade U.S. credit).

EXHIBIT 2.1.6

Framework to Inform Market Adoption of Security Token Issuance



Source: BCG analysis.

Risk Impact

The implementation of DLT in Primary Markets introduces some limited risk mitigation considerations. Refer to the **Chapter 1.4 | Risk Mitigants** section for a discussion of these risks in detail, along with proposed mitigations. This commentary focuses on evaluating the potential of DLT to mitigate existing risks in the Primary Markets stage of the securities lifecycle.

Operational Risk: DLT can mitigate existing operational risk in Primary Market Issuance processes through the use smart contracts to (a) coordinate many-party issuance processes, (b) reduce the chance of errors by an individual party through independently coded checks and (c) use multi-party verification processes to ensure individual errors are not propagated throughout the system. However, these mitigations are likely to be marginal in the near-term, requiring widespread adoption of DLT across the many participants in the primary issuance workflow to be realized in full.

Legal and Compliance Risk: Representing the primary market issuance process on a shared, transparent ledger (at a minimum the non-competitive portions of the process) can aid Transaction Managers in ensuring compliance with legal and regulatory reporting requirements and/or improve transparency for would-be investors. The level of mitigation that can be realized is dependent on the degree to which applicable laws and regulations are updated to allow for DLT-based reporting.

DLT could aid market participants in mitigating some forms of operational risk. Ultimately, the primary market issuance stage of the lifecycle is a key enabler to realize the downstream risk mitigation benefits in the post-trade, and asset servicing and lifecycle management stages of the securities lifecycle.

Secondary Market Trading

This chapter provides an overview of participants, key activities, and critical inefficiencies that exist today. This provides a baseline for an impact assessment of DLT, considering **different models of implementation** and **impact on activities, roles and responsibilities, opportunities**, and **risk**.

SUMMARY OF IMPACT ASSESSMENT — **MEDIUM**

Trading (i.e., order matching) is highly efficient across many asset classes and centralized execution venues (e.g., public equities). No immediate disruption to market structure impact is expected. As the DLT-based ecosystem develops, however, DLT may facilitate access to infrastructure for use across the securities lifecycle, including trading. Crucially, DLT-based investor platforms with features such as Tokenization and fractionalization, could help pool and deepen trading liquidity in secondary markets for traditionally illiquid asset classes, such as unlisted equities and unlisted investment funds, and broaden market access.

Innovative propositions could also be developed, such as automated securities selection and portfolio balancing, and real-time carbon finance tracking. However, establishing these new markets may be a challenge as due to limited liquidity, lack of counterparty certainty, and inability to integrate new processes into existing workflows.

Implementation models: DLT-based Securities are likely be traded on centralized execution venues, then settled on the distributed ledger. Broadly, two forms of execution venue may emerge:

1. **Execution venue for traditional securities:** Transacts at an International Securities Identification Number ("ISIN") level; modifications may be made to incorporate Tokenized Securities matching that ISIN.
2. **Execution venue for DLT-based Securities:** Primarily transacts at a token identifier level, built to natively incorporate DLT-based security features such as token programmability, atomic settlement optionality, and fractionalization.

Activities: Liquidity is likely to pool in select asset classes where there is clear opportunity and market readiness but may not be evenly distributed across asset classes nor Tokenization types. Asset quality, market depth, and listing standards will remain critical factors for market participants as they consider whether they should hold Security Tokens for active trading.

- **Security Tokens have seen low secondary market liquidity** as experimentation has been focused on core DLT infrastructure, primary markets issuance and settlement, and repos.
- Due to a lack of liquidity to-date from fragmentation of on-chain liquidity pools for tokenized financial instruments, **investors are not incentivized to hold Security Tokens for active trading**, which impede Secondary Market liquidity growth and should be addressed to encourage adoption.

SUMMARY OF IMPACT ASSESSMENT	MEDIUM

- As DLT-based markets develop, it is likely liquidity could become bifurcated by security format:
  - Existing investors and automated market makers can bridge liquidity between traditional securities and Tokenized Securities through Tokenization/de-Tokenization workflow.
  - Liquidity cannot be seamlessly transferred into security tokens, reinforcing the need for a distinct security token format basis. Market makers could likely take a role trading this risk, using traditional securities as an imperfect hedge.
  - It should be noted that these risks already exist in today's market, e.g., depository receipts compared with ordinary shares, or multi-listed ETFs and equities.
- Focusing efforts on **building secondary liquidity in smaller pools** of securities to achieve comparable liquidity conditions will likely be more beneficial than attempting to build broad markets simultaneously as markets evolve.

Roles: Market structure is unlikely to be disrupted in the near term, but new DLT-based investor platforms could emerge and mature as the DLT ecosystem develops.

- The current trading ecosystem is a highly complex array of liquidity pools that vary based on asset class, investor base, jurisdiction, and order characteristics (including transaction size, urgency of execution, and signaling of information).
- Existing market structure may be entrenched by the following factors:
  - Trading and settlement roles have value in independence as they have distinct market relationships (front office vs. back office), expertise (human workflows vs. process optimization), and value in the supply chain (high fee rate vs. low fee rate).
  - Compatibility and integration with existing trading infrastructure and independent clearing and settlement providers.
  - Workflows and behaviors are difficult to change (as evidenced in the corporate bond market). New liquidity pools could likely integrate into existing trading workflows and infrastructure.
- That said, the expectation is closed trading models and new secondary mark integrated with DLT investor platforms that are built outside of existing trading workflows and independent to net settlement may realize consolidation of these roles.

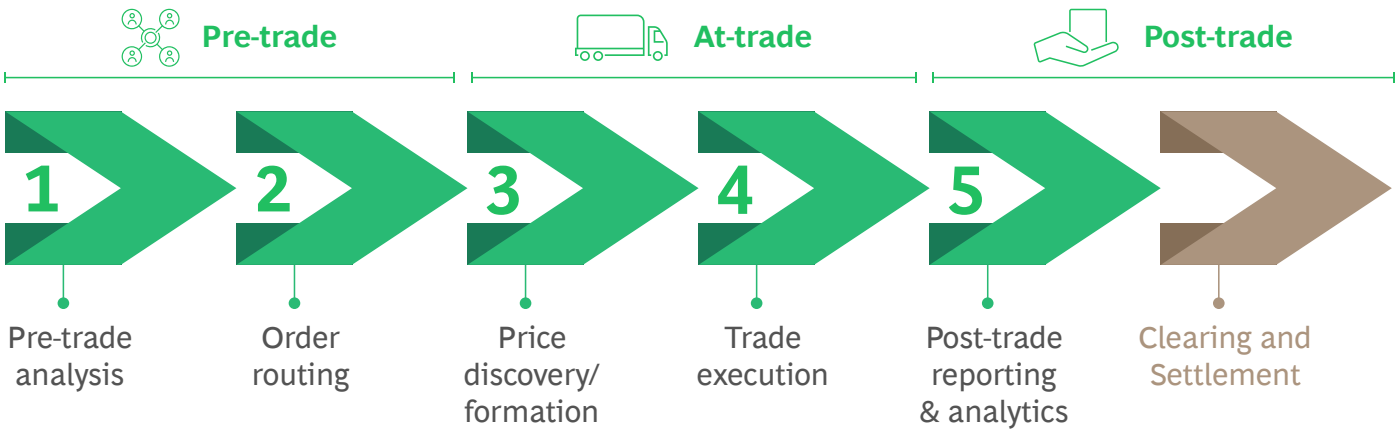
Opportunities: New markets, new protocol, and integration efforts offer attractive opportunities.

- The Tokenization of illiquid asset classes, such as unlisted equities – together with fractionalization, allowing smaller ticket sizes while retaining the programmability benefits of whole-unit DLT-based Securities – offer the most attractive secondary market growth opportunities.
- New features such as automated securities selection for portfolio balancing, interest payment frequency or swaps, ESG tracking; and use of event triggers to enable faster sourcing of securities for use in derivatives.
- There would be a significant additional cost to operate and transact on a duplicative new secondary trading ecosystem initially. To manage this, participants should focus on building secondary liquidity in targeted use cases with an innovative protocol:
  - To aid market adoption, connection to new liquidity pools and integration of workflows into existing systems is critical. OEMS could be leveraged to advance these platform developments. In doing so, they could strengthen their competitive position in a tokenized trading environment.

Current State and Inefficiencies

EXHIBIT 2.1.7

Detailed Pre-, At-, and Post-Trade Workflows



Source: BCG analysis.

Pre-Trade

Pre-trade analysis:
Before a trade is executed, traders conduct pre-trade valuation and analytics to determine optimal order routing and trading tactics, utilizing information in a manner consistent with regulatory requirements. Implementation may be through rules-based trading strategies or on a trade-by-trade basis, in each case compliant with applicable laws and regulations. There are existing inefficiencies around market data accessibility such as, the cost to purchase, and the difficulty to integrate it into pre-trade workflows. In some asset classes, market data may be of poor quality or absent entirely. Proprietary data sets and valuation tools create an unlevel playing field.

Order routing:
Before a trade is executed, traders conduct pre-trade valuation and analytics to determine optimal order routing and trading tactics, utilizing information in a manner consistent with regulatory requirements. Implementation may be through rules-based trading strategies or on a trade-by-trade basis, in each case compliant with applicable laws and regulations. There are existing inefficiencies around market data accessibility such as, the cost to purchase, and the difficulty to integrate it into pre-trade workflows. In some asset classes, market data may be of poor quality or absent entirely. Proprietary data sets and valuation tools create an unlevel playing field.

At-Trade

Price discovery/formation and trade execution:
Price discovery varies based on venue protocol; order books consolidate bid and ask orders, with crossed orders matching a trade, whereas request-for-quote ("**RFQ**") protocol generates quotes from counterparties that are confirmed to create a trade. Illiquid markets present difficulties matching buyers and sellers for instruments at the required volume and price. In these markets, the main inefficiencies are counterparty matching, information leakage, and price information asymmetry. Asset classes with a wide universe of security characteristics, such as corporate bonds, pose particular challenges.

Challenges are also faced in non-electronic markets that are traded telephonically or over email or chat. For example, fully electronic orders represent only 45% of transaction market share in corporate bonds.[205] In these markets, trade details must be captured and fed into post-trade workflows manually for settlement.

After-Trade

Execution venues and market participants record, monitor, and report trade data for risk management and regulatory purposes.

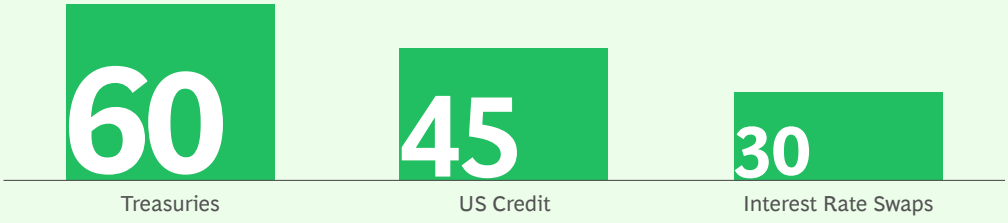
Electronification of Secondary Markets

Electronification first emerged in equities and FX, then across Treasuries, corporate bonds, and derivatives. Today, a significant proportion of the global securities pool has not undergone electronification, as shown in **Exhibit 2.1.8**. While electronic execution is more efficient, some asset classes and trade types rely on channels such as voice and chat. Non-electronic execution is especially prevalent for equities block trades, corporate bonds, and interest rate swaps. The impact of DLT on secondary trading may be limited in markets with a high degree of electronification today.

EXHIBIT 2.1.8

Major Markets Are Still Undergoing Electronification[206]

Estimated institutional client electronic execution market share (%)



Source: Morgan Stanley Equity Research Report.

205. Morgan Stanley, Tradeweb "Why we remain overweight" Research Report, 1 Nov 2022.
206. Morgan Stanley, "Why we remain overweight", Nov 2022.

Summary Impact Assessment: Medium

The overall impact of DLT and DLT-based Securities on Secondary Trading is expected to be **Medium.** DLT itself is not viewed as an impactful force; however, DLT-based investor platforms using new features such as Tokenization and fractionalization could drive impact over the long-term. Secondary trading liquidity must first be established to support a DLT-based ecosystem. This chapter analyzes direct impact and the steps necessary to build secondary trading liquidity.

EXHIBIT 2.1.9

Secondary Market Trading Impact Assessment

Trading	Investors	Broker-dealer	Execution venue	(OEMSs, Risk Management, and Data)
A Pre-trade	Low	Low	Medium	Medium
B At-trade	Low	Medium	Medium	Medium
C After-trade	Low	Low	Low	Medium

Source: BCG analysis.

Models of Implementation

New liquidity pools could likely be required to support secondary trading of DLT-based Securities. Decentralized exchanges ("DEXs") are an emerging model of implementation in Secondary Trading predominantly used today in cryptoasset markets (e.g., on public permissionless networks to trade cryptocurrencies). However, there are initiatives underway such as Project Guardian and others to explore the use of DEX-type infrastructure for use in securities trading that may proliferate as tokenized capital markets expand. While the use of DLT for Books and Records may support elements of the trade lifecycle for traditional securities, it is not relevant for trade execution and therefore is not covered here.

Activities

Trading activities and workflows may broadly remain unchanged from traditional markets; however, adaptations are expected:

Trading Workflow Evolution

Existing workflows can also be adapted to incorporate Tokenized Securities into traditional liquidity pools. RFQ-based execution venues can include additional parameters to specify security format, settlement time, and settlement system. For example, the token identifier (rather than just ISIN) at the point of trade may be included, or the option to lock the token on a distributed ledger until settlement may be utilized.

Transformation Workflows

Workflows may be introduced to bridge liquidity between traditional securities and Tokenized Securities, thereby minimizing price disparity. There are two broad models for bridging liquidity between traditional and tokenized formats of securities:

a. Owners of securities may request their custodian to initiate a Tokenization process which will move the record of ownership from a CSD to the distributed ledger through a Tokenization platform; or

b. Participants in secondary markets may generate trading volume which allows automated market makers to provide cross-format liquidity in return for trading profits.

Assuming equivalently low transaction costs and trading risk across both these models, the combination of these models could support the formation of similar liquidity characteristics across the two security formats..

DLT-based Security trading may allow the following innovations:

- **Market data:** Recording transactions on interoperable and standardized distributed ledgers may improve accessibility and reduce cost of market data.

- **Certainty of settlement:** Optionality for atomic settlement and/or locking Security Tokens on the distributed ledger until settlement could reduce the rate of failed trades, the time delay for settlement and the need to manage risks during legacy settlement periods (as discussed in **Chapter 2.1.3 | Clearing and Settlement**) improving trader outcomes and potentially reducing risks and costs.

- **Order routing:** Enhanced use of data allowed by DLT may improve the ability to identify investors and improve the ability of buyers to identify potential sources of the security product in which they seek to invest.

- **Increased electronic trading:** The design of digital security liquidity pools is likely to be exclusively accessible electronically, which could reduce the proportion of trades executed through voice channels.

Evolved Roles and Responsibilities

Few changes are expected to existing roles and responsibilities of actors in the secondary market trading ecosystem.

Multilateral Trading Facilities ("MTFs") and CSDs

The most publicized potential evolution in market structure is collapsing the distinction between execution venues and clearing and settlement systems. This is supported in the E.U. Pilot Regime, through the creation of the role DLT TSS (trading and settlement system), which is an aggregation of DLT MTF (multilateral trading facility) and DLT SS (settlement system) roles.[207] While this implies MTFs can compete with CSDs to provide settlement services, and CSDs can move up the value chain by aggregating liquidity in competition with MTFs, the potential impact of market structure disruption is considered low for the following reasons:

- Traditional and native Security Token markets may need to operate in hybrid for the foreseeable future, supporting the persistence of existing roles.

- Central Counterparty Clearinghouse ("**CCP**") enabled netting is most effective when trades are pooled from a variety of execution venues. This supports the ongoing role of an independent settlement system, likely to be operated by existing traditional market providers.

- Marketplace operation is a highly specialized business, requiring strong relationships with front-office traders and expertise in evolving market trading protocol. In contrast, CSDs predominantly interface with middle- and back-office stakeholders and focus on implementation of robust processes.

The TSS role is likely of higher utility in closed trading models and new secondary markets that are not reliant on existing settlement infrastructure or integration with existing CCP netting workflows.

OEMSs

OEMSs can have a key role in developing workflows, connecting to different liquidity pools, integrating new data, and enabling investor behavioral change.

Broker-dealers

Current broker-dealer services such as provision of liquidity, risk management, financing, analytics, and advisory may likely evolve to cover DLT-based Securities. Over time, broker-dealers are expected to remain relevant partners for institutional investors.

New entrants

Significant network effects, expertise in market development, and deep integration with existing systems position marketplace operators at a competitive advantage when it comes to developing secondary markets for Security Tokens. While innovation may be pioneered by new entrants, incumbents are expected to form partnerships with, acquire, and/or replicate successful functionality of new entrants to broaden their existing offering.

207. Report on the DLT Pilot Regime, September 2022.

Bridges

A new role/responsibility could be created for a party to bridge liquidity across security formats. Automated market makers may likely perform the role of transforming traditional securities to Tokenized Securities, and vice versa. They may also provide liquidity across liquidity pools.

Financial Impact and Opportunities

The following factors are likely to present a challenge in secondary market trading:

- **Liquidity provision** relies on network effects. New liquidity pools without participation from the full market are highly likely to exhibit poorer liquidity conditions. Execution venues and market participants should prioritize building pockets of liquidity in digital security markets, instead of creating large markets with low participation.
- **The financial cost** to the industry to develop, integrate, and operate duplicative systems may be significant.
- **Securities are often traded in cross-asset baskets** (or lists) to complete sophisticated risk-management processes. For example, lists of OTC derivatives may be traded to achieve margin compression[208] and credit and futures may be traded to manage interest-rate risk.[209] DLT-based trading may need to support multi-asset trade processes.

Risk Impact

Utilizing DLT in Secondary Trading can give rise to a limited set of risk considerations and new mitigations. **Chapter 1.4 | Risk Mitigants** provides an in-depth examination of these risks, along with suggested mitigations. This discussion instead assesses the potential of DLT to mitigate existing risks in the secondary market trading stage of the securities lifecycle.

Operational Risks: In the long-term DLT can enable a net decrease in the total number of systems, platforms, and integrations required to access trading markets. DLT can offer a single, common, interface to connect internal systems with, across many asset classes. This potential for risk mitigation could be especially impactful when combined with the existing protocols (e.g., FIX) that traditional trading systems have used to standardize messaging and cross-participant interactions. In the near-to-medium term this benefit may be incremental as trading systems may need to be duplicated as traditional and DLT-based markets run in parallel.

Liquidity Risk: Fractionalization of DLT-based Securities has the potential to aid market participants in mitigating liquidity risk by allowing smaller ticket sizes and greater investor access. These effects could be particularly impactful in historically illiquid asset classes, such as types of asset-backed-securities.

Given the limited impacts to existing market structure, incremental risk mitigation may be limited. As Secondary Markets for DLT-based Securities mature, this could act as an enabler to the risk mitigations across the post-trade lifecycle, as outlined in Clearing and Settlement, Custody and Asset Servicing.

Clearing and Settlement

This chapter provides an overview of participants, key activities, and inefficiencies that exist today. This provides a baseline for an impact assessment of DLT, considering **different models of implementation** and **impact on activities, roles and responsibilities, opportunities**, and **risk.**

SUMMARY OF IMPACT ASSESSMENT	HIGH

DLT-based clearing and settlement has the potential to act as an additional, complementary channel alongside existing clearing and settlement infrastructure. This is only expected to impact specific asset classes and transaction types that favor adoption and where secondary market liquidity could pool – not the broader traditional market (depending on the evolution of DLT-based capital markets, it may apply to derivative transactions, but at this time, we remain general in our assessment, focusing primarily on DLT-based Securities at this time).

Note: clearing and settlement is defined here to include netting, novation (e.g., CCP-related processes), affirmation, confirmation, and allocation (e.g., post-trade processes), and instruction, confirmation, and execution (e.g., settlement processes).

208. Osttra, Portfolio Compression, Feb 2023.
209. Tradeweb, Multi-Client Net Spotting, Feb 2023.

SUMMARY OF IMPACT ASSESSMENT	HIGH

Implementation models: Four models of DLT-based clearing and settlement workflows are possible. This ranges from Books and Records (i.e., no use of DLT-based Securities and DLT-based Payment Instruments) to fully developed settlement systems for DLT-based Security transactions using DLT-based Payment Instruments. Benefits increase as implementation models broaden in scope.

Synchronization of Clearing and Settlement: For specific asset classes and transaction types, DLT could synchronize clearing and settlement into a continuous single workflow, with smart contracts enabling the frontloading of post-trade and pre-settlement processes into a single transaction. In a DLT-based ecosystem, this could reduce the likelihood of trade fails in specific markets and/or asset classes where this is a known problem and create the potential for back-office efficiencies more broadly. Smart contract execution would require pre-funding and pre-positioning of securities before trades are executed. There are also multiple enablers required including electronification, interoperability with existing systems, and common data standards.

Flexible settlement options: DLT-based settlement infrastructure could play a supporting role in the industry's long-term progression toward more efficient settlement and greater optionality in settlement timing which has the potential to reduce relevant risks. This could give rise to a future capital markets ecosystem where decisions on settlement speed are made on a trade-by-trade basis, driven by needs around liquidity and financial resources. Transaction types such as collateral payments for repos and OTC derivatives could also be served by a DLT-based model with real-time DvP. Today, DLT-based settlement is already occurring in the intraday repos market.

Evolution of CCPs: CCPs play a critical role, including netting transactions and managing counterparty credit risk, which could eventually be supported through smart contracts with appropriate market conduct safeguards. DLT-based settlement in specific asset classes and transaction types can also enable bilateral and multilateral trading that offers an alternative model to central clearing (assuming clearing is not required by regulation), with attractive capital efficiencies and risk mitigation.

Capital efficiency: DLT-based settlement cycles in specific asset classes and transaction types could unlock capital efficiencies in margin and clearing fund requirements for clearing member firms. A recent industry study estimated that a global bank managing around $100 billion in daily repo transactions could realize $150–300 million in annual cost savings by using tokenized collateral and instantaneous settlement.[210] The extent of these benefits will depend on the degree to which the CCP remains prevalent in the post-trade and clearing lifecycle.

Financial, Operational, and Systemic Risk Mitigations: Where DLT-based settlement is operationally feasible and desirable in specific asset classes and transaction types, it could provide alternative approach to address operational inefficiencies and mitigation of replacement cost risk through automated settlement cycles – reduction of settlement risk by means of DLT-based settlement could have material benefits to both individual market participants and financial system. DLT could also mitigate operational risk through automated processing of post-trade activities (e.g., confirmation, affirmation). DLT could also provide an alternative risk mitigation model to CCPs, including the precise allocation of replacement cost and principal risk to transacting counterparties. Resilience could also be increased by distribution across the network, reducing single-points-of-failure.

Current State and Inefficiencies

Over the last two decades, significant advances have been made in clearing and settlement efficiency. This is marked by increased automation, industry-wide data standardization (e.g., International Swaps and Derivatives Association ("**ISDA**"), International Securities Lending Association ("**ISLA**"), **ICMA**, and FinTech Open-Source Foundation's (FINOS) development of the Common Domain Model),[211] and the growth of central clearing to drive counterparty credit risk mitigation. In the ongoing search for further advancements, market participants highlighted specific opportunities that may be addressable by DLT in specific asset classes and transaction types, and may address operational inefficiencies, operating cost, financial resource inefficiencies, and risk within Clearing and Settlement workflows. The industry has also seen substantial gains in settlement efficiency and associated capital savings from the structured transitions to market-wide shorter settlement cycles, most recently the 2024 move to T1 settlement in the US, and expects further gains from the EMEA T1 transition scheduled for 2027. These are summarized below:

Back-Office Operating costs: Batched processing, legacy systems, and other administrative expenses are significant cost drivers for the industry. In payments, cross-border settlement can be almost twenty times more expensive than domestic transactions.[212] This is driven by transaction fees, account fees, compliance fees, and other drivers. Fees are amplified in countries with less established correspondent banking networks.[213] Given a material share of these costs are in highly-efficient products, they may not be immediate targets for transformation but could still drive material cost savings.

210. BCG, Ripple, "Approaching the Tokenization Tipping Point", April 2025.
211. FINOS, "Common Domain Model – Resources", accessed 2025.
212. BIS, "DLT-Based Enhancement of Cross-Border Payment Efficiency – a Legal and Regulatory Perspective", 2022.
213. Ibid.

Opportunity cost of trapped collateral: Market participants fund CCPs by posting collateral, usually in the form of cash or securities for use in a clearing default fund, as well as for margin requirements. The total value of global outstanding collateral exceeded $25.5 trillion EYR in Q1 2024.[214] For CCPs clearing derivatives—where margin requirements are primarily driven by financial risk factors such as market movements over the margin period of risk—the total amount of margin is unlikely to be significantly reduced by DLT, as these risks are not operational in nature (i.e., cannot be eliminated by reducing the settlement period).

Manual processing of collateral payments for centrally cleared OTC derivatives: For centrally cleared contracts with margin requirements, periods of market volatility can suddenly and materially increase margin thresholds, with asset managers rapidly needing to meet margin calls. Asset managers faced spikes in initial margin calls during the high-volatility period of March 2020 after the outset of the COVID-19 pandemic, with increases in initial margin requirements as high as 125% in some equity index futures, when comparing January 1 and March 30, 2020.[215] Manual processing, the lack of data standards and interoperability in the collateral management ecosystem, and delayed settlement can create systemic risk in such scenarios, also demonstrated more recently in the U.K. liability-driven-investing ("**LDI**") crisis in September 2022.[216]

Cost of risk management: Operational, credit, and systemic risk continue to be areas that participants in post-trade processing incur significant overhead to manage. Complex workflows with multiple steps (e.g., confirmation, affirmation, instruction generation) between many participants (e.g., CCPs, clearing members, global and local custodians, CSDs), within post-trade processes, drives reliance on expensive operational risk mitigants such as reconciliations between parties and manual checks. This cost is reported to be rising year-on-year.[217] Deferrals between trade and settlement execution introduces counterparty credit risk, comprised of replacement cost risk and principal risk, that participants manage using a CCP. Since their introduction, CCPs have provided proven and effective risk mitigation. But the model, particularly given the increase in volumes cleared, also represents a single-point-of-failure. Although advances have been made in managing these risks, participants bear significant costs to effectively mitigate them.

Summary Impact Assessment: High

The impact of DLT on Clearing and Settlement is **high, across all participants and most activities.**

This assessment will consider four different models of DLT-based settlement and consider the potential of DLT-based settlement to drive participant choice in settlement cycles. In addition, it will assess the impact of DLT on key workflows in the post-trade value chain, including margin management. Finally, it will describe the financial impact and potential risk mitigations DLT-based settlement may enable.

Models of Implementation

There are four models of DLT implementation within each of Clearing and Settlement to achieve the execution of DvP, the digital exchange of securities and cash that can enable atomic settlement. The models are derived from the varying role (or lack thereof) that DLT could play across both the securities leg and the payments leg of a transaction. A books and record implementation has neither DLT-based Securities nor DLT-based Payment Instruments. In models where DLT-based Securities exist, the payment "leg" can be enabled by traditional or DLT-based Payment Instruments.[218,219] Furthermore, DLT-based Securities systems can exist on a single distributed ledger or be synchronized with multiple distributed ledgers to integrate with a DLT-based payment system.[220] All four models are summarized in the diagram below and explained in further detail.

Settlement System 0 (SS0): No DLT-based Securities or DLT-based Payment Instruments; DLT used as "Books and Records". In this model, there are no forms of DLT-based Securities nor forms of DLT-based Payment Instruments. Instead, DLT acts solely as a cross-participant database facilitating updates between participants, but settlement execution and finality remains with the CSD via custodian accounts and must be reconciled on existing systems.

214. Refer to the Collateral Management use case in Deep Dives. Collateral market tops €25 trillion, expanding the argument for DLT solutions – Finadium.
215. Blackrock, "CCP Margin Practices Under the Spotlight", 2022.
216. Refer to the Collateral Management use case in Deep Dives.
217. Value Exchange, Digital Asset, "Doing Tokenization Right", 2022.
218. BIS, "On the Future of Securities Settlement", 2020.
219. Benos, Garratt, Gurrola-Perez, "The Economics of Distributed Ledger Technology for Securities Settlement", 2019.
220. Adapted from in BIS, "On the Future of Securities Settlement", 2020 & Benos, Garratt, Gurrola-Perez, "The Economics of Distributed Ledger Technology for Securities Settlement", 2019.

EXHIBIT 2.1.10

Impact Assessment of DLT on Activities and Participants in Clearing and Settlement

Clearing	CCP	Clearing Members	Trading Members
Confirmation and matching	High	High	N/A
Risk review	High	High	N/A
Netting	High	Medium	N/A
SSI Generation	High	High	High
Margin Management	High	High	Medium

Settlement	CSD	Local Custodian	Global Custodian	Investor
Instruction	High	High	High	High
Positioning	High	Medium	N/A	N/A
Settlement	High	High	N/A	N/A
Notification	High	High	High	N/A
Fails	High	High	High	High

Source: BCG analysis.

Settlement System 1 (SS1): DLT-based Securities but no DLT-based Payment Instruments; payment settled in traditional accounts. DLT-based Securities would settle on a distributed ledger, but payment would be coordinated through existing payment systems (e.g., FedWire) or in commercial bank model (prevalent among international central securities depositories, such as ClearStream[221]). This model has already seen implementation in the market, with DLTs integrated with traditional payment systems. For example, a World Bank issuance, where Security Tokens called *Bond-i* were issued but payment was settled using cash in traditional accounts.[222] The European Investment Bank digital bond issuance also ultimately settled on Target2, the RTGS system operated by the Eurosystem.[223]

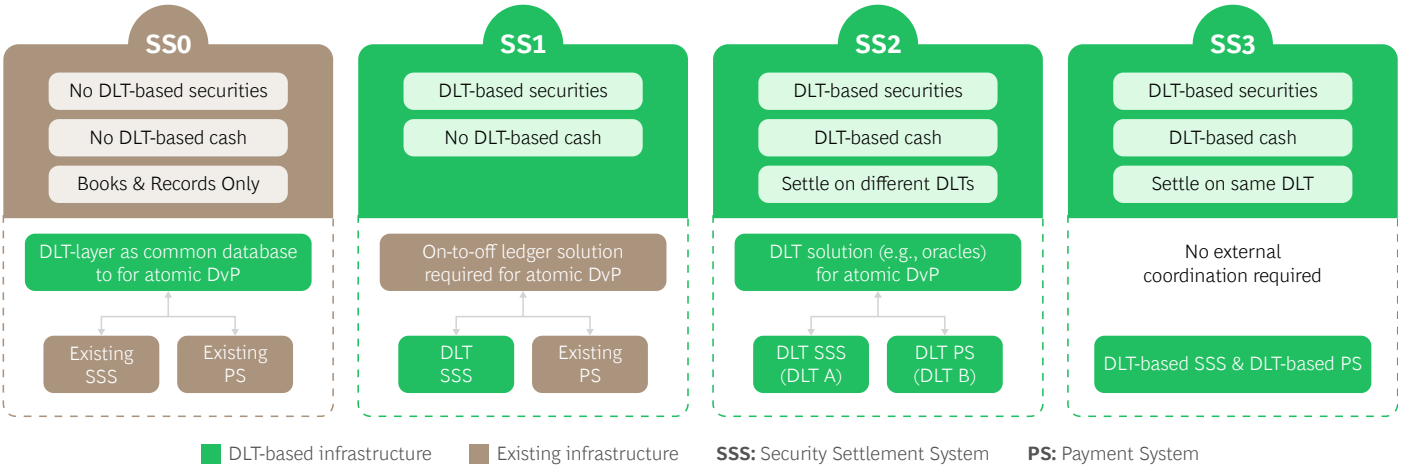
Settlement System 2 (SS2): DLT-based Securities and DLT-based Payment Instruments, settle on different ledgers: DLT-based Securities would settle on one distributed ledger, and payment would be coordinated through interoperability with a separate distributed ledger. This model would facilitate a form of tokenized commercial bank money (including deposits), and DLT-based Payment Instruments issued by a central bank (e.g., wholesale tokenized central bank money or reserves), or use of DLT as the foundation for RTGS systems. Market examples of this include Project Stella (European Central Bank and Bank of Japan), Project Ubin III (MAS),[224] and the Bank of England's synchronization payments layer concept.[225]

Settlement System 3 (SS3): DLT-based Securities and DLT-based Payment Instruments, settled on the same ledger. DLT-based Securities and DLT-based Payment Instruments both settle on the same distributed ledger—this model could simplify settlement and allow for more flexible use of smart contracts and other DLT-native technologies such as composability (outlined in **Chapter 1**).

221. Clearstream, Commercial Bank Money Settlement, 2023.
222. BIS, "On the Future of Securities Settlement", 2020.
223. Central bank interviews.
224. BIS, "On the Future of Securities Settlement", 2020.
225. Bank of England, "Background Guide to Proposed RTGS Functionality: Synchronization", 2019.

EXHIBIT 2.1.11

Comparison Models of DLT-based Settlement Implementation



Source: BCG analysis.

Regulated Settlement Network (RSN): An Example of Model SS3

The Regulated Settlement Network (RSN) represents an operating model with the potential for significant advancement in capital market infrastructure, demonstrating through a proof of concept that shared ledger technology could be utilized to enhance securities and payments settlement. By integrating tokenized central bank and commercial bank deposits alongside Tokenized Securities on a single distributed ledger, the RSN provided a demonstration of how a cohesive and synchronized settlement solution could function. This technology would facilitate atomic Delivery-versus-Payment (DvP) transactions, enabling securities and their corresponding cash payments to settle simultaneously and irrevocably, significantly reducing traditional settlement and counterparty risks.

One key advantage of the RSN would be its continuous operation, offering round-the-clock settlement capabilities. This always-on functionality would support global markets where participants increasingly demand precise and flexible settlement options. Moreover, the RSN's use of smart contracts would automate various transactional processes, reducing manual intervention and potential errors, thus enhancing overall efficiency and accuracy.

Interoperability was central to the RSN proof of concept design, allowing seamless integration with other regulated financial networks and infrastructures. Such connectivity would facilitate comprehensive visibility and improved liquidity management across multiple financial systems. Participants could coordinate transactions effectively, ensuring optimized collateral and liquidity usage.

Additionally, the RSN would address persistent challenges in legacy settlement systems, such as fragmented infrastructures, delayed settlement cycles, and inefficient liquidity management. Its innovative architecture would promote enhanced transparency, operational resilience, and regulatory compliance, positioning it as a critical component of modern financial ecosystems. The potential of the RSN extends beyond conventional securities settlements, offering significant benefits in cross-network correspondent banking transactions, intraday repurchase agreements, and various other complex financial arrangements.

In essence, the initiate exemplifies how shared ledger technology can profoundly transform securities and payment settlements, providing a robust infrastructure to meet the evolving needs of global capital markets effectively.

Activities

DLT-based settlement could emerge as an additional, complementary channel for security settlement alongside traditional settlement infrastructure. The impact of DLT-based settlement is likely to be very focused according to specific asset classes and transaction types that favor adoption. DLT is not intended to drive a market-wide move toward shorter settlement cycles. Instead, DLT-based settlement will be shaped by existing settlement cycles in the industry, along with the specific needs of products, markets, and regulatory constraints. For example, operational processes in securities lending, prime brokerage, mutual fund, and ETF fund management are not presently in a position to benefit from shorter settlement cycles, and existing constraints are not fully addressable by DLT either.[226] If it is not optimized for appropriate asset classes and transaction types, DLT-based settlement could instead introduce capital inefficiencies due to the need for pre-funding of cash and pre-positioning of securities before trade execution. At scale, pre-funding could significantly impact the liquidity of market-makers in Secondary Markets. As a result, the majority of asset classes and transaction types are expected to continue settling through existing Clearing and Settlement infrastructure.

The most significant opportunity for DLT-based settlement is for asset classes or transaction types where it is operationally feasible and desirable to settle with enhanced automation and precision. Key examples are repos and OTC derivatives, where collateral payments play a key role. Market participants have been actively exploring the role of DLT in repos, using DLT to perform settlement on an intraday basis. Benefits include the potential to reduce operating costs, free up collateral, and mitigate replacement cost risk. DLT-based settlement can help market participants address pain points in common processes, including posting collateral for repo transactions or variation margin for derivative contract credit exposures. Examples of this include J.P. Morgan Kinexys and Broadridge DLR. They provide precise DLT-based settlement that can be stipulated in contracts, enabling repo transactions that span hours rather than days.[227] Market innovation with targeted initiatives such as these, are most likely to characterize the adoption of DLT-based settlement rather than a "big bang" wholesale change. This also helps manages concerns around the impacts of pre-positioning securities and cash prior to trade execution on market-maker liquidity — settling trades individually will require more liquidity on hand and could introduce more validations within the post-trade process.[228]

Net securities settlement, and the process of netting (which requires a high degree of legal certainty in settlement finality), is an important tool for the efficient functioning of capital markets. The National Securities Clearing Corporation (a U.S.-based CCP) reduces the value of payments that need to be exchanged daily by 98–99%.[229] This materially reduces required liquidity among market participants and the number of total trades that need to be processed, reducing the burden on post-trade processing and technological systems (thereby driving fewer failed trades). Net settlement enables capital benefits and risk mitigations that will remain relevant even as DLT-based settlement emerges. On a longer timeline, DLT could support netting processes using smart contracts.[230]

In this way, DLT-based settlement could play a supporting role in the industry's long-term progression toward more flexibility and optionality in settlement cycles. Flexible settlement could become a feature of the market.[231] This could give rise to a future capital markets ecosystem where decisions on settlement speed are made on a product-by-product, asset-by-asset, and trade-by-trade basis, driven by needs around liquidity and financial resource efficiency.

The impacts of DLT for specific asset classes and transaction types, in a broader ecosystem characterized by optionality of settlement, is likely to be particularly beneficial in four specific areas : (1) enable automated clearing processes; (2) enable new methods of settlement (delivery-vs-delivery); (3) reduce costs for settlement payments, including cross-border payments; and (4) improve margin management, driving more transparent and precise requirements, and increasing the likelihood that asset managers can meet them. Each of these activity-level impacts is described below.

Automated Post-Trade Processing: Use of DLT could enable relevant participants to use a single source of data, reducing the need for sequential processing (e.g., affirmation, confirmation, match messages) and time-consuming reconciliations between legacy systems throughout the settlement chain. DLT can reduce information costs among participants if interoperability is achieved. Standardized data could significantly improve operational efficiency in post-trade processes.[232,233]

New Settlement DvD: DvD settlement is a type of settlement mechanic gaining unique prominence with the rise of DLT, that consists of swapping one security (or basket of securities) directly for another security (or basket of securities), with no involvement of cash or the traditional custody chain. SS0 (books and record use case) is a predominant model of

226. SIFMA, Letter to Vanessa Countryman, SEC, 2022.
227. Ledger Insights, "DBS Executes Intraday Repo Transaction on JP Morgan Blockchain", 2022.
228. BIS, "On the Future of Securities Settlement", 2020.
229. DTCC, "Advancing Together: Leading the Industry to Accelerated Settlement – A Whitepaper", 2021.
230. Swanson, "Decentralized Financial Market Infrastructure", 2020.
231. FINRA, "Distributed Ledger Technology: Implications of Blockchain on the Security Industry", 2017.
232. Chiu, Koeppl, "Blockchain-based Settlement for Asset Trading", 2018.
233. Benos, Garratt, Gurrola-Perez, "The Economics of Distributed Ledger Technology for Securities Settlement", 2019.

implementation for this settlement mechanic. Participants can swap assets in collateral management/repo transactions on a DLT, settling instantly as the DLT provides constant updates to internal custodian Books and Records (and may not need a lengthy settlement process at the CSD). HQLAx's platform is a market example of DvD settlement, based upon the permissioned R3 Corda network. They have created a DLT-based operating model that enables their clients to exchange ownership of securities, between collateral pools, while the underlying securities remains with the CSD and custodian – such certainty in settlement is aided by the permissioned nature of the network on which this solution is based.[234]

Cross Border Payment vs. Payment ("PvP"): The use of a distributed ledger and DLT-based Payment Instruments could have a significant impact on the cross-border payment system, including in payment vs. payment transactions. This includes faster processing speed, access, interoperability in global payment systems, transparency in counterparty liquidity pools, and ultimately lower costs per transaction.[235] Ease of cross-border transactions may potentially have an impact on securities settlement, by encouraging a greater volume of transactions that have a cross-border payment component. However, implementing any effective cross-border payments solution may require programmability of the underlying DLT-based Payment Instruments to effectively meet compliance requirements in all applicable jurisdictions and is beyond the scope of this report.

Clearing Capital Costs: DLT-based settlement could enable incremental improvements in margin and default fund management — driving transparency, reducing costs, and enabling efficiency.

- **Margin:** DLT could drive more automated, transparent, and efficient margin management enabled by more frequent margin calculation settlement of margin calls. Real-time positions available on a DLT-based settlement system can provide CCPs and participants the data needed to compute current exposure calculations more frequently and precisely. Similarly, the role of DLT to coordinate settlement can shrink the gap between exposure calculations and settlement of variation margin.[236] CCPs and participants can take advantage of DLT to drive transparency in their margin requirements and increase the likelihood of an asset manager's ability to meet them. As DLT supports more efficient settlement cycles, the reduced replacement cost risks could also enable a notional reduction in the total of margin required to mitigate risk of cleared but yet-to-be executed trades.[237] However, not all limitations ae of a technical nature. Some are designed to give participants time for funding and operational processes.

DTCC ComposerX Modernizing Clearing and Settlement

DTCC's ComposerX suite is designed to modernize clearing and settlement processes by integrating digital asset capabilities with traditional financial infrastructure. It provides a unified framework that supports the full lifecycle of tokenized assets—from issuance to post-trade processing—while maintaining compatibility with existing systems.

The Capital Markets Platform ("CMP"), a core component of ComposerX, facilitates the exchange of tokenized securities against digital cash equivalents, such as stablecoins and deposit tokens. This enables real-time, atomic settlement, reducing counterparty risk and enhancing operational efficiency. CMP also automates key post-trade functions, including trade matching, netting, and corporate actions processing, by maintaining an immutable on-chain record of asset activity. This minimizes the need for manual reconciliation and supports seamless integration with existing middle- and back-office systems.

ComposerX incorporates a Compliance Aware Token® Framework that enforces regulatory requirements in real time. This framework automates complex multi-jurisdictional compliance rules, ensuring that transactions adhere to applicable regulations throughout the clearing and settlement process. Designed to be DLT-agnostic, ComposerX supports integration with various blockchain protocols and traditional financial systems, allowing for a gradual transition to digital asset processing without disrupting existing operations.

By addressing the complexities of clearing and settlement in a digital asset context, ComposerX offers a scalable solution that enhances transparency, reduces risk, and improves efficiency across the financial ecosystem.

234. HQLAx Homepage, 2023.
235. Bank of International Settlements (BIS), "DLT-Based Enhancement of Cross-Border Payment Efficiency – a Legal and Regulatory Perspective", 2022.
236. Swanson, "Decentralized Financial Market Infrastructures", 2021.
237. Joint trade and member interviews.

- **Default Fund:** If DLT-based settlement grows in adoption, clearing fund requirements could potentially decrease as trade volume in specific asset classes and transaction types also accrue on DLT-based platforms. This could lead CCPs to revise the level of capital required for management of the margin period of risk.[238] However, this may be less applicable for derivatives CCPs, where the margin period of risk is driven by the close-out period, which could potentially be shortened through technology. The operational and systemic risk implications of distributed margin and default fund management are discussed later under "Risk."

Evolved Roles and Responsibilities

CCP: In the long-term, CCP processes, like netting, could potentially be encoded in smart contracts, supporting the operational role of a CCP. In DLT-based markets for specific asset classes and transaction types, where required, a CCP could fulfill standard setting and system governance functions. Participants could also develop distributed capital market infrastructure, where the responsibility of a CCP in managing default funds and setting margin requirements is spread among market participants and agreed through predefined smart contracts or encoded in market-wide infrastructure.[239]

CSD: The role of a CSD may persist if the impact of DLT is limited to DLT-based Securities for specific asset classes and transaction types. In the DLT-based ecosystem, a key open question is around where settlement finality and beneficial ownership will be recorded. If settlement finality is recorded on a distributed ledger, CSDs could evolve to be a governor of DLT-based settlement systems, but in almost all other models, they are likely to remain a central actor in DLT-based settlement.[240] A detailed analysis of the evolution of the CSD role is explored in **Chapter 2.1.4: Custody**.

Custodian (in role as Cash Settlement Bank): Custodians could remain central in coordinating DvP due to their role as owner and safekeeper of wallets and private keys and may stand to realize significant operational efficiencies in those asset classes and transaction types that transition to DLT-based settlement. Generation, notification, and validation of settlement instructions can be supported through smart contract automation, enabling a greater proportion of custodians to straight-through-process settlement instructions. A custodian's role in cash settlement is likely to continue in DLT-based settlement when the payment leg is coordinated through traditional systems of distributed ledger that is separate to the DLT-based Securities ledger (e.g., SS1 or SS2). Where DLT-based Securities and DLT-based Payment Instruments settle on the same ledger, a cash settlement function may no longer be explicitly required in DLT-based settlement but could evolve to manage the conversion between cash and DLT-based Payment Instruments for investors, provided finality can be achieved with requisite legal certainty. A detailed analysis of the evolution of the custodian role is explored in **Chapter 2.1.4: Custody**.

Trading Member: The role of a trading member in clearing and settlement is likely to be unchanged. However, they can realize significant operational benefit from the automation of post-trade processing (e.g., confirmation/affirmation) and flexible settlement schemes (e.g., instant settlement of repo transactions) that could provide second-order business implications—for example, the ability to settle intraday repo transactions could lower the cost of funding for financial institutions, thereby allowing for greater lending activity.

Financial Impact and Opportunity

DLT-based settlement could present material financial opportunities, both through operational cost savings and financial resource efficiencies. However, DLT-based settlement may, however, introduce new capital constraints due to potential pre-funding requirements, and in the near-term it will require significant upfront investment to deliver new technology.

Capital Efficiency Key drivers of capital efficiencies are (a) potential for more automated settlement cycles—reducing the amount of time capital is trapped as part of margin arrangements or within clearing funds held at the CCP; and (b) mitigated replacement cost risk for trade volumes in selected asset classes and transaction types that accrues to DLT-based settlement. These drivers considered together free previously trapped capital that can be used to generated productive returns, unlocking opportunity costs for primarily for clearing members. This economic opportunity is material.

Capital Cost: DLT-based settlement is likely to require prefunding for transactions and may shift some funding costs from broker-dealers and banks to investors.[241] Additionally, pre-funding ahead of DLT-based settlement cycles could introduce additional friction into the trading process and erode market liquidity, especially in instruments that rely on market-makers to provide continuous two-way pricing. Further, at times of attractive interest rate remuneration, interest paid on overnight central bank deposits may be more attractive than prefunding arrangements, thereby increasing the opportunity cost of prefunding transactions to be instantly settled.

238. BIS defines MPOR as: **Margin period of risk** is the time period from the last exchange of collateral covering a netting set of transactions with a defaulting counterparty until that counterparty is closed out and the resulting market risk is re-hedged.
239. Swanson, "Decentralized Financial Market Infrastructure", 2021.
240. For a complete legal discussion of settlement finality please reference **Chapter 4 | Legal and Regulatory Landscape**.
241. SEC, "Proposed Rule: Shortening the Securities Transaction Settlement Cycle", 2022.

At institutional scale, joint trades and members have indicated that there may be net benefit, when considering capital efficiencies and capital costs in aggregate.

Operational Cost Savings: Key drivers of operational cost savings are (a) reduced fees paid to CCPs for selected asset classes and transaction types, where transaction volumes accrue to settlement on DLT-systems or for DLT-based Securities without the need for a CCP, (b) reduced fixed costs per transaction of DLT-based vs traditional technology infrastructure; and (c) lower likelihood of errors requiring back-office remediation.[242] The most recent institutional estimates of savings have been material *(note: in some cases, current-day versions of these figures may be lower, given advances in post-trade processing and a shift away from T+3 settlement since their last publication):*

- A global bank with $100 billion in daily repo volume could save $150–300 million annually by optimizing collateral usage and enabling faster settlement processing through tokenized collateral and liquidity management.[243]
- A different 2016 study estimated a $1.4 billion USD reduction in total IT and back-office operational costs due to the implementation of DLT in the Clearing and Settlement of the cash equities market alone.[244]
- Market participants, in 2015, estimated that DLT could reduce banks' infrastructure costs attributable to cross-border payments, securities trading, and regulatory compliance by $15–$20 billion USD per annum.[245]
- By some estimates, standardizing trade processing functions, rendering them interoperable, and leveraging economies of scale and network effects could save participants between $2 and $4 billion USD per annum. [246,247]
- A Citi security services survey found 33% of market participants expect DLT to reduce post-trade costs.[248]

It should be noted that operational efficiencies in the post trade space will be balanced in the near-term by overhead of additional resources to build, run, and maintain new technological platforms.

Risk Impact

The implementation of DLT in Primary Markets introduces some limited risk mitigation considerations. Refer to the **Chapter 1.4 | Risk Mitigants** for a discussion of these risks in detail, along with proposed mitigations. This commentary focuses on evaluating the potential of DLT to *mitigate existing risks* in the Primary Markets stage of the securities lifecycle.

Counterparty credit risk: DLT-based settlement can mitigate replacement cost risk due to the use of automation in settlement, DvP, and clearing.[249] This is driven by the reduction in delay between trade and settlement execution. Principal risk can also be mitigated where DvP occurs atomically, which can be enabled by a distributed ledger if chosen, provided the applicable network enables finality as legally defined. If scale is achieved in selected asset classes and transaction types, the notional value of executed but not-yet-settled trades could be reduced, as well as the margin period for CCPs, currently mitigated through capital charges (e.g., collateral), although the majority of margin called by CCPs in derivative transactions is due to counterparty credit risk through the lifecycle of a transaction. DLT-based settlement could also support participants to post margin in real time. In the case of OTC derivatives, this could address variation margin gaps (between posted margin and calculated current exposure of contractual positions) — particularly valuable in times of market stress. Smart contracts could also support the management of margin and clearing funds, with the ledger record of transactions and open positions enabling the allocation of the default waterfall during times of market stress.

Operational Risk: DLT-based settlement could address operational risk for post-trade participants in selected asset classes and transaction types, with improved information sharing and automation in post-trade processes. This could lead to improved data quality between participant systems and reduce the potential for trade fails (though this would only be material in markets such as Europe, and for specific asset classes such as equities). In the long-term, regulators could even directly access post-trade data, creating reports and monitor market health in real time. If predominant, the SS3 model (integrated DLT-based settlement platform), would avoid the risk of coordinating between securities settlement and payment settlement systems (that also exist in traditional markets, through the SS1, and SS2 models).

242. GFMA Member Survey conducted as part of this report, n=25; Avg. Score of 2.0 out of 5.0, 1 is highest level of potential efficiency and 5 is lowest level of potential efficiency.
243. BCG, Ripple, "Approaching the Tokenization Tipping Point, April 2025.
244. Goldman Sachs, "Profiles in Innovation: Blockchain Putting Theory into Practice", 2016.
245. Santander, Innoventures, Oliver Wyman, Anthemis Group, "The Fintech 2.0 Paper: rebooting financial services", 2015.
246. Broadridge, "Charting a Path to Post-Trade Utility: White Paper", 2015.
247. Priem, "Distributed ledger technology for securities Clearing and Settlement: benefits, risks, and regulatory implications", 2020.
248. Citi, "Securities Services Evolution 2022", 2022.
249. Defined by BIS as settlement risk, and comprised of replacement cost risk and principal risk; see BIS, On the Future of Securities Settlement, 2020.

Liquidity Risk: DLT-based settlement could aid in mitigating liquidity risk – specifically the ability of market participants to exchange fiat currency and assets at a fair price. If scale is reached in selected asset classes and transaction types, DLT-based settlement may enable allow asset managers to benefit from automated transactions and the potential for improved liquidity in the market (where liquidity is shallower in traditional markets today). For example, this could be particularly impactful in illiquid asset classes such as certain forms of fixed income securities and unlisted equities. This may have further impact in reducing the market risk associated with these assets as improved liquidity allows for more efficient and transparent price discovery.

Systemic Risk: CCPs provide a proven model to manage systemic risks and ensure financial stability. As volumes of centrally cleared securities have grown, however, this is now itself presenting a source of systemic risk. CCP failures are highly unlikely and effectively mitigated through capitalization. DLT could be used to support CCPs, or provide considerations for a future, alternative model for specific asset classes and transaction types that do not settle through a traditional CCP. For example, using smart contracts and multi-signature accounts, margin, default fund, and additional capital can be pooled at an account controlled by market participants. This could ensure, similar to a CCP today, that a qualified majority of non-defaulting parties have the ability to release funds according to a codified waterfall where risk participation is proportional to risk creation.[250] Many CCPs hold dominant positions within their asset classes due to netting efficiencies, which often favor a single large CCP; fragmenting these netting sets to create DLT-based pseudo-CCPs could increase margin requirements and introduce new risks associated with less centralized responsibility and platform governance. With the appropriate design of the distributed ledger, CCP-style data access could be replicated and protected by the cybersecurity protections of all market participants, thereby distributing operational resiliency among many participants.

Custody

This chapter provides an overview of participants, key activities, and critical inefficiencies that exist today. This provides a baseline for an impact assessment of DLT, considering **different models of implementation** and **impact on activities, roles and responsibilities, opportunities,** and **risk.**

SUMMARY OF IMPACT ASSESSMENT **HIGH**

In this chapter, custody is defined as record-keeping and account-management activities for investor securities and cash.[251]

Implementation models:

1. **Books and records only:** Managing internal records of securities, transactions, positions, and client information on a distributed ledger with other members of the custody chain. Does not involve DLT-based Securities.
2. **Digital Custody:** Administering Books and Records as well as the safekeeping and asset servicing of DLT-based Securities on a distributed ledger across the participants involved in the custody stage of the securities lifecycle. This implementation model could necessitate changes to official methods of record-keeping.

Digital Books and Records could address record-keeping inefficiencies:

- A distributed ledger used across the custody chain could simplify post-trade reconciliations that currently occur between participants, leading to greater operational efficiency through less manual intervention, enhanced data transparency, and auditability. However, DLT may introduce new reconciliations with existing databases as distributed ledger records become a sub-ledger to be integrated into a financial institution's general ledger reporting.
- This solution would not offer the ability to custody DLT-based Securities and broader efficiencies.

Digital Custody could present a further set of changes on top of the Books and Records impacts:

- **Digital Custody could introduce a novel infrastructure for DLT-based asset safekeeping** via the wallet and key model. Custody could gain importance for DLT-based Securities given the dependence on the private key for transactions and the need to diligence new and emerging DLT-based platforms. To safekeep the private key and establish connectivity with existing accounts, custodians may require new sub-custody or third-party services; the degree to which custodians outsource technology capabilities may depend on whether digital custody services providers can scale as volumes increase.
- **Any novel infrastructure is unlikely to displace the account-based custody model in the near or medium term** given the prevalence of traditional assets, presence of tokenized assets that require traditional backing, and regulatory requirements for security accounts in various jurisdictions.
- Digital custody could position traditional, qualified custodians to meet growing client demand for **an integrated, interoperable custody platform across DLT-based and traditional securities**, with DLT-based alternative assets as a key growth area.

250. Swanson, "Decentralized Financial Market Infrastructure", 2020.
251. Other activities performed by a Custodian such as Settlement and Asset Servicing and Lifecycle Management are covered in their respective sections.

SUMMARY OF IMPACT ASSESSMENT	HIGH

Considerations for digital custody adoption:

- **Roles:** Impact on the CSD role and the custody chain could depend on the type of DLT-based security. For Security Tokens, the CSD could evolve towards a governance role in enforcing standards and resolving disputes, while custodians and other intermediaries play a larger role in proposing and validating transactions, and safekeeping private keys on behalf of clients. In the case of Tokenized Securities, the CSD role and the custody chain would remain similar to the status quo for the traditional asset portion.
- **Opportunities:** Large operational cost savings and considerable potential demand for Custody of DLT-based Securities (projected ~$9.4 trillion in assets under custody by 2030) are two major sources of return on investment.[252] Those benefits, however, are realizable only in the long term; costs may be significant in the near to medium term as firms must scale up novel technology and operations while continuing to run processes outside of a distributed ledger.
- **Risk:** DLT could significantly mitigate operational risk through simplification of post-trade reconciliations and reduction of manual intervention. New cybersecurity, regulatory compliance and financial crime, business continuity planning, data privacy, asset onboarding, and vendor risk considerations would need to be managed. Financial institutions may also need to manage operational risk from running different systems in parallel, changing workflows and vendors to DLT-based solutions, and developing technological interoperability and integration between the distributed and traditional ledger.

Current State and Inefficiencies

For the purpose of this analysis, custody is defined as the safekeeping and administration of securities and other assets on behalf of asset managers, asset owners, and trading firms. Additional activities undertaken by custodians, such as transaction initiation, settlement services, and liquidity provision are covered in the relevant lifecycle stages.

There are two core groups of activities:

1. **Record-keeping:** Maintain consistent records of positions and transactions by regularly conducting post-trade reconciliation among custodian, asset manager, sub-custodian, and CSD ledgers.[253]

2. **Account management:** Safekeeping of client securities and cash in accounts segregated from the custodian's own assets and liabilities.[254] This chapter will focus on asset safekeeping, with KYC/AML/CFT covered a later chapter.

Broker-dealers/prime brokers, investors, custodians (global and local), and CSDs form a custody chain through an interdependent set of roles and responsibilities. The CSD or registrar provides the central source of truth on securities ownership (at an institutional-level) that is updated and referenced by the custody chain.

Record-keeping

Financial institutions have continuously enhanced the post-trade reconciliation process with technology. Examples include the ability to do many-to-many matching instead of two-way matching, and the transition from close-of-business batch processing to real-time transactions.[255] Despite these improvements, lack of data standardization and continued manual intervention remain the two prominent Inefficiencies of the process.[256]

Difficulty in securing standardized data inputs is a key driver of post-trade reconciliation complexity. While the industry has been moving toward the ISO 20022 standards from SWIFT, adoption is not yet universal for smaller investment managers, some of whom may rely on email or even fax to instruct.[257] Furthermore, the process of adopting new standards is operationally work-intensive; firms must become familiar with file formats, data tables, and a large list of message codes. They must ensure legacy systems can plug in and populate SWIFT messages reliably and seamlessly. For larger investment managers, a key driver of reconciliation complexity is the sheer number of inputs involved. They could interact with dozens of different custodians, which could multiply the number of reconciliations needed on a regular basis.[258]

252. BCG, Ripple, "Approaching the Tokenization Tipping Point, April 2025.
253. McGill and Patel, "Global Custody and Clearing Services", 2008.
254. McGill and Patel, "Global Custody and Clearing Services", 2008.
255. McGill and Patel, "Global Custody and Clearing Services", 2008.
256. Ibid.
257. Ibid.
258. Ibid.

Finally, financial institutions still rely on manual intervention for the reconciliation process. For example, a large asset manager may employ dozens of workers to examine and resolve breaks in processes.[259] When there is an inconsistency with position or balance data, teams may need to check every transaction within that time period. While this type of check can be trivial in isolation, daily error rates can amount to material operational cost and time on an annual basis.

Summary of Impact Assessment: High

This chapter examines the impact of DLT and DLT-based Securities on custody. It will analyze the impact across the activities, associated Inefficiencies, and technologies established in the previous section. It will then consider the implications on roles and responsibilities, financial, and risk across the custody ecosystem.

Models of Implementation

The impact of DLT on custody may depend on whether financial institutions opt for (1) a books-and-records-only approach or (2) a fully digital custody approach. This section examines the impact of each implementation in turn.

Books and Records Implementation (i.e., for traditional securities)

Under a digital Books and Records implementation, participants in the custody chain could generate and maintain book entries and messages pertaining to securities, cash transactions, positions, and accounts on the distributed ledger. In this case, the distributed ledger is simply a useful reference that streamlines reconciliation and account management activity by breaking down data siloes and enforcing consistency of data values and standards across financial institutions. This solution covers records only, however. The securities and cash themselves do not enter the distributed ledger; they remain on traditional FMIs and based at the CSD.

Because it does not require the creation and custody of DLT-based Securities, the Books and Records implementation can be a first step in the journey toward digital custody. Furthermore, if DLT-based Securities are introduced for custody in the future, members of the custody chain would directly utilize the record-keeping capabilities developed in the Books and Records implementation. This section will examine each capability in turn.

Notably, reconciliation processes would still be necessary, even with the introduction of DLT, since financial institutions will continue to employ traditional ledgers for internal and external reporting for at least the near and medium term. However, having a single distributed ledger could reduce the rate of data discrepancies and increase ledger transparency for those using it.

In a more developed DLT-based ecosystem, the distributed ledger could become the source of truth for all positions and transactions, ensured through consensus among participants. By reducing discrepancies among custodians, investors, asset managers, and CSDs, financial institutions could reduce back-office spend and resources allocated to normalize data into standard, comparable format. DLT could remove significant operational risk and reduce the resources (both full-time equivalents ("FTEs") and financial cost) that custodians and their customers expend manually troubleshooting and resolving breaks and exceptions.

EXHIBIT 2.1.12

Custody Impact Assessment

Custody	Investor (client)[1]	Global Custodian	Local custodian (if applicable)	CSD
Record-keeping	High	High	High	Tokenized securities: Medium Security tokens: High
Account management/ asset safekeeping	High	High	High	Tokenized securities: Medium Security tokens: High
Account management/KYC	High	High	High	Tokenized securities: Medium Security tokens: High

Source: BCG analysis.

259. Ibid.

While DLT may substantially reduce discrepancies in data shared among custody chain participants, it would not eliminate the potential for errors and may still necessitate the need for reconciliation between DLT-based and traditional Books and Records. Errors could still occur upstream for reasons including manual entry errors, client miscommunication, and data formatting. If errors are introduced into the distributed ledger and not identified immediately, they could still flow through the system. DLT may, however, simplify the identification of errors since parties do not need to reconcile records from one system to another to piece together the error. Additionally, DLT-based Securities would introduce another set of sub-ledgers corresponding to the wallet transaction history that would need to be synchronized with a bank's formal, official, general ledger.

Digital Custody Implementation

In the digital custody implementation, DLT is used to represent securities on a distributed ledger, and those securities are formally transacted and processed by the custody chain. Traditional database technology could be used to manage client beneficial ownership of assets issued and recorded on external DLTs. Alternatively, DLT-based Books and Records could be used to convey information. Either solution is required so associated changes to record-keeping outlined above would apply to digital custody as well. In addition, digital custody will impact asset safekeeping, which is the focus of this subsection.

Under digital custody, DLT could have three main impacts on asset safekeeping activities. First, it requires the **safeguarding of both forms of DLT-based Securities**, with a custom set of technology and operations in addition to, rather than in place of, the current account-based custody model. Second, it allows custodians to build a platform that meets expected growth in client demand for **integrated custody of traditional and DLT-based Securities**. Third, DLT-based Securities under Custody ("**AuC**") could feature a **higher share of alternative assets** compared with the existing custody asset mix.

Safeguarding DLT-based Securities

In contrast to the account model for traditional securities, the custody of DLT-based Securities is typically based on a wallet and key model originally designed for use in public-permissionless DLT networks. Holdings exist as a record of transactions on a distributed ledger. The wallet is a front-end application that integrates with the ledger and typically interacts or stores an asset owner's cryptographic keys. There are two types of cryptographic keys. First, is the public key, which is used to derive a public address which acts like a bank account number, and every transaction is linked to the public addresses of both the sender and receiver. A wallet application queries transactions on the ledger to provide a user with details on holdings associated with their public address. Second, is the private key, which is a randomly generated alphanumeric string that is cryptographically linked to the public key at creation. The private key therefore provides the security holder with the control of the DLT-based security associated to the derived public address. A private key must never be divulged to others or lost, since it is the sole component used to unlock access to and transfer of the DLT-based security recorded against the associated public address.[260] Therefore, a custodian's role evolves into safeguarding the private and public keys, which confer the ability to access and transact the DLT-based security. It should be noted that private keys are not a wholly new tool; for instance, custodians manage private keys without DLT to communicate securely over the SWIFT network.

Custody could play a different role in DLT-based Securities relative to traditional securities because secure storage of the private key is paramount. To be executed, all transactions require a digital signature with the private key that controls the asset that is recorded against the public address. If the private key is lost, the investor can lose access to the corresponding securities; there is currently no recourse available on public permissionless networks. The secure custody of the private key is fundamental to any activity in DLT-based Securities. Given their technological expertise, scale, and established regulatory standing, traditional, qualified custodians are favorably positioned to provide institutional-grade services relative to self-custody and exchange-provisioned options.[261]

A custodian may use three primary forms of wallets:

- **Hot Wallet:** A wallet with private keys always connected to the internet; it prioritizes accessibility at the expense of security.
- **Cold Wallet**: A wallet that stores private keys fully offline, not connected to the internet, and could require human intervention for transactions or signing; it prioritizes security at the expense of accessibility.
- **Warm Wallet:** A mix between a hot and cold wallet. The keys are held online, as with a hot wallet, but human interaction or additional security policies (e.g., requiring human interaction to sign a transaction) are required to authorize transactions, as with a cold wallet; a blend between the security and accessibility of the previous two wallet types.

260. Fireblocks, "Digital Asset Custody 101: Guide to Self-Custody, Wallet Options, and More", 2023.
261. Deloitte, "A Market Overview of Custody for Digital Assets: Digital Custodian Whitepaper", Jun 2020.

There are additional security features used in DLT wallets to enhance the security of private keys:

- **Multi-sig Wallet:** A smart contract–based wallet that requires multiple private keys to authorize a transaction, which can be spread across multiple systems. These private keys can be a combination of hot, cold, and warm wallets per criteria encoded into the contract when it is first created.

- **MPC Wallet:** A wallet utilizing a solution where a single private key is sharded and distributed between multiple parties. This method ensures that the private key never exists in its entirety in one place at any given time and enables signatures in a similar way to a multi-sig wallet. The MPC wallet contrasts with multi-sig wallets in that multi-sig wallets require multiple different private keys, whereas an MPC wallet uses a single private key separated into parts. The key shards could also be held in a combination of hot and/or cold key storage systems.

In addition to securely storing private keys, the custodian must also be able to securely generate those keys. There are detailed key-generation procedures that custodians may need to consider. For wallets, account abstraction may be a useful tool if realized in the future. Account abstraction allows an account to be fully programmable. This could potentially allow the signing private key for an account to be changed via social recovery mechanisms to avoid loss of funds, for the creation of wallets without an initial seed (e.g., via email), for transaction fees to be paid with a different token (e.g. ERC-20 instead of ETH), or even allow no gas transactions via sponsored transactions.

In a steady state, custodians could likely use several wallet types (e.g., hot and cold storage) and hardware solutions (e.g., hardware security modules) to meet security, anonymity, flexibility, and transaction throughput demands from clients. In addition, key and wallet generation procedures may simplify substantially as technology providers package these capabilities into software solutions that custodians can readily deploy.

Limitations to the wallet-based model

The wallet-based custody model for DLT-based Securities is unlikely to displace the current account-based model at the CSD for three reasons. First, most outstanding securities is likely to remain outside the distributed ledger for the foreseeable future. Second, regulatory requirements aiming at managing systemic risks could require a CSD operating an account-based system to store the underlying security as a mitigant. Custodians that are safekeeping Security Tokens must ensure that it is always "backed" by the traditional asset at the correct ratio (1:1 or 1:n in the case of fractionalization) to maintain the integrity of the tokenized security.[262] Third, some jurisdictions require transactions to be booked through securities accounts to transfer ownership. Thus, all members of the custody chain need to develop technological interoperability and integration between wallets and legacy account-based systems.

Importantly, while the wallet and key model is the dominant custody model for public networks, it does not need to be the design for private-permissioned networks. Given the higher level of built-in security, especially for small private networks where data is not viewable by the public, custody participants can use accounts with the traditional credentialing technology. Thus, for private networks, participants have more freedom to design the custody model according to use case and the relevant security and regulatory considerations.

Integrated Custody of traditional and DLT-based Securities

The adoption of DLT could mean that an integrated custody model across traditional and DLT-based Securities could emerge as the dominant future packaging of custody services. In BNY and Celent's 2022 Survey of Global Institutional Clients, 72% of investors indicated they prefer an integrated, one-stop shop for digital asset custody, as opposed to best of breed providers for individual needs.[263] This is evidence of a need among institutional investors for a complete, integrated custody platform across traditional and distributed ledgers provided by a traditional player. Additionally, common data standards, such as the CDM, are essential to avoid introducing operational and liquidity risks that could undermine, rather than enhance, efficiency.

Traditional, qualified custodians appear to be well-positioned to deliver integrated custody services for DLT-based Securities. BNY/Celent survey respondents indicated that they would increase portfolio allocations to assets, including DLT-based Securities, by an average of seven percentage points in the next two-to-five years if conditions are favorable.[264]

262. OECD, "The Tokenization of Asset and Potential Implications for Financial Markets", 2020.
263. BNY & Celent, "2022 Survey of Global Institutional Clients", n=271. Respondent panel included asset managers, asset owners, and hedge funds with core activities covering North America, Europe and Asia. Respondents were surveyed from May to June 2022.
264. Ibid.

Higher share of alterative assets

Among the different categories of DLT-based AuC, custodians are likely to see more growth in private market assets. As of 2021, alternative assets represented only 17% of global assets under management ("**AUM**").[265] Broad trends in traditional assets indicate that expected growth in alternative asset AUM (11.7% CAGR) could outpace that of traditional assets (5% CAGR) from 2021 to 2026.[266] Furthermore, market participants identify increased access to alternative assets as a major benefit of DLT-based Securities. In the BNY/Celent survey, respondents ranked access to private equity, real estate, and other alternative asset classes as the top benefit from Tokenization.[267] This preference was corroborated by a survey of joint trades and members for this publication, where respondents ranked private placements, illiquid assets, investment funds, and real estate as the asset classes with the most potential for DLT.[268] A GDF 2024 survey of 100 senior executives managing over $221 billion in assets found that **70%** identified private debt as the first asset class to be tokenized and routinely traded, followed by **62%** for money market funds, underscoring the broad institutional recognition of DLT's potential across asset types.[269]

Evolved Roles and Responsibilities

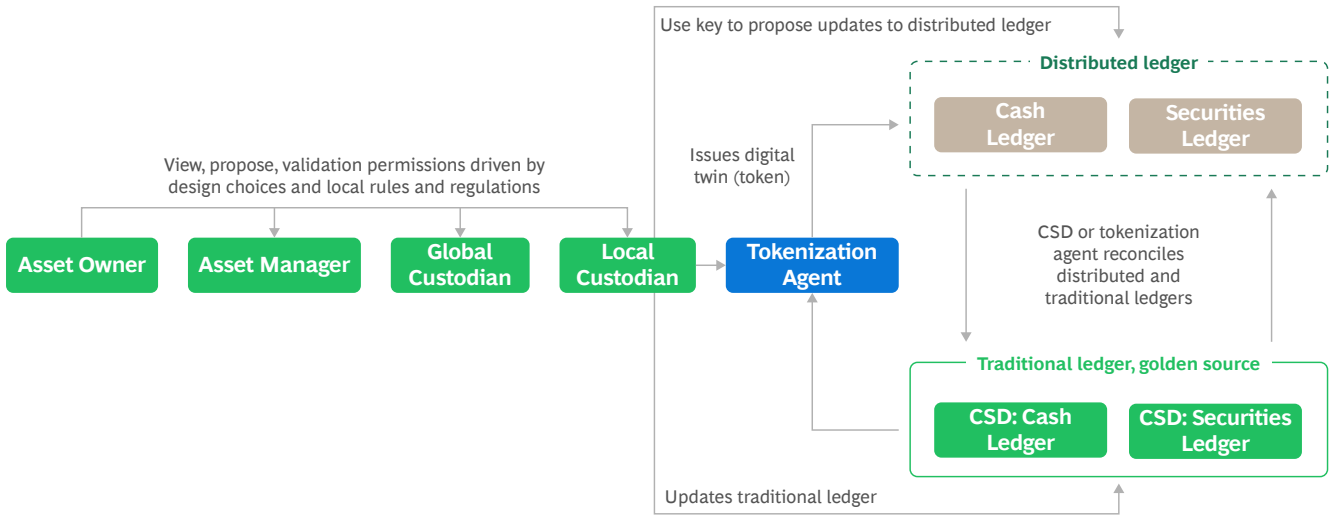
The roles and responsibilities in the custody chain could evolve through the introduction of a distributed ledger. This could create one custody model for Tokenized Securities (Model 1) and another for Security Tokens (Model 2), reversing the general trend toward consolidation that has characterized CSDs over the past few decades.[270]

Tokenized Securities (Model 1): The CSD's traditional ledger, or the predominant model of record-keeping ownership within a given jurisdiction[271], remains the source of truth for the underlying traditional securities holdings. As Tokenized Securities have both an underlying instrument trading and settling on traditional markets in parallel with a digital twin token trading and settling on DLT-based markets, the CSD, or institution nominated as the official record-holder, may likely continue to play its current dual role as official record of ownership and overseer of governance issues for traditional securities holdings (**Exhibit 2.2.13**).

Under Model 1, a Tokenization agent could issue the digital twin Tokenized Security on the distributed ledger on behalf of the local custodian that is storing the traditional asset. For the digital twin, the local custodian or participant with the correct wallet and private key could propose transaction and ownership changes to the distributed ledger. If the DLT-based system executes internalized settlement, it is possible that tokens can be transferred on the distributed ledger without having to update the

EXHIBIT 2.1.13

Model 1 (for Tokenized Securities): The Golden Source Record of Ownership for a Security Remains in a Traditional CSD



Source: BCG analysis.

265. BCG, "Global Asset Management 2022: From Tailwinds to Turbulence", May 2022. AUM is used as a proxy for AuC. Alternative assets include hedge funds, private equity, real estate, infrastructure, commodities, private debt, and liquid alternative mutual funds.
266. Preqin, "2022 Global Alternatives Reports", Accessed 2025.
267. BNY & Celent (2022).
268. GFMA member surveys (Nov-Dec 2022).
269. GDF, "Crypto goes Institutional in 2024" April 2024.
270. European Central Bank, "The Securities Custody Industry".
271. For example, in the US the legal rights of a security holder are based on the official security records of an issuer and where the CSD's nominee is the record holder of the securities positions on behalf of participants and their customers.

traditional ledger on the CSD. However, either the CSD or custodian could need to regularly verify that the record of ownership for the traditional asset exactly matches the record of ownership for the digital twin. For these reconciliations, the traditional CSD ledger could likely remain the golden source of truth, given its legally established nature today (note: for omnibus accounts, there would be no change at the CSD level). Furthermore, the CSD may also play the validator role for updates to the distributed ledger.

The chain of custody could remain as it is today for the underlying traditional assets, thereby maintaining the same custody risk profile. The digital twin would exist in parallel on the distributed ledger, with changes requiring validation by the CSD or according to an alternative mechanism agreed to locally. The CSD or Tokenization agent would need to reconcile between traditional asset and digital twin to ensure consistent records.

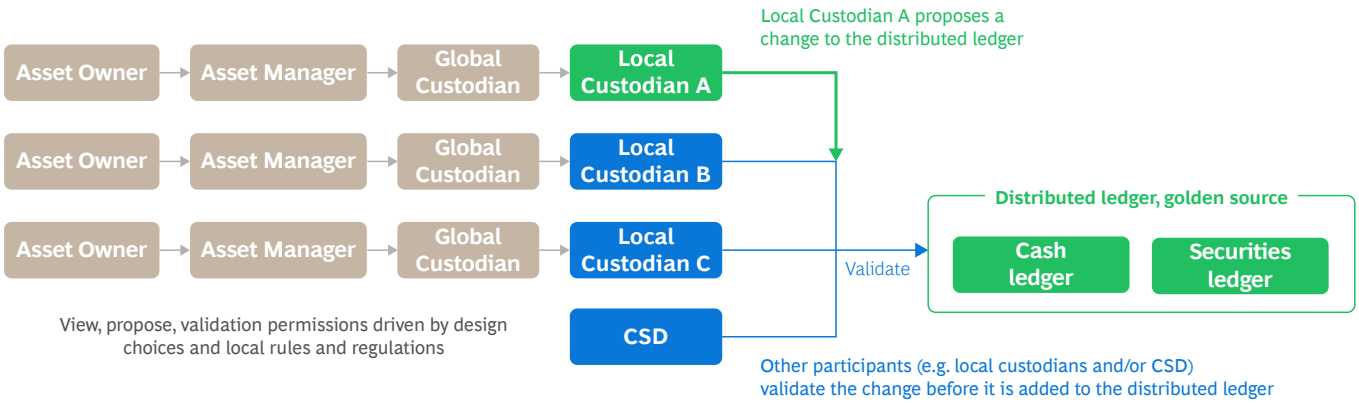
Security Tokens (Model 2): The distributed ledger becomes the golden source of truth. The CSD role may shift toward governance while custodians and other financial intermediaries play a larger role in validating transactions on the distributed ledger (refer **exhibit**). It should be noted that this model assumes regulation that requires the role of a CSD. Depending on the progression of regulation in different jurisdictions, alternative models may also be possible where a CSD may not be required.

Since a Security Token is digitally native, it does not get recorded on a traditional ledger. In this design, assuming a CSD is required, the distributed ledger records ownership of securities and is administered and managed jointly by the CSD and the custodians. The CSD would continue to be a central, trusted authority, but its role **could evolve towards predominantly a governance role with increasing automation, allowing more decentralized methods for updating the distributed ledger.** Governance activities could include enforcing data standards, determining validation mechanics, and arbitrating disputes. In terms of making updates to the distributed ledger, several options are possible. Custodians, brokers, or other direct DLT participants could be responsible for both proposing and validating updates to the shared ledger of securities ownership. Financial institutions dealing with Security Tokens could likely need to continue abiding by local fiduciary, AML, and other financial regulations, suggesting that local custodians could continue playing an important role updating the distributed ledger, as they do today with traditional assets at the CSD. A more centralized design could feature the CSD serving as the sole validator or one of a few.

For Model 2, the level of decentralization is a design decision dependent on several governance and regulatory considerations. First, a consensus mechanism in which custodians or brokers mutually validate their clients' trades could raise competition and disclosure concerns.[272] Custody chain members can potentially mitigate these concerns by implementing zero-knowledge proofs and other privacy-enhancing cryptographic techniques. Second, members need to ensure that the consensus mechanism and associated recourse processes could comply with both legal and governance standards. For example, the CSD role is legally mandated by several jurisdictions (e.g., the U.S.), so any changes to the CSD role resulting from the consensus mechanism would require regulatory blessing.

EXHIBIT 2.1.14

Model 2 (for Security Tokens): The Golden Source of Ownership Exists Solely on the Distributed Ledger, Managed by CSD or Custodians, or Both



Source: BCG analysis.

272. Randy Priem, "Distributed ledger technology for securities Clearing and Settlement: benefits, risks, and regulatory implications", 2020.

In the latest articulation of this report, we introduce **Model 1.5** to highlight an important transitional approach that might bridge the traditional ledger-based custody models (Model 1) and fully DLT-native structures (Model 2). In this transitory model, traditional systems (such as those maintained by a CSD) may coexist with a DLT-based record-keeping system, so as to reap the benefits of enhanced tokenized mechanisms (automated reconciliations, smart-contract-based workflows, while both traditional and digital record-keeping systems remain intact (i.e., when a single equity security has been issued traditionally and trades traditionally, issued traditionally, tokenized, and trades in a tokenized marketplace, and/or issued natively on a DLT and trades in a DLT-based marketplace). This model is broadly equivalent to one in which a security has primary listings on multiple exchanges in jurisdictions where clearance and settlement practices differ in various respects. The rights represented by the security do not change by virtue of the fact that the systems used and settlement practices may vary by jurisdiction, and interoperable settlement systems can help to improve risk management practices and reduce price differences that may arise as the financial effects of different settlement practices are valued by market participants. A coordinated multi-track model of this kind will help financial institutions gradually adapt to new technology-driven approaches, while ensuring lock-step adherence to regulatory compliance in each individual channel. Once tokenization reaches full scale adoption, this approach may no longer be predominant, but analysis suggests it will be an important stepping stone towards the mature future-state of DLT.

Financial Impact and Opportunities

The financial impact of DLT on custody could be considerable. On the cost side, simplification of reconciliations could lower the total cost to serve. Custody of DLT-based Securities could open new ways to serve client demand.

Capital Expenditure

Upfront operational and capital expenditure may be necessary to build out Custody platforms and (at least in the short/medium term) link legacy and DLT-based platforms. Custodians and CSDs alike may need to invest in new technology and resources, with many interviewees indicating the investment phase is at least 5 to 10 years.

Additional technological requirements such as the hardware and software required to run and manage a node, connectivity tools (e.g., external data inputs or oracles, APIs, linked ledger systems), and wallet management controls (e.g., cold storage facilities, key generation algorithms, and computing) are capital expenditures that must be borne in the near term to meet the requirements of clients. Similarly, custodians and CSDs could need additional capital expenditure to bolster and enhance existing cybersecurity controls and adapt them to the specifics of a distributed ledger.

Operating Expenses

DLT also presents opportunity for significant operating expense savings in a mature state, especially as end-to-end efficiencies are realized. However, in the short-to-medium term, those operating expense savings are unlikely to transpire. This is due to the need to run traditional systems in parallel to DLT systems to build regulatory and client trust. As described in previous sections, the true operational efficiencies and cost-saving impact is realized through the impact of DLT-based Securities at scale, reducing the complexity of reconciliation efforts. As of 2015, the annual cost base for post-trade processing was $6–9 billion USD; simplifying these processes could lead to $2–4 billion USD in annual cost savings, of which reconciliations costs are a major portion.[273] When realized, these savings could be passed up the custody chain.

Demand Factors

The market growth opportunity represents a promising avenue for custodian growth and monetization. As of 2022, the stock of DLT-based Securities is $310 billion.[274] While best-case scenarios estimate total market value of $68 trillion, conservative projections indicate that stock is expected to grow to $9.4 trillion by 2030, representing a 53% CAGR.[275] By comparison, AuC for the top 11 custodians grew 5.7% CAGR from 2010 to 2018.[276] Even assuming most of the DLT-based market cannibalizes current non-DLT market value, it represents a shift in growth by market segment. Custodians would be well-placed to invest in Tokenization so they can defend existing AuC outside of a distributed ledger and capitalize on areas of tokenized AuC growth.

273. Broadridge, “Charting a Path to a Post-Trade Utility”, 2015.
274. BCG and ADDX, “Relevance of on-chain asset Tokenization in crypto winter”, 2022.
275. BCG, Ripple, “Approaching the Tokenization Tipping Point, April 2025.
276. BCG, “Asset Servicing Primer”, 2020.

Risk Impact

DLT could introduce limited risk considerations and mitigations when implemented for use in custody. These risks, together with proposed mitigations are discussed in the **Chapter 1.4 | Risk Mitigant**. This section focuses on the impact of DLT on mitigating existing risks in the Custody stage of the securities lifecycle.

Operational Risk: The shared ledger can simplify reconciliation effort, reduce positional deviations between organizations and create a standardized data format for post-trade data. A combination of different nodes allows each participant bespoke, programmable access to the shared ledger of ownership. This drives transparency and trust throughout the custody chain.

Risk-Adjacent Impact, Operational Resiliency: : The distributed nature of the ledger in Model 2 means greater resilience against operational or system outages, as there is no central operator. Existing resiliency and continuity plans have been tested and validated with regulators and can be easily adapted for DLT tech (e.g., ensuring back-up power/generator and the four-eyes principle). The solid regulatory foundation of traditional, qualified custodians could provide a lower-risk means for institutional clients to access DLT-based Securities, compared with self-Custody or other industry options. On the KYC/AML/CFT side, custodians can access client data more efficiently, at lower cost.

Asset Servicing and Lifecycle Management

This chapter provides an overview of participants, key activities, and inefficiencies that exist today. This provides a baseline for an impact assessment of DLT, considering **different models of implementation** and **impact on activities, roles and responsibilities, opportunities,** and **risk.**

SUMMARY OF IMPACT ASSESSMENT **HIGH**

Asset Servicing and lifecycle management covers corporate actions, tax withholding for dividend and interest payments, and regulatory reporting processes.

Models of implementation

- **Books and records only:** Entails posting and managing records on the distributed ledger while the securities themselves stay on a traditional ledger. The level of impact would be a subset of the DLT-based implementation.
- **DLT-based Securities:** This implementation involves the full set of asset servicing and lifecycle management processes for DLT-based Securities, which necessitates records to be posted and maintained on a distributed ledger.

DLT impact is expected to be high for mandatory corporate actions and proxy voting and lower for more complex voluntary corporation actions.

- DLT impact could be realized in two ways. (1) The distributed ledger significantly reduces the need to reconcile among multiple siloed data sources. (2) Smart contracts, built with an industry-wide data standard such as the Common Domain Model, can automate execution by codifying legal rights and obligations from corporate actions into standard, unambiguous, consensus-driven execution parameters tied to the security itself and ensuring quality of execution through verification infrastructure.
- The custodian role could be de-risked, as the likelihood of data discrepancies on the distributed ledger could be greatly reduced. Issuer agents who mostly transmit data currently could see their roles shift to helping issuers engage with smart contract templates and announce corporate actions via DLT. The system could require a governing body to align on corporate action smart contract template standards.
- Except for proxy voting, DLT impact is not expected to be high for voluntary corporate actions due to the operational complexity and the likelihood of substantial activity outside the distributed ledger.
- A Books and Records implementation could benefit from the distributed ledger's golden source of corporate action data, but likely would not deliver smart contract–based corporate action execution.

DLT-based tax withholding could automate the appropriate application of tax relief for each investor at the source (or during the taxable event), reducing the need for a tax-reclaim process.

- If the distributed ledger becomes the source of truth, the withholding process could reduce its dependency on physical documents and wet ink signatures; the risk of tax fraud could also be reduced.
- The extent of impact may depend on whether a DLT-based solution can: (1) protect confidential data while automating tax treaty eligibility determinations; (2) require changes to a jurisdiction's tax code; and (3) accurately withhold for more complex corporate entity structures; each factor could limit the feasibility of DLT-based tax withholding.
- While the main responsibilities of withholding agents, investors, and tax authorities may not change, the system could require a governing body to align on implementation and promote scalability.
- A Books and Records implementation could fully realize DLT-based tax withholding impact.

SUMMARY OF IMPACT ASSESSMENT	HIGH

DLT-based regulatory reporting, a key component of security lifecycle management, could enable embedded supervision, where supervisors automatically monitor compliance of DLT-based positions and transactions in real time via a node on the distributed ledger.

- The single source of truth and accompanying data transparency of DLT could reduce the currently heavy manual and operational processes required to record and report regulatory data.
- Embedded supervision's impact on broader regulatory reporting could be limited until industry and regulators align on approach to realizing three enabling conditions: (1) interoperability among distributed ledgers and with the broader market data, (2) legal guarantee of the integrity of DLT-based Securities, and (3) clearly defined settlement finality, so that the data presented to supervisors is not subject to change.
- While this solution is meant to address DLT-based Securities, a Books and Records implementation involving traditional securities could be a useful pilot.
- For derivatives reporting, the industry should implement Digital Regulatory Reporting[277], which leverages the Common Domain Model by reducing the time, resources and cost needed to implement reporting regulations in multiple jurisdictions. Rather than interpreting and implementing each set of rules individually and then repeating that work in future, if changes are necessary, firms can implement code that has been validated and tested by industry participants and will be updated as new rules emerge or are amended, enabling resources to be reassigned to other projects.

Opportunities: Long-term cost savings from adopting DLT could be meaningful. Corporate action errors can cost custodians over $1 billion USD per year. Unsuccessful tax reclaims cost the industry at least €8 billion per year. Embedded supervision regimes could bring down the cost of compliance, which currently sits at 3–9% of non-interest expense for banks. However, the initial investment may be significant; all required parties must be on the distributed ledger for each of the systems to achieve network effects that justify both set-up cost and the cost of integration. Lack of regulatory clarity regarding smart contract standards, permissibility of tax relief at the source, and DLT-based settlement finality for certain transactions could constrain the growth and adoption of each solution. DLT may also need to prove its value proposition against non-DLT solutions in development.

Risks: New risks could be introduced around privacy, security, and smart contract execution, given the confidential nature of corporation action, tax, and regulatory data. Permissioning, privacy-enhancing cryptography, and cybersecurity could be paramount to system design. Creating a well-controlled smart contract layer may be crucial to automation in all cases.

Current State and Inefficiencies

Asset Servicing is the administration of legal rights and obligations associated with a security post-trade. This section covers three types of Asset Servicing and Lifecycle Management activities: corporate actions, tax withholding, and regulatory reporting.

Corporate actions are events triggered by the issuer that affect the position of the security. There are two types:

a. **Mandatory:** These do not provide the security holder a choice on whether to participate.[278] Examples include dividends, coupon payments, and mandatory stock splits.

b. **Voluntary:** These require a decision on the part of the security owner and additional process involving prompting, receiving, and communicating decisions.[279] Examples include proxy voting, M&A, spin-offs, rights issues, and voluntary conversions.

Tax Withholding: Dividends and interest payments are the two most common income streams that are subject to taxes, and most jurisdictions tax those forms of income via a withholding system.[280] Tax withholding is carried out by the withholding agent (usually the local custodian), with involvement from financial intermediaries.

Regulatory reporting: Periodic reporting of transactions, positions, capital, and measures of financial health to regulators.

277. ISDA Digital Regulatory Reporting – International Swaps and Derivatives Association.
278. Chartered Institute for Securities & Investment, Global Securities Operations, Ed. 18, Apr 2022.
279. Ibid.
280. Ernst & Young, "Withholding tax distributed ledger report", July 2021.

Corporate Actions

Inefficiencies in the corporate action process concern operational risk. The linear data flow from one stakeholder to another means that inaccuracies can easily pass down the chain. The transfer agent, CSD, and custodian are each responsible for their own data integrity. For downstream stakeholders such as the custodian, this dynamic can create distrust in any one source. Given the large costs and contractual liability that custodians can incur from corporate action administration errors, they spend considerable resources on multiple, often duplicative sources of information to confirm the accuracy of data. Firms can use up to seven different data feeds to source and validate information, which itself drives incremental reconciliation costs.[281] Despite these efforts, 56% of corporate action errors still originate from data issues.[282] In 2020, corporate action errors cost 70% of market participants more than $2 million per year.[283]

Tax Withholding

In most jurisdictions, by default, the local tax rate is withheld even for cross-border investments.[284] However, for cross-border income payments, investors can potentially receive tax relief due to tax treaties.

The process to prove eligibility for tax treaty relief is documentation-heavy and time-consuming. A substantial portion of tax treaty documentation is still paper-based and requires wet signatures. Applicants must navigate each intermediary's specific commercial confidentiality and investor privacy obligations.[285] During COVID-19, office closures exacerbated delays in completing paperwork, leading to more missed opportunities for tax relief at the source and a likely future influx of tax reclaim requests.

If investors cannot claim the tax benefit "at the source" or during the taxable event, a reclaim process must be initiated to remove the excess tax withheld. The reclaim process is also typically described as cumbersome.[286] Investors and their agents must file a separate series of documents to the tax authority, and then face a lengthy processing time. As a result, many investors do not complete the reclaim process once started or do not file a reclaim at all, thus paying more tax than necessary.[287]

Slow processing time and complex documentation requests weaken the resiliency of the oversight system. For instance, the European "cum-ex" tax fraud case in 2012 featured a technique employed by investors to complete quick transactions on the dividend pay-out date, then file fraudulent claims for tax relief on those transactions. Given the speed of the transactions and inability of the tax documentation system to keep pace, authorities granted tax relief to many investors who filed fraudulent claims. Overall, E.U. country treasuries lost €55 billion.[288]

The total costs resulting from these tax withholding Inefficiencies is substantial and persistent. The losses amounted to ~€8.4 billion in the E.U. alone as of 2016, including ~€6 billion foregone tax benefits, ~€1.2 billion in operating costs to attain relief, and ~€1 billion in opportunity costs (cash trapped in the relief process).[289]

Regulatory Reporting

Today's regulatory reporting regime for capital markets participants covers millions of transactions and positions spread over a patchwork of different databases.[290] Given the siloed nature of internal and external financial data at many banks, data quality issues are common and some require manual reconciliation to resolve.[291] For instance, European Market Infrastructure Regulations ("**EU EMIR**") require that both parties in a derivative trade report it to a repository with the appropriate Unique Transaction Identifier ("**UTI**"). The UTI is then used to match each counterparty's report. However, this process tends to break down if UTIs are not properly shared; in 2014, DTCC was only able to match ~40% of trade reports.[292] Compounding the data quality issues, banks must convert raw data into a high form of readiness for regulator consumption.

Both data quality issues and rigorous requirements ensure that regulatory reporting and compliance are resource-intensive activities. Survey data indicate that compliance costs account for more than 1% of revenue for most institutions. High operating costs are not limited to regulated entities; the Federal Reserve System spent ~$2 billion on supervision in 2017.[293]

281. The Value Exchange, "From issuer-ready to investor-ready: Removing the manual data burden."
282. The Value Exchange, "Asset Servicing innovation: Are we in the perfect storm?".
283. Kelly Mathieson, "Reimagining the high-stakes, expensive problem of Asset Servicing and Lifecycle Management", Digital Asset.
284. Ernst & Young (2021).
285. Ibid.
286. Ibid.
287. Ibid.
288. Ibid.
289. Ibid.
290. European Central Bank, "The potential impact of DLTs on securities post-trading harmonisation and on the wider E.U. financial market integration", Sep 2017.
291. Raphael Auer, "Embedded supervision: how to build regulation into decentralized finance", BIS Working Papers, Sep 2019.
292. R3, "Applications of Distributed Ledger Technology to Regulatory & Compliance Processes", Dec 2017.
293. Ibid.

The increased cost of regulatory compliance tends to weigh most heavily on smaller financial institutions, where compliance costs account for a higher share of non-interest expense.[294]

Summary Impact Assessment: High

The overall impact on Asset Servicing and Lifecycle Management is **high**, driven by the considerable changes across workflows, roles and responsibilities, technology, risk, and financials.

Models of Implementation

Corporate Actions

DLT could affect corporate action processes in two ways. First, the distributed ledger creates a shared source of truth, reducing the need for custodians to cross-check multiple data sources for accuracy. Second, assuming requisite integrations are made to clearing and settlement systems, smart contracts can automate execution of corporate actions, thereby shortening processing timelines. The mechanics of smart contracts in corporate actions is further elaborated below.

Corporate actions are legal arrangements that confer certain rights on investors and corresponding obligations on issuers, CSDs, and custodians. Smart contracts are therefore well-suited to operationalize corporate actions on the distributed ledger by providing a mechanism to automate and execute based on predefined conditions ("if…then" coding).

EXHIBIT 2.1.15

Impact Assessment of DLT on Activities and Participants in Asset Servicing and Lifecycle Management

	Issuers	Transfer Agent (TA)/Registrar	CSD	Data aggregator	Custodian	Asset Manager (AM)/Investor
Mandatory	High	High	High	High	High	Medium
Voluntary	Medium	Medium	Medium	Medium	Medium	Medium
Proxy voting	High	High	High	High	High	Medium

	Government/ tax authority	Local custodian/ Withholding agent	Global Custodian, fund manager, distributor	End Investor
$	High	High	High	High

	Government/supervisor	Regulated entities
	Medium	Medium

Source: BCG analysis.

294. Ibid.

A smart contract template can serve as an electronic representation of a legal document.[295] A smart contact template consists of legal prose and a series of parameters derived from the prose expressed in a smart contract language that can be used to run processes on the DLT.[296] Each parameter contains at least an identifier, type, and value that can be used as inputs into the smart contract code.[297] An "agreement" is a fully developed template with its bespoke legal agreements and corresponding parameters, usually arrived at as a result of negotiation between the parties to the corporate action.[298]

Smart contract templates and agreements could have two major effects on corporate actions. First, they embed corporate action reference data as intrinsic parameters of the Tokenized Security itself.[299] Corporate actions that are already set out in the prospectus at security issuance (such as scheduled future coupon payments for bonds) can be coded and tokenized immediately. More discretionary corporate actions, such as stock splits and dividend issuances, can then be tokenized and appended as additional smart contract agreements. In this way, the smart contract template system ensures that corporate action reference data are always up to date, creating a clear, immutable audit trail for each Tokenized Security throughout its lifecycle.[300]

Second, the template system forces alignment and clarity on corporate action data.[301] Assuming the template and parameterization process is based on the legal documentation of the corporate action, the process compels issuer and all other members to explicitly agree to the parameters *ex ante*; there is no room for disparities in interpretation.

Specific impact of Books and Records implementation: If financial institutions implement DLT for corporate action Books and Records, they can expect impact to be limited to potential processing efficiencies, data visibility and consistency provided by the distributed ledger. As stated earlier, custodians may no longer need to consult multiple sources to validate corporate action data. The ongoing collaboration between SWIFT and Symbiont is an example of a Books and Records implementation that aims to harmonize data from multiple sources into a single source of truth via DLT and smart contract automation.[302]

However, it would be difficult to realize corporate action **execution** automation without the use of DLT-based Securities. Automated execution envisions that corporate action rights and obligations are embedded with the security itself via smart contracts, usually starting at the point of issuance.[303] DLT-based Securities enable embedded data because composability is a key feature of DLT. On a traditional ledger, the process of designing smart contract–based automation for each security would likely be substantially more difficult.

This section now examines how the effects outlined above apply to dividends, bond coupons, and proxy voting.

Dividends: The impact of DLT on dividend processes can touch two different categories of activities: record date activity and payment processing. On record date under the current process, the issuer or transfer agent consults the register to determine who is eligible for the dividend. However, each member of the custody chain has only one level of visibility, so each successive intermediary must repeat the eligibility and entitlement determinations until the beneficial owners are determined. In a DLT-based system, the shared source of truth could render the eligibility and entitlement calculations straightforward; a smart contract could identify the end investors automatically.

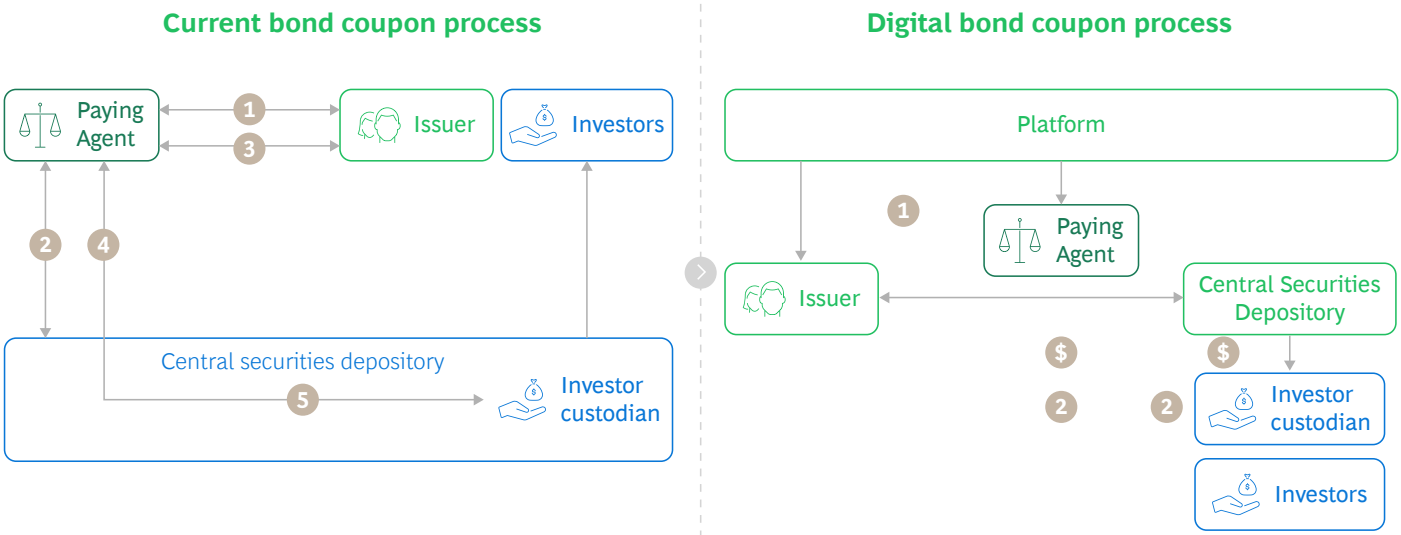
The impact of Tokenization on payment processing depends on the clearing and settlement system in place. If the corporate action ecosystem adopts a distributed ledger but must be integrated with traditional payment rails, the efficiency gains are likely limited.

Bond Coupons: The bond coupon process is streamlined by DLT in a similar way as dividends. The current process involves considerable iteration among multiple stakeholders, as depicted in **Exhibit 2.1.16**.

295. Christopher D. Clark, Vikram A. Bakshi, and Lee Braine, "Smart Contract Templates: foundations, design landscape and research directions", March 2017.
296. Ibid.
297. Ibid.
298. Ibid.
299. Digital Asset, "Reimagining the high-stakes, expensive problem of Asset Servicing and Lifecycle Management", Digital Asset blog, 2022.
300. Ibid.
301. HSG Task Force, "Follow-up analysis for the HSG Task Force on Distributed Ledger Technologies (DLT-TF) on Issuer Corporate Actions Golden Copy", Nov 2017.
302. SWIFT, "SWIFT innovates to remove friction in corporate actions", Sep 2022.
303. Digital Asset (2022).

EXHIBIT 2.1.16

Bond Coupon Payment Process with and without DLT



Source: Singapore Exchange.

In the status quo (left side of **Exhibit 2.1.16**), the process entails: (1) the paying agent notifies the issuer and CSD about the upcoming coupon payment, usually using email or other free text format.[304] (2) The CSD responds with a coupon payment report and reconciles any discrepancies on terms with the paying agent.[305] (3) When payment is due, the issuer transmits the funds to the paying agent.[306] (4) The paying agent then passes the payment on to the CSD.[307] (5) The CSD remits payment to the investor's custodian, who then checks the amounts and credits the investor's account.[308] The flow of information and funds is chiefly linear, with information such as coupon reports passed back and forth and reconciled between issuer, paying agent, and CSD.

A DLT-based system could feature automated coupon payments based on a common, transparent ledger of ownership. Given coupons are usually agreed at issuance and generally require little to no customization, these payments are especially well-suited for smart contract automation. In this scenario, all stakeholders could be connected to a DLT-based platform where they jointly codify the terms and schedules of the bond coupon payment in smart contracts at the time of bond issuance. (1) As the coupon payment nears, smart contracts could alert issuer and paying agent of an upcoming coupon via a standardized platform message, complete with terms and calculated payment amount.[309] (2) After receiving notification with all relevant details, the issuer can pay the appropriate amount directly to the CSD, who then passes on the correct payments to investors.[310] In this scenario, the DLT-based platform has eliminated the need for iteration and reconciliation among issuer, CSD, and paying agent by codifying mutually agreed-upon terms into smart contract code in advance.[311]

Proxy Voting

Today's proxy voting system creates two inefficiencies:

(1) Information risks being lost or distorted through the communication chain. To enable quality control, intermediaries set conservative notification deadlines to allow time for processing and reconciliation.[312]

(2) Reconciliation processes happen at every stage of the chain, thus multiplying the processing cost. There is a real possibility of over-voting or under-voting, in which the total number of votes cast do not match the total number permitted by the shares outstanding. The troubleshooting and remedy process tends to be onerous, including back-and-forth communication (via email, SWIFT messages, API, or bespoke messaging), canceling previously cast votes, and issuing new voting instructions for custodians and investors.[313]

304. Singapore Exchange, "Fixed Income Digital Assets" (White Paper).
305. Ibid.
306. Ibid.
307. Ibid.
308. Ibid.
309. Ibid.
310. Ibid.
311. Ibid.
312. Luis Marado, "Streamline proxy voting and regulatory reporting using DLT", Digital Asset blog, Sep 2020.
313. Ibid.

In a DLT-based solution, the underlying distributed ledger and smart contracts could address these inefficiencies, reducing operational overhead in the proxy voting process. The distributed ledger would enable issuers and the CSD to rapidly identify which investors have voting rights and what proportion of the vote they control. Issuers could be able to communicate directly with shareholders, with detailed company meeting information in line with SRD II.[314] With the use of a smart contract platform, custodians can register client votes or delegate those votes to match another asset manager or owner *automatically* and *transparently* for everyone involved. Due to the automation and digitization provided by smart contracts, custodians can extend voting cut-off times, disclosed in a manner consistent with applicable regulatory requirements. Smart contracts can also reduce operational risk in the voting process. By checking that tokens correspond to the number of votes authorized, smart contracts can ensure there is no over- or under-voting.[315] With the proxy voting process streamlined, the system may see increased participation from retail investors. As of 2024, retail investors voted on just ~30% of shares owned, compared with 78% for institutional investors.[316]

Apart from proxy voting, other voluntary corporate actions, such as M&A, conversions, and warrants, tend to be more complicated transactions that rely on external data and often bespoke arrangements among specific classes of investors. Smart contracts would either need to use non-DLT to DLT data integrations (defined here as oracles) more heavily for these use cases, which introduces operational risk, or one would have to code a one-time smart contract at the time of the event, which may not be cost-effective. For these reasons, voluntary corporate actions (except proxy voting) are less suited for DLT adoption.

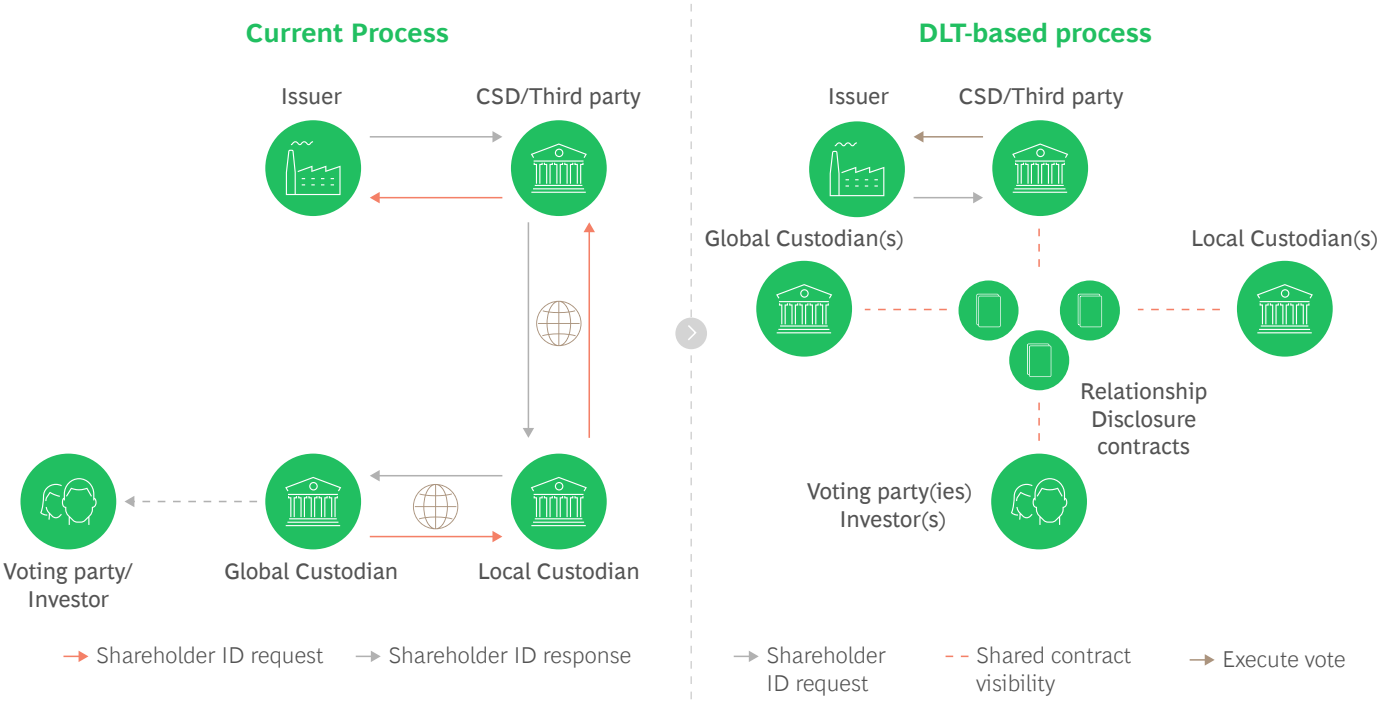
It should be noted that there are other non-DLT-based solutions that can also provide services to simplify proxy voting by taking different approaches to overcome these inefficiencies.

Tax Withholding

The main impact of DLT is that tax withholding can take account of tax treaty benefits and withhold the correct amount of tax at the source of the taxable event, thereby reducing the need for a later reclaim process.

EXHIBIT 2.1.17

Proxy Voting Activities, with and without DLT



Source: : Digital Asset (2020).

314. Ibid.
315. Ibid.
316. Broadridge, Harvard Law School, 2024 Proxy Season Review, Accessed July 2025.

A Permissioned Distributed Ledger Enables Secure Data Sharing in Near Real Time. The distributed ledger at the heart of the new withholding system could facilitate transparency into individual investor countries of residence and allow easy determination of beneficial ownership—the two key parameters to determine eligibility for tax treaty relief. In addition, a distributed ledger–based system replaces the linear, sequential Custody chain with a common source of truth. Investors and withholding agents would be able to view the same documents and transfer them expeditiously.[317] Accessibility and transparency also mean that tax authorities would be able to initiate near-real-time audits.[318] The occurrence of tax fraud scandal could be diminished given the ledger would be updated at a much faster cadence, with constant visibility from the regulator.

Smart Contracts Enable Correct Withholding at the Source, Reducing the Need for the Tax Reclaim Process. Withholding agents can withhold tax accurately during the taxable event itself by replacing the document-based manual workflows with a series of tokens assigned by smart contracts.[319] The tokens could model the dividend entitlements and determine the tax treatment, accounting for relevant tax treaties.

Participants Could Need to Manage Robust Integrations on a Distributed Ledger and off a Distributed Ledger to Enable Each Tax Withholding

While the distributed ledger reduces manual processing costs from handling documentation and reconciling across data sources, it may increase workload for custodians and investors in managing integrations and permissions to protect investor confidentiality and PII.

For tax withholding, investor names, addresses, and taxpayer identification numbers are highly sensitive and protected under GDPR.[320] As such, the system may need to keep that data off the DLT.[321] If the need arises to access documents with sensitive information, participants may need to maintain a parallel system off the distributed ledger system that is tightly integrated with transactions on the distributed ledger. ZKP technology may be necessary to represent a token's private data on the distributed ledger.[322] ZKP provides transacting parties access to the information; third parties could know a transaction occurred and be assured of its validity but would not be able to read the private data involved.[323]

Crucially, the degree of change in tax withholding depends on the jurisdiction's tax laws. A distributed ledger, if implemented and integrated fully, would enable automatic withholding at the source, taking into account tax treaty eligibility. Some jurisdictions do not allow this type of tax relief at the source without preapproval from tax authorities.[324] Assuming no corresponding reforms in the country's tax laws, DLT-based solutions may need to be less ambitious at best or could be stymied at worst. In a less ambitious implementation, the DLT-based withholding solution could simply inform existing tax withholding processes. Smart contracts would not automate tax collection, and the distributed ledger may not be the golden source of truth.

Moreover, the breadth of applicability for DLT-based tax withholding is still unclear. While cross-border dividends and interest payments to individuals are simple, the tax entitlements are notably more complicated for large corporations, which often have a large constellation of legal entities. In those cases, the smart contracts could likely need to account for not only domicile and income source, but also special provisions within the tax code.

Specific impact of Books and Records implementation: DLT-based tax withholding is, by definition, a Books and Records use case. It would require that dividend and interest entitlements be represented on the distributed ledger, with personal tax parameters accessible either on or off the distributed ledger. These records can be entered onto DLT while the securities themselves stay on traditional ledgers.

317. EY, "Withholding tax distributed ledger report", July 2021.
318. Ibid.
319. A non-fungible token (NFT) is a token that is unique, non-divisible, and non-interchangeable for other tokens.
320. Ibid.
321. Ibid.
322. Ibid.
323. Ibid.
324. Auer (2022).

Regulatory Reporting

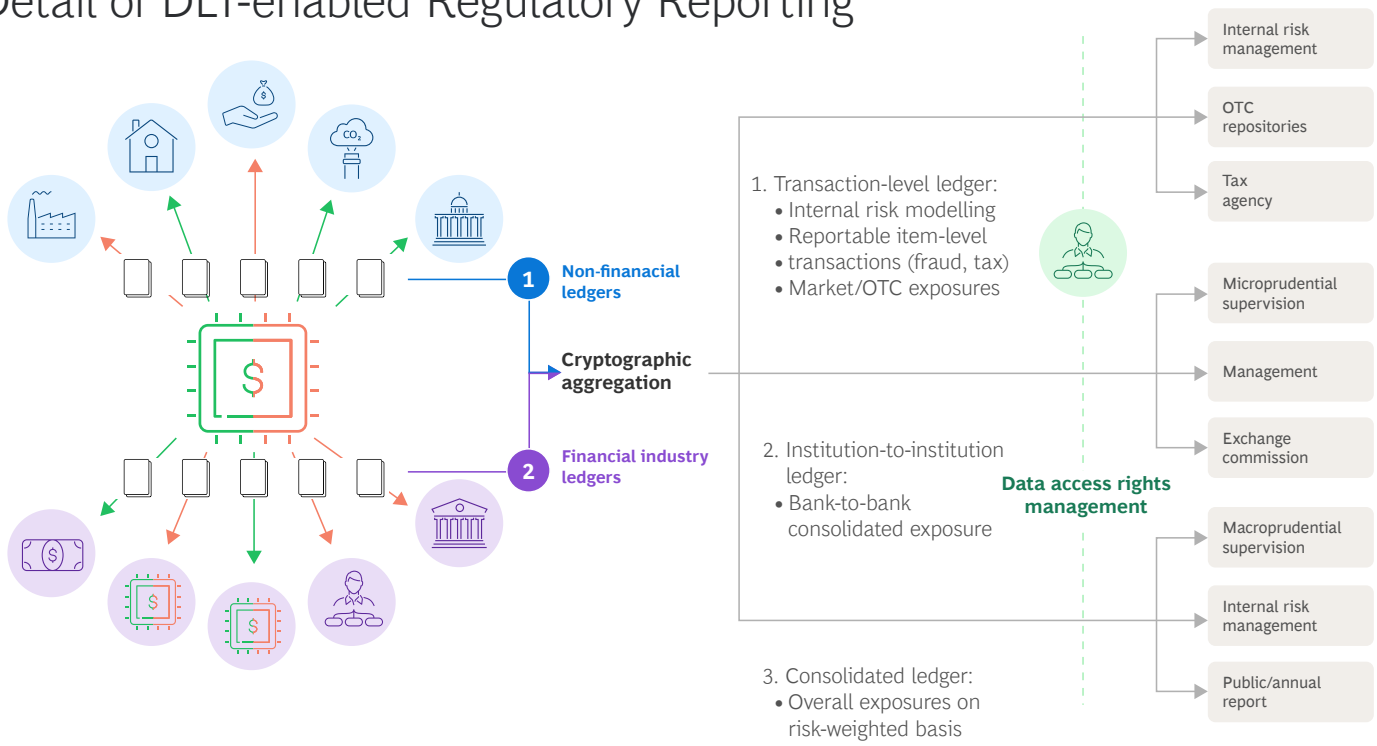
A DLT-based ecosystem can enable an embedded supervision approach. Embedded supervision is a regulatory conceptual framework in which the supervisor monitors compliance automatically by reading the market's distributed ledger in real time rather than periodically through large data requests and reports. ISDA's Digital Regulatory Reporting initiative already provides a framework in which transactions represented using the Common Domain Model can be used to automatically generate reports required by different regulators.

This system could save banks and regulators considerable resources currently absorbed in gathering, cleaning, and reconciling data from multiple databases and formats. For example, DLT could streamline or mostly eliminate UTI matching for derivative trades since it would impose a single trade record between the counterparties.[325] With less time focused on data-quality issues, regulators and regulated entities could more quickly identify sources of risk and focus on areas of non-compliance. In periods of financial stress, both regulators and financial institutions could potentially react more nimbly with the benefit of enhanced transparency and real-time data. For instance, a macro-prudential supervisor could calculate real-time stability and risk metrics for specific institutions.[326] Embedded supervision could also reduce the disproportionate burden of compliance cost currently borne by smaller banks.[327]

It is crucial to note, however, that DLT does not eliminate the need to aggregate data; data localization and privacy laws and resolution planning for systemically important institutions may require data to be dispersed.[328] To the extent that data enters the distributed ledger, the aggregation process can be simplified through greater ledger transparency. In addition, DLT does not absolve financial institutions from monitoring compliance traditionally in non-DLT markets. Ultimately, regulated entities may need to develop an integrated compliance apparatus across traditional and distributed ledger to track their cumulative capital adequacy and prudential positions.

EXHIBIT 2.1.18

Detail of DLT-enabled Regulatory Reporting



Source: Auer (2022).

325. R3, "Applications of Distributed Ledger Technology to Regulatory & Compliance Processes", Dec 2017.
326. Auer (2022).
327. Ibid.
328. R3 (2017).

The new operational challenge for an embedded supervision paradigm lies in permissioning, privacy, and data standards.[329] The system must determine which institutions have access to which ledgers and data stores. An OTC repository, for instance, could access just the transaction-level ledger without being able to see interbank consolidated exposures. A macroprudential authority could access a wider array of data, such as the consolidated ledger showing all transactions and positions (shown in **Exhibit 2.1.18**). For personally identifiable information and other sensitive data, participants may need to consider using private distributed ledgers accessible only by regulators with no presence from other financial institutions. These are major data structure and process changes which could require a long period of study and alignment across industry and regulatory community.

Given the current periodic cadence of regulatory reporting, transitioning to a real-time data-sharing paradigm would likely require a new set of analytical frameworks around data interpretation.

Thus far, embedded supervision is mostly conceptual. To become viable, this solution would require large-scale adoption and guarantee that the distributed ledger embodies final, accurate, and relevant data. There are two key features to note: (1) robust interoperability; and (2) in the case of Tokenized Securities, legal guarantee of the connection between an underlying security and its digital twin.

1. Tools enabling interoperability could be crucial given the numerous reference data fields regulators require for each transaction may lie on different distributed ledgers or on traditional ledgers as well. Oracles could enable the consolidation of data from financial and non-financial ledgers onto the distributed ledger. In addition, they route necessary off-distributed ledger inputs, such as interest rates, to calculate consolidated regulatory metrics.

2. Embedded supervision requires that the distributed ledger be structurally sound. This means that any Tokenized Security (which contains both the security off the DLT and its digital twin on the DLT) must always maintain its integrity, and that integrity must be guaranteed by the legal system.[330] Any discrepancies would distort and compromise the integrity of the system as a whole.

Both features are large challenges that may likely require considerable time and investment to resolve across firms and regulators. Additionally, efficiencies from embedded supervision are limited to DLT-based markets only. Thus, although the impact within DLT-based markets is profound, total impact on consolidated bank regulatory reporting is likely to be muted as long as DLT-based Securities continue to be a small portion of total banking sector assets.

Specific impact in Books and Records implementation: The concept of embedded supervision was designed to regulate and monitor DLT-based Securities. Having the securities themselves legally owned on the traditional ledger while the reporting data is on the distributed ledger could lead to more operational complexity than having all data on the distributed ledger. Complications can arise, given data would need to traverse between two fundamentally different systems. That said, a Books and Records use case without DLT-based Securities could be a useful initial proof of concept to test the cost efficiencies argument

Evolved Roles and Responsibilities

This section will explore the roles that could see material impacts from the introduction of DLT.

Corporate Actions

Issuers of securities would remain responsible for initiating corporate actions, as in traditional markets today and in line with corporate governance, but their method of engagement with the markets could change. In addition to the current modes of press release and regulatory filing, issuers could announce corporate actions on the DLT-based platform. Given the upfront technological costs required to build and maintain a node and the risk framework and controls required to run a node responsibly, issuers may rely more heavily on ***issuer agents*** to transmit the announcement via DLT. This could be a useful role for ***issuer agents***, since some of their traditional role of maintaining the register and calculating routine payments (in the case of a ***calculation agent***) on behalf of the issuer could be replaced via smart contract automation.

329. Ibid.
330. Ibid.

Custodians may expect their operational risk associated with corporate action discrepancies and errors to decrease in a DLT-based system. Custodians currently play the dual role of detecting corporate actions and administering them on behalf of investors. These tasks could be simplified by DLT. Custodians may no longer need to invest heavily in multiple data sources to obtain reliable corporate action data. Moreover, the source of data discrepancies could be more easily traceable to the source or the DLT itself.[331]

The distributed ledger, however, does not eliminate all work for custodians in terms of corporate action communications. The consensus algorithm could require that custodians help validate new corporate actions that have been submitted by issuers or issuer agents. Custodians may play a role in monitoring the smart contracts that automate corporate action processing. Finally, local custodians may continue to play an important role in ensuring compliance with local regulations.

A governing body for DLT-based corporate actions would likely be necessary in the set-up phase of the DLT-based corporate actions system. This consortium of industry stakeholders and public authorities could formulate standards governing the codification of corporate action rights and obligations in smart contracts. This should incorporate existing market standards wherever possible, such as those from the Corporate Actions Joint Working Group ("**CAJWG**"), or instruction formats established in ISO 15022 and more recently in 20022.

Tax Withholding

Withholding agents' core responsibility should not change in a DLT-based system. The technology, however, should make withholding much simpler. Withholding agents would deploy and oversee smart contracts that determine the appropriate withholding rate, inclusive of applicable tax treaties.

Global custodians, fund distributors, and other financial intermediaries could continue their roles supporting investors with documentation needs and requests. They could play a large part in creating and maintaining integrations between secure messaging off the distributed ledger for documents and calculations of tax liability on the distributed ledger.

Tax authorities' core responsibilities are not likely to change. In a DLT-based system, they could likely have more potent and granular oversight capabilities. Audit checks in a DLT-based ecosystem would be conducted in near real-time. Processing of tax reclaims, if necessary, may be significantly simplified and expedited due to the transparent and immutable data stores on the distributed ledger.

A neutral governing body for DLT-based tax withholding could facilitate the development of the DLT-based tax withholding system. This could be a consortium consisting of financial institutions and tax authorities, which could come to consensus on applicability of the system (in the context of the jurisdiction's tax laws), solicit stakeholder feedback, design risk management protocols, and promote the realization of network effects.

Regulatory Reporting

Regulators and regulated entities likely would not see their roles change in regulatory reporting and could benefit from better data quality and lower operational cost. It remains unclear, however, what impact that constant and automatic vigilance may have on regulated entities, given the novelty of having such data in the regulatory field. This dynamic underscores the importance of the system clearly defining which types of data regulators could be able to access through embedded supervision. For that data, both regulators and regulated entities could agree on guidance around interpretation of financial stability metrics in real time.

331. Digital Asset (2022).

Financial Impact and Opportunities

The long-term potential cost savings for DLT in asset servicing and lifecycle management are considerable. Corporate action errors cost the custodian industry over $1 billion USD per year.[332] Though technology is one driver of broader operational inefficiencies, implementing a DLT-based solution could play a role in addressing a portion of that cost. The combined savings for a DLT-based tax withholding system, assuming it reduces most use cases for tax reclaims, could save the E.U. up to €8 billion.[333] Embedded supervision regimes could bring down the cost of compliance, which currently sits at 3–9% of non-interest expense for most banks[334] and more than $1 billion per year for the Federal Reserve.[335]

The profound degree of change to technology and operations required by DLT-based solutions introduces uncertainty into the investment case. In the short-to-medium term, those operating expense savings could likely be incremental, if at all. This is due to the need to run traditional systems in parallel with DLT systems to build regulatory and client trust. At the same time, DLT-based solutions may need to compete against more incremental but lower-cost non-DLT solutions in regulation technology and process optimization. Moreover, these DLT-based systems are dependent on concerted investments by all public and private sector stakeholders to realize network effects. The support and engagement of tax authorities and financial supervisors will be instrumental to the success of DLT-based tax withholding and embedded supervision, respectively.

Risk Impact

Integrating DLT in Asset Servicing can give rise to novel risk considerations that require a comprehensive analysis. **Chapter 1.4 | Risk Mitigants** examines these risks and proposes mitigations. Furthermore, this section evaluates the potential impact of DLT in reducing existing risks in the Asset Servicing stage of the securities lifecycle.

Operational Risks: The data uniformity of the DLT and smart contract automation could drive significant operational efficiency. With a DLT independently validating and maintaining a golden source of data, with shared visibility, all participants could drastically reduce the chances of data discrepancies or disagreements, leading to faster, more efficient corporate actions, tax withholding, and regulatory reporting. Smart contracts can reduce execution risks in processing by reducing opportunities for manual data manipulation, reconciliation, or data entry. These benefits are likely contingent on updated legal and regulatory frameworks that allow automated tax, corporate action, or regulatory reporting, with use of DLT. In the interim, the effect of DLT in mitigating risk may be diminished.

2.2 REGULATORY REPORTING AND KYC

As of 2017, the average annual KYC cost was $150 million for financial institutions with more than $10 billion in revenue.[336] It took between 26 and 32 days to fully vet a customer through KYC procedures; both financial institutions and their clients expected that process to lengthen going forward.[337] Key drivers of KYC cost and processing time are the manual and repetitive nature of the work. A customer must go through a full KYC process with every bank it works with, even if some or most requirements are the same.[338] As a result, clients must process duplicative requests between banks and even among different divisions of the same bank, leading to a heavy documentation workload.[339]

Moreover, the many stakeholders also introduce multiple pass-backs and iterations that lengthen the process timeframe. This cost compounds as a client's business scales.

Clients recognize the KYC process as a growing operational Inefficiency. In a 2019 survey of corporate treasurers conducted by EuroFinance and SWIFT, 93% of respondents indicated that KYC requests were more challenging than five years ago.[340] Clients reported that responding to KYC requests is a daily activity that occupies up to three FTEs throughout the year.[341] More than half of respondents stated they had limited the number of banks they work with for KYC purposes, while 28% said they had abandoned an account opening process one or more times.[342] Thus, the KYC process could continue to be a challenge if no action is taken to streamline its operations.

332. S&P Global Market Intelligence, "De-risking corporate actions processing: getting the right mix of expertise and technology", Jan 2022.
333. EY (2021).
334. Federal Reserve Bank of St. Louis, "Scale Matters: Community Banks and Compliance Costs", July 2016.
335. Auer 2022.
336. Thomson Reuters, "Thomson Reuters 2017 Global KYC Surveys Attest to Even Greater Compliance Pain Points", 2017.
337. Ibid.
338. Jose Moyano & Omri Ross, "KYC Optimization using Distributed Ledger Technology," 2017.
339. Ibid.
340. EuroFinance & SWIFT, "Solving the KYC Conundrum," 2019.
341. Ibid.
342. Ibid.

Challenges—U.S.

As discussed above, KYC/AML/CFT requirements may pose challenges in permissionless environment given that participants are pseudonymous, yet these regimes require identification as part of a strong CDD program and for reporting purposes. The Bank Secrecy Act requires that financial institutions implement risk-based programs that can verify the identity of a customer and perform due diligence such that the nature and purpose of the customer relationship is understood. Regulators such as the SEC historically have highlighted compliance with the Bank Secrecy Act as a priority for firms that offer cryptoasset-related services.[343] As detailed further below, under a controlled-DLT environment, compliance is not only feasible, but could be largely automated. In order to effectively implement such controls and address potential concerns as to fragmentation, the industry needs sufficiently detailed guidance from regulators. Among other things, such guidance should be tailored to the applicable network archetype for which such controls need to be implemented.[344]

Challenges—U.K./E.U.

i. **Wallets.** The obligation to satisfy CDD (as discussed above) must be satisfied in respect of customers' wallets. However, in practice, due to the anonymity of customers' crypto wallets in certain DLT systems, additional operational measures need to be put in place to allow firms to carry out the required CDD.[345] The identity of a customer or beneficial owner must be verified '*on the basis of documents or information obtained from a reliable source which is independent of the customer*'. As discussed under **Chapter 1.2**, it is highly unlikely that, in the context of a permissionless system, it would be possible to obtain the required information from all relevant wallet providers/beneficial owners in order to satisfy relevant CDD. Even if it is possible to obtain the required information, this is likely to require manual reconciliation and processes that may have commercial implications that mitigate potential operational cost-savings associated with DLT-based systems, ultimately acting as a barrier to widespread adoption. Additionally, a key draw of the movement towards DLT-based systems is an increase in accessibility to capital markets, and such rigorous identity verification would sit contrary to this aim.

ii. **Nodes/Participants** in DLT-based systems are typically rewarded with tokens or some other form of value, in return for calculating and recording transactions on a distributed ledger. While the FATF 2021 Guidelines generally exclude transaction fees from the scope of certain requirements, this is not legally binding. As such it is necessary to consider the legal position in each individual jurisdiction, some of which may take a more stringent approach. It is currently unclear the extent to which nodes/participants would fall within the CDD obligation placed on a bank or other in-scope firm. However, it would be reasonable to assume that the obligation would apply. The identity of a customer or beneficial owner must be verified '*on the basis of documents or information obtained from a reliable source which is independent of the customer*'. As discussed under **Chapter 1.2**, in the context of permissionless systems, it would be effectively impossible to comply with CDD obligations as it would require (i) identifying all nodes that are calculating transactions and (ii) to extent that the nodes/participants can be identified, they would not provide the relevant information to carry out the CDD.

Additionally, there are no geographical or jurisdictional restrictions on the location of nodes/participants in permissionless systems. Given the anonymity afforded to nodes/participants in permissionless systems, it is likely to be difficult or impossible for firms to establish any applicable obligations under sanctions regulations for a given node/participant based on the jurisdiction in which the node is located.

Challenges—Hong Kong

Intermediaries engaged in digital asset activities currently may not be caught within the scope of the Anti-Money Laundering and Counter-Terrorist Financing Ordinance ("**AMLO**"). The AMLO amendment bill intends to rectify this by capturing Virtual Asset Service Providers ("**VASPs**") engaging in different virtual asset operations. However, from a practical implementation perspective, considering that virtual assets could fall under different regulatory categories and involve a wide range of possible operations/services, it poses great challenges to regulators from a surveillance and enforcement perspective. It is difficult to strike the right balance between ensuring investor protection and encouraging technology/financial innovation to

343. See **https://www.sec.gov/files/2025-exam-priorities.pdf**.
344. The recent report published by the President's Working Group on Digital Assets recommends that regulators and supervisors develop guidance and best practices that can be used by certain digital asset service providers to ensure compliance with AML/CFT obligations.
345. For example, the identity and ownership of an address can be verified, and this verification process can even be timestamped at the point an organization completes CDD on the specific account by airdropping an NFT.

promote the virtual asset ecosystem. In this respect the amendment bill will first seek to cover centralized virtual asset exchanges (that do not involve instruments regulated under the Securities and Futures Ordinance and therefore do not involve virtual assets that are securities which would be regulated under Securities and Futures Ordinance), and will not yet capture other virtual asset operations at the beginning (e.g., OTC trading, decentralized trading platforms or Custody operations). It is also important for regulators to avoid regulatory overlap in regulating similar virtual asset operations – for example, the Hong Kong Monetary Authority ("HKMA") are facing similar issues in their proposal to regulate stablecoins in Hong Kong, which was announced via a discussion paper on cryptoassets and stablecoins issued in January 2022.[346] As also discussed in **Chapter 4.2.3.1**, there are many existing regimes which regulate "securities" that could potentially capture stablecoin operations. The HKMA, and other regulators, should carefully consider the scope of any new regulatory regimes in order to avoid any overlap between various regulatory regimes, ensure consistency in regulatory standards (with respect to AML, conduct of business requirements, capital requirements, etc.), and promote harmonization across regulatory regimes (such as introducing any cross-regime exemptions).The HKMA have now proposed the introduction of a stablecoin licensing regime in their consultation conclusion, published on January 31, 2023.[347] The proposal sets out the regulatory perimeter for stablecoins, including the activities that will be regulated and the entities that will require licensing.

Challenges—Japan

Crypto-Asset Exchange Service Providers qualify as Specified Business Operators and are obliged to meet the requirements to take AML measures. However, it may be difficult for Crypto-Asset Exchange Service Providers to meet such requirements due to the anonymity afforded to nodes or participants in DLTs, especially in permissionless-type DLTs. For example, Crypto-Asset Exchange Service Providers are required to build a monitoring scheme of Suspicious Transactions and, if a tool to patrol DLTs to check for any Suspicious Transactions is implemented, it will be required to check the details of the transactions conducted via DLTs through the customer's address in order to enhance the effectiveness of patrolling Suspicious Transactions. When permissionless-type DLTs are used, it is likely to be difficult or even impossible for Crypto-Asset Exchange Service Providers to check the details of the transactions or the identity of a node or participant therein. This would be the case for Type I Financial Instrument Business Operator ("**FIBOs**") and/or Type II FIBOs regarding their transactions involving Security Tokens.

Challenges—Singapore

The challenges described in the U.K./E.U. **Chapter 4.1.2** and **4.1.3** would be similar in Singapore. The MAS Money Laundering National Risk Assessment[348] noted that within the financial sector, digital payment token services carry a higher risk of money laundering. The verification of customers and beneficial owners should be made using reliable, independent source data, documents, or information.

In 2024, MAS introduced stricter AML and CFT requirements targeted at digital payment token service providers. From April 2024, all digital payment token service providers holding a payment services licence issued under the Payment Services Act must comply with notices PSN01[349] (generally applicable to specified payment services) and PSN02[350] (specific to digital payment token service providers).

It should be noted that Singapore has implemented the FATF travel rule for digital payment token service providers. Providers that facilitate the sending of digital payment tokens are required to obtain and record accurate originator information and beneficiary information on digital payment token transfers, immediately and securely submit such information to the beneficiary institution and make the information available on request to relevant authorities.

346. HKMA, "Discussion Paper on Crypto-assets and Stablecoins", January 2022: **https://www.hkma.gov.hk/media/eng/doc/key-information/press-release/2022/20220112e3a1.pdf**.
347. "Conclusion of Discussion Paper on Crypto-assets and Stablecoin": **https://www.hkma.gov.hk/media/eng/doc/key-information/press-release/2023/20230131e9a1.pdf**, Hong Kong Monetary Authority, January 2023.
348. MAS, Money Laundering Risk Assessment Report Singapore, November 2024: **https://www.mas.gov.sg/-/media/mas-media-library/publications/monographs-or-information-paper/amld/2024/money-laundering-national-risk-assessment.pdf**.
349. MAS, Notice PSN01 Prevention of Money Laundering and Countering the Financing of Terrorism – Specified Payment Services, 2 April 2024: **https://www.mas.gov.sg/regulation/notices/psn01-aml-cft-notice---specified-payment-services**.
350. MAS, Notice PSN02 Prevention of Money Laundering and Countering the Financing of Terrorism – Digital Payment Token Service, 2 April 2024: **https://www.mas.gov.sg/regulation/notices/psn02-aml-cft-notice---digital-payment-token-service**.

Solutions

The use of DLT in advancing KYC prosses is often cited as a promising use-case for this technology. There are two potential DLT utilities identified here: (1) DLT as a data collection utility, standardizing the collection of KYC data, and (2) DLT as a KYC verification utility, expediting the KYC verification process by validating previously completed verifications through cryptographic tools. However, the impact from these two use cases is likely to be limited. When considering DLT as a data collection utility, existing, purpose-built, non-DLT solutions can address inefficiencies in KYC data collection with far greater efficacy than a DLT-based tool. Further, DLT is unlikely to be used as a KYC verification utility due to the unresolved issue of the substantial legal liability that could arise if financial institutions rely on an erroneous verification without examining the client's underlying credentials. In aim of being comprehensive, these two use cases are examined in greater detail below, with a similar discussion of the challenges that would need to be overcome in order for them to be integrated into a DLT-based capital markets ecosystem.

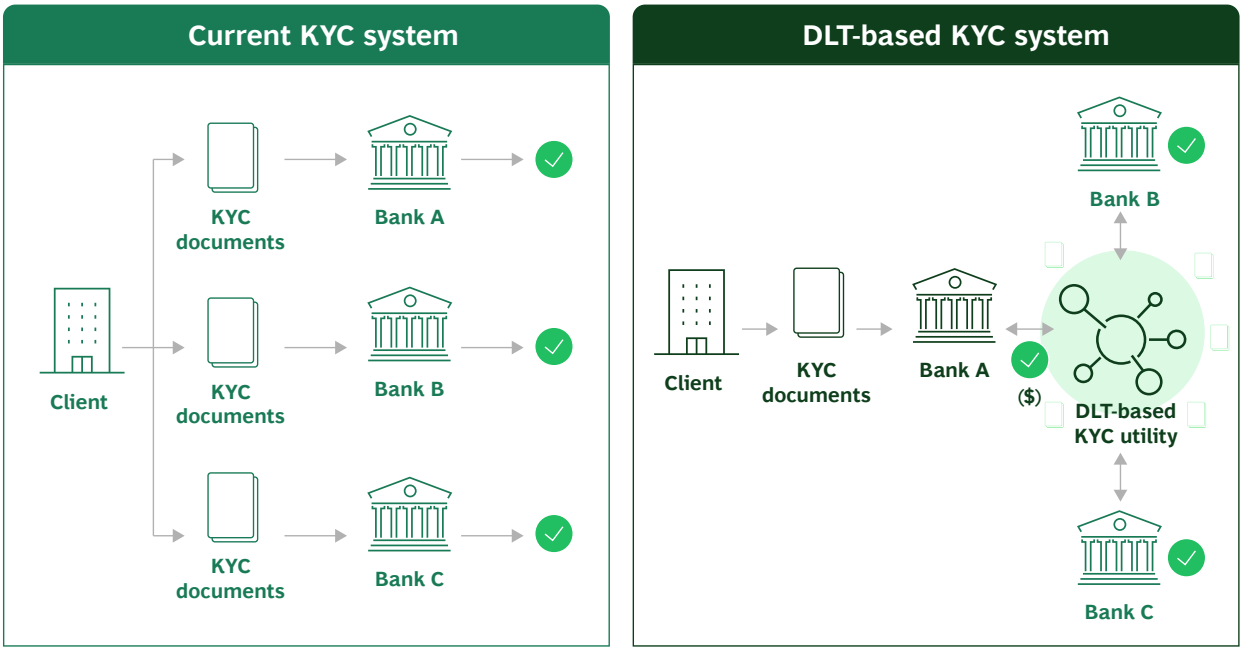
(1) DLT in KYC data collection

The extent to which DLT can support the collection of KYC data varies by network archetype. In a private-permissioned or public-permissioned model, access to the network will remain permissioned by a regulated financial institution who is responsible and capable of upholding institutional-grade KYC data collection standards. Use of DLT for KYC data collection on a public-permissionless network would be considerably more challenging due to increased challenges around the verifiability of third-party credentials and is unlikely to be realized in the near-to-medium term. Described below are considerations and challenges for instituting KYC data collection on a permissioned network.

Under a DLT-based KYC data collection process, clients only need to upload data once to a KYC utility. The KYC utility could then serve as a repository on the distributed ledger housing the authoritative KYC document file for each client.[351] Financial institutions could refer to the KYC document file for clients as a starting point, which should reduce the number of direct data requests that clients receive. For clients that work with multiple financial institutions, the distributed ledger's consensus mechanism can ensure that discrepancies are highlighted and resolved.[352] The KYC utility can provide this level of data sharing and access while also protecting confidential data. For example, highly sensitive information can be stored outside the distributed ledger and encrypted with a cryptographic hash function if it needs to be shared.[353] In this way, the utility would employ a tiered permissions system that shares information on a "need to know" basis.

EXHIBIT 2.2.1

A DLT-based KYC Model Can Standardize and Expedite KYC Processes



Source: Moyano & Ross (2017).

351. Refinitiv, "A Blockchain Enabled KYC Solution: New Horizon or False Dawn?", 2018.
352. Ibid.
353. Ibid.

The key enablers of DLT-based KYC data collection concern data governance and scalability. The value of DLT is premised on standardized entity data that is sharable both conveniently and compliantly. To enable this, financial institutions and regulators would likely need to agree on data formats, privacy safeguards, and sharing processes spanning multiple regulatory regimes.[354] This is likely to be a lengthy journey. Additionally, questions exist around any DLT-based KYC solution's ability to scale. On the technical side, there are concerns regarding whether DLT in this context, can consistently handle enterprise-level throughput.[355] The substantial infrastructure investment and operational set-up cost may represent a significant barrier to entry for smaller financial institutions.[356]

Even if regulators and financial institutions were able to overcome the set-up challenges, it is not evident DLT is required to deliver the benefits of a KYC data utility. For instance, a KYC utility can employ encryption and cryptography to enable secure data sharing and protect privacy without adopting the distributed database architecture that DLT would feature. Additionally, numerous non-DLT solutions seek to streamline the data collection process without requiring a KYC utility. These include workflow tools that automatically fill KYC documents and manage task checklists to data management platforms that can consolidate multiple data systems into unified views for financial institutions.

(2) DLT in KYC verification process

DLT could theoretically reduce lengthy verification processes by introducing confirmation of KYC approval, and the supporting evidence, to the client's authoritative data file. This verification is added by the first institution that screens and validates the client's KYC profile. The first verifier may be a bank (which could be compensated by the other parties for the effort)[357] or a trusted, objective third party that maintains the KYC utility.[358] In either case, the confirmation and evidence allow other institutions to expedite their verification processes, leveraging the work done by the first verifier. A more advanced DLT-based system could adopt a self-verification scheme where institutions can use zero-knowledge proofs and other cryptographic techniques to execute the KYC check in near real-time without referencing the underlying data. The client profile can become a "KYC ID" managed by local authorities and used to check AML sanctions lists as part of cross-border payment processing.[359]

DLT-based KYC verification is not feasible at scale due to liability and governance concerns. Financial institutions may be hesitant to be the first verifier in a DLT-based system for fear of consequences if they commit an error, while other institutions may be hesitant to rely on the first verifier's work. The current margin of error for KYC is low and penalties high for institutions conducting their own KYC checks. The liability is likely to multiply if a verifier supplies an erroneous decision that then propagates through the system. The alternative, which is to entrust a third party to review and verify, may de-risk the system. These challenges must be resolved before DLT-based verification can attain widespread trust and acceptance.

Additionally, using permissioned systems (for example, a fully permissioned DLT, or alternatively a permissioned environment built on top of a public, permissionless DLT) on which participants and nodes are fully identified and have been vetted could help in meeting applicable AML regulations. The use of private transactions and agreements in which access is restricted to participants and node operators on which CDD has been completed could also help to resolve this concern in the context of permissionless systems.

From a legal/regulatory perspective, clarity is required as to whether the technical solutions set out above are an acceptable way for firms to satisfy the applicable obligations under the applicable AML/KYC standards. By way of illustration, it is technically possible to create a protected layer that sits on top of a permissionless framework, producing a permissioned environment that could ensure, among other things, that incentives are not paid to parties that are not compliant with the applicable AML/KYC regulations (i.e., CDD can be conducted in respect of the permissioned participants), or alternatively are in sanctioned jurisdictions. To encourage industry adoption of DLT-based systems and DLT-based Securities, regulators must be clear that firms can utilize such technology without breaching AML/KYC or sanctions requirements.

354. Ibid.
355. Ibid.
356. Ibid.
357. Moyano and Ross (2017).
358. Refinitiv (2018).
359. David Ballashk & Marcus Hartel, "The 'amplus' initiative – a modular approach to improving cross-border payments."

Chapter 3 | Towards A Future DLT-Based Ecosystem

This chapter defines the core components of a future DLT-enabled capital market ecosystem, considers how the evolution toward this ecosystem could occur, and identifies the key barriers that could prevent adoption.

3.1 FUTURE DLT-BASED ECOSYSTEM

A clear shift has occurred from pilot projects to production-grade deployments in asset classes such as tokenized money market funds, investment-grade bonds, private credit, and real estate. Institutional momentum is underpinned by stronger regulatory clarity, growing liquidity in tokenized instruments, and scalable, enterprise-grade infrastructure.

Among the most advanced use cases are tokenized funds, which combine the familiarity of traditional fund structures with the programmability of blockchain-based tokens. These instruments support 24/7 settlement, fractional ownership, and automated compliance, while reducing costs for distribution, administration, and reporting. BlackRock's BUIDL, launched in 2023, has become a reference model—exceeding $2.4 billion in AUM by Q2 2025.

Real-time payment infrastructure is also advancing. Tokenized cash instruments, ranging from stablecoins to tokenized deposits and wholesale central bank money, are increasingly integrated into tokenized asset workflows. Project Helvetia (Switzerland), Project Meridian (UK), and Project Guardian (Singapore) have successfully demonstrated atomic DvP settlement and real-time cross-border functionality.

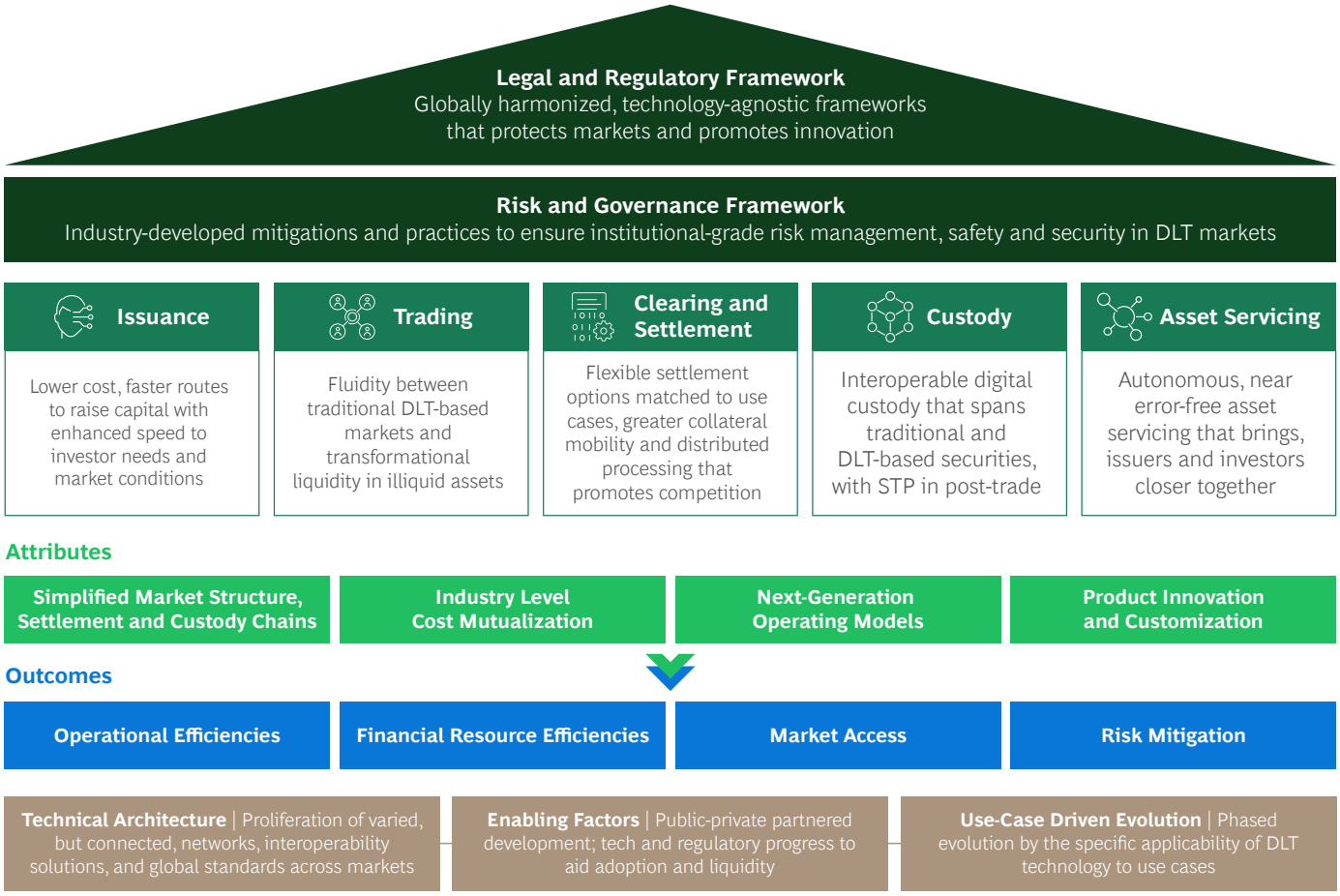
In parallel, legal and policy frameworks are maturing. The EU Pilot Regime allows licensed venues to issue and trade tokenized securities under simplified requirements. The UK's Digital Securities Sandbox, launched in 2024, supports live issuance and settlement of digital securities under regulatory exemptions. These frameworks offer market participants a viable pathway toward scaled adoption.

Technical interoperability remains a priority. Solutions such as SWIFT's interlinking pilot and ISO's Digital Token Identifier (DTI) are emerging to standardize messaging and reference data across DLT platforms and traditional infrastructure. These developments reduce friction in cross-platform workflows and enable asset managers, custodians, and exchanges to coordinate more effectively. Further development of the Common Domain Model has begun and needs to continue to ensure that data is standardized industry-wide.

The evolution toward a future DLT-based ecosystem will not be homogeneous across markets and asset classes. Adoption is likely to be phased, and focused in markets and asset classes where both opportunity and market readiness are best suited. In addition, there are a range of key enablers, which are likely to develop in parallel and could significantly impact timelines in both directions. These factors will influence how the journey towards a future DLT ecosystem unfolds across the near term, medium term, and long–term, described in the following **exhibit**. This ecosystem will operate in the near-term (and potentially in a steady-state future) alongside traditional rails but deliver distinct advantages in speed, flexibility, transparency, and cost.

EXHIBIT 3.1

Core Components of a DLT Ecosystem



Sources: BCG Analysis, GFMA Member Interviews.

Recent reports have highlighted the material expected scale of tokenized real world assets reflecting a technological shift and strategic reorientation within institutions.[360]

3.2 BARRIERS TO ADOPTION

The tokenization of capital markets is expected to scale materially through 2033. Market analysis projects tokenized real-world assets will grow from approximately $0.6 trillion in 2025 to $18.9 trillion by 2033, a compound annual growth rate of over 50%.[361]

But, as presented in the cost-benefit analysis section of the Executive Summary, adopting DLT requires substantial investment, infrastructure overhaul, and long-term institutional commitment. Financial institutions have invested heavily in blockchain projects and consortia over the past decade, with full-scale implementations averaging millions of dollars in investment and often requiring multi-year timelines. Early adopters have faced technical and organizational challenges, particularly around scalability, integration with legacy systems, and cybersecurity, as illustrated by the Australian Securities Exchange's costly and ultimately paused DLT settlement initiative. In response to these complexities, institutions have pursued collaborative approaches, forming consortia such as R3 and Hyperledger to reduce risk, build common standards, and accelerate development. Ultimately, DLT adoption demands a phased, well-governed strategy backed by executive sponsorship and sustained cross-functional coordination.

360. BCG, Ripple, "Approaching the Tokenization Tipping Point, April 2025.
361. BCG, Ripple, "Approaching the Tokenization Tipping Point, April 2025.

EXHIBIT 3.2

Possible Future Developments of a DLT Ecosystem

	TODAY PHASE 1: INSTITUTIONAL READINESS 1–3 years	MEDIUM TERM PHASE 2: COMMECIAL EXPANSION 3–5 years	LONG TERM PHASE 3: MARKET TRANSFORMATION 5–10+ years
	Partnered experimentation to validate technical capabilities & pilots move to production (e.g., repos, bond issuance). Public-private partnerships on legal ambiguities, regulation and best practice risk mitigants.	**Commercial viability** driven by rising issuer and investor demand in selected asset classes, as liquidity establishes. Legal and regulatory frameworks crystallize as benefits proven across jurisdictions.	**Large-scale growth** in issuer and investor demand across primary and secondary markets in selected asset classes. Robust and globally harmonized legal and regulatory frameworks established as DLT-ecosystem matures.
Primary Markets	**Limited demand for DLT-based securities; experimental issuances** • Mix of tokenized security and native security token issuance • Majority of process (e.g., structuring, syndication, book build) performed traditionally, no cost savings • Limited innovation around fractionalization and bespoke products	**Demand emerges in selected asset classes** • Native security token issuances outstrips tokenized securities • Native security issuance process party enabled on DLT, driving speed to market and lower issuance costs • Fractionalized issuance on select DLT platforms; issuers test new products	**Demand overtakes traditional issuance in selected asset classes** • Native security tokens is default format over tokenized securities • Native security issuance process fully enabled on DLT, driving further market responsiveness & savings • Scaled (retail) investor adoption of fractional issues and products tailored to investor needs
Secondary Trading	**Few secondary markets for DLT-based securities; liquidity is low** • Majority of trading venues (exchanges, OTC networks, MDPs) do not offer DLT-based securities • Where trading is possible, participants leverage non-FMI, purpose-built DLT-trading platforms	**Growth in DLT-based secondary market liquidity** • Trading of DLT-based securities emerges in selected trading venues for selected asset classes (e.g., illiquids) • DLT Platforms are integrated with traditional, non-DLT, FMI (e.g., FedNow for payment settlement)	**Majority of liquidity and trading in selected asset classes is via DLT** • Interoperable DLT market allows aggregation of liquidity across OTC markets and greater velocity • DLT-specific FMI matures (e.g., post-trade) • Fractionalization allows precise hedging and risk management
Clearing & Settlement (C&S)	**Testing of DLT-based C&S operational processes** • PoCs demonstrate instant DvP with traditional payment rails (e.g., RTGS) • Instant DvP in live production across repos, enabling intra-day use cases • DvP driven by tokenized commercial bank money, deposits and/or other forms of DLT-based Payment instruments	**DLT-based C&S emerges as alternative DvP channel in selected asset classes** • Instant DvP in live production across selected asset classes • Traditional settlement continue to dominate markets • DvP driven primarily by tokenized commercial bank money, deposits	**Automated, continuous DLT-based C&S is the default in selected asset classes** • Settlement choices driven by needs of market participants • DLT-based C&S enables Opex & capital efficiencies, and mitigates risk • DvP driven by either tokenized commercial bank money or deposits depending on use case
Custody	**Digital custody solutions are limited, propositions focused on cryptoassets** • Custodians focused on custody of cryptoassets to meet near-term market demand • Limited adoption of DLT-based books and records and post-trade operations • Emergence of DLT-based collateral mobility platforms in repos and OTC derivatives	**Growth in digital custody solutions, with move away from cryptoassets** • Custodians build or buy solutions for DLT-based security custody (recordkeeping and automation in post-trade operations) • DLT-based collateral mobility platforms become default option • Clarity on role of national CSDs across major markets	**Digital custody solutions offer DLT-based and traditional custody** • Custodians provide seamless interoperability between DLT-based and traditional securities • DLT simplifies post-trade operations reducing Opex and mitigating risk • Harmonization on roles of CSD across markets
Asset Servicing	**Limited ecosystem around smart contracts (standards, regulation etc.)** • Proof-of-concept testing for smart contracts supporting DLT-based income payments (e.g., coupons, dividends) • Partnerships to build capabilities but open questions remain (e.g., legal, regulatory, risk and governance, standards)	**Growth in piloting of DLT-based asset servicing** • Standardization of smart contracts drives traction in DLT-based income payments (e.g., coupons, dividends) • Functionality to support tax and regulatory reporting processes piloted • Clarity across legal, regulatory, risk and governance frameworks	**DLT-based asset servicing becomes default in selected asset classes** • Corporate actions embedded in smart contracts tied to securities at issuance • Dividends, coupons, and tax withholding processes automated and settled with DLT-based payments • Targeted 'embedded supervision' introduced for real-time regulatory visibility and monitoring
Key Enablers	Cross-industry, public-private partnerships; Regulated, accepted, DLT-based money; Industry-aligned taxonomy and educative materials; Updated fund and investment mandates; Global legal and regulatory framework; Interoperable networks and markets; DLT-specific FMI		

Sources: BCG analysis, GFMA Member Interviews.

While momentum is building, several persistent barriers constrain scalable adoption of tokenization. These challenges span infrastructure, legal certainty, operational maturity, and strategic alignment.

1. Market Liquidity and Participation: Secondary market liquidity for tokenized assets remains shallow. Issuers cite distribution uncertainty, while investors report onboarding friction and limited exit options. The development of regulated broker-dealer networks and market-making protocols is essential to enable meaningful price discovery and trading volume. Until this is achieved, tokenized instruments risk being confined to closed networks with limited utility.

2. Interoperability and Platform Fragmentation: Most platforms remain siloed. Private-permissioned ledgers dominate early use cases but often lack the flexibility to scale across jurisdictions or asset types. Bridging solutions—such as SWIFT's cross-chain messaging and emerging Layer 2 protocols—aim to enable delivery-versus-payment (DvP) and asset composability across platforms. The Common Domain Model needs further development and adoption to ensure that the tokenized and digital market has a solid foundation of industry-wide data standards. However, integration complexity, compliance differences, and the absence of widely adopted standards continue to delay progress.

3. Custody, Compliance, and Operational Readiness: Custody infrastructure for tokenized assets remains fragmented. While some global custodians support tokenized funds and digital asset servicing, capabilities vary by region and asset class. Firms must also build new risk, identity, and compliance tooling to handle wallet permissions, smart contract governance, and regulatory reporting across jurisdictions. Integrating these controls with legacy platforms remains a major undertaking.

4. Legal and Regulatory Gaps: Legal certainty is essential to support lifecycle events such as ownership transfer, settlement finality, and enforcement of smart contract terms. In many jurisdictions, these legal frameworks remain incomplete for some or all platforms. Some progress has been made through EU pilot regimes, UK sandbox permissions, dedicated digital asset statutes in Switzerland and Singapore as well as the recent passage of the GENIUS Act and consideration of digital asset market structure legislation in the United States. However, global fragmentation slows institutional confidence and inhibits cross-border deployment.

5. Cost-to-Operate and Strategic Trade-Offs: The up-front cost of transitioning to tokenized infrastructure remains significant. Full implementation may require investments of up to $100 million depending on institutional scale. Uncertain payback timelines, parallel system maintenance, and lack of standardized ROI benchmarks contribute to internal hesitation. Strategic alignment is further complicated by potential disintermediation, especially for actors that derive margin from legacy infrastructure layers. Tokenization is no longer a theoretical innovation—it is a live strategic transformation. The ecosystem is progressing from pilot to production across multiple jurisdictions, with real-world cost and access benefits emerging in targeted use cases. Institutions that prioritize scalable infrastructure, regulatory alignment, and liquidity coordination will be best positioned to define the next chapter of capital markets.

3.3 IMPERATIVES OF INCLUDING BANKS IN A TOKENIZED ECOSYSTEM

As tokenization evolves, some envision decentralized models operating outside the bounds of traditional financial institutions. However, excluding regulated banks from participating in tokenized finance would introduce material risks and undercut the foundations of trust, safety, and market integrity.

Additionally, banks are well-positioned to drive innovation in programmable financial services through the deployment of smart contracts layered onto tokenized money and assets. This includes automated settlement of transactions, conditional payments, and dynamic liquidity management—particularly in cross-border and multi-asset transactions. Banks can also act as trusted identity anchors and compliance nodes within unified ledger systems, facilitating AML/CFT checks, KYC onboarding, and data privacy without undermining the open architecture of the underlying technology.[362] Their involvement ensures that new financial infrastructure supports both public policy goals and commercial usability, enabling a seamless evolution of the monetary system rather than a disruptive overhaul. As such, the banking sector is not just a participant but a critical enabler of a secure, scalable, and inclusive digital asset ecosystem.[363]

362. Bank of International Settlements, "Novel risks, mitigants and uncertainties with permissionless distributed ledger technologies", August 2024.
363. Bank for International Settlements, "Annual Economic Report 2025, Chapter III: Blueprint for the future monetary system: improving the old, enabling the new", June 2025.

Many of the use cases that have gained institutional adoption today demonstrate the degree of coordination needed between banks and other market participants like NBFIs and digital native firms. Select examples of these use cases are discussed at length in **Deep Dives | Assessing Select Examples of Scaled Adoption**. As tokenized markets continue to scale, they will likely feature a diverse mix of participants. Banks are critical participants to drive and enable this development and in the section that follows, we examine the role they may play in DLT-based Payments and in the broader ecosystem.

Role of Banks in DLT-Based Payment Instruments

As the broader DLT ecosystem scales, the role of regulated banks remains central to ensuring the safe and sound integration of DLT-based Payment Instruments, such as tokenized deposits or stablecoins, into the broader financial system. While banks or digital-native firms may issue the digital tokens themselves, the underlying facilitation (e.g., custody of reserves, fiat settlement) is largely enabled by commercial banks. These institutions safeguard a portion of the fiat assets backing the tokens, facilitate flows across the financial system, and support integration with fiat payment and settlement infrastructure.

This foundational role is increasingly reflected in emerging legislation such as the GENIUS Act, which defines "payment stablecoins" and establishes demand deposits at banks as one of several categories of eligible reserve.[364] Non-bank stablecoin issuers are using regulated banks for fiat settlement, custody and reserve management in several jurisdictions.

Banks already hold deep expertise in risk management, compliance, and credit provisioning, and these functions remain indispensable in a digital framework. Unlike privately issued stablecoins, which today often still operate outside of regulatory perimeters, tokenized deposits issued by regulated banks are directly linked to fiat liabilities and integrated into the legal and institutional architecture of the existing financial system.[365] This may make them well suited to preserve monetary stability while leveraging the efficiencies of DLT networks. As such, the broader DLT-based payment ecosystem is not a replacement for banks, but rather complementary to them, and remains deeply intertwined with them.[366,367]

Role of Banks in Broader Ecosystem

Financial Stability and Regulatory Oversight: Banks are central to the financial system's stability. They manage systemic liquidity, serve as conduits for monetary policy, help fund the real economy, and are subject to prudential supervision. Removing banks from tokenized workflows would impair oversight and increase systemic risk, such as during periods of stress when centralized coordination is vital.

The absence of bank-grade controls in areas such as AML, KYC, and counterparty risk management would widen the regulatory perimeter gap. Pushing regulated financial institutions out of tokenized ecosystems could lead to "parallel, opaque markets" with reduced visibility for supervisors.[368]

Liquidity Fragmentation and Settlement Risks: Tokenized ecosystems rely on safe, scalable DLT-based Payment Instruments. Banks can provide settlement assets, like tokenized deposits, backed by regulatory frameworks and deposit insurance. Projects such as Fnality and the RSN demonstrate how banks can support tokenized settlement without sacrificing control or compliance. Without bank participation, tokenized systems would likely operate on siloed rails—undermining liquidity formation and increasing fragmentation across venues.[369]

Compliance, Identity, and Risk Controls: While DLT is still evolving and technological solutions for addressing illicit activity are continuing to be explored, banks are critical for enforcing financial crime compliance. Decentralized systems may lack the tools and accountability to implement these controls at scale. Without regulated nodes in the network, KYC and transaction monitoring would often be delegated to lightly supervised or technologically incapable intermediaries. Interviewees emphasized the danger of "anonymous liquidity" in tokenized markets—a situation where actors cannot be reliably screened or sanctioned. The risk of AML lapses would increase, particularly if stablecoins or DeFi protocols serve as settlement mechanisms without oversight.[370]

364. See **https://www.congress.gov/bill/119th-congress/senate-bill/1582**.
365. Bank for International Settlements, "Annual Economic Report 2025, Chapter III: Blueprint for the future monetary system: improving the old, enabling the new", June 2025.
366. U.S. Securities and Exchange Commission, "Franklin Templeton – Form N-1A Registration Statement", filed January 3, 2025.
367. Circle Internet Financial, "USDC Transparency and Reserve Reports", Accessed June 2025.
368. Bank of International Settlements, "Novel risks, mitigants and uncertainties with permissionless distributed ledger technologies", August 2024.
369. SIFMA, "Members of the U.S. Financial Sector Demonstrate Feasibility of Multi-Asset and Cross-Network Settlement Using Shared Ledger Technology", December 2024.
370. Bank of International Settlements, "Novel risks, mitigants and uncertainties with permissionless distributed ledger technologies", August 2024.

Reputational Risk and Institutional Hesitation: Excluding banks would erode institutional confidence. Asset managers and pension funds rely on custodians and underwriters to ensure asset safety, governance, and market conduct. In a market without bank participation, onboarding would stall, client flows would hesitate, and adoption timelines would lengthen. Tokenization use cases—from BUIDL to tokenized real estate—are achieving early traction precisely because they leverage trusted banking infrastructure. Leaders are embedding tokenization into existing trust frameworks, not abandoning them.[371]

Conclusion:

As tokenized markets develop, a pluralistic ecosystem may emerge, where regulated banks, NBFIs, and digitally native firms coordinate to unblock development towards key objectives. Regulated institutions, like banks, are critical to create or enable robust DLT-based Payment Instruments to facilitate settlement, ensure compliance, provide operational resilience, and support regulatory objectives. Their participation enhances the credibility and utility of tokenized systems.[372] NBFIs and digital native firms may also help unblock progress by identifying innovative solutions to open technical or operational challenges. Regulators have recognized that an inclusive approach is preferable to forcing activity outside of the regulatory perimeter. In summary, building a mature tokenized ecosystem will require coordination and regulated institutions like banks, which will be foundational participants essential to realizing the full promise of programmable finance – safely, efficiently, and at scale.

371. Ledger Insights, "BlackRock expands tokenized money market fund BUIDL to five more blockchains", November 2023.
372. Bank for International Settlements, "Annual Economic Report 2025, Chapter III: Blueprint for the future monetary system: improving the old, enabling the new", June 2025.

Chapter 4 | Legal and Regulatory Landscape

4.1 LEGAL AND REGULATORY CHALLENGES

This chapter focuses on the legal and regulatory challenges for the valid creation and trading of traditional securities using DLT, such as shares or bonds. Depending on the jurisdiction, these challenges could be categorized as issues surrounding the valid creation and recognition of the security and issues relating to compliance with secondary trading requirements that may arise. Once securities have been validly created and can be validly traded, they should be able to be deployed in the applicable use cases discussed in the **Deep-Dives** referenced in this report.

Please see **Section E of the Executive Summary** for an overview of recent legal and regulatory developments in the major financial centers, together with our recommendations on next steps.

U.S.

Application of U.S. Framework to DLT-based Securities

The following section sets out the application of the U.S. regulatory framework to issuers and intermediaries of a DLT-based Security across its trade lifecycle. Under section 2(1) of the Securities Act of 1933[373] (the **"Securities Act"**), a "security means any note, stock, . . . investment contract . . . or, in general, any interest or instrument commonly known as a 'security[.]'" The Securities Act's expansive definition of "security" has raised notable legal questions for the SEC with regard to certain digital assets, namely how the characteristics of certain digital assets reconcile with the SEC's and U.S. case law's historical interpretation of a security. The *Howey* test, developed by the U.S. Supreme Court in 1946, is the primary legal test for determining whether something is an "investment contract" security under the Securities Act.[374] Recent SEC staff statements,[375,376] have also pointed to the *Reves*[377] test as another threshold test focusing on whether the financial instrument or offering is a "note" under the Securities Act and the Securities Exchange Act of 1934 (the **"Exchange Act"**).[378] So far, in 2025, the White House, the SEC,[379] other regulators, and Congress[380] have increased their engagement with the digital asset industry and recognized a need for regulatory clarity. In this section we will examine the application of the U.S. framework to digital assets qualifying as securities under *Howey* or *Reves*, namely DLT-based Securities. We will then consider DLT-based Payment Instruments. Our analysis references, and is guided by, recent SEC Staff statements that continue to shape the discussion around the regulatory framework for, and classification of, these instruments.[381]

373. 15 U.S.C. § 77a et seq.
374. See SEC v. W.J. Howey Co., 328 U.S. 293 (1946) (holding that an instrument is an "investment contract" security if: (i) there is an investment of money, (ii) in a common enterprise, (iii) with the expectation of profits (iv) to be derived from the efforts of others). See also Reves v. Ernst & Young, 494 U.S. 56 (1990) (resulting in the so-called "Reves family-resemblance test" for "stock" securities, infrequently applied to digital assets in comparison with Howey).
375. See, e.g., Statement by SEC Division of Corporate Finance, Statement on Stablecoins (Apr. 4, 2025), *available at* **https://www.sec.gov/newsroom/speeches-statements/statement-stablecoins-040425**.
376. Enforcement actions under the previous Biden administration also referenced the Reeves test. See, In re Blockchain Credit Partners d/b/a DeFi Money Market, Securities and Exchange Commission File No. 3-20453 (Aug. 6, 2021), *available at* **https://www.sec.gov/litigation/admin/2021/33-10961.pdf** (DMM Order); In re Blockfi Lending LLC, Securities and Exchange Commission Fole No. 3-20758 (Feb. 14, 2022), *available at* **https://www.sec.gov/litigation/admin/2022/33-11029.pdf**.
377. See Reves v. Ernst & Young, 494 U.S. 56 (1990) (detailing the four part test for considering whether an instrument nay be a "note" security: (i) the motivations of the buyer and seller in a transaction, (ii) the plan of distribution of the instrument, (iii) the reasonable expectations of the investing public, and (iv) whether some other factor (e.g., existence of an alternative regulatory scheme) reduces the investment's risk, and renders application of the protections of the federal securities laws unnecessary.)
378. 15 U.S.C. § 78a et seq.
379. See, e.g., Statement by SEC Commissioner Hester M. Pierce, There Must Be Some Way Out of Here (Feb. 21, 2025), *available at* **https://www.sec.gov/newsroom/speeches-statements/peirce-statement-rfi-022125**.
380. See, Press Release by House Committee on Financial Services Chairman French Hill, Chairman Hill Unveils Bipartisan Digital Asset Market Structure Legislation (May 29, 2025), *available at* **https://financialservices.house.gov/news/documentsingle.aspx?DocumentID=409749**.
381. Recent guidance from the SEC Crypto Task Force on various related topics can be found at **https://www.sec.gov/newsroom/whats-new?tag=343331&type=news%2Csecarticle%2Clink&page=1**.

1. Registration and Issuance

The existing registration and disclosure requirements under the Securities Act and the Exchange Act for issuers of traditional securities can be largely compatible with issuers of a traditional corporate form offering DLT-based Securities. While the expansive definition of "issuer" under the Securities Act may create novel issues for securities offered and sold by nontraditional, decentralized entities, such issues are outside of the scope of this report.[382] Despite this, exceedingly few digital asset issuers have registered a digital asset as a security (e.g., INX Limited[383] and Overstock's "digitally enhanced security"[384]).

The main challenge that registration and disclosure requirements may pose for DLT-based Securities is how to adapt existing disclosure rules to this context. On one hand, the current line-item disclosure requirements may fail to account for key aspects of the security and a DLT environment that a purchaser may consider material.[385] For example, DLT-based Securities are generally issued through a smart contract. The deployer of the smart contract can define in code the controls of what the DLT-based Security can and cannot do on the DLT. These controls include transfer restrictions and the ability for an administrator to issue further tokens or burn tokens from supply. While broad principles of risk disclosure could pick up these issues, there is no DLT-specific line-item disclosure requirement related to a code review associated with a DLT-based Security that describes a given token's functionality to an average investor.[386]

On the other hand, the disclosure requirements may also prove to be overinclusive. For example, a central purpose of the current disclosure requirements is to address information asymmetry between issuers, management and promoters on the one hand, and investors on the other hand. However, DLT-based Securities might aid in the absolute or partial mitigation of certain disclosure risks, potentially creating fundamental inefficiencies for some DLT-based-Security issuers and purchasers under existing disclosure requirements. For example, the Exchange Act requires SEC-reporting companies' directors and officers, as well as shareholders who own more than 10% of a given class of equity securities, to report most of their transactions involving the company's equity securities to the SEC within two business days.[387] The burden is placed on the issuer or large shareholder to report because it is not feasible for the SEC or investor to obtain access to each issuer's Books and Records (or their transfer agent's) where ownership of the security is recorded. The same may not be said for a DLT used by issuers. The SEC and investors could have access to the DLT to instantly see the current state of ownership, and event logs could be used to notify when a party surpasses the 10% threshold.

On April 10, 2025 the SEC's Division of Corporate Finance issued guidance clarifying how existing federal securities-law disclosure requirements apply to cryptoasset offerings and registrations.[388] The statement reaffirms that all disclosures must be tailored to the issuer's specific business and presented in clear, concise language, avoiding unnecessary technical jargon and must: (1) accurately describe the issuer's business by focusing on current or proposed activities, delineating between the two, and aligning any disclosures with all public statements and promotional materials (e.g., white papers and developer documentation), (2) highlight risks unique to the asset and the issuer's operations, including price volatility, limited holder rights, valuation and liquidity concerns, technological and cybersecurity vulnerabilities, network or application dependencies, and evolving legal and regulatory risks, and (3) provide sufficient detail related to the security's characteristics including with

382. We note, however, that the broad definition of issuer may pose issues for decentralized entities given that their structures often lack traditional corporate decision-making or controlling bodies. The SEC has suggested that a group of individuals may be held liable for failing to register a security if those grouped individuals were "responsible for the success or failure of the enterprise." See SEC Report of Investigation Pursuant to Section 21(a) of the Securities Exchange Act of 1934: The DAO (Jul.25, 2017) at page 16, *available at* **https://www.sec.gov/files/litigation/investreport/34-81207.pdf**: Decentralized entities typically have flat structures with sometimes hundreds of persons, even thousands, implementing code changes to a protocol in a way that may be directly tied to the success or failure of an enterprise, raising concerns that the broad issuer definition may potentially capture unintended persons in decentralized entities.
383. In April 2021, INX Ltd. (INX), a Gibraltar-based cryptocurrency trading platform, listed the first blockchain token to be registered with the SEC under Form S-1, in an offering that ultimately raised $83.6 million. INX worked with SEC regulators for two and a half years and through sixteen registration amendments to realize the offering. INX used the proceeds to launch its digital trading platforms—initially two separate platforms, one for cryptocurrencies and one for security tokens. In September 2022, INX merged its two trading platforms—cryptocurrencies and securities—into one platform called "INX One." INX claims that its platform constitutes the first fully regulated trading platform for both security tokens and cryptocurrencies.
384. In May 2020, Overstock, the Nasdaq-listed online retailer and technology company, registered and offered a digital dividend (an 'airdrop') to its 40 million shareholders, where one digital voting Series A-1 preferred share of the stock was offered for every 10 shares owned of Overstock. The stock paid a 16-cent annual dividend, sharing liquidation rights of common shares, and would be available for trade only through broker-dealer subscribers to tZero (a blockchain-based ATS marketplace owned by Overstock's subsidiary). See Exhibit (**sec.gov**). But see SEC.gov | SEC Charges Alternative Trading System for Failing to Comply with Certain Requirements of Regulation ATS (describing the SEC's settled charges against tZero in January 2022 for its violation of Rule 301(b)(5) of Regulation ATS under the Exchange Act, among others, given that that tZero failed to meet certain requirements applying to ATS's where the trading of any security has exceeded 5% of the total volume in at least four of the previous six months, including a requirement to establish written standards for granting access to the ATS. In tZero's case, trading of the Series A-1 security increased 100% on the platform by the end of 2021).
385. See Hester M. Peirce, SEC.gov | Outdated: Remarks before the Digital Assets at Duke Conference (January 20, 2023) ("Disclosure under current regulations, however, is not well-suited to elicit the most useful and appropriate information for token purchasers because it does "not cover a number of features unique to digital assets that would undoubtedly be considered important when making an investment decision[.]" . . . Instead, traditional disclosures are "designed for traditional corporate entities that typically issue and register equity and debt securities" and "focus on disclosure about companies, their management and their financial results—topics that poorly fit the decentralized and open-source nature of DLT-based digital asset securities").
386. Id. ("[A] more tailored crypto disclosure regime would be good for investors and crypto companies").
387. See § 16 of the Exchange Act; see also id. §§ 13(d), 13(g) and Regulation 13D-G of the Exchange Act (requiring issuers who beneficially own more than 10% of a given class of publicly-traded equity securities to report their beneficial ownership to the SEC).
388. See, SEC Division of Corporate Finance, Offerings and Registrations of Securities in the Crypto Asset Markets (April 10, 2025), *available at* **https://www.sec.gov/newsroom/speeches-statements/cf-crypto-securities-041025**.

respect to holders' rights, obligations, and preferences, the technical specifications of the security and the mechanisms and rules governing the total supply. In addition to these three core areas, the guidance also reminds issuers to comply with standard requirements for directors and officers, financial statements, and exhibits, ensuring that every aspect of a crypto-asset offering meets the SEC's longstanding principles of full and fair disclosure.

The recently published President's Working Group report on digital assets makes note of the current regulatory disconnect between existing disclosure requirements and the novel characteristics of digital assets and blockchain technology. Accordingly, the report recommends that the disclosure requirements for issuances, over-the-counter trades, and digital asset firms, should be dependent on the nature of the activity and the characteristics of digital assets and blockchain technology while not being any more burdensome than disclosure requirements that apply to similar activities in traditional markets.[389]

2. Listing Requirements and Secondary Trading

DLT-based Securities of a traditional corporate form, the focus of this report, can be largely compatible with the existing listing requirements, such as those mandated by national security exchanges (**"NSEs"**).

The main challenges arise in applying the secondary trading laws, which generally contemplate intermediation, to a system where disintermediation is possible. Specifically, the existing legal framework contemplates the use of a broker-dealer to facilitate secondary trading on NSEs. It is important to note that there is no such requirement for securities not traded on an NSE, such securities can be traded off-exchange or peer-to-peer without a broker-dealer. There are outstanding questions however, on what constitutes an NSE.[390] The scope of NSEs is expected to be a key topic for the SEC's Crypto Task Force as it tackles DeFi. The SEC and the Financial Industry Regulatory Authority (**"FINRA"**) have provided guidance regarding registration requirements for broker-dealers that trade DLT-based Securities, but further clarity and tailoring to gain widespread adoption is needed. To date, secondary trading of DLT-based Securities has been limited and largely confined to ATSs, which are themselves broker-dealers.

More recent steps have been more accommodating towards DLT. In February 2025, SEC Commissioner Hester Peirce, Chair of the SEC's Crypto Task Force asked market participants to provide their views on, amongst other issues, whether a new registration category, with tailored requirements, should be created for crypto-asset trading venues.[391] Commissioner Peirce has indicated that the Crypto Task Force is considering a conditional exemptive order that would allow firms to use DLT to issue, trade, and settle securities in a regulatory "sandbox" while the SEC drafts modifications to existing rules and regulations.[392] EC Chairman Paul Atkins has echoed this view, directing SEC staff to "consider a conditional exemptive relief framework or "innovation exemption" that would expeditiously allow registrants and non-registrants to bring on-chain products and services to market."[393] The President's Working Group report on digital assets, acknowledging that the SEC has exemptive authority under existing federal laws to address concerns related to the issuance and trading of tokenized securities, also discussed the possibility of the SEC crafting an exemptive framework for persons seeking to operate a platform offering tokenized securities.[394]

3. Transfer Agents

On May 15, 2025, the SEC staff issued an FAQ[395] explicitly stating that a registered transfer agent may utilize permissioned DLT as its official master securityholder file, without maintaining a duplicate off-chain database, so long as the transfer agent is in compliance with and continues to satisfy all Exchange Act recordkeeping, reporting, examination, and operational requirements.[396] In practice, this means that transactional and position data (e.g., wallet addresses, transaction

389. See President's Working Group report at page 145.
390. On March 18, 2022, the SEC proposed to amend Exchange Act Rule 3b-16 to, among other things, expand the meaning of an "exchange" to include decentralized protocols. On June 18, 2025, that proposed rulemaking was formally withdrawn. See SEC, Withdrawal of Proposed Regulatory Actions, (Jun. 18,2025), *available at* **https://www.sec.gov/files/rules/final/2025/33-11377.pdf**.
391. Supra note 379.
392. See, SEC Commissioner Hester M. Peirce, A Creative and Cooperative Balancing Act (May 8, 2025), *available at* **https://www.sec.gov/newsroom/speeches-statements/peirce-iismgd-050825**.
393. See, SEC Chairman Paul S. Atkins, Remarks at the Crypto Task Force Roundtable on Decentralized Finance (Jun. 9, 2025), *available at* **https://www.sec.gov/newsroom/speeches-statements/atkins-remarks-defi-roundtable-060925**.
394. This recommendation was endorsed by SEC Chairman Paul S. Atkins who noted, in a speech made the day after the report was published, that he had directed SEC staff to draft "clear and simple" rules of the road for trading of cryptoassets. See, SEC Chairman Paul S. Atkins, American Leadership in the Digital Finance Revolution (Jul. 31, 2025), *available at* **https://www.sec.gov/newsroom/speeches-statements/atkins-digital-finance-revolution-073125**.
395. See, SEC, Division of Trading and Markets: Frequently Asked Questions Relating to Crypto Asset Activities and Distributed Ledger Technology, *available at* **https://www.sec.gov/rules-regulations/staff-guidance/trading-markets-frequently-asked-questions/frequently-asked-questions-relating-crypto-asset-activities-distributed-ledger-technology**.
396. We note that the President's Working Group on Digital Assets also included, in their recently published report, a recommendation to "Modernize transfer agent rules to clearly permit the use of blockchain technology by transfer agents.

IDs, share balances) may reside on-chain, while sensitive personally identifiable information remains securely off-chain, yet the on-chain ledger itself serves as the authoritative record of ownership. In the event of any discrepancy, the transfer agent must update the ledger directly rather than deferring to a private database. By treating the ledger as the master securityholder file, transfer agents can fully leverage the transparency and real-time verification benefits of distributed ledgers while ensuring that all data remains complete, accurate, readily producible to the SEC, and retained for the requisite periods under the SEC rules.

The SEC staff also provided clarity on the registration requirements for transfer agents. In the same FAQ, the SEC staff laid out that any person performing one or more of the five transfer agent activities described in Section 3(a)(25) of the Exchange Act: (i) countersigning securities upon issuance; (ii) monitoring for unauthorized issuances; (iii) registering the transfer of securities; (iv) exchanging or converting securities; or (v) transferring record ownership of securities by bookkeeping entry without physical issuance of securities certificates, must register as a transfer agent with the SEC or with the appropriate federal banking regulator as applicable. Conversely, persons servicing securities not registered under Section 12 of the Exchange Act or engaging only in activities outside of the enumerated Section 3(a)(25) activities with respect to Section 12 securities, are not required to register as transfer agents.

4. Custody

Broker-dealers seeking to custody DLT-based Securities in compliance with SEC rules regarding custody, such as the SEC Rule 15c3-3, have in recent years been constrained to three "buckets", acting solely as placement agents, operating as a non-custodial ATS, or registering as Special Purpose Broker-Dealers (**"SPBDs"**), each of which involved significant business limitations.[397] For example, broker-dealers in the placement-agent or non-custodial ATS buckets, for example, could not hold customer assets, while SPBDs face prohibitive complexity and cost by having to segregate DLT-based Securities from both traditional securities and other digital assets.[398]

More recently, on May 15, 2025, the SEC's Division of Trading and Markets and FINRA's Office of General Counsel withdrew prior staff commentary limiting broker-dealers to the three "buckets" discussed above. In the accompanying FAQs, the SEC Staff confirmed that the 2020 SPBD safe harbor[399], which once served as a limited "custody by design" pathway, is no longer mandatory and emphasized that broker-dealers may establish "control" over digital asset securities under Rule 15c3-3(c) through sub-custody at a bank of other good control location without special-purpose registration. Together, these developments pave the way for a more flexible, DLT-native custody framework aligned with the technology's promise.

On January 30, 2025, the SEC issued Staff Accounting Bulletin No. 122 (**"SAB 122"**), rescinding Staff Accounting Bulletin No. 121 (**"SAB 121"**) and removing the requirement that institutions record client crypto-assets as on-balance sheet liabilities, a change that eliminated a major accounting barrier to banks and broker-dealers interested in offering custody services.[400] [401]

SEC Chairman Paul S. Atkins, in a speech on July 31, 2025, stated that it was incumbent on the SEC to ensure that market participants have "maximum choice" when deciding where to custody cryptoassets.[402] In the same speech, Chairman Atkins also indicated that he had directed SEC staff to consider "… how best to adapt the existing regulatory regime to facilitate the custody of cryptoassets, including possible exemptive or other relief, in addition to changes to the rules themselves."

On July 14, 2025, the FRB, OCC and FDIC released a joint statement issuing guidance outlining risk-management principles for banks that serve as crypto custodians.[403] The guidance not only affirms that there are no extra supervisory expectations with respect to these activities, but also that the agencies continue to "explore ways to provide additional clarity with respect to banks' engagement in crypto-asset-related activities."

The President's Working Group on Digital Assets report, published on July 30, 2025, included several recommendations for federal regulators and Congress to clarify and expand various custody rules related to custody of digital assets by investment advisers and investment companies, trading platforms and other registered intermediaries, banks, and self-custody.[404]

397. See, Division of Trading and Markets, U.S. Securities and Exchange Commission and Office of General Counsel, Financial Industry Regulatory Authority, Joint Staff Statement on Broker-Dealer Custody of Digital Asset Securities (issued on July 8, 2019 and withdrawn on May 15, 2025), *available at* **https://www.sec.gov/newsroom/speeches-statements/joint-staff-statement-broker-dealer-custody-digital-asset-securities**.
398. **https://www.sec.gov/rules/policy/2020/34-90788.pdf**.
399. SEC, Commission Statement, Custody of Digital Asset Securities by Special Purpose Broker-Dealers (Dec. 23, 2020), *available at* **https://www.sec.gov/files/rules/policy/2020/34-90788.pdf**.
400. See **https://www.sec.gov/rules-regulations/staff-guidance/staff-accounting-bulletins/staff-accounting-bulletin-122**.
401. The SEC also withdrew its 2023 proposal to expand the custody rule for investment advisers, stating that the Commission may revisit the issue via a new proposal at a later date. See, Commissioner Mark T. Uyeda, Remarks at the Crypto Task Force Roundtable on Custody (Apr. 25, 2025), *available at* **https://www.sec.gov/newsroom/speeches-statements/uyeda-remarks-crypto-task-force-roundtable-custody-042525**.
402. Supra note 393.
403. See **https://www.federalreserve.gov/newsevents/pressreleases/files/bcreg20250714a1.pdf**.
404. Supra note 66. See also SEC Chairman Paul S. Atkins, in his July 31st speech (see footnote 393) stating, "It will be a priority of my chairmanship to carry out the PWG Report's recommendation to modernize the SEC's custody requirements for registered intermediaries."

5. Settlement and Clearing

In 1975, Congress passed amendments to the Securities Act which facilitated the current clearing agency regime. DLT can solve many of the issues clearing agencies were established to fix through more efficient and advanced technology. Unlike the clearing agency model spurred by the 1975 amendments, execution, clearing, and settlement may now occur in a singular transaction given that many popular DLTs are atomic—where either all transfers occur at the same time or none occur at all. Therefore, for immediate bilateral securities transactions on atomic DLTs, the risk of asset non-delivery at the point of execution is eliminated. In other words, the need for a central role of clearing agencies—to act as a CCP addressing counterparty risk—can be mitigated for these one-off transactions.

Clearing agencies play an integral role in today's markets. While DLT can address many of the issues that clearing agencies were put in place for, including counterparty risk, the current regulatory system may have the unintended consequence of regulating every validator node on a DLT. Such a regulatory system may not only be impractical (some DLTs have hundreds of thousands of validator nodes), but it would arguably apply a legal framework to entities that do not serve the functions we typically associate with a clearing agency.[405] The attendant regulatory requirements and potential liability may deter many participants from acting as validation nodes, thus canceling out some of the key benefits of DLT-based systems.

Application to Digitized Payment Instruments and Issues Related to Assets Held or Intermediated by Banks

1. DLT-based Payment Instruments

The permissibility for a state or national bank in the United States to issue certain DLT-based Payment Instruments stems from guidance issued by the OCC. The OCC is the federal agency responsible for determining the permissibility of activities for national banks, which the FRB and FDIC then impute and apply to institutions subject to their purview. In Interpretive Letter (IL) 1174,[406] the OCC confirmed that national banks may use stablecoins to facilitate payment transactions for customers, participate in independent node verification networks (INVNs), and engage in other related activities, subject to receiving a supervisory nonobjection and demonstrating to its supervisors that it has controls in place to conduct the activity in a safe and sound manner.[407] The FRB following in the OCC's footsteps, acknowledged the potential for banks to issue certain DLT-based Payment Instruments subject to supervisory non-objection, while highlighting its belief that issuing tokens on open, public, or decentralized networks, or similar systems was highly likely to be inconsistent with safe and sound banking practices because it raises concerns related to operational, cybersecurity, and run risks, and may also present significant illicit finance risks. The FRB stated at that time that such risks also were "pronounced" where the issuing bank does not have the capability to obtain and verify the identity of all transacting parties, including for those using un-hosted wallets.[408]

The federal banking regulators more recently took steps to further clarify their supervisory approach to digital assets and payment activities. In early 2025, the FDIC's FIL-7-2025 formally confirmed that institutions need not seek prior FDIC approval before engaging in permissible crypto-asset activities, including tokenized payments,[409] and the OCC's Interpretive Letter 1183 (March 2025) built upon Interpretive Letter 1174 and rescinded earlier restrictive bulletins, reiterating that national banks and federal savings associations may custody and transfer digital assets under existing statutes without additional rulemaking.[410] Meanwhile, the Federal Reserve signaled that it will oversee DLT-based Payment Instruments through its regular supervisory process.[411] Despite these easing of procedural hurdles, all three agencies continue to stress that DLT-based Payment Instruments must operate on permissioned networks with robust identity verification, governance, and compliance frameworks to manage operational, cybersecurity, and illicit-finance risks. The report published by the President's Working Group acknowledges these developments, and encourages the federal banking agencies to relaunch crypto innovation efforts in order to: (i) clarify or

405. Section 3(a)(23) of the Exchange Act finds that a party that is an "intermediary in making payments or deliveries or both in connection with transactions in securities" or that "otherwise permits or facilitates the settlement of securities transactions . . . without physical delivery of securities certificates" is performing the functions of a clearing agency. It is unclear whether participants on the infrastructure layer of DLT would be classified as a "clearing agency" and would thus have to register. For example, validator nodes could be perceived as "facilitat[ing] the settlement of securities transactions" by ensuring that each party holds the assets or funds that it commits to buy or sell. Not only is it unclear how such a validator node would register with the SEC on a practical level (when such registration envisions a centralized entity), but the stringent requirements placed on clearing agencies would also arguably be mismatched when applied to a validator node that neither custodies securities nor serves in the role of reducing counterparty risk.
406. See **https://www.occ.gov/news-issuances/news-releases/2021/nr-occ-2021-2a.pdf**.
407. 88 Fed. Reg.7848, 7850 (Feb. 7, 2023).
408. *Id*.
409. See **https://www.fdic.gov/news/financial-institution-letters/2025/fdic-clarifies-process-banks-engage-crypto-related**.
410. See **https://www.occ.gov/topics/charters-and-licensing/interpretations-and-actions/2025/int1183.pdf**.
411. See **https://www.federalreserve.gov/newsevents/pressreleases/bcreg20250424a.htm**.

expand the recognized, permissible digital asset activities in which banks may engage, (ii) consistent with applicable law, ensure parity in permissibility between bank charter types, and (iii) clarify supervisory expectations on safe and sound conduct that protects consumers and is compliant with applicable laws and regulations.[412]

On the legislative front federal stablecoin legislation has been passed by Congress in the form of the GENIUS Act.[413] The GENIUS Act, signed into law by President Trump on July 18, 2025 defines "payment stablecoins", requires custodians to be regulated entities, licenses payment-stablecoin issuers at the federal and, optionally, state level; imposes one-to-one reserve, capital, liquidity, AML, and consumer-protection standards; prohibit interest payments; and grant regulators backup enforcement authority over state-licensed issuers.[414] In the United States, recent regulatory developments indicate that there is a clear pause, at the federal level, with respect to retail CBDCs. The passage in the House of the CBDC Anti-Surveillance State Act along with the Executive Order issued by President Trump prohibiting federal agencies from taking any action to establish, issue or promote CBDCs, suggest that a federally-issued retail CBDC is unlikely to be pursued in the U.S. anytime soon.[415]

2. Settlement

In the United States, federal regulators have the authority to supervise and oversee certain payment, Clearing and Settlement activities, and certain FMIs. For example, Title VIII of the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 (**"Dodd-Frank Act"**) authorizes the Financial Stability Oversight Council (**"FSOC"**) to designate systemically important payment, clearing, and settlement activities and capital market utilities (**"FMUs"**).[416] It remains to be seen what the effect of the adoption of DLT platforms will be. Legal principles for settlement finality for Payment Instruments is in many cases set forth in commercial law, which may incorporate certain private-sector system rules and contractual agreements.[417] Existing laws, depending on the design of a particular DLT platform, provide mechanisms for parties to demonstrate sound legal bases to support a high degree of certainty with respect to settlement finality of DLT-based Payment Instruments. We note that the CPMI and IOSCO identified "probabilistic settlement" as an issue that certain DLT platforms may face when seeking to achieve settlement finality.[418] Developers and users of DLT-based Payment Instruments have a number of tools to address this consideration, including network and smart contract design, system rules and contractual agreements.

E.U.

From an E.U. perspective, the legal architecture utilized in creating the digital security must be considered at the outset, as each form (set out below) has specific and varying legal and regulatory outcomes.

Legal Architecture for Tokenization

The paragraphs below set out an overview of the three primary methods of Tokenization.

1. **True Tokenization.** This method involves immobilizing an underlying financial instrument and placing it with a nominee, who holds the instrument on trust for a custodian. The custodian then creates the token that represents the underlying financial instrument, granting rights in accordance with the legal structuring of the token (e.g., as set out in the terms and conditions). In the E.U., they are likely to qualify as a financial instrument for the purposes of the Markets in Financial Instruments Directive II (**MiFID II**),[419] subject to any local law requirements around formalities for issuance (as discussed in **Chapter 4.1.2.2** below).

2. **Native digital issuance.** The security is created and exists natively, directly on the distributed ledger as a financial instrument. There is no Tokenization of an underlying asset. Currently, only certain jurisdictions have built a framework allowing native digital issuance of securities for private markets (e.g., France, Germany and Luxembourg).

412. Supra note 66 at page 148.
413. See **https://www.congress.gov/bill/119th-congress/senate-bill/1582/text**.
414. We note that various provisions of the GENIUS Act may be amended should the digital asset market structure bills currently being contemplated pass in their current forms.
415. The stance adopted by the Trump Administration in the Executive Order was reiterated in the report published by the President's Working Group on Digital Assets.
416. P.L. 111-203, the Dodd-Frank Wall Street Reform and Consumer Protection Act.
417. *See e.g.*, UCC § 4A-501.
418. Application of the Principles for Financial Market Infrastructures to stablecoin arrangements (July 2022), paragraph 3.4.2.
419. Directive 2015/65/E.U.

3. **Contractual Tokenization.** This method involves creating an economic exposure to an underlying financial instrument without creating any proprietary rights in that instrument. This effectively constitutes a derivative contract, and accordingly, tokens created via this method are likely to trigger certain regulatory requirements that apply to derivative contracts. DLT is used simply as a record of these contractual rights, with the potential for automation of payment flows under the contract via the implementation of smart contracts. For completeness, it is noted that, to the extent that there are any contractual arrangements between an issuer and a holder of the token that enables the holder of the token to subscribe for an investment, then this may qualify as a warrant.

Assets that fall within category 3 do not create the same legal and regulatory issues in respect of their valid creation and trading as those in categories 1 and 2. This is because the rights that attach to category 3 assets are contractual in nature and so are treated in the same way as any other contractual right. As a result, throughout this report, the E.U./U.K. legal analysis is focused on categories 1 and 2, referred to as 'Tokenized Securities' and 'Security Tokens' respectively, and as "DLT-based Securities" together.

Application to DLT-based Securities and Certain Trading and Markets issues[420]

Issuance

When issuing debt and equity instruments specific requirements and formalities must be considered and complied with. The formalities that apply to the issuance of DLT-based Securities are specific to each E.U. member state (and not harmonized at E.U.-level). These requirements can present certain challenges when considered in the context of DLT-based systems.

1. **Equity instruments (shares).** The extent to which issuances of Security Tokens on DLT-based systems could satisfy the requisite formalities for the valid issuance of equity securities is currently unclear.

2. **Debt instruments (bonds).** To issue bonds natively on a DLT-based system, the issuer must create a token which (a) acknowledges the debt, and (b) creates a validly enforceable obligation on the issuer to pay the debt acknowledged under the token. Both elements are achievable electronically via a DLT-based system. E.U. member states may require jurisdiction-specific formalities when validly issuing bonds. The validity of the issue of native digital bonds in the context of DLT-based systems should be considered on a case-by-case basis, for each member state.

3. **Tokenized Securities.** These financial instruments may have their own specific issuance formalities, however listing requirements, and the issues surrounding settlement and payment, will still be relevant for Tokenized Securities. The specific classification of such tokens depends upon the characteristics of the token and the underlying financial instrument, as well as the local law in the relevant member state. As set out in **Chapter 4.1.2.1**, to the extent that there is an intention to trade these securities on trading venues and enable a liquid Secondary Market it will be necessary to comply with all relevant regulatory requirements that are triggered.

4. **Enforcement of Rights.** When examining the post-issuance lifecycle of Security Tokens, it must be considered how rights and interests (whether legal or equitable) in respect of the digital security can be stapled to an entry in a DLT-based system, so that the holder of the legally enforceable rights is identifiable and able to enforce these rights against a third party. These rights must be created upon issuance in such a way that they effectively transfer between subsequent holders of the digital security.

Generally, the creation of a Security Token must be done in a manner that ensures it embodies a claim to money, as opposed to just evidencing a claim. In most jurisdictions, the act of creating a token does not, by itself, create an enforceable legal obligation. As such, existing mechanisms must be used to create the applicable obligations in order to ensure the thing that is created is actually the issuer's legal obligation. Additionally, when issuing a Security Token, it must be ensured that the obligation is legally owed to the token holder, i.e., that the token is not simply a record of a claim to an underlying physical instrument.

The question of stapling and enforcement of rights will typically be jurisdiction-specific, and as such, it would have to be considered separately in each E.U. member state. Additionally, certain jurisdictions have restricted the issuance of DLT-based Securities to registered form (as discussed below in **Chapter 4.2.2.1**). To encourage widescale adoption of DLT and DLT-based Securities in capital markets, market participants ultimately need clarity, as applicable, that DLT can be utilized in the context of the legal/regulatory framework in question.

420. E.U. law deals with commonalities in E.U. jurisdiction markets but is not jurisdiction specific. As such, securities are issued in accordance with local law requirements.

CSD Requirements

The CSDR designates the functions that a CSD must exercise and sets out various mandatory requirements for CSDs.[421] In order to achieve adoption, perhaps in place of traditional CSDs, DLT-based systems must be able to achieve each of these functions from both a legal and technical perspective.

Provided that the issuance requirements for debt and equity instruments are satisfied by the native digital security, it is technically possible to issue these instruments on a DLT-based system. Generally, one of the key issues with listing, is that transferable securities may only be admitted to trading on a trading venue (including regulated markets) or used as collateral if they are recorded in book-entry form on a CSD. For this to be possible in a DLT-based format, an existing CSD must obtain the relevant regulatory approvals to operate a DLT platform. No CSDs have obtained this form of approval to date. Accordingly, the most prominent native DLT-based Securities issued in Europe have not been listed. It should also be noted that it is not currently clear which form of DLT platform would be able to obtain such approval. Please see **Chapter 2.1** for a discussion of the distributed ledger archetypes and their comparative attributes.

It is worth noting that, to date, in the E.U. three market players have been authorized under the E.U. Pilot Regime to operate a settlement system: CSD Prague authorized to operate a DLT SS, and 21X AG and UAB Axiology DLT both authorized to operate a DLT TSS. These three entities benefit from specific exemptions from CSDR.

Legal clarity is required as to the validity of using DLT-based systems in this context. It should be noted, however, that if market participants wish to undertake private issuances, i.e. not requiring listing or admission to a trading venue, the CSD requirements detailed above should not be applicable.

Secondary Trading

1. **Trading Venues.** The access and licensing requirements set out in the CSDR and MiFID II limit trading venue participants to authorized trading firms. This arguably presents a barrier to widespread adoption of DLT-based systems in capital markets. Proponents of DLT-based systems and DLT-based Securities highlight the potential for greater accessibility and a deeper investor base when trading DLT-based Securities, which includes retail investors who are currently excluded from such participation. As noted above in respect of CSD requirements, this challenge is not relevant if market participants wish to undertake private issuances that will not require admission to a trading venue.

   As noted above, in the E.U., under the E.U. Pilot Regime, certain DLT market infrastructures may apply for temporary exemptions from certain CSDR and MiFID II requirements. In particular, at the request of an operator of a DLT MTF, the competent authority may grant a temporary exemption from that obligation of intermediation in order to provide direct access for retail investors.

2. **Transfer.** When transferring DLT-based Securities, market participants need legal certainty that the relevant transfer has in fact occurred. A legally valid transfer of DLT-based Securities and their associated rights are contingent upon formalities and/or requirements that must be satisfied. Generally, to facilitate secondary trading of DLT-based Securities, the DLT-based system in question must either be: (i) capable of satisfying the applicable formalities and/or requirements or (ii) exempt from the applicable formalities and/or requirements. These requirements are not harmonized across the E.U. and are determined by local laws in each E.U. member state.

   To encourage adoption, regulators and/or legislators need to provide market participants with clarity as to the capacity for DLT-based systems to satisfy or be exempt from these requirements. Importantly, it will be relevant to provide certainty as to typical legal protections to transactions such as netting and settlement finality, particularly to satisfy commonly accepted principles of prudential regulation.

   Please see **Chapter 4.1.3.2** below which sets out considerations in the U.K. that are similarly applicable in the E.U. under jurisdiction-specific corporate law in each member state.

Clearing

There is no mandatory clearing requirement for debt and equity instruments in the E.U. under the applicable regulatory legislation. However, there may be clearing requirements for listed debt and equity instruments within the rules of trading venues. It is currently unclear how, or whether, clearing requirements may be updated for DLT-based systems and DLT-based Securities.

421. For example, under Section A of the Annex to the CSDR, CSDs effectively perform three core services: (i) the initial recording securities in a book-entry system ('notary service'); (ii) providing and maintaining securities at the top tier level ('central maintenance system'); and (iii) operating a securities settlement ('settlement service').

Compliance with E.U.-level Legislation

MiFID II and the CSDR, amongst other E.U.-level legislation, place multiple obligations on FMI. In the context of DLT-based systems, a number of these requirements appear onerous or unnecessary. For example, in such a system the relevant competent authority could hypothetically access the platform as a participant observer, arguably rendering the daily reporting requirements for MTFs under MiFID II unnecessary. Moreover, a DLT-based system could be capable of providing real-time transaction reporting. It could appear that the cost-saving incentives for adoption of DLT-based systems are offset by the cost to market participants of compliance with these requirements, among others. Further consideration is required in respect of compliance in the context of DLT-based systems, particularly as to whether it is possible or necessary to satisfy a given requirement where DLT-based systems are used.

The E.U. has adopted the E.U. Pilot Regime aimed at addressing, amongst other things, issues of legal and regulatory compliance for DLT-based systems. This regime is discussed below in **Chapter 4.2.2**.

Adoption of DLT-based systems could be encouraged by addressing legal definitions, improving legal certainty, and removing certain barriers as discussed throughout this Chapter.

Capital Treatment

Capital requirements are generally determined through a risk-based assessment of the asset in question. The approach to the risk assessment and consequential capital treatment of DLT-based Securities remains unclear. If capital requirements associated with DLT-based Securities are greater than the capital requirements associated with the corresponding traditional securities (i.e. a digital bond versus a traditional bond) or if digitally custodied securities were required to be recorded on the balance sheet of the Custody bank, then this presents a clear barrier to adoption. Generally speaking, the application of any additional charges for the use of DLT are contrary to the principle of same-risk-same-regulatory outcome because in essence a legally recognized security is being treated differently depending on the system in which it is held. As discussed above, the ability of competent authorities to apply an infrastructure risk add-on is not well-founded and ignores the available risk mitigants in real world use cases for the use of this technology.

Application to DLT-based Payment Instruments and issues related to assets held or intermediated by banks

DLT-based Payment Instruments and Settlement

As outlined in **Chapter 1**, DLT-based Payment Instruments can be used to facilitate faster, or even simultaneous, settlement of a digital security transaction. Therefore, legal and regulatory consideration of DLT-based Payment Instruments from a settlement perspective is essential.

The potential application of the FMI Principles as implemented in the relevant jurisdictions (across the E.U.) should be considered in this context. In terms of securities and payment settlement, this will include the application of certain statutory protections such as settlement finality protection, netting and enforceability of collateral arrangements. DLT platforms are not risk-free, however, it will be necessary to evaluate for each platform the extent to which they might replicate the same risks that exist under traditional FMIs and whether they raise new risks, particularly as new commercial and regulatory legal frameworks develop to accommodate these technologies.Further regulatory consideration in this respect is required, particularly as industry begins adopting this technology, as permitted under the EU Pilot Regime (discussed below in **Chapter 4.2.2.3**).

The operational features of any permissionless DLT framework may in practice include different settlement mechanisms. In order to achieve legal settlement finality, it is therefore necessary to determine, based on the design of a particular DLT platform, a precise moment of settlement after which the transaction becomes final and irrevocable. In a permissionless system, the exact moment of operational finality may be nearly impossible to determine due to the probabilistic nature of consensus, potential for chain reorganizations, and lack of a central authority to define or enforce finality. However, the intended scope of any settlement finality requirement must be assessed at the level of the settlement process as a whole and not simply the operational elements. While a clear, legally enforceable determination of when a transaction is settled with finality may be easier to achieve on a DLT-based permissioned environment – either because the environment can be engineered to provide a clear moment of settlement finality, or because it is possible for parties to contractually agree to

settlement finality – market participants and regulators should remain open to the possibility of achieving settlement finality in public permissioned networks with appropriate controls in the long term, with settlement finality determined in accordance with applicable law, including pursuant to statute and principles of property law.

There is an existing E.U.-level framework for issuing electronic money (including, the E-money directive,[422] as implemented in each E.U. member state, and associated pieces of legislation). However, it is unclear how the specific obligations under this framework, for example in relation to the holding and reconciliation of reserves held in DLT-based Payment Instruments, may be satisfied by an e-money issuer using a DLT-based system. Legal and regulatory clarity will be required as to how these requirements may be satisfied, noting that MiCA does not address this point.

Issues beyond Financial Services

The legal analysis contained in this report is not exhaustive, and several relevant legal/regulatory challenges lie beyond the sole scope of financial services, each of which is more broadly relevant to the use of DLT. For completeness, a brief discussion of some of these key areas is set out below. These would require additional consideration.

Qualification of DLT-based Securities of DLT-based Payment Instruments as property. Please see **Chapter 4.1.3.3** below for considerations in the U.K. that are similarly applicable in the E.U. under jurisdiction-specific law in each member state (although the specific analysis in relation to the UK's Property (Digital Assets etc.) Bill will not be applicable for the E.U.).

Data Privacy. In the E.U., specific legislation places restrictions on owners and processors of data, relating to data protection and privacy, as well as the usage, storing and sharing of data.[423] Certain aspects of these regulations may be incongruent with DLT-based systems, for example, the GDPR provides clients with the right to 'erasure' or the 'right to be forgotten', which may not be compatible with the inherent immutability of DLT-based systems.

Tax. There is no harmonized proposal in the E.U. as to the tax treatment of DLT-based Securities or DLT-based Payment Instruments. Tax treatment could have significant impacts on profitability for investors and issuers alike and will vary between jurisdictions.

Legal validity/certainty of Smart Contracts. Smart contracts relate to programmability, which is one of the main potential benefits of DLT. One of the key pre-conditions for programmability is clear legal contracts, which can then be translated into code. Issues with smart contracts that may give rise to disputes include:

- **Validity/certainty.** The analysis concerning whether a smart contract constitutes a legal contract is unclear. There are issues with some of the fundamental principles of contract formation. A contract generally requires an offer and acceptance, consideration and an intention to create legal relations. The parties to that contract must be sufficiently certain, and either a natural or a legal person with the legal capacity to enter into such an agreement. It will not always be possible in the context of smart contracts and DLT-based systems generally, to reliably identify the parties, their capacity, or their intention to create legal relations. This could prevent smart contracts from constituting legal contracts.
- **Insufficiency of code.** There are complexities translating the real-world agreement into code. Discrepancies can give rise to disputes.
- **Mistakes.** Any errors mean that the contract may not be performed as intended. Contract law doctrines developed over centuries are not applied in code simply, especially where intention is necessary for automation.

U.K.

From a U.K. perspective, the legal architecture utilized in creating the digital security must be considered at the outset, as each form (set out below) has specific and varying legal and regulatory outcomes. The position is similar in the U.K. as in the E.U. (as indicated below), but please see specific references in this section to the position under U.K. law.

422. Directive 2009/110/EC.
423. For example, in the E.U., General Data Protection Regulation (E.U.) 2016/679 ("**GDPR**").

Legal Architecture for Tokenization

Please refer to the equivalent E.U. section above (section **4.1.2.1**) for an overview of the three primary methods of Tokenization. We have referred to the specific position in the U.K. below.

1. **True Tokenization.** Under English law, the tokens produced are likely to qualify as specified investments, specifically as "certificates representing certain securities" or as "rights or interests in investments".[424] These are well-recognized structures in the U.K.

2. **Native digital issuance.** The U.K. is still considering the legal framework needed to enable it.

3. **Contractual Tokenization.** Under English law, warrants qualify as specified investments, specifically as *"instruments giving entitlements to investments"*.[425]

The analysis in this Chapter is based on the law as at the date of this report. Please refer to the U.K. regulatory section of the Executive Summary with regards to proposed rules under consultation and upcoming in the U.K. that will amend the regulatory framework and perimeter for crypto-assets.

As stated above, throughout this report, the U.K./E.U. legal analysis is focused on categories 1 and 2, referred to as 'Tokenized Securities' and 'Security Tokens' respectively, and as "DLT-based Securities" together.

Application to DLT-based Securities and Certain Trading and Markets issues

Issuance

Please refer to the equivalent E.U. section above (**Chapter 4.1.2.2**) for an overview regarding the issuance of DLT-based Securities (such overview applies equally in the U.K except with respect to the specific E.U. law references). Please refer to the summary of the position in the U.K. below, as well as the U.K. regulatory section of the Executive Summary regarding the issuance of equity and debt securities under English law (as described under UKJT's legal statement on the issuance and transfer of digital securities).

1. **Equity instruments (shares).** In the U.K., a Security Token issued on a DLT-based system may not comply with the formalities for issuance set out under the Companies Act 2006. Additionally, for equity securities issued under USRs, a U.K. registrar is required to monitor ownership. It is not clear whether a DLT-based system with a multi-jurisdictional spread of nodes would qualify as a U.K. registrar for the purposes of the USRs.

2. **Debt instruments (bonds).** As mentioned in **Chapter 4.1.2.2**. above, in order to issue bonds natively on a DLT-based system, the issuer must create a token which (a) acknowledges the debt, and (b) creates a validly enforceable obligation on the issuer to pay the debt acknowledged under the token. In the U.K., limb (b) is typically achieved via a deed poll which must be validly executed as a deed. It is well established that deeds can be created in electronic form, however, how this is achieved in practice depends on the parties to the deed.

3. **Tokenized Securities.** Tokenized Securities created via true Tokenization (as set out under **Chapter 4.1.2.1**), may be recognized as specified investments under English law, potentially as "certificates representing certain securities" or as "rights or interests in investments".[426]

4. **Enforcement of Rights.** With respect to existing mechanisms that must be used to create the applicable obligations, as discussed above, this can happen in the U.K. for debt instruments via use of a deed poll.

U.K. CSD Requirements

Please refer to the equivalent E.U. section above ("CSD Requirements" under **Chapter 4.1.2.2**) for an overview regarding CSDR, which has been onshored in the U.K. To the extent that a digital issuance would trigger UK CSDR (for example, where securities are admitted to trading or traded on a U.K. trading venue), there is nothing generally precluding a CSD from issuing DLT securities under the U.K. CSDR framework. To date, no U.K. CSDs have obtained the relevant regulatory approvals to operate a DLT platform.

In its Digital Securities Sandbox, HM Treasury is considering how U.K. CSDR may need to change to accommodate digital asset technology, and the new practices associated with it.

424. Under Articles 80 and 88 (respectively) of the Financial Services and Markets Act 2000 (Regulated Activities) Order 2001 (SI 2001/544).
425. Under Article 79 of the Financial Services and Markets Act 2000 (Regulated Activities) Order 2001 (SI 2001/544).
426. Under Articles 80 and 88 (respectively) of the Financial Services and Markets Act 2000 (Regulated Activities) Order 2001 (SI 2001/544).

Secondary Trading

Please refer to the equivalent E.U. section above ("Secondary Trading" under **Chapter 4.1.2.2**) for an overview which applies equally in the U.K. except with respect to the specific E.U. law references. The position in the U.K. has been summarized below.

1. **Trading Venues.** In its Digital Securities Sandbox, HM Treasury is considering how the U.K. CSDR may need to change to accommodate digital asset technology, and the new practices associated with it.

2. **Transfer.** Please refer to the U.K. regulatory section of the Executive Summary regarding the feasibility of digital security transfers under English law, as described under UKJT's legal statement on the issuance and transfer of digital securities.

   One consideration under U.K. law when transferring DLT-based Securities is whether they are treated as securities or as mere contractual claims on the entity that created them. Generally, a contractual right can only be transferred under the law by which the contract is governed, via assignment. A contractual claim will be determined by the laws governing the contract. For example, a legal assignment is only validly made if it is made "in writing" under section136 Law of Property Act 1925. "In writing" could be interpreted broadly in a DLT-based system that envisions full automation via smart contracts, for example. However, market adoption will require certainty on this front.

   Conversely, a bearer security is generally regarded as an item of property in itself. Under U.K. law, it is therefore transferred under the relevant property law, which is dependent upon its situs. For example, the situs of bonds that are represented by a global note is deemed to be the place where the global note is physically present. For registered securities, the situs of the security is deemed to be the place where the register is maintained. In a DLT-based system with a multi-jurisdictional spread of nodes, the register could be seen to be maintained in some or all of the jurisdictions in which a node is located. Therefore, where the governing law is unclear, the requirements for a valid transfer are also not certain.

   Additionally, there are certain formalities under corporate law in relation to the registration and transfer of shares. In the U.K., while DLT-based systems could theoretically handle the various registration requirements upon transfer, the U.K. company would have to ensure that its systems are fully integrated with DLT and that the terms of its constitution are correctly encoded in the smart contracts effecting the changes to registers. Additionally, there may be challenges as to whether certain legal requirements (such as the directors' rights to refusal when registering ownership of the share transfer) could practically be satisfied by DLT-based systems, especially where the intention is to achieve automation of such processes. It should be noted, however, that many "transfers" of financial instruments in capital markets are in fact transfers of beneficial, and not legal title, which generally have less rigorous formalities/requirements.

   There are additional challenges posed in relation to corporate-adjacent rights afforded to holders of equity securities under the applicable corporate law, for example voting rights. It is not yet clear how these rights would be effected on a legal or operational level for Tokenized Securities or Security Tokens.

   Whilst the preceding paragraphs focus on equity instruments (shares), there may be similar requirements for bonds depending on how the bonds in question are structured. Such requirements will be jurisdiction specific.

   In relation to the question of whether digital assets on blockchain are considered personal property in the U.K., please refer to the UK regulatory section of the Executive Summary.

Clearing

There is no mandatory clearing requirement for debt and equity instruments in the U.K. under the applicable regulatory legislation. However, there may be clearing requirements for listed debt and equity instruments within the rules of trading venues. It is currently unclear how, or whether, clearing requirements may be updated for DLT-based systems and DLT-based Securities.

Regulatory Compliance for DLT-based systems

The U.K. has created legislative proposals aimed at addressing, amongst other things, issues of legal and regulatory compliance for DLT-based systems. These proposals are discussed below in **Chapter 4.2.2**.

Adoption of DLT-based systems could be encouraged by addressing legal definitions, improving legal certainty, and removing certain barriers as discussed throughout this Chapter.

Capital Treatment

Please refer to the equivalent E.U. section above ("Capital Treatment" under **Chapter 4.1.2.2**) for an overview which applies equally in the U.K.

There are going to be further developments with respect to the prudential treatment of "qualifying crypto-assets" and "qualifying stablecoins" under the upcoming new regulatory framework for crypto-assets in the UK.

Application to DLT-based Payment Instruments and issues related to assets held or intermediated by banks

DLT-based Payment Instruments and Settlement

Please refer to the equivalent E.U. section above (**Chapter 4.1.2.3**) for an overview which applies equally in the U.K. except with respect to the specific E.U. law references (and whereby the reference to "EU Pilot Regime" will be to "U.K. Digital Securities Sandbox").

In the existing U.K. framework, there is nothing generally precluding a provider using a DLT-based system from qualifying as: (i) a designated payment system (regulated by the Payment Systems Regulator); (ii) a recognized payment system (regulated by the Bank of England pursuant to the Banking Act 2009); or (iii) a designated system under the Settlement Finality Regulations. Indeed, a U.K. provider using a DLT-based platform has already obtained the applicable authorizations to achieve status as a designated and recognized payment system. Obtaining such status now allows operators of payments systems to gain access to the Bank of England RTGS system. In this case, the payment system would benefit from the legal protections of settlement finality, netting (where relevant) and enforceability of any collateral arrangements in respect of this system. Whilst the applicable licensing requirements can be onerous for a provider to obtain, it is certainly possible under existing U.K. law. Further, in April 2019 the Bank of England announced the creation of a new model allowing operators of payments systems to hold funds in an omnibus account to fund their participants' balances with central bank money[427]. Nonetheless, an entity providing such services risks triggering licensing requirements as an e-money issuer, a payment service provider, and/or a bank. Despite this, it is possible, if onerous for an entity to obtain the requisite authorizations. Please refer to the U.K. regulatory section of the Executive Summary in relation to UK regulatory developments in relation to stablecoins.

Issues beyond Financial Services

The legal analysis contained in this report is not exhaustive, and several relevant legal/regulatory challenges lie beyond the sole scope of financial services, each of which is more broadly relevant to the use of DLT. For completeness, a brief discussion of some of these key areas is set out below. These would require additional consideration.

Qualification of DLT-based Securities or DLT-based Payment Instruments as property. Please refer to the UK regulatory section of the Executive Summary on the treatment of DLT-based Securities as property. If treated as property under U.K. law, then transfers of, and rights associated with, DLT-based Securities will, in certain circumstances, be determined by property law as opposed to contract, affording the holder of the token enforceable rights against the issuer and third parties (i.e. rights to the token itself as property).

Data Privacy. In the U.K., specific legislation places restrictions on owners and processors of data, relating to data protection and privacy, as well as the usage, storing and sharing of data.[428] Certain aspects of these regulations may be incongruent with DLT-based systems, for example, UK GDPR provides clients with the right to 'erasure' or the 'right to be forgotten', which may not be compatible with the inherent immutability of DLT-based systems.

Tax. Tax treatment could have significant impacts on profitability for investors and issuers alike.

Legal validity/certainty of Smart Contracts. Please refer to the equivalent E.U. section above ("Legal validity/certainty of Smart Contracts" under **Chapter 4.1.2.3**) for an overview which applies equally in the U.K. Several issues surround the validity of smart contracts under English law, which could thereby impair the potential benefits of smart contracts.

427. Other central bank authorities may take different approaches, see for example the position of the European Central Bank ("**ECB**"): **https://www.ecb.europa.eu/paym/target/target2/shared/pdf/Policy_prefunding_ancillary_systems.pdf**.
428. For example, in the U.K., the Data Protection Act 2018, UK GDPR and (when the relevant sections come into force) the Data (Use and Access) Act 2025.

Hong Kong

Application to DLT-based Securities and certain trading and markets issues

1. **Issuance:** Current rules set out formalities to document the ownership of shares (e.g. share registers), which are incompatible with securities issued on DLT-based systems that utilize automated ownership records. Issuers of DLT-based Securities would be required to reproduce such records in a format compliant with current rules.

2. **Listing requirements:** Shares issued on DLT-based systems would technically be compatible with the current legal regime.

3. **Secondary Trading:** These requirements assume an intermediary that generally must be licensed by the SFC and be an approved exchange participant; certain DLT arrangements may need to be restructured to accommodate an intermediary, especially when using a DLT-based system that does not require an intermediary by default (noting that the system itself would also need to be considered from the perspective of licensing under the regime for the licensing of virtual asset trading platforms).

   There is legal uncertainty as to whether current electronic transaction rules (such as the Electronic Transaction Ordinance) apply to DLT-based transactions and smart contracts. This creates operational difficulties in ensuring the validity and enforceability of transfers of DLT-based Securities under Hong Kong law. In particular, the Electronic Transaction Ordinance carves out the recognition of the validity and enforceability of certain instruments which are executed electronically, such as instruments that are required to be stamped under the Stamp Duty Ordinance (e.g. share transfer documents) and deeds in relation to interests in land. This means that such documents must be executed in wet-ink and are fundamentally incompatible with DLT structures.

   Where Tokenized Securities represent ownership in listed securities, there is legal uncertainty as to whether holders of Tokenized Securities would be subject to the existing market integrity framework, such as disclosure of substantial shareholder rules, investor identification rules and insider trading rules. Similar concerns exist regarding Tokenized Securities which may be classified as OTC derivatives and uncertainty exists over whether they would be subject to the OTC derivatives regime.

4. **Clearing:** Given that there are mandatory clearing obligations for listed securities and OTC derivatives, this may be incompatible with some DLT structures (albeit noting that the February 2024 Hong Kong Government issuance was listed on the Hong Kong Stock Exchange).

Additionally, the legal challenges, hurdles and considerations set out under the Hong Kong legal and regulatory analysis in relation to Sovereign bonds, apply to bonds generally.

Japan

A regulatory framework for transactions in respect of DLT-based Securities has already been implemented in Japan. The regulatory framework is discussed in detail in **Chapter 4.2.4**.

Singapore

Legal Architecture for Tokenization

In Singapore, MAS takes a technology-neutral stance and would examine the characteristics of the token to determine the appropriate regulatory treatment. For instance, if the digital asset has the characteristics of a security such as a share or a bond, it would be regulated under the Securities and Futures Act 2001, similar to other capital markets products. If the digital asset is not such a regulated product but used as a medium of exchange for payment, then it is regulated as a digital payment token under the Payment Services Act 2019.

Application to DLT-based Securities and Certain Trading and Markets Issues

In Singapore, MAS has published "A Guide to Digital Token Offerings", which provides general guidance on the application of the relevant laws administered by MAS in relation to offers or issues of digital tokens in Singapore. Offers of digital tokens that constitute regulated products such as securities are subject to the same regulatory regime under the SFA as offers of such regulated products made through traditional means. Such regulatory requirements would include prospectus requirements unless the offer can be made in reliance on prospectus exemptions.

Similarly, in relation to the secondary trading of digital tokens which constitute regulated products such as securities or derivatives contracts, a person who establishes or operates such a trading platform in Singapore may be establishing or operating an organized market. A person who establishes or operates an organized market, or holds himself out as operating an organized market, must be approved by MAS as an approved exchange or recognized by MAS as a recognized market operator under the SFA, unless otherwise exempt.

Issues Beyond Financial Services

Data Privacy. The Personal Data Protection Commission (**"PDPC"**) has published a Guide on Personal Data Protection Considerations for Blockchain Design.[429] When personal data is written on a DLT network, the decentralized and tamper-resistant attributes of DLT give rise to challenges in complying with the obligations under the Personal Data Protection Act 2012 (**"PDPA"**).[430] For instance, the PDPA prohibits organizations from collecting, using or disclosing an individual's personal data unless the individual gives consent for the collection, use or disclosure of his or her personal data for a specific purpose.[431] This presents a challenge in a permissionless DLT network, where data written on a distributed ledger is publicly accessible by all participants (e.g. node operators), making it impossible for organizations to effectively establish control over the collection, use and disclosure of the data by another participant. In addition, if an organization has fulfilled the purpose of collecting a piece of data, and there is no further business or legal requirement for data retention, the organization should dispose of the data. It can do so either by securely erasing it or stripping personal identifiers from the data. However, as the data committed on a distributed ledger is immutable, it cannot be erased or modified. In view of these challenges, the PDPC has provided some recommendations to ensure personal data on DLT networks still complies with obligations under the PDPA. Such recommendations include not storing personal data on a permissionless DLT network whether in clear text, encrypted or anonymized, unless consent has been obtained from the individual for public disclosure. Even in a permissioned network, given that any personal data written on a distributed ledger in cleartext will be accessible by all other participants that host or operate nodes, access to personal data should be provided only to authorized network participants that have a business purpose to use the data.

Qualification of DLT-based Securities or DLT-based Payment Instruments as property. In the Singapore case of *Janesh s/o Rajkumar v Unknown Person ("CHEFPIERRE")* [2022] SGHC 264, the Singapore High Court held that non-fungible tokens could be considered as property as they satisfied certain legal requirements, where such non-fungible tokens (i) are capable of being isolated from other assets whether of the same type or of other types and thereby identified; (ii) have an owner being capable of being recognized as such by third parties; (iii) where third parties must respect the rights of the owner in that asset and that the asset must be potentially desirable; and (iv) have some degree of permanence or stability.

More recently, the High Court held in *ByBit FinTech Ltd v Ho Kai Xin and others* [2023] SGHC 199 that crypto-assets are property falling within the category of choses in action and are capable of being held on trust. The judgment cited the growing acceptance of crypto-assets as a form of value in everyday life, for example crypto-assets appear on company balance sheets, with accounting standards developed to value and report them as a form of property. Additionally, the Response to Public Consultation on Proposed Regulatory Measures for Digital Payment Token Services published by MAS in July 2023 demonstrated that it is possible for digital assets to be identified and segregated, supporting the argument that they are a form of property capable of being held on trust.

429. PDPC, Guide on Personal Data Protection Considerations for Blockchain Design, 2022.
430. Singapore Parliament, Personal Data Protection Act, 2012 (2020 Revised Edition).
431. Ibid.

4.2 CURRENT STATE OF TOKENIZATION LEGISLATION AND REGULATION

U.S.

DLT-based Securities

While there is still no federal legislative framework expressly governing DLT-based Securities in the U.S., private commercial law has been left to the states, with some states (e.g., Wyoming, Vermont and Arizona) having enacted limited token-friendly statutes.[432] At the same time, the Uniform Law Commission ("ULC"), along with the American Bar Association ("ABA"), have been working to foster harmonization among states through the drafting and enactment of the 2022 amendments to the Uniform Commercial Code ("UCC") related to commercial transactions involving digital assets, with 25 states having adopted the amendments so far.[433] At the national level, regulatory clarity will continue to evolve over time through both legislative efforts and SEC staff guidance, no-action letters and formal rulemakings. Most notably, as discussed above, the SEC's Crypto Task Force is now considering a conditional exemptive order that would temporarily relieve eligible tokenization platforms and trading venues from certain broker-dealer, exchange, and clearing-agency registration requirements to permit real-world testing of DLT-based Securities infrastructure.[434]

DLT-based Payment Instruments

As noted above, the federal banking regulators have begun to treat supervision of DLT-based activities by banks, including payment-related activities, with a commensurate level of oversight as reserved for traditional products and activities.

U.K./E.U.[435]

As discussed, the jurisdiction in which issuances of Security Tokens takes place is critically important when attempting to construct an understanding of the applicable legal position. Each jurisdiction can present separate and independent issues relating to legal certainty when using DLT-based systems. Legal certainty is one of the key factors for market participants considering the issuance of DLT-based Securities in each jurisdiction.

At an E.U. and U.K. level, the E.U. Pilot Regime and UK Digital Securities Sandbox respectively provide a useful opportunity to test DLT-based platforms within more flexible iterations of the existing legal landscape. This is expected to support the development of legal certainty in this area by affording market participants and regulators the opportunity to proactively assess and confront market access barriers.

As such, this section deals with the current position of Tokenization legislation and regulation by jurisdiction and examines the E.U. Pilot Regime and the Digital Securities Sandbox in more detail (see **Chapter 4.2.2.3**. below).

E.U.

In addition to the E.U. Pilot Regime (discussed below), Luxembourg, France and Germany, among others, have distinguished themselves in this field by developing and/or adopting legislation that allows companies to issue securities directly on DLT-based systems. (Although it should be noted that member-state level legislation will only apply in that jurisdiction and not benefit from EU-level recognition.)

The law in Luxembourg permits issuance of dematerialized securities by foreign *and* local companies using DLT. Further, it allows other forms of securities to be converted into Tokenized Securities. This is achieved in Luxembourg by enabling certain

432. **https://stevenscenter.wharton.upenn.edu/publications-50-state-review/**.
433. These amendments included new rules for "controllable electronic records" (Article 12) and amendments to how security interests are perfected in digital assets (Article 9), among other changes. See Uniform Law Commission and American Law Institute, Uniform Commercial Code Amendments (2022).
434. The recently published report by the President's Working Group on Digital Assets recommends that the SEC pursue exemptive orders, safe harbours, or regulatory sandboxes to permit such real-world testing.
435. This section focuses on legislation implemented in the U.K. and E.U. jurisdictions specifically focusing on tokenization and the use of DLT. **Chapter 4.1** discusses a number of existing pieces of legislation that may apply in the context of DLT-based Securities.

firms to act as central account keepers (or similar roles) that perform functions akin to that of a CSD, although it should be noted that this does not circumvent the CSDR requirement discussed under **Chapter 4.1.2.2** above and as such the securities cannot be listed.

French law allows for the issuance, transfer and delivery of Security Tokens on a distributed ledger. This French regime has been developed incrementally by adapting the existing regime for registered bonds and adding protective features for token holders.

Germany has created a new legislative framework for digital assets, permitting the issuance of dematerialized bearer securities. Germany has provided legal certainty by deeming electronic securities to be tangibles and, as such, subject to the existing statutory framework. This treatment supplements the existing regime for bearer securities. Issuers in Germany can now issue native electronic securities instead of issuing physical (global or definitive) notes. This is achieved by formally depositing the applicable terms and conditions and establishing and maintaining a register of the applicable securities holders.

There are limitations in each jurisdiction. For example, in France, outside the E.U. Pilot Regime, only Security Tokens not admitted to the operations of a CSD (and therefore unlisted) can be recorded on a DLT under a registered (*nominatif*) form.[436] French law does not currently allow Security Tokens to be issued in bearer form outside the E.U. Pilot Regime, whereas German law does. Lastly, in Luxembourg, Security Tokens are treated under standard book-entry transfer rules, which do not provide a departure from the process for traditional securities.

The development and implementation of such legislation in E.U. member states provide some legal certainty and means that in these jurisdictions it is possible to *create* such natively issued Security Tokens. However, once created, many of the same post-issuance challenges and hurdles discussed in **Chapter 4.1** above remain relevant. Ultimately, Security Token issuances in E.U. member states remain subject to the requirement to record securities in book-entry form on a CSD (as discussed in **Chapter 4.1**). As such, only private placements are possible for Security Tokens at this stage. Private placements do not create the desired liquidity for DLT-based Securities, in contrast to the liquidity that can be achieved by issuing traditional securities that are admitted to trading-on-trading venues. However, for completeness, it should be noted that the issuers of such non-listed Security Tokens are afforded some Secondary Market liquidity of their non-listed digitally native securities for example, via an admission to listing on the Securities Official List of the Luxembourg Stock Exchange and the use of bulletin boards.

From a practical perspective, the potential cost savings and efficiencies granted by DLT may not be sufficient to compensate issuers for the costs and administrative burdens of complying with the more complex legal and regulatory regimes that are being established in various E.U. member states.

U.K.

In the U.K., the USRs permit a company to issue both equity and debt instruments in dematerialized form, which is generally accepted to include digital-only form. As such, the USRs might allow for the issuance of DLT-based Securities using DLT. However, to benefit from the USRs, securities must be issued on an electronic or digital registry that is operated by a licensed operator. Currently, there is no licensed operator that operates a DLT-based system. The USRs also require securities to be recorded on a register maintained in the U.K., and as such their ownership must be determined in accordance with English law. It is not clear whether a DLT-based system with a multi-jurisdictional spread of nodes would qualify as a U.K. registrar for the purposes of the USRs. Additionally, the obligations prescribed by these regulations are onerous and U.K. firms will need to consider carefully whether to issue debt instruments under them.[437] Accordingly, the USRs are not currently a viable way of issuing a digital security.

Participants are not required to issue DLT-based Securities inside of the USRs. The problem is that, while in principle, it should be possible to rely on pure common law to issue these instruments (i.e., in the context of debt instruments, by creating tokens which (a) acknowledge the debt, and (b) create validly enforceable obligations on the issuer to pay the debt acknowledged under the token to the token holder (as discussed above in **Chapter 4.1.3**)), there remains legal uncertainty as to whether or not valid legal obligations have been validly created when issuing financial instruments in the context of a DLT-based system.

In the UK Digital Securities Sandbox, HM Treasury is considering how the USRs may need to change to accommodate digital asset technology and the new practices associated with it.

436. These restrictions generally limit the securities that can be registered on a distributed ledger to: (i) negotiable debt securities; (ii) units or shares of collective investment undertakings; and (iii) unlisted equity securities issued by joint stock companies.
437. U.K. public companies almost always issue equity securities, but not debt securities, under these regulations.

E.U. Pilot Regime and U.K. Digital Securities Sandbox

In the U.K. and E.U., legislation has been adopted to facilitate the issuance and trading of DLT-based Securities using DLT-based systems, as set out below.

E.U. Pilot Regime

Certain key activities in relation to the lifecycle of financial instruments are regulated by E.U.-level legislation that was drafted before DLT-based systems were poised to enter into widespread use in capital markets. These activities include: (i) the sale and purchase of financial instruments; (ii) transfer of payments; (iii) providing settlement services, recording securities in book-entry form (e.g. see Article 3(2) of the CSDR, as discussed in **Chapter 4.1.2**) and maintaining securities accounts. The E.U. Pilot Regime recognizes that certain requirements under existing E.U. financial services legislation could be restrictive and prevent operators from innovating with DLT in capital markets, which would in turn prevent the development of solutions for trading and settling financial instruments that are issued, recorded, transferred and stored using DLT-based systems. As such, the E.U. Pilot Regime allows applicants to obtain exemptions from certain provisions of CSDR and MiFID II, allowing them to (a) carry out activities for which they would not otherwise be authorized, and (b) refrain from carrying out activities that are imposed by legislation but are ultimately burdensome or irrelevant for DLT-based systems.

The E.U. Pilot Regime focuses on the development of certain FMI actors. Specifically, it envisages the development of DLT-based multilateral trading venues (**"DLT MTFs"**) and DLT-based financial settlement systems (**"DLT SSs"**).[438] Additionally, a third FMI is envisaged that combines each of these roles into a DLT-based trading and settlement system (**"DLT TSS"**).[439] The E.U. Pilot Regime places its own, standalone requirements on participants, and does not restrict participation. However, in addition to the Pilot Regime requirements, participants must satisfy existing requirements, for example under MiFID II and CSDR. DLT MTFs may be operated by investment firms[440] or market operators[441] (i.e., the participant must satisfy the applicable requirements under MiFID II), and DLT SSs may be operated by CSDs[442] authorized under CSDR to run settlement systems. DLT TSSs must be authorized as a CSD *and* a market operator or investment firm. As such, while the E.U. Pilot Regime is theoretically open to new participants, it would be onerous for a firm to obtain the requisite levels of authorization.

a) Participant exemptions

Under the E.U. Pilot Regime, DLT TSSs and DLT SSs are able to apply for exemption from the listing requirement under Article 3 of CSDR, that transferable securities may only be admitted to trading on a trading venue (including regulated markets) if they are recorded in book-entry form on a CSD. As discussed in **Chapter 4.1.2**, this requirement is one of the hurdles currently preventing the listing of DLT-based Securities in the E.U. If such an exemption is obtained, the security will be traded directly on a DLT SS. This will be a marked step forward in the E.U., where, to the extent that there has been any trading of financial instruments issued, recorded, transferred and stored using DLT, it has been limited to private placements and OTC trading. This will appeal to multiple market participants including (i) investors looking to diversify their portfolios with DLT-based Securities and (ii) issuers seeking the liquidity offered by established E.U. trading venues.

Another significant exemption under the E.U. Pilot Regime is the exemption from MiFID II intermediation requirements for DLT MTFs. This exemption will theoretically allow retail investors to gain direct access to the DLT MTF's platform, and to deal on their own account. This exemption is appealing as it reduces intermediation fees and the number of actors required in the trade and post-trade processes, and expands the potential investor base, providing greater liquidity, and allowing issuers to access different investor profiles. The E.U. Pilot Regime will, however, place requirements on these retail investors, as set out in Article 4(2) of the E.U. Pilot Regime, including, for example, that they (i) must have sufficient trading ability, competence and experience, (ii) cannot be market makers on the DLT MTF, and (iii) must not use a high-frequency algorithmic trading technique on the DLT MTF. These requirements maintain financial stability and integrity on the trading venues, but (i) in particular preclude a significant proportion of retail investors from participating. It remains unclear how such experience could be demonstrated, and what level would be considered sufficient.

DLT MTFs will also be able to apply for exemption from transaction reporting requirements under MiFIR[443]. Such requirements may be unnecessary in the context of a DLT-based system, given that it will be possible for the applicable competent authority to be granted direct access the platform as an observer participant.

438. ESMA, Report on the DLT Pilot Regime, September 2022.
439. Ibid.
440. As defined in Article 4(1), point (1) of Directive 2016/65/E.U. ("**MiFID II**").
441. As defined in Article 4(1), point (18) of MiFID II.
442. As defined in Article 2(1), point (1) of Regulation (E.U.) 909/2014.
443. Regulation (E.U.) 600/2014.

Under the CSDR, CSDs perform three core services: (i) the initial recording of securities in a book-entry system (**"notary service"**); (ii) providing and maintaining securities at the top tier level (**"central maintenance system"**); and (iii) operating a securities settlement (**"settlement service"**).[444] Performing (i) or (ii) of these functions while operating a Security Settlement System will trigger a licensing requirement under CSDR, a feature that is retained under the E.U. Pilot Regime for entities establishing a DLT SS or DLT TSS. The E.U. Pilot Regime takes a step toward recognizing that, if DLT-based systems are used, there is arguably a reduced need for the CSD as a means of providing the notary service. In respect of the other essential services provided by CSDs in current trade and post-trade processes (i.e., by effecting the settlement of transactions as a Security Settlement System, acting as a depositary and offering investor CSD services similar to those offered by a custodian), the E.U. Pilot Regime will provide an opportunity for FMI to test the efficacy of DLT-based systems to carry out these processes while maintaining safe, integral capital markets.

It appears that the CSDR security registration requirement (Article 3(2)) is not switched off where securities are registered and settled by a non-CSD DLT TSS and therefore, it appears that issuers are required to deposit publicly traded securities (or when used as collateral) in a CSD despite the availability of non-CSD DLT TSS. This would in practice constrain DLT TSS to DLT financial instruments that are privately placed and traded over the counter (OTC).

The E.U. Pilot Regime allows DLT Security Settlement Systems and TSSs to apply for exemptions from certain requirements. It is designed to create the possibility of instantaneous settlement.

b) Conditions to participation

The E.U. Pilot Regime is limited to certain financial instruments, including in particular: (i) shares issued by issuers with a market capitalization of less than EUR 500 million; and (ii) bonds or securitized debt (including depositary receipts or money market instruments but excluding those that embed a derivative or complicated structure) with an issue size of less than EUR 1 billion. Additionally, financial instruments issued on DLT under the E.U. Pilot Regime can only be recorded or admitted to trading on an authorized DLT market infrastructure if the aggregate of all such financial instruments recorded or admitted to trading on the DLT market infrastructure does not exceed EUR 6 billion. These limits have received widespread criticism as being too low. Although the short-term aim is to provide a sandbox environment for DLT-based systems to be tested in the context of capital markets (as opposed to the long-term aim of facilitating access to capital), the application of DLT-based systems in capital markets should arguably be tested at scale.

Investor protection, transparency, market integrity and financial stability are protected under the E.U. Pilot Regime via further requirements placed on participants, including the need to provide (i) a detailed business plan that details how the DLT would be used and the applicable legal terms, (ii) specific and robust IT and cyber arrangements relating to the use of DLT, (iii) appropriate measures for the safeguarding of clients' funds, and even (iv) an exit plan in the event that the E.U. Pilot Regime is discontinued.[445]

c) Issues with the E.U. Pilot Regime

1. **Conditions to participation.** As noted above, the conditions to participation have received widespread criticism. This is the primary issue with the EU Pilot Regime.

2. **Secondary trading.** Whilst the E.U. Pilot Regime allows greater investor participation in theory by giving national regulators some discretion, there are issues with the approach taken which mean that issues surrounding secondary trading remain. The E.U. Pilot Regime sets out essentially the same requirements as in Article 53(3) MiFID II, i.e. there is little improvement on the participation from the current legal and regulatory framework.[446] The E.U. Pilot Regime makes an express reference to operators permitting natural persons to deal on their own account; however, it is unclear how a natural person could demonstrate that they have "a sufficient level of trading ability, competence and experience". The requirement is in fact more onerous than that under Article 53(3)(b) MiFID II, as it also requires that the participant has a "knowledge of the functioning of Distributed Ledger Technology".[447]

   Additionally, there is a licensing issue. The activity of "dealing on own account" in respect of financial instruments that are admitted to trading on a trading venue is an investment service/activity under MiFID II[448] and as such would require the participant to be licensed to deal on their own account. Article 2 MiFID includes a carve-out for dealing on one's own account from the licensing requirement (other than in respect of commodity derivatives or emission allowances or

444. Section A of the Annex to the CSDR.
445. Article 7 of the E.U. Pilot Regime.
446. This applies to both regulated markets and MTFs as a result of Article 19(2) MiFID II.
447. See, for example, Article 4(2)(b) of the E.U. Pilot Regime.
448. Annex 1, Section A, Point (3) MiFID II.

derivatives thereof)[449]. However, this exemption does not apply where the person in question is a member or participant of an MTF. There is no exclusion or modification of Article 2 under the E.U. Pilot Regime, and so the only option for members, participants or the MTFs themselves would be to argue that this activity is not undertaken on a professional basis. Regardless, this leaves uncertainty in relation to the requirement for licensing. This lack of clarity presents practical issues for DLT market infrastructure, issuers and participants alike.

3. **Cash leg.** As discussed above, the E.U. Pilot Regime allows participants to apply for an exemption to the requirement that CSD transactions must be settled in traditional cash and allows transactions to be settled with DLT-based Payment Instruments, including wholesale tokenized central bank money, tokenized commercial bank money and e-money tokens. However, neither MiCA nor the E.U. Pilot Regime, as currently drafted, provide a framework that enables the creation of a payment platform that tokenizes money and can provide settlement by facilitating the cash leg of a digital security transaction.

4. **Cross-border issuance.** The E.U. Pilot Regime is only available for issuers established in one of the E.U. member states, which makes it difficult to rely on cross-border frameworks. Multi-jurisdictional access is a key benefit of DLT-based systems, and this limitation is a drawback of the E.U. Pilot Regime.

   As mentioned above, in a joint paper published on 9 April 2025, the French Autorité des marchés financiers and the Italian Commissione Nazionale per le Società e la Borsa highlight the low number of players authorized under the E.U. Pilot Regime and suggest amendments to enhance the competitiveness of this regime[450]. See also ESMA's Report on the Functioning and Review of the DLT Pilot Regime.[451]

U.K. Digital Securities Sandbox

The Financial Services and Markets Act 2023 amended U.K. legislation to allow for the creation of a sandbox (or multiple sandboxes). These sandboxes allow FMI to implement and test the efficiency and effectiveness of technology, including, but not limited to, DLT-based systems (the "Digital Securities Sandbox" or "DSS"). The Digital Securities Sandbox has been defined and brought into effect by the Financial Services and Markets Act 2023 (Digital Securities Sandbox) Regulations 2023, which came into effect on 8 January 2024. The Digital Securities Sandbox is analogous to the E.U. Pilot Regime, in that it allows certain entities to apply to be temporarily exempted from specific requirements under financial services legislation.

A distinguishing feature of the U.K.'s Digital Securities Sandbox is that it envisages the modification and application of certain existing laws to permit the issuance of DLT-based Securities. This is a key difference of the Digital Securities Sandbox compared to the E.U. Pilot Regime, which only allows the disapplication of existing laws. The scope of the Digital Securities Sandbox is limited to certain relevant enactments, including the Companies Act 2006 and requirements under the USRs. However, it may not be wide enough to cover other legislation that impacts on the ability to trade DLT-based Securities, such as tax legislation.

The Digital Securities Sandbox goes further than the E.U. Pilot Regime by allowing HM Treasury to permit a broad participation in the Digital Securities Sandbox, including FMI providers, participants in these systems and, theoretically, unregulated service providers such as technology companies.

Please refer to the Executive Summary for further detail on the UK's Digital Securities Sandbox.

Comments on the E.U. Pilot Regime and UK DSS

A potential outcome of both Pilot Regimes and UK DSSs (subject to the review of the relevant authorities) is that the applicable legal and regulatory regimes in the E.U. and U.K. respectively could be permanently amended to provide the same regulatory and legal landscape as experienced by Pilot Regime or DSS participants. Such permanent amendments would arguably be a significant step forward in supporting the adoption of DLT and DLT-based Securities in capital markets. However, there will need to be further work undertaken to address the shortcomings under the E.U. Pilot Regime, as set out above.

449. Article 2(1)(d) MiFID II.
450. **https://www.amf-france.org/sites/institutionnel/files/private/2025-04/amf_consob_position-paper-towards-a-more-competitive-european-pilot-regime.pdf.**
451. **https://www.esma.europa.eu/sites/default/files/2025-06/ESMA75-117376770-460_Report_on_the_functioning_and_review_of_the_DLTR_-_Art.14.pdf.**

Digital Euro proposal

As mentioned above, on 28 June 2023, the European Commission published its Digital Euro Proposal. The digital euro would constitute a liability of the European Central Bank and the euro system offered in digital form for use by citizens and business to make payments.[452] While the E.U. Pilot Regime allows a DLT-FMI to settle transactions using wholesale tokenized central bank money, it is unlikely that the digital euro under the current project will be able to be used to facilitate the cash leg of DLT-based Securities settlements, as this proposal excludes the use of digital euro for wholesale payments. In February 2025, the ECB officially confirmed a separate wholesale tokenized central bank money project, aimed specifically at enabling use cases such as securities settlement. Unlike the retail digital euro, this wholesale effort could be a game changer for the tokenization of capital markets in Europe.

Digital Pound joint consultation

In January 2024, HM Treasury and the Bank of England published a joint consultation response on the potential case for a digital pound and the key features of such a model.[453] HM Treasury and the Bank of England published an update in January 2025.[454].[455]; they are developing a more detailed policy and technology framework for a potential digital pound, although no decision has been made on whether to proceed with a digital pound.

Capital Treatment

As discussed earlier in this report, in December 2022, the Basel Committee on Banking Supervision issued a prudential standard on banks' cryptoasset exposures.[456] In relation to SCO60 generally, please refer to the Executive Summary. In the UK, the PRA has decided to delay the implementation of Basel 3.1 in the UK by one year until 1 January 2027.[457] The PRA has also proposed to delay the implementation of the market risk modelling elements of Basel 3.1 for another year until 1 January 2028, largely to allow for coordination between international groups engaged in cross-border trading activity.[458]

Hong Kong

DLT-based Securities

1. The regulators in Hong Kong have adopted a technology-neutral regulatory approach and are seeking to regulate cryptocurrencies, digital tokens and related activities by introducing new legislation or issuing guidelines around the existing regulatory framework. DLT-based Securities are not regulated by default but the SFC issued a statement on September 5, 2017 clarifying that where certain digital tokens have terms and features that would classify the digital assets as “securities” under the SFO (e.g. where they represent equity ownership or debt issuance akin to “shares” or “debentures”), they would fall within the ambit of regulatory oversight.[459] As such, depending on the terms and features of the digitized security, they could be subject to the securities laws of Hong Kong. The SFC also clarified in its Statement on Security Token Offerings on March 28, 2019 that digital assets that are digital representations of ownership of assets (e.g. commodities or real estate) or economic rights (e.g. a share of profits or revenue) utilizing DLT are likely to be securities under the SFO.[460]

2. If a digital security falls within the definition of “securities” under the Securities and Futures Ordinance, the full securities regulatory regime in Hong Kong applies. For example, any person who markets and distributes DLT-based Securities in Hong Kong is required to be licensed by the SFC. In addition, the SFC has issued a host of additional requirements applicable to parties engaging in digital assets activities. For example, in the SFC's Statement on Security Token Offerings on March 29, 2019, the SFC introduced enhanced investor protection measures that apply to parties engaging in securities token offerings, such as selling restrictions (limiting offerings to professional investors only), enhanced due diligence requirements on issuers, and warning disclosure requirements.

452. Report on a digital euro October 2020.
453. **https://www.bankofengland.co.uk/-/media/boe/files/paper/2024/responses-to-the-digital-pound-consultation-paper.pdf**.
454. **https://www.bankofengland.co.uk/report/2025/digital-pound-progress-update**.
455. **https://www.bankofengland.co.uk/report/2025/digital-pound-progress-update**.
456. **https://www.bis.org/bcbs/publ/d545.pdf**.
457. **https://www.bankofengland.co.uk/news/2025/january/the-pra-announces-a-delay-to-the-implementation-of-basel-3-1**.
458. **https://www.bankofengland.co.uk/prudential-regulation/publication/2025/july/basel-3-1-adjustments-to-the-market-risk-framework-consultation-paper**.
459. SFC, "Statement on initial coin offerings", 5 September 2017: **https://www.sfc.hk/en/News-and-announcements/Policy-statements-and-announcements/Statement-on-initial-coin-offerings**.
460. SFC, "Statement on Security Token Offerings", 29 March 2019: **https://apps.sfc.hk/edistributionWeb/gateway/EN/circular/doc?refNo=19EC19**.

3. However, Hong Kong regulators have increasingly recognized the need to regulate digital assets that do not strictly conform to the definition of "securities". In the SFC and HKMA Joint Circular on intermediaries' virtual asset activities on January 28, 2022, the SFC set out additional requirements applicable to intermediaries engaging in virtual asset activities, and the definition of virtual asset was designed to capture a broad range of non-central bank issued digital tokens, irrespective of whether they constituted "securities" or not.[461]

4. In October 2022, the SFC announced a wealth of measures in a push to encourage growth of the digital asset market and DLT innovation. The SFC has indicated that it will set out a detailed modified Security Token regime in due course which is expected to relax current rules, such as the removal of the automatic classification of Tokenized Securities as "complex products" (which are subject to enhanced suitability requirements), and instead the SFC's preliminary view is that Tokenized Securities would be treated in a similar way to traditional financial instruments[462]. The Hong Kong government has also indicated that it is open to future review on property rights for DLT-based Securities and the legality of smart contracts in order to provide a solid legal foundation for their development[463].

5. In the context of amendments to the Anti-Money Laundering and Counter-Terrorist Financing Ordinance introduced in June 2022, and which introduced the new licensing regime for virtual asset service providers, a definition of "virtual assets" was introduced to Hong Kong statute for the first time. The broad and inclusive definition is subject to exceptions for certain specified "cryptographically secured digital representations of value" including (amongst other exceptions) if it "constitutes securities or a futures contract" (section 53ZRA). This definition of "virtual assets" is now being referenced across subsequent legislation and regulatory guidance, with the effect that the Hong Kong regulatory landscape is increasingly articulated for the purposes of regulatory characterization.

DLT-based Payment Instruments

The current stance of the HKMA is that cryptocurrency (in the context of Bitcoin) is to be regarded as a "virtual commodity" and not legal tender, and it does not qualify as a means of payment or electronic/digitized money. Further, in a statement released by Hong Kong's Customs and Excise Department (C&ED) in April 2014, it was stated that: "Bitcoin and other similar virtual commodities are not 'money' and do not fall within the regulated regime administered by C&ED". The Financial Services and the Treasury Bureau also stated in its Consultation Conclusions to the consultation on legislative proposals to enhance anti-money laundering and counter-terrorist financing regulation in Hong Kong that virtual assets are not legal tender.[464]

There remains no overarching regulation for digital money operations. Various regulatory regimes may apply that have not been harmonized or tailored to cater for the structure and reality of digital money and similar products. These include the existing securities law regime mentioned in **Chapter 4.2.3.1**, banking and money broker licensed activities under the Banking Ordinance, money lender licensed activities under the Money Lenders Ordinance, stored value facility operator licensed activities under the Payment Systems and Stored Value Facilities Ordinance, the money service operator licensed activities (with respect to money changing and money remittance) under the Anti-Money Laundering and Counter-Terrorist Financing Ordinance and the Stablecoins Ordinance (with reference to fiat-referenced stablecoins) also under the Anti-Money Laundering and Counter-Terrorist Financing Ordinance. Issuers and intermediaries involved in digital money operations typically have to assess each product on a case-by-case basis, some of which may be riskier than others from a regulatory perspective.

The HKMA reviewed the need to enhance the existing regulatory framework and issued a discussion paper in January 2022 to consult the industry regarding future regulation of digital money, with a particular focus on regulation of payment-related tokens (such as stablecoins and asset-backed payment tokens) at this stage.[465] The HKMA have now concluded this consultation, and the Stablecoins Ordinance was enacted on 21 May 2025, establishing a licensing regime for fiat referenced stablecoin issuers in Hong Kong which will come into effect on 1 August 2025.[466]

461. SFC and HKMA, "Joint Circular on intermediaries' virtual asset-related activities", 28 January 2022: **https://apps.sfc.hk/edistributionWeb/gateway/EN/circular/intermediaries/supervision/doc?refNo=22EC10**.
462. SFC, "Embracing Innovation, Regulation and the Future of Finance Keynote address at Hong Kong FinTech Week 2022", 31 October 2022: **https://www.sfc.hk/-/media/EN/files/COM/Speech/HKFW-Speech---Eng_20221031.pdf?rev=34b90c7d8dce42ad9215da652cd77dc5&hash=E11F1164D81137053A27C6CEEFACE9D3**.
463. SFC, "Policy Statement on Development of Virtual Assets in Hong Kong", 31 October 2022: **https://gia.info.gov.hk/general/202210/31/P2022103000454_404805_1_1667173469522.pdf**.
464. Financial Services and the Treasury Bureau, "Public Consultation on Legislative Proposals to Enhance Anti-Money Laundering and Counter-Terrorist Financing Regulation in Hong Kong Consultation Conclusions", May 2021: **https://www.fstb.gov.hk/fsb/en/publication/consult/doc/consult_conclu_amlo_e.pdf**.
465. HKMA, "Discussion Paper on Crypto-assets and Stablecoins", January 2022: **https://www.hkma.gov.hk/media/eng/doc/key-information/press-release/2022/20220112e3a1.pdf**.
466. Government welcomes passage of the Stablecoins Bill, 21 May 2025: **https://www.hkma.gov.hk/eng/news-and-media/press-releases/2025/05/20250521-3/**.

In addition, ongoing efforts by the HKMA are exploring the issuance of a retail CBDC in Hong Kong, namely the e-HKD. In October 2021 and April 2022, the HKMA published a discussion paper to consult the public regarding various design considerations (including issuance mechanism and legal considerations) as well as use cases of e-HKD on both the technical and policy front.[467] After collecting feedback from market consultation, the HKMA in September 2022 released a position paper titled "e-HKD: Charting the Next Steps" to announce the next steps in launching e-HKD, which would involve the identification of areas in which legislative amendment is required to enable a digital form of fiat currency with legal tender status, and the launch of CBDC pilot programs.[468] Similar projects are underway in relation to the research and development of utilizing CBDC for wholesale cross-border payments,[469] including in Project mBridge. The mBridge project team has involved the HKMA working with the Bank for International Settlements Innovation Hub Hong Kong Centre, the Bank of Thailand, the Digital Currency Institute of the People's Bank of China, the Central Bank of the United Arab Emirates, and the Saudi Central Bank, to develop a multi-central bank digital currency platform shared among participating central banks and commercial banks, built on Distributed Ledger Technology to enable instant cross-border payments and settlement. It was announced in June 2024 to have entered the "Minimum Viable Product" stage, referring to a basic version of a product, containing enough features to be launched and used by early adopters.[470]

Capital Treatment

As discussed earlier in this report, in December 2022, the Basel Committee on Banking Supervision issued a prudential standard on banks' cryptoasset exposures.[471] In relation to SCO60 generally, please refer to the Executive Summary. On 11 July 2025, the HKMA published a set of amendment rules that will implement SCO60 with effect from 1 January 2026.[472]

Japan

Current framework for transactions in tokens representing securities

As mentioned in **Chapter 4.1.5**, a regulatory framework for transactions in respect of DLT-based Securities has already been implemented in Japan. The FIEA was amended in 2019 to regulate transactions of tokens representing securities in an attempt to facilitate capital formation in this manner while protecting investors. The amendment came into force in May 2020.

Characterization as security

Under the amendment to the FIEA, tokens representing (i) a conventional class of financial assets listed as "Type I Securities" under the FIEA (such as shares and bonds) or (ii) an interest in a collective investment scheme, would be deemed to be "securities".

Issuance of Type I Security Tokens

As a general rule, the issuer of the securities must file a Securities Registration Statement prior to the commencement of the offering of the securities, unless the offering satisfies the conditions for relying on a private placement exemption.

The FIEA introduced a new private placement framework for the situation where the Type I Securities are recorded and transferable electronically by means of DLT. The tokens representing such Type I Securities (Type I Security Tokens) may be offered for sale without registration if the tokens are, in the Primary Markets, offered only to qualified institutional investors (QIIs) as defined in the FIEA or to a small number of investors (fewer than 50), and a technological restriction is implemented to limit transfers in the Secondary Market. Such restriction might be that, for example, (i) only QIIs can acquire the tokens

467. HKMA, "e-HKD: A technical perspective", October 2021: **https://www.hkma.gov.hk/media/eng/doc/key-functions/financial-infrastructure/e-HKD_A_technical_perspective.pdf** and HKMA, "e-HKD: A Policy and Design Perspective:", April 2022 **https://www.hkma.gov.hk/media/eng/doc/key-functions/financial-infrastructure/e-HKD_A_Policy_and_Design_Perspective.pdf**.
468. HKMA, "e-HKD – Charting the Next Steps", September 2022: **https://www.hkma.gov.hk/media/eng/doc/key-information/press-release/2022/20220920e4a1.pdf**.
469. HKMA and Bank of Thailand, "Leveraging Distributed Ledger Technology to Increase Efficiency in Cross-Border Payments": **https://www.hkma.gov.hk/media/eng/doc/key-functions/financial-infrastructure/Report_on_Project_Inthanon-LionRock.pdf**.
470. Government press release, "Project mBridge reaches MVP stage", 5 June 2024: **https://www.info.gov.hk/gia/general/202406/05/P2024060500245.htm**.
471. **https://www.bis.org/bcbs/publ/d545.pdf**.
472. **https://www.info.gov.hk/gia/general/202507/11/P2025071000787.htm?fontSize=1**.

or (ii) the transferor can only transfer the tokens it holds all together to one transferee. A person who visits the website on which an offering of Type I Security Tokens is announced or reported could be deemed an offeree, and therefore, in practice, it will be important to limit persons with access to any marketing website to ensure that applicable restrictions are complied with when conducting private offerings of Type I Security Tokens without securities registration.

Issuance of Type II Security Tokens:

The legal treatment of tokens representing an interest in a collective investment scheme and transferable electronically by means of DLT differs depending on whether certain technological restrictions on transfer are imposed or not.

Without a satisfactory technological restriction that (i) makes the tokens capable of transfer only to QIIs or certain eligible investors, and (ii) each transfer of tokens requires an offer by the transferor and consent from the issuer, the tokens will qualify as "FIEA Security Tokens" and will be regulated in the same manner as Type I Security Tokens as explained above.

However, satisfaction of the technological restriction conditions above means the tokens are not classified or regulated as **"FIEA Security Tokens"**, which means that they can be offered and sold more easily. The marketing of those tokens (Type II Security Tokens) must be handled by a Type II FIBO licensed entity (which is regulated to a lesser extent than a Type I FIBO licensed entity). Or, if the investors to whom the Type II Security Tokens are marketed are limited to a group comprised of at least one QII and fewer than 50 certain experienced investors, the issuer of the Type II Security Tokens may seek to rely on the FIEA Article 63 exemption from the Type II FIBO licensing requirement to conduct the marketing of the Type II Security Tokens. In terms of the management of the funds raised by way of an offering of the Type II Security Tokens, the issuer must be registered as an Investment Manager. Otherwise, the issuer would need to rely on the FIEA Article 63 exemption from the investment management license requirement.

Secondary Trading:

The secondary trading of any financial instruments in the course of business will, in most circumstances, trigger licensing requirements for any operator of trading and this regime equally applies to activities in respect of trading of Type I Security Tokens or Type II Security Tokens given that Type I Security Tokens and Type II Security Tokens fall under "securities" under the FIEA.

Clearing:

There is no mandatory clearing requirement for issuance of debt and equity instruments under the FIEA. Accordingly, Type I Security Tokens and Type II Security Tokens can be issued without clearing requirements, as is the case for debt and equity instruments regulated under the FIEA.

Listing:

There is no mandatory listing requirement for the offering of debt and equity instruments under the FIEA (the relevant requirement was abolished in 1998). Accordingly, Type I Security Tokens and Type II Security Tokens can be offered without listing requirements, as is the case for debt and equity instruments regulated under the FIEA. However, it is required to obtain proprietary trading system operation permission for Type I FIBO to operate proprietary trading system for the Type I Security Tokens and Type II Security Tokens.

Scope of Tokenization Legislation in Japan

Financial regulation inevitably raises the question of extraterritorial application. As long as a Japanese resident can possibly access the transactions of Security Tokens or cryptoassets, extraterritorial application of the FIEA or Japanese Payment Services Act arises even if the transaction is based in another jurisdiction and is in a language other than Japanese. As Japanese residents can be solicited in these circumstances, the FIEA or Japanese Payment Services Act would apply, as would the relevant regulatory regime(s) in other jurisdictions where the relevant transaction (for example ICO) is based.

The scope of Security Token regulations under the FIEA

As discussed above, a regulatory framework for transactions in respect of Type I Security Tokens and Type II Security Tokens has already been implemented in Japan.

One matter which needs further consideration is, if the financial asset that the tokens represent is designed so that it does not fall within any of the definitions of Type I Securities or interest in a collective investment scheme, whether the tokens may be

sold without the regulatory constraints under the FIEA. Within the current framework, the answer seems to be 'yes' as the definition of Type I Securities encompasses a limited list of specific instruments and does not include a catch-all category to capture instruments that do not fall within any of the specific instruments but have the general nature of securities.

However, such tokens might fall within the definition of cryptoassets under the Japanese Payment Services Act, which imposes registration requirements on dealers in cryptoassets. Therefore, in determining business strategy in Japan, both the definitions of Type I Securities and collective investment schemes under the FIEA, as well as the definition of cryptoassets under the Japanese Payment Services Act, must be considered.

The regulation of stablecoins in Japan

In June 2022, an amendment to the Japanese Payment Services Act, which aims to regulate digital money to be used for fund transfers and payments, including stablecoins, was enacted in Japan. The amendment reflects the international discussion surrounding stablecoins, especially the FSB's final report and recommendations on the Regulation, Supervision and Oversight of "Global Stablecoin" Arrangements published in October 2020 (**"the 2020 FSB Recommendations"**) and is therefore in line with regulations being considered in other jurisdictions such as the U.S. and E.U., which regulate similar digital assets. Japan has opted out of a CBDC approach (although the Bank of Japan announced that it would commence a demonstration experiment with Japanese mega banks in early 2023), instead allowing private firms to issue stablecoins. The amendment enables the use of legislatively permitted stablecoins in Japan. Permission to issue stablecoins in Japan is only granted to licensed banks, fund transfer agents, and trust companies. Since 2023, a registration requirement has also been applied for the distribution of stablecoins, as well as the issuance of stablecoins.

As set out in the 2020 FSB Recommendations, stablecoins can be categorized according to the various types of stabilization mechanisms used. Stablecoin designs currently reflect two broad types of mechanisms, i.e., asset-linked and algorithmic.

The issuance of stablecoins in Japan has already been restricted to licensed banks, fund transfer agents and trust companies. Also, the transfer and management of stablecoins has been regulated since June 2023 and a license under the Japanese Payment Services Act is required. A firm obtaining the new license will be subject to codes of conduct, such as anti-money laundering and countering the financing of terrorism.

Singapore

The regulatory approach in Singapore has been to look beyond the label of an asset, and examine its features and characteristics:

- For instance, if the digital asset has the characteristics of a security such as a share or a bond, it would be regulated under the Securities and Futures Act 2001, similar to other capital markets products. If the digital asset is not such a regulated product but is used as a medium of exchange for payment, then it is regulated as a digital payment token under the Payment Services Act 2019.
- In relation to stablecoins, following its October 2022 consultation paper on the Proposed Regulatory Approach for Stablecoin-Related Activities[473], MAS published its response setting out the proposed regulatory approach to stablecoins[474] and finalized its stablecoin regulatory framework[475]. The framework relates to single-currency stablecoin pegged to either the Singapore Dollar or other G10 currencies issued in Singapore. Requirements such as reserve asset backing, timely redemption at par, prudential requirements and disclosure through issuing a white paper, as well as compliance with existing AML/CFT and cyber risk standards have been proposed. MAS has stated that it continues to take a technology-neutral stance and will examine the characteristics of the stablecoin to determine the appropriate regulatory treatment, and whether an asset will fall under the Payment Services Act 2019 and the stablecoin framework. MAS will continue to review industry developments relating to stablecoins and is in the process of preparing necessary legislative amendments to implement the stablecoin framework[476].
- Payment token derivatives (i.e., derivatives contracts that reference payment tokens as underlying assets) as a general asset class are currently not regulated under the Payment Services Act 2019 as digital payment tokens or the Securities and Futures Act 2001 as derivatives contracts. However, MAS regulates payment token derivatives that are offered on approved exchanges, as these are considered systemically important trading facilities, as well as where MAS-regulated entities offer such payment token derivatives to retail investors.

473. MAS, Proposed Regulatory Approach for Stablecoin Related Activities, October 2022.
474. MAS, Response to Public Consultation on Proposed Regulatory Approach for Stablecoin-related Activities, August 2023.
475. MAS Finalises Stablecoin Regulatory Framework.
476. MAS, Frequently Asked Questions on the Payment Services Act, April 2024.

The Financial Services and Markets Act 2022 ("FSMA 2022") was passed by Parliament in April 2022 and has been implemented in phases, with the final phase commencing on 30 June 2025. Under FSMA 2022, financial institutions which provide digital token services must obtain a licence to operate in Singapore, including service providers offering digital token services exclusively to users outside of Singapore. FSMA 2022 will regulate virtual asset service providers established in Singapore that provide virtual asset services outside of Singapore to fully align with enhanced FATF standards on virtual asset service providers and mitigate reputational and money laundering and terrorist financing risks.

MAS FinTech Regulatory Sandbox

MAS established the FinTech Regulatory Sandbox in 2016 to encourage and enable experimentation of technology innovation in financial services, within a well-defined space and duration where MAS would provide the requisite regulatory support. The Regulatory Sandbox was enhanced with Sandbox Express in 2019 to provide firms with a faster option for market testing of certain low-risk activities in pre-defined environments, and the Sandbox Plus which is open to firms proposing to introduce technology not yet applied in financial service in Singapore. This FinTech Regulatory Sandbox framework is available for firms looking to apply technology in an innovative way to provide new financial services that are regulated by MAS and is not specific to the use of DLT.

MAS does not currently see a compelling case for a retail CBDC in Singapore. However, it continues to actively explore good use cases for digital currencies. Project Orchid published a blueprint in November 2023 detailing the infrastructure needed to build the technical capabilities and competencies necessary for MAS to issue a retail CBDC, should the need arise, as well as the commercial and operational considerations of deploying digital money.

4.3 CONSIDERATIONS FOR LEGAL AND REGULATORY NEXT STEPS

To encourage widescale adoption of DLT and Tokenization in the context of capital markets, market participants generally need two key elements from a legal/regulatory perspective. First, there must be legal certainty that the digital security created in a given instance legally qualifies as the asset it is intended to be, with associated rights that can be enforced against the relevant parties (including, for example, the issuer, a counterparty to the transaction, and/or a third party, if applicable). To that end, any framework needs to (i) clarify conflicts of laws, ownership of digital assets and how to effectively pledge and perfect digital assets as collateral, and (ii) clarify insolvency treatment of digital assets. Second, there must be a regulatory framework that provides certainty that the activities carried on by market participants in respect to these DLT-based Securities are permissible. Such a framework could provide clarity as to (i) how financial institutions can hold DLT-based Securities; and (ii) the roles of financial institutions as, among other things, intermediating entities and custodians, in the context of DLT-based systems. These two requirements apply to all use cases for DLT and Tokenization in capital markets and are jurisdictionally agnostic. However, the steps required to achieve these are specific to each jurisdiction.

Legal/Regulatory framework—U.S.[477]

Clear, Established Regulatory Perimeter

- A clear and established regulatory perimeter for digital assets is more critical than ever. Congress should work towards passing legislation that defines a federal framework for digital assets. Any such legislation should codify clear definitions of digital assets and allocate regulatory responsibility between the SEC and the CFTC. Both the Senate Banking Committee draft and the House-passed CLARITY Act would address this topic in varying ways. As currently drafted, both the Senate Banking Committee draft and the CLARITY Act would introduce definitions to classify "digital assets," address the treatment of "investment contracts" under federal securities law, create special disclosure requirements for certain digital asset offerings, and amend the federal banking laws in various respects to address digital assets, among other changes.[478] As Congress continues to consider market structure legislation, we emphasize that it is imperative that any resulting regulatory framework integrates digital assets into the existing financial regulatory architecture: applying securities laws to investment products, banking and payments laws to monetary instruments, and commodities/futures laws to commodities and related derivatives, with coordination among agencies to avoid gaps. In the interim, regulators should continue to use their authorities judiciously to provide guidance. A clear regulatory perimeter will

477. We note that the recently published report by the President's Working Group on Digital Assets addresses many of the topics below and similarly urges Congress and federal regulatory agencies to enact legislation and provide more regulatory clarity on permissible activities and best practices.
478. See, e.g., the CLARITY Act at § 103 and § 106. The Senate Banking Committee draft is *available at* **https://www.banking.senate.gov/imo/media/doc/senate_banking_committee_digital_asset_market_structure_legislation_discussion_draft.pdf**.

protect consumers, reduce illicit arbitrage, and give responsible innovators the legal certainty to develop compliant DLT-based products in the U.S. Banking agencies should continue to take steps to ensure that regulated banks can effectively participate in the expanding digital ecosystem, including through further guidance on permissible activities and prudential standards (including capital) as appropriate.

- Regulators should continue to engage in an active dialogue with industry participants to accomplish these goals.

Issuance and Disclosure

- The SEC should continue to consider what material information is needed by investors of DLT-based Securities and whether certain traditional disclosures are unnecessary or should be modified, for example, if such information is already publicly available on DLT, building on the guidance it published earlier this year by working expeditiously with issuers and other stakeholders bringing new products to market. We acknowledge that the digital asset market structure legislation currently under consideration would further address this issue by tailoring disclosure obligations for certain digital asset offerings, but work would remain in relation to tokenized securities.

Listing Requirements and Secondary Trading

- The SEC's clarifications on certain listing requirements and secondary trading questions are a step in the right direction towards fostering robust, compliant markets. We also applaud SEC leadership on their decisions to rethink restrictive rule proposals and consider exemptive orders for secondary trading. Going forward, we would welcome further clarity on listing standards and market structures, in particular around when registration requirements apply in connection with DLT-based infrastructure.

Transfer Agents

- The SEC's clarification with respect to when transfer agents can rely on DLT as the master securityholder file was a welcome and positive development. We echo Commissioner Peirce's statement that these are incremental steps and there is more to be done.[479] The SEC should fully modernize transfer agent regulations for the DLT era and update its rules to explicitly accommodate tokenized securities. We also encourage the SEC to consider whether certain decentralized systems might eliminate the need for a traditional transfer agent altogether for some securities (for instance, a fully on-chain system where a smart contract updates balances in real time). If so, regulations should permit an issuer to apply for an exemption or modified transfer-agent registration in such cases, to avoid duplicative bureaucracy when the technology itself performs the function.

Custody

- We strongly support the actions taken by the SEC, FINRA, OCC, FRB and FDIC as it relates to the clarification and easing of certain guidelines as it relates to permitted custodial activities and accounting treatment.
- The SEC also should continue its work to update its SPBD guidance by removing restrictions on full-purpose broker-dealers custodying DLT-based Securities and to update its investment adviser and investment company custody rules to address DLT-based Securities.

Settlement and Clearing

- We reiterate our call for additional clarity and guidance by the SEC and clearing agencies about issues such as whether validator nodes used to run a DLT are performing functions of a clearing agency, who can become a member of a CCP that clears DLT-based Securities, and even the role of clearing agencies for DLT-based Securities on a distributed ledger.

DLT-based Payment Instruments

- As above, we reiterate our call for regulators to provide a clear path for banks to issue DLT-based Payment Instruments to facilitate settlement and financing transactions, including by providing any clarifications or modifications that may be necessary to reflect the unique ways in which DLT technology functions and help further develop or clarify legal principles that apply to aid parties with the legal bases for transactions settled through DLT platforms.
- To achieve the cross-border benefits of DLT technology for securities and payment settlement, U.S. regulators also should adopt rules for institutional arrangements involving DLT-based Payment Instruments that are consistent with FMI principles.

479. See, Commissioner Hester M. Peirce, An Incremental Step Along the Journey: The Division of Trading Markets' Frequently Asked Questions Relating to Crypto Asset Activities and Distributed Ledger Technologies (May 15, 2025), *available at* **https://www.sec.gov/newsroom/speeches-statements/peirce-tm-faq-051525**.

Legal/Regulatory framework—U.K. and E.U.

U.K.

As discussed in **Chapter 4**, E.U.-level legislation as retained in U.K. legislation can present legal challenges in the context of DLT-based systems, often due to a lack of clarity as to its application. Examples include certain requirements under UK CSDR and MiFID II, some of which has been addressed to an extent by the legislative proposals included in the Digital Securities Sandbox.

The Digital Securities Sandbox is expected to perform a constructive role in incentivizing market participants, regulators and legislators to actively engage with the barriers to widescale adoption.

One area in which the Digital Securities Sandbox could differentiate itself from, and improve upon, the E.U. Pilot Regime, is to provide a framework that enables the creation of a payment platform that tokenizes money and as such can provide settlement by facilitating the cash leg of a digital security transaction.

Broadly speaking, the Digital Securities Sandbox falls short in that it does not apply across the full legal framework, but is instead to a limited set of financial services legislation. In particular, it does not deal with the valid creation of native DLT-based Securities, which will remain a point of legal uncertainty unless there is legislation put in place to clarify or allow for this (as noted in **Chapter 4.2.2**, legislative frameworks contemplating this have only been implemented in certain jurisdictions). Market participants may be reluctant to take on the legal risk associated with engaging in the issuance and trading of DLT-based Securities without the appropriate legislation or regulators providing clarity that the issuance of DLT-based Securities is possible under legal frameworks in the relevant jurisdictions.

In addition, there is further work to be done to establish an effective framework for the issuance and implementation of DLT-based Payment Instruments in the settlement of DLT-based Securities, as discussed in **Chapter 4.1** and **5.2**. There are also many jurisdiction-specific issues relating to the issuance and trading of DLT-based Securities across the U.K.

There are further legislative and regulatory issues beyond financial services. As set out in **Chapter 2.2**, for example, clarity is required as to the application of applicable AML/KYC regulations in the context of DLT-based systems.

In each case, to encourage adoption of DLT-based systems in capital markets, legal and regulatory clarity is required as to whether: (i) such requirements can be satisfied using DLT-based systems; or (ii) parties utilizing DLT-based systems are exempt from complying with such requirements. This could be achieved via the publication of regulatory guidance, or the direct amendment of the relevant pieces of legislation. As mentioned in previous sections, for the purposes of issuing financial instruments under the USRs (as is common for equity securities and sovereign bonds in the U.K.), it should be clarified whether the requirement for a U.K. registrar can be satisfied when using a DLT-based system using a multi-jurisdictional spread of nodes.

As discussed in **Chapter 4**, permanent amendments of applicable legislation akin to those proposed under the Digital Securities Sandbox would arguably be a significant step forward in supporting the adoption of DLT and DLT-based Securities in capital markets. There will need to be further work undertaken to address the shortcomings under the Digital Securities Sandbox, as set out above, and in **Chapter 4.2.2**.

E.U.

As mentioned above with respect to the U.K., E.U.-level legislation (as implemented in E.U. member states) can present legal challenges in the context of DLT-based systems, often due to a lack of clarity as to its application. Examples include certain requirements under CSDR and MiFID II, some of which have been addressed to an extent by the legislative proposals included in the E.U. Pilot Regime.

The E.U. Pilot Regime is expected to perform a constructive role in incentivizing market participants, regulators and legislators to actively engage with the barriers to widescale adoption. However, as set out in **Chapter 4.2.2.3**, the E.U. Pilot Regime has a number of issues, including the imposed thresholds, lack of clarity on access, licensing requirements for participants and cross-border issuance difficulties.

In a joint paper published on 9 April 2025, the French *Autorité des marchés financiers* and the Italian *Commissione Nazionale per le Società e la Borsa* highlight the low number of players authorized under the E.U. Pilot Regime and suggest amendments to enhance the competitiveness of this regime.[480]

In a report "on the functioning and review of the DLT Pilot Regime published on 25 June 2025, the ESMA presents strategic recommendations to the European Commission about (i) how to make the E.U. Pilot Regime more attractive to the market, and (ii) suggested amendments to the E.U. Pilot Regime to make it permanent and allow for more flexibility in the regulatory thresholds or eligible assets depending on the risks of each business model.[481]

These issues should be considered by the relevant authorities when conducting interim and final reviews and ultimately addressed when developing a permanent legal and regulatory framework for DLT-based systems in capital markets.

Additionally, in a DLT ecosystem, market participants will require legal certainty relating to the transfer of DLT-based Securities, so that in each case they can be certain that the transaction has actually occurred. As discussed in **Chapter 4.2.2**, the E.U. Pilot Regime goes some way to address issues surrounding transfer, for example by disapplying relevant requirements under the CSDR. However, even under the E.U. Pilot Regime, there are certain other requirements that prevent adoption, for example they require existing authorized persons to adapt their business model and invest in the requisite technology to adopt DLT in circumstances where they may not want to. As such, adoption is arguably at the discretion of these incumbent authorized persons. Additionally, while the E.U. Pilot Regime is open to new entrants, the required authorizations to act as, for example, a CSD, create a barrier to entry for these entrants, both in terms of expense and time. Greater regulatory clarity regarding how the relevant FMI and other participants can obtain the requisite authorizations to operate DLT-based systems would support adoption.

As discussed in **Chapter 4**, permanent amendments of applicable legislation akin to those proposed under the E.U. Pilot Regime would arguably be a significant step forward in supporting the adoption of DLT and DLT-based Securities in capital markets. However, there will need to be further work undertaken to address the shortcomings under the E.U. Pilot Regime, as set out above, and in **Chapter 4.2.2**.

Legal/Regulatory framework – Hong Kong

The regulators in Hong Kong have adopted a “same activity, same risk, same regulatory outcome” principle (that is technology neutral) and are seeking to regulate virtual assets, digital tokens and related activities by introducing new legislation or issuing guidelines around the existing regulatory framework. While early guidance on whether different virtual assets might fall under the definition of “securities” under the SFO had provided clarity in the initial stage of developing the digital asset ecosystem in Hong Kong, the proliferation of and rapid changes in the landscape from new technologies to new products including the Tokenization of traditional securities necessitate more digital asset-specific laws and regulations, especially with regards to:

1. a legal framework that provides for recognition of documentary formalities and evidence of title consistent with DLT-based, electronic and/or smart contract solutions;

2. the adaptation of securities market transaction structures that are compatible with DLT, especially around areas of issuance, secondary trading and clearing mechanisms of various forms of securities;

3. clear statutory definitions of the rights, obligations and valid forms of ownership and transfer of various classes of regulated digital assets in light of the use of distributed ledger and smart contracts, including creating regional/market standards as applicable for DLT-native securities; and

4. replacement of the blanket restriction on distribution of certain types of digital asset-related investment products to retail investors with categorization of investors that is sensitive to market development and responsive to different investor risk characteristics in order to allow more retail access to digital assets.

   On top of recent initiatives to regulate the digital assets which do not strictly conform to the definition of “securities” (e.g. through imposing additional requirements applicable to regulated intermediaries engaging in virtual asset activities as discussed in **Chapter 4.2.3**), regulators should stay close to market developments and issue timely guidance to provide greater market clarity and confidence.

480. **https://www.amf-france.org/sites/institutionnel/files/private/2025-04/amf_consob_position-paper-towards-a-more-competitive-european-pilot-regime.pdf.**
481. **https://www.esma.europa.eu/sites/default/files/2025-06/ESMA75-117376770-460_Report_on_the_functioning_and_review_of_the_DLTR_-_Art.14.pdf.**

Legal/Regulatory framework – Japan

As mentioned in **Chapter 4.2.4** above, a regulatory framework for transactions in respect of DLT-based Securities has already been implemented in Japan. However, there are still open questions about more substantial matters, for example, when the transfer of title to DLT-based Securities is recognized and how to perfect the transfer of title to DLT-based Securities. If these outstanding questions are solved (ideally, resolved legislatively), it would be easier and more secure to conduct transactions for DLT-based Securities in Japan and Japan may be able to move towards a DLT-based ecosystem. Also, with the revision of the Japanese Payment Services Act in June 2025, it has become possible for the regulator to issue an order to prevent the outflow of assets overseas in order to guarantee the return of assets to domestic users in the event of the bankruptcy of stablecoin operators and cryptoasset operators.

Legal/Regulatory framework – Singapore

As previously mentioned in **Chapter 4.2.5** above, MAS plans to implement its stablecoin framework through legislative amendments, which will be open to public consultation. In the meantime, MAS has begun to accept stablecoin issuers' license applications who are expected to satisfy key requirements under the published framework.

MAS has also issued a consultation paper on a prudential framework for banks' exposures to digital assets.[482] Such framework is intended to provide banks with clarity on how to measure the risks of their digital asset exposures and maintain adequate capital to address these risks and reduce risks of spillovers into the traditional banking system. The proposed amendments are intended to take effect from 1 January 2026.

Legal/Regulatory framework – Conclusion

Generally, regulators and legislators should refer to industry preference for incremental development of regulation and/or legislation, so that innovation is allowed to flourish. There are specific considerations at national and international level that must be taken into account when considering the future framework for DLT-based Securities and DLT-based Payment Instruments. Specific consideration is also required as to the differences in legal and regulatory treatment when considering private or public DLT networks (with or without a permissioned environment).

482. MAS, Consultation Paper on the Prudential Treatment of Cryptoasset Exposures and Requirements for Additional Tier 1 and Tier 2 Capital Instruments for Banks, March 2025.

Chapter 5 | Reccommendations And Calls To Action

These recommendations have been developed with the common goal of establishing network effects, governed by clear legal, regulatory, and risk management frameworks that ensure safe and secure innovation. They are each accompanied by specific calls to action, intended as practical next steps to deliver on the benefits of innovation.

The current DLT-based ecosystem is primed for future growth. Primary and secondary markets are beginning to reach critical mass in select asset classes and product types. **At this transitional stage, all market stakeholders should come together and proactively shape the ecosystem across the core components as identified in this report.**

The following recommendations are designed to mobilize the full spectrum of market participants toward the successful scaling of a DLT ecosystem in capital markets. While public policy and regulatory clarity remain crucial enablers, this roadmap prioritizes clear industry commitments, actions that can be taken now, unilaterally or in collaboration with peers, to build momentum and unlock value.

Each recommendation begins with the industry's path forward, and identifies where public sector alignment can reduce friction, improve coordination, or enhance scalability. A foundational policy enabler for financial services activities serving clients globally will be timely determinations under local cross-border regimes, including principles-based comparability assessments of supervisory and regulatory regimes to support cross-border liquidity and growth.

RECOMMENDATION 1: ACCELERATE MARKET DEVELOPMENT IN HIGH-POTENTIAL ASSET CLASSES

Tokenization is most impactful where traditional frictions—cost, latency, or access barriers—are highest. These include private credit, structured bonds, real estate, and money market funds. Early market activity supports this: tokenized MMF AUM grew from ~$600M USD to over $5B in AUM in ~18 months. Yet secondary market activity remains shallow, and issuance often depends on bilateral placements. To scale, liquidity must be pooled, and infrastructure must be institutional-grade.

Call to Action | Prioritize tokenization efforts on asset classes such as those with high operational inefficiencies and market readiness and build scalable issuance and trading infrastructure.

Key Near-Term Industry Recommendations:

Form consortia to support common issuance, trading, and servicing platforms for tokenized assets—especially in real estate, structured credit, and short-duration bonds.
Embed fractionalization and programmability into token design where appropriate to broaden access and enable composability across platforms and portfolios.
Prioritize infrastructure development, particularly through the adoption of standardized models, to support the scaling of tokenization in use cases such as collateral and repo.
Collaborate with market makers and index providers to define benchmarks, pricing feeds, and risk parameters for tokenized versions of traditional assets.

Policy Enablers:

Enable tokenized funds, bonds, and credit products to operate under existing investment rules, including eligibility for regulatory portfolios, bank liquidity coverage, and solvency frameworks.
Expand the scope of public-sector digital issuances, including sovereign bonds and development finance instruments, to catalyze adoption and market infrastructure.
Facilitate the use of tokenized instruments as collateral in repo, margin, and central bank operations, subject to risk-based criteria.

RECOMMENDATION 2: CLARIFY LEGAL FOUNDATIONS AND ALIGN REGULATORY TREATMENT

Legal uncertainty is one of the most cited barriers to scaling tokenized capital markets. Many jurisdictions still lack statutory recognition of tokenized securities, enforceability of smart contracts, or clear legal frameworks for DLT-based settlement finality. This undermines market confidence and prevents global interoperability. For instance, even where tokenized bonds have been successfully issued, limitations on legal transfer or settlement finality have confined them to private placements or pilot regimes. Legal uncertainty also arises from the divergence between operational control (i.e. possession of private keys or rights to invoke smart contracts) and legal ownership. Without a common legal understanding, cross-border issuance and custody remain legally risky and operationally complex. Divergences in how permissioned and permissionless blockchains are treated, especially in prudential frameworks, further exacerbate regulatory fragmentation and arbitrage risk.

Call to Action | Establish clear and consistent legal and regulatory frameworks for tokenized financial instruments, focusing on asset classification, settlement finality, contract enforceability, consumer protection, and cross-border recognition.

Key Near-Term Industry Recommendations:

Conduct legal mapping exercises to benchmark how tokenized instruments are treated across major jurisdictions, identifying inconsistencies in settlement law, bankruptcy treatment, and enforceability.
Develop and promote adoption of standard legal documentation for tokenized bonds, funds, and structured instruments, covering smart contract terms, ownership, and disclosure.
Partner with legal institutions and industry groups to define baseline legal principles (e.g., digital bearer vs. registered form) that support industry-wide confidence in DLT-based issuance
Introduce market practices consistent with the baseline legal principles supporting DLT-based issuance to demonstrate their practical applications in real world use cases.
Develop financial literacy initiatives to equip market participants with the knowledge required to navigate tokenized financial markets responsibly.

Policy Enablers:

Publish guidance and interpretations, and grant targeted exemptions, to support the introduction of principles-based market practices supporting DLT-based issuance when permitted by the applicable regulatory framework in each jurisdiction
Amend national securities laws to explicitly recognize digital tokens as valid representations of financial instruments and to establish rules governing their issuance, transfer, and custody.
Clarify the application of settlement finality frameworks to DLT-based systems, including permissionless networks where risk controls and validator governance are robust.
Specifically for collateral use cases, ensure there is regulatory certainty regarding the use of tokenized and digital assets for uncleared margin and CCP margin, reducing any global disharmonization issues.

RECOMMENDATION 3: ESTABLISH INTEROPERABILITY TO PREVENT MARKET FRAGMENTATION

DLT platforms are proliferating, but most operate in isolation. Interoperability is not just a technical challenge—it is a strategic imperative. DLT networks must be enabled to seamlessly communicate between each other but also with legacy financial market infrastructures and regulatory systems. Without common standards for identity, smart contracts, and messaging, market liquidity remains fragmented, and infrastructure integration is prohibitively expensive. For example, tokenized settlement frequently requires reconciliation with multiple ledgers and custodians. Without shared protocols and compliance layers, the network benefits of tokenization will not materialize. The Common Domain Model is a shared canonical representation of trade data and event logic. Cross-chain solutions that do not share trade lifecycle semantics may entrench fragmentation at a deeper level than infrastructure alone.

Call to Action | Design and promote adoption of interoperability standards that enable DLT networks, traditional systems, and regulatory infrastructure to communicate securely and efficiently.

Key Near-Term Industry Recommendations:

Standardize smart contract (using the Common Domain Model as a standardized data model) interfaces and templates to support cross-platform execution and reduce custom development costs for each asset class.
Implement shared and non-proprietary data and messaging protocols (e.g., ISO 20022, ERC-3643, ERC-1400) for token creation, asset servicing, and event reporting. Further develop and adopt the Common Domain Model industry-wide to align contractual logic, data lineage, and state transitions across chains.
Build secure cross-chain bridges with governance and audit controls that enable token transfers and asset recognition across DLT ecosystems

Policy Enablers:

Mandate or endorse minimum interoperability standards, including the Common Domain Model, for tokenized financial instruments as part of regulatory licensing for market infrastructure providers
Coordinate with international standard-setters to align on cross-border data models, smart contract audit standards, and identity frameworks.
Incorporate interoperability testing as a standard feature to validate that new DLT systems can integrate with legacy FMIs and public infrastructures.

RECOMMENDATION 4: ADDRESS TECHNICAL AND OPERATIONAL INTEGRATION GAPS

DLT platforms often lack the controls and integrations needed to meet the operational standards of regulated institutions. Key concerns include wallet management, smart contract governance, auditability, and data reconciliation. Moreover, legacy systems struggle to interface with DLT-based infrastructure without costly middleware or duplicated processes.

Call to Action | Establish secure, modular frameworks for wallet custody, contract execution, and systems integration that meet regulatory and institutional-grade standards.

Key Near-Term Industry Recommendations:

Define minimum standards for key management and custody, including support for multi-party computation (MPC), multi-signature protocols, and private key recovery.
Adopt formal verification and third-party audit frameworks for smart contract deployment, including fallback mechanisms and kill switches.
Develop modular APIs and reconciliation tools to synchronize tokenized asset records with enterprise systems (e.g., general ledger, risk engine, reporting tools).
Build systems and operational models leveraging the Common Domain Model.

Policy Enablers:

Publish Good Practices for DLT operational resilience, including wallet security, system integrity, and oversight of smart contract execution.
Address how DLT-specific risks can be addressed by existing cyber risk, outsourcing, and operational risk guidelines.
Support pilots that allow financial institutions to validate DLT integrations before production deployment.

RECOMMENDATION 5: ENABLE SCALABLE SETTLEMENT WITH TOKENIZED MONEY AND STABLE PAYMENT INSTRUMENTS

DLT-based Securities cannot achieve full efficiency without DLT-native Payment Instruments. Today, most tokenized transactions are settled via off-chain systems, reintroducing manual processes and counterparty risk. Regulated tokenized deposits and stablecoins offer programmable, precision settlement, enabling potential for instant Delivery versus Payment (DvP). Despite this momentum, tokenized deposit and stablecoin use remains constrained by cross-border legal ambiguity driving infrastructure fragmentation.

Call to Action | Support adoption of tokenized Payment Instruments for wholesale settlement and ensure their integration with securities platforms and traditional payment infrastructure.

Key Near-Term Industry Recommendations:

Integrate tokenized cash instruments such as tokenized deposits and stablecoins into settlement workflows for repo, corporate bonds, and MMFs to enable atomic DvP.
Design programmable settlement logic (e.g., conditional release, escrow, T+0) using smart contracts tied to regulated stablecoins or tokenized deposits, leveraging the Common Domain Model work already underway to develop a unified model for representing tokenized securities and cash instruments for both the legal foundation and functionality of the smart contract and the asset attributes.
Collaborate on interoperable frameworks linking DLT-based settlement systems with traditional RTGS platforms and cross-border networks.

Policy Enablers:

Provide legal certainty and licensing frameworks for fiat-backed tokenized deposits and fiat-backed stablecoins, including requirements for redemption, reserves, and supervision.
Facilitate interoperability with central bank settlement systems, including through omnibus accounts or wholesale central bank money. Encourage central bank settlement systems to use the Common Domain Model.
Incorporate tokenized Payment Instruments into financial stability frameworks, recognizing them as legitimate payment rails subject to appropriate controls.

RECOMMENDATION 6: FOSTER PUBLIC-PRIVATE COORDINATION

Siloed development of tokenization platforms is repeating legacy fragmentation. Without coordinated approaches to infrastructure – across custody, identity, and compliance – scalability and trust will be limited. Public-private coordination has already proven effective: tokenized green bonds, central bank pilots, and stablecoin networks have benefited from early policy engagement. But broader alignment is needed to avoid duplicative systems, ensure regulatory compliance, and accelerate network effects. The next phase must prioritize shared development and joint progress.

Call to Action | Coordinate across public and private sectors to design interoperable frameworks, define technical and legal standards, and build a foundation for globally interoperable tokenized markets.

Key Near-Term Industry Recommendations:

Contribute to shared infrastructure, where necessary, layers for compliance, identity, custody, and settlement that are vendor-neutral and open to promote the development of interoperable markets.
Adopt governance models that balance competition and collaboration, such as consortium-led issuance hubs, regulated networks, and shared utilities.
Support early public-private pilots, with transparent objectives, performance metrics, and scalability plans.

Policy Enablers:

Lead cross-jurisdictional efforts to facilitate timely determinations under recognition regimes, including for settlement finality, custody, and asset classification.
Fund or facilitate critical infrastructure components needed to meet regulatory objectives, such as transaction reporting and compliance registries.
Create public-private advisory forums – beyond pilot regimes—to facilitate dialogue and further support the development of tokenized market infrastructure, drawing lessons from global regulatory colleges and FMI oversight forums.

Deep Dives | Assessing Select Examples of Scaled Adoption

Capital markets use case activity reflects key trends across asset class, geography, and capability type across three specific areas: (1) Collateral Management, (2) Fixed Income Issuance; and (3) Tokenization of Funds. These use cases showcase real-world decisions that financial institutions have made around technology, risk, and governance. It also provides practical evidence of benefits enabled by DLT.[483]

EMERGING DLT-BASED CAPITAL MARKETS USE CASE OVERVIEW

The deployment of DLT in capital markets is entering a new phase. Since the last publication of this report, activity has shifted from limited-scale experimentation to live production. Major institutions are now transacting on tokenized platforms, embedding DLT into funding, settlement, and asset servicing workflows. This momentum reflects not only technological readiness but also growing alignment among infrastructure providers, regulatory pilots, and investor demand.

As highlighted in *Approaching the Tokenization Tipping Point* (Ripple and Boston Consulting Group, April 2025), institutional tokenization volumes are accelerating, particularly in fixed income, money markets, and real-world assets. This progress is supported by enhanced infrastructure and clearer regulatory frameworks in jurisdictions such as the European Union, United Kingdom, and Singapore. These developments indicate that tokenization is no longer a peripheral innovation track. It is increasingly viewed as a core strategy for modernizing capital markets.

At the same time, joint trades and members remain pragmatic. Discussions across jurisdictions reveal both optimism and caution. Institutions widely recognize the long-term value of tokenization, but adoption is still shaped by near-term challenges. These include regulatory divergence, limited interoperability, inconsistent definitions, and operational complexity. Many market participants emphasize that legal certainty and supervisory alignment are just as critical as technical innovation.

- Adoption is concentrated in asset classes with the clearest incentives. These include intraday liquidity, repo financing, and digitally native bonds.
- Market structure remains fragmented. Many platforms are isolated or proprietary and lack integration with wider capital markets infrastructure.
- Product development is outpacing regulatory standardization. This is especially true for fund structures and fixed income instruments, where there is demand for clearer guidance on classification, usage, and risk treatment.
- Use case viability increasingly depends on jurisdiction-specific legal form, infrastructure maturity, and the credibility of the settlement mechanism.

483.GFMA, “Why Basel Should Not Apply A Blanket Infrastructure Risk Add-On For Group 1 Cryptoassets”, 2022.

Three categories where adoption is most advanced:

Repo and Collateral: DLT is helping institutions modernize how they manage collateral and liquidity. Real-time settlement, reduced processing friction, and better visibility into asset mobility are allowing firms to unlock trapped capital and reduce operational risk in repo and derivatives markets. Post-settlement of collateral processing, such as corporate actions, coupons, and dividends, as mentioned above, can all be streamlined with DLT. And, with improved post-settlement collateral processing, current operational challenges to the market would be mitigated, allowing more types of collateral to be used and further reducing cost of funding and decreased investment performance to end users.

Fixed Income Issuance: Tokenized bond issuance is showing measurable gains in cost efficiency, speed, and transparency. Issuers are testing how legal instruments can be combined with programmable infrastructure for improved servicing and investor access.

Tokenization of Funds: Digital fund structures, including tokenized money market funds, are enabling near-instant settlement, improved redemption and collateral management processing, and lower distribution costs. These developments also raise important questions around fund classification, regulatory treatment, and eligibility for collateral use.

Each use case is evaluated using a consistent framework:

Overview of Use Case: A detailed description of the operational and strategic considerations for a use case is paramount to aiding industry and regulatory understanding. In the following chapter we will describe how each use case works in as much detail as required to provide a true operational understanding of how these use cases work.

Credibility of the Settlement Asset Used: The nature of the settlement asset is a foundational consideration. Whether the transaction uses tokenized deposits, fiat-backed stablecoins, or wholesale tokenized central bank money, this choice influences risk exposure, legal enforceability, and compliance requirements. Settlement mechanisms that are issued by regulated financial institutions and tied to fiat currency have emerged as preferred models, though approaches vary across regions and platforms.

Interoperability across Networks: The ability to connect across DLT systems and integrate with traditional capital market infrastructure is essential for achieving scale and liquidity. Platforms that operate in isolation may deliver localized efficiencies, but they are often unable to support market-wide adoption. Interoperability solutions, including bridges, custodial models, and shared messaging standards, are critical for expanding utility and reducing fragmentation.

Distinguishes between two primary layers of DLT deployment

Infrastructure-Layer Use Cases: These focus on the foundational elements of DLT systems. They include network design, consensus protocols, data privacy architecture, and integration with existing financial infrastructure. Institutions in this category are often developing new distributed ledgers or adapting core systems for regulated use.

Key examples include:

- **Canton Network:** A privacy-preserving blockchain network built for financial institutions, with support from Goldman Sachs, Microsoft, and Deloitte. It connects participants through a common infrastructure while allowing transaction privacy and regulatory compliance.
- **Hyperledger Fabric:** A modular, enterprise-grade DLT framework developed by the Linux Foundation. It enables permissioned environments and is widely used for building scalable enterprise blockchain applications.
- **Euroclear's D-FMI:** Euroclear's Digital Financial Market Infrastructure supports issuance and settlement of digital-native securities and has been used in partnership with the World Bank.

Application-Layer Use Cases: These are built on top of existing DLT networks and focus on user-facing functionalities, such as asset issuance, investor onboarding, compliance automation, and lifecycle servicing. Application-layer innovations tend to abstract the underlying technology and instead emphasize product structuring, legal compliance, and user experience.

Key examples include:

- **Securitize:** A platform that allows compliant issuance and management of digital securities, including tokenized equity and fund shares. It supports both primary and secondary transactions.
- **HQLAX:** A solution that enables high-quality liquid asset ("HQLA") transfers via a digital collateral registry. It improves settlement timing and collateral reuse without moving the underlying assets.
- **Paxos Settlement Service:** A DLT-based platform for settling U.S. equities. It allows for same-day settlement and is integrated with traditional broker-dealer infrastructure.

Many institutional platforms span both layers. For example, a tokenized bond may rely on infrastructure-level decisions for settlement, while simultaneously embedding features such as automated income distribution, investor whitelisting, or smart contract governance. Understanding the layered structure of DLT deployment is essential for assessing technical viability, legal compatibility, and market fit. The sections that follow will apply this framework to the three primary categories of use cases. Each example offers insight into what is working today, what remains unresolved, and where further coordination between industry and regulators will be necessary to scale adoption.

DEEP DIVE #1: COLLATERAL MANAGEMENT

Collateral management, and repurchase agreements (repos), and are both **fundamental mechanisms in capital markets**. Collateral management refers to the processes that ensure exposures under various financial transactions (repos, derivatives, securities loans, etc.) are **secured with assets**, thereby mitigating counterparty credit. Repos allow financial institutions to **finance holdings or raise short-term liquidity by borrowing against high-quality securities**, while enabling cash investors to earn secured returns.[484] In essence, a repo is a sale of securities coupled with an agreement to repurchase them later (often the next day) at a set price – **effectively a collateralized loan**.[485] Together, robust collateral and repo functions support **market liquidity and stability** – for example, repos provide market-makers with the cash and securities needed to buffer imbalances in trading, helping keep bond markets liquid and reducing financing costs for issuers while collateral management mitigates counterparty risk.[486]

Role, Objectives, and Key Stakeholders

Strategic Objective: The core goal of repo and collateral management is to efficiently allocate liquidity within the financial system while controlling risks. Repos enable institutions to manage short-term funding securely, supporting critical market functions such as dealer inventory financing, leveraged investing, and safe cash investment by asset managers.[487] Institutions can extend their counterparty exposure further with the guardrails of prudent collateral management.

Operational Objective: Repos allow firms to optimize liquidity with operational ease, and collateral management ensures the timely delivery of appropriate assets to meet obligations, such as repo transactions or derivatives margins.

Key Stakeholders: The repo and collateral ecosystem includes sell-side banks and dealers who intermediate funding, buy-side participants (asset managers, pension funds, hedge funds, insurers), market infrastructure providers (triparty agents, custodians, CCPs), central banks utilizing repo operations, technology providers, and regulators overseeing systemic stability. Improvements in repo and collateral management practices thus have broad implications for capital market efficiency and stability.[488]

Market Scale and Activity in 2024: Repos and collateralized financing markets operate at **enormous scale globally**, underpinning trillions of dollars in daily transactions. In 2024, repo activity continued to expand, reflecting high demand for secured financing. **Global repo outstanding volumes are to the order of tens of trillions: for example, in Europe the repo market reached a record €11.1 trillion in outstanding contracts as of June 2024** (measured by a semi-annual survey covering 61 institutions).[489] This European figure – up about 7% year-on-year – marks the *minimum* size, since it does not capture all firms.[490] In the United States, repos are likewise a critical funding channel. As of mid-2024, total repo borrowing stood at about **$6.2 trillion outstanding**, of which roughly $5.1 trillion was private-sector (the remainder being Federal Reserve reverse repo balances).[491] The U.S. repo market has grown significantly in recent years – primary dealers' repo volumes rose from around $5 trillion a few years ago to over **$7 trillion by 2024**, according to industry estimates.[492]

Such figures underscore that repo markets are **comparable in size to or even larger than underlying cash markets**. For perspective, in Canada the annual repo trading volume of government bonds was nearly 3 times the volume of cash bond trading.[493] Major electronic trading platforms have reported surging repo volumes as well. For instance, Tradeweb (a global trading venue) saw **average daily repo trading of $623 billion in 2024**, a jump of almost 30% from the prior year.[494] By December 2024, daily volumes on that platform were exceeding $680 billion, reflecting a year-end surge in activity.[495] This growth has been driven by factors such as central banks unwinding asset purchases (thus increasing the supply of securities available for repo) and a shift of cash out of central bank facilities back into private markets.[496]

484. Philippe Muller, Maksym Padalko, "The New Repo Tri-Party Canadian Collateral Management Service: Benefits to the Financial System and to the Bank of Canada", February 2025.
485. Financial Stability Oversight Council Annual Report 2024, Accessed 2025.
486. Securities Industry and Financial Markets Association, 2025.
487. Philippe Muller, Maksym Padalko, "The New Repo Tri-Party Canadian Collateral Management Service: Benefits to the Financial System and to the Bank of Canada", February 2025.
488. Financial Stability Oversight Council Annual Report 2024, Accessed 2025.
489. "47th ICMA ERCC European Repo Market Survey", November 2024.
490. Ibid.
491. Financial Stability Oversight Council Annual Report 2024, Accessed 2025.
492. Josh Galper, "Collateral Market Tops €25 trillion, expanding the argument for DLT solutions", August 2024.
493. Philippe Muller, Maksym Padalko, "The New Repo Tri-Party Canadian Collateral Management Service: Benefits to the Financial System and to the Bank of Canada", February 2025.
494. Daniel Tison, "Tradeweb Reports 29.8% YoY Rise in Repo ADV for 2024", January 2025.
495. Ibid.
496. Ibid.

In addition, the collateral impact of the industry is extreme, with the total value of global outstanding collateral exceeding $25.5 trillion EYR in Q1 2024.[497] This includes repo, which is the majority at 82%, securities lending at 10%, OTC derivatives at 5%, and 3% with CCPs.

Just in derivatives, ISDA reports that leading derivatives market participants subject to the margin rules collected $1.5 trillion in IM and VM at year-end 2024, up by 6.4% versus the previous year.[498] This included $431.2 billion of IM and $1.0 trillion of VM. In addition, the survey finds that $389.8 billion of required IM was posted by all market participants to major CCPs for their cleared IRD and CDS transactions at the end of 2024.

Inefficiencies and Pain Points in the Current Model

Despite its critical role, the traditional repo and collateral management model suffers from **several inefficiencies and pain points** that market participants increasingly view as targets for transformation. Many of these issues stem from the operational complexity of moving collateral through a web of different systems, intermediaries, and jurisdictions.

Several **specific pain points** arise from this legacy model:

- **Latency in Settlement:** Traditional repo settlements (often T+0 or T+1) frequently rely on batch processes and intraday cut-offs, creating delays. This restricts firms from swiftly reusing collateral or addressing margin calls, forcing them to maintain excess liquidity buffers. Cross-border time zone constraints also impact the efficient mobility of collateral in the global market, requiring pre-funding that is costly and operationally intensive.[499]
- **Operational Fragmentation and Reconciliation:** Repo and collateral transfers involve multiple ledgers (buyers, sellers, custodians, triparty agents), leading to daily reconciliation challenges. Manual processes, common at many institutions, increase operational risk and cost due to frequent discrepancies and errors.
- **Counterparty Risk and "Give-Up" Exposure:** The current repo system often involves "give before you get" practices, creating brief periods of over-collateralized credit exposure, which impacts cost of funding. Timing mismatches in collateral substitutions and fragmented settlement platforms compound these risks, despite mitigants such as haircuts and credit lines.[500]
- **Liquidity Fragmentation:** Collateral held across different custodians leads to fragmented liquidity pools, complicating asset mobilization. Firms may struggle to efficiently allocate collateral, causing unnecessary borrowing and liquidity traps where assets become effectively immobilized. Also, firms that do not have holistic collateral management practices or suffer from multiple systems to source collateral internally could benefit from interoperability with both external and internal partners. In times of market volatility, the liquidity fragmentation, even if only fueled by data inconsistencies, can further increase the cost of funding and need to over-collateralize, and in turn, increasing counterparty risk.
- **Regulatory and Reporting Burdens:** Complex post-crisis regulations (e.g., Securities Financing Transactions Regulation ("SFTR")) require detailed repo transaction reporting. Aggregating data from legacy systems is burdensome and costly, reducing regulators' transparency. Regulatory constraints such as balance-sheet impacts and eligible collateral limitations further restrict efficient collateral management.
- **Operational Costs:** Fragmentation, manual interventions, redundant reconciliation, and outdated systems significantly raise direct and indirect operational costs. These inefficiencies increasingly appear unsustainable compared to faster, simpler settlement practices emerging in other capital market areas.

Given these pain points, it is no surprise that both industry and regulators have been exploring improvements. **Targets for transformation** include achieving real or near-real-time settlement of repo trades, **automating collateral allocation and substitutions**, creating unified views of collateral across silos, and reducing the need for duplicative reconciliation. In recent years, attention has turned to new technologies – in particular, **DLT and tokenization** – as potential enablers of these improvements.

497. Refer to the Collateral Management use case in Deep Dives. Collateral market tops €25 trillion, expanding the argument for DLT solutions – Finadium.
498. ISDA 2024 Margin Survey: **https://www.isda.org/a/EyfgE/ISDA-Margin-Survey-Year-end-2024.pdf**.
499. "Transforming Collateral Management with DLT", September 2024.
500. Ibid.

Applying DLT and Tokenization: Use Cases and Benefits

DLT offers a novel approach to addressing many of the inefficiencies outlined above. In essence, DLT can serve as a **single**, **shared source of truth** for transaction records and asset ownership, accessible simultaneously by multiple parties. Tokenization is the process of representing traditional assets (such as securities or cash balances) as **digital tokens on such a ledger**, enabling them to be transferred with cryptographic security and near-instant finality. In the context of repo and collateral management, DLT and tokenization have moved from theory to practice through a number of **live use cases and pilot projects**, which demonstrate tangible benefits:

- **Near Instant Settlement:** DLT significantly accelerates repo settlements from traditional batch processes (T+0 or T+1) to near real-time completion within minutes or seconds. For instance, J.P. Morgan's DLT-based platform has already processed billions in trades, enabling same-day or intraday repo settlements and enhancing liquidity management.[501]
- **Delivery-vs-Payment and Atomic Exchange:** DLT enables simultaneous ("atomic") swaps of cash and securities or collateral-to-collateral exchanges, eliminating intraday "give before get" risks.[502] Platforms such as HQLA allow instant transfers of asset ownership without physically moving securities, greatly reducing operational steps, settlement fails, and intraday exposures.[503]
- **24/7 Availability and Flexibility:** Unlike traditional systems limited to business days and set hours, DLT networks operate continuously, enabling collateral transfers at any time. This allows real-time margin calls and corporate actions, improving liquidity management and reducing idle collateral buffers.
- **Improved Transparency and Tracking:** A shared distributed ledger offers participants and regulators near-real-time visibility of transactions and collateral positions, simplifying compliance and reporting. Programmable tokens with embedded eligibility criteria further enhance transparency, reducing operational risks related to collateral allocation.
- **Operational Efficiency and Automation:** Smart contracts driven by industry-wide data standards like the CDM automate key repo and collateral management tasks such as maturity execution, interest calculation, and margin calls, significantly reducing manual errors and reconciliation efforts. DLT's shared ledger eliminates redundant reconciliation steps by providing a unified, trusted data source for all parties. Golden records can contain pertinent information, such as transfer agent, custodian, pledgor, and receiver for money market funds, expanding the use of the eligible collateral type beyond a cash sweep vehicle.
- **Collateral Mobilization and Optimization:** Tokenization enables previously illiquid assets (e.g., money market fund shares) to be instantly mobilized as collateral. Platforms facilitating tokenized collateral networks allow firms to swiftly redeploy idle collateral across asset classes, enhancing overall market liquidity and reducing unnecessary asset buffers.[504] The CDM can also provide benefits to eligible collateral representation in a standardized digital format, thus reducing collateral-related disputes and streamlining cross-product operational processing with decreased data-related friction.

These examples underscore that DLT and tokenization are no longer just theoretical in capital markets – they are being **applied in live environments by major institutions**. Broadridge Financial Solutions, a global FinTech firm, has launched a DLR platform that is now used by a network of banks and buy-side firms. By late 2024, Broadridge reported its DLR platform was facilitating about **$1 trillion in average monthly volume** of repo transactions[505], indicating growing acceptance. Market infrastructure entities such as **Deutsche Börse and Eurex** have invested in digital collateral initiatives (e.g. the HQLA platform is a partnership involving Deutsche Börse), and central securities depositories such as **Euroclear** have trialed tokenized collateral mobility solutions.[506] These initiatives have shown quantifiable benefits such as **reduced settlement times (from hours to seconds), lower operational loss incidents**, and **more effective balance sheet usage** for participants. Crucially, these improvements have been achieved *without* compromising the core risk management objectives of repo and collateral management – if anything, features such as atomic settlement and better transparency **enhance risk control**.

501. Tom Phillips, Paul Pirie, "Collateral Management Guide 2023: The evolution of DLT", October 2022.
502. Ibid.
503. "Transforming Collateral Management with DLT", September 2024.
504. Tom Phillips, Paul Pirie, "Collateral Management Guide 2023: The evolution of DLT", October 2022.
505. "Broadridge Announces First High-Quality Liquidity Asset Use Case for its Distributed ledger Repo Platform", September 2024.
506. Ledger Insights, "Euroclear Launches Tokenized Collateral Initiative with Digital Asset", February 2025.

Challenges and Considerations for DLT Adoption

While the potential benefits of DLT in repo and collateral management are compelling, it is equally important to acknowledge the **challenges and limitations** that have emerged. Transforming such a large, systemically important market does not happen overnight, and there are significant **practical and regulatory hurdles** to broad adoption of distributed ledgers in this context:

- **Regulatory and Legal Uncertainty:** Existing legal frameworks were not designed for tokenized assets, creating uncertainty around legal finality and enforceability across jurisdictions. Institutions currently use parallel traditional processes or third-party custodians to mitigate risks. Regulatory clarity is evolving (e.g., the E.U. Pilot Regime, the UK's Digital Securities Sandbox (DSS) and U.S. commercial code amendments), but until frameworks mature, legal ambiguity remains a significant barrier. Regulatory updates regarding eligible collateral with CCPs and per ncleared margin rules for derivatives need to be updated on a global view. Also, eligible collateral disharmonization (money market funds in the US vs. EU) needs to be resolved for widespread use of tokenized MMFs.[507]

- **Interoperability with Legacy Systems:** Integrating new DLT platforms with legacy systems (trading, risk, custody) poses significant complexity. Achieving real-time synchronization and developing standards for interoperability are ongoing challenges. Industry efforts, such as linking DLT platforms to payment systems (e.g., Broadridge with Fnality), show promise, but without broad interoperability, new liquidity silos could emerge.[508]

- **Scalability and Performance:** DLT systems have shown promising early results in handling repo market volumes but haven't been fully stress-tested at global scale. High transaction volumes and low-latency requirements remain a key concern. Permissioned networks, using faster consensus mechanisms, address some issues, but market participants and regulators still need clear evidence of robustness under extreme market conditions.[509]

- **Adoption and Network Effects:** DLT's benefits depend on broad adoption, creating a coordination challenge as firms hesitate to join without existing wide participation. Initial DLT solutions have been limited or closed-loop, while broader adoption requires overcoming inertia, transitional costs, and clarifying governance. Hybrid models, with traditional and DLT-based processes coexisting, are likely until the industry fully transitions.

- **Cybersecurity and Operational Risks:** DLT introduces new cyber and operational risks, such as vulnerabilities in smart contracts and complexities in key management. Safeguarding digital tokens requires specialized custodial services and robust operational protocols. Ensuring network resilience and continuity demands new expertise and thorough testing, creating additional operational risk management considerations.

- **Lack of Adoption of Industry-Wide Data Standards:** The industry must contribute to the development of and adopt the Common Domain Model to ensure that data is universally interoperable and improvements in one area of the repo and collateral management process are not diminished because of transmission and data mapping challenges. Data standards spanning legacy and new DLT platforms will be critical in the short-term, especially with digitized documents (pre-smart contracts) and eligible collateral representation. Adopting the CDM, which has been built by ICMA, ISLA, and ISDA and is governed under FINOS, the Common Domain Model should be more widely adopted either via translation mapping with proprietary data models or used natively.

In summary, the application of DLT and tokenization to repo and collateral management is a promising development, with real gains demonstrated in live projects such as faster settlement, reduced risk, and efficiency improvements. These benefits align closely with the strategic goals of the repo market – namely, to lower friction in moving liquidity and collateral while safeguarding the system. However, the transition must be managed carefully. Regulators are supportive but cautious, ensuring that resilience and integrity are maintained. Industry stakeholders must collaborate to address interoperability and agree on standards. It is likely that, in the coming years, we will continue to see a *hybrid approach*: incremental adoption of DLT for specific use cases (such as intraday repos, cross-custodian collateral swaps, or central bank digital collateral trials) alongside the traditional architecture. As challenges are ironed out – with clear regulatory frameworks, proven scalability, and demonstrated interoperability – DLT could gradually become an integral part of the plumbing of global repo markets. The introduction of these technologies in such a foundational domain of finance is being handled with appropriate caution, but the direction is set real-world use cases to date have shown that a more efficient, tokenized repo and collateral ecosystem is achievable, bringing the prospect of a faster, safer, and more transparent market for all participants.[510,511]

507. "How Can Collateral Management Benefit from DLT?", January 2020.
508. Clelia Frondaroli, "Broadridge Partners with Fnality", April 2025.
509. "How Can Collateral Management Benefit from DLT?", January 2020.
510. Josh Galper, "Collateral Market Tops €25 trillion, expanding the argument for DLT solutions", August 2024.
511. Tom Phillips, Paul Pirie, "Collateral Management Guide 2023: The evolution of DLT", October 2022.

Collateral Use Case #1: J.P. Morgan Kinexys Digital Financing for Intraday Repo

EXHIBIT DD.1

Case study: JP Morgan Kinexys Intra-day Repos – Fully on-chain collateral and cash exchange for repo transactions

Overview

- Web-based application provides access to secured financing, enabling financial institutions and corporations to settle repo transactions within minutes
- Uses J. P. Morgan's private, permissioned blockchain

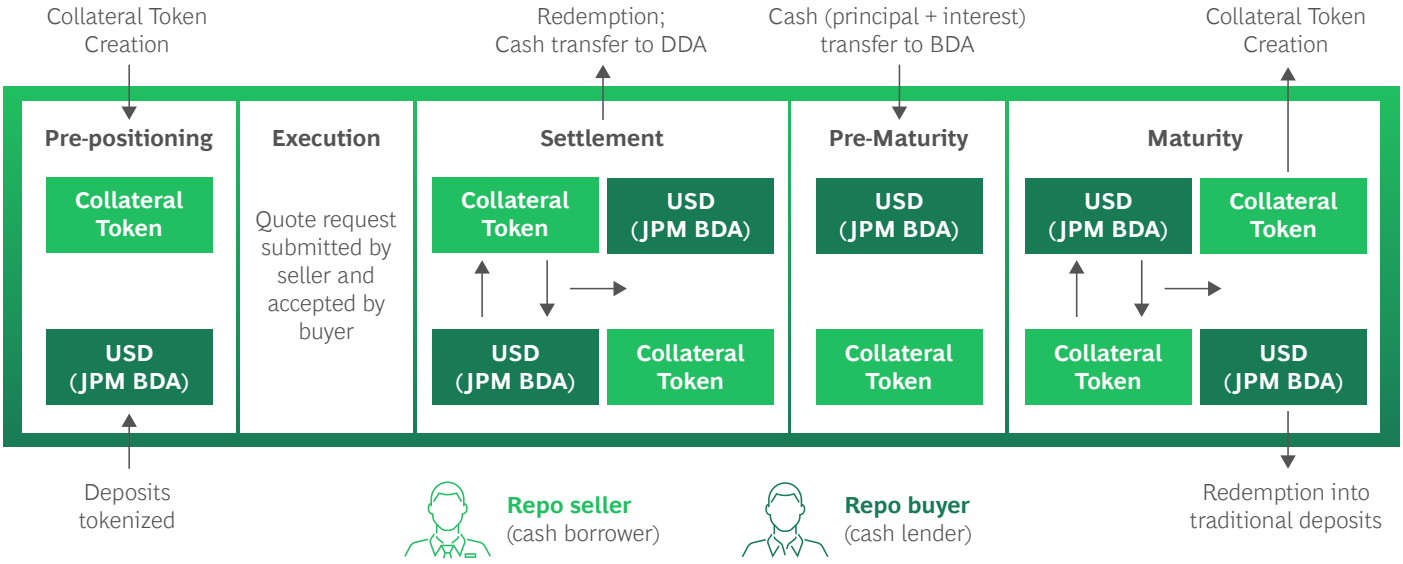
Key benefits

- Increased precision of settlement and maturity times (intra-day vs overnight)
- Settlement efficiency
- Improved counterparty credit risk

Market traction

- Increased precision of settlement and maturity times (intra-day vs overnight)
- Settlement efficiency
- Improved counterparty credit risk

How it works



Source: JP Morgan and BCG, "The Future of Distributed Ledger Technology in Capital Markets"; GFMA member inputs; BCG analysis.

Overview of Use Case

Digital Financing on Kinexys is J.P. Morgan's distributed-ledger solution for intraday repurchase agreements (repos) – short-term, secured financing transactions completed within the same day. Launched in 2020 (rebranded as **Kinexys Digital Assets** by 2024), this platform enables borrowers and lenders to **exchange cash for tokenized collateral** and settle repo trades in minutes or hours rather than the traditional overnight or multi-day cycle.[512,513] The key innovation is **programmable, on-chain settlement** of both legs of the repo: the cash lender's funds (the balances of which are recorded on the blockchain) and the borrower's collateral (in the form of a digital token representing a security entitlement) are delivered near-simultaneously on the ledger at a pre-agreed time, specific to the minute. Recording the trade agreement in a smart contract and settling on a programmable ledger reduces the operational stresses of uncertain asset movements.[514] This allows a bank

512. Ledger Insights, "JP Morgan using blockchain for repos, but it's not the first", December 2020.
513. Businesswire, "J.P. Morgan Executes Intraday Repo Transaction Using Blockchain", December 2020.
514. Ibid.

needing short-term liquidity to **borrow cash intraday** by temporarily selling high-quality securities, and automatically repurchase them a few hours later – a process difficult to arrange in legacy systems but now streamlined via blockchain.[515] This results in a new, low-cost liquidity tool for treasury departments to add to their tool kit.

Workflow and Participants: In a typical Digital Financing transaction, a **cash provider** (repo buyer) and a **collateral provider (repo seller)** transfer assets using the blockchain ecosystem. The borrower's collateral is tokenized on the platform by being transferred to an account in the name of the collateral token agent as a securities intermediary for the benefit of applicable Digital Financing participants at a traditional triparty agent. Once the collateral and its value are confirmed as being held at such an account, a collateral balance is minted on-chain. The lender's cash is provided in the form of cash held in a **J.P. Morgan blockchain deposit account**. Next, both parties agree on the terms (collateral type, amount, interest, and an intraday maturity time. At the agreed start time, a smart contract or programmed instruction settles the first leg of the repo – the lender receives the collateral, and the borrower receives the cash balances – **settling the repo within minutes**.[516] Because this is done on a shared ledger, both parties have an immediate, synchronized record of the exchange. The repo then unwinds at the pre-set maturity (often just a few hours later): the contract automatically returns the collateral to the original owner and the cash (with interest calculated to-the-minute) back to the lender.[517,518] For example, in January 2025 Santander executed two **programmable intraday repos** on Kinexys – one for $50 million and one for €50 million – each scheduled to execute and then **redeem 3 hours later**, demonstrating how such repos can be timed and automated precisely.[519] These transactions involved Santander as the repo seller (posting collateral) and J.P. Morgan as the buyer, and notably included a euro-denominated repo – the **first intraday euro repo** done by a non-J.P. Morgan entity on the platform.[520]

Platform Operations and Technology: The intraday repo application runs on a **permissioned DLT network** developed by J.P. Morgan (called Kinexys Digital Assets). It is built on an **enterprise Ethereum-based ledger**, adapted for privacy and performance.[521] All participants are permissioned financial institutions (initially mostly J.P. Morgan and its clients). J.P. Morgan acts as the network operator and provider of the **blockchain deposit accounts** used for settlement. Crucially, the platform integrates with traditional market infrastructure for custody and record-keeping. For instance, in early pilot trades J.P. Morgan enlisted **BNY as the triparty collateral agent**, meaning BNY held the underlying securities and ensured that on-chain token transfers corresponded to legal changes in collateral ownership.[522] This approach mirrors a traditional tri-party repo arrangement, but with the **repo, settlement and return all handled by self-executing code** on the shared ledger. The use of a single, shared source of truth for cash and collateral eliminates settlement mismatches and delays – in the words of J.P. Morgan's developers, it "supports unique functionality like atomic trade settlement" to **unlock trapped intraday liquidity** and reduce operational frictions.[523]

Participants access the platform through secure nodes or interfaces provided by J.P. Morgan, and they remain subject to full KYC/whitelist requirements.

Adoption, Volume, and Milestones: J.P. Morgan first **deployed the intraday repo platform in late 2020**, conducting an initial live trade between its broker-dealer and banking arm using blockchain deposit accounts for the cash leg.[524] After proving out the concept internally, the bank opened the platform to select external counterparties in early 2021. Several milestones illustrate the platform's growth since then:

- *2020 (Launch):* **Kinexys Digital Assets** intraday repo goes live in pilot. First trades between J.P. Morgan affiliates settle in **hours instead of days**, using **blockchain deposit accounts** to achieve instantaneous DvP.[525,526] Simulations are run with Goldman Sachs and others, with BNY participating as triparty agent.
- *Mid-2021:* Rollout to a limited number of U.S. market participants begins. J.P. Morgan's platform is one of the first live DLT repo applications, although initial usage is cautious and often involves J.P. Morgan on one side of the trade as principal.
- *May 2022:* **BNP Paribas** becomes the **first European bank** to execute an intraday repo on the platform, joining as a participant on Kinexys Digital Assets.[527] By this point, the intraday repo application had processed over **$300 billion** in cumulative repo transactions since launch.[528]

515. ICMA, "Tracker of New FinTech Applications in Bond Markets", Accessed 2025.
516. Businesswire, "J.P. Morgan Executes Intraday Repo Transaction Using Blockchain", December 2020.
517. ICMA, "Tracker of New FinTech Applications in Bond Markets", Accessed 2025.
518. Finadium, "Santander executes intraday repo on J.P. Morgan's Kinexys", January 2025.
519. Ibid.
520. Ibid.
521. ICMA, "Tracker of New FinTech Applications in Bond Markets", Accessed 2025.
522. Businesswire, "J.P. Morgan Executes Intraday Repo Transaction Using Blockchain", December 2020.
523. Ibid.
524. Ibid.
525. Ibid.
526. Ledger Insights, "JP Morgan using blockchain for repos, but it's not the first", December 2020.
527. ICMA, "Tracker of New FinTech Applications in Bond Markets", Accessed 2025.
528. Ibid.

- *Late 2022 – 2023:* J.P. Morgan expands the range of collateral and integration with other tokenization initiatives. It launches a **Tokenized Collateral Network** (with BlackRock and Barclays as participants) to extend the platform's use to tokenized money market fund shares and other assets for collateral purposes.[529] The Kinexys platform also begins handling **multi-currency** transactions; a euro-denominated blockchain deposit account is introduced (and later GBP denominated blockchain deposit accounts), setting the stage for intraday repos in EUR and GBP
- *Mid 2024:* The platform reaches scale: J.P. Morgan reveals that its blockchain network has processed **over $1 trillion** in notional transactions across applications since launch.[530] On average it was handling about **$2 billion in transactions per day** by 2024. To encourage broader use, J.P. Morgan announces plans to **open the network to third-party developers** so that other firms can build on it and tokenize assets using the platform.[531] OCBC partners with JPMorgan on the first intraday repo showcasing the ability for 3rd parties to act as Repo Buyers (cash lenders).
- *Early 2025:* The intraday repo product is operating in USD and EUR, with global banks as users. **Santander CIB's intraday repo in January 2025** (50 million in USD and €50 million in EUR) marks the first euro intraday repo with a non-J.P. Morgan counterparty.[532]

Usage and Reach: The platform's **user base** remains select and institutional. Aside from J.P. Morgan's own treasury and broker-dealer units, known participants have included **Goldman Sachs** (in early trials), **BNP Paribas**, **Santander**, and **BlackRock/Barclays** (the latter via the collateral tokenization project).[533,534] Geographically, activity has centered on the U.S. and Europe: U.S. dollar repos (often with US Treasuries as collateral) were first, followed by euro transactions in Europe, and now the groundwork is in place for sterling and other currencies. The platform is **permissioned and private**, so adoption is measured in terms of volume and key client participation rather than number of retail users. Even with a modest number of participants, the high-value nature of repo trades means volumes are significant.

In summary, Digital Financing via Kinexys represents a **pioneering use of DLT in fixed-income collateral management**, delivering intraday liquidity optimization. It leverages J.P. Morgan's role as a trusted intermediary to combine **traditional repo market practices with blockchain speed and automation**. By drastically shortening settlement times and enabling fine-grained control (such as hour-by-hour borrowing with interest calculated per minute), it addresses a real inefficiency in capital markets.[535] This use case is often cited as a tangible example of how enterprise blockchain can solve "plumbing" issues in finance – freeing up intraday liquidity and reducing risk – rather than just experimenting for its own sake.[536]

Settlement Asset

Legal Finality and Protections: Settlement finality on the platform is achieved through a combination of technological design and legal agreements. Technically, the blockchain uses a permissioned consensus mechanism (J.P. Morgan's network is built on Ethereum's architecture with a private, fast consensus protocol) that ensures once a transaction is confirmed on the ledger, it is irreversible and final within seconds.[537] There is no concept of probabilistic settlement or lengthy clearing. Atomic DvP settlement provides that either both sides of the repo settle or nothing does (reducing "leg risk" where one party delivers but the other fails).[538] From a legal standpoint, J.P. Morgan has put in place a robust contractual framework to ensure that an on-chain transfer equals a legally binding transfer of ownership (for collateral) or funds (with respect to blockchain deposit accounts). Participants in Kinexys sign agreements (or repo contract appendices) stipulating that the digital ledger records are the authoritative evidence of entitlement. In other words, moving a token on the Kinexys ledger is given the same legal effect as, say, transferring a security entitlement through a traditional securities settlement system. Achieving this required significant legal engineering. In fact, industry experts noted that intraday DLT repos became viable at scale only after extensive legal work by the world's largest banks to adapt master repo agreements and custody arrangements to digital tokens.[539]

Type of Asset and Rights: The cash leg in Kinexys intraday repos is settled using blockchain deposit accounts. Blockchain deposits accounts are just like traditional demand deposit accounts, except the recordkeeping is done using blockchain rather than traditional ledger systems. In practice, a participant must hold a demand deposit account with J.P. Morgan to fund a blockchain deposit account; once the demand deposit account is funded, the bank then transfers the funds to the relevant blockchain deposit account. Blockchain deposit accounts were first denominated in US dollars, and by 2022–2024

529. Ledger Insights, "BlackRock, Barclays join JP Morgan's Tokenized Collateral Network", October 2023.
530. Ledger Insights, "JP Morgan to Open Up Onyx Digital Assets to third party application", May 2024.
531. Ibid.
532. Finadium, "Santander Executes Intraday Repo on JP Morgan's Kinexys", January 2025.
533. ICMA, "Tracker of New FinTech Applications in Bond Markets", Accessed 2025.
534. Ledger Insights, "JP Morgan using blockchain for repos, but it's not the first", December 2020.
535. ICMA, "Tracker of New FinTech Applications in Bond Markets", Accessed 2025.
536. Risk.net, "Real-time repo needed for non-stop trading – DRW's Wilson", May 2023.
537. ICMA, "Tracker of New FinTech Applications in Bond Markets", Accessed 2025.
538. Businesswire, "J.P. Morgan Executes Intraday Repo Transaction Using Blockchain", December 2020.
539. Securities Finance Times, "Santander CIB programmable intraday repo trade with JP Morgan", January 2025.

J.P. Morgan extended the denominations to multiple currencies. For example, it launched a Euro-denominated blockchain deposit account (used in the Santander EUR repo) and a Sterling-denominated blockchain deposit account. No separate asset is created when funds are transferred into a blockchain deposit account, nor does J.P. Morgan custody or segregate special reserve assets in relation to a blockchain deposit account or engage in any stabilization activity. From the perspective of a client, a balance in its blockchain deposit account, like a balance in its traditional deposit account, is simply considered to be cash due from J.P. Morgan, and from the perspective of J.P. Morgan, a balance in the blockchain deposit account of a client is simply considered to be a general liability of J.P. Morgan to the client.

On the collateral side, the tokens represent the security entitlements in securities (such as Treasury bonds or other fixed-income instruments) for the duration of the repo. Typically, the actual securities remain in custody (for example, at BNY or another custodian/triparty agent) and are not physically delivered to the cash lender. Instead, the collateral token agent, acting as securities intermediary, treats the token-holder as the security entitlement holder. Transfer of that token is recognized as transfer of the security entitlement to the security. Thus, settlement finality for the collateral leg is buttressed by conventional commercial law – the repo buyer's interest in the collateral is protected just as in a normal repo (with the added benefit that the DLT record is immediate and transparent to both sides). In case of a default (e.g. if the repo seller fails to repurchase), the legal remedies would mirror those in standard repo agreements: the buyer (cash lender) would have the right to liquidate the collateral held and net proceeds applied per the contract.

In summary, settlement finality is provided for both technically and legally: the DLT platform provides for atomic exchange on a tamper-proof ledger, while the legal structure provides that those ledger entries are enforceable and equivalent to traditional settlement. Participants have strong protections: each party either gets exactly what was agreed (cash vs collateral) at the time of settlement, or the trade does not execute – there is no exposure to intraday settlement risk. The rights attached to the cash are those of a bank depositor, and the rights to collateral are those of a repo buyer under GMRA (with legal title to securities during the repo). Notably, achieving this required close coordination with legal regimes; as one industry source observed, these intraday DLT repos have only become possible "due to the development of underlying blockchain technology and extensive legal work done by the world's largest banks" to reconcile DLT with law.[540]

Interoperability and Network Architecture

Network Model: Kinexys Digital Assets operates on a **permissioned blockchain-based platform** owned and operated by J.P. Morgan. The underlying blockchain-based platform is built on an **Ethereum-based distributed ledger** but is not public – only authorized institutions (nodes) can participate.[541] In its current form, the network's governance is **bank-led**: J.P. Morgan developed and runs the infrastructure, acting as the central node provider and service operator. In 2024, J.P. Morgan indicated plans to **open the network to third parties** so that other firms can host applications or even tokenize assets on this blockchain.[542] This suggests a future where multiple financial institutions could operate nodes or contribute to governance, increasing decentralization within a controlled framework. Even so, the network is **not open to the all participants** – it's a closed loop of known participants (banks, corporates, custodians) who are vetted and bound by network rules.

Interoperability with Traditional Systems: Rather than existing in isolation, Kinexys is deliberately integrated with the **traditional capital market infrastructure**. One aspect of this is connectivity to **banks' internal systems** – for example, a participant's treasury management system or collateral management system can be linked via API to the Kinexys platform, feeding it instructions to initiate a repo or update balances. J.P. Morgan has built gateways so that when blockchain deposit account balances recorded on the blockchain are updated, the equivalent ledger entry in the core banking system is updated in near real time. Moreover, the platform supports **DvP settlement** in a way that can plug into existing workflows. A trade executed on a trading platform (or even negotiated by phone) can be settled on Kinexys by sending settlement instructions to the blockchain, similar to how one would send instructions to DTCC or a triparty agent – except here the instruction triggers a smart contract.

Interoperability with Other DLT Networks: Recognizing that the future may hold multiple blockchain networks in finance, J.P. Morgan has worked on cross-platform interoperability. A prime example is the integration with **Broadridge's DLR platform**. Broadridge's DLR (another permissioned blockchain used by many dealers for overnight and term repo) historically used traditional payment rails for the cash leg, which created delays.[543] In 2024, Broadridge and J.P. Morgan announced that **blockchain deposit accounts would be used on Broadridge's DLT** to enable fully atomic on-chain settlement on that platform.[544] Essentially, **J.P. Morgan's blockchain deposit accounts can now interoperate with a**

540. Securities Finance Times, "Santander CIB Executes Programmable Intraday Repo Trade with JP Morgan", January 2025.
541. ICMA, "Tracker of New FinTech Applications in Bond Markets", Accessed 2025.
542. Ledger Insights, "JP Morgan to Open Up Onxy Digital Assets to Third Party Applications", May 2024.
543. Markets Media Group, "Broadridge, JP Morgan Accelerate Repo Settlement", May 2024.
544. Ibid.

third-party repo network, meaning a dealer on Broadridge can settle in funds recorded on a blockchain ledger without leaving the DLT environment. This is a significant step: it suggests a future where **multiple blockchain networks link up**, using cash that is record on a blockchain ledger as a bridge. Horacio Barakat of Broadridge noted that bringing blockchain deposit accounts onto DLR allows repo settlement cycles "as short as [counterparties] want, down to a minute," improving flexibility and liquidity management.[545] He also predicted that this **interoperability between DLR and blockchain deposit accounts will spur further development of the intraday repo market**.[546]

At present, **Kinexys resembles traditional market structure in many ways** – it has known participants, roles for custodians, and a hub (JPM) that ensures trust – but it delivers the **transactions in a digitally native form**. In effect, it's an overlay network that digitizes current processes. The **infrastructure mirrors the existing repo market**: bilateral (or tri-party) repos, governed by the same legal agreements, and involving the same asset types. However, it introduces *digitally native capabilities* such as smart contract automation and 24/7 connectivity. One could say it's **evolutionary rather than revolutionary** in market design. It does not replace central counterparties or trading venues; instead, it upgrades the **post-trade settlement layer** to be near real-time and programmable. J.P. Morgan's approach thus far has been to **integrate with the grain of the financial system**. For instance, the platform can facilitate **DVP for intraday repos without altering how securities are issued or how payment systems work** – it simply synchronizes a blockchain-based ledger entries of those elements. In time, as more assets become tokenized on various platforms (from government bonds to money market instruments), Kinexys is positioned to tie into those as well. Indeed, the platform's **Tokenized Collateral Network** already demonstrated using **tokenized money market fund shares as collateral** on-chain, hinting that it can support a broader set of digital assets beyond just Treasury tokens.[547]

In summary, Kinexys's architecture is a **private, enterprise blockchain network** marrying the strengths of DLT (real-time, shared truth, smart contracts) with the **structures of traditional finance** (known intermediaries, legal contracts, central governance). It is interoperating with other systems gradually – both other DLT networks (Broadridge DLR, possibly others) and the existing banking infrastructure (custody accounts, payment networks for on/off-ramps) – rather than existing in a vacuum. This approach helps with adoption, since participants do not have to abandon their current processes entirely; instead, they interface with a new settlement network that runs in parallel and delivers new capabilities. In effect, **Kinexys acts as a bridge between legacy finance and the emerging tokenized financial ecosystem.**

Conclusion

Digital Financing on Kinexys thus stands as a leading example of DLT in mainstream finance: it operates under the radar of end-users but delivers tangible improvements in speed, efficiency, and flexibility, all while fitting into the current regulatory and market landscape. As the technology and legal frameworks continue to mature, one can expect intraday DLT repo to move from a niche pilot to a standard tool in liquidity management, contributing to safer and more efficient capital markets.[548,549]

545. Ibid.
546. Ibid.
547. Markets Media Group, "Broadridge, JP Morgan Accelerate Repo Settlement", May 2024.
548. Securities Finance Times, "Repo panel", January 2025.
549. Risk.net, "Real-time repo needed for non-stop trading – DRW's Wilson", May 2023.

Collateral Use Case #2: Broadridge Distributed Ledger Repo

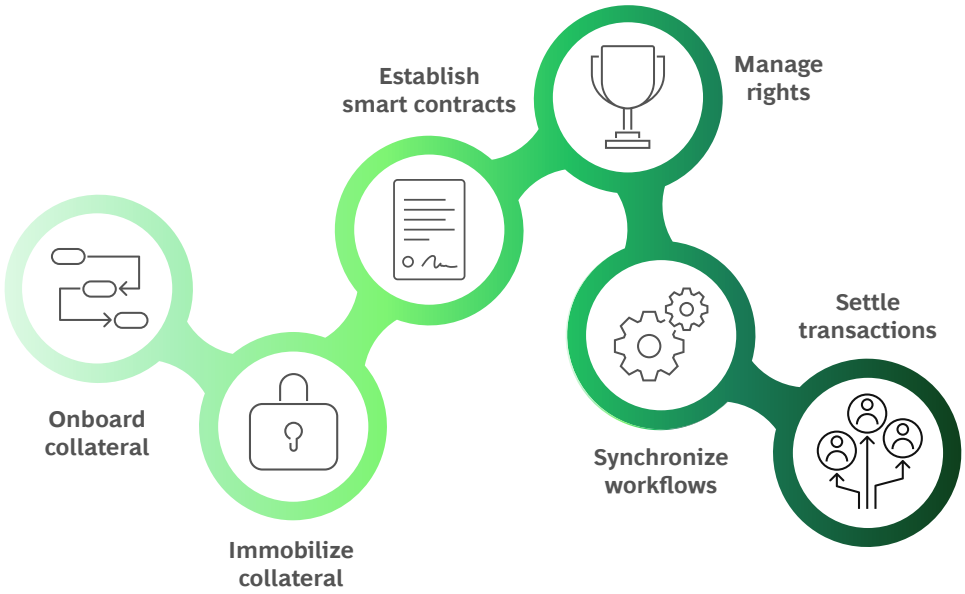
Overview of Use Case

Broadridge's **DLR** platform is a live application of blockchain in the repo market, designed to make repo transactions faster, safer, and more efficient. In essence, DLR provides a single **shared ledger** where market participants can **agree on trade terms, execute the repo contract, and settle both legs of the repo** transaction. This addresses longstanding pain points in the $10+ trillion global repo market – a market historically plagued by manual processes, fragmented records, and settlement failures.[550] For example, U.S. Treasury settlement fails averaged ~$40 billion *per day* over 12 months (as of April 2023), incurring millions in penalties. By creating one **"golden record"** of the trade lifecycle accessible to all parties, DLR eliminates asynchronous processes and reduces these costly fails. Major institutions have taken notice: **20 of the 24 primary dealer banks in the U.S.** are using Broadridge's DLR to process their repo trades.[551] Notable early adopters include UBS (which joined in 2021) and Société Générale (joined in 2022), among other leading global banks.[552] The platform is operated by Broadridge (a financial technology provider), but its stakeholders span the sell-side (broker-dealers/primary dealers) and increasingly the buy-side institutions that engage in repo financing.

When two parties agree to a repo trade (say, Party A needs cash and offers Treasury bonds as collateral to Party B), they can enter the trade details directly into the DLR system. The platform uses **smart contracts** to encode the repo agreement – including the collateral details, repo rate, term (overnight, intraday, or term), and repayment amount.[553] **Collateral is "on-boarded" and immobilized**: the underlying securities (e.g. Treasury bonds) are placed in a custody account or otherwise **locked** in the traditional infrastructure, and a **tokenized representation** of those securities is created on the ledger.[554] This token effectively confers ownership rights of the collateral. **Cash remains off-chain** in the current live implementation – the actual cash leg is still paid through conventional means (such as Fedwire or bank transfer).[555] However, the DLR platform coordinates the **simultaneous exchange** (DvP) by ensuring that the collateral token only transfers to the cash provider when the cash payment is confirmed, and vice versa for return leg. At the repo's maturity, the process is reversed: Party A repays the cash plus interest, and the tokenized collateral is returned to A (and eventually "un-immobilized" from the custody account back to A's direct control). Throughout the repo's life, both parties see a **synchronized, real-time view** of the trade's status and any lifecycle events (such as rate adjustments or early termination) are automatically managed by the smart contract.[556] This shared ledger approach obviates the need for each party to reconcile separate records, greatly reducing operational risk.

EXHIBIT DD.2

Workflow of Broadridge's DLT Repo Platform



Source: Digital Asset, "Customer Story: Broadridge", June 2024.

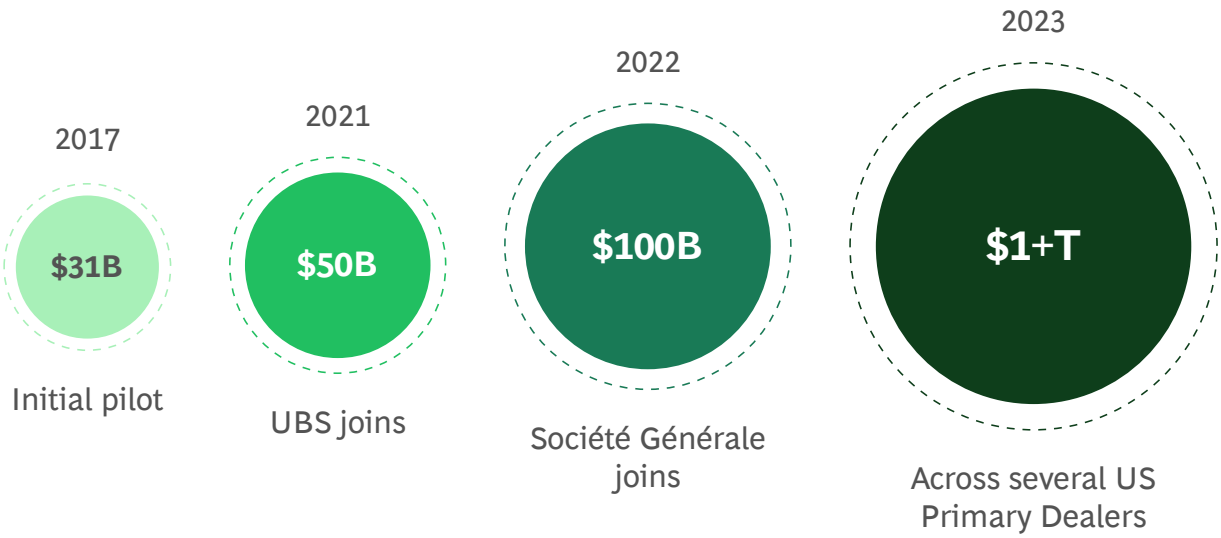
550. Digital Asset, "Customer Story: Broadridge", June 2024.
551. Ibid.
552. Ledger Insights, "SocGen joins Broadridge blockchain Repo platform", June 2022.
553. Ibid.
554. Ibid.
555. Ibid.
556. Digital Asset, "Customer Story: Broadridge", June 2024.

The **technology stack** underpinning DLR is built on **Digital Asset's Daml smart contract language and the Canton DLT platform**.[557] Canton is a privacy-centric, permissioned blockchain. It allows each bank to host a node that only shares relevant data with counterparties of a trade, while a central coordination ensures consistency. All **market rules and legal terms are embedded in the smart contracts**, meaning the platform can automatically enforce collateral eligibility, haircuts, margining, and other repo parameters without manual intervention.[558] According to Broadridge, the DLR smart contracts clearly define all **roles, rights, and obligations** of the counterparties, and every step is auditable. In other words, the system doesn't just track who owes what – it also embeds the repo's legal agreement into the code, ensuring that (for example) the repo buyer's right to liquidate collateral in event of default is preserved ("secured parties remain secured").[559] The platform was designed to integrate with **existing infrastructure** (it "couples DLT with existing operational account structure"), so it works in concert with custodian banks, tri-party agents, and payment systems rather than replacing them.[560] This eases deployment because banks can use DLR alongside their current repo processing frameworks.

Adoption and scale. Broadridge began piloting DLR in 2017 with a small group of banks (Société Générale and Natixis were involved in the first pilot).[561] After years of development, DLR **went live in June 2021** for bilateral repo transactions.[562] UBS was among the first to use the live platform in 2021, and by mid-2022 Société Générale and others had joined. Usage has grown **exponentially** as more participants onboarded. Just a year later (by August 2022), daily volumes had surged to **$35+ billion**.[563] By 2023, with **several U.S. primary dealers live, the platform was processing over $1 trillion of repo transactions per month** (roughly $50–60 billion per day on average).[564] As of late 2024, Broadridge reported monthly volumes around **$1.5 trillion**, reflecting continued growth and new use cases.[565]

EXHIBIT DD.3

Exponential growth in average daily volumes and market participation



Source: Digital Asset, "Customer Story: Broadridge", June 2024.

It's important to note that DLR's **user base spans regions and is expanding**. Initially, activity centered on U.S. **Treasury repos** (USD cash against U.S. government bonds), given Broadridge's strong U.S. client base and the USD repo market's size. But the platform is not limited by geography or collateral type – Broadridge deliberately built DLR to be **asset-agnostic and global** in reach.[566] Indeed, there have been cross-border repo transactions on DLR (e.g. in 2023 UBS and an Asian bank executed the first **cross-border intraday repo** via DLR, swapping USD cash and non-U.S. collateral within the same day).[567]

557. Ibid.
558. Ibid.
559. Ibid.
560. Securities Finance Times, "Distributed Ledger Technology: New designs for securities finance", Accessed 2025.
561. Ledger Insights, "SocGen joins Broadridge blockchain Repo platform", June 2022.
562. Ibid.
563. Ibid.
564. Securities Finance Times, "UBS executes first cross-border repo trade on Broadridge's DLR platform", April 2023.
565. Ledger Insights, "ICMA updates repo agreement for digital assets", August 2024.
566. Digital Asset, "Customer Story: Broadridge", June 2024.
567. Securities Finance Times, "UBS executes first cross-border repo trade on Broadridge's DLR platform", April 2023.

In 2024, a **tier-1 Canadian bank** became the first to use DLR for a high-quality liquid asset (HQLA) management use case, essentially extending the platform beyond traditional repo into straight **collateral mobility** (the bank can lock assets such as government bonds and transfer them between its entities or to other parties via the ledger).[568] Broadridge cites this as an example of DLR's flexibility – one client even used it for **outright sales of securities for cash**, not just repos. Moreover, Broadridge is encouraging **buy-side firms** (such as asset managers and hedge funds) to join the network, often via **sponsored repo** arrangements (where a dealer sponsors a client into a cleared repo).[569] The vision is a broad ecosystem of dealers, clients, and perhaps clearing agents interconnected on the ledger, which creates a network effect: the more participants on DLR, the more beneficial it is (since any two can directly transact and benefit from instant settlement).[570] Broadridge executives have described DLR as **"transforming repo market infrastructure"**, not only for bilateral deals but potentially to streamline intracompany (internal treasury) movements and other financing workflows.[571]

Key benefits realized: Early results indicate significant efficiency gains. By synchronizing the cash and securities movements, DLR achieves true **delivery-versus-payment** (albeit with cash via existing rails) and nearly **eliminates settlement fails**, which in turn saves participants money on avoidable penalty fees. Banks report that using DLR for intraday repos or other short-term funding has cut down their need to tap emergency funding late in the day (avoiding punitive rates of 100+ basis points for last-minute borrowing).[572] **Overdraft charges** from failed settlements – which could cost up to 300 bps in fees – are largely avoided thanks to DLR's settlement certainty.[573] Additionally, the ability to **reuse and mobilize collateral quickly** means firms don't have to hold as large a buffer of idle assets, thus reducing **over-collateralization** and improving balance sheet usage. Broadridge estimates clients see around a **25% reduction in clearing and settlement costs** when using the platform, due to these efficiencies. These are meaningful savings in the context of razor-thin repo lending spreads.[574] Beyond cost, there's a **risk reduction** element that's hard to quantify: with an automated, real-time ledger, the **operational risk** of manual errors or disputes is minimized, and **counterparty risk** is reduced by instantaneous settlement (no overnight credit exposure if doing intraday repos, for instance).[575] All of this contributes to a safer plumbing for the financial system – aligning with regulators' post-crisis goals for more resilient market infrastructure.

Settlement Asset

Settlement asset (cash and collateral): In the live DLR implementation, the **cash leg is settled in fiat currency via traditional payment systems**.[576] There is no native "cash token" on the platform (at least not yet in production).[577] Instead, when two parties execute a repo on DLR, they will pay and receive the cash through normal channels – typically bank wire transfers or central bank payment systems such as Fedwire for USD.[578] The platform records the obligation and can mark it as paid once confirmation is received, but the cash itself "remains off chain".[579] **On the collateral side**, DLR tokenizes the securities being used as collateral. Participants **immobilize the collateral** in a custodian or clearing system account – meaning the bonds or other securities are parked in a controlled account and cannot be transferred through conventional means during the repo's term.[580] Against that immobilized asset, a **digital token or digital record is created on the DLT** to represent the security. This token can then be instantly transferred between the repo counterparty addresses on the ledger, reflecting a change in beneficial ownership of the collateral. In practical terms, if Party A sells bonds to Party B for the repo, the **DLR token representing those bonds moves to Party B's side** at the repo's start (while the bonds stay in the custodian, earmarked for B).[581] When the repo is unwound, the token goes back to A (and A's right to withdraw those bonds is restored). Because of this design, **settlement finality** on DLR is achieved by the simultaneous updating of token ownership and the off-chain cash payment – a delivery-versus-payment where one leg is on-chain and the other off-chain, coordinated by the platform. The DLR smart contract will only execute the token transfer at the repo start once the cash payer has fulfilled their obligation (which may be verified by an outside system or a manual confirmation), ensuring that neither party is exposed.[582] Likewise, at repo maturity, the return of collateral is contingent on the repayment of cash and accrued interest. This conditional logic is automated. The result is that **legal ownership of the collateral is transferred at the same moment that cash changes hands**, meeting the definition of DvP settlement finality – even if the cash leg's finality technically occurs in Fedwire or TARGET2, etc., the platform links the two events.

568. Ledger Insights, "Broadridge expands DLT repo solution for HQLA workflow with Canadian Tier 1 bank", September 2024.
569. Ledger Insights, "Analysis: Broadridge demos intraday repo settled with tokenized cash via Fnality", April 2025.
570. Securities Finance Times, "UBS executes first cross-border repo trade on Broadridge's DLR platform", April 2023.
571. Securities Finance Times, "Distributed Ledger Technology: New designs for securities finance", Accessed 2025.
572. Digital Asset, "Customer Story: Broadridge", June 2024.
573. Ibid.
574. Digital Asset, "Broadridge Distributed Ledger Repo Case Study", April 2023.
575. Ibid.
576. Ibid.
577. Ibid.
578. Ledger Insights, "SocGen joins Broadridge blockchain Repo platform", June 2022.
579. Digital Asset, "Broadridge Distributed Ledger Repo Case Study", April 2023.
580. Ibid.
581. Ibid.
582. Ibid.

It is worth noting that Broadridge is actively working to bring the cash leg onto the platform in the future using regulated digital cash. In April 2025, Broadridge demonstrated an integration of DLR with **Fnality's** Payment System, which is a platform for tokenized central bank deposits.[583] In that demonstration, they showed an **intraday repo settled with a tokenized version of central bank money**, so that both the cash and collateral were exchanged on ledgers atomically.[584] This points toward a future state where DLR could use **DLT-based Payment Instruments** for instant settlement. For now, however, live trades use conventional cash settlement with the ledger providing a synchronized workflow around it.

Legal mechanisms and finality: From a legal perspective, a repo executed on DLR is still a **repo** – the fundamental legal nature of the transaction has not changed, even though the record-keeping is on a DLT. In a standard repo (under frameworks such as **GMRA** or equivalent), one party sells securities to another with a commitment to repurchase later; legally, title to the collateral actually transfers to the cash provider during the repo term. DLR preserves this concept: when the collateral token transfers on the ledger, it is intended to represent an actual **transfer of title/ownership** of the underlying security from the seller to the buyer.[585] To make this robust, all DLR participants enter into contractual agreements that recognize the DLR ledger records as the authoritative evidence of ownership and obligations. In other words, the participating banks sign an addendum or a rulebook for the platform stating that, for any repo transacted through DLR, the token movements carry the same legal effect as moving securities in, say, DTCC or Euroclear. If a dispute arises, the ledger's record should be admissible to confirm who owns what at any given time.

One key legal concern is **settlement finality and insolvency protection**. In traditional systems, once a transfer is final (e.g. securities delivered vs payment received), that transfer is irrevocable and protected even if a party defaults immediately after. DLR aims to give the same assurance. Technically, Canton (the DLT) provides immediate finality of transactions (no probabilistic confirmation or lengthy block times – once the nodes confirm the transaction, it is final). Legally, because the participants agree that a token transfer is equivalent to the ownership transfer of the underlying asset, the moment the ledger updates, the buyer of the collateral has a legally enforceable right to that collateral. If the seller were to go bankrupt immediately afterwards, the buyer's ownership claim to the collateral should be honored (the asset should not be pulled into the seller's estate, because of repo safe harbor provisions and the fact that title passed before bankruptcy). **Repo safe harbors** under U.S. law (which exempt repo transfers from bankruptcy stay and allow immediate liquidation) are intended to apply equally to DLR-facilitated repos, as long as the repo is documented under a valid master agreement. The DLR system also **ensures the secured party's interest is maintained** – for instance, if Party B holds the collateral token, Party A cannot somehow reuse or move the underlying collateral elsewhere until B is paid back. This was emphasized by Broadridge: "secured parties remain secured" throughout the trade.[586] That suggests the platform has mechanisms to prevent double-pledging or unauthorized transfers of collateral tokens, and that it manages substitutions or corporate actions on the collateral in a controlled way, so the lender's rights are never compromised by the digital format.

In summary, **DLR's legal structure** marries traditional repo law with new technology: participants use standard agreements (with new annexes/clauses as needed) to ensure a **token is equivalent to the asset it represents**, and that ledger movements are the equivalent of final transfers of ownership. Settlement finality is achieved through both the technology (Canton DLT's finality) and legal acknowledgment that once the ledger records receipt of the asset or cash, is it then that party's with no possibility of clawback. The platform itself does not introduce new legal entities or tokens of ambiguous status – it deals with **real-world assets (cash and bonds) in a digitally recorded manner**, which has helped it avoid legal uncertainty.

Interoperability and Network Architecture

Network type and architecture: Broadridge DLR is set up as a **private, permissioned distributed ledger network** – essentially a consortium-style blockchain rather than a public one. Only authorized participants (approved financial institutions and relevant service providers) can run nodes or access the network. Broadridge itself serves as the network operator and technology provider. The underlying ledger is built on the **Canton blockchain** developed by Digital Asset, which is tailored for institutional use.[587] Canton's architecture is unique in that it enables **interoperability among multiple applications and maintains privacy**: data is shared on a need-to-know basis between counterparties, and a central coordination service (often called the **"Global Synchronizer"** in Canton) ensures that all nodes agree on the set of transactions (thereby preventing double-spending or inconsistent states). This means, for example, Bank A's node and Bank B's node might record a repo between them, but other bank nodes won't see the details of that trade – they might only see

583. Broadridge, "Broadridge Collaborates with Fnality to Enable Real-Time Settlement for Intraday Repo Transactions", April 2025.
584. Ledger Insights, "Analysis: Broadridge demos intraday repo settled with tokenized cash via Fnality", April 2025.
585. Ledger Insights, "SocGen joins Broadridge blockchain Repo platform", June 2022.
586. Digital Asset, "Customer Story: Broadridge", June 2024.
587. Digital Asset, "Broadridge Distributed Ledger Repo Case Study", April 2023.

aggregate state if needed or nothing at all. Such a design is crucial in finance where confidentiality is important. Broadridge has leveraged this so that each participant essentially has their own ledger view of trades they are involved in, but the **smart contracts synchronize** across both parties' nodes.[588]

The **consensus mechanism** in a network such as DLR (using Canton) does not rely on mining or proof-of-work consensus. Instead, it likely uses a form of **Byzantine Fault Tolerant ("BFT") consensus or trusted nodes** to order transactions. In practical terms, since Broadridge is the operator, it may run certain validator or coordinator nodes that order the blocks of transactions. Each repo transaction is cryptographically signed by the parties and then confirmed by the network. Once confirmed, it's final – there is no concept of chain reorganization or probabilistic finality. This immediate finality is important for a settlement system (all parties want certainty once a trade is purportedly "done"). The **scalability** of DLR has been demonstrated by its volume growth – handling up to ~$1.5 trillion a month without issues implies the network can process a very large number of transactions and updates.[589] The **Canton/Daml combination** is known to be quite scalable because it does not broadcast all information to every participant; it is more akin to a series of bilateral (or small multilateral) ledgers that are synchronized. Broadridge mentioned that **privacy and data segregation are built-in** to the integration, and that the platform is **"scalable to handle increasing volumes"** and a wide array of repo types (intraday, overnight, term, etc.) across jurisdictions.[590] This suggests that adding more participants or more trades will not slow down the network linearly, since partitioning of data limits unnecessary processing for unrelated parties.

Interoperability with other systems: One of DLR's strengths is that it is integrative rather than isolated. On the legacy side, DLR connects with the real-world settlement infrastructure for securities and cash.[591] For instance, if a repo involves U.S. Treasuries, those Treasuries ultimately reside in the Fed's book-entry system (Fedwire Securities) or in a custody account at a bank. DLR must coordinate with those systems to **immobilize and release collateral**. Although details are not publicly spelled out, it is likely that at the start of a DLR repo, the selling party (or a triparty agent on their behalf) moves the securities into a designated custodian account (perhaps a segregated DLR omnibus account) – effectively flagging them as pledged. The DLR tokenization would be tied to that action. When the repo is over, DLR would signal to release the securities back to the seller's normal account. This requires integration via APIs or messages to the custodian or depository. The **workflow synchronization** mentioned by Broadridge indicates that DLR is connected to participants' internal systems too, so that when a repo settles on DLR, the participants' general ledger, treasury systems, and risk systems get updated (likely via real-time feeds). On the **cash side**, since payment is conventional, if the two parties settle via a Fedwire transfer, DLR might receive a message or be manually updated to indicate that the payment was received, triggering the collateral transfer. In some cases, if both participants have an account at the same custodial bank, that bank could coordinate the DvP (acting almost like an escrow agent who only executes delivery when funds are received). Therefore, **DLR sits as a layer above existing FMI**, orchestrating them. Broadridge has emphasized that DLR was designed to **work with existing depositories, payment rails and participants' underlying technology**.[592] This ensures that DLR's novel features (such as 24/7 capability or intraday settlement) still ultimately tie back to real-world settlement finality in central bank money and securities depositories.

On the **DLT interoperability** side, Broadridge is proactively connecting DLR with emerging digital networks. A prime example is the interoperability **with Fnality**: Fnality is essentially a consortium creating **distributed payment systems backed by central bank funds**. In April 2025, Broadridge and Fnality completed a **proof-of-concept linking DLR and Fnality's network**.[593] In the test, an intraday repo was settled using **tokenized funds in Fnality's network** (which are a digital representation of funds at a central bank) – meaning the DLR smart contract directly interfaced with the Fnality ledger to atomically exchange a securities token for a cash token.[594] Essentially, DLR treated the Fnality token as the settlement asset for the cash leg. The success of this demo suggests that once Fnality (or similar DLT0-based Payment Instruments) go live and are widely accessible, DLR could incorporate them for production trades. Another integration is with **J.P. Morgan's Kinexys Digital Payments** platform (formerly known as JPM Coin), which offers blockchain deposit accounts.[595] Blockchain deposit accounts represent deposit liabilities of J.P. Morgan for use by its clients on blockchain platforms; Broadridge's Horacio Barakat noted that DLR had already **integrated with Kinexys Digital Payments** as one of the digital cash options they explored.[596] That likely means if two parties to a repo both have JPMorgan accounts and use blockchain deposit accounts, DLR can trigger a blockchain-recorded payment on Kinexys in synchrony with the repo's collateral transfer. These efforts indicate that **DLR is moving toward full "atomic settlement"** – where both legs of a repo can occur on-chain, possibly across interconnected ledgers (one for cash, one for securities). DLR is taking a cautious, step-by-step approach: DLR first addressed the DLT for collateral and will then plug in digital cash when it becomes available.

588. Ibid.
589. Ledger Insights, "Broadridge Demos Intraday Repo Settled with Tokenized Cash via Fnality", April 2025.
590. Digital Asset, "Customer Story: Broadridge", June 2024.
591. Digital Asset, "Broadridge Distributed Ledger Repo Case Study", April, 2023.
592. Ibid.
593. Broadridge, "Broadridge Collaborates with Fnality to Enable Real-Time Settlement for Intraday Repo Transactions", April 2025.
594. Ibid.
595. Ledger Insights, "Analysis: Broadridge demos intraday repo settled with tokenized cash via Fnality", April 2025.
596. Ibid.

In summary, **network architecture** of DLR is a closed, high-performance ledger network using Canton/Daml, governed by Broadridge with bank participation. It prioritizes privacy and finality, scales to large volumes, and integrates with existing systems. **Interoperability** is a key strength, allowing DLR to serve as a nexus between the legacy world (custodians, payment systems) and emerging digital cash/blockchain services (Fnality, JPM Kinexys Digital Payments, etc.).[597] DLR aligns more with **traditional FMI in governance and compliance**, but introduces **digitally native capabilities** such as programmable, instantaneous settlement and tokenized assets that modernize the repo market's functionality.[598] This positions it as a catalyst for gradual industry transition to DLT, rather than a radical replacement of existing financial infrastructure.

Conclusion

Overall, Broadridge's DLR case exemplifies how **Distributed Ledger Technology can be deployed in a live, regulated market to solve real problems**. It has achieved a notable level of adoption (major global banks, trillions in volume) and is evolving alongside regulatory and market developments. By focusing on **integration and legal certainty**, it has thus far avoided the pitfalls that some crypto-related projects faced. If it continues on this trajectory, DLR or similar DLT platforms could become a **standard component of market infrastructure**, operating under the hood to settle trades instantly while market participants and regulators gain confidence from the improved efficiency and transparency.

Legal Considerations[599]

The repo market is a central pillar to the efficient working of many capital markets. The key function of the market in relation to Intra-day repos, is the provision of short-term funding in an efficient manner, thus allowing many other markets to operate more efficiently. The size and importance of this market can be seen by the fact that the 61 institutions that responded to **ICMA's** European Market survey in December 2024[600] had an aggregate total outstanding value of repo contracts of EUR 10,860 billion.

DLT-based Securities and DLT-based Payment Instruments (if used to enable settlement) are a key focus for the Intra-day repo market expanding because the potential speed of settlement makes it possible to have repo transactions with terms of only a few hours.

Intra-day Repos

For the purposes of this report, the discussion is limited to the **GMRA**,[601] which is the most recently published version of ICMA's master agreement non-U.S. repo transactions and the 1996 Master Repurchase Agreement (the **"MRA"**), which is the primary standardized form for U.S. repurchase transactions. Additionally, the discussion is limited to repurchase transactions where the Purchased Securities are DLT-based Securities, although similar considerations would arise if any Margin Securities were DLT-based Securities. Other digital assets are not considered, save as a point of contrast.

The GMRA anticipates that the Purchased Securities will be "securities or other financial instruments", and the MRA anticipates that the Purchased Securities will be "securities or other assets", each of which are broad definitions. Industry may find a consensus as to how DLT-based Securities will, in and of themselves, be capable of satisfying this definition in the various legal systems but if they do not meet the definition then this would be a contractual point that could be addressed in any future market documentation (and in the interim, resolved by the parties agreeing an appropriate amendment to the GMRA or MRA between them). There is no further consideration of any points which could likely be satisfactorily resolved by parties through a contractual solution.

There are, however, several areas that might benefit from additional clarification to aid parties with the legal bases for market practices adopted by the parties. These are considered in turn below.

597. Ledger Insights, "Analysis: Broadridge demos intraday repo settled with tokenized cash via Fnality", April 2025.
598. Ledger Insights, "ICMA updates repo agreement for digital assets", August 2024.
599. In this deep-dive, references to law and regulation are to US law and regulation, unless stated otherwise.
600. **https://www.icmagroup.org/assets/documents/Regulatory/Repo/Surveys/ICMA-European-Repo-Market-Survey-Number-48-Conducted-December-2024-Published-April-2025-090425.pdf?utm_source=ICMA+Total+Subscribes&utm_campaign=ecad6edbed-EMAIL_CAMPAIGN_2025_APR_EUR+REPO+SURVEY+PR&utm_medium=email&utm_term=0_-74d917e8a6-257670038**.
601. **https://www.icmagroup.org/assets/documents/Legal/GMRA-2011/GMRA-2011/GMRA%202011_2011.04.20_formular.pdf**.

1. **Financial Collateral Arrangements.** The treatment for repurchase transactions conducted under a GMRA is dependent on receiving positive netting or set-off opinions. In some non-U.S. jurisdictions (for example the EU), the positive analysis is dependent on the arrangement qualifying as a title transfer financial collateral arrangement under the relevant implementation of the financial collateral arrangement directive (the **"FCA Directive"**).[602] In this regard, particular focus will be given to whether specific DLT-based Securities qualify as financial collateral (i.e. financial instruments, cash or credit claims). Of these, it is financial instruments (as defined in the FCA Directive) that are most likely to be relevant. The definition from the FCA Directive is copied below, although it is worth noting that different jurisdictions may have implemented the FCA Directive differently.

   "Financial instruments" means shares in companies and other securities equivalent to shares in companies and bonds and other forms of debt instruments if these are negotiable on the capital market, and any other securities which are normally dealt in and which give the right to acquire any such shares, bonds or other securities by subscription, purchase or exchange or which give rise to a cash settlement (excluding instruments of payment), including units in collective investment undertakings, money market instruments and claims relating to or rights in or in respect of any of the foregoing.

   This definition was not drafted with DLT-based Securities in mind. Further development of legal principles as to how DLT-based Securities fall within this definition, *i.e.*, whether a given digital security is "negotiable on the capital market" in its own right and/or otherwise qualifies as a financial instrument, for example by virtue of conferring a right to acquire such shares, bonds or other securities by an exchange, can help parties by providing a legal foundation with stability, clarity and predictability for transactions.

   In the United States, parties also seek positive netting opinions in connection with repo transactions. Positive netting opinions depend on whether the contract meets certain specified standards for the safe harbor exemptions from the automatic stay that otherwise applies under insolvency laws. Accordingly, it may be beneficial for U.S. repo transactions if these standards were clarified to confirm that they are inclusive of DLT-based Securities, given that DLT-based Securities did not exist at the time of drafting.

   Without further development on these points, growth in the market might be expected to occur more slowly while a market consensus develops.

2. **Property Rights and conflicts of laws.** For transactions under the GMRA, the economics of repurchase transactions are derived from the analysis that the Purchase Securities are property that has been transferred outright to the Buyer on the Purchase Date. In the MRA, the parties both express an intent that the transactions under the MRA are sales and purchases and not loans and also provide for a backstop provision that grants the buyer a security interest in the Purchased Securities. Further development of relevant legal principles related to the creation and perfection of a security interest in DLT-based Securities and DLT-based Payment Instruments and conflicts of laws analysis for DLT[603] could aid parties with the legal bases for repo transactions and associated rights.

   Unresolved legal questions can lead to an additional level of uncertainty that is likely to slow or fragment any market development in relation to DLT-based Securities. Various initiatives are seeking to resolve these points currently and provide the legal foundation for parties to rely on (for example, the UNIDROIT Digital Assets and Private Law Working Group[604] and the American Law Institute and the Uniform Law Commission,[605] the two sponsors of the UCC, in the United States). Therefore, this issue is not considered further here other than to note that the repo market is an international market and would therefore benefit significantly from a consistent approach across all relevant jurisdictions.

3. **Agency relationships.** Many participants in the repo market enter into transactions through an entity acting as an agent to Custody and help with the management of the collateral. For repo transactions that use DLT-based Securities and DLT-based Payment Instruments as collateral, this may lead to additional questions related to how DLT-based Securities and DLT-based Payment Instruments should be held for such market participants (either on a segregated or omnibus basis) to ensure legal certainty in the event of close-out. As legal precedents and market practices in this area continue to develop, clarity on the permissibility of such activities from regulators and supervisors could encourage more agents that are regulated institutions to act in these capacities.

602. Directive 2002/47/EC of the European Parliament and of the Council of 6 June 2002 on financial collateral arrangements, as amended.
603. The decentralised nature of DLT means that the traditional conflicts of laws analysis might not be applicable.
604. **https://www.unidroit.org/work-in-progress/digital-assets-and-private-law/#1622753957479-e442fd67-036d.**
605. **https://www.uniformlaws.org/committees/community-home?communitykey=1457c422-ddb7-40b0-8c76-39a1991651ac.**

4. **Regulatory capital treatment.** In November 2024, the BCBS revised the prudential standard on banks' cryptoasset exposures.[606] Recognition by the BCBS that repos that use DLT-based Securities and DLT-based Payment Instruments based on permissionless ledgers as collateral should not be automatically excluded from the definition of Group 1 assets subject to certain considerations would further the BCBS' goals of being technology neutral, and enacting rules that are in line with its "same activity, same risk, same regulatory outcome" guidelines. In relation to SCO60 generally, please refer to the Executive Summary.

5. **Regulatory classification and tax treatment.** Further development of principles in these areas would help ensure that market participants will be comfortable that the treatment of repurchase transactions in respect of DLT-based Securities and DLT-based Payment Instruments reflects that of repurchase transactions in respect of traditional securities and traditional cash.

Variation Margin

Where the OTC derivatives are uncleared and the parties are in scope of applicable uncleared margin rules, the parties will be required to post VM. As can be seen, the efficient posting and collection of VM is of critical importance to the reduction of credit risk in the market, just as OTC derivatives are a critical tool for the controlling of market risk.

The EU's EMIR,[607] and the corresponding legislation in the UK as amended following Brexit (**"UK EMIR"**) not only regulate how much VM must be exchanged (and when) but also what assets can be posted as collateral ("Eligible Collateral"). Similar restrictions are found in other sets of uncleared margin rules. The purpose of these legal requirements is to ensure that parties to OTC derivatives contracts mitigate their trading risks such that counterparty credit and operational risk are reduced when trading in OTC derivatives that are not cleared by a CCP.

For the purposes of this report, this discussion is confined to VM posted under the terms of a 2016 Credit Support Annex for VM governed by English law (the **"VM CSA"**) and a 2016 Credit Support Annex for VM governed by New York law (the **"NY VM CSA"**) and assuming the VM consists of DLT-based Securities. Other Digital Assets are not considered, save as a point of contrast.

As for intra-day repos above, the following discussion does not include consideration of points which could be satisfactorily resolved by parties through a contractual solution, for example, by defining the "Eligible Credit Support (VM)" in a way that includes the relevant Digital Assets. ISDA has published Tokenized Collateral Model Provisions[608] to address these contractual aspects for variation margin. There are several areas in the existing legal framework which might benefit from additional clarification. These are considered in turn below and cross-reference to the repo transaction considerations above where the points are of a similar nature.

1. **Financial Collateral Arrangements.** The treatment for collateral posted under a VM CSA or NY VM CSA is dependent on receiving positive netting opinions. In some EU member state jurisdictions, the positive analysis is dependent on arrangement qualifying as a title transfer financial collateral arrangement under the relevant implementation of the FCA Directive, as noted above in relation to repo transactions, and similar considerations apply in relation to the posting of VM. In the United States, similar to the analysis noted above, a positive opinion depends on whether the contract meets certain specified standards for the safe harbor exemptions under insolvency laws.

2. **Property Rights and conflicts of laws.** The economics of VM posted by way of title transfer (an approach commonly used for VM outside the United States) are derived from the analysis that the VM is property that has been transferred outright to the collateral receiver on the date of transfer. In the United States, a security interest in the collateral is typically granted. Further development of legal principles related to the creation, perfection and enforcement of security interests in DLT-based collateral could aid parties with the legal bases for their transactions and associated rights. As noted above in relation to repo transactions, the novelty and decentralised nature of DLT gives rise to several issues and similar considerations apply in relation to the posting of VM.

3. **Uncleared Margin Rules.** As stated above, UK EMIR and EU EMIR, amongst other sets of uncleared margin rules (including U.S. rules and regulations), regulate how much VM must be exchanged, when this VM must be exchanged, and what assets constitute Eligible Collateral.

606. **https://www.bis.org/basel_framework/chapter/SCO/60.htm?inforce=20260101&published=20241127.**
607. Regulation (EU) No 648/2012 of the European Parliament and of the council of 4 July 2012 on OTC derivatives, central counterparties and trade repositories, as amended.
608. See, ISDA, Tokenized Collateral Model Provisions for Inclusion in ISDA 2016 Credit Support Annexes for Variation Margin (VM), *available at* **https://www.isda.org/book/tokenized-collateral-model-provisions-for-vm-csa/#:~:text=Variation%20Margin%20(VM)-,Tokenized%20collateral%20model%20provisions%20for%20inclusion%20in%20ISDA%202016%20Credit,ledger%20technology%20(Tokenized%20Collateral)%20as.**

The definitions related to Eligible Collateral were not drafted with DLT-based Securities in mind. Further development of legal principles in this area might include considering whether the definitions across the different uncleared margin rules would benefit from clarification, rather than necessitate firms take a view on whether any individual Digital Security is within the scope of the applicable uncleared margin rule sets.

Development in the market might be expected to occur more slowly while a market consensus develops in relation to any problematic rule sets or Digital Securities.

Regulatory harmonization regarding discrepancies between the US and EMIR uncleared margin rules eligible collateral, such as money market funds, needs to be resolved before cross-border implementation of tokenized money market funds for uncleared margin derivatives' collateral purposes.

4. **Regulatory capital treatment.** As noted above in relation to repo transactions, the BCBS's prudential standard on banks' cryptoasset exposures could act as an impediment to market development, for example due to punitive treatment of permissionless ledgers.

Hong Kong

Since documentation of repurchase transactions in Hong Kong largely adopt the GMRA and are commonly governed by English law, the U.K./E.U. analysis on the regulatory landscape and points above are generally applicable to Hong Kong.

The key differences under Hong Kong law are highlighted below:

1. Currently there is no Hong Kong equivalent of the FCA Directive. Accordingly, in Hong Kong, it is typically necessary to satisfy 'true sale' transfers and positive close-out netting analysis.

2. Regarding VM requirements, financial institutions are subject to the HKMA Supervisory Policy Manual CR-G-14 on Non-centrally Cleared OTC Derivatives Transactions – Margin and Other Risk Mitigation Standards (**"CR-G-14"**), which sets out the minimum standards that the HKMA expects authorized institutions, such as banks, to adopt in relation to margin and other risk mitigation techniques for non-centrally cleared OTC derivatives transactions.[609] Schedule 10 of the Securities and Futures Commission of Hong Kong's (**"SFC's"**) Code of Conduct for Persons Licensed by or Registered with the SFA also elaborates on the risk mitigation requirements and margin requirements in relation to non-centrally cleared OTC derivative transactions.[610]

   Separately, with respect to collateralized transactions by way of security, uncertainty remains over what type of security can be granted and enforced (and how to grant and enforce such security) over digitized securities, for example, whether it is possible to create/register a fixed or floating charge over certain types of digitized security which affects priority and enforceability of such charges. Further, there could also be uncertainties over legal recognition of security document if they are "digitized" (e.g., in the form of smart contract or executed through electronic signatures). For example, where the security is required to be registered with the Companies Registry of Hong Kong, such registration procedures include the delivery of the certified copy of the security instrument. This would create difficulties where there may not be such an instrument in the context of digitized securities, and the current definition of a "certified copy" in the Companies Ordinance is unclear as to how an instrument created/stored on the DLT may be certified as a true copy.

Singapore

Much of the discussion covered above under the U.K. and E.U. legal and regulatory analysis are jurisdictionally agnostic. However, there are certain differences. Singapore does not have an equivalent of the FCA Directive. Accordingly, in Singapore, it would typically be required to satisfy 'true sale' transfers and positive close-out netting analysis.

In relation to uncleared margin rules, MAS has issued the Guidelines on Margin Requirements for Non-Centrally Cleared OTC Derivatives Contracts. Paragraph 7.1 of the Guidelines provides a list of eligible collateral to meet IM and VM requirements. As for the U.K./E.U., the list of Eligible Collateral was not drafted with DLT-based Securities in mind, and it might be helpful to consider whether the list would benefit from clarification in this regard.

609. **https://www.hkma.gov.hk/media/eng/doc/key-functions/banking-stability/supervisory-policy-manual/CR-G-14.pdf.**
610. **https://www.sfc.hk/-/media/EN/assets/components/codes/files-current/web/codes/code-of-conduct-for-persons-licensed-by-or-registered-with-the-securities-and-futures-commission/Code_of_conduct_05082022_Eng.pdf?rev=0fd396c657bc46feb94f3367d7f97a05.**

Japan

Intra-Day Repos

In Japan, the Financial Instruments and Exchange Act **("FIEA")** was amended in 2019 to regulate transactions of tokens representing securities in an attempt to facilitate capital formation in this manner while protecting investors. The amendment came into force in May 2020. As such, a regulatory framework for transactions in respect of DLT-based Securities has already been implemented in Japan (this framework is examined in further detail in **Chapter 4** below). Under this framework, tokens representing (i) a conventional class of financial assets listed as Type I Securities under the FIEA (such as shares and bonds) or (ii) an interest in a collective investment scheme, would be deemed to be "securities". In the case of Intra-Day Repos of traditional "securities", such Intra-Day Repos are subject to the regulations under the FIEA for the sale and purchase of "securities". Accordingly, Intra-Day Repos of tokens representing such "securities" would also be subject to the regulations under the FIEA for the sale and purchase of such "securities". In terms of financial collateral arrangements, the netting of tokens representing "securities" is not distinguished from the netting of "securities" themselves. Therefore, there does not seem to be specific discussion on the netting of tokens representing such "securities". On the other points, the analysis discussed in the U.K./E.U. legal and regulatory analysis above would generally be applicable to Japan.

Variation Margin

With regards to financial collateral arrangements, there has not been discussion to carve out tokens representing "securities" from applicable financial collateral in Japan. In terms of property rights and conflicts of laws, the analysis discussed in section 4.2.4 would generally be applicable to Japan. In terms of uncleared margin rules, requirements for securities to be qualified as VM (**"Qualified Securities"**) are stipulated in a public notification issued by the Japanese Financial Services Agency. However, the current public notification has not been drafted with DLT-based Securities in mind, therefore it would be expected to specify whether tokens representing Qualified Securities are also qualified as VM. In addition, regarding regulatory capital treatment, the current capital adequacy regulation is not made with DLT-based Securities in mind either and it would need to be seen how tokens provided as VM may be treated in the future.

DEEP DIVE #2: FIXED INCOME ISSUANCE

DLT and tokenization are emerging as transformative mechanisms within fixed income issuance, one of the cornerstones of global capital markets. Traditionally, bond issuance involves multiple intermediaries and sequential, manual processes, resulting in delayed settlement cycles and operational inefficiencies. Settlement periods of two days or longer tie up capital, elevate counterparty risk, and necessitate extensive reconciliation efforts among issuers, underwriters, custodians, and investors. Cross-border issuance further exacerbates these challenges, creating fragmented liquidity pools, operational complexities, and limited transparency.

Role, Objectives, and Key Stakeholders

Strategic Objective: The core goal of applying DLT and tokenization to fixed income issuance is to enhance market efficiency, reduce settlement risk, and streamline operational processes. By digitizing bonds on shared, immutable ledgers, stakeholders seek to accelerate settlement cycles, improve liquidity management, and deliver greater transparency and operational certainty.

Operational Objective: Tokenization of bonds enables atomic DvP, ensuring simultaneous, instant exchange of securities and payment tokens on-chain. This model minimizes settlement and counterparty default risk, reduces operational overhead through automation, and provides continuous, real-time market access and transaction transparency.

Key Stakeholders: The ecosystem for tokenized fixed income issuance involves diverse participants, including sell-side investment banks and broker-dealers that structure and underwrite bonds; issuers such as sovereign governments, supranational institutions, and corporations seeking cost-effective and rapid access to capital; buy-side investors such as asset managers, pension funds, and insurers requiring liquidity and transparency; central securities depositories and custodians managing the safekeeping and authoritative records of digital assets; market infrastructure operators launching and managing digital trading venues; and regulators and central banks actively involved in fostering secure, compliant, and stable markets. Collectively, advancements in tokenization have broad implications, promising substantial improvements in the efficiency, resilience, and accessibility of fixed income markets.

Market Overview and Tokenization Milestones (as of 2024)

The global fixed income market is **enormous in scale**, dwarfing equity markets. As of the end of 2023, **global fixed income securities outstanding exceeded $140 trillion**, and annual bond issuance consistently measures in the tens of trillions (about $27 trillion in new long-term bonds issued in 2024 alone)[611]. By contrast, the portion of this market that has been **tokenized** remains **minuscule but rapidly growing**. Only within the last few years have we seen the first live digital bond issuances. In 2018, the World Bank's pioneering *"Bond-i"* (a ~$110 million blockchain bond) was an early proof of concept.[612] Since then, adoption has accelerated: **in 2022 there were just 9 new "blockchain bonds" issued, rising to 16 in 2023, and by mid-2024 the count was 14 issuances worth ~$1.2 billion** (already outpacing the previous year). An industry survey in 2024 found a notable shift in sentiment, with **38% of market participants indicating they are considering DLT for debt issuance**, up from 29% a year prior.[613]

Several **key milestones and live pilots** mark this evolution. **Supranational issuers and sovereigns** have led many early tokenization deals under highly regulated conditions. The **European Investment Bank (EIB)** issued a €100 million **two-year digital bond on a public blockchain in April 2021**, settling in cooperation with Banque de France (which provided a tokenized central bank euro for on-chain DvP).[614] This was among the first fully regulated institutional bonds recorded on Ethereum. The EIB followed up with multiple digital bonds, including a £50 million pound-sterling tokenized bond in 2023 and a €100 million 5-year bond in late 2024.[615] Each of these served as a **real-world test of DLT in primary issuance** – for example, EIB's early trials demonstrated same-day or next-day settlement, automated coupon payments. On the sovereign side, **Hong Kong's government made headlines in February 2023 with the world's first tokenized green bond issued by a government.** This HK$800 million (~USD 100 million) 1-year green bond was issued under Hong Kong law and **settled T+1 with atomic DvP on a private blockchain network** (using GS DAP, Goldman Sachs' tokenization platform). The HKMA acted as both issuer's agent and operator of the bond's clearing system, ensuring that on-chain records were **legally recognized as the definitive record of ownership**

611. SIFMA, Capital Markets Factbook, Accessed 2025.
612. World Bank, "World Bank Prices First Global Blockchain Bond, Raising A$110 Million", August 2018.
613. OMFIF, Digital Assets 2024, Accessed 2025.
614. EIB, "EIB Issues it's First Ever Digital Bond on a Public Blockchain", April 2021.
615. European Investment Bank, "EIB Issues its first ever Digital Bond in Pound Sterling", January 2023.

– a crucial legal innovation.[616] This was followed in February 2024 with the issuance by **Hong Kong's government** of approximately HK$6 billion worth of "digitally native" green bonds denominated in HK dollars (HKD2 billion tranche), Renminbi (RMB 1.5 billion tranche), US dollars (USD 200 million tranche) and euro (EUR80 million tranche) under the Government Green Bond Programme. This used a private blockchain network (HSBC's Orion platform as part of the HKMA's Central Money Markets Unit (CMU)), and the bonds were constituted on-chain without first being issued in a traditional central securities depositary, and with direct participants in the platform holding legal (rather than beneficial) title and with their on-chain records again **legally recognized as the definitive record of ownership**. The bonds were also listed on the Hong Kong Stock Exchange.[617] This was followed in September 2024 with HSBC issuing a HKD 1 billion English-law governed digital bond using its Orion platform in Hong Kong, and further issuances, including in December 2024 by Zhuhai Huafa Group, an issuer incorporated in Greater China, in a 3-year 1.4 billion RMB-denominated digital bond offering, demonstrating the capacity of the Hong Kong regime to accommodate private issuers, incorporated in various jurisdictions, and digital bonds governed by the laws of various jurisdictions. In Europe, **Germany's Finance Agency and KfW** (a German public development bank) have also tested blockchain-based bonds under the country's eWpG electronic securities law. In August 2024, KfW issued a €50 million 3-month digital note which was **settled one day after pricing (T+1) using the Bundesbank's "trigger" bridge to central bank money**, demonstrating successful **DLT-based DvP in euros with automated exchange of tokens.** These milestones, alongside numerous private-sector trials, underscore that tokenization of bonds has moved beyond theory into practice.[618]

Importantly, the aggregate volume remains very small relative to the overall market – a recent industry report shows that **DLT-based fixed income issuance reached roughly €3 billion in 2024**, which is a **260% increase from ~€848 million in 2023** but still a tiny fraction of global bond issuance.[619] This growth in 2024 was boosted by special initiatives (the European Central Bank's market trials contributed about €1 billion, and an Swiss National Bank (SNB)-led trial about €0.8 billion, together accounting for 60% of the total).[620] Even excluding those central bank-led transactions, **the tokenized bond issuance volume roughly doubled year-on-year**, signaling broader momentum. Many of **these digital bonds have been issued in jurisdictions with supportive legal frameworks** – notably Europe (under EU or English law), and Asia (Singapore and Hong Kong), often by highly rated issuers. Platforms such as **SIX Digital Exchange (SDX) in Switzerland and HSBC's Orion platform** have facilitated a large share of the 2024 issuances.[621] Meanwhile, the E.U. **Pilot Regime (effective March 2023)** created a regulatory sandbox for market infrastructures to handle tokenized securities. Under this regime, licensed exchanges and CSDs can obtain temporary exemptions to issue, trade, and settle **DLT-based financial instruments** within a controlled environment. This has spurred a wave of **DLT market infrastructure projects in Europe**, with 2024 seeing the first regulated platforms for digital bond trading and custody go live. In summary, as of 2024, tokenization in fixed income has advanced from isolated prototypes to **live transactions in multiple major jurisdictions**, but the scale remains **pilot-level** (billions, not trillions) and these projects are still carefully overseen by authorities.

Objectives and Inefficiencies in Today's Fixed Income Issuance

Fixed income markets, crucial to global finance, are hampered by inefficient issuance and settlement processes involving multiple intermediaries. Traditional settlements, often taking T+2 days or more, expose counterparties to prolonged credit and settlement risks. For instance, a conventional European Investment Bank (EIB) bond might require up to five days to settle, whereas a blockchain-based digital bonds may achieve settlement in a single day. Additionally, each participant maintains separate ledger records, leading to manual reconciliations that are prone to errors and delays. Cross-border issuances further intensify these issues due to fragmented infrastructures and reliance on correspondent banking, limiting transparency and causing liquidity fragmentation.

How DLT Is Alleviating Pain Points: Use Cases and Outcomes

Early DLT applications in bond issuance demonstrate tangible improvements in settlement speed, efficiency, and transparency. Notably, the European Investment Bank's 2021 blockchain-based bond reduced settlement from five days to one, substantially lowering counterparty risk and enabling atomic DvP.[622] Hong Kong's tokenized green bond also demonstrated integrated digital lifecycle management, including instant settlement and automated coupon payments on-chain, significantly reducing operational complexity and reconciliation efforts.[623]

616. Hong Kong Monetary Authority, HKSAR Government Inaugural Tokenized Green Bond Offering, February 2023.
617. HKMA, HKSAR Government's Digital Green Bonds Offering, Feb 2024.
618. ICMA, Tracker of New Fintech Applications in Bond Markets, August 2024.
619. AFME, DLT-Based Capital Market Report – Size and Growth of the Global DLT Wholesale Market, February 2025.
620. Ibid.
621. Ibid.
622. EIB, "EIB Issues it's First Ever Digital Bond on a Public Blockchain", April 2021.
623. HKMA, HKSAR Government's Digital Green Bonds Offering, Feb 2024.

Tokenization has reduced issuance costs by digitizing record-keeping and bypassing certain intermediary fees. Platforms such as BNP Paribas' "NeoBonds" allow all stakeholders—including regulators—to track ownership and transaction histories in real-time, greatly simplifying compliance checks.[624] Experimental projects, such as the BIS Innovation Hub's Project Genesis, even linked tokenized bonds with real-time IoT environmental data, showcasing how programmability enriches bond transparency.

Market liquidity and accessibility may also benefit from DLT, as continuous trading on digital platforms could enhance global liquidity pools and investor participation. Early pilots indicate potential for fractional and smaller-denomination bond issuances, potentially broadening investor access, though institutional investors still dominate. Market participants remain cautiously optimistic, expecting substantial adoption within a few years, but emphasize the importance of flexible settlement cycles (T+1 or T+2) to balance operational practicality and liquidity management.[625]

Benefits Realized vs. Ongoing Limitations

DLT and tokenization in fixed income issuance offer significant advantages, notably faster settlements, reduced counterparty risk, lower operational costs, enhanced transparency, and potentially broader market access. Real-world pilots demonstrate tangible benefits such as near-instant settlement (minutes instead of days), automated processes reducing errors, and projected operational cost saving 40-60%.[626] Regulators appreciate improved real-time oversight, which could reduce systemic risk and simplify compliance. Flexibility in settlement cycles (e.g., T+0 or T+2) could further enhance market efficiency.[627]

However, challenges remain substantial. DLT's scalability for high-volume markets is largely untested. Legal and regulatory frameworks vary significantly across jurisdictions, creating uncertainty about enforceability and finality of tokenized securities. Interoperability issues persist, given numerous proprietary platforms lacking common standards, potentially further fragmenting liquidity.[628] Additionally, the limited availability of safe digital settlement assets such as wholesale tokenized central bank money complicates full-scale adoption. Concerns around governance, cybersecurity risks, smart contract vulnerabilities, and integration into existing financial infrastructures further impede rapid deployment.[629]

In conclusion, while early DLT deployments confirm significant potential to streamline bond markets, substantial adoption depends on overcoming regulatory, operational, and technological barriers. Stakeholders remain cautiously optimistic, actively collaborating on standards, legal clarity, and interoperability frameworks. Tokenization represents a realistic vision for more efficient and transparent fixed income markets, but realizing this vision requires prudent evolution of regulatory and market structures alongside technological innovation and adoption of industry-wide data standards.[630]

624. BNP Paribas, "Digital Bonds Using Blockchain vs. Traditional Bonds", December 2024.
625. Digital assets 2024 - OMFIF.
626. BCG, Ripple, Approaching the Tokenization Tipping Point, April 2025.
627. FSB, "The Financial Stability Implications of Tokenization", October 2024.
628. BNP Paribas, "Digital Bonds Using Blockchain vs. Traditional Bonds", December 2024.
629. FSB, "The Financial Stability Implications of Tokenization", October 2024.
630. ICMA, Tracker of New Fintech Applications in Bond Markets, August 2024.

Fixed Income Use Case #1: SIX Digital Exchange (SIX) and UBS AG Digital Bond Use Case

Overview of Use Case

The **SIX Digital Exchange (SDX)** is a Swiss-based, fully regulated capital market infrastructure for digital assets. Launched in late 2021, SDX received FINMA licenses to operate both a stock exchange and a CSD for blockchain-based securities.[631] It provides an integrated platform for the **issuance, listing, trading, settlement, and custody** of digital securities under Swiss regulatory oversight.[632] The **UBS AG digital bond** issued on SDX is a flagship example of this new infrastructure in action, representing one of the first large-scale implementations of DLT in a traditional bond market context.

UBS's digital bond (2022): On November 3, 2022, UBS AG issued a CHF 375 million three-year senior unsecured bond with a 2.33% coupon, natively on the SDX DLT platform.[633] This bond was **100% digital** (no paper or physical global certificate) and was recorded on SDX's distributed ledger, **yet it was dual-listed** on both SDX's digital exchange and the conventional SIX Swiss Exchange. Notably, it carried a single ISIN for both venues – a **"single-ISIN" structure** – so that the digital bond did *not* require a parallel traditional issuance ("twin bond"). This was a world-first: UBS's bond was the first ever **publicly traded, regulated digital bond by a global banking institution** that investors could access through either DLT-based infrastructure or traditional market channels.[634] In legal and economic terms, the instrument was **equivalent to a conventional UBS senior note** – same rank, same payment obligations, same credit rating – but with issuance and settlement taking place on a blockchain-based system.[635]

Participating firms and roles: In this use case, **UBS AG** was the issuer of the bond (raising funding as it would with any bond issuance). **SIX Digital Exchange** operated the DLT platform on which the bond was issued, and **SIX Swiss Exchange** provided the traditional trading venue for dual-listing.[636] Post-trade services were provided via **SDX CSD** (the digital ledger-based CSD run by SIX) and **SIX SIS** (the national CSD for Switzerland), which are linked. UBS's bond was arranged to be accessible to a broad investor base: even those without any blockchain infrastructure could buy it through their banks on the regular exchange, while tech-savvy institutions could opt to settle on SDX directly. This was made possible by a critical integration between the new and old infrastructure, as described below.

How the bond issuance and settlement works: The UBS digital bond was created on the SDX ledger as a native digital asset, represented by tokenized securities entries in SDX's **main register** (the authoritative record in the CSD).[637] During the **issuance process**, UBS and its syndicate banks carried out familiar steps such as drafting a term sheet, collecting investor orders, and allocating bonds – largely using traditional workflows off-chain (e.g. using order books and communication via banks).[638] Once allocations were final, the issuance was settled on SDX: investors' custodians received the bond tokens in their SDX CSD account against payment of the issue price. On SDX, **settlement is atomic and instant** – meaning the cash leg and the bond tokens change ownership simultaneously on the ledger, with no lag.[639] The SDX CSD, running on DLT, updates ownership in real-time, so **settlement is effectively T+0 (immediate)** instead of the typical T+2 cycle.[640]

Operational model and participant roles: The SDX model preserved the **role of banks as intermediaries**. In the primary market, banks in the syndicate gathered orders from their clients and interacted with UBS to place the bond – this remained a manual or off-chain process involving the same participant roles as a traditional bond issuance.[641] In the secondary market, trading could occur either on SDX's own digital exchange order book or on the SIX Swiss Exchange (the UBS bond was listed on both). Regardless of trading venue, the **custody and settlement** could happen on either the SDX CSD or via SIX SIS. If two SDX members traded the bond on the SDX platform, they would exchange the security for digital cash tokens on-chain within seconds. If two investors traded through the traditional exchange and wanted to settle in the conventional way, that trade would clear through the usual channels and settle in SIX SIS (with the bond ultimately moving

631. SIX, "SIX Digital Exchange Gets Regulatory Approval from FINMA", September 2021.
632. SIX, "SIX Digital Exchange Established Operational Link to SIX SIS", October 2022.
633. UBS, "UBS AG launches the world's first digital bond that is publicly traded and settled on both blockchain-based and traditional exchanges", November 2022.
634. Ibid.
635. Ibid.
636. Ibid.
637. Ibid.
638. Ibid.
639. UBS, "UBS AG launches the world's first digital bond that is publicly traded and settled on both blockchain-based and traditional exchanges", November 2022.
640. SUERF, "Towards Tokenized Bond Markets? Lessons from Switzerland", December 2024.
641. Ibid.

from a SDX account to a SIS account via the link). Importantly, an investor without any DLT access was not at a disadvantage – they could trade the bond on SIX like any other Swiss bond, and their bank's SIX SIS account would be credited at settlement. Meanwhile, SDX's ledger would simply show that the SIX SIS omnibus account now holds those tokens on behalf of that investor.[642] This design meant the **digital and traditional systems work in tandem**.

Single-ISIN and market reach: By using a single ISIN and connecting the infrastructures, UBS and SDX achieved a unified market for the bond. There was **no fragmentation of liquidity** into separate instruments – the digital bond was the same bond in both venues. This greatly expanded the potential investor base, as noted by SDX: the single-ISIN solution "leads to the greatest possible market reach for native digital bond issuances".[643] In practice, any qualified investor worldwide who could hold a normal Swiss franc bond could also hold the UBS digital bond, either directly on SDX or indirectly via their custodian. For instance, some investors purchased the bond through the traditional exchange and held it at Euroclear/Clearstream via links to SIX SIS, demonstrating that even non-Swiss, international investors could participate without needing to interface with the blockchain.[644] This was a strategic choice to ensure the use case was about efficiency and innovation, not about creating an exclusive market silo.

Quantitative insights: The UBS digital bond was **CHF 375 million**, issued at par. It carries a 2.33% fixed coupon and will mature in November 2025.[645] The bond's size (roughly $460 million) made it a benchmark-sized issue, and at issuance it was reported to be fully placed with institutional investors (the investor breakdown was not publicly detailed for UBS's bond, but it is comparable to other Swiss franc bonds of similar size). In terms of **transaction volume and adoption**, this landmark deal helped bring SDX's total volume of digital bond issuances above CHF 1 billion. By mid-2024, cumulative issuance on SDX's platform reached about **CHF 1.3–1.4 billion across roughly 10 bonds**.[646] The geographic scope of activity has been primarily within Switzerland (most issuers and lead banks are Swiss, and many investors are Swiss-based), but there is growing international involvement – for example, the **World Bank's 2024 digital bond** on SDX saw some allocations to central banks and official institutions outside Switzerland.[647] SDX's participant network is expanding, with global banks (such as **Commerzbank** and **Standard Chartered**) joining as members to enable cross-border access.[648,649]

Key milestones and developments (2021–2025): To put the UBS use case in context, the past few years have seen a series of milestones for SDX and digital bonds in Switzerland:

1. **November 2021 – SDX Launch:** SDX went live with its first digital bond issuance, a CHF 150 million bond by SIX Group (the exchange operator itself) to inaugurate the platform.[650] This initial bond was partially issued on DLT and partially in traditional form (a "twin" structure), as a pilot to demonstrate the technology.

2. **October 2022 – SDX–SIS Link:** SIX Digital Exchange established an **operational link with SIX SIS** (the traditional CSD), allowing digital CHF bonds on SDX to be held and settled in SIS accounts.[651] This created the technical and legal bridge enabling the single-ISIN model for future issuances.

3. **November 2022 – UBS Digital Bond:** UBS AG issued its CHF 375 million digital bond (the focal use case of this chapter) on SDX, dual-listed on SDX and SIX Swiss Exchange.[652] This was the first public, **benchmark-sized** digital bond by a global bank on a regulated platform, garnering significant market attention.

Further activity has been summarized in the **exhibit** below:

642. Ibid.
643. UBS, "UBS AG launches the world's first digital bond that is publicly traded and settled on both blockchain-based and traditional exchanges", November 2022.
644. World Bank Group, "World Bank partners with Swiss National Bank and SIX Digital Exchange to advance digitalization in capital markets", May 2024.
645. UBS, "UBS AG launches the world's first digital bond that is publicly traded and settled on both blockchain-based and traditional exchanges", November 2022.
646. Ledger Insights, "Swiss wholesale CBDC trial with SDX extended by 2 years", June 2024.
647. World Bank Group, "World Bank partners with Swiss National Bank and SIX Digital Exchange to advance digitalization in capital markets", May 2024.
648. Ledger Insights, "Swiss wholesale CBDC trial with SDX extended by 2 years", June 2024.
649. SDX "SIX Digital Exchange Gets Regulatory Approval from FINMA", September 2021.
650. Ian Allison, "Switzerland's Six Digital Exchange Launches with Blockchain Bond", May 2023.
651. SDX, "SIX Digital Exchange Established Operational Link to SIX SIS", October 2022.
652. UBS, "UBS AG launches the world's first digital bond that is publicly traded and settled on both blockchain-based and traditional exchanges", November 2022.

EXHIBIT DD.4

The Swiss Digital Bonds' Ecosystem

Year	Digital Bond Issuance					Volume	
						Helvetia Phase III	Overall
2021	SIX CHF 28.6mn					0	28.6mn
2022	UBS CHF 375mn					0	375mn
2023	Città di Lugano CHF 100mn	Helvetia Phase III Kanton Basel-Stadt CHF 105mn		Helvetia Phase III Kanton Zürich CHF 100mn		205mn	305mn
2024	Helvetia Phase III Città di Lugano CHF 100mn	Helveti Phase III st.gallen CHF 100mn	Helveti Phase III UBS CHF 150mn	Helvetia Phase III THE WORLD BANK CHF 200mn	Helvetia Phase III (Extended) Città di Lugano CHF 120mn	670mn	670mn
Total						CHF 875mn	CHF 1.379bn

Sources: SUERF "Towards Tokenized Bond Markets? Lessons from Switzerland, BCG Analysis.

In summary, the UBS digital bond use case exemplifies how a major bank leveraged a DLT-based capital market infrastructure to issue a **real-world bond** in a regulated environment. It demonstrated faster settlement and operational efficiency while preserving broad investor access. Over the last 2–3 years, this pioneering transaction has been followed by multiple other issuances on SDX, progressively scaling up the platform's usage (from Swiss francs 28 million in 2021 to over 1.3 billion CHF by 2024).[653] The use case underscores an important point: **tokenization and DLT can be implemented in a way that complements, rather than upends, traditional market structures**, easing the path for adoption.[654]

Settlement Asset

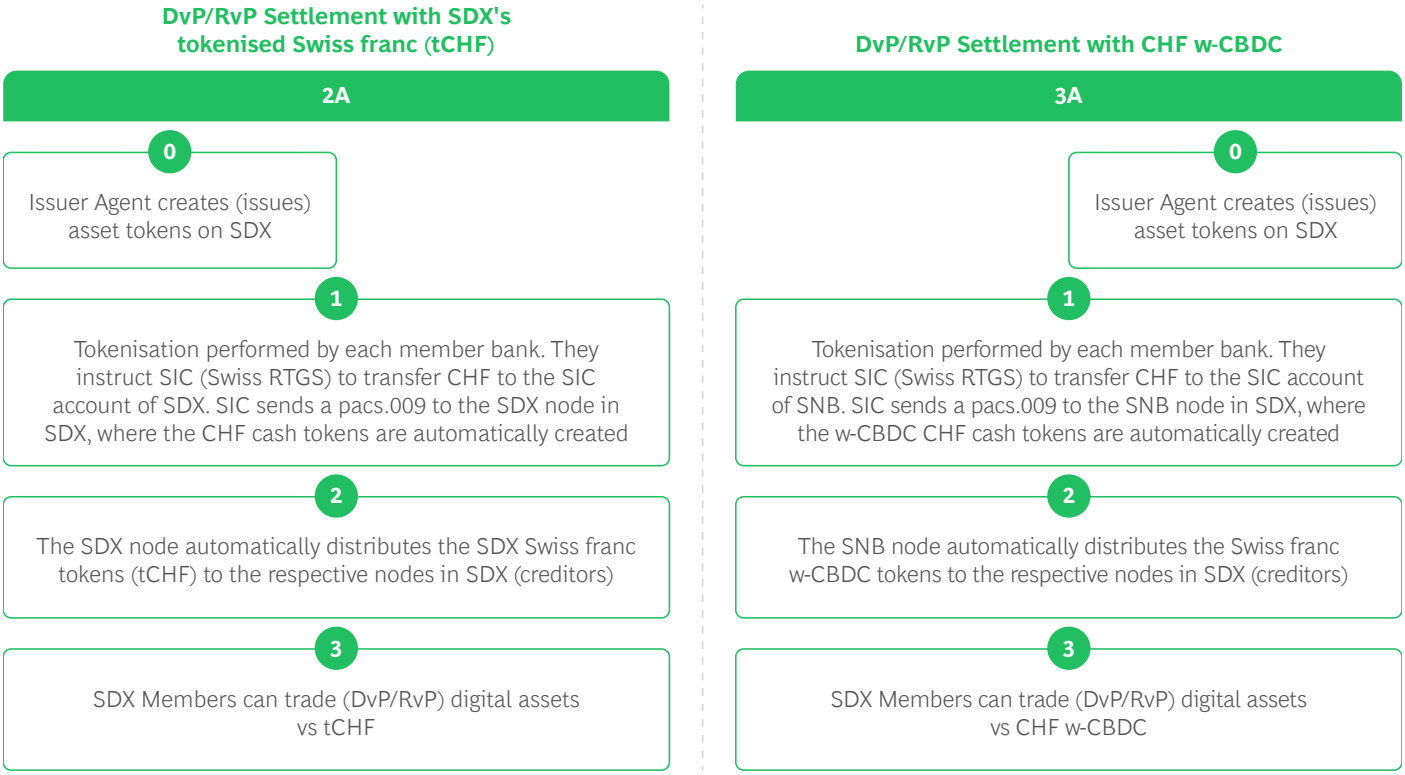
Settlement asset on SDX: To enable atomic DvP on the ledger, SDX utilized a **tokenized form of Swiss franc** on its platform. In practice, this meant that participating banks transferred CHF liquidity into a special account (presumably at the SNB or a commercial bank) in exchange for receiving **digital CHF tokens** (often termed "cash tokens") on the SDX ledger that represented that cash.[655] These tokens were essentially a 1:1 claim on Swiss franc deposits, allowing SDX to simulate cash leg movements within the DLT system. For example, in the **City of Lugano's first digital bond (Jan 2023)**, settlement was done using such tokenized CHF: Lugano's investors paid in fiat CHF which was converted to on-ledger tokens, and against those tokens they received the bond in SDX CSD.[656]

Wholesale CBDC pilot: In late 2023, the landscape evolved with the introduction of **SNB's wholesale CBDC (wCBDC)** on SDX. Under **Project Helvetia Phase III**, the SNB itself **issued digital Swiss franc tokens** (wCBDC) onto the SDX platform for participating banks to use.[657] During the pilot (Dec 2023 – June 2024), six bond issuances (collectively ~CHF 750 m) were settled using SNB's wCBDC.[658] This included the World Bank's CHF 200 m bond and UBS's CHF 150 m second digital bond, among others.[659] The process is demonstrated in the **exhibit** below:

653. SUERF, "Towards Tokenized Bond Markets? Lessons from Switzerland", December 2024.
654. Ledger Insights, "Swiss wholesale CBDC trial with SDX extended by 2 years", June 2024.
655. SUERF, "Towards Tokenized Bond Markets? Lessons from Switzerland", December 2024.
656. Ibid.
657. World Bank Group, "World Bank partners with Swiss National Bank and SIX Digital Exchange to advance digitalization in capital markets", May 2024.
658. Ledger Insights, "Swiss wholesale CBDC trial with SDX extended by 2 years", June 2024.
659. Ibid.

EXHIBIT DD.5

Settlement Asset Workflows for SDX Issuances



Sources: SUERF "Towards Tokenized Bond Markets? Lessons from Switzerland, BCG Analysis.

Settlement finality (technical and legal): On the technical side, SDX's DLT (Corda-based) reaches settlement finality when a transaction is confirmed by the required nodes (including notary service) – at that point, token transfers are irrevocably executed. The platform is designed so that once a trade is matched and instructed for settlement, the atomic swap of bond token for cash token is either done in its entirety or not at all, with no interim state. This is analogous to a DvP in a CSD: either both securities and cash settle, or nothing does. Because SDX is a regulated **CSD**, the finality of transfers on its ledger is also recognized under Swiss law. Switzerland's legal framework (the FMIA and Federal Intermediated Securities Act, among others) was updated to accommodate DLT-based settlements. In particular, Swiss law explicitly allows the creation of **"ledger-based securities"** which are securities whose legal ownership is defined via an entry in a distributed ledger that qualifies as a **main register**[660] SDX's CSD is such a main register for the bonds it issues. Transfers on the SDX ledger achieve **legal finality at the moment of ledger settlement**, backed by the same legal certainty as transfers in SIX SIS.

To elaborate on legal rights: holders of the UBS digital bond have the **same legal claim against UBS AG** as they would if they held a traditional UBS bond in a securities account. The bond's terms are defined in a prospectus (and/or final terms) just like any Swiss franc bond, specifying UBS's obligation to pay interest and principal. The fact that the bond is "digital" does not change investor rights – UBS explicitly noted that the digital bond "has the same instrument structure, legal status and rating as a traditional UBS AG senior unsecured note".[661]

Settlement finality from a legal perspective is further buttressed by designating SDX (and its notary function) under the umbrella of the Swiss **Finality** infrastructure. Switzerland is not in the EU, but it has analogous protections: FINMA's regulations and Swiss National Bank oversight ensure that once a transaction is settled on SDX, it is final even if a participant later defaults. The **atomic DvP** nature means there is no credit risk window where one side is unfulfilled. FINMA's approval of SDX as an exchange/CSD included vetting its DLT model for compliance with these principles.[662] For cross-border aspects, SIX SIS's involvement means that when tokens move to SIS (through the operational link), they effectively become regular

660. SUERF, "Towards Tokenized Bond Markets? Lessons from Switzerland", December 2024.
661. UBS, "UBS AG launches the world's first digital bond that is publicly traded and settled on both blockchain-based and traditional exchanges", November 2022.
662. Ian Allison, "Switzerland's Six Digital Exchange Launches with Blockchain Bond", May 2023.

intermediated securities in SIS; at that point, Swiss law and the rules of SIX SIS govern finality (which are aligned with the **Swiss Finality Act** and international standards). Notably, the World Bank's digital bond explicitly stated that the **securities are governed by Swiss law**, meaning any legal disputes or questions (e.g., around ownership transfers or insolvency treatment) would be resolved under Swiss jurisdiction, which has clarity on DLT securities.[663]

Rights and claims of token holders: Token holders (investors) have all the **economic rights** (coupon payments, redemption, etc.) that the bond promises. Coupons and redemptions on SDX are handled via smart contract-like actions or on-chain corporate actions: for instance, the World Bank's bond was set to pay coupons and principal in tokenized CHF on SDX to the token holders.[664] If an investor holds via SIX SIS, then SIX SIS (as a nominee on SDX) receives those tokenized CHF or wCBDC and passes the cash to the investor through normal payment systems. If UBS defaults, token holders would claim in UBS's insolvency no differently than traditional noteholders of equal seniority. There is no additional collateral or asset backing just because it is on DLT – it is an **unsecured bond** of UBS AG. The legal structure is designed such that holding the digital bond is **economically and legally the same as holding a traditional book-entry bond**.

In summary, the settlement and legal underpinnings of the UBS digital bond use case show a careful blending of novel technology with **established legal principles**.

Interoperability and Network Architecture

DLT network type and architecture: The SDX platform uses a **permissioned DLT network.** Unlike public blockchains (Bitcoin, Ethereum) which anyone can join and validate, SDX's ledger is restricted to authorized participants – mainly regulated financial institutions. Technologically, SDX is built on **R3 Corda Enterprise**, a distributed ledger framework tailored for financial use cases.[665] Corda operates through a network of known nodes where transactions are validated by a consensus service (called a *notary* in Corda) rather than by proof-of-work or proof-of-stake. This means that when UBS's bond tokens are transferred on SDX, a designated trusted node (or cluster of nodes) ensures the transaction is unique and final. The choice of Corda reflects SDX's priorities: **privacy, scalability, and integration**. Only the parties to a given bond trade (and the CSD/notary) see the transaction details, which preserves confidentiality in line with bank secrecy norms. The system is also scalable in the sense that it does not broadcast every trade to all members, reducing bottlenecks. **Consensus mechanism**: Corda uses a form of **Byzantine Fault Tolerant consensus** via its notary infrastructure. Essentially, when two parties agree on a trade, they propose a transaction updating the bond ownership and cash balances; the notary checks that the tokens are valid and not double-spent and then cryptographically signs off, which commits the transaction. This yields immediate finality – once notarized, a transaction is final and irrevocable. There is no block-chaining of many unrelated transactions together as in traditional blockchains; instead, confirmations are on a per-transaction basis. The system thus achieves **high throughput and low latency** settlement, which is important for a market infrastructure (trades can settle in seconds).

Network governance model: SDX is operated by **SIX Group**, and governance is largely centralized in this operator (subject to regulatory oversight). SDX trading has recently been consolidated with SIX, streamlining digital asset trading under a single regulated infrastructure.[666] The network's rules are set by SDX's regulations (which FINMA approves). **Member access** is tightly controlled: banks, broker-dealers, and other institutional players must undergo an onboarding process to run a SDX node or to become a participant. In effect, SDX functions as a consortium or **private network** where SIX is the operator and participants are the member firms – very much analogous to a traditional exchange/CSD membership structure, but with nodes and smart contracts rather than purely central software.

Interoperability with traditional systems: Perhaps the most distinctive feature of the SDX setup is its **interoperability with traditional capital market infrastructure**. Rather than exist as an isolated DLT network, SDX was designed to connect to **the incumbent systems**. The prime example is the **operational link between SDX CSD and SIX SIS** established in 2022.[667] This link bridges the ledger-based securities and conventional securities custody.

Beyond the SIS link, SDX's interoperability extends to international central securities depositories. As noted, SIX SIS acts as a conduit to **Euroclear and Clearstream**, large ICSDs.[668] In the World Bank's 2024 bond, for instance, foreign investors holding through Euroclear could still buy the bond; Euroclear relied on an account link with SIX SIS, which in turn had the link to SDX. This multi-layer linkage meant **SDX-settled securities can be held by global investors using their existing custodian relationships.** Such interoperability is a strong point of this model, as it does not require every end-investor or institution to reinvent their operations to handle DLT.

663. World Bank Group, "World Bank partners with Swiss National Bank and SIX Digital Exchange to advance digitalization in capital markets", May 2024.
664. Ibid.
665. Ian Allison, "Switzerland's Six Digital Exchange Launches with Blockchain Bond", May 2023.
666. SDX, "SDX announces the consolidation of trading for digital assets into SIX Swiss Exchange", May 2025.
667. SDX, "SIX Digital Exchange Established Operational Link to SIX SIS", October 2022.
668. World Bank Group, "World Bank partners with Swiss National Bank and SIX Digital Exchange to advance digitalization in capital markets", May 2024.

DLT network vs traditional FMI: Architecturally SDX **closely resembles a traditional FMI** in structure. It has an exchange (trading platform) – although as of June 2025, new digital bonds will trade only on the traditional SIX exchange, essentially phasing out the separate SDX order book – and it has a CSD for settlement and custody.[669] The roles of brokers, dealers, custodians, paying agents, etc., remain largely the same. This conscious mirroring means that many processes (such as corporate actions, regulatory reporting, etc.) could be adapted from existing frameworks. In effect, SDX chose a **"hybrid" model**: leveraging DLT for settlement efficiency and new capabilities (such as atomic DvP, 24/7 potential, smart contract features for asset servicing), but **retaining the governance and participant structure** of traditional markets.

Interconnection with other DLT platforms: As of now, SDX does not have a direct technical connection to other unrelated DLT networks (such as Ethereum or others). Each issuance on SDX is on **SDX's private ledger only**.

Consensus, scalability, and performance: The SDX/UBS bond use case did not encounter scaling limits in any reported way. The architecture, using Corda, is designed to scale to institutional transaction loads.[670]

The interoperability and architecture of SDX demonstrate an compelling **use case for DLT as a tool**. The system connects with existing market structure and the technology choices prioritize confidentiality, finality, and regulatory compliance. The UBS digital bond was able to be jointly issued in a DLT environment and traditional FMI because of this design. Market participants could thus experience the benefits (faster settlement, potentially lower operational risk, innovative features) without needing to overhaul business workflows. This interoperability model is a useful use-case blueprint for other digital market infrastructure projects.

Conclusion

In summary, SDX/UBS digital bond use case is a promising example of DLT for use in fixed income markets. **Swiss authorities provided a clear legal path and close oversight, which has enabled innovation** in live markets. Key policy considerations – such as maintaining settlement finality, protecting investors, and safeguarding financial stability – have been addressed through a combination of legal reforms and technical design (e.g., atomic DvP, use of wCBDC, integration with existing systems). Market participants have responded with growing interest, as evidenced by multiple issuances and the involvement of high-profile institutions. While still in a nascent stage (the volumes are a modest proportion of global bond markets), the UBS digital bond use case has been a **proof-of-concept at scale**, showing that DLT can be woven into the fabric of capital market infrastructure a promising development for DLT in the future of capital markets.

669. SDX "SIX Digital Exchange Gets Regulatory Approval from FINMA", September 2021.
670. Ledger Insights, SIX Digital Exchange to Settle Stock Trading Using R3's Corda Blockchain, March 2019.

Fixed Income Use Case #2: Euroclear Asian Infrastructure Investment Bank (AIIB) Digitally Native Note

Overview of Use Case

The Asian Infrastructure Investment Bank (AIIB) partnered with Euroclear in August 2024 to issue a **digitally native bond** ("Digitally Native Note", or "DNN") on Euroclear's **Digital Financial Market Infrastructure ("D-FMI")** platform.[671] This was a landmark issuance – **the first US dollar-denominated digital bond on Euroclear's DLT platform and the first by an Asia-based issuer**.[672] The bond was a 2.4-year $300 million sustainable development note rated AAA by Moody's, S&P, and Fitch.[673,674] It was **priced on 20 August 2024 and settled on 22 August 2024 (T+2)**, in line with conventional market timelines.[675] This places the AIIB bond among the largest digital bonds to date globally.[676]

Organizations and roles: AIIB was the issuer, **Euroclear Bank** acted as the CSD and platform operator, and two banks – **Citi and BMO Capital Markets** – led the distribution.[677] Citi served as **dealer and issuing/paying agent**, while BMO was a co-dealer.[678] Euroclear's **Digital Securities Issuance (D-SI)** service facilitated the entire primary market workflow on DLT: **issuance, book-building, distribution to investors, and DvP settlement** in a single integrated process.[679] The bond was assigned an ISIN **XS2615318362** and **listed on the Luxembourg Stock Exchange's regulated market**, making it a public benchmark transaction.[680]

Operational workflow: The issuance workflow largely followed a standard Euro Medium Term Note ("EMTN") process, but on a DLT backend. At pricing, the lead managers (Citi, BMO) collected investor orders and set the terms. Using Euroclear's D-SI platform, Citi as issuing agent **digitally created the new bonds (DNN tokens) on the ledger**, and investors' securities **wallets** on D-FMI were credited with their allotted bonds against payment.[681] **DvP settlement in USD** was achieved on the DLT platform, meaning investors received the bonds at the same time their cash payment was confirmed.[682] Notably, settlement **occurred in under a day,** allowing **issuance and initial secondary trading to settle on the same day** (T+0) if needed, although in this case a conventional T+2 cycle was used.[683] Once issued and settled, **the digital bonds were seamlessly transferred to Euroclear's traditional settlement system** on the same day.[684] This integration enabled investors and market makers to **hold and trade the AIIB bond within their existing Euroclear Bank accounts** in the same way as any other international bond, using established trading venues and infrastructure.[685] By close of issuance day, the DNN was accessible in **standard securities accounts**, ensuring normal post-trade operations (custody, corporate actions, etc.) under familiar processes.[686]

Involved parties and ecosystem: The use case spanned multiple financial infrastructure players, underscoring a hybrid model. **Euroclear Bank**, as an International CSD, was the issuer CSD and maintained the official record of the security.[687] **Luxembourg Stock Exchange** listed the bond and thereby provided regulatory oversight and transparency to the market.[688] Additionally, the bond was made eligible for clearing in **HKMA's CMU** ("Central Moneymarkets Unit") and **SIX Swiss Exchange's** settlement system.[689] In practice, this means that investors in Asia or Switzerland could hold and settle the bond through their local CSD links (the digital bond positions can be mirrored in HKMA's or SIX's clearing systems).[690] Such multi-CSD interoperability broadened the geographic reach of the issuance (Europe, Asia, and beyond) without fragmenting liquidity. On the advisory side, top international law firms were involved – **Clifford Chance advised AIIB, and Allen & Overy (in alliance with Shearman & Sterling) advised the dealers** – highlighting the importance of legal structuring in this innovative transaction.[691]

671. Euroclear, "Asian Infrastructure Investment Bank issues its first DNN", August 2024.
672. Ibid.
673. Ibid.
674. AIIB, "AIIB issues its first digitally native note on Euroclear's D-FMI platform", August 2024.
675. Ibid.
676. Ledger Insights, "AIIB digital bond issued via Euroclear reaches $500m after $200m tap", October 2024.
677. Euroclear, "Asian Infrastructure Investment Bank issues its first DNN", August 2024.
678. Ibid.
679. Euroclear, "D-FMI: Digital Financial Market Infrastructure", Accessed 2025.
680. Euroclear, "Asian Infrastructure Investment Bank issues its first DNN", August 2024.
681. Euroclear, "D-FMI: Digital Financial Market Infrastructure", Accessed 2025.
682. Ibid.
683. AIIB, "AIIB issues its first digitally native note on Euroclear's D-FMI platform", August 2024.
684. Euroclear, "D-FMI: Digital Financial Market Infrastructure", Accessed 2025.
685. Ledger Insights, "AIIB issues $300m digital bond using Euroclear infrastructure", August 2024.
686. Ibid.
687. AIIB, "AIIB issues its first digitally native note on Euroclear's D-FMI platform", August 2024.
688. Ibid.
689. Euroclear, "Asian Infrastructure Investment Bank issues its first DNN", August 2024.
690. Ibid.
691. AIIB, "AIIB issues its first digitally native note on Euroclear's D-FMI platform", August 2024.

Key facts and scale metrics: The AIIB digital bond carried a **4.00% coupon** (semi-annual) and matures on **15 January 2027**.[692] It was issued under AIIB's EMTN program as a **direct, unsecured obligation of AIIB**.[693] The transaction raised **$300 million for AIIB's sustainable development financing** needs, and due to oversubscription, the tapping brought the size to $500 million, underlining investor interest.[694,695] **Over 15 institutional investors** (all qualified investors) participated in the initial issue – a relatively small but significant group given the novel format. The issue was **AAA-rated** and came from a **supranational issuer**, which gave investors comfort despite the new technology. The **market coverage** was international: AIIB bonds typically attract investors from Asia, Europe, and the Middle East, and the listing in Luxembourg and clearance via Euroclear/CMU/SIX enabled global access. This use case demonstrated that even a **high-grade, publicly offered bond can be issued and settled on DLT at scale** without disrupting market access or liquidity. Euroclear noted that the DNN platform is designed to support issuances **"at scale" and broad adoption of digital bonds** by leveraging existing market structures.[696] The AIIB deal was indeed viewed as a **"milestone transaction of many firsts"**, paving the way for further digital issuance by attracting issuers and investors from across the world.[697]

Settlement Asset

Settlement asset: The cash leg of the AIIB digital bond was settled in **traditional fiat currency** (**USD**) **held as commercial bank money** within Euroclear's system. Euroclear Bank **handled the USD payments via its existing payment network** (investors paid USD into their Euroclear cash accounts or via correspondent banks, as with any dollar-denominated Euroclear settlement).[698] On the DLT platform, these cash movements were represented such that **DvP finality** could be achieved: when an investor's USD payment was confirmed, the corresponding DNN token was delivered to that investor's wallet on the ledger.[699] This atomic DvP on DLT was crucial to mirror the risk-free settlement of traditional systems. **Euroclear's D-FMI is integrated with its traditional settlement system**, so once the DLT-based DvP occurred, **records of cash and securities were automatically reflected in Euroclear's books**.[700] In effect, the DLT platform acted as an extension of Euroclear's existing infrastructure, with Euroclear Bank guaranteeing the cash settlement in its role as settlement agent.

Settlement finality: Legally and technically, settlement finality was achieved to the same standards as in traditional Euroclear operations. **Euroclear's DLT platform is fully CSDR-compliant and is part of Euroclear Bank's designated securities settlement system**.[701] This means that transfers of the AIIB digital bond on the platform enjoy the protections of the EU Settlement Finality Directive and relevant Belgian/Luxembourg law, as Euroclear Bank (incorporated in Belgium) operates the system. **Once a transaction is recorded on the D-FMI ledger and integrated into Euroclear's books, it is irrevocable and final** under the prevailing legal framework.[702] Technically, the D-FMI uses **R3 Corda DLT**, which achieves consensus via a notary mechanism to prevent double-spending.[703] When the notary service validates a bond transfer against payment, that transaction is considered final on the ledger. The **integration with the traditional CSD ledger effectively anchors the DLT transaction in the legal finality of Euroclear's system**.[704]

Legal status of the security and investor rights: The digital bond was structured to give investors **the same legal rights and protections as a conventional bond**. AIIB's note is a **direct, unsecured debt obligation** of AIIB, governed by **English law** (as per the EMTN program).[705] Each investor's ownership is represented by a token on the D-FMI ledger, but from a legal perspective, that token equates to a book-entry security entitlement held through Euroclear – **a dematerialized bond**.[706] Luxembourg Stock Exchange officially classifies the AIIB DNN as a **"security token" admitted to its official list**, but importantly it is admitted on the **regulated market**, meaning it had to meet all the regulatory requirements of a public bond issue (disclosure, prospectus approval if required, etc.).[707,708] Investors thus benefit from the usual safeguards: a listed security framework, AAA credit quality of the issuer, and clearly defined legal terms (coupon, maturity, repayment obligations) as per the offering documentation.[709] **Holding the bond via DLT does not diminish investor rights** – holders are entitled to semi-annual interest and full principal repayment at maturity, just as with any AIIB bond. Euroclear's role as CSD and common safekeeper ensures that the digital issuance is recognized under law as valid book-entry holdings. Notably,

692. Ibid.
693. Ibid.
694. Euroclear, "Asian Infrastructure Investment Bank issues its first DNN", August 2024.
695. AIIB, "Investing with Impact: AIIB's Sustainable Development Bonds", May 2025.
696. AIIB, "AIIB issues its first digitally native note on Euroclear's D-FMI platform", August 2024.
697. Ibid.
698. Euroclear, "D-FMI: Digital Financial Market Infrastructure", Accessed 2025.
699. Ibid.
700. Ledger Insights, "AIIB issues $300m digital bond using Euroclear infrastructure", August 2024.
701. Euroclear, "Asian Infrastructure Investment Bank issues its first DNN", August 2024.
702. Ledger Insights, "AIIB issues $300m digital bond using Euroclear infrastructure", August 2024.
703. R3, Glossary – Notary, Accessed July 2025.
704. Ibid.
705. AIIB, Base Prospectus Supplement – Global Medium Term Note Program, April 2024.
706. Ibid.
707. Luxembourg Stock Exchange, "AsiainfraInvBk 4%", August 2024.
708. AIIB, "AIIB issues its first digitally native note on Euroclear's D-FMI platform", August 2024.
709. AIIB, Base Prospectus Supplement – Global Medium Term Note Program, April 2024.

no physical global certificate was used; instead, the bond was **fully dematerialized on DLT** in line with recent legal reforms in Luxembourg and other jurisdictions that enable ledger-based securities.[710] The transaction involved external counsel to ensure that **the tokenized bond meets all legal definitions of a security**.[711]

Interoperability and Network Architecture

DLT network type and architecture: Euroclear's D-FMI platform operates on a **permissioned, private DLT network (consortium-type)** built on **R3 Corda technology**.[712] **Euroclear Bank serves as the network operator**, and key entities (such as the issuing agent, dealers, and CSD) interface with the DLT. Corda's design uses a **notary node to achieve consensus** on transactions ensuring fast confirmation and preventing double spends of securities.[713] The system is engineered for **high reliability and compliance**, aligning with financial industry requirements. **Governance of the network is centralized under Euroclear's control. Scalability** is addressed through the hybrid model: the D-FMI itself can handle issuance and a certain volume of transactions on-chain, but because it off-ramps assets to the traditional platform for secondary trading, it avoids hitting a throughput bottleneck on the DLT. In effect, **the DLT network is used for those parts of the process where it adds efficiency (initial issuance and atomic settlement), while heavy ongoing trading is handled by Euroclear's existing settlement engine**.[714,715] This architecture prevents the fragmentation of liquidity – the AIIB bond trades just like any other Euroclear-held bond post-issuance, instead of being confined to a DLT environment.

Integration and interoperability with traditional systems: A standout feature of this use case is **seamless interoperability between the DLT platform and traditional market infrastructure**. Euroclear **fully integrated D-FMI with its conventional settlement system**, meaning every digital bond issued is automatically recognized in the main Euroclear Bank system.[716] Investors did not need any new technology or wallets on their end; if they are Euroclear participants, they simply see the AIIB bond in their account and can settle trades as usual. This integration was key to **avoiding a bifurcation of liquidity or technology adoption**.[717] As AIIB's Treasurer noted, market participants could buy and sell the digital bond "within their existing account structures," avoiding any need to "embrace DLT" directly or face operational fragmentation.[718] In practice, immediately after issuance on DLT, Euroclear **transferred the securities balances and cash proceeds from the DLT ledger to its traditional ledger**.[719] The bond then became **fungible with other securities for secondary clearing and settlement**. This hybrid model ensures that interoperability with **trading venues, settlement channels, and liquidity facilities** is maintained.[720] By aligning D-FMI with existing post-trade processes (and complying with CSDR), Euroclear effectively bridged the new DLT network to the established **international securities infrastructure**.[721]

Interoperability with other DLT and external networks: While the AIIB use case did not explicitly involve connecting multiple blockchains, Euroclear's strategy emphasizes **interoperability with other emerging digital networks**. The AIIB bond itself could be **held in token form at Euroclear or mirrored into other CSDs (HKMA's CMU, SIX in Switzerland) via existing links**.[722]

Network governance and alignment with market infrastructure: Euroclear's D-FMI is often described as a **"digital hybrid" model** – it uses cutting-edge DLT but remains tightly aligned with traditional FMI governance.

Conclusion

In conclusion, the Euroclear-AIIB digital bond use case illustrates that with careful attention to legal structure, regulatory compliance, and system design, **DLT can be integrated into capital markets in a prudent, stepwise manner.** The use case navigated potential regulatory ambiguities by working within established frameworks (CSDR, listing rules) and was compliant with the relevant regulatory standards in the respective jurisdiction (for example Belgium and Luxembourg). It addressed market and policy concerns by ensuring **no disruption to liquidity or investor rights**, and showcased DLT benefits such as increased efficiency (faster settlement) and resilience (distributed technology under a controlled setup). Moving forward, this issuance is likely to have utility as a successful use-case for **broader adoption of digital securities**. It stands as a **neutral, professional benchmark**: a digital bond that is at once innovative and yet fully recognizable under existing institutional frameworks, thereby building confidence for future digital issuance projects worldwide.[723]

710. Luxembourg Stock Exchange, "Security Tokens", Accessed 2025.
711. AIIB, "AIIB issues its first digitally native note on Euroclear's D-FMI platform", August 2024.
712. Ledger Insights, "AIIB issues $300m digital bond using Euroclear infrastructure", August 2024.
713. R3, Glossary – Notary, Accessed July 2025.
714. Euroclear, "D-FMI: Digital Financial Market Infrastructure", Accessed 2025.
715. Ledger Insights, "AIIB issues $300m digital bond using Euroclear infrastructure", August 2024.
716. Euroclear, "Asian Infrastructure Investment Bank issues its first DNN", August 2024.
717. Ledger Insights, "AIIB issues $300m digital bond using Euroclear infrastructure", August 2024.
718. Ibid.
719. Euroclear, "D-FMI: Digital Financial Market Infrastructure", Accessed 2025.
720. Euroclear, "Asian Infrastructure Investment Bank issues its first DNN", August 2024.
721. Ledger Insights, "AIIB issues $300m digital bond using Euroclear infrastructure", August 2024.
722. Euroclear, "Asian Infrastructure Investment Bank issues its first DNN", August 2024.
723. Ibid.

EXHIBIT DD.6

Primary Market Issuances: Development has been fostered by a small number of issuers, including EIB and the HK government

	EIB-Mercury	EIB-Venus	EIB-Mars	HK-Evergreen 1	EIB-Saturn	HK-Evergreen 2
Date	**Apr–21**	**Nov–22**	**Jan–23**	**Feb–23**	**Jun–23**	**Feb–24**
DLT network	Public permissionless	Private Permissioned	Private Permissioned + Public Permissioned	Private Permissioned	Semi Permissioned	Private Permissioned
Currencies	EUR	EUR	GBP	HKD	SEK	HKD, CNH, EUR, USD
Total deal size (USD equiv.)	107m	107m	63m	100m	95m	750m
Number of External Investors	Less than 5	Less than 5	Less than 5	Less than 5	Less than 5	More than 50
Governing Law	France	Luxembourg	Luxembourg	Hong Kong	Lux	HK
Digitally native or tokenised?	Digitally native	Digitally native	Digitally native	Tokenised	Digitally native	Digitally native
Access via CSD accounts?	No	No	No	No	No	No
Platform	SOCIETE GENERALE	Goldman Sachs	HSBC	Goldman Sachs	CRÉDIT AGRICOLE	HSBC
Other Syndicate Members	Santander, Goldman Sachs	Santander, SOCIETE GENERALE	BNP PARIBAS, RBC	HSBC, ICBC, CRÉDIT AGRICOLE	SEB	ICBC, CRÉDIT AGRICOLE, Goldman Sachs, UBS

Source: "The Impact of Distributed Ledger Technology in Global Capital Markets", GFMA, BCG, Clifford Chance and Cravath, April 2023.

Project Mercure: EIB digital bond on public DLT, April 2021

In April 2021, EIB issued a DLT-based bond on Ethereum, the first multi-dealer led digitally native issuance using a public network.[724] Apart from its novelty, this issuance was notable because it was settled through CBDC from the Banque de France.[725] It also marked the first time the bond was sold to third parties, as opposed to pre-identified counterparties.[726] Key terms of the issue are summarized in the **exhibit**.

EXHIBIT DD.7

Summary of Key Terms, EIB Issuance (April 2021)

Issue Amount	**€100M**
Pricing Date	27 April 2021
Settlement Date	28 April 2021
Maturity Date	28 April 2023
Coupon	0.000%, annual
Re-offer Yield	-0.601%
Re-offer Price	101.213%
Governing Law	French law
Joint Lead Managers	Goldman Sachs, Santander, Société Générale
Registrar, Fiscal Agent, Settlement Agent and Platform Manager	Société Générale – FORGE
Legal advisers	Linklaters LLP (to EIB) and Allen & Overy LLP (to the joint lead managers)
DLT network	Ethereum (public DLT network)

Source: EIB.

724. European Investment Bank, "EIB issues its first ever digital bond on a public blockchain," Apr 2021.
725. Ibid.
726. Ledger Insights, "Goldman, Santander, SocGen help European Investment Bank issue €100m public blockchain bond," Apr 2021.

Issuance details

The EIB bond was a €100 million issuance of 2-year AAA-rated bonds on the SG Forge platform, which runs the on public Ethereum DLT network. The selection of a public DLT network was notable given that previous experiments from sovereign issuers had used permissioned private DLT network.[727] While the network was permissionless, the application provided by SG Forge for the issuance was tightly permissioned.[728] This meant that all tokens had whitelisting in place to restrict holders to only the eligible counterparties and investors.[729] Furthermore, there were smart contracts that conducted KYC/AML/CFT and sanctions checks to verify counterparty identities before the relevant transaction could take place.[730] Finally, in accordance with French law, SG Forge maintained a monitoring system outside of the blockchain ledger for the bondholders' positions to track any potential operational risk issues.[731]

The issuance was arranged under the Société Générale's Compliant Architecture for (DLT-native) Security Tokens ("CAST") standard, which is designed for French law and regulation.[732] The bond tokens were designated under French law as MiFID2 financial instruments.[733] Although the bonds were fully digitally native, the issue was legally equivalent to a traditional bond's rights and obligations.[734] Fitch Ratings, which provided the credit rating for the bond, noted that the DLT underlying the issue did not create any additional credit risk compared with a traditional bond issuance.[735] In accordance with French law, the issue proceeded without a traditional CSD or CCP, opting for a DLT-based registry instead.

The bond settled on a T+1 timeframe using a CBDC proxy provided by the Banque de France, meaning that the bond completed issuance, trade, and settlement entirely on the distributed ledger. Banque de France used smart contracts to issue and control CBDC tokens and ensure simultaneous CBDC transfer in accordance with DvP.[736]

Key Benefits

- EIB benefited from the lower cost of issuing on a public DLT network.
- The programmability of the SG Forge ecosystem allowed for robust layers of permissioning, security, and control on top of the public DLT layer.
- The issue demonstrated that a digitally native issuance can fit within a regulatory framework as legally equivalent to a traditional bond.

Project Venus: EIB digital bond on private DLT network, Nov 2022

EIB issued its second digitally native bond token in November 2022, this time on a private, permissioned DLT network via GS DAP, Goldman Sachs' tokenization platform. A notable aspect of this issuance was the same-day T+0 settlement across two distributed ledgers in partnership with the Banque de France and Banque Centrale de Luxembourg. In addition, the bond was admitted to the Luxembourg Stock Exchange and used the Common Domain Model for associated interest rate swaps (refer **exhibit**).[737]

EXHIBIT DD.8

Summary of Key Terms, Project Venus

Issue Amount	€100M
Pricing date	29 November 2022
Settlement date	29 November 2022
Maturity date	29 November 2024
Coupon	2.507%, annual

727. Ibid.
728. SIFMA, "Why Basel Should Not Apply A Blanket Infrastructure Risk Add-On For Group 1 Cryptoassets," Nov 2022.
729. Ledger Insights (2021).
730. SIFMA (2022).
731. Ibid.
732. Ibid.
733. Ibid.
734. Fitch Ratings, "Fitch Assigns European Investment Bank's Proposed Digital Bond Issuance 'AAA' Rating," Apr 2021.
735. Ibid.
736. Banque de France, "Experiment on the use of Central Bank Digital Currency (CBDC)," Apr 2021.
737. EIB, "EIB innovates further with Project Venus, the first euro-denominated digital bond on a private blockchain," Nov 2022.

Re-offer yield	2.507%
Re-offer price	100%
Governing law	Luxembourg law
Admission	Luxembourg Stock Exchange SOL (Securities Official List)
Joint lead managers	Goldman Sachs Bank Europe SE, Santander, Société Générale
Legal advisors	Clifford Chance (to EIB) Allen & Overy LLP (to the joint lead managers) Ashurst (to GS DAP™)
DLT network	Private DLT-network via Tokenization platform by Goldman Sachs (Hyperledger BESU/DAML)
Central Account Keeper	Goldman Sachs Bank Europe SE
Account Keeper	Société Générale Securities Services Luxembourg (SGSS Luxembourg)

Source: EIB.

Issuance Details

The issuance was issued, recorded, and settled as the first transaction on GS DAP, Goldman Sachs' tokenization platform. The DAP platform runs a private-permissioned distributed ledger using Digital Asset's DAML smart contract language and its Canton private DLT network.[738] Given the private-permissioned nature of the system, all participants were controlled and screened by default.

The settlement mechanism this time was atomic, completing the process in less than one minute.[739] In this implementation, clients purchased Security Tokens with cash. Goldman Sachs and the other lead managers (Santander and Société Générale) then settled the purchases on DLT using euro-based CBDC. The cash leg relied on a separate permissioned distributed ledger jointly operated by Banque de France and Banque Centrale du Luxembourg.[740] Settlement was therefore "cross-chain" between the central bank and Goldman Sachs' distributed ledger; it required a trusted message exchange protocol (HTLC) to coordinate the simultaneous exchange of experimental CBDC tokens for bond tokens in accordance with DvP.[741]

The bond was issued under Luxembourg law and subsequently the first syndicated digital bond to be admitted to the Luxembourg Stock Exchange.[742] Moody's, which gave the issue an Aaa rating, based its adjudication on EIB's strong credit position and robust risk management practices.[743] It noted the novelty and potential cyber risk posed by issuing the bond using DLT. However, it emphasized that the credit risk of the issue is ultimately dependent on EIB itself, not on the technology underpinning the issue.[744] Furthermore, it noted that the technology risk posed by DLT was "limited" by the private-permissioned nature of the platform, and the separation between EIB's internal technology systems and the DLT platform.[745]

Finally, the DAP platform supported an associated interest rate swap as a hedging instrument using the CDM, intended as a first trial of future on-DLT interest rate solutions.[746]

Key Benefits

- EIB benefited from the low issuance cost and successfully demonstrated atomic settlement.
- Permissioning, security, and control were built into the DAP platform and cash settlement distributed ledgers themselves.
- The issue successfully demonstrated a cross-distributed ledger settlement involving communication between the securities ledger and cash ledger.
- The interest rate swap could lead to further innovation with CDM-based derivatives on the GS DAP platform.

738. Digital Asset, "Goldman Sachs' Tokenization Platform GS DAP, Leveraging Daml, Goes Live," Jan 2023.
739. Ibid.
740. Banque de France, "The Banque de France and the Banque centrale du Luxembourg jointly conducted a successful wholesale central bank digital currency initiative," Nov 2022.
741. Ibid.
742. Ibid.
743. Moody's, "Moody's assigns Aaa rating to EIB's second digital bond," Nov 2022.
744. Ibid.
745. Ibid.
746. EIB (2022).

Project Mars: EIB GBP digital bond on private and public DLT networks, Jan 2023

On January 31, 2023, EIB issued its latest digitally native bond, and its first in pound sterling. This bond—a £GBP50 million 3-year floating rate note—was issued on both private and public distributed ledgers. Firstly, the bond was issued on a private-permissioned DLT network on HSBC's Orion platform. At the same time, HSBC Orion also mirrored key anonymized details of the issuance on a public DLT network. The bond is "digitally native", represented in securities tokens. Payment for bonds is processed on the platform using tokenized DLT GBP. BNP Paribas and RBC Capital Markets were the other joint lead managers.

EXHIBIT DD.8

Summary of Key Terms, Project Mars

Issue Amount	GBP£50M
Pricing date	31 January 2023
Settlement date	02 February 2023
Maturity date	03 February 2025
Coupon	SONIA + 12bps
Re-offer yield	SONIA + 12bps
Re-offer price	100%
Governing law	Luxembourg law
Admission	Luxembourg Stock Exchange SOL (Securities Official List)
Joint lead managers	BNP Paribas, HSBC, RBC Capital Markets
Legal advisors	Clifford Chance (to EIB) Allen & Overy LLP (to the joint lead managers)
DLT network	Private DLT-underpinned platform, via Tokenization platform by HSBC
Central Account Keeper	HSBC Continental Europe, Luxembourg Branch
Account Keeper	HSBC Bank, U.K. BNP Paribas Securities Services Royal Bank of Canada

Source: EIB.

Issuance details

This inaugural issuance on the HSBC Orion platform was the first ever GBP tokenized bond. The platform is the first to use the Central Account Keeper (**"CAK"**) status in Luxembourg digital assets regulation. The bond was issued under Luxembourg Law and is listed on the Luxembourg Stock Exchange. Money movement was handled by the creation of a settlement tokens backed by cash held at HSBC and deposited by Secondary Account Keepers. This approach allows later adoption of CBDCs or other money options, as they arise.

Issuing on both private and public networks was novel. The private DLT network is built using technologies including Hyperledger Fabric, and DAML smart contracts running on Canton. The public DLT network is Ethereum Mainnet. For future issuances on the platform the decision to use both private and public DLT networks, or just private, will be an issuer decision.

Key Benefits

- EIB benefited from low issuance cost and demonstrated atomic settlement with a floating rate coupon.
- The three banks gained significant insight into the operational and legal complexities of the market, and the platform is the first to use the CAK in Luxembourg law.
- The platform provides a simple low impact adoption pathway for existing market participants that enables transition to shorter settlement cycles.

Project Evergreen I: HK digital bond on private DLT network, Feb 2023

On February 15, 2023, the Government of Hong Kong issued its first tokenized green bond—a HK$800 million offering under the Government Green Bond Programme. The bond was issued using GS DAP, Goldman Sachs' tokenization platform and settled on a private-permissioned DLT network. Payment and lifecycle events—including coupon payments, secondary trading, and redemption—are executed using HKMA-issued cash tokens. On-chain records serve as the legally definitive source of ownership. The transaction marks the first government-issued tokenized green bond globally and forms part of Hong Kong's broader strategy to position itself as a hub for digital assets and sustainable finance. Ashurst advised Goldman Sachs on both the development of GS DAP and the execution of the transaction.

EXHIBIT DD.9

Summary of Key Terms, Project Evergreen I

Issue Amount	HK $800M
Pricing date	February 15, 2023
Settlement date	February 16, 2023
Maturity date	February 16, 2024
Coupon	4.05%
Re-offer yield	4.05%
Re-offer price	100%
Governing law	Hong Kong Law
Admission	Hong Kong Stock Exchange (HKEX)
Joint lead managers	Bank of China, Credit Agricole CIB, Goldman Sachs, HSBC
Legal advisors	Allen & Overy (to issuer) Ashurst (to Platform Provider) Linklaters (to banks and trustee)
DLT network	Private DLT-underpinned platform, via Goldman Sachs' DAP™ platform
Central Account Keeper	Goldman Sachs
Account Keeper	Bank of China Credit Agricole CIB Goldman Sachs HSBC Bank ICBC

Sources: HSBC.

Issuance details

Issued under the Hong Kong Government Green Bond Programme, it was executed on GS DAP, Goldman Sachs' tokenization platform and settled on a private-permissioned DLT network. The issuance used HKMA-issued cash tokens for delivery-versus-payment settlement on a T+1 basis, and all bond lifecycle events, including coupon payments and redemption, are processed on-chain.

On-chain records serve as the legally definitive record of ownership. The bond is cleared through the Central Moneymarkets Unit (CMU) and benefits from statutory settlement finality under Hong Kong law. This transaction follows earlier private sector trials and demonstrates government-scale deployment of tokenization infrastructure.

Key Benefits

- Enabled fully digital settlement and lifecycle management using central bank cash tokens.
- Demonstrated legal and regulatory readiness for tokenized government securities in Hong Kong.
- Showcased the GS DAP platform's ability to support sovereign issuances and complex market infrastructure requirements.

Project Evergreen II: HK digital bond on private DLT network, Feb 2024

On September 27, 2024, HSBC issued HK$1 billion in digitally native notes via its proprietary DLT platform, HSBC Orion—marking the first corporate issuance of its kind in Hong Kong. The transaction builds on the earlier landmark tokenized green bond by the HKSAR government, also executed on HSBC Orion. The notes are listed on the Hong Kong Stock Exchange and cleared through the Central Moneymarkets Unit (CMU) operated by the Hong Kong Monetary Authority (HKMA). Ashurst advised HSBC on the legal and regulatory structuring of the issuance, reinforcing collaboration between key stakeholders in advancing Hong Kong's digital asset ecosystem.

EXHIBIT DD.10

Summary of Key Terms, Project Evergreen II

Issue Amount	HK $1B
Pricing date	September 27, 2024
Settlement date	September 29, 2024
Maturity date	September 29, 2025
Coupon	3.6%
Re-offer yield	3.6%
Re-offer price	100%
Governing law	Hong Kong Law
Admission	Hong Kong Stock Exchange (HKEX)
Joint lead managers	Credit Agricole CIB, Bank of China, ICBC, UBS, HSBC
Legal advisors	Ashurst (to issuer) Clifford Chance (to platform provider)
DLT network	Private permissioned blockchain via HSBC Orion
Central Account Keeper	HSBC
Account Keeper	Credit Agricole CIB Bank of China HSBC ICBC UBS

Sources: Ashurst, HSBC.

Issuance details

HSBC issued HK$1 billion in digitally native notes through its proprietary DLT platform, HSBC Orion. This marks the first digitally native bond by a Hong Kong corporate issuer, following the HKSAR government's earlier use of the same platform. The bond is settled on a private-permissioned blockchain network, with full lifecycle events—including secondary trading, coupon payments, and redemption—executed digitally.

The notes are listed on the Hong Kong Stock Exchange and cleared through the Central Moneymarkets Unit (CMU), under Hong Kong law. The issuance showcases HSBC Orion's flexibility in supporting both sovereign and corporate digital bond offerings.

Key Benefits

- Enabled end-to-end digital issuance and settlement within an institutional-grade blockchain environment.
- Demonstrated HSBC Orion's capability to support corporate bond issuance at scale.
- Reinforced Hong Kong's position as a leading hub for digital assets and capital markets innovation.

Legal Considerations

The legal and regulatory considerations for sovereign bonds are largely covered in **Chapter 4** for U.S., U.K., E.U. and other jurisdictions.

U.K./E.U.

In principle, there is nothing that would expressly prevent the use of DLT in relation to the native issuance and trading of sovereign bonds. Generally, however, one of the main considerations when analyzing sovereign bond issuance in the context of DLT-based systems is whether the sovereign has adequate powers under the relevant legislation to pursue a digital issuance of sovereign bonds. Such legislation would have to be considered on a case-by-case basis and may contain requirements that are incompatible with a digital issuance, for example by mandating that the issuance takes place in certificated form or that the bonds are made available to certain persons. Provided the relevant legislation is compatible with digital issuance, then the digital sovereign bond issuance would still face the legal and regulatory challenges and hurdles that apply to debt instruments generally, as are set out in detail in **Chapter 4**. These challenges include: (i) whether the digital security issued constitutes a valid debt instrument in accordance with the laws of the local jurisdiction; (ii) whether, upon creation, the structure is such that it grants a legally enforceable obligation to the token holder; and (iii) whether the debt instrument (issued on a DLT-based system) can be traded in accordance applicable pieces of E.U.-level and UK legislation (for example, in accordance with book-entry requirements Article 3(2) of the Common Securities Depository Regulation (CSDR)).[747]

For a full legal and regulatory analysis of the current framework for debt instruments generally, and the challenges surrounding the application of DLT-based systems, please see **Chapter 4**.

Practically, there may be other factors that present challenges in the context of a sovereign bond issuance. Due to their public status, sovereigns may have a particular sensitivity to legal risk, and in practice sovereign issuers often rely on established value chains (and the checks and balances applied therein) to ensure legal certainty. Arguably, a key component of this reliance is the knowledge that adequate legal checks are being completed across the intermediaries by virtue of applicable regulation. By way of example, in the U.K., gilts are issued onto CREST, which qualifies as an "Operator" for the purposes of the Uncertificated Securities Regulations 2001[748](the "**USRs**"). As an Operator, CREST must comply with certain requirements, for example compliance with sanctions and the relevant AML/KYC legislation (for a discussion of such requirements, please see **Chapter 2.2** above). Accordingly, CREST's participants are authorized for the purposes of the relevant legislation, reducing the legal risk to which the sovereign issuer is exposed. Operating in an established value chain mitigates the risks of an open market.

The barriers to adoption of DLT are generally the same as for commercial bond issuances except that, due to the special position of sovereign entities, it is arguably more important to ensure that the chain of intermediaries and participants in the process are being regulated and monitored. Similar to the discussion in **Chapter 2.2**, this is likely to be achieved via the use of permissioned environments, either on private or public DLT networks.

Sovereigns are often keen to ensure that there is an unrestricted ability to tap existing bond issuances, which is usually achieved by issuing new bond tranches that are fungible with previous a previous tranche of bonds that have been issued by them. Therefore, a vital further consideration when implementing DLT-based systems in the context of sovereign bond issuances is to ensure that fungibility can be assured, such that holders are not able to distinguish between the relevant tranches of the same series of bonds.

On a national level, it should be considered whether the applicable statute or regulation may have to be clarified or amended. For example, in the U.K., gilts are one of the few debt securities issued under the USRs. It is unclear whether a DLT-based system utilizing a multi-jurisdictional spread of nodes could satisfy the requirement for a U.K. registrar under the USRs. Legislators and regulators could provide certainty to issuers (sovereign or otherwise) by clarifying that this requirement is either satisfied, or disapplied in respect of financial instruments issued under the USRs. Practically speaking to issue debt instruments using a DLT-based system under the USRs would require an Operator (e.g., CREST) to operate a suitable DLT platform. No Operators do so at present, and as such the USRs are not currently a practical option for the issuance of Digital Sovereign Bonds. Please see Section E of the Executive Summary for a summary of the U.K.'s DIGIT and DSS.

Secondary Market (Tokenized Securities):

While the discussion above contemplates the sovereign entity completing a native issuance of bonds, this is not the only relevant application of DLT in this context. Even if the sovereign entity issues traditional debt instruments, market participants may be able to create Tokenized Securities, in accordance with the "True Tokenization" process, as set out in **Chapter 4**. In this case, the same legal and regulatory challenges and hurdles that apply to the issuance of DLT-based Securities generally would be relevant for consideration (see **Chapter 4.1**).

747. Regulation (E.U.) No 909/2014.
748. The Uncertificated Securities Regulations 2001 (SI 2001/37755).

Hong Kong

The Government Bond Programme and Government Green Bond Programme are initiatives of the Hong Kong Government to develop the local bond market in Hong Kong. The bonds issued under these Programmes are a form of securities which are subject to the existing securities regulatory framework in Hong Kong including the Securities and Futures Ordinance ("SFO").

Where sovereign bonds are to be tokenized, below are several key legal and regulatory points which may benefit from additional clarification:

1. **Token creation and documentary formalities.** The documents required to support a sovereign bond's legal structure is multifold, including constitutional documents, subscription agreements and registry filings. The Tokenization process will need to clearly define which part of the bond issuance process and the relevant documents are "tokenized", what "Tokenization" of a certain process or document really means (e.g., whether the information is stored on a distributed ledger, or an agreement is executed using smart contract, and what rights and obligations a Security Token issued in this process confers), including whether a copy/version of the same exists outside of a distributed ledger and what its legal effect is in case of discrepancy.

   Further, the issuer may need to have Tokenization-specific documents in place, including a token purchase agreement that outlines the rights of investors and the tokenized bond offering details, tokenized bond creation deed/terms of the token, smart contract code, custody deed, disclosure documents including technical papers, underwriting agreement and third-party agreements with service providers including technology auditors and software/platform developers.

   As discussed in further detail in **Chapter 4**, there is legal uncertainty as to how current electronic transaction rules (e.g., the Electronic Transaction Ordinance) apply to DLT-based transactions and smart contracts, in particular potential non-recognition of electronic execution of certain instruments that are required to be stamped under the Stamp Duty Ordinance, transactions involving government entities where only limited certification authorities are recognized under the Electronic Transactions Ordinance, and deeds. This means the valid execution of such documents could be incompatible with migration to DLT absent legal clarification or update.

2. **Ownership and transferability.** Formal recognition of the legal nature, including what constitutes evidence of ownership, of tokenized bonds is required. Technical aspects of evidence of title should also be clarified, such as whether such evidence should be on a public or private network and the number of confirmations that will be required for a tokenized bond's transfer to be final.

   Clarification is required as to the content of a transfer of a tokenized bond – whether the transfer includes with it the legal rights and obligations of the bond or any rights on a distributed ledger or outside of a distributed ledger, or is merely a representation of a beneficial interest in the token or any underlying asset. The documentation on a distributed ledger/on an issuance platform should clearly delineate the consequences of a transfer, as well as potentially automating the corresponding notice procedures, assignments, or any other transfer mechanics.

3. **Suitability and investor protection.** Existing investor protection provisions including suitability and disclosure requirements may need to be updated in view of Tokenization, such as whether a tokenized bond would be a "complex product" due to its specific structure on the DLT or depending on exactly which part of the bond issuance is "tokenized". More regulatory guidance would be welcome on how various risks regarding the suitability of a tokenized bond vis-a-vis a client can be ascertained (e.g., the measurement and standards for product risk and concentration risk etc.), and guidance should be given to outline distributors' obligations and factors to be considered when evaluating the suitability of the tokenized bonds to clients.

Singapore

In Singapore, the issuance of Government securities and Treasury Bills are governed by the Government Securities (Debt Market and Investment) Act 1992. MAS is appointed to act on the Government's behalf as an agent for issuing of Government securities or Treasury Bills for moneys borrowed under this Act.

There is also the Significant Infrastructure Government Loan Act 2021, which authorizes loans to be raised by the Government in relation to nationally significant infrastructure. Similarly, MAS is appointed to act on the Government's behalf as an agent for issuing of securities for moneys borrowed under the Act. An inaugural sovereign green bond was issued in August 2022 under this Act.

Similar to how the issuance of digital tokens which constitute regulated products such as security tokens, are subject to the same regulatory regime under the Securities and Futures Act 2001 (the "SFA"), i.e. they are considered as offers of securities made through traditional means, MAS takes a technology-neutral stance towards the issuance of sovereign bonds whether digital or made through traditional means.

DEEP DIVE #3: TOKENIZATION OF FUNDS

Tokenization of investment funds, particularly money market funds ("MMFs"), is being pursued to transform capital markets through enhanced efficiency, transparency, and accessibility. This initiative involves digitizing fund shares using DLT to streamline and modernize traditional market infrastructure, closely paralleling the roles and mechanisms established within repos and collateral management.[749]

Strategic Objectives:

The strategic objective of tokenizing investment funds mirrors the repo and collateral management systems—efficiently allocating liquidity within capital markets while effectively controlling and mitigating risks. By tokenizing fund shares on blockchain technology, stakeholders aim to significantly reduce counterparty credit risk through accelerated settlement cycles (potentially instant or T+0).[750] This shortened settlement window greatly reduces the likelihood of counterparty default, aligning closely with the secured lending nature of repo markets, where timely settlement and liquidity management are essential. Additionally, tokenization strategically aims to unlock new liquidity pools by enabling fractional ownership and peer-to-peer transfers of fund shares at any time, including beyond traditional market hours, thereby broadening investor participation and market access.[751] Specifically for collateral purposes, tokenized MMFs will reduce liquidity concerns to the funds and also the entities that currently are liquidating money market funds to post cash as VM and then reinvesting into a money market fund post-collateral settlement. With tokenized MMFs, the transfer agent, custodian, pledgor, and receiver will all be part of the golden record and a margin call will be able to be settled with an eligible (government securities-only) MMFs without the additional operational and liquidity risks.[752]

Operational Objectives:

Operationally, tokenization seeks to create a robust, unified system of record with real-time updates and transparent asset transfers. These operational goals directly address traditional inefficiencies such as delayed settlement, manual processes, and fragmented records—issues similarly addressed by effective collateral management and repo operations.[753] Tokenized fund shares enable immediate and transparent transactions, significantly minimizing the risks of settlement failures and reducing reliance on intermediaries. Moreover, smart contracts, built with industry data standards like the Common Domain Model, embedded in tokenized fund platforms automate compliance checks, dividend distributions, and other administrative processes, significantly cutting operational costs and administrative burdens, comparable to efficient collateral management practices.

Key Stakeholders:

The key stakeholders involved in the tokenization of investment funds reflect the broader repo and collateral ecosystem. Sell-side banks and broker-dealers are actively participating, leveraging tokenization to improve settlement efficiency and offer innovative liquidity products. Asset managers benefit from enhanced distribution capabilities and access to a broader investor base. Market infrastructure providers, including custodians, transfer agents, FinTech platforms, and CCPs, are essential in facilitating the technological and operational transition. Institutional investors, such as corporate treasurers and fund allocators, gain significant advantages through improved liquidity management and potentially higher yielding, more secure cash management solutions.[754] Lastly, regulators and policymakers play a crucial role, engaging with these innovations to balance the benefits of enhanced market efficiency against the overarching goals of maintaining financial stability and investor protection.

749. World Economic Forum, "Asset Tokenization in Financial Markets: The Next Generation of Value Exchange", May 2025.
750. Ibid.
751. Linh Tran, "Key Insights from 'Tokenized Funds: The Third Revolution in Asset management Decoded'", 2025.
752. BCG, "Tokenized Funds – The Third Revolution in Asset Management Decoded", October 2024.
753. Ibid.
754. Ibid.

2024 Market Activity: Facts and Figures

Tokenized fund offerings gained significant momentum in 2024, moving from small pilots into broader market activity. By late 2024, the aggregate assets under management AUM in tokenized funds exceeded **$2 billion** globally.[755] This figure, while still a tiny fraction of the multi-trillion-dollar fund industry, reflects rapid growth from virtually zero just a few years prior. Notably, this AUM was spread across several major fund managers – a handful of large asset management firms launched tokenized funds (including money market or short-duration funds) that collectively reached the $2 billion milestone.[756] In one example, a leading global asset manager (Blackrock) introduced a tokenized U.S. dollar liquidity fund in 2024 that attracted over **$500 million in assets within a few months** of launch.[757] By early 2025, that fund's AUM had surpassed **$1 billion**, underscoring the accelerating interest once such products come to market.[758] These early entrants suggest growing demand, especially among institutional and digital native investors, for the convenience and features offered by on-chain funds.[759] Importantly, activity has not been confined to one region; **multiple jurisdictions saw high-profile tokenized fund initiatives in 2024**. For instance, in Europe a major asset manager launched its first tokenized fund, while in Asia and the US, large firms partnered with FinTech platforms to put money market funds on DLT infrastructure.[760] Several **global banks and custodians also participated** in these projects, either as tokenization service providers or by facilitating distribution on proprietary networks.[761]

In terms of asset focus, **money market funds have been a focal point** for tokenization. Tokenized MMFs allow nearly instant redemption and usage of shares, effectively bridging traditional cash management with digital rails. Beyond MMFs, 2024 also saw tokenization applied to other fund types such as private equity and private credit but **tokenized cash and liquidity funds led the activity** due to clear demand for on-chain cash equivalents.[762] Broadening participation, coupled with an estimated **85% year-over-year growth** in the overall tokenized real-world asset market (reaching about $15 billion excluding stablecoins in 2024), signals that fund tokenization is quickly moving past the proof-of-concept stage and into a scaling phase.[763] Still, it bears noting that **$2 billion AUM is a very small fraction** of even the U.S. money fund sector (roughly $7 trillion in assets).[764] Thus, tokenized funds remain in an early – albeit rapidly evolving – stage of adoption.

Frictions in Traditional Money Market Funds

Enthusiasm for tokenizing funds arises from key inefficiencies in the traditional MMF model. A major friction is operational latency, with typical settlement cycles of T+1 or T+2 days delaying liquidity and increasing counterparty risk. Even after adopting T+1 settlement in markets such as the U.S., cross-border transactions remain slow due to differing time zones and processing schedules, causing inconvenience and risk for institutional treasurers.[765]

Another significant challenge is reconciliation burdens. Today's process involves multiple intermediaries, each maintaining separate ledgers and relying on fragmented, message-based communications. This creates errors, additional costs, and a lack of real-time visibility, with no single definitive ownership record.[766]

Liquidity and trading flexibility are further constrained. Investors can redeem MMF shares only during business hours and through specific channels, limiting intraday and after-hours access. Fund pricing typically occurs just once daily, resulting in outdated valuations.[767] Operational and compliance costs are elevated by manual administrative processes, including shareholder management, transaction handling, and compliance checks such as KYC/AML. Regulatory measures like liquidity fees and redemption gates are cumbersome under current infrastructure. Overall, traditional fund management involves slow processing, operational complexity, fragmented data, and limited flexibility—areas tokenization aims to address through enhanced speed, transparency, and automation.[768]

755. Ibid.
756. Ibid.
757. Ibid.
758. MarketsMedia, "BlackRock Tokenized Fund Surpasses $1bn in AUM", March 2025.
759. BCG, "Tokenized Funds – The Third Revolution in Asset Management Decoded", October 2024.
760. The Investment Association, "Tokenized Funds", 2025.
761. Ibid.
762. BCG, "Tokenized Funds – The Third Revolution in Asset Management Decoded", October 2024.
763. Linh Tran, "2024: The Year of Institutional Real World Asset Tokenization", 2025.
764. "Release: Money Market Fund Assets | Investment Company Institute", June 2025.
765. BCG, "Tokenized Funds – The Third Revolution in Asset Management Decoded", October 2024.
766. Ibid.
767. Ibid.
768. Duncan Moir, "How Tokenization and Blockchain is Changing Money Market Funds", January 2024.

Implications of DLT and Tokenization for Funds

Adopting DLT and tokenization in fund deployments offers clear benefits, alongside notable challenges. Early implementations significantly reduce settlement times—from days to seconds—enabling T+0 settlement and lowering counterparty risks.[769] Tokenized funds also support continuous trading beyond traditional market hours, enhancing liquidity and flexibility. Transparent, blockchain-based ledgers provide regulators and participants with near-instant visibility of transactions, improving oversight. Automation through smart contracts simplifies corporate actions, compliance checks, and dividend distributions, reducing errors and administrative costs. Tokenized funds can integrate seamlessly with digital financial services, allowing investors to use shares as collateral or in decentralized finance applications.[770]

Despite these advantages, considerable limitations persist. Tokenized funds currently target limited, mostly institutional markets, resulting in lower liquidity. Many claimed efficiencies remain theoretical and have not yet been validated at scale.[771] Technical challenges, particularly interoperability between various DLT platforms and legacy systems, create fragmentation. Additionally, the absence of widely accepted regulated stablecoins or central bank digital currencies hampers seamless on-chain settlements.[772] Regulatory uncertainties across jurisdictions further complicate cross-border tokenization efforts.[773] Finally, operational risks, including cybersecurity threats and governance issues related to managing digital assets, highlight the need for careful oversight as adoption grows.[774]

In summary, the use of DLT for fund tokenization in 2025 has begun to **demonstrate real improvements –** faster settlement, better transparency, automated workflows, and expanded functionality of fund shares. These benefits align well with the policy goals of more efficient and resilient market infrastructure. However, this innovation also comes with **important caveats**. The technology is developing and **scaling:** current projects are essentially pilot-scale, and **broader adoption will depend on resolving interoperability, establishing regulatory clarity, and proving demand** beyond niche investors.[775] policymakers and industry participants are watching these developments closely. If the challenges can be addressed, tokenized funds could potentially transform fund markets much as ETFs did a few decades ago. In the meantime, a cautious, fact-based approach is warranted. The following sections of this report will delve deeper into these trends, providing data and analysis on the evolving tokenized funds landscape of 2025.

769. BCG, "Tokenized Funds – The Third Revolution in Asset Management Decoded", October 2024.
770. Ibid.
771. FSB, "Financial Stability Implications of Tokenization", October 2024.
772. Ibid.
773. Ibid.
774. Ibid.
775. Ibid.

Tokenized Funds Use Case #1: Franklin Templeton OnChain U.S. Government Money Market Fund (FOBXX)

Overview of Use Case

Franklin Templeton's **Franklin OnChain U.S. Government Money Fund (FOBXX)** is a pioneering use of DLT in a traditional financial product. It is a U.S.-registered government money market fund whose share ownership is recorded on blockchain networks, making it the **first mutual fund to use a public blockchain as its system of record**.[776] Franklin Templeton, a global asset manager with over $1.5 trillion in assets, launched this fund in 2021 as a proof-of-concept for blockchain-based mutual fund operations.[777] In essence, FOBXX functions like a conventional money market fund – investing primarily in U.S. government securities and maintaining a stable $USD1.00 share price – but **investors interact with it through digital tokens and wallets instead of paper share certificates or traditional accounts.**[778]

How the use case works in practice: Investors can access FOBXX via Franklin Templeton's dedicated mobile application **Benji Investments**, or through an institutional web portal.[779] After completing compliance onboarding, an investor funds their account either by depositing U.S. dollars (via bank transfer) or by converting **USDC stablecoin into FOBXX fund shares** within the app.[780] Each share of the fund is represented by a digital token (often referred to as the **"BENJI" token**) **on a blockchain**, which are fund shares. When an investor purchases shares, the fund's transfer agent issues the equivalent BENJI tokens to the investor's blockchain wallet. **FOBXX's portfolio managers then invest the cash in a conservative portfolio of government-backed assets (e.g., U.S. Treasury bills, government agency debt, and fully collateralized repurchase agreements) to generate a money market yield.**[781] The workflow thus involves traditional fund management on the back end, with a blockchain-based ownership record on the front end. Key participants include Franklin Templeton (as the fund sponsor and manager), the fund's transfer agent (maintaining the official share ledger on blockchain), the investors (retail and institutional), and the public blockchain networks that host the tokenized shares.

Workflow and user experience: Once shares are purchased and tokenized, investors hold their FOBXX tokens in a **digital wallet** linked to the Benji app. They can monitor their balance and earned yield through the app, which reflects live data from the blockchain. Notably, Franklin Templeton recently enabled **peer-to-peer on-chain transfers** of the fund tokens: **investors may send FOBXX tokens directly to another whitelisted investor's wallet without going through traditional intermediaries**.[782] This is a significant innovation – it brings mutual fund shares closer to the transferability of cash or stablecoins, while still preserving regulatory controls. In practice, an investor could, for example, pay another party by transferring FOBXX tokens to them, after which the recipient can either hold the tokens (earning daily yield) or redeem them for cash via the fund. Redemption works much like a normal MMF: an investor instructs the fund (through the app) to redeem some or all tokens, and the fund pays out the equivalent amount in fiat USD to the investor's bank, or potentially in USDC if the investor prefers digital settlement (the latter was facilitated by integrating USDC on-ramps in the app).[783] All purchase and redemption requests are processed during normal business hours on business days, aligning with the traditional daily liquidity cycle of mutual funds (transactions are queued and settled at the end of the day at the $USD1.00 net asset value).[784]

Benji Investments mobile app and web interface, which investors use to access FOBXX and other tokenized assets. The fund's digital platform allows investors to manage their shares in a user-friendly way. Through the app, **users can purchase FOBXX shares, view their portfolio** (with real-time fund balance and accrued income), and initiate transfers or redemptions. This mobile-first, blockchain-enabled approach lowers barriers to entry and helps bridge traditional investors into the world of on-chain finance, while still offering the familiar benefits of a regulated money market fund (stability, liquidity, and transparency).

Quantitative insights and milestones: Since its inception, FOBXX has seen steady growth and expanding functionality. The fund launched in April 2021 on the Stellar blockchain with a limited set of investors.[785] By April 2023, Franklin Templeton reported operational success and extended the fund's reach to the Polygon network (an Ethereum Layer-2), to tap into the broader Ethereum ecosystem and improve interoperability.[786] At that time, the fund was still relatively small, but growing. **In 2023–2024, Franklin Templeton aggressively expanded the fund's multi-chain support: adding Arbitrum (another**

776. Avalanche, "Franklin Templeton Launches Tokenized Money Market Fund BENJI on the Avalanche Network", August 2024.
777. Ibid.
778. Franklin Templeton, Frankin Onchain U.S. Government Money Fund Prospectus, January 2025.
779. Ibid.
780. Ibid.
781. Ibid.
782. Ibid.
783. Avalanche, "Franklin Templeton Launches Tokenized Money Market Fund BENJI on the Avalanche Network", August 2024.
784. U.S. Securities and Exchange Commission, "*Franklin Templeton – Form N-1A Registration Statement*", Filed January 3, 2025.
785. Avalanche, "Franklin Templeton Launches Tokenized Money Market Fund BENJI on the Avalanche Network", August 2024.
786. Franklin Templeton, "Franklin Templeton Money Market Fund Launches on Polygon Blockchain", April 2023.

Ethereum scaling network) in mid-2024,[787] **Avalanche in August 2024,**[788] **Aptos (a non-EVM Layer-1 blockchain) in late 2024,**[789] **and Base (Coinbase's Layer-2 network) in October 2024.**[790] By early 2025, **FOBXX was also available on Solana**, reflecting demand to support a high-performance blockchain environment.[791] Throughout this timeline, Stellar has remained the default record-keeping blockchain where most retail accounts reside, but the optionality to issue and/or transfer tokens to other networks was introduced.[792]

Alongside network expansion, the fund's AUM have grown markedly. **FOBXX reached about $USD420 million in net assets by mid-2024**,[793] then **surpassed $USD740 million by mid-2025**.[794] This makes it the **second-largest tokenized money market fund as of 2025**.[795] The broader tokenized money fund market (across all providers) has been expanding — roughly **$USD1.8 billion in combined assets by August 2024 —** indicating growing investor appetite for blockchain-based mutual funds and cash management products.[796] In terms of usage volume, Franklin Templeton has not publicly disclosed daily transaction counts, but the enablement of peer-to-peer transfers and multi-chain activity suggests an uptick in on-chain transaction volume as the fund scaled. Each new chain integration was a milestone not only for Franklin Templeton but also for the blockchain networks: for instance, the launch on Base was the first tokenized fund on that network,[797] and the launch on Arbitrum was touted as a "stamp of approval" that U.S. regulators are comfortable with L2 blockchains for recordkeeping.[798] These milestones underline how FOBXX's development has balanced innovation with compliance, gradually increasing functionality (such as adding wallet interoperability and support for user-managed keys) while staying within the boundaries of traditional mutual fund operations.

In summary, the Franklin OnChain U.S. Government Money Fund demonstrates a compelling **use case of DLT in asset management:** it delivers the low-risk yield and liquidity of a government money market fund, packaged with the efficiencies and flexibility of blockchain technology. The use case functions through a **hybrid model** – traditional in its investment strategy and regulatory structure, but novel in its **tokenized share ledger and peer-to-peer transaction capabilities**. Franklin Templeton's role has been critical as the trusted financial institution deploying this product, ensuring that despite the high-tech underpinnings, investors receive the expected safeguards and service of an institutional-grade fund. Publicly available figures attest to the success so far: USD hundreds of millions in AUM, thousands of transactions, and a growing base of users who are effectively interacting with a mutual fund through their digital wallets – a use-case of how blockchain could modernize capital market workflows.[799]

Settlement Asset

Settlement asset: The asset being transacted in this system is the **tokenized share of the money market fund**, effectively a digital representation of a USD-denominated mutual fund share. Each BENJI token corresponds to one share of FOBXX and is designed to maintain a stable value of approximately USD1.00 (since the fund uses amortized cost accounting to stabilize its NAV).[800] In practical terms, the BENJI token is like a tokenized dollar that carries the legal and economic rights of a mutual fund share. When two parties settle a transfer on the blockchain, what changes hands is this fund share token. The underlying settlement medium for fund subscriptions and redemptions remains fiat currency: investors ultimately invest U.S. dollars (or USDC which the platform converts into U.S. dollars) to buy the tokens and can redeem tokens back into U.S. dollars. However, on a peer-to-peer level, **transferring FOBXX tokens is akin to settling with a tokenized fiat instrument**, since each token is backed by a correspondingly valued share in a cash-equivalent fund portfolio (albeit, in contrast to a fiat instrument, subject to the balance from to time and security of the fund's custodian). No separate stablecoin or cash token is needed for on-chain transfers – the token itself is the settlement asset representing a claim to the assets (from time to time) in the fund's custodial account.

787. Cointelegraph, "Franklin Templeton's tokenized money fund launches on Arbitrum", August 2024.
788. Avalanche, "Franklin Templeton Launches Tokenized Money Market Fund BENJI on the Avalanche Network", August 2024.
789. Cointelegraph, "Franklin Templeton's onchain money fund goes live on Aptos blockchain", October 2024.
790. Cointelegraph, "Franklin Templeton launches tokenized money fund on Base", October 2024.
791. CoinDesk, "Franklin Templeton Expands $594M Market Money Fund to Solana", February 2025.
792. Franklin Templeton, Frankin Onchain U.S. Government Money Fund Prospectus, January 2025.
793. Cointelegraph, "Franklin Templeton's tokenized money fund launches on Arbitrum", August 2024.
794. CoinDesk, "Franklin Templeton Expands $594M Market Money Fund to Solana", February 2025.
795. Ibid.
796. Avalanche, "Franklin Templeton Launches Tokenized Money Market Fund BENJI on the Avalanche Network", August 2024.
797. Cointelegraph, "Franklin Templeton launches tokenized money fund on Base", October 2024.
798. Cointelegraph, "Franklin Templeton's tokenized money fund launches on Arbitrum", August 2024.
799. Franklin Templeton, "Franklin Templeton Money Market Fund Launches on Polygon Blockchain", April 2023.
800. Ibid.

Settlement finality mechanisms: Finality in FOBXX is achieved directly on-chain, where tokens issued on a public blockchain serve as the authoritative system of record ("**SOR**") for share ownership. Once a transaction is validated and recorded to the blockchain, it is considered legally and operationally final, eliminating the need for downstream reconciliation or duplication in internal systems. Unlike some traditional fund structures that rely on internal ledgers mirrored by blockchain records, FOBXX operates under a native digital issuance model, where the blockchain itself reflects definitive ownership. The blockchain-integrated recordkeeping system ensures that tokens represent actual ownership, while personally identifiable information ("**PII**") is securely maintained in a separate off-chain database by the Transfer Agent. This design enhances transparency, reduces operational risk, and enables a higher degree of settlement finality consistent with regulatory expectations and the evolving role of DLT in capital markets.[801]

A critical component of settlement finality here is the ability to **reverse or correct transactions under exceptional circumstances**, something not available in typical public blockchain transactions. Franklin Templeton has implemented administrative features in the smart contract/token design so that **the transfer agent can unilaterally control and rectify the ledger if needed**.[802] For example, if an erroneous transaction occurs or if a transfer to an unauthorized wallet somehow transacted the transfer agent can **burn (i.e. cancel) the mistakenly issued tokens or reassign tokens as necessary** to correct the record.[803] This ensures that legal finality aligns with an error mitigation capabilities, protecting investors. In normal conditions, this power is not used – a routine token transfer between two valid investors will be final on-chain and respected as final by the fund. But the existence of an "undo" mechanism governed by the transfer agent means that **ultimate settlement finality is achieved when the transfer agent affirms the transaction**. This approach marries the blockchain's speed and transparency with the **legal assurance that there is no detriment to investor interests by an irrecoverable error**. From a technical perspective, once a token is in an investor's wallet, they have control to initiate further transfers. However, **every wallet is associated with a known investor's identity in the transfer agent's system**, preventing unauthorized or non-compliant settlements from taking place. Thus, settlement finality is a blend of **blockchain consensus finality plus a layer of oversight** – the transfer agent can consider a transfer final for legal purposes once it is irreversible on-chain *and* passes any compliance checks, at which point the official share register is updated.

Legal structure and investor rights: The Franklin OnChain U.S. Government Money Fund is organized as a **regulated mutual fund** (an open-end investment company under the Investment Company Act of 1940 (the "Investment Company Act")). Investors in FOBXX tokens are legally shareholders of the Franklin Templeton fund, with all the rights and protections that entails. This means that a token holder's rights include: **the right to redeem shares on demand at NAV** (which the fund strives to keep at USD1),[804] **the right to receive dividends** (the fund accrues income from its investments, typically paid as additional shares to maintain the USD1 price), and **voting rights on certain fund matters**. For instance, shareholders can vote to elect the fund's board of trustees or approve material changes, as detailed in the fund's offering documents (the trust uses a typical mutual fund governance structure with proportional voting power by share count).[805] The **ownership claim is pro-rata on the fund's underlying assets**: since it is a government money market fund, each share (token) represents an interest in a pool of short-term U.S. government securities and cash. Importantly, **investors benefit from the regulatory protections of Rule 2a-7 of the Investment Company Act**, which imposes high liquidity requirements and credit quality standards to reduce risk. For example, the fund must hold at least 10% of its assets in daily liquid instruments and 30% in weekly liquid assets, and invest only in very short-term, high-quality debt (money-market funds are subject to 60-day weighted average maturity and 120-day weighted average life caps).[806] These rules are designed to ensure that even if many investors redeem at once, the fund can meet withdrawals without breaking the USD1 NAV. Token holders thus have **legal assurance of liquidity and asset quality** similar to any traditional money market fund investor.

The **legal structure ensures clarity of investor protections**. The tokens do not represent a claim on the blockchain protocol or any crypto-assets; they represent a claim on a **registered MMF**. Jurisdictionally, the fund is established in the United States (Delaware statutory trust or similar structure) and falls under U.S. law. Any disputes or legal questions would be handled in U.S. courts under securities law and contract law applicable to the fund's shareholder agreements. Token holders have the same legal standing as if they were on the fund's traditional share register. Notably, the fund's documents clarify that U.S. securities laws govern the relationship between the fund and investors, and that using blockchain for share

801. U.S. Securities and Exchange Commission, "*Franklin Templeton – Form N-1A Registration Statement*", Filed January 3, 2025.
802. Ibid.
803. Ibid.
804. Franklin Templeton, "Franklin Templeton Money Market Fund Launches on Polygon Blockchain", April 2023.
805. U.S. Securities and Exchange Commission, "*Franklin Templeton – Form N-1A Registration Statement*", Filed January 3, 2025.
806. Ibid.

records **does not change the fund's legal obligations or the shareholders' rights** – it is simply a different medium of recordkeeping. For additional investor safety, Franklin Templeton's transfer agent is a regulated entity that by law must exercise care in maintaining accurate shareholder records and safeguarding assets. The integration of blockchain within the structure required the transfer agent to build in compliance features: for example, every investor's wallet is whitelisted and linked to verified identity, and certain types of accounts (such as retirement accounts or omnibus intermediaries) are not allowed to use the tokenized platform to avoid complexity or regulatory uncertainty.[807] This ensures that **each token is always associated with a legally recognized account holder** in the fund's records, preserving the chain of legal ownership.

In terms of **settlement asset legal classification**, the BENJI token is deemed a **security (fund share)**, not a currency. This is important for legal finality and rights: holders are protected by securities law (anti-fraud provisions, disclosure requirements, etc.), and the tokens can only be traded or transferred in compliance with securities regulations. Franklin Templeton's approach essentially wraps a traditional security in a digital token form. Thus, token holders do not have to worry about issues such as the token being considered a "deposit" or "commodity" – it is clearly a share of a regulated fund. **Final settlement of a transaction legally occurs when the transfer agent registers the new owner of the share**. Because the transfer agent's system is integrated with a blockchain, this registration is instantaneous following an on-chain transfer. The **combination of technical finality and legal finality gives investors confidence that when they transact in FOBXX tokens, they are receiving a legally robust settlement:** once an investor's wallet shows the tokens and the transfer agent's ledger aligns, the investor has an enforceable ownership claim that cannot be unilaterally reversed by a counterparty.

In summary, FOBXX uses a **tokenized settlement asset (fund share token)** that settles on-chain with near-instant finality, where tokens issued on blockchains serve as the system of record. Investors enjoy the **same rights and protections as traditional mutual fund shareholders.** The legal structure (a U.S. Investment Act fund) underpins trust in the settlement asset.

Interoperability and Network Architecture

DLT network type and design: Franklin Templeton's FOBXX operates on a **hybrid public-permissioned blockchain model.** The fund leverages public blockchains (meaning the networks themselves are open and decentralized to varying degrees) but imposes permissioned access for holding and transferring the specific fund tokens. Initially, the fund launched on the **Stellar network**, a public blockchain known for fast and low-cost transactions. Stellar serves as the **primary ledger** for most FOBXX tokens in circulation.[808] Over time, Franklin Templeton extended support to *additional blockchain networks* to enhance interoperability: **Ethereum (and EVM-compatible chains)** such as Polygon and Arbitrum, other Layer-1s such as **Avalanche**, **Solana**, and **Aptos**.[809] Each of these blockchains is **public**; transactions can be seen by anyone and the network is not controlled by a single entity, but Franklin Templeton runs a **permissioned token smart contract** on each. Only authorized addresses (wallets of investors who have passed compliance checks and are entered in the fund's registry) can hold or transact the FOBXX tokens on these networks.

The multi-network blockchain means **FOBXX is blockchain-agnostic in principle** – the fund's share tokens exist as **parallel representations on multiple ledgers**, all managed by the fund's transfer agent to ensure the total supply across all networks equals the fund's shares outstanding. The **network architecture** involves smart contracts or token programs on each blockchain that implement the fund share token with specific controls. For example, on Ethereum and Polygon, FOBXX likely uses an ERC-20 smart contract with modifications (administration roles to allow mint/burn and to enforce transfer restrictions). On Stellar, a blockchain which does not use smart contracts in the same way, the token may be configured as a native asset with certain issuer flags (Stellar allows an issuer to require approval for transfers, etc., which aligns with permissioned operation).[810] Each network's token contract is linked to Franklin Templeton's systems, so that **when shares are issued or redeemed, or moved between networks, the appropriate contract is instructed to mint or burn tokens** accordingly.[811]

807. Ibid.
808. CoinDesk, "Franklin Templeton Expands $594M Market Money Fund to Solana", February 2025.
809. Ibid.
810. U.S. Securities and Exchange Commission, "*Franklin Templeton – Form N-1A Registration Statement*", Filed January 3, 2025.
811. Ibid.

Consensus mechanisms and performance: Because FOBXX spans different blockchains, it benefits from their diverse consensus algorithms and performance characteristics:

- **Stellar:** Uses a federated consensus model (Stellar Consensus Protocol) with validator nodes. It offers **fast finality (to the order of 3-5 seconds)** and negligible transaction fees, which is ideal for high-frequency or small transactions. Stellar's design prioritizes speed and has built-in features for asset issuance, which may have influenced Franklin's choice to use this blockchain initially.

- **Ethereum (Mainnet and Layer-2s such as Polygon, Arbitrum, and Base):** Ethereum Mainnet now uses Proof of Stake (with finality typically within a few minutes or less), but its gas (i.e., transaction) fees are high and throughput limited. Franklin Templeton **acknowledges this by setting a very high minimum investment for using Ethereum Mainnet (about $USD5 million) due to cost considerations**.[812] Instead, they emphasize **Layer-2 networks**: Polygon (which uses a Proof-of-Stake sidechain and commit scheme), Arbitrum and Base (which are rollups inheriting Ethereum security). These Layer 2s **provide much higher scalability and lower costs**. For instance, Polygon's fees are very low, and it has a high TPS capacity; Arbitrum and Base bundle many transactions into one, reducing cost per transaction. The **choice of Polygon in 2023 was to tap into Ethereum's broad ecosystem while avoiding Mainnet's bottlenecks**.[813]

- **Avalanche:** A high-speed Layer-1 using its Avalanche consensus protocol, which achieves **sub-second finality** and high throughput.[814] Avalanche's C-Chain (EVM-compatible chain) is likely where FOBXX tokens reside, giving them the benefit of Ethereum-like smart contracts but with faster settlement. Avalanche was chosen, as Franklin noted, for its **EVM compatibility, low latency, and customizable subnets** (although FOBXX operates on the main chain, not a subnet).[815]

- **Solana:** A high-performance Layer-1 blockchain using Proof of Stake and Proof of History consensus, capable of thousands of TPS with ~1 second or less block times. Solana's addition in 2025 suggests Franklin Templeton wanted access to an even broader base of cryptoasset users (Solana is popular for its DeFi and trading communities) and to leverage its speed. Solana does not use the EVM, so supporting it meant deploying a token program specifically for Solana (likely using Solana's SPL token standard, again with some authority control).

- **Aptos:** A newer Layer-1 blockchain that uses a variant of Byzantine Fault Tolerance consensus and the Move programming language. Aptos aims for high throughput (tens of thousands of TPS theoretically) and was appealing enough for Franklin Templeton to integrate in 2024.[816] Aptos is non-EVM, which shows Franklin's commitment to **interoperability across different technology stacks** (they have not limited the product just Ethereum-based blockchains).

Despite the variety of blockchains etc, Franklin Templeton manages this through a **unified governance model** for the token. The **governance model** here refers to how decisions are made about the token's operation and which networks to support. Franklin Templeton as the fund manager and transfer agent effectively has centralized governance over the token issuance and features (investors do not vote on technical matters of the token; their voting rights are about the fund's investment policies, not the IT implementation). Franklin Templeton can decide to add a new blockchain network, as it did with approvals in 2023-2025 for each addition, based on internal assessments and presumably regulatory comfort. Each new network is evaluated for security, reliability, and compliance. For example, **when adding Polygon and Arbitrum, Franklin Templeton noted those networks' maturity and adoption in the Ethereum ecosystem**.[817] Likewise, the decision to use **Stellar as primary blockchain** was likely due to its built-in compliance features and low cost, which are well-suited for being the "home" ledger for many small retail accounts (minimum investment on Stellar is only $USD20).[818] In contrast, networks such as Ethereum or Avalanche have higher barriers (Ethereum's $USD5M minimum, and Avalanche's $USD100k minimum) to ensure only appropriately sized accounts deal with potentially higher fees.[819] This governance approach aligns the network choice with user profiles, achieving scalability without burdening all users with, say, Ethereum fees.

Interoperability mechanisms: A standout feature of FOBXX is **interoperability across blockchains**. Franklin Templeton achieved this without relying on external bridges or wrap/synthetic tokens; instead, the transfer agent serves as the "bridge authority." If an investor wants to migrate their token holdings from one blockchain to another (say, from Stellar to Ethereum), they can request this through the platform. The **process (as described in filings) involves burning the tokens on the source chain and minting new tokens on the destination chain** in the same amount.[820] For example, an investor holding 100 FOBXX tokens on Stellar could have those 100 tokens retired (burnt)on Stellar and then receive 100 tokens (minted) on

812. Ibid.
813. Franklin Templeton, "Franklin Templeton Money Market Fund Launches on Polygon Blockchain", April 2023.
814. Avalanche, "Franklin Templeton Launches Tokenized Money Market Fund BENJI on the Avalanche Network", August 2024.
815. Ibid.
816. Cointelegraph, "Franklin Templeton's onchain money fund goes live on Aptos blockchain", October 2024.
817. Franklin Templeton, "Franklin Templeton Money Market Fund Launches on Polygon Blockchain", April 2023.
818. U.S. Securities and Exchange Commission, "*Franklin Templeton – Form N-1A Registration Statement*", Filed January 3, 2025.
819. Ibid.
820. Ibid.

Polygon, with no change in their ownership stake.[821] *No dual claims are created*: at any given time, each share exists on only one network at the time. This controlled interoperability avoids the complexities and risks of third-party token bridges (which can be targets of hacks). It's essentially an administrative transfer – while the blockchains themselves are not directly interoperable, Franklin Templeton's system ensures a smooth off-chain coordination to achieve cross-chain movement of assets.

From the user perspective, interoperability means **more flexibility and potentially more integration opportunities**. If a user wants to utilize FOBXX tokens in an Ethereum DeFi application, they would prefer to hold them on Ethereum or an EVM chain. In contrast, if the user wants cheaper, faster transactions, they might stay on the Stellar or Base blockchain. Franklin's design caters to both. It's worth noting that the **tokens on different networks are fungible in the sense that each represents a share of the same fund**, but technically they are separate instantiations (e.g., an ERC-20 token vs. a Stellar token). Franklin Templeton mitigated any confusion by using the same ticker and name across networks and by tightly controlling the supply on each.

Network governance and security: Each underlying blockchain has its own governance (e.g., Ethereum's community, Solana's validators, etc.), which is outside Franklin Templeton's control. This raises the question of how the fund handles blockchain-specific events: for example, what if a blockchain undergoes a fork or a major outage? The fund's documentation addresses this in the "risk factors" section. Since the **transfer agent can pause or halt transactions if needed**, they could choose to suspend recognition of a particular blockchain's transactions during a fork until clarity is achieved. The **primary record on Stellar** might serve as a reference in extreme cases (Stellar itself could fork, but it has a different consensus model with less forking typically). By participating on multiple networks, the fund also gains a form of redundancy: if one network is down or congested, investors could move (or be moved) to another network to transact (although that is predicated on being able to access the first network to burn tokens – an outage might temporarily lock tokens on that chain). In extreme cases, holdings can be migrated from a failing network to an alternative network, with the original network no longer recognized by the transfer Agent. This approach provides a form of "super redundancy," enabling even severe public blockchain failures to be mitigated—often with less complexity than the routine migration between traditional relational database systems ("RDMS") used for legal systems of record.

In terms of **scalability**, the multi-blockchain approach is quite powerful. The combined throughput of Stellar + Polygon, Arbitrum, and others is enormous, far beyond what a single blockchain could handle. Franklin Templeton likely does not need that level of scale yet (the volume of transactions for a single fund, even with thousands of investors, is not extremely high), but it future-proofs the platform. As more funds or more users come on board, they could distribute load across networks. It also helps to manage transaction costs for users. For instance, smaller retail investors are auto-directed to Stellar by default (to minimize their costs), whereas an institutional investor who might want to custody tokens in their own Ethereum wallet can do so if they meet the minimum size (and presumably are willing to bear gas costs).[822] This **aligns network choice with user needs** in a pragmatic way.

Interoperability with traditional systems: The architecture of FOBXX is designed to align with traditional capital market infrastructure where necessary. The **fund's custody of actual assets (i.e., cash, and Treasuries)** remains in traditional institutions – a custodian bank holds the U.S. government securities and cash in the fund's portfolio (as mandated by the Investment Company Act). The existence of tokens does not alter that; it only changes how ownership of the fund is tracked and transferred. Similarly, the **fund's accounting, valuation of assets, and NAV calculation occur off-chain** in the usual manner (the fund administrator calculates income and ensures $USD1.00 NAV maintenance, etc., each business day). Once the NAV and dividend factors are determined, they can be applied on-chain by adjusting token balances (e.g., if interest is paid daily, new fractional tokens might be issued to each holder to represent the accrued interest – or the fund could simply accrue internally and increase NAV. However, since they maintain a constant $USD1 value, it is likely they periodically credit additional shares/tokens as dividends).

The **transfer agent's blockchain system** keeps track of who owns what. The SEC was comfortable with this setup, indicating that from a regulatory standpoint the blockchain ledger is an acceptable alternative to, say, a Transfer Agent's SQL database.[823]

In terms of aligning or diverging from *digitally native design*: FOBXX is not a fully decentralized, autonomous financial instrument (unlike, say, a purely on-chain stablecoin or a DeFi lending pool). it is a hybrid. It aligns with traditional finance by requiring investor identity verification, operating within regulatory constraints, having off-chain governance (by a centralized manager and board), and using real-world assets as backing. At the same time, it adopts a digitally native approach by issuing tokens

821. Ibid.
822. Ibid.
823. Cointelegraph, "Franklin Templeton launches tokenized money fund on Base", October 2024.

on blockchains that are the fund's share ownership, enabling self-custody (investors control their own tokens/wallets), using smart contracts for instantaneous settlement, and potentially being composable with other blockchain services (although within limits set by compliance). This careful architecture shows a **close alignment with traditional financial safeguards (through the legal structure and centralized oversight) while embracing the efficiency and openness of DLT networks**. In essence, Franklin Templeton built a mini capital market infrastructure for its fund: **a permissioned token on a public network that parallels the role of a transfer agent, exchange, and central securities depository all in one**. This could be a blueprint for how traditional funds integrate with blockchain – keeping the familiar roles but changing the medium.

Finally, it is worth noting **interoperability with users' existing crypto holdings**: by accepting USDC and operating on networks such as Ethereum, FOBXX can plug into the existing digital asset ecosystem. For example, an investor already holding USDC can seamlessly move into FOBXX via the app (the USDC is likely converted to fiat currency and invested in the fund).[824] In the future, if allowed, an investor might even be able to use FOBXX tokens as collateral in a crypto borrowing platform or trade them on a digital exchange. Those use cases are nascent and depend on regulatory approval, but **the technical groundwork (tokens on interoperable chains) is laid**. Franklin Templeton has indicated future plans for features such as secondary market trading and collateral mobility for the fund tokens, which would further increase interoperability with the wider financial system (e.g., using FOBXX tokens in repo or as loan collateral).[825] Any such steps will be taken carefully, aligning with the fund's conservative nature and compliance requirements.

Conclusion

Franklin Templeton's FOBXX stands as a **groundbreaking, but carefully constructed DLT use case in capital markets**. It showcases that distributed ledgers can be integrated into regulated financial products to improve efficiency and broaden access, all while maintaining robust investor protections. The use case's success so far – measured by growing assets, expanding technology integrations, and regulatory acceptance – suggests that similar models could be adopted for other funds and financial instruments. The chapter of FOBXX is still being written, with ongoing developments in interoperability and potential regulatory evolutions. Nonetheless, it provides a powerful case study in how a financial institution can deploy blockchain technology to modernize a traditional product, balancing innovation with compliance. Franklin Templeton has effectively bridged the gap between **traditional money market fund investing and the digital asset ecosystem**.[826]

824. Avalanche, "Franklin Templeton Launches Tokenized Money Market Fund BENJI on the Avalanche Network", August 2024.
825. Ibid.
826. Franklin Templeton, "Franklin Templeton Money Market Fund Launches on Polygon Blockchain" April 2023.

Tokenized Funds Use Case #2: BlackRock USD Institutional Digital Liquidity Fund ("BUIDL")

Overview of Use Case

BlackRock's **BUIDL** – the *BlackRock USD Institutional Digital Liquidity Fund* – is a pioneering use case of DLT in traditional asset management. Launched in March 2024 on the Ethereum blockchain, BUIDL is a tokenized short-term U.S. treasury fund that allows qualified investors to hold and transfer shares of a USD liquidity fund as digital tokens.[827,828] The fund is managed by BlackRock (the world's largest asset manager) and tokenized by **Securitize**, a regulated tokenization platform that serves as the fund's transfer agent and distributor.[829] In practice, BUIDL functions much like a traditional treasury fund – investing in high-quality, short-term instruments – but with the added capabilities of blockchain-based settlement and the potential for 24/7 transferability. Key characteristics of this use case include its rapid growth, institutional scale, and integration with both FinTech and traditional finance infrastructure, as detailed below:

- **Launch and Scale:** BlackRock unveiled BUIDL as its first tokenized fund on a public blockchain in March 2024.[830] Within six weeks of launch, BUIDL became the world's largest tokenized fund, capturing nearly 30% of the tokenized U.S. Treasury market and reaching over **$650 million** in assets.[831] Growth continued through 2024 and early 2025 – by March 2025 BUIDL's AUM had **surpassed $1.7 billion**, and recently reached nearly $2.9 billion by June 2025.[832]

- **Participants and Workflow:** The fund is offered to investors primarily to institutional investors.[833] The minimum initial investment is $5 million. Investors subscribe to the fund through Securitize's online platform, undergoing full **KYC/AML verification** and accreditation checks.[834] Upon subscribing, an investor transfers in U.S. dollars (or potentially USDC stablecoins) and receives **BUIDL tokens** representing shares in the fund. BlackRock manages the underlying portfolio, while **BNY**, as custodian and administrator, holds the fund's assets and helps bridge the fund to traditional systems.[835] Investors can hold BUIDL tokens in various custody setups – for example, with digital asset custodians such as **Anchorage Digital Bank, BitGo, Coinbase Custody, or Fireblocks**, all of whom were early DLT ecosystem participants.[836] The **workflow** resembles that of a traditional fund with daily subscriptions/redemptions, but ownership is recorded on blockchain ledgers. Holders can **transfer tokens peer-to-peer** to other approved investors **24/7/365**, in contrast to traditional fund shares that may be transferred, if approved by the fund, only during banking hours.[837,838]

- **Technology and Operations:** Initially issued as an ERC-20 compliant token on **Ethereum**, BUIDL has since become **multi-chain**. By late 2024 it expanded to five additional blockchains – **Aptos, Arbitrum, Avalanche, Optimism, and Polygon** – and in March 2025 it launched on **Solana** as well.[839] This **multi-blockchain architecture** means the fund's tokens can exist on seven networks in total, leveraging each network's strengths (for example, Ethereum's broad adoption and Solana's high speed, Layer-2 networks' low fees, etc.). Despite spanning several ledgers, the token represents the same single fund; Securitize's platform coordinates the issuance and redemption across chains to ensure the total token supply remains consistent with the fund's net assets. Only whitelisted wallet addresses can hold BUIDL tokens, enforcing the **permissioned access** within these public networks.[840] Each BUIDL token seeks to maintain a stable value of **$1.00** by design, and the fund accrues income for investors through daily interest which is paid out as additional tokens daily.

- **Adoption and Usage:** Although BUIDL's AUM is large, the number of direct holders is relatively small, reflecting its institutional focus. These likely include **crypto firms' treasury accounts, FinTech yield platforms, and other corporate investors** seeking permissioned on-chain cash management.[841] Notably, startup Ondo Finance created a product (Ondo's "OUSG") that invests in BUIDL and offers investors exposure with a lower minimum (around $5,000).[842] By late 2024, Ondo's vehicle accounted for roughly $192 million of BUIDL's balance – indicating that some BUIDL demand is indirectly sourced from a broader accredited market via such intermediaries.

827. Ledger Insights, "BlackRock expands tokenized money market fund BUIDL to five more blockchains", November 2023.
828. Businesswire, "BlackRock Launches Its First Tokenized Fund, BUIDL, on the Ethereum Network", March 2024.
829. Ibid.
830. Ledger Insights, "BlackRock expands tokenized money market fund BUIDL to five more blockchains", November 2023.
831. Linh Tran, "2024: The Year of Institutional Real World Asset Tokenization" Accessed 2025.
832. RWA.xyz, BUIDL, Accessed July 2025.
833. PR Newswire, BUIDL Tokenized by Securitize Surpasses $1B in AUM, March 2025.
834. Arbitum, Securitize BUIDL Step Application, Accessed July 2025.
835. Businesswire, "BlackRock Launches Its First Tokenized Fund, BUIDL, on the Ethereum Network", March 2024.
836. Ibid.
837. Ibid.
838. CoinDesk, "BlackRock, Securitize Expand $1.7B Tokenized Money Market Fund BUIDL to Solana: March 2025.
839. Ibid.
840. Businesswire, "BlackRock Launches Its First Tokenized Fund, BUIDL, on the Ethereum Network", March 2024.
841. Ledger Insights, "BlackRock expands tokenized money market fund BUIDL to five more blockchains", November 2024.
842. Ibid.

Settlement Asset and Legal Structure

Settlement Asset: The asset being used for settlement in BUIDL is neither a central bank currency nor a traditional stablecoin, but rather a **tokenized security** – specifically, a digital share of a U.S. dollar-denominated liquidity fund. Each BUIDL token represents one share in the BlackRock USD Institutional Digital Liquidity Fund, which invests **100% of its assets in cash, U.S. Treasury bills, and fully collateralized repurchase agreements**.[843] In economic terms, holding the token is equivalent to holding a USD1 share of a money market fund, with the token's value anchored around USD1 and supported by the underlying portfolio. Importantly, BUIDL tokens **accrue dividend income**: the fund's interest earnings (from T-bill yields and repo rates) are **distributed to token holders as new token**s on a daily basis.[844] This means an investor's token balance grows over time to reflect earned yield, rather than the token price fluctuating.[845] Therefore, the token serves as the settlement asset itself (a claim on the fund's net assets), and its stability is predicated on BlackRock's fund maintaining a stable NAV through its high-quality investments. BUIDL is not a fiat-issued stablecoin and not legal tender – it is a security token, giving the holder a redeemable claim on the underlying pool of dollar assets.

Settlement Finality: Transactions in BUIDL achieve settlement finality through the finality mechanisms of the underlying blockchains combined with the fund's legal structure. When a BUIDL token transfer is executed on a blockchain (e.g., Ethereum or Solana), the transfer is recorded in that ledger once the block is confirmed and finalized. This record is then updated in an off-DLT relational database system that is operated under the sole discretion of the funds Transfer Agent whose system of record serves as legal record of ownership. Hence, this provides the potential for near-real-time finality; ownership changes settle within minutes, a stark improvement from the T+1 or T+2 settlement delays common in traditional fund transfers. This process is enabled by Securitize's smart contracts, which ensure that only valid, authorized transfers occur. Each token is a restricted security that can only move between wallets that have been whitelisted (pre-approved) by the transfer agent, preventing unauthorized or illegal settlements.[846] This improved process was a key attraction of the platform, providing "transparent settlement" of fund transactions around the clock.[847]

To connect these digital settlements with traditional money flows, **BNY** plays a crucial interoperability role.[848] As the fund's custodian and administrator, BNY coordinates movement of cash in the traditional banking system with the subscription and redemption of fund shares recorded by the transfer agent and the creation or destruction of the token by the tokenization agent.[849] For example, on subscription, an investor might send USD via wire or ACH to the fund's bank account and Securitize then mints the corresponding BUIDL tokens to the investor's wallet. On redemption, the process reverses: tokens are burned, and the equivalent cash is paid. This design ensures that **token circulation is always fully backed** by real assets held by the custodian, and that a token holder can redeem their token for USD1 (plus accrued interest) through legally enforceable rights against the fund.

Legal Rights and Protections: Holders of BUIDL tokens have essentially the same legal rights as an investor in a conventional private fund, with some additional considerations due to the digital format. Each token represents a **beneficial ownership interest** in the pooled fund assets. Token holders are entitled to their pro-rata share of the fund's income (paid as additional tokens) and can **redeem tokens for cash** (or in-kind assets, if ever necessary) pursuant to the fund's offering terms. The fund seeks to maintain a stable USD1.00 NAV per share, but it is **not guaranteed** – as disclosed, BUIDL "may not be able to maintain a stable value of USD1.00 per token at all times".[850] This means that in extreme circumstances (e.g. a major market dislocation or default of a holding), the token's value could fall below USD1, just as a traditional money market fund could "break the buck." However, the investment strategy (100% government-backed and cash assets) minimizes this risk, and any valuation change would be transparently reflected in token holdings (e.g., via a reduction in new dividend tokens issued).

Legal and Regulatory Structure: Legally, BUIDL is a limited company incorporated under the laws of the British Virgin Islands and operates as a **private fund** under U.S. law. It is **not registered** under the Investment Company Act (which governs mutual funds and retail money market funds). Instead, it operates under **Section 3(c)(7)** of that Act, which exempts funds sold only to "qualified purchasers" (generally high-net-worth or institutional investors).[851] Likewise, the offering of BUIDL tokens is conducted under an exemption from securities registration – specifically **Rule 506(c) of Regulation D** under the Securities Act.[852] Rule 506(c) allows general marketing of a private offering (hence BlackRock's public press release

843. Ibid.
844. MEXC, "In Depth Analysis of BlackRock BUIDL", July 2025.
845. Ibid.
846. Ibid.
847. Ibid.
848. Ibid.
849. Ibid.
850. Ibid.
851. Ibid.
852. Ibid.

and promotions) but mandates that sales be made only to **accredited investors** whose status is verified. In fact, BUIDL imposes an even higher standard by limiting investors to *qualified purchasers*, aligning with the Investment Company Act Section 3(c)(7) fund requirements. These legal constraints mean that BUIDL tokens **legally constitute unregistered securities** (specifically, security tokens) and are subject to the same transfer restrictions as any other privately offered fund. Tokens can **only be held or traded among eligible investors** who have been onboarded through Securitize (which, as a registered broker-dealer, serves as the placement agent).[853] There is no public secondary market or exchange listing for BUIDL – the press release explicitly notes that the interests "will not be listed on any exchange".[854] Instead, liquidity is provided by the ability to redeem with the issuer, or potentially peer-to-peer transfers.

Interoperability and Network Architecture

Network Type and Architecture: BUIDL is deployed across multiple **public DLT networks**, illustrating a unique multi-chain strategy for a financial instrument. Rather than using a private or consortium blockchain, BlackRock chose to issue BUIDL on **public permissionless blockchains** – including Ethereum mainnet and others – but with a **permissioned access layer** for token holders. The initial launch was on Ethereum (a public **proof-of-stake blockchain**), leveraging its mature infrastructure and security.[855] In the months following, Securitize and BlackRock expanded BUIDL to several **Ethereum Layer-2 networks** and alternative Layer-1 chains, to improve speed and lower transaction costs. By November 2024, BUIDL tokens were live on **Aptos** (a Move-based PoS chain), **Arbitrum** and **Optimism** (Ethereum Layer-2 rollups), **Polygon** (an EVM sidechain), and **Avalanche** (a high-throughput blockchain), in addition to Ethereum.[856] In March 2025, **Solana** (a high-performance chain using proof-of-history consensus) became the seventh blockchain in the BUIDL network roster.[857] On each of these chains, BUIDL exists as a smart-contract token that abides by that chain's token standard (for example, ERC-20 on Ethereum, and SPL token on Solana, etc.), with the contract logic ensuring only authorized transfers can occur.

The **consensus mechanisms** securing these networks vary (Ethereum's PoS finality, Solana's PoH/PoS, Avalanche's DAG-based consensus, etc.), but from BUIDL's perspective they all serve to maintain a ledger of token ownership. The fund does not rely on any single blockchain for its operation; rather, it treats all the supported chains as valid platforms where its tokens can reside. This architecture positions the fund to meet investors "where they are": different participants have different blockchain preferences or integrations (for instance, digital-native firms on Ethereum vs. trading firms on Solana). BlackRock's partner Securitize manages the **token smart contracts and mint/burn process** across these networks to ensure the aggregate token supply remains 1:1 with the fund's assets.[858] Whenever tokens are created on a new chain (due to new subscriptions or chain-to-chain transfers), a corresponding subscription of cash is recorded by the custodian; whenever tokens are destroyed (redemptions or moving off a chain), the assets are released or reallocated.[859]

Permissioned Token Model: Although the underlying blockchains are public, BUIDL's operation is permissioned at the token level.[860] Each BUIDL token contract incorporates logic (often via an allowlist or whitelist) so that only wallets belonging to verified, eligible investors can hold or transfer the token.[861] Securitize, as the transfer agent, controls this whitelist. In practice, an investor undergoes onboarding (completing KYC/AML and accreditation checks) and then provides one or more wallet addresses to Securitize. These addresses are added to the token contract's whitelist on the relevant chain. The token contracts will **reject any transfer** involving a non-whitelisted address – enforcing compliance in a fully automated way. This design aligns with regulatory requirements and means BUIDL tokens cannot be freely transferred to the general public or to unknown parties. The **governance model** for the token contracts is centralized: Securitize (and ultimately BlackRock as the issuer) can pause transfers or update rules if necessary, and they manage upgrades to the smart contracts.[862]

Interoperability Features: BUIDL's approach to manage interoperability is through the issuer/agent rather than trustless bridges. If an investor wishes to move their BUIDL holdings from one blockchain to another, Securitize can facilitate a burn-and-reissue: the tokens on Chain A are redeemed (burned) and an equivalent number of tokens are minted for the same investor on Chain B. This ensures no duplication of claims. There is no permissionless arbitrage or free-flow bridge between chains for BUIDL – all cross-chain movement goes through the fund's oversight. While this introduces some friction (and requires coordination with the transfer agent), it avoids the smart-contract risks of open bridges. It's a design choice balancing safety and interoperability.

853. Ibid.
854. Ibid.
855. Ledger Insights, "BlackRock expands tokenized money market fund BUIDL to five more blockchains", November 2024.
856. Ibid.
857. CoinDesk, "BlackRock, Securitize Expand $1.7B Tokenized Money Market Fund BUIDL to Solana: March 2025.
858. MEXC, "In Depth Analysis of BlackRock BUIDL", July 2025.
859. Ibid.
860. Ibid.
861. Ibid.
862. Ibid.

TradFi Alignment vs. Digital Native Design: The infrastructure of BUIDL is best described as a **hybrid of traditional capital market infrastructure and digitally native architecture**. The fund mirrors the traditional model: assets are custodied by a reputable bank, the manager and service providers are regulated entities, and investor rights are defined by legal contracts. BUIDL behaves like a money market fund.

On the other hand, BUIDL's **operational fabric is digitally native**. The use of public blockchains means settlement is decentralized and not reliant on any single company's database (albeit that the settlement governance is permissioned). The ability to transact 24/7, peer-to-peer, with cryptographic ownership is a hallmark of digital-native assets. The fund's **governance processes** (such as changing a smart contract parameter) are centralized, but the actual **transaction processing** is decentralized across node operators worldwide. Additionally, BUIDL's presence on-chain enables it to plug into other digital platforms – e.g. being used as collateral in a future on-chain lending platform or integrated into treasury management dApps – in ways a traditional fund could not without significant interfacing. Indeed, startups such as Ondo have already built a DeFi-like wrapper around BUIDL to broaden access, and one could envisage permissioned liquidity pools or trading venues where BUIDL tokens trade against other digital assets, bringing liquidity to what was previously an off-chain asset.[863]

In summary, BUIDL's network architecture leans on public, **permissionless networks for efficiency and reach**, but confines their openness with a **permissioned layer for compliance**. It aligns with *TradFi* in its trust structure and regulatory footing, yet it adopts *digitally-native* elements by making a traditionally static product (a money market fund share) **programmable and always-on**. This fusion illustrates how DLT can modernize market infrastructure: rather than replacing the roles of custodian, transfer agent, or regulator, it augments them – automating certain functions and extending the operating hours and connectivity of the product. In effect, BUIDL behaves like a digitally-native twin of a traditional fund, bringing the best of both worlds: institutional-grade asset safety on one side, and blockchain-based settlement and composability on the other.

Conclusion

In conclusion, BlackRock's BUIDL stands as a **leading case of institutional DLT adoption**, showing how a decades-old instrument structure (a treasury fund) can be enhanced with blockchain technology. If BUIDL continues on its current path, it could support a new era where **TradFi infrastructure and DLT converge**, enabling funds and financial products that are at once highly regulated yet as agile and accessible as digital assets. The chapter of BlackRock's BUIDL in the DLT story is thus a case study in balancing innovation with regulation – an approach that may well define the next stage of capital market modernization.

863. Ledger Insights, "BlackRock expands tokenized money market fund BUIDL to five more blockchains", November 2023.

Tokenized Funds Use Case #3: Spiko EU T-Bills Money Market Fund

Overview of Use Case

The **Spiko EU T-Bills Money Market Fund** is a tokenized European money market fund that invests exclusively in short-term government debt (Treasury Bills) of top-rated Eurozone countries. It is structured as a sub-fund of the Spiko SICAV (an open-ended investment company) and operates under the EU's UCITS fund framework.[864] Uniquely, this fund's share registry is fully tokenized on distributed ledgers, making it one of the first regulated UCITS funds in Europe to issue shares as blockchain tokens.[865,866] The fund launched in mid-2024 and quickly gained traction, reaching over **$250 million in AUM** by July 2025.[867] As of early 2025 it had **1,100+ on-chain holders** of its tokenized shares, including around **700 business clients** (e.g. corporate treasuries and institutions) alongside individual investors.[868] Each token represents a fund share with a variable NAV (value started near €1.00 and accrues interest daily) – by May 2025 the euro fund's NAV per share was about €1.033, reflecting earned yield.[869]

Deploying Entity & Operation: The initiative is led by **Spiko**, a Paris-based FinTech founded in 2023 by former financial regulators, in partnership with established financial institutions.[870] **Twenty First Capital**, a regulated asset management firm, serves as the fund's management company (investment manager), while **CACEIS Bank** (Crédit Agricole's custody arm) is the independent custodian holding the underlying assets. PwC audits the fund, and the French law firm Gide provided legal structuring advice.[871] Spiko itself provides the technical platform for issuance and investor interface but does not hold client funds on its own balance sheet.[872] Investors (retail or corporate) access the fund through the **Spiko web app or API** integration, allowing seamless subscriptions and redemptions with a low minimum investment of €1,000.[873] When an investor subscribes, they transfer in fiat currency (EUR) to the custodian bank; the fund then mints the equivalent number of **EUTBL tokens** (the on-chain fund shares) to the investor's address.[874] Redemptions work in reverse: tokens are burned and fiat currency is paid out from the fund's accounts, with no fees or notice periods.[875] This operational model enables **daily liquidity** (investors can withdraw any business day) and in practice **same-day settlement**, given the fund complies with money market fund rules requiring high liquidity.[876] Notably, because the shares exist as tokens, investors can also **transfer their fund shares peer-to-peer 24/7** outside the platform's business hours.[877] For example, one allowlisted investor can send EUTBL tokens to another allowlisted investor at any time, instantly shifting ownership of the underlying shares.[878] This 24/7 transfer capability, combined with the daily accrual of interest (pegged to risk-free rates such as the Euro Short-Term Rate, €STR), provides a novel way for holders to earn treasury yields with flexibility.[879]

Workflow and Participants: In summary, the fund's lifecycle involves several participants in a streamlined digital workflow:

Investors undergo KYC/AML checks before depositing EUR or USD, after which they receive EUTBL tokens representing fund shares. These tokens can be stored in Spiko's custodial wallet (standard mode) or transferred to a self-managed blockchain wallet (expert mode), with real-time visibility into balances and daily interest accrual. Spiko's platform acts as both user interface and middleware, automating token minting/burning during subscriptions and redemptions. It enforces wallet-level restrictions via an allowlist and provides APIs for FinTech or corporate treasury integration. The fund is managed by Twenty First Capital, a licensed investment firm that executes strategy through Eurozone T-Bills and repos while ensuring regulatory compliance. NAV is calculated daily, and each token's value directly corresponds to the fund's underlying assets. Importantly, the fund's share registry is maintained directly on-chain, bypassing traditional securities depositories. CACEIS acts as the custodian bank, safeguarding cash and securities under UCITS rules. Investor funds are held securely at the custodian—Spiko never touches them—ensuring segregation and protection. Subscriptions begin with fiat transfers to CACEIS, after which tokens are issued. Redemptions burn tokens and trigger same-day fiat payouts to bank accounts. Token transfers are allowed peer-to-peer among

864. Spiko, SPIKO SICAV – Prospectus Articles of Association, February 2025.
865. Spiko, "Spiko launches the world's first tokenized Money Market Funds", June 2024.
866. Twenty First Capital, "Spiko EU T-bills Money market Fund", Accessed July 2025.
867. Rwa.xyz, "Spiko EU T-Bills Money Market Fund", Accessed July 2025.
868. Ibid.
869. Spiko, SPIKO SICAV – Prospectus Articles of Association, February 2025.
870. Ibid.
871. Ibid.
872. Ibid.
873. Spiko, "Documentation", Accessed July 2025.
874. Spiko, "Documentation", Accessed July 2025.
875. Spiko, "Spiko launches the world's first tokenized Money Market Funds", June 2024.
876. Spiko, "Bpifrance announces its subscription to Spiko's tokenized money market fund, using its own cash reserves", April 2025.
877. Spiko, "Spiko launches the world's first tokenized Money Market Funds", June 2024.
878. Spiko, "Transfers & Redemptions", Accessed 2025.
879. Twenty First Capital, "Spiko EU T-bills Money market Fund", Accessed July 2025.

approved addresses, legally transferring share ownership instantly on-chain. Although no public exchange exists, these OTC-style transfers provide significant flexibility and liquidity beyond traditional fund setups.[880.881,882]

Quantitative Insights: The Spiko Euro T-Bill fund began operations in May 2024, and within its first year it demonstrated significant uptake.[883] By early 2025 it amassed over **$200 million AUM** and continued growing (over $250M by July 2025).[884] This scale, while modest relative to giant money market funds, is notable for a blockchain-based fund in Europe. The **transaction volume on-chain** is also substantial: in a recent month, over $43 million worth of EUTBL tokens changed hands across ~625 transfers between holders.[885] This indicates active use – investors are not only buying and holding but also moving tokens (for portfolio rebalancing or operational needs). The fund had **1,103 token holders** as of mid-2025, ranging from retail users to large entities such as **Bpifrance** – France's public investment bank – which became a notable participant by investing a portion of its cash reserves into the fund.[886] Each share/token is in the **€1 range** in price (initially set at €1.00), and the NAV per share floats slightly with accrued interest (for example, about €1.03 as of May 2025, reflecting the yield earned over time).[887] The fund charges a low management fee (0.25% annually) and no entry/exit fees, aiming to closely deliver the risk-free rate net of minimal costs.[888] In terms of market coverage, as a UCITS fund it can in principle be offered across the EU; currently, the focus is on European investors (the fund is domiciled in France and marketed under French AMF approval).[889] U.S. investors are not allowed (to avoid U.S. securities law issues).[890] **The geographic scope** of usage so far is primarily France and Europe, given marketing in those regions, but the infrastructure (being on public blockchains) is globally accessible if regulatory permissions are addressed. The project timeline has been rapid: conceived in 2023, regulatory approval and fund launch in H1 2024, and key milestones such as surpassing €100M AUM by late 2024 (unofficially reported) and onboarding institutional participants by 2025. In April 2025, the partnership with Bpifrance was highlighted as a milestone signaling institutional confidence in this DLT-based approach.[891] Overall, the use case demonstrates how traditional cash-management products (such as a T-Bill fund) can be enhanced via blockchain to offer 24/7 transferability and integration with digital finance rails, all while operating within a fully regulated framework.

Settlement Asset and Legal Structure

Settlement Asset: The primary asset involved is the **tokenized fund share** itself (EUTBL token), which represents a pro-rata claim on the fund's portfolio of EUR-denominated government T-Bills. When investors buy into the fund, they use **fiat currency (EUR)** outside the blockchain (e.g., a SEPA bank transfer) – effectively exchanging central bank money for the tokenized shares. Redemptions are settled in traditional fiat currency through the custodian bank.[892] Once issued, however, the **tokens serve as the settlement vehicle** for any on-chain transfers of ownership. In other words, if two parties trade fund shares, the delivery of the EUTBL token itself constitutes settlement of that trade (no separate cash leg on-chain, unless the parties privately exchange payment). The token is **denominated in the same currency as the fund (EUR)** and its on-chain value tracks the fund's NAV. Settlement of token transfers relies on the underlying blockchain mechanics: an ERC-20 token transfer, once confirmed in a new block, is considered final delivery of the asset to the recipient.[893] Notably, because the tokens are on public networks, **technical settlement finality** comes from the blockchain's consensus (for example, on Ethereum a transaction is typically irreversible after a few block confirmations, given Proof-of-Stake finality). There is no separate central clearing or T+2 delay; transfers are near-instant (typically seconds on L2 networks or a minute on Ethereum) and **irrevocable** once recorded. The prospectus explicitly states that the fund's shares are not registered on Euroclear France or any traditional CSD – instead the official **share register is maintained on distributed ledgers** (Ethereum and certain Layer-2 chains).[894] This means a blockchain transaction **updating the token ledger is the legal record of ownership**. In practical terms, when a token transfer is executed to an allowlisted address, **legal title to that portion of the fund's shares passes to the new holder at that moment**.[895] The transfer is "free of payment" on-chain; if it is an outright sale, the payment (euros or other compensation) would occur off-chain between the two parties. The *settlement asset* for the fund's internal operations remains fiat currency: when the fund itself settles redemptions or investments, it does so by moving euros (or dollars for the USD fund) through the traditional banking system. However, the innovation is that the

880. Spiko, "Spiko launches the world's first tokenized Money Market Funds", June 2024.
881. Spiko, SPIKO SICAV – Prospectus Articles of Association, February 2025.
882. Spiko, "Documentation", Accessed 2025.
883. Rwa.xyz, "Spiko EU T-Bills Money Market Fund", Accessed July 2025.
884. Ibid.
885. Rwa.xyz, "Spiko EU T-Bills Money Market Fund", Accessed 2025.
886. Spiko, "Bpifrance announces its subscription to Spiko's tokenized money market fund, using its own cash reserves", April 2025.
887. Rwa.xyz, "Spiko EU T-Bills Money Market Fund", Accessed July 2025.
888. Rwa.xyz, "Spiko EU T-Bills Money Market Fund", Accessed July 2025.
889. Ibid.
890. Twenty First Capital, "Spiko EU T-bills Money market Fund", Accessed July 2025.
891. Spiko, "Bpifrance announces its subscription to Spiko's tokenized money market fund, using its own cash reserves", April 2025.
892. Spiko, "Spiko launches the world's first tokenized Money Market Funds", June 2024.
893. Spiko, "Transfers & Redemptions", Accessed July 2025.
894. Spiko, SPIKO SICAV – Prospectus Articles of Association, February 2025.
895. Ibid.

ownership of the fund shares settles on-chain, providing continuous finality and transparency. In summary, the tokens representing shares are effectively the settlement instrument on the DLT side, while **central bank money** (fiat currency) is used for entering or exiting the DLT system.

Settlement Finality – Legal and Technical: Legally, the arrangement leverages French regulations that recognize ledger entries on a blockchain as an official securities register. The fund's documentation makes clear that **investors consent to the DLT-based issuance** and that the tokens are the technical form of the share.[896] At subscription, an investor chooses one of the approved blockchains to hold their shares, and the manager will register the shares on that ledger accordingly.[897] Once recorded, the **blockchain record is authoritative** – there is no parallel traditional certificate. Finality in the legal sense is achieved when a token transfer is confirmed on the ledger, at which point the fund's manager deems the share register updated. Each transfer is **"legally binding" upon the holder's cryptographic signature** (private key signature) and cannot be reversed unilaterally.[898] The prospectus warns investors that losing control of one's private keys or sending tokens to an improper address could mean loss of ownership, underscoring that **token custody and transfers are at the investor's risk**, much like holding a physical bearer instrument.[899] Technically, finality relies on the consensus of the chosen network. There is no separate "settlement layer" or custodian-based reconciliation needed for share transfers – once the chain says the token transferred, that is the final settlement.

Legal Structure and Holder Rights: The fund is organized as a **French SICAV UCITS** fund, which means each token holder is essentially a shareholder of the SICAV (specifically of the EU T-Bills sub-fund) with the associated rights and protections.[900] Under the UCITS and Money Market Fund regulations, investors benefit from strong safeguards: the fund's assets are segregated with a custodian and cannot be claimed by the manager or platform's creditors.[901] Token holders have the **right to redeem** their shares on demand at the current NAV (with no gates or lock-ups, aside from the standard daily cutoff).[902] They also have the right to any distributions, though in this case the income is accumulated into the NAV (no periodic dividend – interest is reflected by NAV increase).[903]

One important legal aspect is the **allowlist/KYC regime**: only verified investors' blockchain addresses are permitted to hold the fund tokens.[904] This means that even though the tokens exist on public blockchains, any transfer to an address that has not been KYC-approved by the platform will fail. This structure preserves compliance (no unknown or sanctioned persons can secretly acquire the security token) and ensures that all token holders are known to the fund's registrar in real life. The prospectus and onboarding agreements stipulate that an investor cannot circumvent the KYC process – any attempted transfer to a non-whitelisted address would not execute on the smart contract level.[905] Thus, token holders' rights are intertwined with their status as recognized investors in the fund's register. If a holder loses authorized status (e.g., due to sanctions), the platform can presumably revoke or restrict transfers from that address. This mechanism provides a **legal protection** by upholding securities laws (preventing free trading to the public), but it also means token holders are not completely permissionless. That said, among allowlisted members, the tokens are freely transferable, and the **holder of the token is conclusively presumed to be the owner of the fund shares** so represented.[906]

In terms of **settlement finality protections**, the use of a regulated custodian and traditional banking for cash settlement means that when investors cash out, they receive fiat currency in their bank accounts. The legal finality of redemption is when the custodian confirms payment; on the token side, finality is when the token burn is confirmed on-chain.[907] In summary, token holders have legally-enforceable rights to the fund's NAV and are protected by fund regulations and custody law, with the blockchain acting as the medium of record for those rights.

896. Ibid.
897. Ibid.
898. Spiko, "Transfers & Redemptions", Accessed July2025.
899. Spiko, "Open-Ended Investment Company with Sub-Funds", February 2025.
900. Ibid.
901. Spiko, "Regulatory Framework", Accessed July 2025.
902. Ibid.
903. Spiko, "Spiko Funds", Accessed 2025.
904. Spiko, "Transfers & Redemptions", Accessed July 2025.
905. Ibid.
906. Ibid.
907. Spiko, "Deposits and Withdrawals", Accessed July 2025.

Interoperability and Network Architecture

DLT Network Type: The Spiko EU T-Bills fund operates on a **public/permissioned blockchain model** – meaning the underlying networks are public blockchains, but the token contract itself is permissioned in terms of permitted counterparties (transfers restricted to allowed addresses).[908] Specifically, the fund's share tokens are deployed as smart contracts on multiple **public blockchain networks**: Ethereum Mainnet and several Ethereum-compatible Layer-2 networks including Polygon (Proof of Stake sidechain), Arbitrum One (rollup), Base (Coinbase's Layer-2), and Starknet (a ZK-rollup).[909] The project deliberately chose public decentralized ledgers (as opposed to a private or consortium blockchain) to maximize transparency and interoperability.[910] By using widely adopted chains such as Ethereum, the tokens can be held in standard digital wallets and potentially interact with other on-chain services (subject to whitelisting), aligning with Spiko's vision of "internet-native" financial instruments.[911]

Spiko's smart contracts for the fund shares are **ERC-20 tokens with added features**.[912] They implement extensions such as ERC-1363 (which allows a token transfer to call receiver logic) and ERC-2612 (permit signatures for gasless approvals).[913] The contracts are also upgradeable via a UUPS proxy pattern, meaning the code can be updated (under strict controls) to adapt to future needs or security improvements without replacing the token itself.[914] This upgradeability is important given the evolving multi-chain environment – it allows adding new networks or modifying allowlist rules if regulations change, with minimal disruption.

Interoperability Mechanisms: A hallmark of this use case is **cross-chain interoperability**. Because the fund's tokens exist on multiple networks, Spiko had to ensure that the total token supply remains consistent with the fund's NAV (preventing double spending across chains). The solution is a form of **managed bridging** or multi-chain issuance. According to the prospectus, the share register can be maintained on any of the approved DLTs, and an investor chooses a preferred network for their shares.[915] If an investor later wants to change networks, the platform likely facilitates a burn on one chain and re-mint on another (effectively a cross-chain transfer via the custodial backend). **Spiko acts as the gatekeeper and bridge**: it controls the minting function on each chain and only mints new tokens when new money comes in, ensuring that the sum of tokens on all networks equals the total shares of the fund. This is different from permissionless bridges; it is more akin to an administrative transfer aligned with the share register. It guarantees that **interoperability does not fragment ownership** – wherever the token resides, it represents the same fund share.

On the **traditional interoperability front**, the Spiko fund integrates with conventional finance through APIs and standard reports. For instance, Spiko offers an API so that FinTech companies or corporate treasurers can plug the fund into their platforms.[916] This enables interoperability with existing systems: companies can use Spiko's API to move money into the fund or query balances, without manually dealing with blockchain transactions (the complexity is abstracted away). Additionally, because the fund is a regulated product, it produces normal financial reports, and has an ISIN code (FR001400ODL1 for the euro fund) and Bloomberg tickers (SPKEUMM), meaning it can be identified in financial databases.[917,918] This bridges the gap between the digital representation and traditional fund databases – for example, Bloomberg terminals can display the fund, and one can look up its price on aggregators such as CoinGecko.[919]

Scalability and Performance: By deploying on Layer-2 networks and sidechains, the architecture is built for scale.. Scalability is further enhanced by the fact that issuing or redeeming shares does not involve any batch settlement delays – as soon as cash is confirmed and tokens minted, the investor can use them immediately. In short, the architecture is closer to a **digitally native infrastructure** in its continuous availability and use of open networks, even though access is permissioned.

Spiko itself markets to **Web3 users** by highlighting that one can earn "risk-free rate on-chain", implying these tokens might be used in the decentralized finance ecosystem (e.g. used as collateral on a lending protocol that whitelists them).[920] Indeed, by making the tokens ERC-20 standard, it is possible for other compliant DeFi platforms to support them in the future. This

908. Spiko, "Transfers & Redemptions", Accessed July 2025.
909. Ibid.
910. Spiko, "Spiko's Smart Contracts", May 2025.
911. Ibid.
912. Ibid.
913. Spiko, "Spiko's Smart Contracts", May 2025.
914. Ibid.
915. Spiko, "Open-Ended Investment Company with Sub-Funds", February 2025.
916. Spiko, "NAV Data Feed", Accessed July 2025.
917. Ibid.
918. Ibid.
919. Bloomberg, "Spiko EU T-bills Money Market Fund", Accessed 2025.
920. Spiko, "Bpifrance announces its subscription to Spiko's tokenized money market fund, using its own cash reserves", April 2025.

contrasts with private bank-led DLT projects that often use proprietary networks and restrict interoperability. Here, **interoperability is achieved at two levels**: between the fund and various blockchains (multi-chain issuance), and between the blockchain tokens and other financial systems (via APIs and recognition in data feeds). This comprehensive interoperability design positions the Spiko MMF as a bridge between traditional cash management and the emerging tokenized finance ecosystem.

Conclusion

In conclusion, the Spiko EU T-Bills Money Market Fund stands as a proof of concept realized in operation for DLT in mainstream finance. It shows that with careful adherence to regulation and smart use of technology, blockchain can modernize the plumbing of a traditional financial product. The use case has navigated regulatory requirements successfully (obtaining UCITS/Money Market Fund approval) and addressed typical policy concerns (investor protection, AML, custody) by marrying the strengths of TradFi institutions (custodian, audits, oversight) with the efficiency of blockchain settlement. The broader market conditions of the mid-2020s – rising interest rates, increased institutional openness to tokenization, and demand for better cash management options – have provided a conducive environment for its growth. Going forward, this model has the potential to influence both regulators and market participation in how they approach the tokenization of other low-risk financial products, balancing innovation with stability.

Legal Considerations

There are various legal structures by means of which an asset can be tokenized. The methods available, and the requirements to achieve each, will depend on the legal and regulatory framework of the jurisdiction in which the asset is being tokenized.

Typical legal structures that can be used to tokenize assets include (but are not limited to):

1. the creation of a contractual framework under which economic exposure to the asset is created with no associated proprietary interest in the asset itself, effectively constituting a contract for differences, which would attract the applicable derivatives regulation in a given jurisdiction;

2. the creation of fractional entitlement to a pool of assets (either by contract or otherwise), which may be considered in certain jurisdictions to be a collective investment scheme, which would typically be subject to applicable rules for investment funds (for example, in the E.U., AIFMD); or

3. the creation of asset-backed tokens, whereby the reference asset is not fiat currency, and the token holder has a right of redemption either to the asset or a representative monetary value. For example, in the E.U., MiCA provides a framework allowing for the issuance of Asset Reference Tokens.[921,922] While the use of this legal structure may have been intended for the creation of stablecoins, it is also a means by which assets can be tokenized. As such, it is relevant in this context.

Once the regulatory treatment of the digital asset has been established, the activities that a regulated financial institution or service provider is able to carry out in respect of these will depend on its regulatory treatment, as well as the legal and regulatory framework of the jurisdiction in which the asset is being tokenized. In some jurisdictions, there may be nothing preventing financial institutions from carrying out certain activities, for example providing custodial services, in respect of some or all types of digital asset; however, other jurisdictions may actively prohibit the holding of certain other kinds of digital assets, or impose stringent/prohibitive capital requirements when holding these assets, making it impractical or impossible for financial institutions to do so. Similar considerations apply to other activities carried out by financial institutions or service providers, for example trading in or issuing of digital assets. Each activity will be subject to different rules and it will be necessary for the financial institution or service provider to see whether each activity will be permitted in the relevant legal and regulatory framework.

For collateral use, regulatory clarifications may be required regarding the use of tokenized funds as eligible collateral under the uncleared margin rules, and harmonization issues (-e.g., different rules for when a money market fund securities are eligible) need to be resolved between US and EMIR uncleared margin rules regarding the use of money market funds, tokenized or tradfi, cross-border.

Ultimately, clarity is required from legislators and regulators as to the delineation between the different categories of tokenized assets, so that it is clear which regulations apply to which type of asset. Additionally, clarity is required from regulators in relation to the ability of financial institutions to custody each form of tokenized asset for clients. The same consideration applies for other types of activity including (but not limited to) trading in or issuing of digital assets.

921. It should be noted that, in certain jurisdictions there are currently restrictions on the assets that can back a stable coin, for example in Hong Kong, stablecoins can only be backed by fiat currency, and in Singapore this is restricted further to a single type of fiat currency for a given stablecoin.
922. It should be noted that, these regimes are not available in all jurisdictions.

ANNEX | CFTC GMAC Approach for Classification of Digital Assets

APPROACH FOR THE CLASSIFICATION AND UNDERSTANDING OF DIGITAL ASSETS

A clear, consensus-driven approach to classifying assets and the functions they serve underpins robust markets and effective regulation. The evolving digital asset ecosystem has led many to develop proprietary taxonomies to classify digital assets and their related technology. In recognition of this progress, the Commodity Futures Trading Commission's Global Markets Advisory Council for Digital Asset Markets **("CFTC GMAC DAM")** Subcommittee (the **"Subcommittee"**) has engaged digital asset stakeholders across the broader digital asset ecosystem to build a common approach for the classification and understanding of Digital Assets (**"Approach"**).

This Approach aims to set out consistent language for participants in the digital asset ecosystem to promote innovation, identify and address risk considerations, and enable effective regulatory understanding. With this objective in mind, the Approach builds upon the considerable classification efforts of global prudential standard setters and regional authorities, including the Bank for International Settlements (**"BIS"**), the Financial Stability Board and others.

The Subcommittee recommends this Approach be considered an initial basis for a consensus-driven, functional taxonomy. However, as the digital asset ecosystem continues to evolve, so too will the terminology used to classify it. The Subcommittee will reassess any future developments to provide further recommendations to this Approach, based on the guidance of its members. The Subcommittee seeks to support effective rules and regulations for Digital Assets, and recommends continued collaboration between industry, standard-setting bodies, and the regulatory community.

This Subcommittee highlights that this taxonomy is intended to be used as an aid to help draft future legislation, regulations, policies, procedures, and other situations where a common approach to understanding Digital Assets is needed. However, legislative and rule-making efforts for the creation of a regulatory framework regarding Digital Assets are at different levels of maturity across regions and jurisdictions. As such, the Subcommittee also notes that the Approach is drafted in a jurisdictionally agnostic manner, and does not attempt to clarify defined terms in any specific existing published legislative or regulatory text.

Definition | Digital Asset: a controllable electronic record[923], where one or more parties can exclusively exercise control through transfer of this record **and** where the controllable electronic record itself is uniquely identifiable.[924, 925, 926, 927, 928, 929] Excluded from the definition of Digital Asset are those controllable electronic records that exist in and function solely as part of a financial institution's books and records.

923. As defined by UCC 12-102(a)(1).
924. For an appropriate legal definition of control, we refer readers to Principle 6 of the UNIDROIT Principles on Digital Assets and Private Law or the Uniform Commercial Code (UCC) Article 12 – which are broadly aligned and define control by reference to digital asset, protocol or system conferring on the a person: (the exclusive ability to prevent others from obtaining substantially all of the benefit from the digital asset; (ii) the ability to obtain substantially all of the benefit from the digital asset; and (iii) the exclusive ability to transfer the aforementioned abilities to another person. Specifically, UCC Article 12 defines a Controllable Electronic Record (CER). In this context, control is defined as the holder of a CER having the power to "avail oneself of substantially all the benefit of the record", "exclusively prevent others from doing so", and "to be able to transfer control of the record to another party" while being able to "identify oneself as holding those powers"; International Standards Organization, ISO/TC 307, 2016.
925. The Subcommittee highlights that efforts to define Digital Asset to date have often focused on the underlying technology and/or technical attributes of said technology. For this Approach, the Subcommittee has aimed to consider a technologically-agnostic approach, to ensure the forward applicability of the definition.
926. Miller, Tokenizing Financial Assets – A Legal Approach, 2023.
927. BIS, A Blueprint for the future monetary system, June 2023.
928. These properties may also be known as the "core" and "service" layer of an asset; BIS, The Tokenization Continuum, April 2023.
929. This definition does not intend to include all existing electronic records, such as those where existing rules and regulations may apply (e.g., electronic security records). In these instances, they would not meet the standard of control, transfer, unique identifiability, and/or self-referential status outlined in the above definition.

Broadly, Digital Assets may serve a variety of economic functions such as a store of value, medium of exchange or payment, a means for investment or trading, or a utility to access other goods, governance, or other services. Within those functions, when those assets have the characteristics of regulated instruments that do not qualify as Digital Assets, a specific regulatory framework may already apply, and the Subcommittee believes that digitization does not, as a legal or practical matter, alter the functioning of the product or service, with the result that it is unnecessary to look beyond the existing classification for the regulated instrument.

To the extent that the use of technology impacts the operational risk profile, the relevant systems and control requirements that apply to those activities should be adjusted by each institution to monitor, measure, and mitigate risks. For example, there are different types of networks on which Digital Assets may exist.[930] The Subcommittee recognizes the importance to not classify digital assets by reference to the type of database or network type on which they are issued/recorded. Doing so is inconsistent with how financial instruments (and non-financial instruments) today are classified and could have unintended consequences for the application of market regulations. Further analysis of the infrastructure is outside the scope of this document at this current time and will be considered in further work by the **Subcommittee**.

Given the nature of Digital Assets, regulators and standard-setting bodies should consider key features beyond economic function to classify these assets and determine what regulatory framework, if any, is adequate. This is similar to how frameworks, such as those that are used for classifying a security or financial instrument, are applied today.

The features of a Digital Asset include, but are not limited to, how the asset: (1) is issued; (2) holds value, (3) confers rights, (4) has fungibility, (5) can be redeemed, and (6) is recorded in books and records. The Subcommittee has endeavoured to define these features below. Digital Assets in this classification have at least one or more of the features captured in the categories, but it should be noted that there may be features developed in the future that have not yet been contemplated at this time. Similarly, not all Digital Assets classified here, have all these features. This is therefore intended as a starting point designed to support regulators and policymakers to take a use case driven approach to evaluate which types of regulations should apply to which type of assets. As these assets evolve and new ones are created, this classification will need to be evolved.

For this classification approach, the Subcommittee has identified a defining set of features pertaining to controllable electronic records:

1. Issuer:

a. Definition: the entity that issues a Digital Asset or for whom a Digital Asset is being issued by a service provider; the entity upon which the person controlling the Digital Asset may have legal claim, for the value of the asset (which necessarily varies by asset type); some Digital Assets may not have an issuing entity (e.g., a bitcoin)

b. Example: a Central Bank is the "issuer" of a central bank digital currency ("CBDC")[931].

2. Mechanism Underpinning Asset Value:[932]

a. Pegged:

i. Definition (Pegged): a Digital Asset attempts to maintain a peg if its market price is referenced to the notional value or amount (as may be applicable) of a different asset, basket of assets, index or any other variable on a consistent basis; the market price may reflect the value of a claim on a particular backing asset or entitlement to a fixed amount of value; the value of "pegged" assets may be enabled through "backing"[933].

930. The Subcommittee notes it has not defined those terms in this Approach because it is beyond the Subcommittee's scope in exercise and believes including definitions and explanations of varying networks detracts from a simple taxonomy that regulators may use. The Subcommittee will endeavor to create a larger, deeper taxonomy in the future that would include such definitions.
931. The Subcommittee notes that specific CBDC arrangements may vary across jurisdictions and may not explicitly conform to the digital asset definition set out here.
932. "Peg" and "Collateralization" are concepts that have been examined in further detail by BIS and definitions here adapt and expand on existing taxonomic efforts; BIS, CPMI, IOSCO, Application of the Principles for Financial Market Infrastructures to Stablecoin Arrangements, July 2022; BIS, Will the Real Stablecoin Please Stand Up, Nov 2023.
933. Note – the Subcommittee highlights that the term "pegged" implies a consistent and locked reference of notional value. In practice, the secondary market price of a pegged Digital Asset may fluctuate due to trading activity, but this is not a feature unique to Digital Assets. For example, there are fiat currencies that are "pegged" to the US dollar. However, in practice, the exchange rate between the currencies is subject to fluctuation.

1. **Definition** (**Backing**): an asset or basket of multiple assets that purport to guarantee or fund redemptions of the Digital Asset (note that the assets backing a Digital Asset may consist of various asset classes that could differ from the reference asset of the pegged Digital Asset; for example, the Digital Asset may reference the US Dollar, but the backing assets may include high quality liquid assets such as US Treasuries as cash equivalents held in reserve).

   Example (**Pegged & Backed**): many **Stablecoins** are examples of pegged and backed Digital Assets (e.g., pegged to the price of one US Dollar and backed either 100% by cash, or by a combination of cash, cash equivalents, and other assets held in a custody account to maintain the value of the peg).[934]

b. Unpegged:

i. Definition: not designed to reference the value of another asset and, therefore, its price is free-floating, determined by market supply and demand for that asset.

ii. Example: many **Cryptoassets**, such as bitcoin or ether, are unpegged.

3. Rights Conferral:

a. Definition: the attribute of a Digital Asset to provide the party (or parties) that control such Digital Asset a legally enforceable claim or rights against the **issuer**. For example, a monetary claim, rights to participate in future revenue distributions, or share in the losses of, or participate in other arrangements by the issuer such as voting, coupon payments, etc.

b. Example: the owner of a **Tokenized Security** is conferred the rights to the recurring cashflows it may pay and or any other applicable rights (e.g., voting rights).

4. Fungibility – Fungible vs. Non-Fungible:

a. Fungible:

i. Definition: a Digital Asset with individual units that are interchangeable on a like-for-like basis.[935]

ii. Example: Ether is fungible with other Ether tokens.

b. Non-Fungible:

i. Definition: a Digital Asset with individual units that are not interchangeable on a like-for-like basis; these Digital Assets could also be described as "unique" or "one of a kind".[936]

ii. Example: Non-Fungible Tokens representing individual pieces of art, with unique artistic features (and where price often varies due to these features), and thus cannot be interchanged with other Non-Fungible Tokens; two **Stablecoins** (as defined herein) from different issuers would not be fungible.

5. Redeemability – Redeemable vs. Non-Redeemable:

a. Redeemable:

i. Definition: the ability to relinquish ownership of a Digital Asset in exchange for equivalent value in another asset class, such as money.[937,938]

ii. Example: fixed income **Financial Digital Assets** (as defined herein) may be redeemable for their notional value upon maturity; other **Tokenized Securities** (as defined herein) may be redeemable for the underlying traditional security it represents.

934. The Subcommittee notes that certain forms certain forms of asset-backed securities and/or collective investment schemes may also be considered "backed" based on the specific application of local laws and regulations.
935. BIS, The Technology of Decentralized Finance (DeFi), Jan 2023.
936. BIS, The Technology of Decentralized Finance (DeFi), Jan 2023.
937. The feature of redeemability has been further explored in the context of stablecoin Digital Assets; BIS, Will the Real Stablecoin Please Standup, Nov 2023.
938. Further, operational redemption procedure, the liquidity of the pool of redemption assets, and the speed of redemption execution (including during periods of market stress) are all characteristics of a Digital Asset that must be considered in determining whether it is redeemable.

b. Non-Redeemable:

i. Definition: a Digital Asset where no issuer exists, or the issuing entity has no obligation to redeem the asset.

ii. Example: Ether is not redeemable for any reference asset.

6. Nature of Record – Digital Twin vs. Digital Native:[939]

a. Digital Twin:

i. Definition: an electronic controllable record representing an asset that has been immobilized on another system of record, and reconciled with that original system of record to ensure ownership is reflected precisely.[940]

ii. Example: a **Tokenized Alternative Asset** (as defined herein) (such as **Tokenized Real Estate** as defined herein) is a Digital Twin of that alternative asset that has been immobilized on another system of record.

b. Digital Native:

i. Definition: a Digital Asset representing the primary record of value, that is not recorded on another system of record and does not require reconciliation with another system of record.

ii. Example: a bitcoin is a Digital Native because it is the original record of value that does not need to be recorded elsewhere to verify ownership.

Note: There may be tokenized arrangements (e.g., in the case of tokens representing a fractionalized interest in a security) that may not be wholly categorized by one of these two features. In these instances, this attribute may not be relevant.

In addition to the attributes that help set out the nature of a Digital Asset, there are other attributes related to a Digital Asset's **intended use case** or **function** that may also be effective tools to understand when seeking to classify them. The Subcommittee notes that the primary objective of this document is to set out definitions. Any relevant regulatory understanding should also account for and vary based on these characteristics. These include:

- **Types of users/holder types** *(e.g., retail vs. wholesale);*
- **intended end user** *(e.g., consumer product vs. financial product);* and
- the entity that serves as the custodian (e.g., regulated depository institution), if any.

939. The Subcommittee notes that these terms are important to the classification of Digital Assets as they provide context as to the various record-keeping approaches that may be used to record ownership.
940. Note: A Digital Twin Digital Asset can be issued after the asset it represents has been created. The Digital Twin does not need to be created at the same time.

Classification of Digital Assets

A. Money or Money-Like Digital Assets

For a Digital Asset to be classified as money or a money-like Digital Asset it must meet one of the following three conditions: reliable store of value, medium of exchange, and unit of account.

Digital Money

1. **Central Bank Digital Currencies (CBDC):** digital tokens representing a claim on a central bank for a fixed amount of central bank money denominated in a single currency; also, a liability of a central bank, with no credit or liquidity risk. It may or may not be programmable.[941, 942, 943]

    a. **"General Purpose" or "Retail" CBDC:** a CBDC that is specifically designed for use in transactions and holdings by individuals and/or small and medium-sized enterprises;

    b. **"Wholesale" CBDC:** a CBDC that is specifically designed for wholesale use in transactions and holdings by regulated financial institutions and could be used in the facilitation of regular financial markets functions (e.g., settlement of securities transactions).

    The Subcommittee notes that as specific CBDC arrangements vary by jurisdiction, the attributes of a **Retail CBDC** and **Wholesale CBDC** may also necessarily vary (e.g., fungibility between the two types).

2. **Bank Deposits:**

    a. **Tokenized Deposits:** digital tokens that represent an existing record of a traditional ownership claim for a bank deposit on the token-issuing bank or depository institution, for a fixed amount of commercial bank money denominated in a single currency.[944]

    b. **Deposit Tokens:** transferable digital tokens issued by a licensed depository institution which evidence a deposit claim against the token-issuing bank or depository institution, for fixed amount of commercial bank money or fiat cash denominated in a single currency.[945]

    The Subcommittee notes that this definition should be considered in the context of the applicable legal framework and local regulations of a given jurisdiction. The intent of the definition drafted here is to reflect a global perspective.

3. **"Reserve-Backed" Digital Currencies:** a privately issued (e.g., by a financial market infrastructure provider digital token where the value of the issued token is **backed** by central bank reserves.[946]

Money-Like Digital Assets

4. **Stablecoins:** privately-issued, money-like, digital token that aims to maintain a stable value relative to a **peg** specified by a reference asset(s) and designed to minimize value fluctuations relative to these reference assets(s). They are **not** issued by a central bank. They must also be at least **fully backed by** one or more assets specified under the specific regulatory framework, including:[947, 948]

    a. Cash: to one or a combination of fiat currencies

    b. Securities: low risk, highly liquid securities such as those classified as High-Quality-Liquid Assets ("**HQLA**") under the BCBS LCR30 framework (e.g., US Treasury Bills)[949]

941. BIS, Central Bank Digital Currencies: System Design & Interoperability; BIS Technology of Retail Central Bank Digital Currency, Mar 2020; BIS, Central Bank Digital Currencies, Mar 2018.
942. Board of Governors of the Federal Reserve System, CBDC, Apr 2023.
943. In some jurisdictions, CBDCs may be classified as legal tender.
944. For tokenized deposits, the ultimate record of ownership will continue to be maintained elsewhere.
945. The Subcommittee notes that (**a**) **and** (**b**) should not be considered new forms of money, but are subject to the same standards as traditional deposits.
946. The Subcommittee notes that these tokens may also be referred to as Synthetic CBDCs.
947. BIS, CPMI, IOSCO, Application of the Principles for Financial Market Infrastructures to Stablecoin Arrangements, July 2022; BIS, Will the Real Stablecoin Please Stand Up, Nov 2023.
948. The Subcommittee notes that in some arrangements, the specific combination of assets used to back a Digital Asset it may change its nature. For example, certain Digital Assets that are backed by physical gold and other commodities may be classified as digital derivatives in certain jurisdictions.
949. BIS (BCBS), Liquidity Coverage Ratio (High-quality liquid assets), Dec 2019.

The Subcommittee notes that to meet the classification standard of a **Stablecoin**, the **issuer** should provide for the timely redemption of the **Stablecoin**, including during times of market-wide or **issuer**-specific stress (e.g., redemption demands that may exceed the available liquidity for backing assets, or other events that could potentially call into question the solvency of the **issuer**). In practice, the means by which this is achieved may vary.

The Subcommittee also notes that **Stablecoin** issuers use different asset classes to maintain parity with the value of the reference asset. For issuers who hold higher-risk backing assets or no backing assets in the collateral reserve, such as Cryptoassets (as defined in **Section D**), **the Subcommittee would not classify these as Stablecoins**. This is due to the potential for incremental liquidity risk and volatility that could lead to a loss of confidence in the issuer's ability to provide for the timely redemption of the Stablecoin. Further, this loss of confidence may lead to secondary market effects affecting the parity of the **Stablecoin** to the reference asset, also known as a "depegging" event. The Subcommittee would instead classify such digital assets as **Other Cryptoassets**.

The Subcommittee further notes that some **Stablecoin** issuers use algorithms to automate the processes that manage supply and demand of stablecoins in relation to the value of the underlying backing reserve. This mechanism has been commonly conflated with the "**Cryptoassets**" category described above and as "algorithmic stablecoins," which may not have **any backing assets** and purport to solely maintain a peg through use of supply and demand mechanics.[950]

The Subcommittee highlights that in some **Stablecoin** arrangements, issuers may use an algorithm to manage their backing reserve. Such an approach in itself gives rise to the same types of risks as manual reserve management, and is not a differentiated characteristic of a **Stablecoin** arrangement. Rather, it is the determination of whether a backing reserve exists and, if so, whether the assets chosen to be held in this backing reserve are of sufficient quality so as to support the liquidity, timely redeemability, and peg maintenance requirements of the **Stablecoin** arrangement.[951]

Ultimately, the **backing** of a **Stablecoin** must consist of assets of a sufficient quality to effectively mitigate liquidity risk and maintain a stable **peg**. In practice, the exact means of **backing Stablecoins** may vary.

B. Financial Digital Assets[952]

Typical use cases include financial investment, financial return, and access to capital markets.

1. Securities (and other financial instruments):

a. **Tokenized Security:** a **Digital Twin** token that represents an underlying security or financial instruments issued on a different platform (e.g., a traditional CSD or registrar), where such representation itself satisfies the definition of a security/financial instrument under local law.

b. **Security Token:** a **Digital Native** token that satisfies the applicable regulatory definition of a security or financial instrument under local law.

2. Derivatives:

a. **Tokenized Derivative:** a **Digital Twin** token that represents an underlying derivative instrument issued and recorded on a different platform, where such representation itself satisfies the definition of a derivative under local law.

950. BIS, CPMI, IOSCO, Application of the Principles for Financial Market Infrastructures to Stablecoin Arrangements, July 2022; BIS, Will the Real Stablecoin Please Stand Up, Nov 2023.
951. The Subcommittee also highlights that certain characteristics such as the maturity profile of any non-cash assets held as backing for a stablecoin, and the auditability of a Stablecoin's backing, are important factors in mitigating liquidity risk, ensuring timely redeemability, and maintenance of a peg.
952. This category encompasses different regulated instruments from a legal perspective, which may attract different regulatory treatment amongst themselves and across jurisdictions.

b. **Derivative Token:** a Digital Native token that satisfies the applicable regulatory definition of a derivative instrument under local law.

The Subcommittee highlights that traditional derivative contracts which provide exposure to an underlying Digital Asset (e.g., bitcoin futures) are out of the scope of this document and not considered here, regardless of settlement type (e.g., physically or net in cash).[953]

C. Alternative Digital Assets

Typical use cases include representation of interest in a good or non-financial asset

1. **Tokenized Alternative Assets: Digital Twin** tokens representing an interest in, entitlement to, or claim on, an alternative (or non-security) asset (or claim on the issuing entity for the asset, where applicable), where such representation itself satisfies the definition of such interest, entitlement, or claim under local law; these alternative digital assets may include:

   a. Tokenized Physical Commodities (e.g., wheat, oil, corn);

   b. tokenized Real Estate; or

   c. other Tokenized Assets of Goods (e.g., carbon credits, art, intellectual property rights, and intangible, discrete assets that only exist in digital form on a programmable ledger platform).

   If certain activities are performed on a tokenized non-financial asset, **the classification category may change**. For example, in the case of Tokenized Real Estate, fractionalization may convert the Alternative Digital Asset to a Financial Digital Asset.

D. Cryptoassets (often referred to as Cryptocurrencies)[954]

Typical use cases include a network-specific medium of exchange, unit of account for transaction fees, speculative investment, and branded store of value.

1. **Platform Cryptoassets: non-redeemable Digital Native** tokens, with **no rights conferred** against the **issuer** (if one exists), that may be exchangeable for specified value, is hard coded into any underlying platform and must serve one or both of the following functions:

   a. Cryptographic economic incentive to maintain and secure to network or application infrastructure including preservation of processing throughput (e.g., through payment of "gas fees" or staking); or

   b. universal medium of exchange of the underlying network infrastructure.

   Examples of **Platform Cryptoassets** include bitcoin or ether tokens

2. **Other Cryptoassets: non-redeemable Digital** Native tokens, with **no rights conferred** against the **issuer** (if one exists), that are used as a speculative investment.

   Examples of **Other Cryptoassets** include "meme-coins" such as shiba inu coin.

   As all **Cryptoassets** are not pegged to the value of a reference asset, do not represent ownership or other legal claim against a company or other type of issuer, nor guaranteed by a regulated financial institution, their value is driven by market dynamics and/or supply and demand mechanics.

953. The Subcommittee notes that, in practice, derivatives that provide for physical delivery of a Digital Asset, may be classified differently by applicable regulators, according to local law, in some cases depending on whether the contract is an exchange-traded derivative subject to an established regulatory regime or an over-the-counter derivative.
954. The Subcommittee notes that while Cryptocurrencies is the term used to classify these Digital Asset's in practice, these Digital Assets typically do not meet the standard required to be considered "currency" and propose an updated classification approach. The Subcommittee also notes that in certain public-sector and private-sector publications, "cryptoasset" and/or "cryptocurrency" has been used as a catchall term for Digital Assets.

E. Functional Digital Assets

Typical use cases include governance or access to a specific infrastructure or app, and specific functional utility.

1. **Functional Digital Assets:** digital tokens that **cannot be exchanged for value** issued (where applicable) to provide the owner of the token with a specific utility such as:

   a. Application-specific governance rights, voting weights, or decision-making authority; and

   b. record of entitlement right to rewards or revenue from a specific application or community.

   As the Digital Asset ecosystem continues to evolve, the Subcommittee recognizes that there may be additional functions or utilities that are not contemplated at this time, and as such expects this classification category to continue to evolve over time.

F. Settlement Controllable Electronic Records

Typical use cases include digital record-keeping, particularly in facilitation of financial transactions.

1. **Settlement Tokens:** digital tokens where such representation itself does not satisfy the definition of a security bank deposit, nor financial instrument under local law and is used solely to transfer or record ownership or perform other middle/back-office financial functions (e.g., collateral transfer, recording of ownership); often exists temporarily, typically for the length of the transaction it facilitates. This may be called the "books-and-records" use case, and a **Settlement Token** would not be considered as Digital Asset as defined herein.

G. Other Digital Assets

The Subcommittee recognizes the potential for future innovation and has retained this bucket for new developments that may arise in the digital assets ecosystem.

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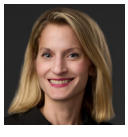

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