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Central Bank Exploration of Tokenized Reserves

Tansaya Kunaratskul, Ashley Lannquist, André Reslow, and Nicolas Xuan-Yi Zhang

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Abbreviations

CSD	central securities depository
DLT	distributed ledger technology
DvP	delivery versus payment
EM	emerging market
FI	financial institution
FMI	financial market infrastructure
FX	foreign exchange
NBFI	nonbank financial institution
PvP	payment versus payment
RTGS	real-time gross settlement
SDX	SIX Digital Exchange
SNB	Swiss National Bank
wCBDC	wholesale central bank digital currency

I. Introduction

Over the past decade, central banks have been exploring potential benefits of distributed ledger technology (DLT) to enhance wholesale payments. Initially focused on domestic applications involving DLT-based central bank money for interbank settlement, these efforts have since also expanded to cross-border payments and tokenized asset settlements. Central banks are reassessing how to modernize payment systems and ensure the continued provision of risk-free central bank money in a fast-evolving digital financial landscape (Bank of Canada and others 2025). One such option is to make wholesale central bank money available on a DLT-based infrastructure.

Wholesale central bank money in DLT experiments is sometimes called “wholesale central bank digital currency” (wCBDC), or more precisely, “tokenized reserves.” The latter term is preferred because it emphasizes that the only change lies in the technology settling reserves as they already exist in digital form.

This Fintech Note explores the opportunities, risks, and policy implications of tokenizing reserves, while leaving it to each jurisdiction to determine whether to adopt the solution or pursue alternative approaches. The key messages of this Fintech Note are as follows:

- Central banks explore tokenized reserves as a way to preserve the safety, liquidity, and policy role of central bank money within tokenized ecosystems by enabling risk-free settlement and support for more efficient, automated, and resilient wholesale payment systems.
- To ensure policy effectiveness, central banks must align their approach to implementing tokenized reserves with their policy objectives. This involves selecting ledger designs, governance structures, and stakeholder engagement that reflect the desired levels of control, risk tolerance, and authority over issuance, access, data, and system continuity.
- Although tokenization may not fundamentally affect central banks’ ability to implement monetary policy, it could introduce enhancements such as programmable or automated liquidity management, which may require updates to governance, legal frameworks, and risk management.
- Alternative solutions to tokenized reserves exist—such as real-time gross settlement (RTGS) links, omnibus accounts, and privately issued tokenized money. Each offers varying degrees of risk, cost, control, programmability, and alignment with policy objectives.
- As central banks explore the potential of tokenized reserves, they may adopt varying strategic approaches—guided by policy goals, market readiness, and institutional capacity, and supported by research, testing, and legal preparation.

This Fintech Note is structured as follows: it first defines tokenized reserves and outlines key policy objectives. It then explores implementation considerations and central bank roles; assesses the implications for monetary policy implementation; compares alternative solutions; and offers guidance on timing, prioritization, and central banks’ strategic choices, with the last section containing the conclusion. This Fintech Note aims to offer lessons and a framework of analysis to help countries evaluate tokenized reserves; it does not intend to endorse or reject them as a policy option. The Note is technical in nature and does not offer policy messages. It merely provides tools and conveys real-world experiences to help policymakers consider broader policy questions.

II. Definitions and Policy Objectives

With the growing interest in financial asset tokenization, central banks are exploring the potential value, implications, and feasibility of tokenized reserves. This section aims to clarify the concept of tokenized reserves by outlining the definition and the key policy objectives driving central banks' explorations as well as highlighting their potential use cases and applications.

Definitions—What Are Tokenized Reserves?

Wholesale central bank money, commonly known as reserves, refers to money issued by central banks to financial institutions (FIs), typically commercial banks and other licensed financial intermediaries, for settling interbank payments and implementing monetary policy (see, for example, Bailey 2024).[1]

With growing market interest in tokenized financial assets, central banks are exploring ways to make their reserves available on similar technology to support payment and settlement of these assets. Tokenization of financial assets involves issuing digital tokens, which either represent these assets or constitute the assets themselves, on trusted, programmable ledgers—commonly adopting permissioned distributed ledger technologies.[2] As such, "tokenized reserves," in this Fintech Note, refer to money with the following characteristics:

- A direct liability of the central bank.
- Issued using DLT.
- Accessible only to a predefined group of institutions—typically FIs.

The term "tokenized reserves" is sometimes used interchangeably with "wCBDC." For example, in BIS and CPMI (2024), wCBDC is largely understood as "wholesale tokenized central bank money," and the Swiss National Bank (SNB) describes Project Helvetia III as piloting "tokenized central bank money for wholesale use, often referred to as wholesale CBDC" (Jordan 2024).

However, definition and interpretation of wCBDC vary across institutions, and are sometimes used to describe a wider range of innovations, not specific to tokenization, in wholesale central bank money. For example, Bank of England (2024a) describes wCBDC as "a new platform for the distribution of wholesale central bank money which unlocks separate functionalities or efficiencies to those enabled by real-time gross settlement (RTGS) systems." Reserve Bank of Australia (2024) describes it as "a digital form of money issued by the central bank that would only be able to be held by a limited range of entities for use

[1] Wholesale central bank money differs from retail central bank money (such as banknotes, coins, and retail central bank digital currencies) in that it is only available to a predefined group of institutions, typically commercial banks and other licensed financial intermediaries. Retail central bank money, by contrast, is available also to the general public, including households and merchants.

[2] Although other database structures are technically possible, this Note assumes tokenization occurs through DLT given its current prevalence, while acknowledging the uncertainty surrounding future technological adoption. Distributed ledgers are databases shared across multiple computers, with built-in mechanisms to automatically reconcile different copies of that distributed database on different computers. They are configured with various governance and access policies and tools, allowing flexibility in how computer nodes are managed, programs deployed, and data accessed or modified. DLT adopted a modular technology stack similar to the Internet, allowing flexible configuration across layers (Schär, 2021; Budau and Tourpe 2024). In permissioned ledgers, access to the infrastructure is restricted to approved participants under defined rules, whereas permissionless ledgers allow anyone to join, validate, and interact without prior approval. However, for both cases, such access rules apply only to the infrastructure level and do not govern the tokens or smart contracts deployed on it.

in wholesale payment and settlement systems […using] an entirely different form of technology that offers new capabilities and/or permits new types of transactions.” The term wCBDC can sometimes misleadingly suggest that central banks are contemplating an entirely new product. However, central bank reserves are already available in digital form to selected FIs. Current experiments merely consist of making these reserves available using novel technology.

This Fintech Note uses the term “tokenized reserves” to refer specifically to central bank reserves issued on DLT, distinguishing them from the often broader and less consistently defined term “wCBDC.”[3] Similar to traditional reserves and all different definitions of wCBDC, tokenized reserves are central bank liabilities backed by the full balance sheet and the legal and institutional credibility of the public sector. Thus, the key distinction lies in the underlying technologies.

Policy Objectives and Use Cases for Tokenized Reserves

Central banks investigating tokenized reserves generally cite two main policy objectives: (1) preserving the advantages of central bank money in a future tokenized financial system and (2) enhancing the efficiency of the wholesale payment system.[4]

Preserving the Advantages of Central Bank Money

Central bank money is the most liquid and safe asset in the economy. In the current monetary system, central banks supply reserves to commercial banks and other FIs, enabling interoperability and settlement of interbank transactions. The use of central bank money for interbank settlement is essential for maintaining financial stability, as it minimizes credit and liquidity risks. This practice is underscored by international standards, such as Principle 9 of the Principles for Financial Market Infrastructures, which recommends interbank settlement in central bank money where practical and available.[5]

Beyond interbank settlements, reserves are key to monetary policy implementation. By setting policy rates and managing reserve levels through monetary policy instruments, central banks influence system liquidity and interest rates in financial markets, thereby helping to steer economic activity in accordance with central bank policy objectives. Moreover, during periods of financial stress, central banks can inject liquidity into the system through reserves, thus stabilizing markets, supporting confidence among FIs, and ensuring the continued flow of credit. As lenders of last resort, central banks can provide emergency liquidity through reserves to troubled FIs during times of financial stress or crisis, thereby helping to contain contagion risks and maintain financial stability.

Some central banks are assessing the role of their reserves in an environment where DLT gains traction in financial markets. If FIs increasingly transact in tokenized assets, central banks may explore options to

[3] Relatedly, Bank of Canada and others (2025) use the term “wholesale central bank money tokens.”

[4] According to the 2024 BIS survey on CBDC, 75 percent of surveyed central banks showed interest in wCBDC [tokenized reserves] and they see “preserving the role of central bank money as an important or very important reason for potential issuance [… and] central banks mentioned that it could preserve the role of central bank money as a settlement asset for transactions involving tokenised assets, such as tokenised securities” (Illes, Kosse, and Wierts 2025).

[5] In addition, Principle 9 of the Principles for Financial Market Infrastructures suggests that if central bank money is not used for settlement, financial market infrastructures should minimize and strictly control the credit and liquidity risks associated with the use of commercial bank money, including establishing and monitoring adherence to strict criteria for settlement banks.

effectively settle those payments in DLT-based central bank money. Offering tokenized reserves may help preserve the advantages of central bank money as a risk-free and effective settlement asset while mitigating credit and liquidity risks from privately issued money (Bank of Canada and others 2025). Alternative options are also possible (see the "Alternative Solutions for Settling Tokenized Assets" section).

Enhancing the Efficiency of the Wholesale Payment System

Central banks' initial interest in DLT focused on its potential to improve efficiency, resilience, and transparency of financial systems through tokenized reserves. Experiments—such as Project Jasper, Ubin, Inthanon, and Khokha —centered on domestic wholesale settlement.

Unlike traditional wholesale payment systems—such as RTGS systems that rely on centralized infrastructure—DLT offers a distributed architecture in which transaction records are synchronized and replicated across multiple participating nodes. Such design can enhance resilience by reducing single points of failure and ensuring continuity of operations if parts of the network are disrupted. In addition, transparency can be higher because of shared data access, which supports improved monitoring, reporting, and regulatory compliance. Nevertheless, this transparency should be carefully balanced with data privacy and sensitivity because certain financial information should remain confidential or accessible only to eligible parties (BIS and CPMI 2017). In addition, DLT enables programmability through smart contracts, which can automate conditional payments and complex workflows.

Although early experiments with DLT focused on replicating existing RTGS systems, many projects did not find strong evidence for transitioning to DLT-based interbank payment systems for simple use cases, particularly in jurisdictions where trusted participants—such as central banks and FIs—already operate efficient centralized infrastructures. Moreover, centralized systems typically outperform DLT in speed and scalability, especially when consensus among multiple validators is required.

As a result, later DLT projects have shifted focus toward more advanced use cases, mainly involving delivery-versus-payment (DvP) settlement for asset transfers and payment-versus-payment (PvP) settlement for cross-border payments. DvP ensures that securities are delivered only when payment is made. Similarly, PvP ensures that a currency transfer occurs only when the counter-currency is received. Both mechanisms are critical for supporting market stability as they reduce counterparty default risk during settlement.

Although traditional wholesale interbank systems, such as RTGS systems, can already support DvP and PvP settlement mechanisms, the key innovation introduced by tokenized reserves lies in atomic settlement from having money and assets on the same ledger (see Box 1). In current securities markets, central securities depositories (CSDs) and central counterparties typically facilitate DvP settlement by linking securities delivery to cash payment. In foreign exchange (FX), CLSSettlement provides PvP settlement for major currencies by synchronizing both legs of FX transactions.[6] These arrangements

[6] CLSSettlement is an FMI that mitigates risk in FX transactions using PvP settlement to ensure that both legs of multicurrency transactions are settled simultaneously, so neither party is left at risk if one fails to deliver. This is particularly important where different time zones and banking hours create risks. Currently, it supports settlement of the 18 most actively traded currencies.

remove principal risk, relying on legal and institutional safeguards to manage timing mismatches, operational dependencies, and counterparty risk. Tokenized reserves experiments seek to complement these legal and institutional mechanisms by employing technology for supporting DLT-based payments—namely smart contracts to facilitate atomic DvP or PvP settlements, ensuring that asset and payment transfers are simultaneous and irrevocable, and in some cases, also composable with other applications with atomicity guarantees (OECD 2025).

Box 1. Atomicity and Atomic Settlement

Atomicity refers to the ability to provide a technical guarantee that a multistep database operation executes in full or not at all. Applying this concept to financial transactions, atomic settlement is guaranteed through technology, ensuring that all legs of a multistep transaction are completed, or none are. Transfers cannot occur in isolation, removing the risk that one party delivers, while the other fails to oblige the transaction.

"Strict" atomicity and atomic settlement in the strict sense are only guaranteed when both assets and payments are recorded and settled on a single ledger with a unified execution environment. In such cases, smart contracts can enforce delivery and payment simultaneously, with settlement finality provided by the consensus mechanism, rather than enforcement through legal or institutional arrangements.

Cross-ledger transactions can, at best, achieve "weak" atomicity. Mechanisms such as hash-time-locked contracts coordinate transaction executions across ledgers by acting as technical escrows, releasing transfers only if cryptographic conditions are met within a time window. These arrangements require all ledgers to be live and synchronized, introducing operational complexity, timeouts, and risks of settlement failure or dispute. Therefore, cross-ledger arrangements cannot replicate the guarantees of strict atomicity achievable under a single ledger environment.

All references to atomicity and atomic settlement in this Note will refer to the strict form, unless otherwise specified.[1]

Sources: Authors; Cabedo and others forthcoming; and Lee, Martin, and Müller 2022.

[1] Definitions of atomic settlement vary. The term is sometimes used to simply describe conditional settlement and sometimes to imply settlement that is both simultaneous and instant. Although tokenization sometimes is used to shorten the time gap between trading and settlement, instant properties are not inherent to atomicity, and the conditionality should be seen as a technical guarantee.

Some experiments have explored multilateral settlement platforms to streamline cross-border payments using tokenized reserves. Examples include Project mBridge, Dunbar, Jura, and Agorá.[7] These platforms, built on shared operations and governance, have demonstrated the ability to execute real-time, peer-to-peer, atomic PvP transactions between commercial banks in different jurisdictions with tokenized reserves linked to their respective central banks. With smart contracts, operational workflows for complex, multicurrency transactions can be automated, lowering manual effort and enabling real-time synchronization.

[7] In additional to central bank reserves, Project Agorá also experiments tokenizing commercial bank deposits to ensure its prototype solution could support credit intermediation while facilitating payments.

In addition, central banks have experimented with the possibility to enable more complex, conditional workflows involving multiple assets, currencies, or stages—such as delivery-versus-payment-versus-payment (DvPvP)—to be executed atomically. The ability of smart contracts, tokens, protocols, or applications to interact and trigger each other's execution—known as "composability"—could better support automated complex financial arrangements and synchronized settlements across different systems or assets. Combined with atomicity, this ensures that transactions are properly executed and settled. Experiments such as Project Jura and Guardian have demonstrated how tokenized reserves can facilitate such multi-leg, programmable transactions across currencies, asset classes, and jurisdictions. The Hong Kong Monetary Authority (2024) recently launched a sandbox for Project Ensemble to support industry-driven interbank settlement use cases with experimental tokenized money. This initiative paves the way for further experimentation with both DvP and PvP settlements.

The remainder of this Note mostly focuses on tokenized reserves in domestic DvP settlement, while in-depth analysis involving cross-border and multicurrency settlement is left for future analysis.
Use cases for tokenized reserves will vary by jurisdiction, depending on policy goals and local challenges. In some advanced economies, the priority is often to preserve the role of central bank money in future tokenized asset settlements rather than to improve already efficient interbank payment systems. While for some emerging markets, they may find unique opportunities in tokenized reserves as DLT and tokenization may offer a pathway to modernizing financial market infrastructures (FMIs)—though this comes with important cost and risk considerations (Illes, Kosse, and Wierts 2025; Box 2).

Box 2. Emerging Markets' Exploration

This box highlights issues emerging markets (EMs) are exploring with tokenized reserves. Although the focus here is on potential benefits, associated costs and risks could also arise and warrant an in-depth, separate analysis once sufficient experience has been accumulated. For example, tokenized reserves could help enhance the efficiency of cross-border payment and trades, but may also complicate capital flow management. Ultimately, technology should complement—not replace—strong institutions, sound policies, and robust legal frameworks, as poorly implemented technologies could undermine public trust and resilience.

- **Better enforcement of rules or policies**: Compliance for financial market infrastructures in EMs may face additional challenges compared to advanced economies, often reflecting less robust legal and regulatory enforcements. Therefore, by leveraging technology to embed crucial rules directly at the infrastructure level, EMs may enhance policy implementation and ensure compliance from all participants. For example, in the context of central securities depositories (CSDs), some treasuries are setting a minimum tradable amount of securities as part of a policy to diversify the investor base. In today's indirect holding model, brokers might be tempted to adjust this threshold to save operational costs. By integrating the CSD and tokenized reserves on a single ledger, the operations and settlement can comply with the rules and policies and can be enforced through technological implementation.[1]
- **Cross-border payments and trade finance**: Many EMs rely on trade, foreign investment, and remittances, but usually face greater friction in cross-border payments compared to advanced economies, such as high foreign exchange (FX) and compliance costs. Distributed ledger technology (DLT) and tokenized reserves have shown potential to address some of this friction, as demonstrated by some experimental cross-border projects. For example, Project Mandala showed the potential of DLT for streamlining compliance for cross-border transactions, showcasing how regulatory requirements could be managed in the context of cross-border tokenized reserves.[2] Project Rialto demonstrated how automated market makers for wholesale FX conversion, using tokenized reserves as a settlement asset, could support lower FX costs and secured instant cross-border retail payments.[3] In addition, central bank-led collaborative projects—such as Banco Central do Brasil and the Hong Kong Monetary Authority under Project Ensemble and Drex pilot program, and the Bank of Ghana with Monetary Authority of Singapore—have experimented with tokenizing real-world goods such as agricultural products. These initiatives used tokenized reserves for atomic settlements in trade finance, aiming to boost trust among importers and exporters, enhance transparency in supply-chain tracking, and improve access to funding for local firms.[4]
- **Capital market development**: Some EMs have shown increasing interest in exploring tokenized reserves and assets to support the development of capital markets in several aspects, including improving investor access, operational efficiency in asset issuance, and liquidity and tradability of assets (Leung and others 2023). For example, fully atomic settlement for money and assets within the same ledger could improve trust as well as address counterparty and settlement risks associated with collateral pledging and rehypothecation.[5] In addition, tokenization may streamline the asset lifecycle by automating processes such as issuance, trading, and ownership transfers, thereby reducing reliance on intermediaries and lowering associated costs. Smart contracts also allow for flexible fractionalization, thus lowering investment minimum thresholds, widening investor base, and enhancing asset liquidity.

[1] For instance, setting the minimum tradable unit at the asset layer in the IMF's ASAP (Access, Service, Asset, Platform) model would shift the current practice in the CSD, where tradable units are determined at the service layer by brokers using their individual IT systems (Budau and Tourpe 2024).

[2] DLT-based cross-border systems can input data from other governmental services such as identity, company registries, and tax agencies into tokenized assets, thereby enhancing compliance. Tokenized reserves issued on that platform can increase trust by providing central bank money as a safe and trusted settlement asset.

[3] As opposed to over-the-counter for FX transactions, where the size of the dealer also plays a role in risk mitigation, this can result in preferential pricing that varies based on the dealer's geography and local currency.

[4] For more information, see Bank of Ghana (2024) and Hong Kong Monetary Authority (2024).

[5] It is important to note that tokenization alone does not automatically enable new eligible collateral or reduce the risk of certain types of collateral.

III. Implementation Considerations

This section explores key considerations for implementing a tokenized reserve system. It examines various ledger architectures and operating frameworks, outlining the functions central banks should retain direct control over to safeguard their core mandates. Each model involves trade-offs, and the most suitable approach will depend on each country's institutional, technological, and market context.

Implementation Models

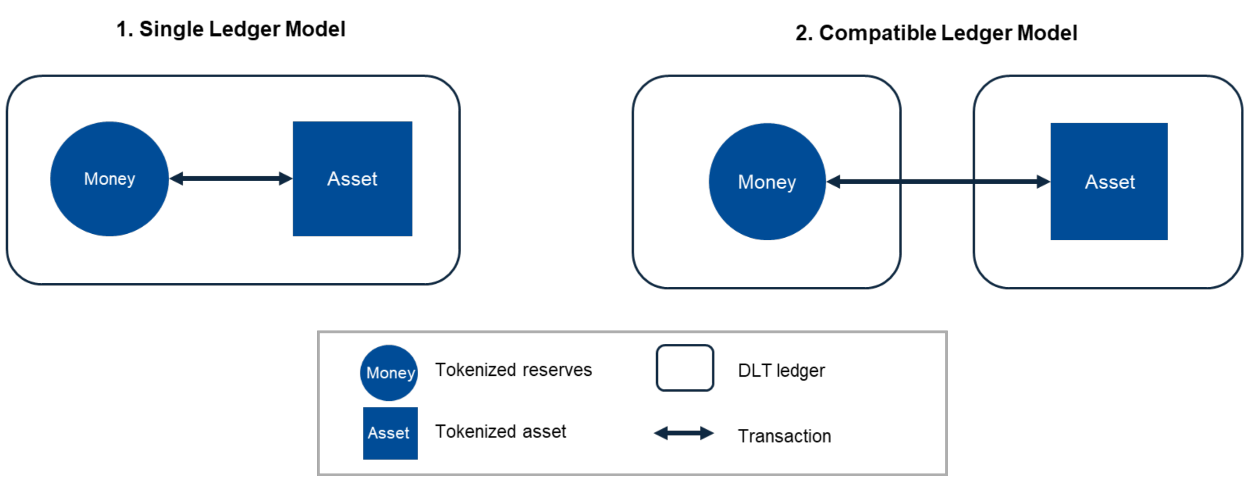
When considering the tokenization of reserves, central banks must evaluate potential implementation models. There are two essential questions: (1) should tokenized reserves be issued on an exclusive ledger or on a ledger together with other tokenized assets, such as government or corporate bonds; and (2) what framework should govern the operation and management of the ledger?

Defining Basic Ledger Models

Drawing on IMF (2024), there are two main high-level ledger models for tokenized reserves (Figure 1):

- **Single ledger**: Tokenized reserves and other assets such as bonds or securities are issued and exchanged on the same ledger.
- **Compatible ledgers:** Tokenized reserves are issued on a dedicated ledger without other types of assets and can interoperate with other ledgers containing tokenized assets.

Figure 1. Ledger Models for Tokenized Reserves and Assets



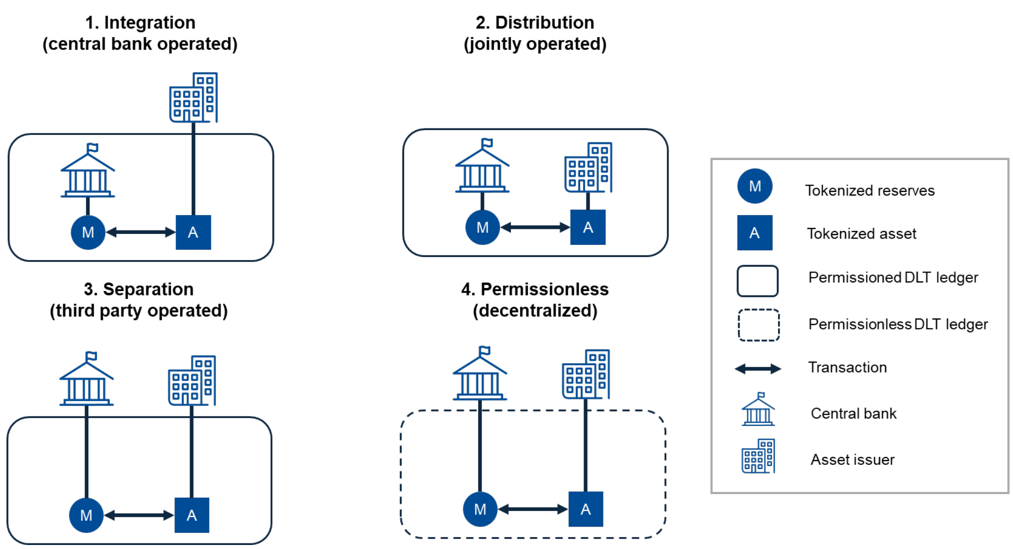
Source: Authors.
Note: DLT = distributed ledger technology.

Operating Models for a Single Ledger

The operating model for a single ledger determines the degree of the central bank's involvement in managing and overseeing tokenized reserves and assets under the same ledger. Drawing on the typology presented by Neuhaus and Plooij (2023), four models can be identified (see Figure 2):[8]

- **Integration (central bank operated):** The central bank controls the operation and governance of the ledger hosting both tokenized reserves and other assets. The central bank is the main operator and determines the governance of the system. For example, it can set access policies to determine which institution can issue securities on the ledger or host nodes.
- **Distribution (jointly operated):** The ledger is operated and governed jointly by the central bank and other stakeholders, such as private institutions or other central banks. The central bank shares decision-making and operational responsibilities with other stakeholders.
- **Separation (third party operated):** The central bank issues tokenized reserves on a ledger operated by a third party, typically a private infrastructure provider. The ledger is usually permissioned and tailored for financial market transactions. The central bank acts primarily as a participant and, where appropriate, as a regulator or overseer.
- **Permissionless (decentralized):** The central bank issues tokenized reserves on a permissionless DLT infrastructure. This infrastructure is open and public, allowing anyone to participate without requiring approval from a central authority. It is defined by decentralized governance with no single entity controls the ledger. The central bank operates as a peer participant on equal footing with all other network participants.

Figure 2. Operating Models for a Single Ledger



Source: Authors.
Note: DLT = distributed ledger technology.

[8] The first two models—integration and distribution—are based on Neuhaus and Plooij (2023), while this Note adds two additional models—separation and permissionless. Note that, as discussed in footnote 2, governance and policies defined at the infrastructure layer—which are what distinguish the different models listed here—do not have to be necessarily the same for tokens or smart contracts deployed on this infrastructure because it can be different for "Asset and Service layers" (Budau and Tourpe 2024).

The four models are not always distinct because hybrid ones are possible. For example, a central bank could operate its own ledger, as in an integration model, but allow a consortium of private firms to manage some functions, thereby edging toward a distribution model. Similarly, a private platform operator could be subject to tight joint governance with the central bank, blurring separation and distribution models.

Some of these models have been explored in central banks' experiments. For instance, the integration model was explored by the Banco do Brasil as part of their Drex project. Project mBridge, which aims to enhance cross-border payments, adopts the distribution model. Developed collaboratively by four central banks, mBridge allows each participating central bank to issue its own tokenized reserves for cross-border payments on a multicurrency platform with shared governance and operational responsibilities. The separation model is adopted in Project Helvetia, where the SNB issued tokenized reserves onto the SIX Digital Exchange, a DLT-based exchange operated by the private SIX Group. In this setup, SIX Digital Exchange, as a regulated private FMI, operates the DLT platform, while the SNB provides tokenized wholesale central bank money for settlement. In addition, analogies to some of these models can also be found in current, non-DLT, large-value payment and CSD arrangements (see Box 3).

The permissionless model is technologically possible, yet it entails numerous operational challenges, such as transaction scalability and costs, governance, and accountability. Principle 2 of the Principles for Financial Market Infrastructures emphasizes governance, states: "An FMI should have governance arrangements that are clear and transparent, promote the safety and efficiency of the FMI, and support the stability of the broader financial system, other relevant public interest considerations, and the objectives of relevant stakeholders" (CPMI-IOSCO 2012, p. 1). Implementing this principle in a permissionless DLT environment can be challenging because system management lies outside the control of any single institution. Although no central bank has yet adopted the permissionless model, there is a possibility that the option may be chosen for exploration in the future.

Box 3. Non-distributed Ledger Technology Case Studies of Integration, Distribution, and Separation Models

- **Integration:** T2S (Eurosystem), Fedwire Securities (United States), and BOJ-NET JGB Services (Japan) all illustrate different examples of integration between cash and securities (Bank of Canada and others 2025). Rwanda provides another good example. Its only central securities depository (CSD) is owned and operated by the National Bank of Rwanda, and holds both government and private securities and central bank money. Rwanda stands out for integrating private securities, as publicly operated CSDs typically are limited to government securities (Wendt, Katz, and Zanza 2019).
- **Distribution:** In Canada, the large-value payment system, Lynx, is owned and operated by Payments Canada, a not-for-profit, public-purpose organization, where the Bank of Canada is a member. The central bank provides integration of settlement accounts, enabling settlement in central bank money, thus reflecting the distribution model with some similarities to a separation approach. In this case, central bank money is issued on a system that is managed and operated by several stakeholders through a joint organization.
- **Separation:** Switzerland's Swiss Interbank Clearing is a real-time gross settlement system and operated by a private entity SIX Interbank Clearing, demonstrating a separation model. The Swiss National Bank provides integration of settlement accounts and oversees the system but does not own or operate it. In the context of securities settlement, Euroclear Sweden also adopts the separation approach. As a private CSD, it settles private securities in central bank money through Riksbank accounts integrated into its platform. This setup remains rare, as few other private CSDs combine securities and central bank money on the same system.

Source: Authors.

Operating Models for Compatible Ledgers

For a compatible ledger model, the tokenized reserves' ledger is likely to be fully owned and operated by the central bank, similar to its current management of a wholesale payment system and similar to the integration model described earlier. This model enables central banks to maintain direct control of critical rules and functions, such as setting eligible criteria for participants and interoperable ledgers, as well as issuing, redeeming, and validating tokenized reserves.

The compatible ledger model could adopt an alternative approach where the central bank outsources the operations to a third-party provider, similar to the separation model for a single ledger described earlier. In such cases, a third-party entity would manage the ledger containing tokenized reserves, but the central bank would retain a strong influence of critical rules and functions. Switzerland's current Swiss Interbank Clearing system would be a comparable non-DLT example (Box 3).

Factors Influencing Tokenized Reserves Implementation

Selecting the appropriate ledger and operating models for tokenized reserves require careful consideration. Each option presents distinct benefits and trade-offs, meaning that central banks may adopt different implementation approaches based on their policy objectives for tokenized reserves. The remainder of this section outlines key technical opportunities and risks of different models, examines macrofinancial implications, identifies critical functions that central banks should retain control over, and highlights additional considerations for implementation.

Technical Opportunities and Risks

Selecting an implementation model is critical because it determines technical opportunities and risks. For example, single and compatible ledgers differ in their support for advanced programmability opportunities, such as atomic settlement and complex multistep transactions (for example, DvP, PvP, or DvPvP) that execute automatically and simultaneously.

A single ledger model is generally regarded as a more feasible and operationally sound approach for implementing more advanced programmability. By allowing for seamless executions of complex transactions, supported by smart contracts deployed on the same DLT, the model can potentially improve efficiency and unlock new financial services (Cabedo and others, forthcoming). Moreover, a single ledger can uniquely guarantee strict atomic settlements, allowing for computationally guaranteed transactions by smart contracts without involvement of a third-party legal entity, such as a broker-dealer or central counterparty, thereby mitigating counterparty and settlement risks. For example, if one party lacks sufficient funds or assets for one leg of a two-way or multistep transaction, the entire transaction will fail. If programmability and atomicity are priorities, however, a central bank may favor the single ledger model.

While a compatible ledger model can enable programmable settlements using smart contracts on different DLT ledgers, conducting a transaction between ledgers introduces operational and other technical and nontechnical risks and vulnerabilities. It may require an orchestrating entity to facilitate communication and a third-party entity or legal agreements to insure against failed executions. Technical choices such as compatible DLT consensus protocols and standards around messaging, data, and compliance are also important to reduce friction and improve interoperability and safety.

While a single ledger model generally offers a more efficient and reliable manner to implement advanced programmability, such as atomic settlement, a compatible ledger model can still enable DvP or PvP settlement. Yet, the latter generally relies on the use of a third party to effectively reduce operational and counterparty risks, and potentially to support cross-ledger communication. The extent to which this distinction matters is left to policymakers to decide, keeping in mind their goals and objectives.

While tokenized reserves can offer potential efficiencies, they also introduce new implications and risks that central banks must carefully manage. With simultaneous settlements, this could increase pre-funding requirements and liquidity needs. If settlements are executed instantly, transactions can only occur if cash and assets are immediately available, eliminating the possibility of netting obligations. This environment may not be appealing for some financial market participants (OECD 2025). Moreover, technical vulnerabilities in smart contracts, poor governance, and unintended automation can heighten risks. Capitalization on DLT features, such as increased data sharing and transparency, may raise privacy concerns. In addition, 24/7 operations could add complexity and demand stronger risk and liquidity management frameworks.

The central bank's ability to manage these risks depends largely on the chosen operating model. For example, in an integration model, the central bank retains full control over the ledger and directly implements safeguards. However, expanding its operational role by developing and running an integrated single ledger could risk crowding out private sector innovation and expose the central bank to greater operational, cyber, and reputational risks. By contrast, a separation model delegates day-to-day management and technical resilience to a third-party operator, while the central bank sets key policy parameters as the issuer of tokenized reserves. This approach reduces the central bank's control but encourages private sector innovation.

Macrofinancial Implications

In a single ledger environment where central bank money and assets are interconnected, the combination of transaction dependencies, faster settlement speed, atomicity, and automation can amplify contagion risks, potentially affecting financial stability. For example, the tight integration of smart contracts can create vulnerabilities where an error in one contract can quickly spread to others through automated processes (Danmarks Nationalbank 2025). In addition, programmability enables the creation of complex assets whose returns and risks may rely on multiple underlying assets or prior transactions. This interconnectedness can increase the risk exposure for a broader group of investors, particularly if any of the underlying assets encounter difficulties.

For compatible ledgers that consist of multiple individual ledgers, operating them without adequate interoperability mechanisms and common standards can heighten the risk of market fragmentation. This fragmentation could lead to various market inefficiencies, including decreased liquidity, increased transaction costs, loss of economies of scale, and information asymmetry. For example, if tokenized reserves can only settle on certain ledgers, identical bonds existing across different ledgers may trade at different prices, potentially undermining the benchmark yield curve.

Access policies for tokenized reserves can carry significant macrofinancial implications across all ledger and operating models. By extending access to entities such as nonbank financial institutions (NBFIs) or foreign FIs, central banks may promote competition, innovation, and financial inclusion. However, this broader access involves trade-offs. Although traditionally limited to well-regulated institutions to preserve financial and payment stability, expanding access can introduce operational and financial risks, increase supervisory complexity, and potentially weaken banks' funding models if deposits shift to tokenized reserves (IMF 2020; BIS 2021; Bank of England 2024b; World Bank 2024).[9] Similarly, granting access to foreign institutions could enhance cross-border payments. Nevertheless, depending on each country's setup, it may also introduce risks such as increased capital flow volatility or greater currency substitution (IMF 2024; Reuter and others 2025). Importantly, these benefits and trade-offs associated with access policies are complex and would apply to both traditional and tokenized reserves. They require careful evaluation within each jurisdiction's institutional, legal, and market context.

[9] The impact on banks' profitability and stability from broadening access would depend on funding sources and market conditions. For example, banks might rely more or less on retail/wholesale funding and the strength of their initial financial position would determine their ability to withstand impacts. In addition, solvency risks may arise only if profits decline significantly or turn negative.

Lastly, central banks may consider implementing monetary policy through tokenized reserves, mirroring their approach with traditional reserves. The feasibility of such a shift will likely depend on the extent to which tokenization is adopted across the financial system. As adoption grows, the demand for central bank money—both in traditional and tokenized forms—could change, depending on the access policy as well as rising tokenization use cases that would demand central bank money settlements. In this new environment, central banks will need to ensure effective transmission and implementation of monetary policy. A more detailed discussion is given in the next section.

Critical Ledger Management Functions and Controls for Central Banks

When selecting ledger and operating models, central banks should ensure that they retain direct control over key functionalities of tokenized reserves. These critical functions include issuance and redemption, access and eligibility, data management, settlement halts, and settlement continuity. The extent to which different implementation models enable the central bank to exercise such control is discussed in this section.

Issuance and Redemption

Like their authority over traditional reserves, central banks should retain exclusive control over the issuance and redemption of tokenized reserves by managing the conversions between traditional and tokenized reserves. This principle applies across all models. In central bank-operated ledgers, control is direct. In operating models that allow for external operators, smart contracts controlling the minting and burning of tokenized reserves should be restricted to central banks only. In distribution models, joint governance must ensure that issuance authority rests solely with the central bank. In a separation model, the system operator may be a third party, but issuance and redemption functions should remain exclusively under the central bank's technical or contractual control, as seen in Project Helvetia. Even in a permissionless model, the central bank should control the issuance and rules in related smart contracts to prevent unauthorized duplication or manipulation of the supply of tokenized reserves by other participants.

Access and Eligibility

Controlling access and eligibility to hold and transact in tokenized reserves is another core central bank function, as discussed in the "Macrofinancial Implications" section and further explored in the "Monetary Policy Implementation with Tokenized Reserves" section. Central banks should also retain the ability to suspend accounts and freeze tokens if needed. These controls enable central banks to manage reserves effectively and balance key trade-offs related to stability, policy transmission, and financial integrity. Integration models offer the strongest central bank control, while in distribution and separation models, access control must be negotiated and secured through technical tools or legal agreements that restrict use to preapproved counterparties. In a permissionless model, access must be fully secured through technical tools—such as setting criteria for wallet or node access to hold tokenized reserves and initiate transactions. For example, whitelisting can ensure that only eligible institutions can hold and transact tokenized reserves.

Data Management and Transparency

Central banks should maintain visibility into transaction data for policy, oversight, and risk-monitoring purposes, even as data privacy remains important. For tokenized reserves, transparency is essential to monitor performance, detect illicit activities, and inform monetary operations. The level of transparency should be defined upfront, as it shapes the implementation model. Central bank-operated and integration models would offer full visibility. In a distribution model, data-sharing agreements or node access for supervisory functions can secure necessary visibility. In a separation model, transparency must be established through contractual rights or technical arrangements, such as audit trails or observer nodes. A permissionless model can pose challenges, as pseudonymity limits the central bank's ability to track and interpret activity and may require external analytics to draw meaningful insights.

Ability to Halt Settlements

Central banks should be able to halt and potentially reverse settlement of tokenized reserves in emergencies, such as cyberattacks, technical failures, or participant insolvency. This capability is especially critical in 24/7 systems, in which traditional downtime no longer provides natural buffers. A ledger operated by a central bank offers the clearest path, with emergency stop functionality under the direct control of the central bank. In distribution and separation models, halting settlement typically requires pre-agreed processes, smart contract mechanisms, and contractual rights granting central banks sufficient authority—such as those used by the SNB in Swiss Interbank Clearing. In a permissionless model, full-system halts are nearly impossible, even though the central bank can embed administrative controls, such as freezing or revoking functions in token contracts. However, these only affect the token layer, requiring the central bank to coordinate with other participants to ensure that broader application-level controls are also in place.

Continuity of Settlement

In addition to the ability to halt settlement, ensuring continuity of central bank settlement services is also essential. A central bank-operated ledger allows direct operational control, contingency planning, and recovery mechanisms. In distribution models, contingency planning is shared with partners operating the ledger. On the contrary, in a separation model, the central bank would rely on the third party's arrangements, and regulatory and oversight authority where applicable. However, some central banks may not be able to rely solely on external arrangements, necessitating their own safeguards and contingency solutions.[10] In a permissionless model, the central bank would have no operational control or regulatory influence over the underlying infrastructure because resilience relies on the broader network's consensus and technical design.

Some Additional Considerations Affecting Model Selection

In addition to the technological opportunities, macrofinancial implications, central bank's critical functions and controls discussed earlier, other factors can shape the feasibility and suitability of different models.

Legal foundation is essential across all ledgers and operating models. This includes smart contract operations and the legal recognition of tokenized money and settlement finality. Separation models, especially those involving private ledgers, may require additional legal adaptation to ensure that the central bank's rights and liabilities are well defined. In some jurisdictions, certain operating models might not be legally feasible and thus not an option. When legally possible, the legal basis must be clear and enforceable. In-depth legal assessment of the different models is left for future work.

[10] For example, in the Riksbank's analysis of the Eurosystem's T2 platform, the special security protection assessment concludes that an appropriate contingency solution is needed if transitioning to the T2 platform. One precondition is that the European Central Bank authorizes the Riksbank to provide its own contingency solution, over which it has sufficient autonomy (Sveriges Riksbank 2024).

The ability to implement capital flow management measures also matters in some jurisdictions. The models such as the integration one enable the central bank to enforce and retain direct control. In contrast, separation or permissionless models may complicate implementation of the measures, requiring coordination with third-party operators or full reliance on smart contract capabilities for execution.[11]

Institutional capacity, resources, and risk appetite are other key factors. Central banks with strong operational capabilities and low tolerance for risks may lean toward compatible ledgers and integration models. If greater openness to collaboration with private sector is encouraged, distribution or separation models would be more feasible, provided that the private operator can meet regulatory and technical expectations and the central bank can effectively oversee the arrangement. Relatedly, the cost of developing and operating tokenized reserves is another key consideration. Beyond initial investment, central banks must account for system implementation and the development of skilled personnel to operate and maintain tokenized reserves. For example, if they adopt an integrated model, they will likely bear most of these costs. By contrast, using operating models involving external operators could enable cost sharing, though it could raise risks of operational shortcomings.

Financial market development can also influence model selection. In less developed or smaller markets, the private sector's limited capacity could hamper the ability to support complex platforms, making integration or public-led distribution more practical—assuming sufficient public sector capacity. By contrast, advanced markets with more mature FMIs and robust regulatory regimes may find separation models viable. However, it is important to note that the decision is not static, and transitions can occur over time.

Finally, the nature of tokenized assets, a country's specific economic context, and the existing market infrastructure can affect model selection. If the policy focus is primarily on supporting tokenization of government securities, a clear arrangement and coordination between central banks and fiscal authorities would be essential. Therefore, tighter public sector control through integration or distribution may be more appropriate. In jurisdictions where private entities already manage core FMIs and most private assets will likely be tokenized on privately operated ledgers, issuing tokenized reserves through a separation model may be more practical.

[11] See also He and others (2023) and Reslow, Soderberg, and Tsuda (2024) for more details on "smart CFMs."

IV. Monetary Policy Implementation with Tokenized Reserves

Monetary policy implementation is at the heart of central banking, aimed at managing system liquidity and market interest rates to achieve price stability and growth. It involves operations taken by a central bank to manage the liquidity of reserves and to steer interest rates, with the goal of achieving objectives of economic and price stability. Central banks use various monetary policy instruments to manage liquidity in the banking system, including open market operations, reserve requirements, and standing facilities. With these instruments, central banks can either stimulate the economy by lowering interest rates and injecting liquidity into the system or cool it down by raising rates and reducing liquidity.

If tokenization gains broad-scale adoption in the financial markets and central banks opt to issue tokenized reserves, they should ensure that monetary policy implementation would remain effective in safeguarding stability and controlling inflation. In this case, tokenized reserves could potentially also present an opportunity to modernize monetary operations by harnessing the new functionalities and capabilities offered by tokenization and DLT. Even if central banks do not immediately implement monetary policy through tokenized reserves, it is important that they develop a clear understanding of how tokenization aligns with existing monetary policy instruments.

Tokenization would not fundamentally affect the central bank's ability to implement monetary policy. The ability to perform core operations—such as liquidity provision, interest rate steering, and collateralized operations—would remain intact but could be enhanced through automation, programmability, and composability. However, the shift toward more automated and instantaneous settlement in a tokenized environment could enhance capital allocation and affect liquidity dynamics across money and asset markets. For example, collateralized transactions could benefit from reduced lock-up periods for collateral, thereby improving liquidity efficiency and freeing up capital for other uses (Agur and others 2025). In addition, if central banks expand access to tokenized reserves to a broader set of market participants, such as NBFIs, or enable new wholesale use cases, the demand for wholesale central bank money could change. This transformation would prompt both central banks and market participants to rethink and adjust their liquidity management practices.

The remainder of this section is structured around two illustrative scenarios: (1) a fully tokenized financial system has emerged, and all reserves are tokenized; and (2) a partially tokenized financial system in which tokenized and traditional reserves coexist. The discussion focuses on operational and liquidity implications, noting that many questions remain open and that further research is warranted.

Scenario 1: Only Tokenized Reserves Exist as Wholesale Central Bank Money

This scenario assumes that tokenization has been widely adopted for financial assets and the central bank decides to fully replace traditional reserves with tokenized reserves to support their settlements in central bank money at the interbank level. Although such a scenario may be unlikely to materialize in the near term, it can offer valuable insights into how monetary policy implementation could evolve in response to a tokenized financial ecosystem.

As such, monetary policy implementation and market conventions would need to be redesigned to adapt to a more continuous, automated, and composable settlement environment. The programmability and 24/7 availability enabled by DLT could allow monetary policy instruments to easily operate faster or beyond the standard business hours.[12] Thus, traditional conventions in financial markets—such as end-of-day cutoffs or day counts for interest rate calculation—may no longer be applicable. As a result, central banks would need to redesign the operational frameworks, including instruments such as reserve requirements and standing facilities, to function effectively in a continuous-time system.

Tokenizing monetary policy instruments could enhance flexibility and efficiency in central bank operations. DLT-based smart contracts allow modular upgrades and rapid implementation changes (Schär 2021; BIS Innovation Hub and FRBNY 2025).[13] For example, smart contracts could automatically and continuously optimize liquidity management or trigger fine-tuning facilities, based on predefined parameters such as volatility in market rates or the level of system liquidity. Central banks might also issue digital instruments—such as tokenized central bank bonds—on the same ledger as tokenized reserves to support efficient liquidity absorption. Also, commercial banks could automatically adjust reserve balances in real time to meet reserve requirements or manage intraday liquidity through tokenized collateral (see Box 4 for examples of DLT-based monetary policy implementation experimentations). Although these technologies offer operational benefits, they must be carefully integrated with human oversight to ensure sound judgment and policy alignment.

[12] The shift to continuous operations stems from broader changes beyond DLT, but tokenization may accelerate it.

[13] This is referred as layers in the DeFi stack in Schär (2021). Layered and modular systems (called abstraction of designs in computer science) allow for greater isolation between services, making them more resilient, easier to maintain, and better suited to continuous innovation. Schär (2021) and Budau and Tourpe (2024) divide structures in DLT systems into four layers, analogous to the Open Systems Interconnection (OSI) model for the internet—each layer has defined responsibilities and interfaces. This setup allows for technical upgrades within one layer without disrupting others.

Box 4. Experimentation of Distributed Ledger Technology-Based Monetary Policy Implementation

Project Pine

In 2025, the Federal Reserve's New York Innovation Center and the BIS Innovation Hub collaborated on Project Pine, which developed a prototype for implementing monetary policy in a fully tokenized environment. The prototype effectively demonstrated how tokenized reserves and securities could facilitate monetary policy implementation using smart contracts to automate core functions. It explored four monetary tools: (1) interest-bearing reserves, (2) open market operations, (3) collateral management, and (4) asset purchases. In addition, the prototype included a smart contract toolkit that tested innovative functions, such as creating facilities and exchanges and managing collateral. These smart contracts helped streamline the operations, while various parameters and scenarios could be adapted for different monetary policy frameworks.

Project Helvetia Phase III's Digital SNB Bill

In June 2024, the Swiss National Bank (SNB) became the first central bank to execute a live monetary policy operation using distributed ledger technology. The SNB issued 64 million Swiss francs in 7-day digital SNB bills, settled in tokenized reserves on the SIX Digital Exchange platform. The pilot demonstrated the potential of distributed ledger technology for monetary policy implementation, improving transparency and internal workflows. However, it also revealed challenges related to cash management. For conventional SNB bills, reserves are transacted directly in the Swiss Interbank Clearing system. By contrast, the process for digital SNB bills involved an additional step where tokenized reserves were exchanged for Swiss Interbank Clearing balances as part of the tokenization process before settling the bill payments.

Sources: Bank for International Settlements 2025; and Gerosa, Gloede, and Müller 2024.

Collateralized transactions in monetary policy implementation—such as repurchase agreements, securities lending, and collateralized loans—could be enhanced through the integration of tokenized reserves and tokenized assets used as collateral. By embedding eligibility checks, settlement logic, and risk parameters directly into smart contracts, tokenized collateral could enhance and automate processes in collateral management, such as real-time margin calls, dynamic collateral substitution, and execution of collateralized payments through atomic DvP settlements.[14] In addition, some central banks require banks to over-pledge collateral to cover potential liquidity needs. DLT and smart contracts can enable on-demand liquidity access by allowing collateral to be used on a "just-enough" basis to secure transactions. This enhances overall liquidity efficiency and reduces the opportunity cost of locking up assets as collateral (Bank of Thailand 2018; Lee, Martin, and Townsend 2024; Agur and others 2025).

Moreover, tokenization could enable the transformation of less liquid, complex, or non-standardized assets—such as loan portfolios—into tradable digital tokens. This can improve their tradability and liquidity, facilitate price discovery, and support more accurate asset valuation.[15] If these tokenized assets meet the central bank's risk management criteria, they may become eligible as collateral for monetary

[14] Project Pine experimented using smart contracts for central bank operations and showed that many smart contracts for automating asset servicing required both money and securities to be tokenized since the smart contracts needed to interact with both.

[15] While more empirical evidence is yet to be established for different types of tokenized assets, the study by Leung and others (2023) shows that tokenized bonds exhibit higher liquidity than conventional bonds by having lower bid-ask spreads, and even more so if the tokenized bonds are offered to retail investors.

operations. In emergency lending scenarios, where central banks expand collateral eligibility to include less liquid assets, tokenization can help mobilize these assets quickly and reduce fragmentation—particularly when both assets and reserves are on a single ledger.

Although tokenization could potentially support asset standardization and mobilization, it does not alter an asset's fundamental characteristics or automatically render it eligible as collateral. Proper risk management and asset valuation will still be necessary. In fact, adopting tokenized reserves for collateralized transactions in monetary operations could introduce new risks such as cybersecurity risks, operational risks for erroneous smart contracts, and contagion risks from close integration of collateral and reserves, thus necessitating a rigorous risk evaluation and framework (BIS and CPMI 2024). Therefore, central banks should redesign their risk management practices for tokenized assets, including appropriate haircuts as well as a legal framework to recognize these tokenized assets as eligible collateral.

Scenario 2: Both Tokenized and Traditional Reserves Coexist

In this scenario, financial markets have partially adopted tokenization and the central bank decides to issue tokenized reserves alongside traditional ones. This setup allows for evaluating both a transition phase and a possible long-term equilibrium with parallel systems.

As tokenized and traditional reserves coexist, central banks could face an operational challenge marked by liquidity fragmentation. This dual structure would result in central bank money being distributed across two reserve pools—one within the traditional RTGS system and the other in a DLT-based system. If these reserves are not seamlessly interchangeable, liquidity may become siloed, complicating the central bank's ability to effectively manage liquidity to steer short-term interest rates.

Moreover, variations in the design and policies governing the two types of reserves could also lead to liquidity fragmentation. For example, differences in remuneration or access could encourage FIs to shift liquidity to whichever form of reserves is more attractive. If one system offers higher interest rates, banks may be incentivized to sweep balances into that system, potentially creating volatility in the money markets (Kunaratskul, Reslow, and Singh 2024). Moreover, if settlement operations are not well integrated across platforms, the central bank may face challenges in coordinating liquidity provision to accommodate heightened demand, especially during periods of financial distress.

To manage risks and ensure smooth coexistence between traditional and tokenized reserves, central banks must adopt coherent policies and operational safeguards. This includes coordinated liquidity monitoring, improved liquidity forecasting, and interoperability for seamless transfers between reserve types. To ease initial adoption, central banks may allow only intraday balances of tokenized reserves, requiring end-of-day conversion back to traditional reserves.[16] Legal and economic equivalence—such as harmonized access, remuneration, and regulatory treatment—is essential to preserve fungibility and

[16] Tokenized reserves' experiments including Project Jura and Project Helvetia followed such an intra-day setup. Notably, some central banks have already experienced operating payment systems with differing hours, such as RTGS systems with limited operating hours and always-on fast payment systems, which could offer useful precedents for managing such complexity.

reduce operational complexity.[17] For example, overnight tokenized reserves should earn the same interest and count equally toward reserve requirements to avoid reserve demand volatility.

Finally, in a dual-reserve environment, central banks can decide where to implement monetary policy. If the tokenized segment grows and plays a larger role in the wholesale market, central banks could consider operating in both reserve systems to ensure effective policy transmission. This transition will require careful planning to maintain a cohesive liquidity management framework.

Monetary Policy Implementation across Operating Models

The functionality of DLT's smart contracts used for monetary policy operations depends on the ledger's programmability standard, while the flexibility in those standards determines how quickly central banks can update policy logic in response to changing conditions.

Governance of tokenized reserves determines how easily the programmability standard can evolve. Even if the current ledger supports the required logic, new policy needs may require updates. The ability to implement those changes depends on how the system is governed.

The operating model defines the level of control the central bank has. In an integration model, the central bank retains full authority to write, deploy, and update smart contracts, enabling rapid adjustments and custom features. A distribution model allows significant influence but requires coordination with partners, making updates slower. In a separation model, the central bank depends on third-party operators for changes, reducing flexibility. In a permissionless model, any protocol updates need broad network consensus, slowing responsiveness but allowing innovation from the broader community.

[17] See Bank of England (2024a), which argues that wCBDC ("tokenized reserves") "should be indistinguishable in their core economic characteristics" from RTGS-based reserves, and Jordan (2024) states that the wCBDC ("tokenized reserves") used in Project Helvetia III are "economically and legally equivalent to sight deposits on the SNB balance sheet."

V. Alternative Solutions for Settling Tokenized Assets

Beyond tokenized reserves, alternative solutions exist for settling wholesale tokenized financial asset transactions. Some of these solutions require central banks to take a leading role, whereas others allow for the private sector to provide solutions for tokenized asset payment and settlement. This section provides a discussion of alternative solutions, and of how central banks could weigh various options (Bank of England 2024a; Cambridge Centre for Analytical Finance 2024).

Real-Time Gross Settlement Link

An RTGS link, also known as "a trigger solution" or "synchronization," creates a technical bridge or involves a synchronized operator to coordinate tokenized asset delivery on a DLT platform with payment and settlement in traditional central bank reserves through the RTGS systems.[18] As such, it is considered a compatible ledger model. The two legs of the transaction—asset transfer and payment—are mutually conditional using smart contracts, where the asset is transferred only if a payment is made and vice versa. An RTGS link can be seen as a simple way to achieve central bank money settlement on a DvP basis for tokenized asset transactions. Examples of these types of models can be found in the Bundesbank's "Trigger Solution" (Deutsche Bundesbank 2021), Banca d'Italia's "TIPS Hash-Link" proof of concept (Banca d'Italia 2023), and the Bank of England's "RT2"—a renewed RTGS service with synchronization functionality (Bank of England 2025).

Omnibus Account

In 2021, the Bank of England implemented the omnibus account solution for settlement of tokenized payments on private, programmable asset platforms, which is fully funded by reserves (Bank of England 2021). Under this solution, a licensed FMI operating a permissioned DLT platform could hold funds in an omnibus account with the central bank. FIs participating in the FMI can transfer reserves into the omnibus account, and the FMI then issues private money tokens for settling transactions on the DLT platform.[19] The on-chain money is issued by the FMI yet fully backed by the omnibus account.[20] Omnibus account arrangements allow for settlement using tokens on the DLT platform outside of RTGS operating hours and with added functionalities, such as programmability, provided that the FIs have prefunded their omnibus accounts (Bank of England 2021). The omnibus approach, viewed through the lens of IMF (2024), can be considered a "common ledger" while it creates a "bridge" to allow for coordinated

[18] SNB Chairman Thomas J. Jordan highlighted the RTGS link scheme in a 2024 speech: "A second question concerns whether wCBDC is the best solution for settling tokenized assets in central bank money. In Switzerland, there are other possible solutions, such as linking platforms for tokenized assets with today's SIC payment system" (Jordan 2024).

[19] For example, the Sterling Fnality Payment System uses the Bank of England's omnibus account solution to hold participant funds and issues DLT-based settlement tokens representing claims on this pool of funds.

[20] In general, the legal arrangement between the participants and the FMI can take different forms and the funds in the omnibus account may legally belong to the FMI or to its participants (Bank of Canada and others 2025). Although different omnibus account structures can exist, this Note considers a case where tokenized money issued against omnibus account funds is regarded as settlement in private money, similar to Bank of Canada and others (2025).

transactions of tokenized money and assets on the same ledger, mixing aspects of single and compatible ledger models.

Privately Issued Tokenized Money

Instead of central banks, private institutions (such as commercial banks) or NBFIs (such as fintechs) could issue tokenized money denominated in local currency for payment and settlement of tokenized assets within a programmable environment. Currently, there are three major types of privately issued tokenized money for wholesale payment, with possible varying design features.

In terms of ledger models, similar to tokenized reserves, these privately issued tokenized money can operate on a single ledger with tokenized assets, or in a compatible ledger arrangement (IMF 2024).

- **Tokenized deposits** are nontransferable claims on the issuing bank but can be used for wholesale payments. Transactions of tokenized deposits between institutional clients of the same bank are settled internally within the issuing bank, whereas transactions between clients of different banks require an additional step—interbank settlement through a private settlement bank (using traditional or tokenized deposits) or the central bank (using traditional or tokenized reserves).
- **Deposit tokens**, also known as "balance-sheet-backed" stablecoins, are issued by banks and transferable between institutional clients of different banks. They are claims on the issuing bank's balance sheet rather than their segregated assets. Moreover, unlike traditional or tokenized deposits, their value can deviate from par. Transactions involving deposit tokens transfer the claim between holders without affecting bank balance sheets; only issuance and redemption of the tokens have balance sheet implications (Garratt and Shin 2023).[21]
- **Stablecoins** are transferrable like deposit tokens but differ in two ways: first, they are backed by "reserve" assets—such as financial assets, commodities, or other crypto assets—to maintain a stable value (Adrian and others, forthcoming). Second, unlike deposit tokens, which are issued by commercial banks, stablecoins can also be issued by nonbanks, such as NBFIs and fintech firms. Given the wide varieties of stablecoins, depending on their stability mechanisms, this Note focuses on "fiat-backed" stablecoins to enable a meaningful comparison with tokenized reserves. These stablecoins are denominated in existing currencies and backed by financial assets—such as government bonds—in the same currencies.[22]

Comparing Tokenized Reserves to Alternatives

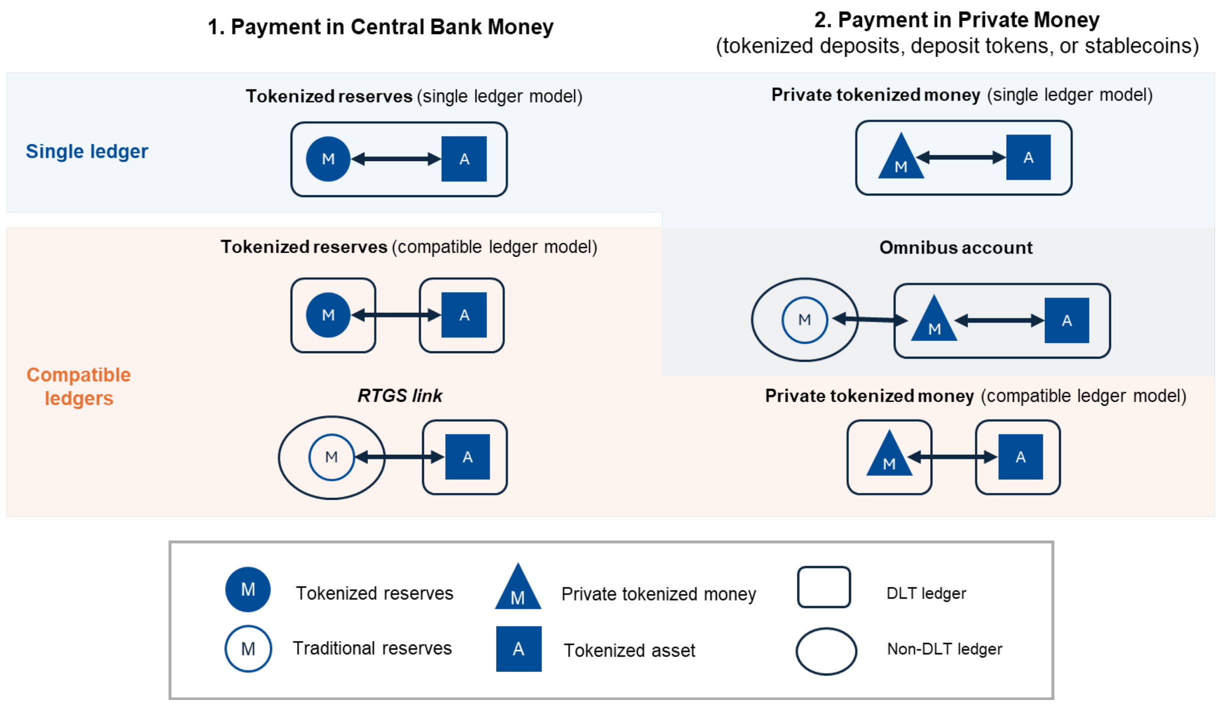
The alternatives for settling tokenized assets can be compared along several dimensions. This section focuses on three key elements: the use of central bank money, and the ability to support and achieve atomic or DvP settlement. These three elements are central because they determine the safety of the settlement asset, the degree of automation and programmability possible, and the robustness of risk elimination in transactions. Other factors—such as implementation cost, scalability, interoperability, legal certainty, and operational resilience—are also important and require further analysis given the specific context of jurisdictions. These should be carefully considered when central banks compare the benefits,

[21] If the final owner of the token at the time of redemption is not a client of the issuing bank, then this redemption process would entail a settlement process between the issuing and final owner's banks.

[22] Stablecoins not in scope include those backed by commodities, other crypto assets, and so-called algorithmic stablecoins.

risks, and implications of different solutions. Figure 3 illustrates the six solutions all together, organized by the type of settlement asset and ledger design, and Table 1 summarizes their capabilities across the three core elements.

Figure 3. Tokenized Asset Settlement Solutions



Source: Authors.
Note: DLT = distributed ledger technology; RTGS = real-time gross settlement.

All six solutions support DvP settlement, enabling conditional exchange of tokenized assets and money to reduce settlement risk. This foundational capability ensures that each option is viable for securely settling tokenized asset transactions.

Achieving atomic settlement is more complex, depending on the system architecture. Tokenized reserves and assets issued on a single ledger, omnibus account solutions, and privately issued tokenized money on single ledgers all enable atomic settlement. In these setups, money and assets coexist on the same ledger, allowing transactions to be settled as a single, inseparable operation. Tokenized reserves issued on compatible ledgers, RTGS links, and private tokenized money on separate ledgers do not offer this functionality, thus limiting opportunities for advanced programmability. Although compatible ledger models can come close to atomicity through solutions such as hash time-locked contract, they cannot reach strict atomicity.

Credit and liquidity risk distinguish the use of central bank money from privately issued money. Tokenized reserves and RTGS links settle in central bank money, the safest form of settlement asset. Omnibus accounts backed by funds at the central bank reduce credit risk significantly but still depend on robust oversight of the operator. Privately issued tokenized money without direct central bank backing carries higher credit and liquidity risks, reflecting the credit worthiness of the issuer and the quality of the assets (OECD 2025). Stablecoins illustrate this risk most clearly because their stability depends on the overall risks of their underlying assets as well as the issuers' reserve management. If stablecoins are backed solely by central bank reserves, they would resemble the omnibus account solution described earlier.[23] However, stablecoins backed by other assets could experience volatility in value, because of fluctuations in those reserve assets.[24] Moreover, as highlighted in Adrian and others (forthcoming), other factors can amplify risks. For example, allowing the rehypothecation of reserve assets by using these assets as collateral to borrow—and then reinvesting the proceeds for higher yields—may enhance their returns but also increase leverage by the stablecoin issuer.

The comparison among these three elements highlights the trade-offs among the six solutions (Table 1). Tokenized reserves under a single ledger model offer the broadest capabilities, combining central bank money, atomic settlement, and DvP settlement. RTGS links also support DvP settlement in central bank money, but can only achieve "weak" but not "strict" atomicity. Some private tokenized money offers atomic and DvP settlement, but the credit risk is material as central bank money is not used. Some stablecoin arrangements can lower credit risk by holding prudent, high-quality assets. Omnibus account solutions can also lower the credit risk of other privately issued money by secure backing of central bank money, but proper oversight remains essential.

Table 1. Comparing the Capabilities of Solutions for Tokenized Asset Payment and Settlement

Which solutions achieve certain goals? Yes (Y) or No (N)

Solution	DvP Settlement?	Atomic Settlement?[1]	Central Bank Money Settlement?
Tokenized reserves—*single ledger*	Y	Y	Y
Tokenized reserves—*compatible ledgers*	Y	N	Y
RTGS link	Y	N	Y
Omnibus account[2]	Y	Y	N
Private tokenized money—*single ledger*	Y	Y	N
Private tokenized money—*compatible ledgers*	Y	N	N

Source: Authors.
Note: DvP = delivery versus payment; RTGS = real-time gross settlement.
[1] Atomic settlement refers to "strict" atomicity and not "weak" atomicity, as elaborated in Box 1.
[2] For omnibus accounts, some jurisdictions might come to the conclusion that settlement happens in central bank money. However, if the "N" for central bank money settlement for omnibus accounts is changed to "Y" with the argument that the final settlement is done using the funds in the omnibus account held in the RTGS system, the "Y" for atomic settlement would need to be changed to "N." Aligned with the paper from Bank of Canada and others (2025), this Note considers tokenized money issued against omnibus account funds as settlement in private money.

[23] In the SNB's Project Helvetia, it also examines "ways in which private token money that is backed one-to-one by sight deposits at the SNB, can be legally structured in such a way that, in the event of the bankruptcy of the token issuer, it would have a risk profile comparable to that of central bank money" (Maechler and Moser 2023).

[24] Some emerging regulations are seeking to require stablecoin issuers to hold safe liquid assets or additional equity capital.

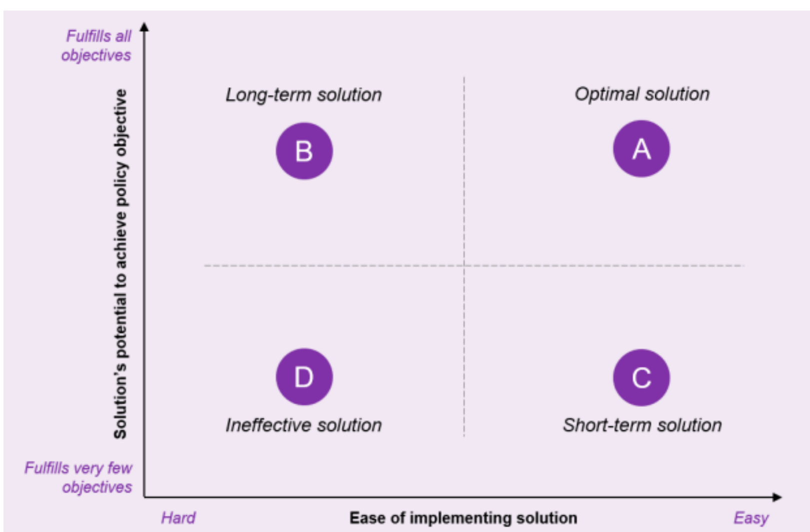
VI. Charting Exploratory Work

Central banks should carefully consider their priorities and resources as they decide to explore tokenized reserves or alternative solutions. They are not mutually exclusive and central banks may choose to pursue multiple solutions, if deemed appropriate. Some solutions may be easier and less costly to implement in the short term, meeting some but perhaps not all policy objectives. In such a case, they could be prioritized in the short term, while a more complex solution could be developed later. This approach may be especially appropriate if tokenized markets are still at a nascent stage domestically. For example, the European Central Bank plans to first implement an RTGS link, with tokenized reserves as a possible next step if the market evolves (ECB 2025).

Policymakers can apply a simple framework to assess and prioritize different solutions for tokenized asset settlement. As illustrated in Figure 4, the framework shows a two-dimensional visualization: the *y-axis* represents *suitability*, indicating how well a solution aligns with policy goals and objectives; and the *x-axis* reflects *feasibility*, capturing the ease of implementation based on factors such as time, complexity, and resource requirements (Patel, Kasiyanto, and Reslow 2024). Central banks can reflect on their policy objectives and internal capacities as they employ this framework.

Figure 4. Prioritization Framework

(Identifying solutions, labeled A–D, based on feasibility and suitability)



Source: Patel, Kasiyanto, and Reslow 2024.

Strategic Approaches for Engaging with Settlement Solutions

As central banks explore tokenized reserves or other alternatives, they can consider choosing among four approaches for engaging with tokenized asset markets: *inaction, wait and see, enablement, and catalyst*. The chosen strategy can help develop internal alignment and transparency on the intent, intensity, and scope of actions related to the chosen settlement solution and complementary activities. Furthermore, the adopted strategic approach can be dynamic and change, given relevant factors such as shifts in market development, internal capacity and resourcing, and central bank and other public sector priorities.

The first strategy is "*inaction*," adopted when central banks see tokenized reserves or related initiatives as not currently relevant or feasible. The second strategy is "*wait and see,*" where central banks monitor key development, gather data, consult stakeholders, and may conduct legal reviews or small-scale proof-of-concept experimentation without committing to implementation. Both strategies emphasize observation over action and may be suited for central banks facing resource constraints, or uncertainty about business rationale for the benefits of DLT (OECD 2025).

The "*enablement*" approach focuses on establishing a foundation for market-led developments by investing in research, infrastructure, and regulatory frameworks. This strategy encourages market readiness without demanding immediate growth. Many central banks experimenting with tokenized reserves follow this approach, using pilots or prototypes to build legal and technical capacity while awaiting private sector demand.[25] Moreover, central banks could engage in short-term solutions, such as an RTGS link, while they investigate the feasibility and desirability of more involved tokenized reserves. Finally, central banks could engage in supplemental activities. For instance, legal and regulatory activities are imperative to establish a legal basis, regulatory clarity and guidance, and measures to ensure the safety of DLT-based solutions.

Finally, the "*catalyst*" approach requires proactive engagement from central banks to the extent that they are confident in the benefits of market tokenization and equipped with substantial resources and support to stimulate market adoption. By developing RTGS links or making their reserves available for settlement on DLT-based infrastructure, central banks could encourage the issuance of tokenized assets and possibly the development of compatible infrastructure. This strategy could involve comprehensive engagement with public or private sector, such as the issuance of tokenized central bank, government, or corporate bonds. It is important to note that even if a central bank actively engages in tokenized reserves, it does not imply abandoning traditional reserves. Both systems can operate in parallel to provide redundancy and support a smooth transition.

[25] For instance, the Bank of England (2024a) report about payment system innovation states, "The extent to which programmable platforms could impact on our monetary and financial stability objectives will ultimately depend on the likelihood that financial markets take up these technologies at scale. The Bank's current assessment is that the likelihood of this remains uncertain. However, preparation for potential widespread adoption is important to ensure we continue to meet our objectives" (p. 5).

Notably, with wait-and-see, enablement, and catalyst strategies, central banks can continue to conduct research about asset and reserve tokenization, including DLT technical capabilities, macrofinancial implications of tokenized reserves, cybersecurity and legal risks, and other essential issues within these active strategies.[26] Such research is currently underway worldwide. A central bank can monitor tokenized financial market development in other countries, conduct technical experiments of its own, review theoretical and empirical work by other researchers and institutions, and participate in global communities and dialogue on the subject.

Lastly, central banks should analyze local financial market challenges to determine whether tokenization could potentially address specific goals or pain points. Also, their strategies and policy choices could differ across jurisdictions, shaped by variations in resources, legal frameworks, and policy priorities (Bank of Canada and others 2025).

[26] Given any chose strategic approach, central banks can follow the IMF's "5P methodology" for CBDC project management (Tourpe, Lannquist, and Soderberg 2023). If a central bank chooses to pursue tokenized reserve issuance (referred to as wholesale CBDC in the 5P paper), it should conduct a thorough research and preparation phase regardless of the strategic path (beyond inaction). With an enablement or catalyst strategic path (beyond wait and see), if the central bank is experimenting with and potentially issuing tokenized reserves, it should follow the phased experimentation and development process as outlined in the 5P methodology: proof of concept, prototype, pilot, and potentially production.

VII. Conclusion

The growing interest in tokenization and DLT within financial markets has led many central banks to reconsider the role of central bank money in these emerging ecosystems. Most prominently, central banks seek to preserve the roles of wholesale central bank money or reserves as risk-free and secure settlement assets for interbank transactions. This Fintech Note discusses important questions that arise for policymakers:

- If financial markets start to widely adopt tokenization, should central banks issue tokenized reserves by making reserves available on a DLT for payments and settlements of tokenized assets?
- If so, which implementation approach best suits meeting their policy objectives, and what key factors would they need to consider?
- How do alternative solutions for supporting the payment and settlement of tokenized assets, such as an RTGS link and privately issued tokenized money, compare with tokenizing reserves?
- Which strategic approach should the central bank adopt, considering the central bank's policy direction, market demand for tokenization, and its capacity and resources to explore tokenized reserves or alternative solutions?

This Fintech Note seeks to provide guidance for central banks as they seek answers to these questions. It offers a framework for comparing tokenized reserves with alternative solutions for the DvP-based settlement of tokenized asset markets. In addition, it discusses implementation considerations for central banks in future tokenized asset markets, keeping in mind institutional constraints, market trends, and the central bank's own views about the opportunities with tokenization and DLT. The Note outlines four strategic approaches—inaction, wait and see, enabling private sector innovation, or adopting a public sector catalyst role—that can support internal alignment and transparency around the intention and intensity of the central bank's activities.

Central banks should evaluate DLT and the tokenization of reserves with a balanced assessment of potential benefits and risks based on their countries' context. The subject remains exploratory, and the extent to which DLT and tokenization will be adopted for wholesale payments and FMIs is still uncertain. Legal requirements and resource constraints should also be taken into account. Above all, central banks must remain grounded in a deep understanding of the fundamental economic challenges faced in their economies and financial systems, and continue to pursue sound, evidence-based policies that serve the public interest. Policymakers should also recognize that DLT, including issuance of reserves, is not a solution for structural issues but a complement to strong institutions, sound policies, and robust legal frameworks. Ultimately, central banks' strategic decisions and chosen policy options could vary across jurisdictions, reflecting differences in available resources, legal systems, and policy priorities.

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