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WHOLESALE CENTRAL BANK DIGITAL CURRENCY AND SYNCHRONISED RESERVES IN TOKENISED ASSET SETTLEMENT

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Abstract

Tokenised securities require a dependable cash leg, but this requirement does not establish that a new wholesale central bank digital currency (CBDC) is economically preferable to synchronising existing reserve accounts with an asset platform. This article develops a functional comparison of these settlement architectures. Official reports on Helvetia, Jura, mBridge, Meridian and the Eurosystem’s 2024 exploratory work are assessed according to settlement asset, linkage mechanism, finality, liquidity commitment and operational recovery. The evidence establishes the feasibility of several approaches under their respective test conditions, while providing limited information for a causal comparison of production costs. A balance-time framework shows that liquidity cost depends on the amount and duration of committed funds, rather than transaction speed alone. An explicitly hypothetical calculation values the release of UZS 100 billion two days earlier at approximately UZS 54.79 million when the annual marginal carrying rate is 10%. This is a one-off scenario, not an estimate of project savings. The article proposes a matched-instruction evaluation protocol that separates architecture from netting rules, prefunding and operating hours. The resulting decision criterion is conditional: a wholesale CBDC is justified by additional functionality and risk-adjusted resource savings relative to a credible reserve-based alternative, rather than by tokenisation or pilot transaction volume in isolation.

Keywords: Wholesale CBDC; tokenisation; delivery versus payment; reserve money; liquidity; settlement finality.
JEL classification: E42; E58; G21; G28.

Introduction

Tokenisation changes how claims on assets are recorded and transferred. It does not, by itself, determine how the corresponding payment should settle. One approach places a wholesale central bank digital currency on a platform that also supports tokenised assets. Another coordinates an asset ledger with reserve transfers in an existing real-time gross settlement (RTGS) system. Both can seek delivery versus payment, but they allocate liquidity and operational dependencies differently.

The policy question is therefore comparative: when does a wholesale CBDC provide additional economic value relative to synchronising existing central bank reserves with a tokenised asset platform? Answering it requires a credible alternative architecture and common transaction

requirements. A successful transfer on a new platform demonstrates that a transaction can be completed under specified conditions; it does not establish that the same result could not be achieved more cheaply through integration with existing infrastructure.

This article contributes a functional evidence matrix, a transparent liquidity-cost framework and a protocol for comparing settlement architectures. The analysis distinguishes three claims that are often conflated: technical feasibility, legal effectiveness and economic superiority. It also shows why lower settlement latency can coexist with greater liquidity commitment if the new arrangement requires more extensive prefunding or loses existing netting benefits.

The article is an analytical policy study. It does not estimate a treatment effect from proprietary settlement data or claim that any architecture is universally superior. Its practical contribution is to specify what must be held constant, what must be measured and which inferences the published evidence can support.

2. Settlement functions and the economic benchmark

Delivery versus payment links the transfer of a security to the corresponding payment so that principal is not delivered without receipt of the other leg. Payment versus payment applies the same principle to two currency obligations. The Principles for Financial Market Infrastructures distinguish settlement finality, money settlements and exchange-of-value settlement systems; Principles 8, 9 and 12 are especially relevant to this comparison (CPSS–IOSCO, 2012).

The identity of the settlement asset must be distinguished from its technical representation. Central bank money can be recorded in a conventional reserve account or represented on another infrastructure subject to the relevant legal arrangements. Using a central bank liability addresses the credit exposure associated with the cash settlement asset, but does not eliminate operational disruption, legal uncertainty or the need to obtain liquidity when obligations fall due.

Technical atomicity and legal finality are also distinct. A protocol may condition the execution of two ledger updates on a common event. Whether the resulting transfers are irrevocable and enforceable depends on the applicable legal framework, rulebook and recognition of ownership. This becomes particularly important when an operator or participant becomes insolvent. A common ledger does not independently answer those legal questions.

Neuhaus and Plooij (2024) frame the settlement challenge around the relationship between distributed ledger technology (DLT) and access to central bank money. This perspective supports evaluating interoperability and market integration alongside platform functionality. The economically relevant benchmark is the least-cost credible arrangement capable of meeting the required safety, access and service standards, including feasible improvements to existing systems.

The comparison here concerns two stylised architectures. In the first, a wholesale CBDC provides the cash leg on, or closely integrated with, the asset platform. In the second, a synchronisation mechanism coordinates asset transfers with existing reserve accounts. Actual implementations can combine elements of both. The classification is functional, not a claim that every project fits a mutually exclusive technological category.

Method and evidential limits

The case evidence is drawn purposively from official reports covering 2021–2025. Helvetia, Jura and mBridge provide different examples of wholesale central bank money on new platforms; Meridian illustrates synchronisation; and the Eurosystem's exploratory work allows comparison across several interoperability solutions. Selection is based on variation in settlement arrangements and the availability of primary documentation. It is not a comprehensive survey of all projects or a ranking of their current status.

For each case, the unit of comparison is the tested settlement function. The review records the environment, settlement asset, linkage mechanism and scope of reported activity. Prototype results, controlled experiments and real-value transactions are distinguished. Project volumes are retained in their original currencies and reporting periods because converting them into a common currency would not make their transaction mix, duration or objectives comparable.

The published reports do not supply a harmonised panel of operating costs, liquidity requirements and outage losses for the two architectures. A regression or pooled effect estimate would therefore create precision unsupported by the data. Instead, the article combines a structured case comparison with a reproducible sensitivity calculation and a proposed evaluation protocol. All numerical liquidity scenarios are illustrative rather than calibrated estimates for Uzbekistan.

What international projects establish

Helvetia Phase II tested integration between wholesale CBDC and commercial banks' existing systems in a test environment involving five banks (BIS Innovation Hub, SNB and SIX, 2022). The Swiss National Bank (SNB) subsequently reported that six banks participated in the initial phase of its real-value pilot from December 2023 to June 2024, with transactions totalling approximately CHF 750 million (SNB, 2025). These are different stages of evidence. Integration in a test environment and settlement of live transactions are important milestones, but neither figure supplies a matched cost comparison with reserve-based settlement.

Project Jura explored cross-border settlement using euro and Swiss franc wholesale CBDCs on a third-party platform, including delivery-versus-payment and payment-versus-payment transactions (BIS Innovation Hub, Banque de France and SNB, 2021). Its relevance extends beyond processing speed: access by non-resident institutions, governance and the legal treatment of cross-border transfers are part of the settlement problem. A controlled real-value experiment does not establish general legal compatibility across jurisdictions.

The 2022 mBridge pilot involved 20 banks in four jurisdictions over six weeks. Participants executed 164 payment and foreign-exchange transactions with a total value exceeding USD 22 million (BIS, 2022). These observations demonstrate activity within the pilot's scope. They do not identify a steady-state distribution of bank participation, liquidity demand or operating cost. In particular, dividing the total transaction count equally across banks would manufacture a participant-level activity measure that the aggregate data do not contain.

Project Meridian demonstrated a prototype synchronisation mechanism linking central bank money in an RTGS system with an asset registry. The synchronisation operator coordinated settlement without holding the assets or funds itself (BIS Innovation Hub and Bank of England, 2023). Meridian Securities subsequently examined synchronisation in the context of tokenised

securities (Bank of England, 2025). Together, these projects make the reserve-based alternative relevant to the tokenisation debate. Their prototype findings do not establish production resilience or comprehensive life-cycle costs.

The Eurosystem's May–November 2024 exploratory work involved 64 participants across nine jurisdictions and settlement of nearly EUR 1.6 billion in central bank money (ECB, 2025). It used three interoperability solutions: the Bundesbank's Trigger Solution, the Banque de France's Full DLT Interoperability solution, and the Banca d'Italia's TIPS Hash-Link solution. The programme distinguished real transactions in production environments from mock experiments. Its aggregate volume therefore cannot be attributed to one common-ledger CBDC design or interpreted as evidence that such a design dominated synchronisation.

Table 1. Reported settlement evidence and its limits

Project and period	Reported scope	Inference not established
Helvetia II 2022	Integration tests with five banks in a test environment	Production cost advantage
Helvetia initial live phase 2023–2024	Six banks; approximately CHF 750 million	Savings relative to matched reserve settlement
Jura 2021	Real-value EUR and CHF DvP and PvP experiments	General cross-border legal compatibility
mBridge 2022	20 banks; four jurisdictions; 164 transactions; over USD 22 million	Steady-state liquidity and operating costs
Meridian 2023	RTGS and asset-registry synchronisation prototype	Production resilience and life-cycle costs
Eurosystem 2024	64 participants; nearly EUR 1.6 billion; three solutions	Dominance of one architecture

Sources: BIS (2022); BIS Innovation Hub and partners (2021, 2022, 2023); SNB (2025); ECB (2025). Figures refer to different currencies, periods and test conditions and are not a performance ranking. DvP = delivery versus payment; PvP = payment versus payment.

The common evidential result is feasibility under heterogeneous conditions. Nominal volume is not a common measure of economic efficiency: one large securities issue can produce greater value than many smaller payments while revealing less about sustained throughput or recovery under stress. A meaningful comparison requires comparable workloads, operating conditions and cost definitions. The case record provides candidate architectures and practical constraints for that comparison, rather than its final answer.

Architecture and the allocation of risk

Integration and liquidity fragmentation

A common execution environment can simplify coordination between the asset and cash legs and support conditional transfers. The associated liquidity effect depends on how central bank money enters and leaves that environment. If participants must prefund balances that cannot

readily be reused elsewhere, a fast local settlement process can fragment liquidity across platforms. If conversion is reliable, inexpensive and available when needed, that fragmentation may be smaller.

Synchronisation can retain cash in existing reserve accounts until the settlement conditions are met. This may preserve access to an established liquidity pool. However, earmarking funds still has an opportunity cost, and the service depends on the availability of both systems and their connection. Retaining the account location is therefore not sufficient evidence that liquidity is unencumbered.

Failure states and finality

Separate ledgers require a protocol for delayed acknowledgements, lost messages, timeouts and recovery after a partial execution. A participant must not resend a payment merely because an acknowledgement has not arrived. The protocol needs a unique instruction identifier, authoritative status queries and protection against repeated execution. A common platform reduces some coordination boundaries but creates its own dependencies on platform availability and governance.

Failure analysis should distinguish instructions that can safely be cancelled from transfers that have become final. Once a legally final transfer has occurred, recovery cannot simply assume that the ledger may be rolled back. Asset ownership, cash settlement and the treatment of participant insolvency must remain consistent with the governing rules. These requirements should be evaluated in both architectures rather than attributed automatically to the presence or absence of distributed ledger technology.

Table 2. Functional comparison of settlement architectures

Criterion	**Wholesale CBDC with an asset platform**	**Synchronisation with existing reserves**
Cash representation	Central bank liability represented on the designated platform	Balance in an existing central bank reserve account
Coordination	Conditional execution within or across integrated platform components	Coordination of cash and asset states across systems
Liquidity constraint	Conversion terms and potential platform prefunding	Earmarking, liquidity availability and operating hours
Operational dependency	Platform availability and recovery arrangements	Availability of both systems and their connection
Legal requirement	Recognised cash and asset finality	Consistent finality and ownership across systems

Source: Author comparison informed by Helvetia, Meridian and the Eurosystem reports. These are stylised arrangements; neither column represents every implementation.

Gross settlement and netting

Comparisons can be misleading when a technological change is bundled with a change in settlement convention. Moving from deferred net settlement to immediate gross settlement may reduce some exposures while increasing funding needs. Conversely, liquidity-saving mechanisms can reduce required balances within an RTGS arrangement. These changes concern economic rules as well as technical implementation.

Architecture should first be tested under common settlement rules to isolate its contribution. A second comparison can then evaluate the complete policy package, including different netting arrangements, opening hours or access criteria. Both comparisons are useful, but they answer different questions. Reporting them separately prevents improvements due to longer operating hours from being credited entirely to a new form of money.

Measuring the cost of committed liquidity

The balance and duration principle

Let $B_j(t)$ denote the incremental balance committed to settlement under architecture j at time t and unavailable for its next-best feasible use. Let $r_j(t)$ be its annualised marginal net carrying cost. For t measured in days, an illustrative continuous-time carrying-cost identity is:

$$C_j = (1/365) \int_0^H r_j(t) B_j(t)\, dt. \quad (1)$$

The horizon H and rates must use a consistent day-count convention. The calculation uses calendar days and an actual/365 basis for transparency. If committed balances receive remuneration or the foregone alternative already earns a return, $r_j(t)$ should reflect the relevant net spread. Substituting a policy rate without examining the funding or opportunity-cost channel can overstate the economic cost.

The integral emphasises a distinction between turnover and funding. A balance can settle many transactions through reuse. Applying a funding rate to annual gross transaction value as though all of it were continuously committed would generally overcount the exposure. The relevant objects are the time profile of balances and the funding constraints faced by participants, including peaks where liquidity is scarce.

For a single constant balance L released Δd days earlier, at a constant annual net carrying rate r, the conditional cost reduction simplifies to:

$$\Delta C = L \times r \times \Delta d / 365. \quad (2)$$

Equation (2) is a simple-interest calculation, not an estimated model of project returns. It assumes that the released balance has an alternative use and that no offsetting increase in prefunding occurs. Table 3 applies it to an explicitly hypothetical UZS 100 billion balance, three annual rates and three release intervals.

Table 3. Illustrative carrying cost avoided in UZS million

Annual net carrying rate	0 days earlier	1 day earlier	2 days earlier
5%	0.00	13.70	27.40
10%	0.00	27.40	54.79
15%	0.00	41.10	82.19

Source: Author calculations. L = UZS 100 billion; $\Delta C = L \times r \times \Delta d / 365$. Values are rounded independently to two decimal places. The calculation concerns one balance commitment and does not estimate annual project savings.

At 10%, releasing the full balance two days earlier gives UZS 54.79 million after rounding. The zero-day column is zero because this specific timing channel generates no gain when the release time is unchanged. That does not imply that all other benefits of an infrastructure change are zero. Equally, the two-day result is not an annual saving or a forecast of a CBDC pilot's performance.

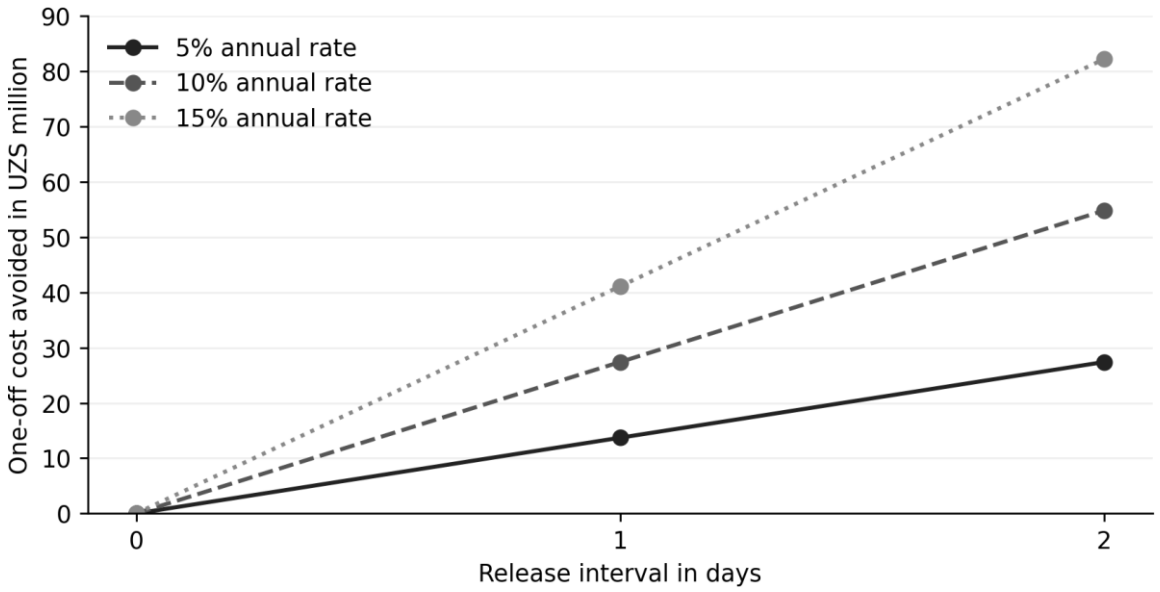


Figure 1. Illustrative carrying cost avoided by releasing UZS 100 billion earlier.

Author calculations using Equation (2). The rates are hypothetical annual net carrying costs. Lines connect scenario values and do not represent observed project outcomes.

Faster settlement can commit more liquidity

A simple counterexample shows why latency alone is insufficient. Suppose one arrangement commits UZS 10 billion for two days, while another commits UZS 30 billion for one day. At a common carrying rate, the relevant balance-time exposures are 20 and 30 billion UZS-days. The second arrangement halves the duration but raises the illustrative liquidity cost by 50%. These are assumed values, not observations from the projects reviewed.

This result does not imply that net settlement is always preferable. Other changes in principal risk, replacement costs, collateral use and operational effort may outweigh a higher liquidity

requirement. It establishes only that shorter settlement time does not logically imply lower funding cost. Evaluation must measure both the amount and duration of committed funds, and report the effect of netting and intraday reuse.

From a liquidity calculation to a decision criterion

For a fixed assessment horizon, let S be verifiable savings in processing and reconciliation resources, ΔC the liquidity-cost reduction relative to the benchmark, and K the additional integration and operating cost. Before attempting to monetise risk changes, the cost comparison favours the new arrangement only when S + ΔC exceeds K. This is an accounting decision criterion, not a welfare theorem. Costs borne by different participants should be identified so that a transfer of fees is not mistaken for a reduction in real resource use.

Risk benefits require separate evidence about exposures, event probabilities and losses. Where these are not credibly measurable, the comparison should retain explicit safety constraints and stress-test outcomes rather than invent a single risk-adjusted return. Life-cycle assessment must also include conversion, migration, participant connectivity and decommissioning costs. A low marginal transaction cost can coexist with substantial fixed expenditure and network coordination costs.

A protocol for comparable evaluation

Establish the baseline and replay common instructions

The first step is to identify a specific settlement problem and a feasible reserve-based response. For a tokenised security, the baseline should describe the existing asset registry, cash settlement process, reconciliation requirements and sources of delay. The proposed synchronisation alternative should be sufficiently developed to be a credible comparator, rather than an intentionally weak representation of legacy infrastructure.

A matched-instruction exercise can then replay the same authorised or suitably anonymised instruction stream through the two architectures in controlled environments. The stream should preserve arrival patterns, transaction values, counterparties and dependencies. Initial liquidity, eligible collateral, settlement priorities and external liquidity access should be equalised for the first comparison. Where the systems cannot implement identical rules, the differences and their economic consequences should be reported explicitly.

The common observation window should cover submission, acceptance, completion, rejection and recovery. Reporting only completed instructions conditions the results on success and can hide queues, failures or exclusion of difficult transactions. Median and tail completion times should be reported together with unresolved instructions and the timing of final cash and asset transfers. Stress scenarios should be prespecified rather than selected after observing favourable results.

Measure balances and operational dependencies

The liquidity record should distinguish free balances, earmarked balances, balances transferred to separate platforms and collateral committed to obtaining liquidity. It should report peak commitments as well as balance-time exposure, because a modest daily average can conceal

an expensive intraday peak. A funding calculation must state which commitments are incremental to the benchmark and how remuneration is treated.

Operational testing should include delayed or duplicated messages, loss of a connection, platform unavailability and participant failure. Relevant outcomes include consistent final states, time to recovery, unresolved obligations and the need for manual intervention. Stress tests establish performance under defined disruptions; they do not estimate the frequency of real-world incidents. Legal analysis should separately establish how finality, ownership and insolvency rules apply.

Assess full costs and external validity

Resource costs should be recorded for the central bank, market infrastructure and participants, including integration and ongoing support. Estimates should identify assumptions about transaction scale and the treatment of fixed costs. A second-stage test can vary opening hours, netting rules and market access to evaluate the complete proposed service, while retaining the initial comparison that isolates architecture.

Replay exercises cannot capture every strategic response. Banks may alter liquidity management, instruction timing and participation when a service becomes permanent. Market-makers may respond to changes in collateral mobility or settlement risk. Controlled comparisons should therefore be followed, where warranted, by a limited live evaluation with explicit access rules and monitoring. Neither stage should be described as a causal estimate of economy-wide benefits without an appropriate research design.

Implications for Uzbekistan and limits of the analysis

For Uzbekistan, the framework supports beginning with a measurable bottleneck in a particular asset market. If the difficulty is reconciliation or coordination with the cash leg, integration with existing reserves may address it. If a required function cannot be delivered reliably through that route, a wholesale CBDC may warrant further testing. The case should be based on the incremental result and its full cost, not the presumed modernity of a platform.

The UZS scenario is provided to make the liquidity channel reproducible. The assumed rates are not quotations of current policy or bank funding rates, and the balance is not an observed settlement requirement. Local calibration would require instruction-level timing, balance encumbrance, remuneration and marginal funding information. This article does not have those data.

Further limitations follow from the evidence base. Official project reports may emphasise successful functions, while unsuccessful configurations and full costs may be less visible. Project participants and transaction sets are selected, and live pilot volumes are not comparable measures of steady-state performance. The balance-time framework abstracts from nonlinear liquidity scarcity, collateral constraints and feedback between settlement queues and funding demand. These issues should be incorporated when data allow; their omission prevents a universal architectural ranking.

Conclusion

Tokenised asset settlement does not logically require a new wholesale CBDC. Published projects demonstrate several ways to connect assets with central bank money, including synchronisation with existing reserves. They establish feasibility under specified conditions but do not provide a uniform estimate of comparative production costs.

The economic comparison must jointly measure committed balances, their duration, operating resources and performance under failure. A matched-instruction protocol can separate architectural effects from changes in netting, prefunding and operating hours. A cost-based case for wholesale CBDC issuance requires demonstrable net savings relative to a credible reserve-based alternative, together with compliance with the required legal and operational standards. Additional functionality should be assessed against its incremental cost. That conclusion must be established for the intended market rather than inferred from tokenisation or aggregate pilot volume.

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