

WHOLESALE CENTRAL BANK DIGITAL CURRENCIES (wCBDCs):

Approaches, Implementation
Strategies and Use Cases

With the
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NatWest

Disclaimer: Data for this report has been gathered from many sources, including in-person interviews and desktop research for many jurisdictions. While every reasonable effort has been made to verify the source and accuracy of the data collected, the research team cannot exclude potential errors and omissions. Opinions expressed in this report and in the interviews reflect those of the authors and not necessarily those of their respective institutions.

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Forewords



Cambridge
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Finance

In recent years, much attention has been given to the retail application of Central Bank Digital Currencies (CBDCs). Discussions and initiatives surrounding wholesale CBDCs have gained significant momentum in the past 24 months, to the extent that they are now eclipsing retail CBDC in terms of attention and development.

This shift has been driven by the increasing tokenisation activities in financial markets, alongside the rise of stablecoins and tokenised bank deposits. For instance, according to a report by Bernstein, stablecoin issuers now the 18th largest holder of U.S. Treasury notes, surpassing many sovereign states.

Central banks now face a key decision: should they enhance their existing Real-Time Gross Settlement (RTGS) systems to meet the demands of the digital economy, or should they embrace the potential of cash tokenisation by issuing wholesale CBDCs on blockchain networks?

At the Cambridge Centre for Alternative Finance (CCAF), our Cambridge Digital Asset Programme (CDAP) aims to shed light on the rapid digitisation of assets and value transfer systems, by collaborating with 18 leading public and private sector institutions on empirical research, education and capacity building. As part of this initiative, we have launched this study, which combines desk research with insights from industry and regulatory interviews to explore the motivations, challenges and opportunities facing both the private and public sectors in their approach to wholesale CBDCs.

We are grateful for the support of NatWest, a key member of CDAP, in the production of this report. We hope the report will provide valuable insights on key opportunities and risks surrounding wholesale CBDCs, help facilitate public-private dialogue and further our collective understanding of this rapidly evolving space.

Bryan Zhang
Co-Founder and Executive Director
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Forewords



In the past two years, the idea of tokenisation in traditional financial markets has moved from conceptual theory to active experimentation. Many institutions across the world believe in the potential for tokenisation to substantially upgrade the wiring of how capital markets function, and throughout these experiments the demands for forms of wholesale CBDC to support and enable this thesis grows.

Despite this, clarity on what the industry means by a wholesale CBDC, how it could be designed and implemented, and what the tangible near-term cost/benefit/risk analysis is, remain elusive. At NatWest, we believe in exploring and participating in the experimentation of emerging technologies to benefit our customers, regulators, and the wider industry. For example, the recent Eurosystem exploratory work on new technologies for wholesale central bank money settlement has provided a valuable opportunity for participants to execute transactions using three proposed models to settle across existing TARGET Services and novel financial market infrastructure.

We are grateful to support the Cambridge Digital Asset Programme with their investigative report and research on the topic of wholesale CBDC. We hope the research advances the discussion beyond theory and concept, to considered practical implementation, through highlighting what and where a wholesale CBDC can support in advancing the functioning of our financial system – if at all.

Nick Pedersen
Managing Director,
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Executive Summary

Financial markets are at a crossroads. The slow but steady increase in tokenisation of assets, combined with an explosion of stablecoins (with market cap growing from \$60bn in mid 2021 to over \$170bn today) and increasing focus by banks on tokenising their deposits, is leading to major questions for central banks on how to maintain financial stability and the singleness of money as markets become increasingly digital.

Around the world, many central banks have been focused on retail Central Bank Digital Currency (CBDC) research, with Bahamas and Nigeria implementing digital versions of their currencies, and China implementing a multi-year pilot. These initiatives ensure continued access to central bank money as physical cash usage declines and digital economies develop. However, in the last two to three years, activity in wholesale CBDC has grown significantly as wholesale markets have moved from proof of concept to implementations of asset tokenisation increasing the need for digital money for the cash leg of transactions. Settling in central bank money brings finality and other benefits and is thus safer and more efficient. If market participants need a wholesale CBDC to do that, then central banks may want to meet that demand.

This report, based on extensive research, industry consultations and interviews with regulators, examines the key motivations, models, and policy considerations for wCBDC (wholesale Central Bank Digital Currency). It discusses the need for wCBDCs as a risk-free settlement asset to support digital transaction infrastructure and mitigate potential instability arising from reliance on tokenised private assets. Central banks are considering wCBDCs as an alternative to upgrading Real-Time Gross Settlement (RTGS) systems, aiming to keep pace with programmable, always-on infrastructures that facilitate real-time, cross-currency liquidity and tokenised asset transactions. We have examined:

1. The variety of possible settlement assets from wCBDC through to Stablecoins and their features and risks.
2. The different models for how a wCBDC could be made available and how they compare.
3. Key experiments from the PoCs and trials that have taken place between central banks and market participants worldwide—such as the European Central Bank's DLT experiments, Bank of England's Project Meridian, and cross-border projects led by the Bank for International Settlements (BIS)—are analysed for their insights on wCBDC viability.
4. Evolving infrastructure options for wCBDCs that are positioning to support tokenisation of tokenised assets and central bank money, also highlighting the growing need for interoperability across different platforms.
5. Policy, regulatory and legal implications for the above, and the need for central banks to focus on the “how” rather than “if”, while still ensuring the safety and resilience of the financial system.

We also examine the case for change, how the competing forces of increasing tokenisation of financial markets and the evolving central bank perspective on the availability of risk-free settlement assets may evolve.

There are several findings from our research. First and foremost, that there is no single and accepted definition of wholesale CBDC, including within the central banking community. The term is associated with tokenised central bank money by some and not by others. Clearly a single and accepted definition will help understanding and communication. From the wide range of approaches to delivering a wCBDC, we see an immediate benefit that could be gained by the so called “Synthetic CBDC” in those countries that facilitate it (at present, just the UK), a desire in the industry for the “Distribution” approach where tokenised wCBDC facilitates settlement on a single ledger, but

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acceptance that intermediate approaches such as enhancements to the RTGS (operating hours, etc.) and “trigger” or “synchronisation” approaches are the most likely developments to be offered by central banks.

We also identify the wide range of public and private infrastructure options bidding to support future tokenised markets. Our conclusion is that while there is broad agreement that there will not be “one ledger to rule them all”, the nature of any principles-based approach to infrastructure needs to be determined quickly through public/private collaboration to avoid the risk of “balkanisation” with the resulting dependencies on interoperability and bridges and the consequent operational and security risks.

We identify a gap between the expectations and actions of market participants and central banks regarding wCBDCs. While our sample size is small, both the quantitative and qualitative comments from interviewees point to the existence of such a gap, and by implication a need to bridge it through further public/private collaboration. On one side of the gap, market participants are increasingly using stablecoins

and tokenised deposits as settlement assets, on the other side the rate of progress of central banks in supporting these market developments are seen by some as “slow and steady”.

Finally, we consider the case for change. Whilst there are many estimates of the proportion of financial assets that will become tokenised by 2030, there are fewer estimates of the savings that may accrue as a result, and fewer still financial analyses of the case for wCBDC specifically and no estimates that we have found for the business case for individual market participants.

It is clear to us that this and the other topics referred to in the interviews are front of mind for both public and private sectors and the answers to the many questions we have analysed will best be solved by increasing public and private collaboration, combined with a clear understanding and commitment to a more efficient and safer future state, and solving the thorny question of how to pay for it. We hope that this report provides timely and insightful analysis of a critical aspect of the development of digital financial markets.

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11. South African Reserve Bank
12. NatWest
13. Reserve Bank of Australia
14. Commerzbank
15. European Central Bank
16. Deutsche Bourse/Clearstream
17. Deutsche Bundesbank
18. SocGen Forge
19. HSBC
20. Fidelity International
21. Citibank
22. ABN Amro

Methodology and Report Structure

The Cambridge Centre for Alternative Finance (CCAF) at the Cambridge University Judge Business School has undertaken detailed analysis of the motivations, use cases, approaches and the legal, regulatory and policy implications for wholesale central bank digital currencies, based on insights and data available from existing regulatory initiatives, academic and market studies.

Data was collected primarily via desktop research between August to October 2024 and included primary data sources (official documents and statements) as well as secondary data sources. In all cases, desktop research was supplemented with interviews with representatives of regulatory authorities, market participants such as major financial institutions and private sector companies. All interviews were conducted on a non-attributable basis.

The report is divided into six sections:

Section 1

Provides an overview of the definition of a wholesale CBDC, the rationale for its existence and its positioning within the financial markets.

Section 2

Identifies and reviews the various approaches of how a wholesale CBDC could be made available to market participants.

Section 3

Analyses the experiments and various proof of concepts performed by central banks globally to evaluate wholesale CBDC approaches.

Section 4

Reviews various distributed (and non-distributed) ledger-based infrastructures that have been promoted by public and private sectors, on which a wholesale CBDC could be implemented, as well as design considerations underlying each option.

Section 5

Assesses current and key policy, legal and regulatory aspects in relation to a wholesale CBDCs.

Section 6

Discusses considerations for how a wholesale CBDC could be implemented, including the motivations of wholesale firms to participate, possible implementation effort for financial institutions, and the complexities for international alignment (which may be perceived as critical for international wholesale payments). It also discusses whether a case for change can be made for adoption of wholesale CBDCs.



Introduction

01



1. Introduction

At the heart of today's financial system, underpinning the two-tier, commercial and central bank money system, is the central bank's real time gross settlement system, or RTGS. The RTGS, as the name implies, settles transactions between commercial banks in central bank money, using their accounts at the central bank, on a real time basis with no netting. The RTGS ensures fast, secure and final payments for high value transactions. The RTGS in the UK is CHAPS, in the EU it is Target 2, and in the US it is the Fedwire. Central bank money in commercial bank's accounts typically reside as account entries in a database and, in this sense, is digitised, rather than digital.

Central Bank Digital Currency (CBDC) is a digital form of public money issued by the central bank as a direct liability of the central bank or government. This generally means that, like cash or central bank reserves, it has no counterparty nor credit risk. By extension, CBDC is formally part of the national currency system, which means that the law ensures the equivalence at par value with all other forms of money within the regulatory perimeter (i.e. cash, bank reserves, bank deposits and e-money). The relationship between these different forms of digital money, together with stablecoins and cryptoassets (which many do not see as a form of money, at least in the context of legal recognition) are shown below.

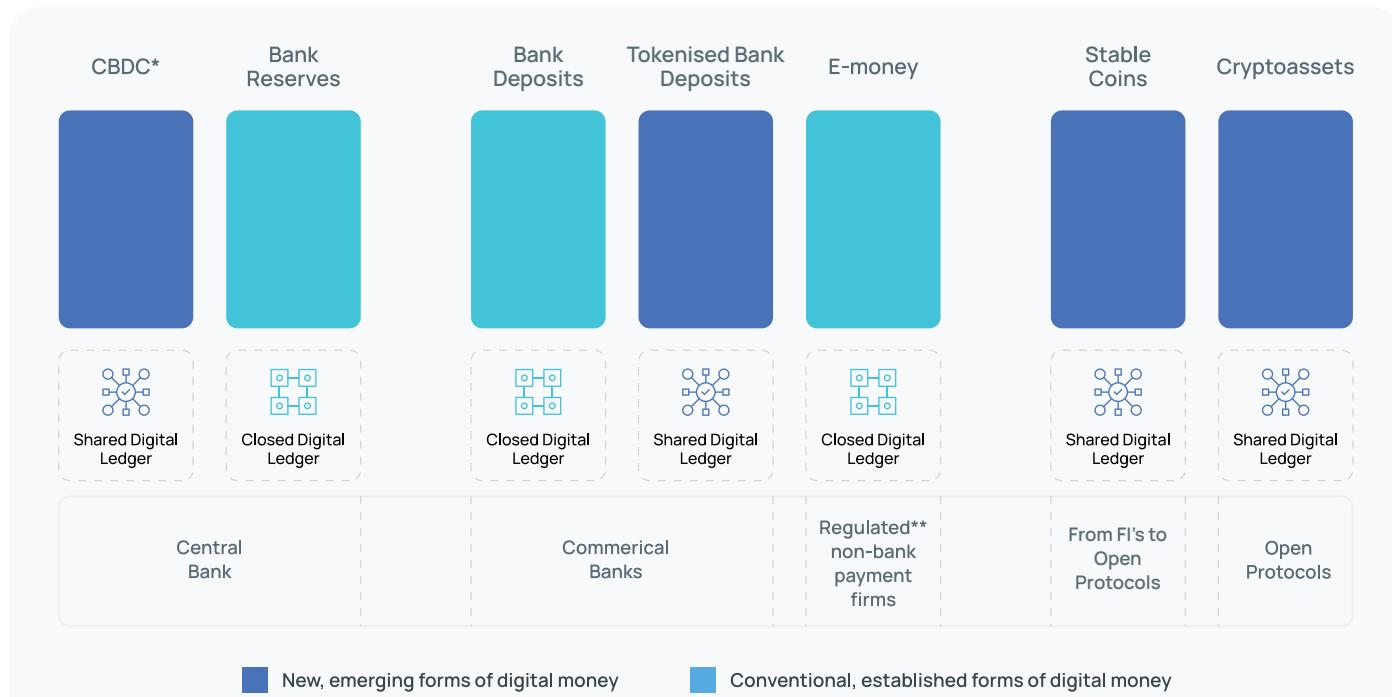


Figure 1: Digital Money Instruments

* Not yet available, may not be on a shared ledger

** Defined as 'formally integrated into the natural currency system.'

Source: Cambridge Centre for Alternative Finance. Digital money overview. Cambridge Digital Money Dashboard. <https://ccaf.io/cdmd/dm101/digital-money-overview>

1. Introduction

There are two main CBDC arrangements: retail CBDC, which is available to the general public (like cash); and wholesale CBDCs, where participation is generally restricted to select financial institutions.

Wholesale CBDCs (or wCBDCs as we will refer to it in this report) are typically used for interbank settlements and cross-border payments. As a wCBDC is in a digital form, it may be enabled by shared ledgers that, dependent on the underlying design, offer greater functionality than established electronic forms. As such one of the key motivations for central banks to issue wCBDCs is to facilitate increased efficiency and reduced risk of wholesale transactions. Reserves in comparison are constrained by the functionality and availability of the RTGS.

In recent years there has been a significant increase in the issuance on account of tokenised assets in the financial markets industry. Digital bonds represent one example, when compared to conventional bonds they are considered to primarily differ with the settlement of the asset outside the traditional market infrastructure.¹ Examples include the issuance of the World Bank's digital bond, Bond-i, in 2018, thereafter many issuers such as the European Investment Bank (EIB) and Hong Kong Monetary Authority (HKMA) have issued digital bonds which now have a cumulative value more than \$3.8bn between 1 January 2022 to 25 July 2024, according to OMFIF's Digital Assets 2024 report.² In

addition, tokenisation has advanced significantly in other areas such as money market funds, repo, private equity and real estate. Some market participants estimate that the size of tokenised markets could reach trillions of dollars within the next decade, e.g. Citibank estimate \$4.6-5.1Tn over a range of asset classes from non-financial corporate debt to real estate by 2030³. Tokenisation of collateral in particular is seen as having a major impact in terms of collateral mobility and reduced cost.

As tokenised markets continue to develop, the need for a digital form of central bank money increases, not only as a safer means of settling transactions in tokenised assets (vs private assets such as stablecoins and cryptoassets), but also to facilitate atomic settlement. Atomic settlement is based on settlement occurring if and only if both asset and cash are present, thus eliminating settlement and counterparty risk. As a result, wCBDC has received significantly more focus from both central banks and market participants to the extent that it is now at the cusp of overtaking retail CBDCs as a major development in the financial system. Indeed, in November 2024, the Reserve Bank of Australia announced Project Acacia, focused on exploring the development of wCBDC and tokenised deposits, and MAS announced the SGD Testnet to allow participants in Projects Guardian and Project Orchid to make payments and settle securities transactions in wCBDC.

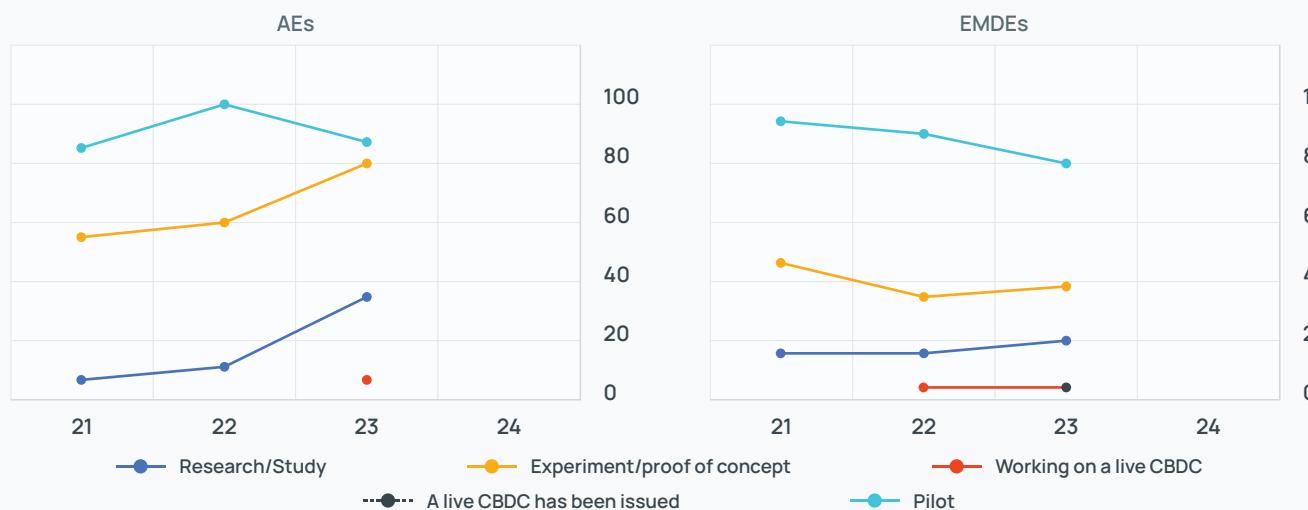


Figure 2

Alberto Di Iorio, Anneke Kosse and Ilaria Mattei (2024), Embracing diversity, advancing together – results of the 2023 BIS survey on central bank digital currencies and crypto

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At the same time, the development in wCBDC projects globally has seen a significant upsurge. The responses to a BIS survey of central banks on wCBDC research, PoC and pilot activity above illustrates the migration in effort from research to pilots and PoCs, particularly in advanced economies. Indeed, as Di Iorio et al (2024) find, “the likelihood that central banks will issue a wholesale CBDC within the next six years now exceeds the likelihood that they will issue an rCBDC.”¹ Whilst the ECB continues with the rCBDC Digital Euro “Preparation Phase”, the increasing focus on wCBDC is further evidenced by an increasing focus of central banks on wCBDC in recent months, examples of which include:

- **Reserve Bank of Australia**, who have stated that: “compared to retail CBDC, the potential benefits and use cases for a wholesale CBDC seem more tangible at this point”. Additionally, “The most compelling proposition in favour of CBDCs relates to increasing innovation and efficiency in wholesale markets, particularly ‘tokenised’ asset markets”.³
- **Bank of England**, whose recent Discussion Paper⁴ states “Central bank money must therefore keep pace with technological advances in financial markets such as tokenisation. Accordingly, the Bank is considering innovations in wholesale central bank money to ensure it continues to play its critical role as an anchor for confidence in the financial system.”
- **European Central Bank**, who have been conducting trials of the wCBDC approaches proposed by the Banque de France, Banca D’Italia and the Bundesbank, together with 60 European participants with €530m of transactions settled.
- **Globally**, as of March 2024, BIS details there are 36 Central Bank wCBDC initiatives¹ 103 of which are public research studies and 22 of which are ongoing or completed pilots, many of the latter being in Europe (ECB, BoE, with SNB being one of the most advanced).
- The **mBridge platform**, a multi-CBDC platform resulting of the cooperation of four central banks, in its ongoing MVP mode has settled several billion cross-border PvP transactions between the participant jurisdictions.

Despite appearing ‘novel’, the existence of central bank money in digital form has spanned decades. Given its semblance to existing forms of central bank money, the concept of wCBDCs can therefore lend itself to varied meanings and interpretations. A convincing use case for any wCBDC should not only allow for clear distinction with electronic central bank reserves, but also define various approaches, benefits and risks in its usage. In this study, we aim to answer these questions, specifically the following key issues:

1. What is a wCBDC?
2. Is there a best approach for delivering a wCBDC?
3. Is there an “innovation gap” between the industry and central banks, and is it widening?
4. What are the risks of non-central bank money settlement assets growth?
5. Is there a case for change regarding wCBDC?

Setting the context

At the outset, we must define what is a wCBDC. On a high-level, a review of definitions across the European Central Bank (ECB), Bank of England (BoE), US Federal Reserve (US Fed), Bank of Japan (BoJ), Peoples Bank of China (PBoC), Swiss National Bank (SNB), Bank of Canada (BoC) and the Monetary Authority of Singapore (MAS) shows some level of consistency, e.g. the ECB states “Wholesale CBDC is often presented as a new concept, but central bank money has in fact been available in digital form for wholesale transactions for decades. The debate is therefore not about whether to provide digital central bank money for wholesale transactions, but about possible technological changes in how this money is provided.” Similarly, the Bank of England² defines a wholesale CBDC as “a form of central bank money that would be available only to banks and other financial institutions for large-value payments and settlements, akin to reserves held in accounts at the central bank,”⁴ but also states in their 2024 Discussion Paper wCBDC is “a new platform for the distribution of wholesale central bank money which unlocks separate functionalities or efficiencies to those enabled by RTGS systems. That said, there is no settled definition of wCBDC among central banks.”



1. Introduction

The need to clarify the exact definition of a wCBDC has repeatedly been raised by the industry in our interviews, as some see it as synonymous with a tokenised form of central bank money and others take a more general view.

Existing definitions of a wholesale CBDC define the term narrowly – primarily a reflection of its experimental phase. In considering new digital forms of money, we argue that ‘form’ follows ‘function’ can serve as a guiding principle. While the term ‘digital’ in a wCBDC implies the non-cash nature of central bank money as an electronic medium of transfer and the use of ‘wholesale’ implies that its access is restricted to banks and other counterparties in central bank operations⁵, in essence, it is the combination of three core features that characterise a wCBDC, the third of which potentially distinguishes it from other forms of digital central bank money:

1. **Claim on central bank:** since central bank money constitutes a claim on central bank and a wCBDC is a ‘digital form’ of central bank money, by extension a wCBDC will always be a claim on central bank.
2. **Restricted:** a wCBDC is generally restricted to a user group (i.e. banks and other financial institutions which are counterparties in central bank operations and can hold central bank reserves and/or have access to the RTGS) and limits expansion of the reserve system to the wider private sector.
3. **Programmability:** conceptually, ‘programmable money’ refers to a set of ‘built-in’ rules that can impose both restrictions and new innovative uses cases for digital money and can be natively implemented. In contrast, ‘programmable payments’ allow for a transfer of money predetermined by a set of conditions (i.e. time, payment amount, type of transfer etc.). This unique characteristic (in the context of programmable money) allows a wCBDC to go beyond the traditional execution of regular payments that already exist in current financial market infrastructures and is an essential feature for many novel use cases, including intermediary-free transferability and fully autonomous payments (contrasted with ‘digital’ money’, where this is not possible), to settle the cash leg of transactions in tokenised assets, as well as to enable functionalities that provide a higher level of automation and process optimisation in securities settlement. An open

question is who would have the responsibility to build this functionality, i.e. the central bank or wholesale institutions. In the case of a rCBDC, programmability is seen by the Bank of England, for example, as the role of a payment interface provider role. Programmability isn’t necessarily restricted to token-based implementations but is frequently associated with DLT and smart contracts.

However, in considering the nature of the form a wholesale CBDC can take, several considerations need to be further examined.

1. **Implementation:** will the value of wCBDC used by a bank be fully integrated and aligned with their account at the central bank, or will it be a separate account solely in support of the subset of transactions settled in wCBDC? If accounts are not integrated then there is a risk of liquidity fragmentation, which could clearly be a concern.
2. **Rules:** if a wCBDC is in token form, what rules should it be subjected to, what programmability will be possible, and will it exist on a central bank operated ledger or a single shared ledger?
3. **Access:** will a wCBDC only be available for wholesale institutions for interbank settlement or will its use be allowed for other scenarios, such as a risk-free settlement asset for Fast Payment System (FPS) transactions (in effect another interbank settlement) or card transactions, or as a backing asset for certain stablecoins? As noted by the RBA³ the latter example puts wCBDC indirectly in the hands of retail consumers and demonstrate the risk of blurring between wholesale and retail CBDC.

In addition, there are several legal and regulatory considerations for wCBDC which we will return to in Section 5.

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1.1. What problems are we trying to solve?

Given the recent activity regarding wCBDC around the world, it is useful to consider the problems wCBDCs are trying to solve. As stated earlier, a wCBDC represents a risk-free asset for the settling of interbank transactions in digital form (to the extent that central bank money is risk free). Other forms of digital money such as commercial bank money, tokenised deposits or stablecoins carry risks, particularly counterparty risks, which can become a significant concern in times of market stress. This is one of the reasons why central banks, with their mandate for financial stability typically favour wholesale settlement in tokenised transactions in central bank money (be it wCBDC or another approach), rather than tokenised deposits or stablecoins.

In part, these aspects reflect that we are in the nascent stages of wCBDC development, with a need for the various central bank and industry PoCs and experiments to inform the detailed design of a wCBDC implementation.

Another aspect of this question is what need is **uniquely solvable** by a wCBDC versus other forms of money or money instruments. Opinions in our interviews varied greatly on this question. Some interviewees highlighted the need for tokenised wCBDC to support guaranteed atomic settlement of tokenised assets and cash on a single ledger, together with new functionalities:

"You need a unified ledger for guaranteed atomic settlement, for example the risk of a break if you have to unwind if an asset is on a different platform to the cash." [Central bank](#)

"There are promised benefits of integrated settlement associated with programmability and composability which can't be achieved with synchronised approaches." [Central bank](#)

"A trigger approach may work for most things, but not for some margin cases like intraday liquidity swaps in FX." [FMI](#)

Others highlighted the efficiencies of today's infrastructure reducing the benefits of tokenised approaches:

"Today's processes and infrastructures are already quite efficient. The bar is set high on current systems". [Central bank](#)

"We haven't seen a convincing use case for wCBDC yet". [Central bank](#)

Many interviewees also made comparisons between wCBDC and the enhancing of RTGS platforms:

"I find it hard to differentiate between a wCBDC and an upgraded RTGS". [Market participant](#)

"Regarding wCBDC vs RTGS – it's not just a question of operating hours. You need automation, time to settle, many different pieces create the wCBDC concept". [Central bank](#)

From our discussions, there are a range of aspects in answering this question, in particular what operating hours, programmability and responsiveness an enhanced RTGS can deliver and when, versus the greater flexibility of a fully tokenised wCBDC implementation. Regardless, as we will see in section 6.2, there is already a perceived innovation gap between central banks and market participants, with tokenised markets using stablecoins as a settlement asset on the buy-side, and tokenised deposits on the sell-side due to a lack of wCBDC. Thus, market developments may bring this question to the fore.

We will now review two high level use cases for wCBDCs, typically spread across three domains with their own set of design considerations: (a) cross-border transactions between central banks; (b) domestic transactions between commercial banks; and (c) cross-border transactions between commercial banks.

1.1.1. Delivery-versus-Payment

Delivery vs Payment or DvP refers to the settlement mechanism by which the transfer of an asset such as a security with the corresponding payment happening simultaneously. There are three basic models of DvP⁵, varying according to whether the securities and/or funds transfers are settled on a gross (trade by trade) basis or on a net basis, and in terms of the timing of the finality

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of transfers. This protects the counterparty from the risk that the seller of a security may not receive payment after delivering the asset, whereas the buyer is protected from not receiving the asset after making the payment.

Model 1: Systems that settle transfer instructions for both securities and funds on a trade-by-trade (gross) basis, with final (unconditional) transfer of securities from the seller to the buyer (delivery) occurring at the same time as final transfer of funds from the buyer to the seller (payment).

Model 2: Systems that settle securities transfer instructions on a gross basis with final transfer of securities from the seller to the buyer (delivery) occurring throughout the processing cycle, but settle funds transfer instructions on a net basis, with final transfer of funds from the buyer to the seller (payment) occurring at the end of the processing cycle.

Model 3: Systems that settle transfer instructions for both securities and funds on a net basis, with final transfers of both securities and funds occurring at the end of the processing cycle.

1.1.2. Payment-versus-Payment

Conversely Payment vs Payment or PvP, refers to the situation when both legs of a transaction are cash, typically foreign exchange (FX). Today, CLS (Continuous Linked Settlement) provides settlement for 18 major currencies on a PvP basis, with settlement happening on a netted basis. Many currencies however are not supported and are subject to much higher settlement risk. According to the Committee on Payments and Market Infrastructures, the proportion of non-PvP FX trades (60% in 2019) is increasing year on year.

1.1.3. Other use cases

There are other use cases where a wCBDC can be used for anchoring settlement in central bank money, such as the retail FPS in place in many countries around the world and currently being implemented in many more. This case has been recently analysed by the World Bank, where a bridge could be used to pass settlement instructions from the FPS to the wCBDC platform to allow settlement between the Payment Service Providers on either end of the transaction.

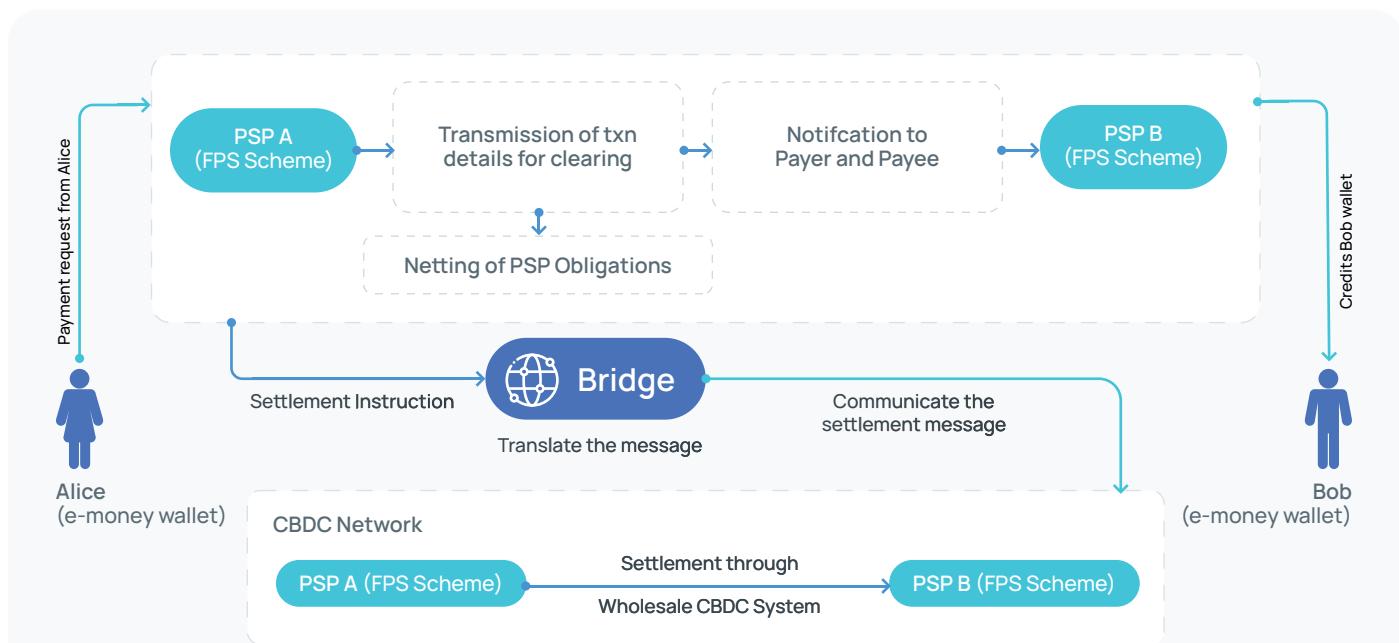


Figure 3

Source: Interoperability between central bank digital currency systems and fast payment systems, World Bank Group 2024.

1. Introduction

1.2 Defining alternative approaches to settlement assets

To serve as an effective settlement asset, the form of money needs to satisfy several criteria including:

1. **Stability:** The asset must maintain a stable value to not impact the settlement process.
2. **Liquidity:** The asset needs sufficiently liquidity to avoid delayed or failed settlement issues
3. **Legal and Regulatory compatibility:** The asset needs to conform with the appropriate legal, regulatory, and operational processes in terms of settlement finality. Once a trade is settled, it must be both legally enforceable and irrevocable.

Settlement in central bank money is viewed by central banks as the bedrock of the two-tier monetary system. In this context, wholesale settlement in central bank money usually takes place in the RTGS system typically operated by the central bank. RTGS systems tend to have fixed operating hours and have limited ability in terms of programmability: as such they have constraints in supporting the 24x7, programmable nature of tokenised assets.

Of course, one of the options to provide cash settlement facilities for tokenised assets is to upgrade the RTGS so that its operating hours are increased to 24x7, new functionality is added to facilitate programmability and integration with the world of tokenised assets. This is part of thinking behind the “synchronisation” solution tested as part of the BIS Innovation Hub and Bank of England Project Meridian. It is along similar lines as the Bundesbank “Trigger” solution – where in both cases a synchronisation function links settlement of a tokenised asset leg with cash settlement in the RTGS.

“It’s really kind of a choice between whether you would build a wholesale CBDC or upgrade the RTGS.” **Market participant**

As defined, a wCBDC represents a central bank liability in digital form, but other characteristics such as access, ledger architecture etc. are decisions that need to be made in its implementation.

One central bank sees this choice between enhanced RTGS and wCBDC as a “not a binary choice but rather

a spectrum.” We will discuss comparisons of these approaches later, but for now, let us consider the choices for the settlement asset itself.

1.2.1. Synthetic CBDC

One model of settlement asset is a so-called ‘synthetic CBDC’, which is a settlement asset in central bank money but is a liability on a commercial organisation rather than the central bank, and therefore, is not strictly speaking a CBDC by our earlier definition, however this terminology has been used by the IMF so we include it here. The best example of this is Fnality, a UK-regulated payments operator, with 20 major institutions as shareholders, which uses an Omnibus account, provided by the Bank of England to offer tokenised PvP and DvP. Fnality has completed several PoCs and is progressing to live deployment in the UK. Section 3.6 discusses Fnality as a case study.

“It’s like a pre-paid card for wholesale money!” **Market participant**

1.2.2. Tokenised Bank Deposits

Tokenised bank deposits are the digital equivalent of a traditional commercial bank deposit. This form of deposit functions as an emerging digital money instrument typically issued by means of shared ledgers, a new representation mechanism that endows them with potentially greater functionality than traditional bank money issued via conventional electronic ledgers (the extent of which depends, among others, on the design and openness of the underlying system). Tokenised bank deposits can operate ‘24x7’ and are not restricted to bank opening hours. They can also support programmability and reduce the cost of payments.

As a liability of a commercial bank, tokenised deposits have a higher risk relative to a wCBDC as a settlement asset. That said, they are being used in the live production service of the SIX Digital Exchange (SDX) for settlement and corporate actions of digital bonds,

1. Introduction

where tokenised deposits backed by reserves were deposited on 1 to 1 basis at SDX's Swiss National Bank account.

However, we understand that banks still prefer the risk-free nature of native wCBDC, which is being evaluated as part of the BIS Project Helvetia, mBridge and Agorá initiatives.

Kinexys (formerly Onyx) by JP Morgan

One of the earliest examples of tokenised deposits was JPM Coin launched in late 2020. The “JPM Coin System” is a digital representation of depository account which facilitates the movement of funds across the JPMC branch network in real time. As implemented, it is not a bearer token but rather a Blockchain Deposit Account, on the Quorum private-permissioned blockchain.

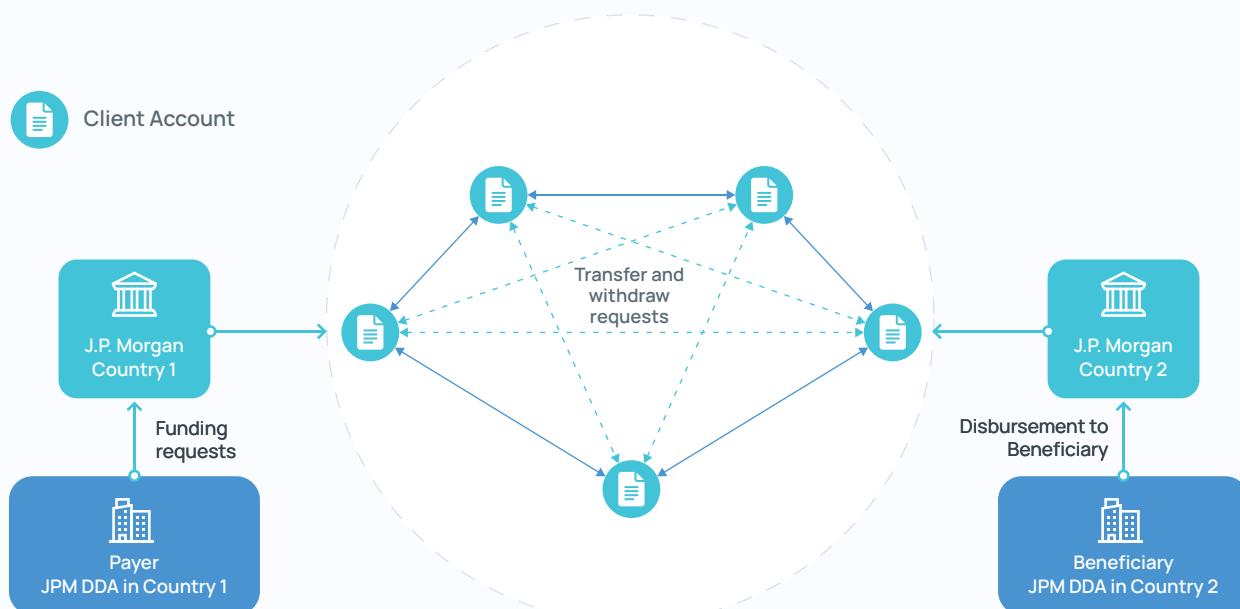


Figure 4: JPM Coin System

Using blockchain allows JPM Coin System to operate 24x7x365 and to offer programmability in terms of payments. Today over \$1Bn per day flows through JPM Coin, much of this through the Onyx Digital Finance platform which enables intra-day repo with real-time transaction settlement, reporting and active intraday liquidity management with charging of interest by the minute.

However, the JPM Coin System is ultimately constrained by essentially only being usable across the JPM network. JPM has collaborated with DBS, Temasek and Standard Chartered in launching Partior as a platform using a shared ledger to settle across banks. However, extending such an inter-bank settlement platform one bank at a time is clearly a significant challenge. Having said that, JPM Coin Systems has clearly demonstrated how blockchain can transform payments and wholesale transactions through the use of an always-on programmable platform.

1. Introduction

1.2.3. Stablecoins

Stablecoins are digital assets that seek to maintain a stable value against another asset or basket of assets, typically a fiat currency. They are a form of private money and the targeted stability in value sets them apart from other cryptoassets, particularly when linked to fiat currency value. "Stablecoins are room-temperature superconductors for financial services" according to Patrick Collison, co-founder of Stripe.

The term 'stablecoins' is colloquially used to describe a range of instruments with different issuers and characteristics. It is possible to distinguish three categories: fiat-backed stablecoins, which are issued as monetary liabilities of the issuer, crypto-collateralised and algorithmic stablecoins, where value is supported by an algorithm, e.g. automatically increasing or decreasing supply in response to fluctuations in price, which may or may not have a formal issuer.

Stability in value is dependent on the mechanism design of each arrangement. Fiat-backed stablecoins attempt to maintain a stable value by managing a reserve portfolio of cash, money market instruments, etc. Crypto-collateralised stablecoins attempt to maintain stability by issuing new units against eligible digital assets at specific penalty rates (over-collateralisation) reflecting individual volatility risk. Algorithmic stablecoins attempt to maintain stability by dynamically adjusting the supply through the issuance of seigniorage shares. Users should be aware of the risks inherent in each category, as well as the individual risk profile of each arrangement within these categories.

Like other cryptoassets, stablecoins are emerging digital instruments issued in the form of transferable digital tokens on a range of shared ledgers, including open and permissionless chains. As a result of their pegged exchange rate to fiat currencies (theoretically eliminating price volatility), global availability to retail users and attractive functionality (on account of native interoperability with applications on the same shared ledger rails), they have significantly grown in popularity in recent years, with market cap having now grown to over \$170bn (see <https://ccaf.io/cdmd/>). There are also an expanding number of use cases beyond the original use as a fiat-based on/off ramp for cryptoasset trading;

and widespread and growing usage for payments in countries with less stable national currencies and less efficient payments frameworks. As stablecoins are often denominated in dollars, the drivers of demand are the same as the drivers of demand for dollars in these economies.

Stablecoins can also provide a much lower cost competitor to traditional correspondent banking between emerging market and developing economy (EMDE) currencies (e.g. Argentina Pesos) via a major currency-based stablecoin bridge. In Q2 2024, stablecoins were reported to have facilitated a massive US\$8.5 trillion in transaction volume across 1.1 billion transactions, double that of Visa's US\$3.9 trillion in transactions during the same period. We should note that while Visa and Mastercard can monitor who is making the payments where stablecoins cannot - this might in part explain their relative attractiveness and strong growth. Another advantage is that they can be used easily in web3, which Visa and Mastercard cannot. Yet there are risks and stablecoin issuers have an inherent incentive to invest funds in risky assets to earn a return. Many do not provide transparency about where exactly they invest. Their position as a settlement asset is constrained by the risk of depegging and potentially illiquidity, especially in times of market stress, as well as credit limits for larger transactions. With the rapid development of regulated stablecoins in an increasing range of jurisdictions, these issues may be reduced, and their attractiveness and ease of access could increase.

1.2.4. Summary of settlement asset types

As we have seen, there are a wide range of potential settlement assets with varying characteristics and risk profiles. The table below illustrates this and how they compare with wholesale CBDC. Clearly whilst a wCBDC will always be the lowest risk settlement asset, today central banks are still at the trials stage with no full implementations meaning that other approaches need to be considered. Note that the table is illustrative and that the defining features of each money instrument may be different in practice.



1. Introduction

	wCBDC	Synthetic CBDC	Tokenised Deposit	Stablecoin
Holders Rights	Against Central Bank	Against issuer, backed by Central Bank reserves	Against Commercial Bank, which has access to CB liquidity and deposit insurance	Against issuer and/or backing assets
Reserves	Full	Full	Fractional	Full
Issuer	Central Bank	Regulated FMI	Commercial Bank or Licensed Financial Institution	Private Companies and some banks
Identification of User	Required	Required	Required	Not required
Cross-border capability	Potentially high (mBridge, Agora)	Limited (dependent on central bank agreement)	Limited within bank network or via inter-bank settlement (Partior/RLN)	High
Form	Token or Account	Token	Account (or Token in the case of Deposit Tokens)	Token
Settlement Finality	Immediate and final on transfer	High supported by central bank	Guaranteed by issuing bank	Conditional based on issuer protocol; probabilistic settlement on public chain
Liquidity	High, direct access to central reserves	Moderate to high depending on omnibus account funding	High based on deposit liquidity	High, generally on-chain; redemption risks in periods of market stress
Regulatory Compliance	Central Bank compliance and control	Central Bank and Payment Systems Regulator	Strictly regulated	Regulations vary according to jurisdiction

Increasing risk as a settlement asset

Approaches to wCBDCs



2. Approaches to wCBDCs

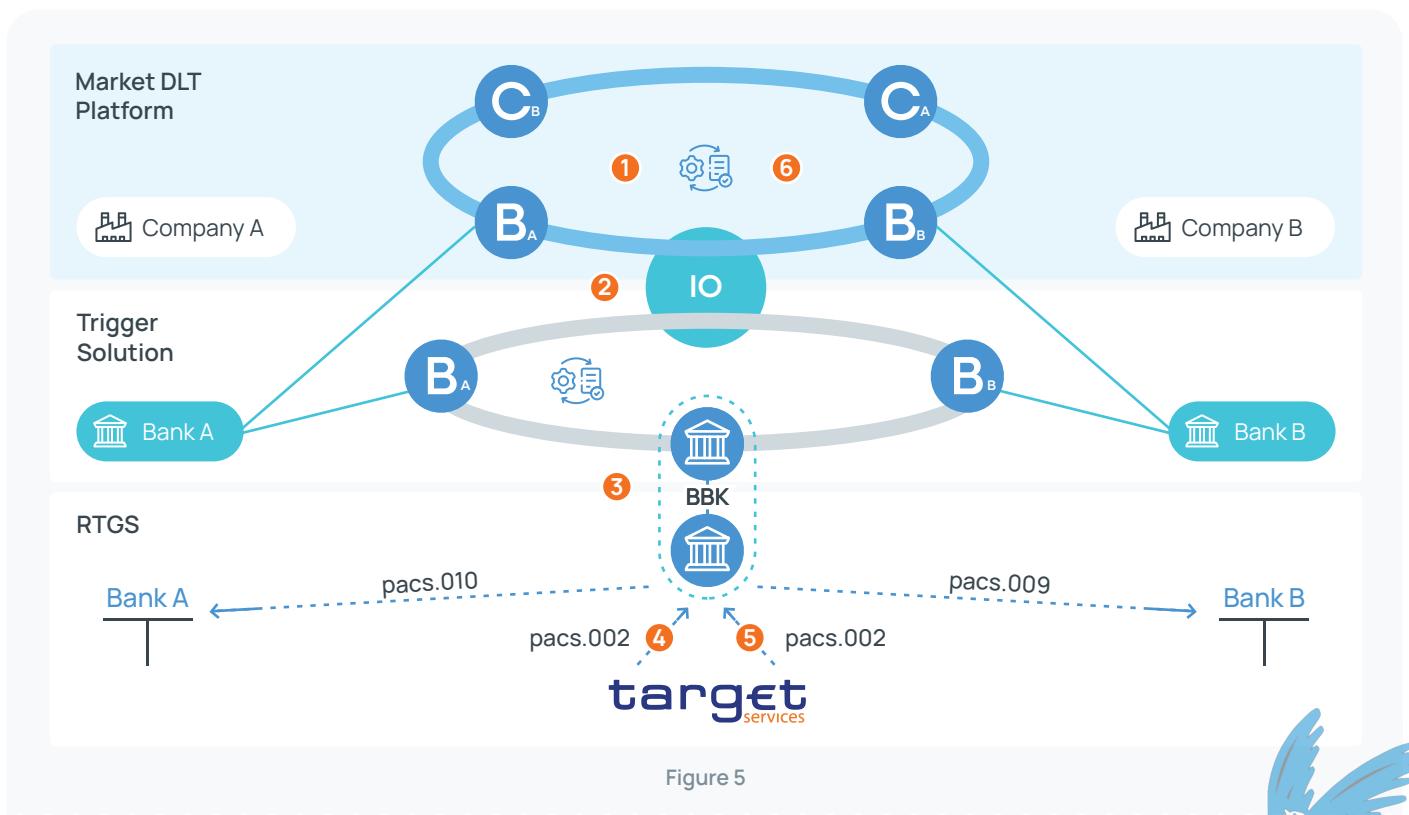
As the global financial landscape evolves, central banks are exploring different models for deploying wCBDCs. These approaches can be broadly categorised into five frameworks: (i) synchronisation and trigger approaches; (ii) the integration model with a platform supporting both wCBDC and tokenised assets; (iii) the distribution model or bridging model connecting a wCBDC to distributed ledger technology (DLT) platforms supporting other assets; (iv) the interoperability model; and (v) settlement through privately operated synthetic CBDCs. Each approach offers a unique balance of decentralisation, security and interaction with the private sector, reflecting diverse priorities such as scalability, financial stability and privacy.

2.1 Synchronisation Approach

The synchronisation approach involves the coordination of two distinct platforms: one managing

the asset leg, often tokenised on a DLT or other non-RTGS platform, and the other handling the cash leg, which is settled through a RTGS system. It should be noted that if we define wCBDC to be in central bank money in tokenised form, then the synchronisation approach is not strictly speaking a wCBDC as it simply a means of integrating settlement of the tokenised asset leg on a ledger with a corresponding update of the RTGS for the settlement of the cash leg,

A key feature of this approach is the “trigger mechanism”, which ensures assured settlement. This means that both legs of the transaction (the asset transfer and the corresponding cash transfer) are mutually conditional, guaranteeing that the asset transfer occurs only if the cash transfer is completed, and vice versa. While atomic settlement emphasizes the indivisibility and simultaneous nature of transaction legs, assured settlement focuses on guaranteeing the finality of settlement, potentially using various risk management strategies.



2. Approaches to wCBDCs

The Figure 5 shows an example of the following process:

1. Buyer and Seller agree on the exchange of Eligible Assets against EUR in an Eligible Market DLT Platform.
2. According to the Interoperability Mechanism, a Payment Instruction will be created through a smart contract in the Trigger Solution;
3. Deutsche Bundesbank converts the Payment Instruction in the Trigger Solution into ISO 20022 messages and submits them via ESMIG to T2/RTGS;
4. A direct debit is sent via the Network Service Provider to T2 to debit the payer bank's RTGS DCA and credit an interim account of Deutsche Bundesbank. Information on the successful or failed settlement will be sent to the Trigger Solution;
5. A credit transfer is sent via the Network Service Provider to T2 to debit the interim account of Deutsche Bundesbank and credit the payee bank's RTGS DCA. Information on the successful or failed settlement will be sent to the Trigger Solution.
6. The status of the Payment Instruction is provided to the Eligible Market DLT Platform where the assets are finally transferred.⁶

This synchronisation reduces counterparty risk, as the transfer of assets and funds occurs in a coordinated manner across different systems. This structure may require an external entity, such as a new Financial Market Infrastructure provider (FMI), to oversee and ensure seamless coordination between the two platforms. By using such a mechanism, even without wCBDC, the model achieves a secure and efficient cross-platform settlement process.

Trigger solutions, while innovative, are limited in their applicability. They fail to support a substantial portion of use cases arising from tokenisation technology and DLT that require programmability, composability and 24/7 availability unless RTGS operating hours are extended, which may be necessary for various applications, such as intraday foreign exchange swaps. This limitation underscores the need for more flexible solutions that can accommodate complex financial transactions. Although, some respondents from the private sector considered trigger solutions to be 'good enough' for the time being, with a strong focus on tokenised deposits and their legal and regulatory positioning, a significant amount of dissatisfaction has been voiced by banks regarding the reliance on traditional RTGS systems which some believe 'don't work super well'.

"The trigger solution gathered more interest, but of course, it's less satisfying for us." [Central bank](#)

2.2 Integration Model

The integration model involves a central bank-operated DLT platform that manages both asset and cash tokens within a unified system. This model offers the advantage of having a single DLT platform for all

"We're already looking at margin use cases where "trigger solution" isn't going to work. But nothing's even been built around it. I can imagine the future markets which potentially automate lending between banks. Like, how is that all going to be anticipated by specific models?" [Market participant](#)

"I think the risk with the trigger mechanism is that it's really just a halfway house. If you take away the idealism surrounding blockchain and tokenisation in general, do you see it as a way to unlock the full range of benefits rather than just half? If it doesn't require a substantial investment in integration and adoption, then reducing the benefits by 80 percent raises concerns. It makes you question why that is, especially since the cost classification can erode significantly." [Market participant](#)

Due to these drawbacks, some believe this approach is unlikely to dominate in the long term. However, interviewees acknowledged that the synchronisation approach might still be efficient for DvP scenarios, particularly in markets like the bond market, where 24/7 availability is less critical.⁷ In such markets, transactions often occur during specific windows aligned with traditional banking hours, making the limitations of RTGS-based systems less of an issue. It may also be a lower risk stepping stone to more advanced methods such as the Distribution Model.

transactions, streamlining processes and reducing complexity by eliminating the need for separate ledgers, and is often referred to as a 'unified ledger'.

2. Approaches to wCBDCs

The benefits of this approach lie in the fact that private sector market participants may not need to own or manage the infrastructure themselves depending on its implementation, which significantly reduces the operational risk they bear. They would still however need to be able to link and interact with the new infrastructure and issue assets/deposits onto it.

Costs could also be reduced by an estimated 40-50%, according to some interviewees. However, many respondents expressed scepticism about the ability of central banks to develop the necessary infrastructure quickly, especially given the complexity, cost-benefits calculations and scale of the task. Additionally, public sector respondents demonstrated a cautious attitude, hesitating to disrupt the existing financial system too abruptly. This cautious approach reflects concerns

about the potential risks and unintended consequences of a rapid overhaul, leading to a preference for gradual evolution over sudden transformation.

Similar concepts have arisen such as the Regulated Liability Network (RLN). This approach provides enhanced control and oversight using an infrastructure operated in this case probably by a third party or FMI, with the central bank overseeing the platform. Again, it simplifies settlement, increases security, and minimizes fragmentation in financial systems. However, given the potential need for a FMI to run the network, this in turn may need funding from the industry to build and run such a utility. (Note, depending on its implementation, RLN could also be considered as an example of the Distribution Model).

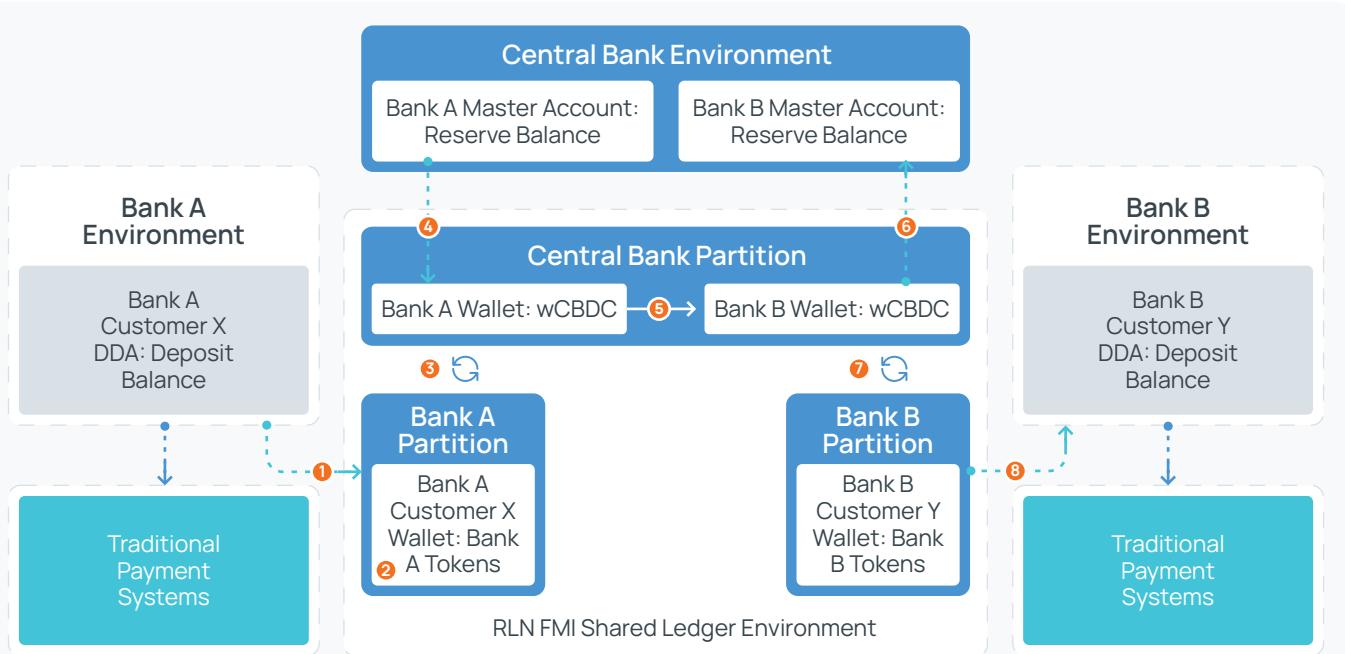


Figure 6

RLN diagram shows the flow:

1. A customer of Bank A transfers a portion of their deposit balance to an RLN Token balance. This function is provided by the electronic banking system of Bank A.
2. The customer instructs a payment to a counterparty at Bank B.
3. The RLN evaluates the ability to execute the end-to-end transaction.
4. The Treasury Operations team at Bank A will have made sure that sufficient wholesale CBDC is available in their RLN Wallet to conduct the anticipated transactions for the day.
5. The transfer of wholesale CBDC within the RLN environment is necessary to settle the transaction between Bank A and Bank B.
6. The Treasury Operations team at Bank B will have real-time visibility over receipts into their RLN wallet holding wholesale CBDC.
7. RLN updates the balances simultaneously to settle the transaction "atomically." Bank A, Bank B, and the Central Bank partitions are updated at the same time, and a single record is created of the settlement.
8. The beneficiary of the payment may transfer the RLN Token balance to their deposit account if they wish. This function is provided by Bank B's electronic banking system.⁸

2. Approaches to wCBDCs

RLN is a conceptual project that aims to create a shared ledger for various types of regulated liabilities, including CBDCs, tokenised bank deposits, and electronic money. Although still in the experimentation stage, the RLN is under development in US and UK as a joint project involving prominent financial institutions such as Citi, HSBC and Mastercard. RLN in the US has since evolved into the Regulated Settlement Network (RSN), focused on wholesale use cases (discussed further in section 4.1.2).

Similar to RLN, is the Commercial Bank Money Token (CBMT) PoC in Germany, led by the German banking association, six German banks and six companies. CBMT used a “coloured token” approach

to demonstrate interbank settlement using several different technologies.

“One difference though is that we must preserve the two-tier banking system and be able to connect and do these settlement chains across these various institutions like we are doing today, but just efficiently, atomically, risk-free. Market participant

However, concerns remain over potential biases towards specific platforms, prompting discussions about establishing criteria for DLT platforms eligible for wCBDC issuance as well as requirements for issuing wCBDC on a common platform accessible to multiple private FMs.

2.3 Distribution Model

The Distribution Model involves the use of a bridge to connect a central bank-operated DLT platform, which handles the cash leg, with a third party-run asset ledger. Other market participant DLT platforms can also connect to this shared ledger via the same bridge. Settlement occurs on a single, unified shared ledger, ensuring streamlined and secure transactions. This necessitates a wCBDC token implementation for the cash leg to deliver atomic

settlement with the tokenised asset leg. This model promotes interoperability across different platforms, while maintaining a central point for settlement. It is reportedly the preferred approach among members of the Association for Financial Markets in Europe (AFME) due to its efficiency and ease of integration. The design of the distribution model must balance central bank control with the benefits of leveraging existing infrastructure and private sector innovation.

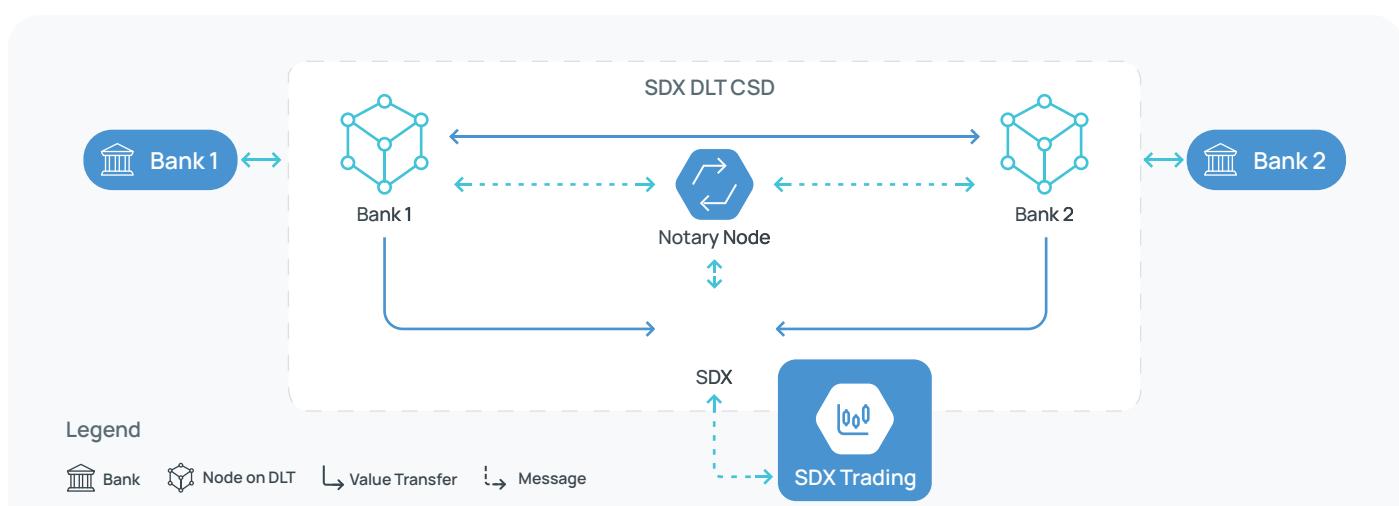


Figure 7: Topology of SDX

Source: Bank for International Settlements. (2020). Project Helvetia: Settling tokenised assets in central bank money. <https://www.bis.org/publ/othp41.htm>.

2. Approaches to wCBDCs

There are several ways to distribution model implementation in terms of different issuance channels for wCBDC, focusing on two primary methods:

1. issuance through the RTGS system, which leverages the existing RTGS infrastructure to distribute wCBDC to eligible commercial banks.
2. issuance through monetary policy transactions, which explores the possibility of distributing wCBDC as part of the central bank's monetary policy operations, potentially expanding access beyond institutions currently eligible for RTGS participation.

There are various considerations involved in designing a CBDC distribution model, balancing the need for central bank control with the potential benefits of leveraging existing infrastructure and private sector participation.

The first group, represented by central bank officials, advocates for tokenised solutions and a centralised framework. One central bank representative stated, "Distribution model is the only solution that offers wholesale CBDC in a tokenised format. Both the Trigger and TIPS solutions settle in TARGET, which is central bank money, but not in a digital form." This view underscores the belief in the unique advantages of tokenization for wholesale CBDC, highlighting the potential benefits of centralised systems. Additionally, another central bank representative noted, "We currently have three liquidity pockets: one is RTGS, which represents cash; another handles securities; and the third is for collateral. Our view is to create a net for a liquidity pocket that would be digital money. However, this needs to be integrated into the overall liquidity that banks manage. The idea is not to create something that can be included in monetary reserves, but rather to design it so it forms part of the entire liquidity management framework that banks utilise." This reflects a strategic intention to integrate digital currency within existing liquidity management frameworks, thereby reinforcing the central bank's control over monetary operations.

In contrast, market participants place greater emphasis on operational efficiency and the advantages of distributed models. One participant remarked, "What

is ideal for us is the distribution model. Since we are also operating on several platforms, we need to focus purely on operational units. Regardless of how popular a top-level feature is, there will always be an operational element involved. <...> We had to develop many plans for operational aspects, which can be alleviated depending on whether it's central bank-hosted or distributed. The question is: can we access it in a way that is useful?" This highlights a preference for distribution models that prioritise functionality in diverse operational contexts. Another market participant echoed this sentiment, stating, "The distribution model is preferred and is ideal for us – for example, what if the pipe (trigger mechanism) fails causing operational issues? We need access on a usable basis." Here, the focus is on the reliability and usability of distributed systems, which are seen as crucial for practical implementation.

Furthermore, a market participant noted the significance of existing networks, stating, "We have all these other networks. If we can access and settle through them, that's where the benefit lies." This underscores the belief that operational advantages can be realised by leveraging established systems rather than relying solely on centralised approaches.

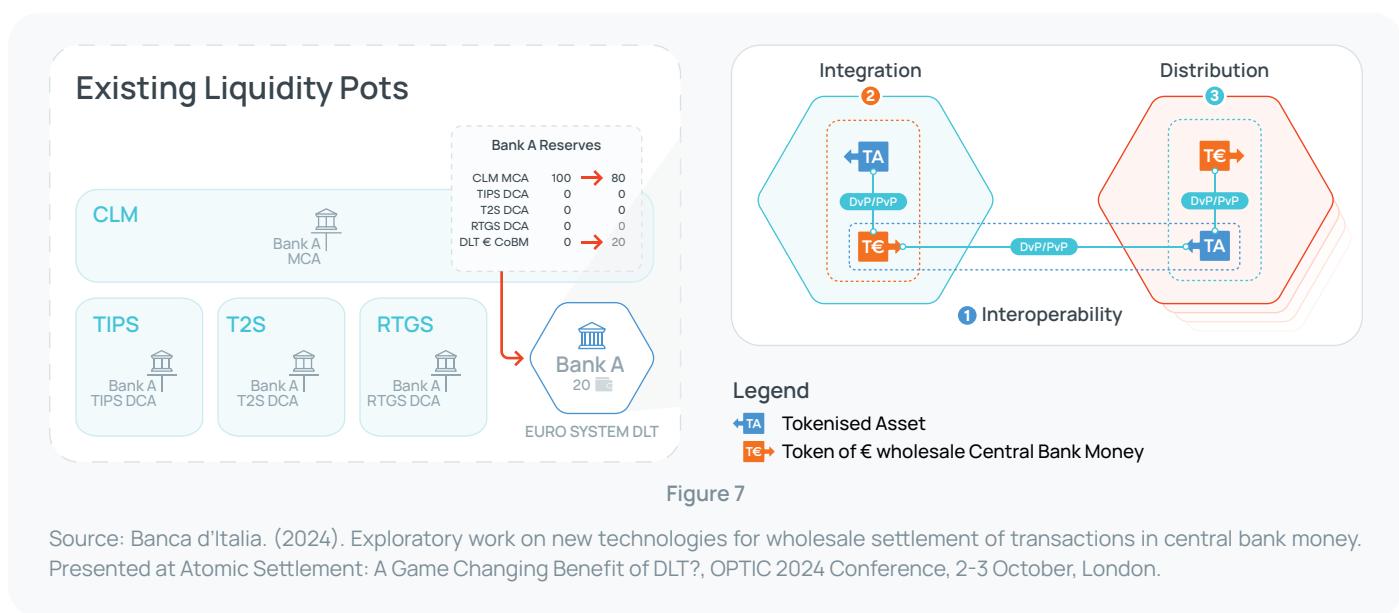
These observations indicate that while central bank representatives advocate for the innovative potential of distribution model within a centralised framework, market participants prioritise operational efficiency and integration within existing networks.

2. Approaches to wCBDCs

2.4 Interoperability Model

The Interoperability Model refers to a system where two or more ledgers operate in tandem, with one ledger managed by a central bank hosting a wCBDC, while the other ledger contains various tokenised assets. These assets are linked and exchanged between ledgers through an 'interoperability mechanism', which ensures seamless transfers, synchronisation, and verification of data across both systems. As described by the Banque de France, the difference between the Interoperability Model and the Distribution Model is that:

- in the INTEROPERABILITY MODEL, this mechanism synchronises the transfers carried out on the two DLTs. In other words, the assets remain on their respective DLT and the DvP is performed between the DLTs.
- while in the DISTRIBUTION MODEL, representative tokens of the euro wCBDC issued on the Eurosystem DLT are created on the shared DLT and the DvP is performed on the latter.



"The one that makes the most logical sense is as you said is the single shared ledger. However, I have a bi-pragmatic bias that I think the bridge is the one that will actually work." Market participant

"Linking systems is always something where you lose some of the benefits associated with all these new capabilities." Central bank

2.5 Privately Operated Synthetic CBDCs

Privately operated synthetic CBDC models use an omnibus account structure, where settlement tokens represent the cash leg of transactions. These tokens are backed by central bank deposits held by participating institutions, ensuring that the synthetic CBDC is fully collateralised and bankruptcy remote. In this model, the settlement process is managed by a regulated private operator, but the underlying value is guaranteed by the central bank reserves of

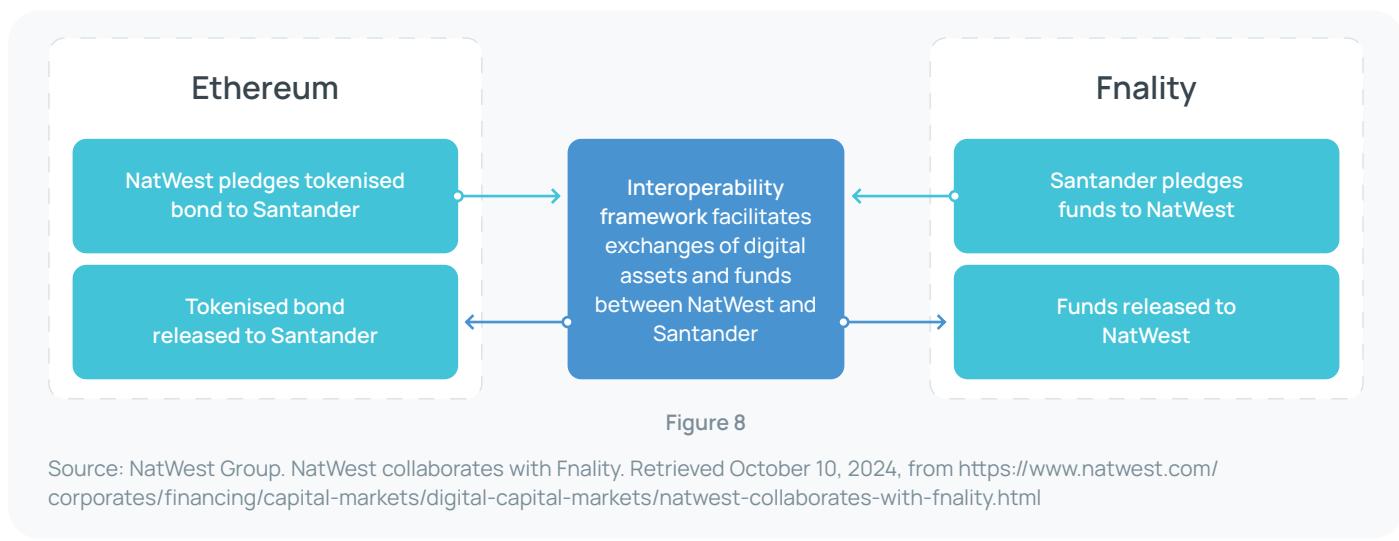
the institutions involved. This approach provides the benefits of central bank-backed stability while allowing private entities to handle the operational aspects of settlement. The settlement token itself is a liability on the private entity rather than the central bank.

The most developed example of this approach is Fnality, a project to develop a system that utilises an omnibus account model to facilitate the settlement

2. Approaches to wCBDCs

of transactions in central bank money. As detailed in the whitepaper, Fnality is not issuing a distinct wCBDC. Instead, participating financial institutions pool their central bank deposits into a shared omnibus account held at the central bank⁹. Fnality then creates settlement tokens on its platform, representing claims on these pooled central bank funds. These settlement

tokens are used to settle transactions between participants on the Fnality platform, ensuring payments are fully backed by central bank money. This approach aims to offer the benefits of wCBDC, such as reduced settlement risk and increased efficiency, without requiring the creation of a new form of central bank money. This is discussed in detail in section 3.6.



Source: NatWest Group. NatWest collaborates with Fnality. Retrieved October 10, 2024, from <https://www.natwest.com/corporates/financing/capital-markets/digital-capital-markets/natwest-collaborates-with-fnality.html>

Market participants argue that central banks are too slow to act, but private sector alternative solutions carry risks and therefore cannot be seen as a complete substitute for central bank-issued wCBDCs:

"We just can't wait for central banks to move at their own pace. Instead of creating the same layer of money, we're going to innovate the mobility of money outside of the central bank framework." **Market participant**

"Is there a scenario in which the operating company can go bankrupt, leading to a liquidity issue, if not

a counterparty issue? because the only entity that cannot really go bankrupt is the central bank, not an entire private entity like Fnality." **Market participant**

"Fnality has become a bit like a private members' club: if I'm a member, I can bring a friend. But if you want to get in, you'll have to buy me a drink, which is kind of like the fees we pay to correspondent banks. So, do we want multiple private members' clubs to develop, or do we want one accessible members' club?" **Market participant**

2.6 Summary of wCBDC models

There is no obvious answer as to whether Synchronisation, Integration, Distribution, or Interoperability approach is superior, as each presents a distinct cost-benefit balance that varies based on the specific goals and functionalities that wCBDCs aim to achieve. The effectiveness of each approach depends not only on technical feasibility but also on the strategic objectives set by central banks and financial institutions. Below, we attempt to make a comparison

between these different models across several selected criteria, providing a clearer understanding of their relative strengths and weaknesses.

The selected criteria for evaluating the approaches to implementing wCBDCs encompass a range of factors essential for assessing their effectiveness and feasibility. Relative Complexity and Ease of Implementation are crucial as they influence how

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quickly and easily these systems can be integrated into existing financial infrastructures. Impact on Existing Systems is vital for understanding potential disruptions to current processes and ensuring a smooth transition. Cross-border Capability addresses the potential impact on international transactions, while Scalability ensures that the systems can handle increasing transaction volumes over time. Regulatory Challenges highlight the legal considerations that must be navigated to ensure compliance, and Privacy Considerations focus on safeguarding user data in digital transactions. Operational Efficiency evaluates how well each approach improves overall performance, and Flexibility for Future Innovations assesses the ability to adapt to emerging technologies. Additionally, Central Bank Control reflects the degree of oversight central banks maintain, while Commercial Bank Role considers the involvement of traditional financial institutions in the new system. Lastly, Technology Requirements and Potential for Reducing Intermediaries are crucial in determining the technical feasibility and efficiency gains of each approach, along with the Liquidity Management Impact, which looks at how the implementation may affect financial stability. The analysis does not include expected revenue opportunities and implementation costs, as these factors can vary significantly depending on the country, institution and other contextual variables. Together, these criteria provide a holistic framework for comparing the various approaches to wCBDC implementation.

The table below provides a visual summary of how these approaches align with the specified criteria, facilitating a clearer understanding of their respective strengths and weaknesses. The circles represent a qualitative assessment using Harvey balls, where the fullness of the circle indicates the relative strength or impact of each criterion for the respective approach. A fully filled circle signifies a strong alignment with the criterion, while a partially filled or empty circle reflects a lesser alignment. This visual representation allows stakeholders to quickly compare the different approaches, making it easier to identify which may be more suitable for their specific needs and objectives. Of course, market participants will also consider revenue opportunity as part of any assessment of

wCBDC approach, but we have not taken this into account in the following analysis.

It is essential to note that this table offers a subjective evaluation based on current understanding and available data. The scores of evaluation can vary depending on individual interpretations of the selected criteria and the results of pilots and proofs of concept. Additionally, the emergence of new information regarding these models, along with results from ongoing experiments, may lead to changes in the evaluation. Actual implementations may vary widely and are influenced by numerous factors, including technological advancements, regulatory environments and specific design choices made by central banks. Before any implementation, stakeholders should consider these additional factors to ensure a comprehensive viability assessment of each approach.

The distribution model emerges as the most promising avenue for realising the full potential of DLT, offering comprehensive tokenisation and enhanced decentralisation, which in turn fosters greater flexibility. This model has garnered considerable interest among market participants, despite its complexity and the higher costs associated with implementation. However, from the perspective of the public sector, the implications of diminished central bank control pose a significant barrier to the distribution model adoption, leading many central banks to favour alternative models.

In contrast, the upgraded RTGS system presents several advantages over existing frameworks, with lower complexity, costs, and associated risks. Nevertheless, it falls short of fully capitalising on the transformative capabilities of DLT and tokenisation. As such, both the upgraded RTGS and synchronisation models are perceived by some stakeholders as interim solutions. The ongoing evolution of digital capital markets will inevitably heighten the demand for central banks to explore DLT-based solutions, ensuring that the need for innovation persists even after the successful deployment of the upgraded RTGS and synchronisation models.

2. Approaches to wCBDCs

Comparison of different approaches to wCBDCs

Criteria	Trigger/ Synchronisation	Integration	Distribution	Interoperability	Synthetic CBDC	Upgraded RTGS
Complexity	●	●	●	●	●	●
Fast Implementation Speed	●	●	●	●	●	●
Impact on Existing Systems	●	●	●	●	●	●
Cross-border Capability	●	●	●	●	●	●
Scalability	●	●	●	●	●	●
Regulatory Challenges	●	●	●	●	●	●
Privacy Considerations	●	●	●	●	●	●
Operational Efficiency	●	●	●	●	●	●
Flexibility for Future Innovations	●	●	●	●	●	●
Central Bank Control	●	●	●	●	●	●
Commercial Bank Role	●	●	●	●	●	●
Technology Requirements	●	●	●	●	●	●
Potential for Reducing Intermediaries	●	●	●	●	●	●
Liquidity Management Impact	●	●	●	●	●	●

Source: Cambridge Centre for Alternative Finance. (2024). Comparison of different approaches to wCBDCs.

Note: This evaluation may be subjective and based on the team's analysis of various models.



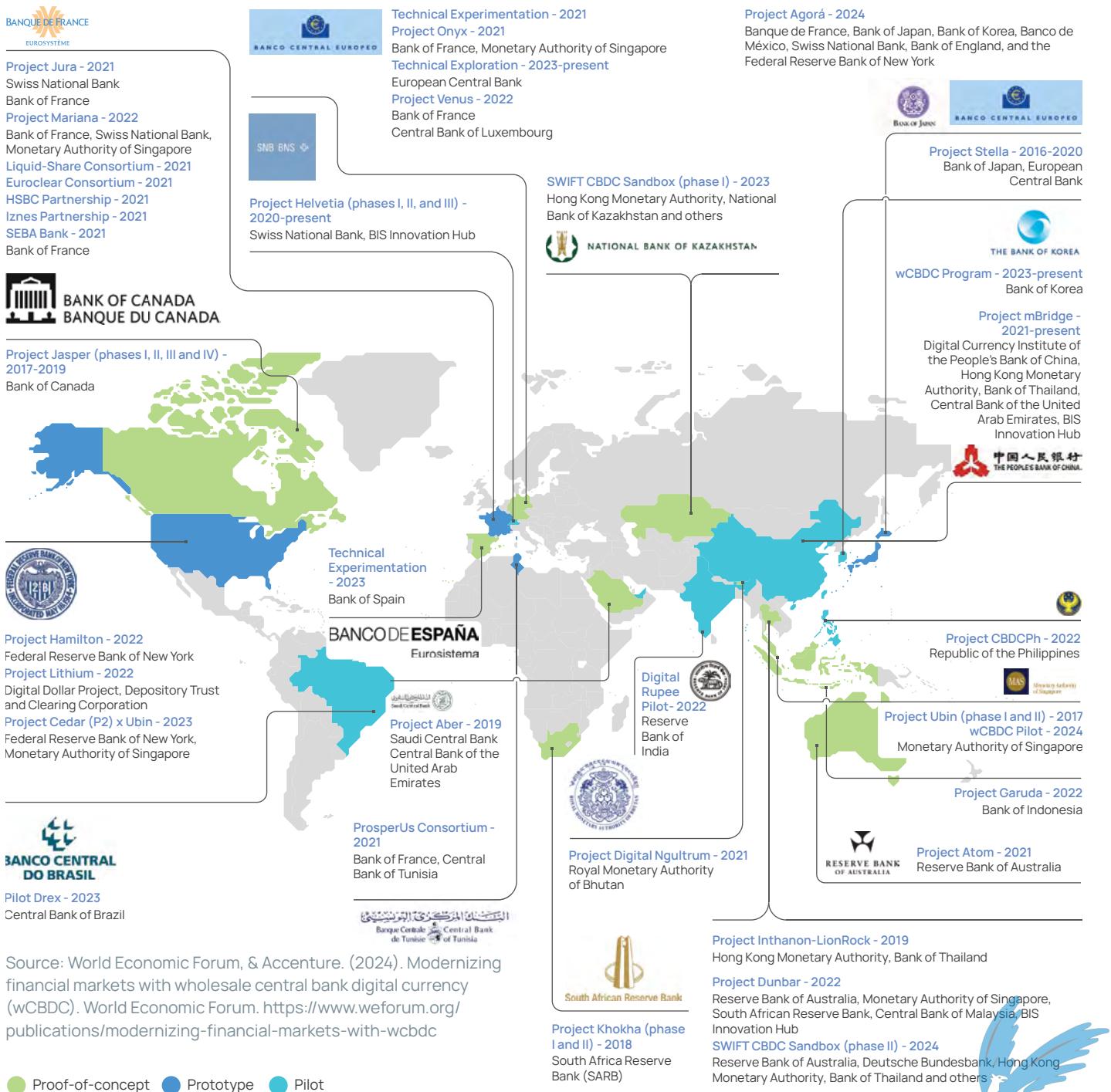
Use Cases and Insights from CBDC Experiments

03



3. Use Cases and Insights from CBDC Experiments

Numerous experiments have been launched in the last few years by central banks to assess the effectiveness, risks and potential impact of these approaches.



Source: World Economic Forum, & Accenture. (2024). Modernizing financial markets with wholesale central bank digital currency (wCBDC). World Economic Forum. <https://www.weforum.org/publications/modernizing-financial-markets-with-wcbdc>

3. Use Cases and Insights from CBDC Experiments

These case studies provide valuable insights into how different CBDC models function in practice and reveal important lessons on their implementation. Below, we outline key use cases from central banks experimenting with the direct issuance, trigger mechanism, hybrid/synthetic models and DLT-based models.

3.1 The European Central Bank's synchronisation and DLT experiments

The European Central Bank (ECB) has experimented with diverse initiatives focused on the potential of wCBDCs to enhance financial integration across Europe. The ECB explored synchronisation and DLT approaches to wCBDCs, exemplified by pilot projects in Italy, France and Germany. Each of these projects aims to address the existing complexities and fragmentation within the European financial landscape.

In light of these advancements, on 7 October 2024 a proposal by Piero Cipollone, Member of the Executive Board of the ECB, at the Bundesbank Symposium on the Future of Payments has emerged to establish a “European ledger”, envisioned as a unified platform that could streamline the interaction between central bank money, commercial bank money, and other digital assets¹⁰.

The Bundesbank's “trigger solution”

The Bundesbank's ‘trigger solution’ acts as a technological bridge between their TARGET2 RTGS system and private DLT platforms. This allows assets to be transferred on a DLT platform, while the corresponding cash leg is settled on TARGET2. Essentially, the DLT platform acts as a trigger for payments on the existing RTGS infrastructure, ensuring atomic settlement. While similar to the BoE's synchronisation approach (see section 3.2), the trigger solution differs slightly in how it earmarks funds within the RTGS system.

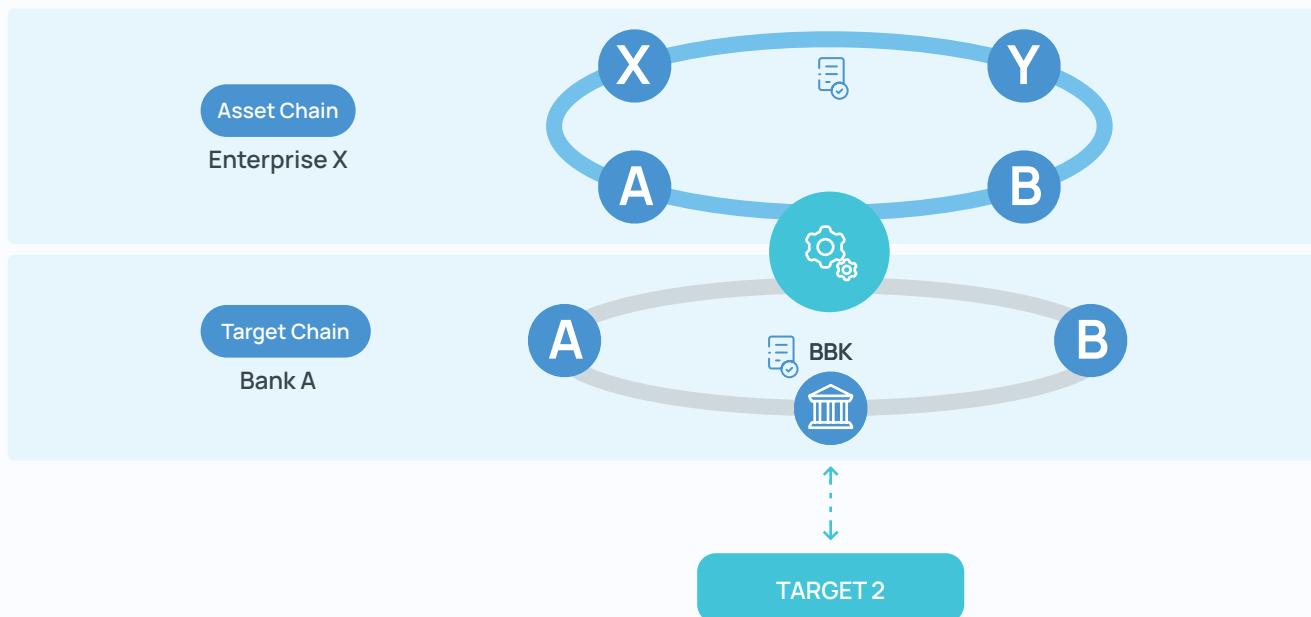


Figure 9

Source: Deutsche Bundesbank

3. Use Cases and Insights from CBDC Experiments

The Banca d'Italia's 'TIPS Hash-Link'

The Banca d'Italia's 'TIPS Hash-Link', takes a slightly different approach. Instead of using the TARGET2 system directly for cash settlement, it leverages a separate platform linking to the TARGET Instant Payment System (TIPS), the Eurosystem's instant payments platform. Like the other two approaches, assets are transferred on a market DLT platform, but the corresponding cash leg is settled in central bank money on the TIPS-like platform. An API gateway is used to bridge the two platforms and ensure atomic settlement.

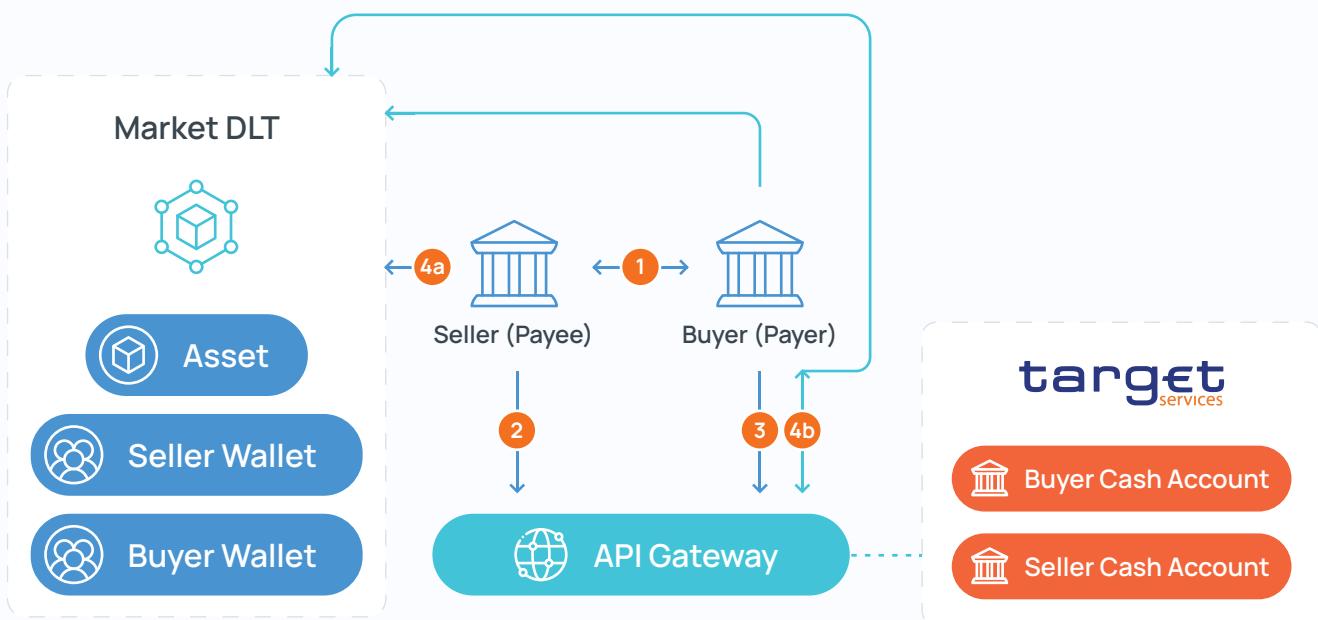


Figure 10

Source: Banca d'Italia. (2024). Exploratory work on new technologies for wholesale settlement of transactions in central bank money. Presented at Atomic Settlement: A Game Changing Benefit of DLT?, OPTIC 2024 Conference, 2-3 October 2024, London.

Banque de France's Full DLT Solution

The Banque de France has developed a DL3S (Distributed Ledger Securities Settlement System), a “full DLT interoperability solution” to facilitate seamless cross-border settlement of tokenized assets using wCBDC in the Integration Model approach. The solution aims to enable atomic DvP and PvP transactions between wCBDCs issued by different central banks on separate DLT platforms. Central to this solution is the “Eurosystem DLT”, a proprietary infrastructure that connects with various market DLTs. TARGET participants could then use Euro wCBDC on this platform for settlement purposes. This Eurosystem DLT would be designed to connect with various “market DLTs”, which could be operated by private market participants or other central banks, both within and outside the EU. This interconnected network would facilitate the flow of both cash (in the form of wCBDCs) and securities, enabling cross-border transactions.

3. Use Cases and Insights from CBDC Experiments

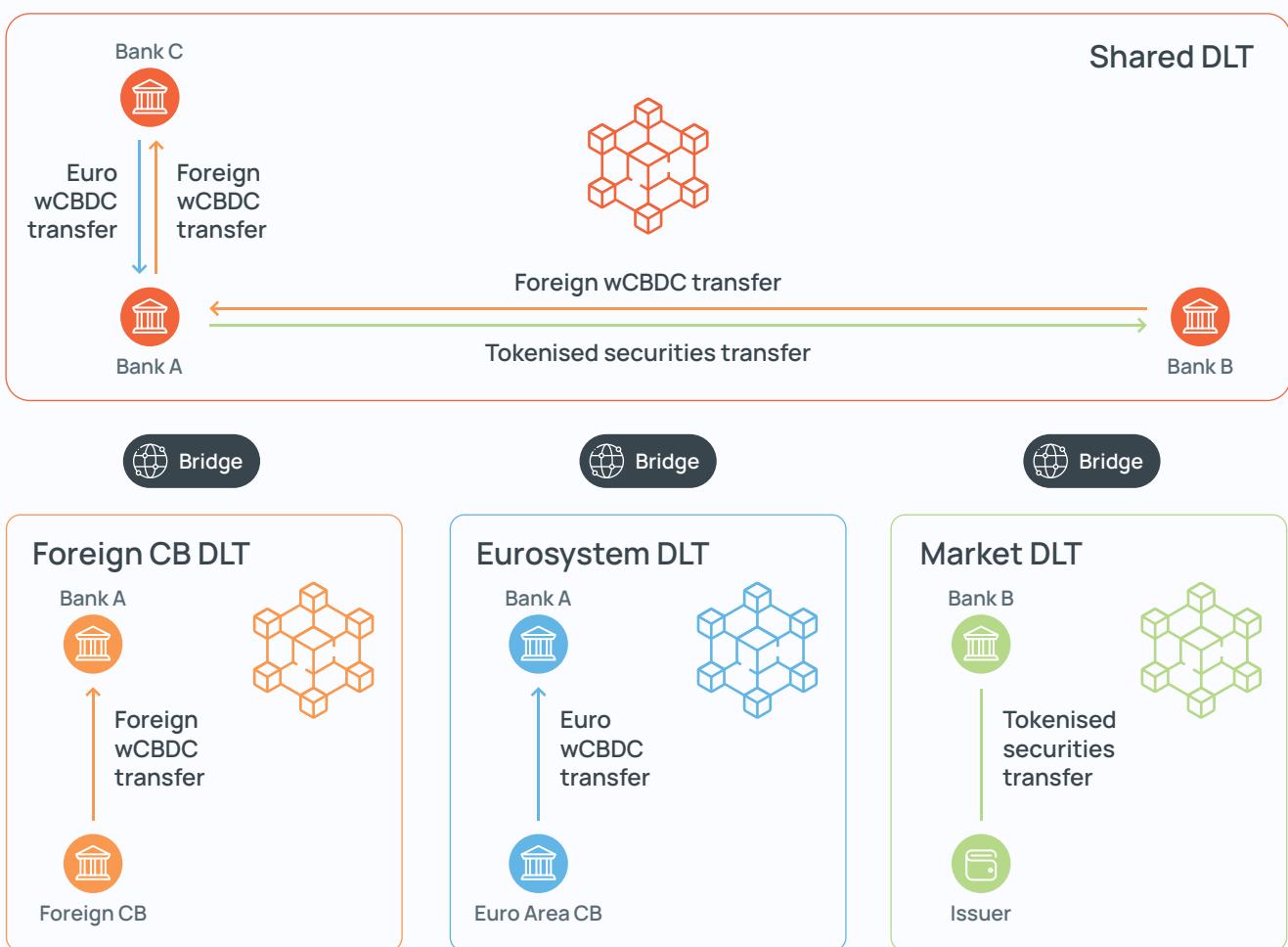


Figure 11

Source: Banque de France. (2023). Stabilité financière : Rapport sur les monnaies numériques de banque centrale [Financial Stability: Report on Central Bank Digital Currencies]. https://www.banque-france.fr/system/files/2023-08/Banque_de_France_stabilite_financiere_rapport_mnbc_2023.pdf

Even though the various ECB models share a common underlying logic, there is some political tension regarding which country's approach will ultimately prevail. Respondents from the private sector noted that, from a technical integration standpoint, Germany's approach is considered the easiest to integrate with, Italy's ranks second in terms of difficulty, and the approach by France is viewed as the most complex to adopt. At the same time, the French approach was regarded as the most beneficial in the long term, as it is the only initiative among the three that incorporates both tokenisation and DLT. This disparity in ease of integration likely stems from differences in the technological frameworks, regulatory

environments and infrastructure designs of each country.

The political dimension adds another layer of complexity, as each nation may push for its model to become the standard, reflecting broader strategic interests beyond just technical considerations:

"I think ECB's a unique beast because it has to deal with all these different central banks." **Market participant**

"There was no commitment from the ECB to discuss anything about what would be used next year. They've said that they're going to extend the use of

3. Use Cases and Insights from CBDC Experiments

these settlement networks next year, but they've made no kind of commitment at all on what it would look like. So very difficult to say where it will go." *Market participant*

"Partly it is a political play between Italy, France and Germany. But essentially it was those banks that came together and said, okay, we can run the T2S system together." *Market participant*

3.2 Bank of England: Synchronisation (Meridian, Meridian FX and proposed experiments)

The BIS Innovation Hub London and Bank of England's Project Meridian examined a synchronisation approach akin to those of the ECB's initiatives, though it presented a distinct design variation. The underlying principle remained consistent: connecting a DLT platform with the RTGS system. This prototype utilised a hypothetical house purchase transaction where a digital deed, representing a property, is transferred on a DLT platform, while the corresponding payment is settled through the RTGS system. A key component of Meridian is the introduction of a 'synchronisation operator', which would act as an intermediary between the RTGS system and external platforms to facilitate synchronised settlement.

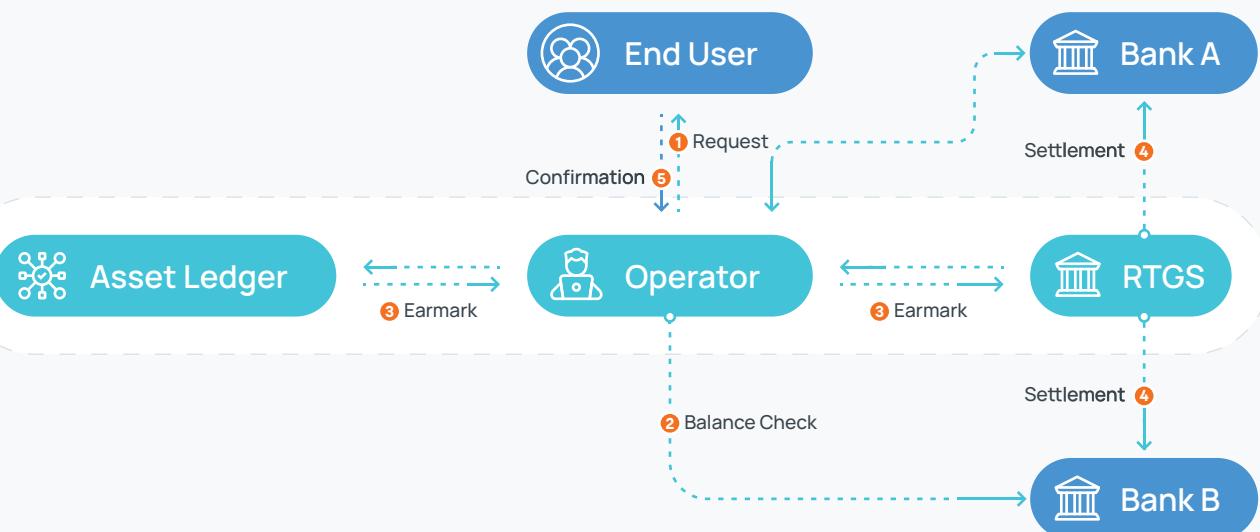


Figure 12

Source: Bank for International Settlements (BIS) & Bank of England. (2023, April 19). Project Meridian: innovating transactions with synchronisation. BIS Innovation Hub. <https://www.bis.org/about/bish/topics/fmis/meridian.htm>

Following Project Meridian, the Meridian FX project extended these concepts to the foreign exchange (FX) market. This initiative tested synchronising FX transactions between central banks' RTGS systems, showcasing the benefits of atomic settlement and providing insights into how RTGS systems can interoperate with new technologies such as the 3 ECB solutions and how a synchronisation approach could deliver more efficient settlement, addressing the cost, risk and settlement times for cross-border FX transactions.

In addition, in their July 2024 "Approach to innovation in money and payments" Discussion Paper, BoE proposes 3 DvP experiments focused on tokenised bonds, a PvP experiment building on the Meridian FX initiative and an interoperability experiment which might become part of Project Agorá (see section 3.3).

Despite the Meridian project, most of the interviewees mentioned BoE initiatives in the context of their collaboration with Fnality.

3. Use Cases and Insights from CBDC Experiments

3.3 BIS cross-border wCBDC experiments

The BIS is a leading institution in fostering collaboration among central banks worldwide. Through its Innovation Hubs, the BIS is facilitating a range of projects that explore the cross-border applications of wCBDCs, seeking to address critical challenges in the global financial landscape. On this topic, BIS' most notable initiatives include Project Agorá, which focuses on the efficiency of cross-border payments using DLT; Project Jura, aimed at improving the settlement process between the Swiss franc and the euro; and Project Dunbar, which investigates the potential for wCBDCs to enhance cross-border transactions among multiple jurisdictions.

While the potential for cross border experiments is a compelling use case and has been at the forefront of BIS wCBDC experiments as seen below, there are two major challenges to cross border payments and the corresponding bank model generally: (i) the friction and cost to commercial banks due to the domestic/international interoperability; and (ii) the banks' own (usually outdated) technology solutions. This presents a two-sided issue: on one hand, banks are reluctant to replace old technology due to cost constraints, on the other hand, the costs and resource requirements needed changes every year on account of developments in regulatory infrastructure. Another important highlight of these experiments is that they are designed to upgrade existing infrastructure. It remains to be seen whether this will result in a competitive advantage for banks and their revenue, and whether it will reduce the technology burden in given incremental regulatory developments (or at least make it cheaper to meet new requirements).

Project Jura

Project Jura was a collaborative initiative involving the Banque de France, the Swiss National Bank, and the BIS Innovation Hub. The project explored the use of wCBDCs for cross-border securities settlements and foreign exchange transactions across separate DLT platforms. The project explored different interoperability solutions, including using a single shared platform and connecting separate platforms through interoperability protocols. Also, Jura explored the concept of using subnetworks and dual notaries as a mechanism for ensuring control and security in a cross-border wCBDC system. This approach involves creating separate subnetworks on a DLT platform for different jurisdictions, with transactions requiring validation from notaries representing both jurisdictions. This enhances privacy and allows each central bank to maintain control over its own wCBDC within its designated subnetwork.

"I think a very important takeaway from the Jura is that the complexity arises when considering how to extend this to a production environment. The complexity is linked to access to central bank money. Ultimately, it is a policy decision whether central bank money should be available to non-domestic financial institutions as well."

Market participant

3. Use Cases and Insights from CBDC Experiments

Project Agorá

Project Agorá is a major initiative led by BIS, with the participation of 7 central banks and over 40 financial institutions. The project “builds on the unified ledger concept proposed by the BIS and will investigate how tokenised commercial bank deposits can be seamlessly integrated with tokenised wholesale central bank money in a public-private programmable core financial platform.” The initial focus is on transforming correspondent banking and is intended to be a 12-18 month journey for the firms concerned. As both a leading example of international public/private collaboration, a practical demonstration of the Unified Ledger construct, and as a major step in potentially transforming financial service, it is one of the most significant initiatives in the industry.

Having said that, opinions vary in terms of what the outcome will be, and how such a vision may be implemented in practice:

“Project Agorá is creating in effect a multi-currency RTGS” **Market Participant**

“Agorá is just a better set of rails and a modular upgrade to SWIFT i.e., SWIFT on DLT with settlement.” **Market participant**

“Agorá is a very interesting project in the sense that it wouldn’t require, at least from the outset, a change to the access criteria to wholesale central bank money. This is a highly policy relevant aspect” **Central Bank**

“If you rely solely on wholesale CBDC, you need to consider extending access to wholesale central bank money. This is a delicate issue. Agorá, by extending this setup with tokenized deposits, could potentially address this challenge.” **Central Bank**

Other interviewees expressed concerns on the risks associated with Agorá:

“There is a risk of replicating today’s set up; a correspondent banking network just on a new stack.” **Central bank**

“Agorá needs to prove what it can do, needs to make the case vs improved RTGS” **Market participant**

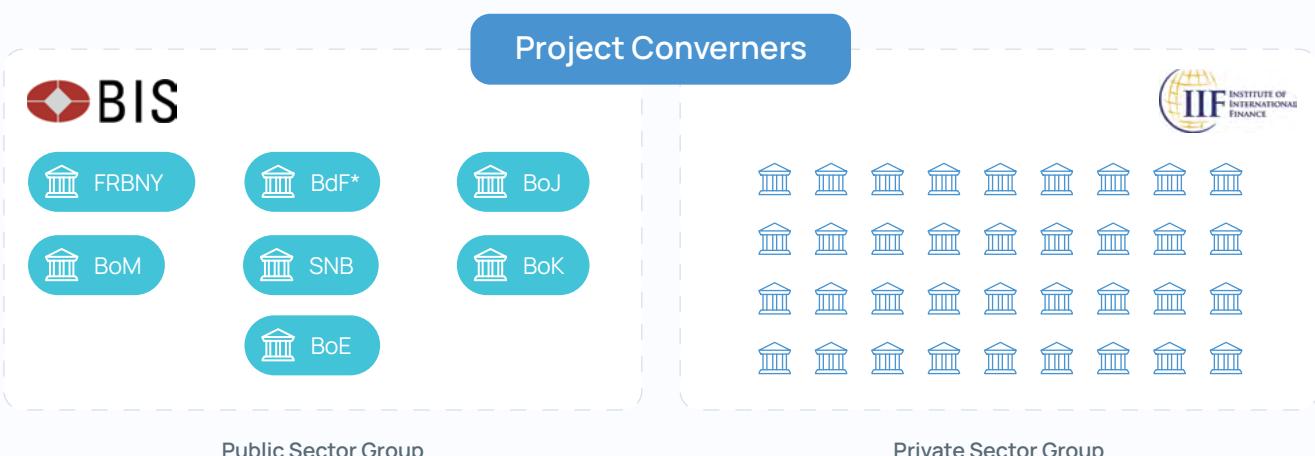


Figure 13

Source: Bank for International Settlements. Agorá application package. Bank for International Settlements. https://www.bis.org/innovation_hub/projects/Agorá_application_package.pdf

3. Use Cases and Insights from CBDC Experiments

mBridge

Project mBridge is an initiative co-led by the Hong Kong Monetary Authority (HKMA), Bank of Thailand (BoT), Central Bank of the United Arab Emirates (CBUAE), People's Bank of China Digital Currency Institute (PBC DCI) and the Hong Kong BIS Innovation Hub (BISIH HK). The initiative aims to explore wCBDCs application for cross-border payments. It began as discussions in 2021 and reached the MVP stage in 2024. The initiative's approach to CBDCs focuses on their ability to serve as the "payment-leg" in settling commercial transactions, both domestically and internationally. By utilising DLT as a synchronised record-keeping platform and incorporating smart contracts for automated execution, mBridge aims to overcome the limitations of traditional cross-border payment systems, which often involve multiple intermediaries, leading to increased costs and frictions.

According to BISIH, "Participating central banks have deployed consensus nodes and commercial banks are conducting real-value transactions on a continuous basis. The platform also supports key functions for central bank and commercial bank participants. This includes CBDC issuance and redemption, FX payment versus payment (PvP), CBDC transfers, queue management and balance alerts, along with information management features. Furthermore, access control allows the implementation of a maker and checker system, ensuring that no single person has full control over a transaction. Finally, commercial banks continue to ensure compliance with their respective AML/CFT regulations off bridge."

The uniqueness of the mBridge initiative lies in enabling real-time quota monitoring, closer collaboration, and customisation options. There are two primary use cases explored within the mBridge project: FX derivatives/Dual Currency deposits for corporate and institutional investors; and an enhanced Wealth Management Connect for individual investors.

One of the key benefits highlighted is real-time quota monitoring, a feature that would allow central banks to gain instant visibility into the usage of applicable quotas for cross-border transactions. This real-time oversight would enable prompt enforcement and reduce the administrative burden associated with traditional reporting mechanisms.

Project Dunbar

Project Dunbar was led by the BIS Innovation Hub and central banks from Australia, Malaysia, Singapore and South Africa. The project focused on addressing three critical challenges: access for non-resident banks, managing jurisdictional boundaries, and establishing effective governance. It focused on the "single system with multiple CBDCs" model, where participating central banks and financial institutions would transact directly with each other in wCBDCs on a common platformⁱⁱⁱ. Prototypes were designed to support both "hybrid" and "direct" wCBDC access models, addressing the challenge of enabling non-resident banks to access wCBDCs while respecting regulatory frameworks. In a hybrid model, non-resident banks would access wCBDCs through sponsoring banks, while a direct model would allow direct access, subject to regulatory approval. The prototypes on Corda and Quorum DLT platforms implemented logically separated sovereign networks, ensuring each participating central bank retained control over its monetary sovereignty, network membership criteria and governance policies.

3. Use Cases and Insights from CBDC Experiments

3.4 Swiss National Bank and SDX

The Swiss National Bank (SNB) has been exploring wCBDCs through several initiatives. The Helvetia pilot, launched in 2020, aimed to assess the integration of a wCBDC into Switzerland's financial system in collaboration with the Swiss Digital Exchange (SDX). Additionally, in 2021, the SNB initiated Project Jura for cross-border settlements using wCBDCs mentioned earlier.

The Helvetia pilot

The Helvetia pilot, a multi-phase research project, was a collaborative effort between the Swiss National Bank (SNB), the Swiss BIS Bank Innovation Hub, and SIX Group AG. The project investigated the integration of tokenised assets and central bank money on the SDX platform. Phase I focused on two proofs of concept: the issuance of a wCBDC; and establishing a link between the SDX securities settlement platform and the existing central bank payment system. Phase II expanded on Phase I by incorporating commercial banks and integrating wCBDC into core banking systems

1. Phase III ([launched in December 2023](#)) involved a limited-time pilot program where the SNB issued a live Swiss Franc wCBDC for settling digital securities transactions on the SDX platform
2. The wCBDC was utilised for selected primary market transactions and was designed for intraday use, meaning it was converted back to traditional reserves at the end of the day.

The project's use of DLT enabled the creation and transfer of wCBDC on the SDX platform, allowing for the settlement of digital securities in central bank money. This a rare example of a central bank issuing a tokenised wCBDC onto a third party operated ledger and having all necessary controls in place to be able to do that. The Swiss National Bank has decided to continue the Helvetia initiative with a pilot phase that will extend at least until June 2026¹¹.

"Helvetia was a great example of public-private collaboration. I believe this is essential for the success of such projects. It has been an iterative journey; we started in 2019 and only moved into the pilot project in 2023. Also, Helvetia has demonstrated that central banks can indeed be agile." [Central Bank](#)

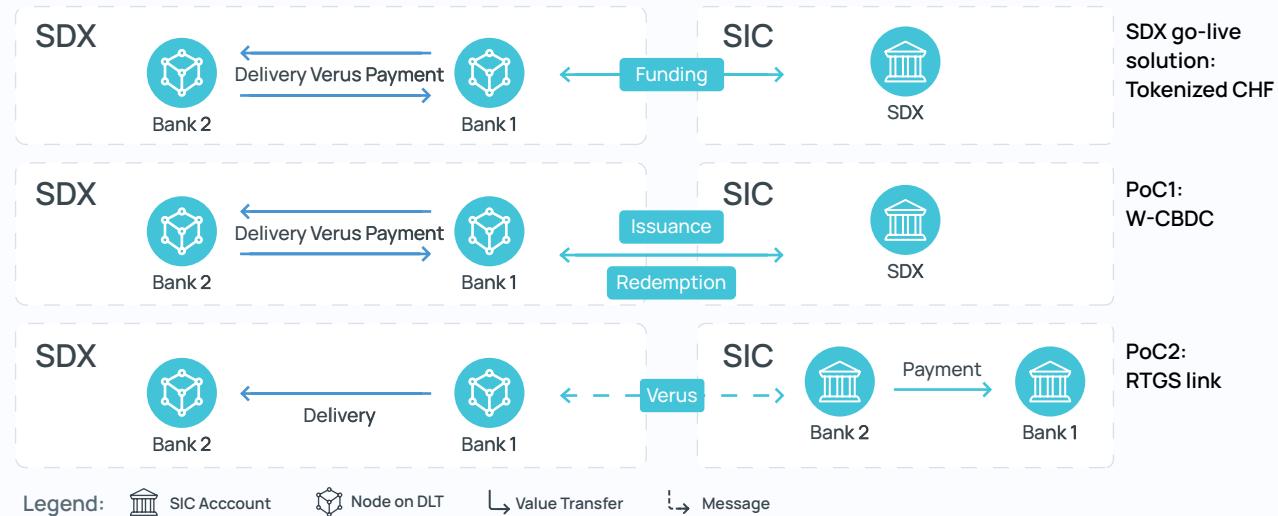


Figure 14

Source: Bank for International Settlements. (2020). Project Helvetia: Settling tokenised assets in central bank money. <https://www.bis.org/publ/othrop41.htm>

3. Use Cases and Insights from CBDC Experiments

	PoC1, wCBDC	PoC2, RTGS link
Benefits	wCBDC “onledger” enables the full functionalities of SDX’s DLT platform: <ul style="list-style-type: none"> ■ Execution of programmable business logic (“smart contracts”) ■ Atomic multilateral settlement 	An RTGS link: <ul style="list-style-type: none"> ■ Does not raise major new legal or policy questions, as central bank money always remains in the RTGS system ■ Would require only minor adjustments to the central bank’s business processes
Challenges	Issuing a wCBDC: <ul style="list-style-type: none"> ■ Raises numerous legal and policy questions ■ Requires substantive adjustments to the central bank’s business processes 	Now CBDC “onledger” limits functionalities of the SDX platform: <ul style="list-style-type: none"> ■ Limited execution of smart contracts involving reserve balances ■ Atomic multilateral settlement of DvP transactions not feasible with RTGS link due to the current setup of SIC (sequential settlement, queuing mechanism, lack of simultaneous blocking mechanism)

Source: Bank for International Settlements. (2020). Project Helvetia: Settling tokenised assets in central bank money.

<https://www.bis.org/publ/othp41.htm>

SDX

David Newns, head of SIX Digital Exchange (SDX), emphasises the need for a “riskless settlement asset” to underpin the entire financial system, arguing that this is essential for building a truly robust and trustworthy blockchain-based infrastructure: “Without a riskless settlement asset at the base of the entire edifice, we cannot build everything on top of it and be assured of a firm foundation”. SDX’s own experience with tokenised deposits highlights the limitations of current systems. Despite being innovative, these deposits still carry counterparty and liquidity risks, leading to additional capital charges for banks and ultimately hindering wider adoption.

Newns underscores Switzerland’s unique position in the development of wCBDCs due to a few factors, including the country’s collaborative relationship between the SNB and financial market infrastructures, combined with a proactive and supportive regulatory approach. In terms of challenges, he sees the high investment costs for institutions, the inherently slow pace of change in the global financial system, and the complexities of navigating geopolitical considerations while achieving regulatory harmonisation across different jurisdictions. He states:

“...This is a lot to ask for investing in this technology from these multiple projects, which is a significant burden. An organisation like mine is not flush with cash just sitting around waiting to be spent on endless CBDC projects....”



3. Use Cases and Insights from CBDC Experiments

The interview also highlighted the critical role of governance in ensuring the success of wCBDC initiatives, particularly when it comes to managing the complex interplay between regulated activities, participants and the underlying technology.

Newns notes that:

"...The most important aspect of adoption here will be governance. We need to consider the governing body that manages the network, including who gets to participate and how those decisions are made. Additionally, there is another layer of governance related to the technology itself. It might involve multiple pieces of technology, but it is essential to establish a clear separation between governance and technology..."

3.5 Fnality

Fnality offers an approach to developing a private-sector response to wCBDCs, using the “synthetic CBDC” model. By maintaining funds in central bank accounts while using blockchain as an accounting system, Fnality’s model seeks to deliver the reliability of central bank-backed money with the flexibility and innovation that blockchain offers. Rhomaios Ram, CEO at Fnality, suggested that Fnality’s solution may bridge gaps in CBDC models. In this context, he sees Fnality’s model as a potential complement to wCBDCs rather than a direct competitor.

A recurring theme in the interview was the nuanced balance between stability and adaptability within the digital currency landscape. The advantage of a project like Fnality is that it operates within the existing regulatory framework, functioning as a payments processor that complies with current regulations. This eliminates the need for regulatory changes, which many interviewees identified as a major bottleneck. Because Fnality avoids these regulatory hurdles, the timeline for implementation and adoption is much faster compared to the lengthy process required for the full launch of wCBDCs. As a result, unlike many other projects discussed in this report, Fnality is currently live and operational in the United Kingdom.

Ram reflected that at the beginning they were following the principle “let’s try and glue everything we’re doing into the existing framework”, and this approach proved to be helpful. However, this approach is limited by the policies of central banks in different

countries. Fnality’s current design requires the use of an omnibus account, meaning that any country that does not have or does not plan to implement such an account will present an additional challenge for the Fnality team to find an alternative mechanism within the specific regulations of that country. A notable example of this limitation was Fnality’s failure to reach an agreement with the Swiss National Bank in the initial negotiations, highlighting the challenges it faces in expanding across jurisdictions with varying regulatory and operational frameworks.

The relationship between tokenised assets and digital cash is another intriguing aspect of Fnality’s vision. The CEO recognises a “chicken and egg” scenario, where tokenised assets and digital currency systems must grow in tandem to achieve maximum effectiveness. “It would be slightly pointless for us to get very far ahead if there’s nothing else to settle against,” he notes, illustrating how Fnality’s success is inherently tied to the broader adoption of tokenised assets.

He also questions the notion that a single blockchain or digital currency system could dominate the global financial landscape. Instead, he envisions a fragmented but interoperable ecosystem, where various blockchain and digital currency platforms coexist. This perspective is rooted in the diversity of regulatory and legal environments worldwide, which complicates efforts to create a one-size-fits-all solution.



3. Use Cases and Insights from CBDC Experiments

Finally, trust and security emerge as foundational principles in Fnality's design. Although Fnality operates within a private-sector framework, it mirrors the high credit quality associated with central bank money by maintaining reserves in central bank accounts. Because of that Ram stated "I don't think trust is going to be a problem," suggesting that heavy regulation and strong legal protections can foster user confidence without direct involvement from central banks. He believes so because the liability for the funds in the omnibus account does not rest with the private entity.

These funds are considered bankruptcy remote from Fnality and are not liabilities of the central bank. Instead, the funds are classified as a liability of the participants collectively. But other participants mentioned that they see potential liquidity risks there. According to them, in the event of a default by one of the participating banks within the omnibus framework, other banks could face delays in accessing their funds until essential initial steps in the default resolution process – such as receivership or liquidation – are completed.

Infrastructure/ Design Implications



4. Infrastructure/Design Implications

4.1 wCBDC Infrastructure Developments

The question of the underlying blockchain infrastructure for a wCBDC has grown more complex in recent years. There are essentially three categories of blockchain infrastructure: (i) private-permissioned chains; (ii) public-permissioned chains; and (iii) public-permissionless chains. The characteristics of these three categories are illustrated below:

Defining characteristics	Private-permissioned	Public-permissioned	Public-permissionless
Governance	Centralised	Centralised (for the relevant application)	Decentralised
Accessibility to users	Closed	Closed (for the relevant application)	Open
Control over privileges	Can be defined as requirement	Users authenticated for specific roles	All users can perform all roles
Identification requirements	All users Known	All users known (for the relevant application)	Pseudonymous
User base	Very Limited (by design)	Limited (for the relevant application)	Broad
Interoperability	Can be developed as required but lower ease of implementation	Can be designed as required (for the relevant application)	Higher interoperability given existing DLT-based ecosystem

Source: GFMA – Impact of Distributed Ledger Technology in Global Capital Markets

<https://www.gfma.org/wp-content/uploads/2023/05/impact-of-dlt-on-global-capital-markets-full-report.pdf>

Sell-side firms in the US have largely been confined to private-permissioned blockchains such as Hyperledger Besu because of the regulatory concerns regarding public chains. Meanwhile buy-side firms have been able to utilise public blockchains such as Ethereum (Blackrock) and Stellar (Franklin Templeton). Indeed the FSB note that “the market value of tokenised money market products, including MMFs holding US Treasuries, roughly doubled from May 2023 to May 2024 to more than US\$1 billion outstanding on permissionless blockchains”. Private sector entities have progressed with public-permissioned approaches such as the Canton Network, whilst in parallel, focused on the need to preserve the singleness of money and the two-tier banking system, the public

4. Infrastructure/Design Implications

sector have proposed the concept of a unified ledger for both central bank and commercial bank liabilities, with proposed public-permissioned approaches such as the MAS Global Layer One and the BIS Finternet. The different perceptions of these differences are illustrated in the following survey of 494 market participants by Citibank⁷.

Question: for the following asset classes, which type of networks do you expect to use?

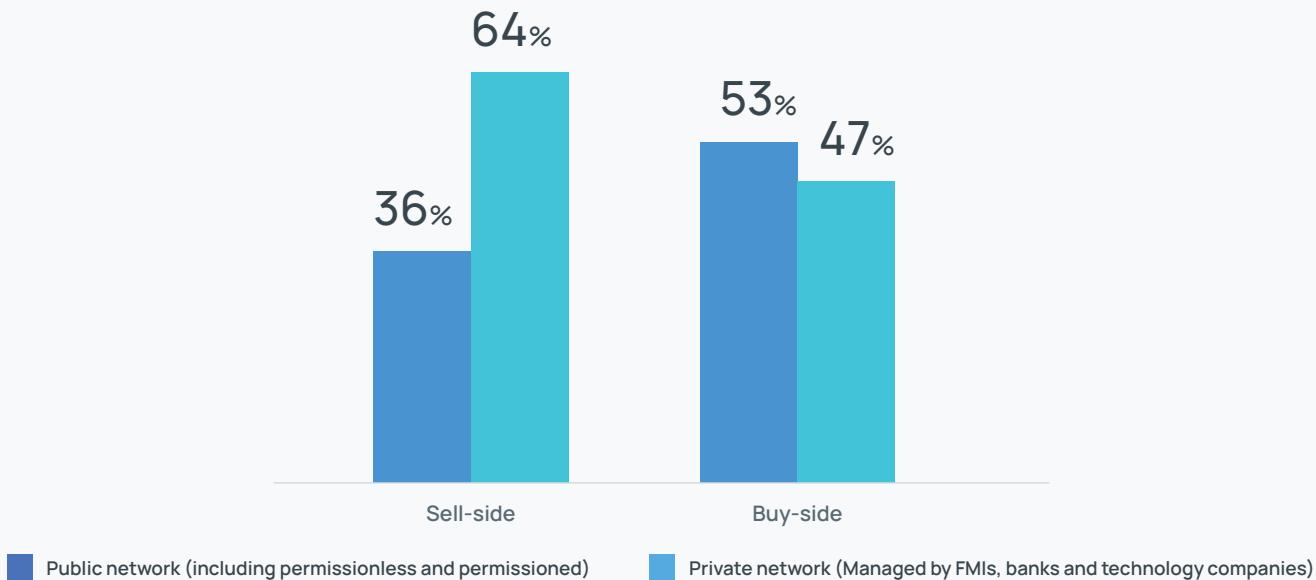


Figure15: Preferred network type across all asset classes.

The evolution of DLT infrastructure will have a major impact on the level of “balkanisation” that might exist of the future financial markets landscape, with one extreme of “blockchain islands” supporting specific use cases with the consequent dependence on interoperability solutions, such as those being tested by SWIFT with Chainlink, and JP Morgan with Ownera. At the other extreme, universal acceptance of public blockchains may solve many of these issues but this would face major challenges in terms of regulatory compliance.

Several banks in our interviews highlighted the need for wCBDC to be ultimately available on public-permissionless chains:

“The action is not happening in the private permissioned space.” **Market participant**

“Regulated money has to go where the economic actors are, including public chains” **Market participant**

“BIS Capital rules effectively rule public chains out”
Market participant

However central banks remain concerned about questions of the governance model for public-permissionless chains, how operational settlement finality is achieved when settlement is probabilistic, and their operational resilience characteristics, especially in times of market stress.

The exact nature of this future landscape will therefore impact how a wCBDC is made available, especially for those wCBDC options that involve a third party operated ledger for tokenised assets, and for those use cases focused on international payments.

Let us now consider these individual infrastructure developments in more detail.

4. Infrastructure/Design Implications

4.1.1. Canton Network

The Canton Network is a public-permissioned network launched by Digital Asset Holdings. Its first PoC took place in 2023 with 15 asset managers, 13 banks, 4 custodians, three exchanges and one financial market infrastructure provider. The banks included BNY, Standard Chartered and Goldman Sachs. 22 decentralised applications (dApps) were tested including trading, margin and financing solutions including asset tokenisation, repo, securities lending and digital cash. Subsequently, Digital Asset Holding announced the 'Global Synchronizer' which is positioned as a decentralised and transparently governed interoperability service for the Canton Network, attempting to address financial industry calls for a unifying infrastructure to facilitate industry connectivity, optimise liquidity management and deliver on the potential of a global economic network. A Global Synchronizer Foundation was also announced in collaboration with the Linux Foundation to coordinate governance of the Global Synchronizer ecosystem.

4.1.2. RLN and RSN

The Regulated Liability Network originated from an initial proposal by Tony McLaughlin from Citibank, leading to the publication of a white paper⁸ and two subsequent PoCs - one in the US, based on Digital Asset/Canton and SETL technologies with the US Fed's Innovation Centre and ten banks,¹² and one in the UK. RLN is envisaged as a new "financial substrate" to provide a shared ledger infrastructure for both central bank and commercial bank liabilities, and potentially regulated stablecoins. Each project is currently conducting a second phase: the Regulated Settlement Network PoC¹⁰ in the US, focused on DvP and using Canton; and the RLN UK Experimentation Phase (following on from the earlier Discovery Phase), led by UK Finance and 11 financial institutions, using Quant and R3 Corda. The RLN UK project was focused on five use cases, one of which was wholesale tokenised bond settlement with simulated wCBDC. It used a "federated network of network" model for the ledger component, rather than a shared ledger implementation, which illustrates the design choices that need to be made

between what functionality (programmability, etc.) needs to be implemented at an orchestration layer vs at the shared ledger layer (in smart contracts).

"Programmability doesn't need to be in the token but can be at the orchestration layer as shown in UK RLN"
Market participant

4.1.3. Global Layer 1

Global Layer 1 is an initiative of the Monetary Authority of Singapore (MAS), which published a white paper¹¹ on their concept of a regulated public-permissioned network in June 2024. The vision behind GL1 is to provide a "shared ledger infrastructure across jurisdictions to deploy inherently interoperable digital asset applications, governed by common standards and technology for assets, smart contracts, and digital identities." MAS is now collaborating with several banks, including BNY, Citi and JPM to develop the initiative further.

4.1.4. Finternet

In June 2023, as part of a speech on the Future Monetary System, Augustin Carstens, General Manager of the BIS, proposed the vision of a Unified Ledger which would "be a network of networks that would allow various components of the financial system to work seamlessly together." Subsequently this vision took a step forward with his and Nandan Nilekani's proposal of the Finternet¹³, which has the objective of delivering "multiple financial ecosystems interconnected with each other, much like the internet, designed to empower individuals and businesses by placing them at the centre of their financial lives." This vision has now taken a step forward toward reality with the creation of an open source initiative.¹³



4. Infrastructure/Design Implications

4.2 The Infrastructure Complexity

The infrastructure initiatives noted above, together with the continuing progress of private-permissioned blockchains, such as R3 Corda (use by SDX in Project Helvetia and by RLN UK Phase 2) and Hyperledger Fabric (used in the Bundesbank and Banque de France wCBDC trials) together with the public chains such as Ethereum, Solana etc. illustrate the risk of fragmentation of the future digital financial markets landscape.

Interviews with market participants indicated a positive view of market collaborations to progress the move to digital financial markets, and a concern that with so many initiatives fragmentation may get worse:

"If done wrongly fragmentation could occur - especially with additional DLT infrastructures" **Market participant**

This also raised the question as to what extent central banks or regulators should be the lead in these collaborations, such as is the case with BIS's Project Agorá. Some market participants saw the coalescing to a single platform to avoid the fragmentation risk and to drive industry adoption needed such leadership.

"Adoptions needs to be driven by the regulator or the central bank to move the market forward. It needs a regulator push, as in the case of open banking in the UK" **Market participant**

In turn this raises the question as to whether the regulator or central bank should also dictate the underlying technology infrastructure to be used. The recent speech by ECB Executive Board Member Piero Cipollone¹⁵ is a case in point, which makes the case for a "European ledger, which would be a single-platform

solution where assets and cash would coexist on one chain." From the ECB's perspective, this would help maintain the role of central bank money in digital financial markets, as well as help with the promotion of "robust, stable and integrated European capital markets", integration being a key objective of the EU's Capital Markets Union initiative. The ECB also recognises the choices to be made, as in the words of Cipollone "The option would therefore be to allow the coordinated development of an ecosystem of fully interoperable technical solutions."

From market participants' perspective, many would prefer technology infrastructure to be chosen by participants:

"Banksshouldbeabletochoosetechnologythemselves, technology neutrality is being sacrificed." **Market participant**

As proposed by BIS in the case of the Finternet, the answer probably lies in a set of standards and protocols that implement the necessary security, resilience and compliance of shared ledgers on the basis that there will not be a single "ledger that rules them all":

"There won't be one universal ledger, there will be more than one - the community needs to come together, enabling where the industry needs to get to." **Market participant**

How current private-permissioned platforms and public-permissionless chains fold into this model remains to be seen, and indeed whether the request from several of our interviewees for EVM compatibility as a means of refactoring applications will be fulfilled.



Policy, Regulatory and Legal Aspects

05

5. Policy, Regulatory and Legal Aspects

5.1. Policy and Regulatory Considerations

Central banks globally possess twin-fold objectives: maintaining financial stability and monetary stability. Given central bank money (in the form of central bank reserves) is the lowest risk form of sovereign money in a given jurisdiction, it often acts as a preferred settlement asset by central banks. This is also mandated by existing international standards as applicable to financial market infrastructures (FMI), which state that settlements should be in central bank money “where practical and available.”¹⁴

New private forms of money (such as stablecoins) fulfil this need - by maintaining a purported stable value relative to a specified asset or a specified pool or basket of assets, a stablecoin can be used as a means of payment and/or store of value. However, as recent wave of insolvencies has shown, these assets are not bankruptcy remote, thus introducing various types of risks (i.e., insufficient supply of assets, default of the issuer or other forms of credit and liquidity risks).

The risk of settlement activity moving away from central bank money to such private settlement assets has therefore served as a strong case for central banks to explore new forms of central bank money. Given the recent evolution of tokenisation in the markets, this has been further supplemented by demands for a tokenised form of central bank money to facilitate increased settlement efficiency. Even beyond this use case as a safe settlement asset, wCBDCs could also help allow interoperability and standardization among new types of private digital money (viz. tokenized bank deposits, high-quality asset-backed stablecoins etc.). In this capacity, wCBDCs would function similarly to settlement balances held at the central bank, which facilitate the settlement of payments made with commercial bank money.

From an industry perspective, this likewise provides strong incentives. A wCBDC would uniquely enable central bank money to operate directly on a DLT (or any other technology), offering a completely safe and liquid payment method within that environment. Issuing a wholesale CBDC could also drive financial innovation and decrease transaction costs by leveraging new technology. Given that these benefits are cost-effective, implementing a wCBDC can increase competition in the financial sector by lowering barriers for new entrants. These could further complement policy motives to advance development of wholesale CBDC infrastructure.

While the scale of a DLT-based wCBDC is currently limited, given the purported benefits and increased market activity on wCBDC projects, there is a potential for it to pose material risks. We highlight four initial areas that may require policy or regulatory intervention.

“It is not only the technical layer, but also the policy layer that needs catching up.” Market Participant

“The major issues lie not on the technical side, but on the policy side.” Market Participant

5.1.1. Monetary Policy and Financial Stability Considerations

As compared to rCBDCs where disintermediation and potential impacts on monetary policy are apparent, it is unlikely that wCBDCs may cause disintermediation if the users of a wCBDC were to remain largely restricted to banks and their current counterparties. Any negative implications for monetary policy implementation and financial stability might therefore be manageable. While so, it is not completely free of risks. For instance,

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financial stability risk may be heightened due to increased speed and interconnectivity of transactions enabled by wCBDCs, besides the fact that in scenarios where wholesale cross-border issuance is possible (such as Project Agorá), this may raise additional macro-financial risks if it is easier to do currency substitution.

Issuing wCBDC to settlement account holders and their sponsored participants in exchange for settlement account balances could impact the central bank's approach to monetary policy. Settlement account balances are a crucial factor in shaping monetary policy, as they directly affect the cash rate¹⁵, a key short-term risk-free benchmark in many markets. Therefore, decisions on how to structure and implement this type of wCBDC would need to be made carefully, considering the potential effects on the broader monetary framework.

The RBA's Project CBDC Pilot report suggests that if a wCBDC is mainly used for payments and generates little or no interest, demand for it would likely remain low, stable and predictable, making its impact on settlement account balances more manageable under typical conditions.¹⁶ However, if there is greater interest in holding wCBDC as a store of value—either due to a competitive interest rate or its appeal as a safe asset, particularly among entities that usually lack access to settlement accounts—this could lead to higher holdings and increased volatility in both cash flows and settlement account balances, potentially affecting the cash rate.

Finally, an introduction of a third form of money, alongside cash and commercial bank deposits, would mean that a further component of non-cash central bank money besides deposits in central bank accounts would be tied up in the wholesale token, with implications for monetary policy implementation and commercial bank capacity for money creation.

5.1.2. Governance considerations

A frequently overlooked aspect in designing a decentralised system is determining which entities are authorised to operate a node. In a centralised system,

a system operator typically handles transaction validation and system maintenance. However, in a decentralised setup, several key factors need to be considered: (a) how to ensure control and access for the central bank; (b) the implications for its role as the lender of last resort; © which entities, if any, besides the central bank should be allowed to operate a node; (d) whether entities other than the central bank should be permitted to validate wCBDC transactions; (e) the operational requirements for various design options; and (f) the level of access granted to node operators.

Addressing these questions involves consideration of various technical, legal, and systemic risks. While DLT allows for decentralised validation and recording of transactions, some aspects of the system will continue to remain centralised. For instance, in permissioned chains, a system operator would still play a role in maintaining the system, which introduces risks similar to those found in existing centralised systems. However, these risks would be compounded by additional challenges arising from the decentralised operation of the blockchain components of the system. In certain cases, a regulatory oversight if the system was assessed to be systemically important would be warranted.

The governance of platforms with a broader scope—whether in terms of assets, participants, or use cases—would likely be more complex than that of platforms with a narrower focus. Issuers and holders of various asset types would have distinct needs and may need to be involved in the platform's governance. As a result, designing such platforms and establishing their governance framework is likely to take longer. If the requirements of different users and operators are too divergent, it may become challenging to reach an agreement that accommodates everyone.

5.1.3. Expansion of access to central bank money to non-bank market participants

In certain pilots (such as RBA's Project Atom), a two-tier model for issuing CBDC has been proposed, in which a CBDC is issued by the RBA to settlement account holders, who, in turn, can facilitate the acquisition of

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CBDC by their sponsored wholesale customers. This is different from other projects where use of wCBDC is limited to commercial banks only (which already have access to digital central bank money via their settlement accounts).

Clearly, offering eligible non-bank wholesale market participants access to CBDC for settling transactions and holding it as a store of value presents several potential advantages. For instance, these participants would gain an additional option for storing liquid assets—one that carries no credit risk, as it represents a claim on the central bank. Additionally, in specific scenarios like syndicated loans, the facility agent could see improvements in both efficiency and risk management, given its role in coordinating payments among syndicate members in such lending arrangements.

Issuing a wCBDC in such situations shifts a liability from a commercial bank, with whom the central bank has an established relationship, to the central bank itself (that can be held by a wider range of sponsored wholesale market participants with whom the central bank does not have a direct relationship). In these cases, the legal nature of the claim associated with holding wCBDC would change, particularly for entities that lack a direct relationship with the central bank. Besides the financial stability risk arising from expansion of access in such manner which needs to be carefully studied, central banks would need to consider how any restrictions on access to and use of wCBDC could be enforced for sponsored participants outside their direct oversight. It should also be noted that where rCBDCs are being considered without limits, this may effectively act as a wCBDC if entity restrictions are not considered. Similar legal implications could arise in instances where an omnibus account structure is used for wCBDC issuance.

A central bank could, in principle, set limits on who can access wCBDC and how it can be utilised. These restrictions could take various forms, with some being more difficult to implement than others. It is likely that access to a wCBDC would be confined to wholesale market participants needing it for settlement purposes. However, this would require further examination of key issues, such as: (a) how to define a 'wholesale market participant'; (b) what criteria determine eligibility

as a sponsored participant; © how restrictions on participation would be enforced; and (d) whether there should be additional limitations on how sponsored participants are allowed to use wCBDC.

5.1.4. Liquidity management

Issuing a wCBDC could influence the liquidity management strategies of settlement account holders. By requesting CBDC from the central bank in exchange for their settlement account balances, these holders would essentially be dividing their liquidity into two distinct pools: one for settlement accounts and another for wCBDC. This division introduces liquidity risk, contingent on how quickly and easily holders can transition between their settlement account balances and CBDC. As a result, it is essential to develop effective mechanisms that help settlement account holders navigate their liquidity management.

The introduction of a wCBDC could, thus, add new risks and complexities to how banks and other financial institutions handle their settlement accounts. Moreover, it could also lead to fragmented liquidity, a concern that could have significant consequences during times of crisis.

Conclusions

Issuance of digital money to financial institutions in support of monetary and financial stability objectives by central banks is however not new. In this sense, a wholesale CBDC could be perceived as an evolution rather than a revolution, with several perceived benefits over current settlement systems. Besides serving as an ultimate and safest form of asset for settlement of wholesale market transactions, it could also function across both centralised and decentralised systems as well as other tokenised assets. This can not only provide discernible advantages such as increased liquidity, improved settlement, atomic fractionalisation and programmability, but also unlock further innovation, by reducing intermediation, increasing transparency (especially in greenfield markets) and providing efficiencies in existing asset settlement mechanisms.

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The question facing central banks therefore is not whether to make a wCBDC available, rather what approach to take, whilst still ensuring the safety and resilience of the financial system.

"Understanding how big of a constraint is present in regulatory alignment is a key challenge for central banks." Market participant

"Technology is just a means of achieving an appropriate security infrastructure. But this should not drive regulatory decision-making." Market Participant

5.2. Findings from CCAF Regulator Knowledge Exchange Poll

To validate our findings, a survey was carried out in October 2024 via CCAF's Regulator Knowledge Exchange (RKE), a collaborative platform designed for financial regulators worldwide, with active participation from approximately 2,400 regulators globally (as of 2024). The survey asked regulators about their engagement in the development of a wholesale CBDC, motivations, current expectations and potential benefits. The results of the poll support many of our findings and provides valuable insights into the perspectives of regulators.

Out of a survey population of 73, a significant majority, 35.6%, identified enhanced payment efficiency as the primary advantage, indicating a strong consensus on the need for faster and more reliable payment systems. Following this, 24.7% highlighted improved cross-border transactions, reflecting a keen interest in using wCBDCs to streamline international payments, which are often cumbersome and costly. Additionally, 17.8% of participants emphasised the importance of better oversight and regulation, suggesting that wCBDCs could serve as effective tools for enhancing monitoring and compliance within the financial ecosystem.

What do you consider to be the main benefit of implementing a wholesale CBDC in your jurisdiction?

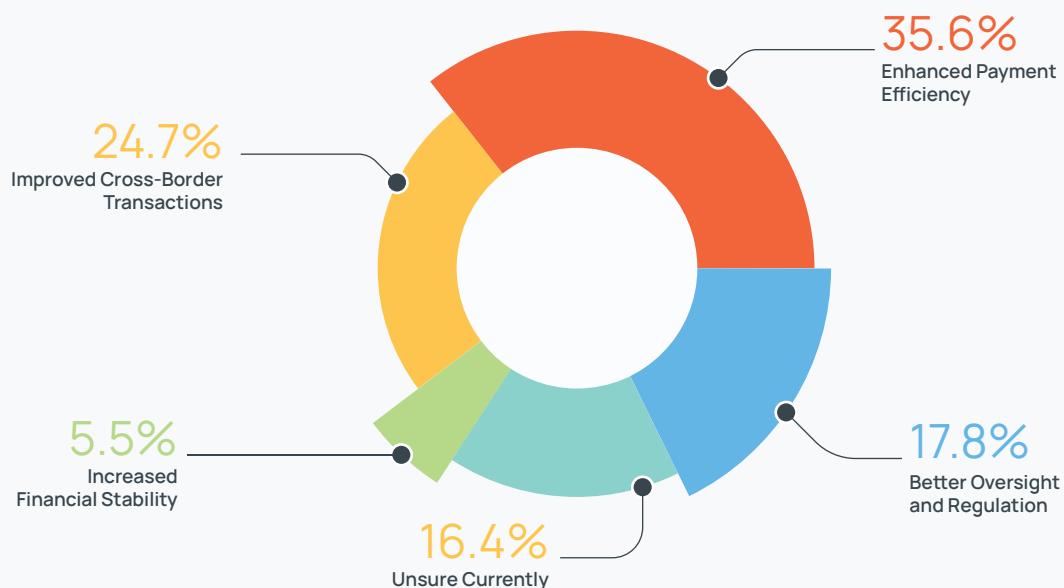


Figure 16

Source: Cambridge Centre for Alternative Finance. (2024, October). Regulator Knowledge Exchange poll results.

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The expected timeline for implementing wCBDCs varies greatly across jurisdictions. Most respondents believed it will take between three to five years for widespread adoption. However, some regulators anticipate implementation within the next year, and others foresaw a much longer timeline, with plans extending beyond five years. This variation indicates not only the differing levels of regulatory readiness, but also the current motivations within regulators to prioritise

wCBDCs projects, compared to prevailing settlement mechanisms. However, a significant increase in the use of wCBDCs for wholesale payments and securities settlement can be expected in five to ten year horizon, across geographies and asset classes. Particularly, as overall industry moves towards DLTs, wCBDCs could become systemically relevant for securities generally.¹⁷

How soon do you anticipate your jurisdiction will consider the implementation of a wholesale CBDC?

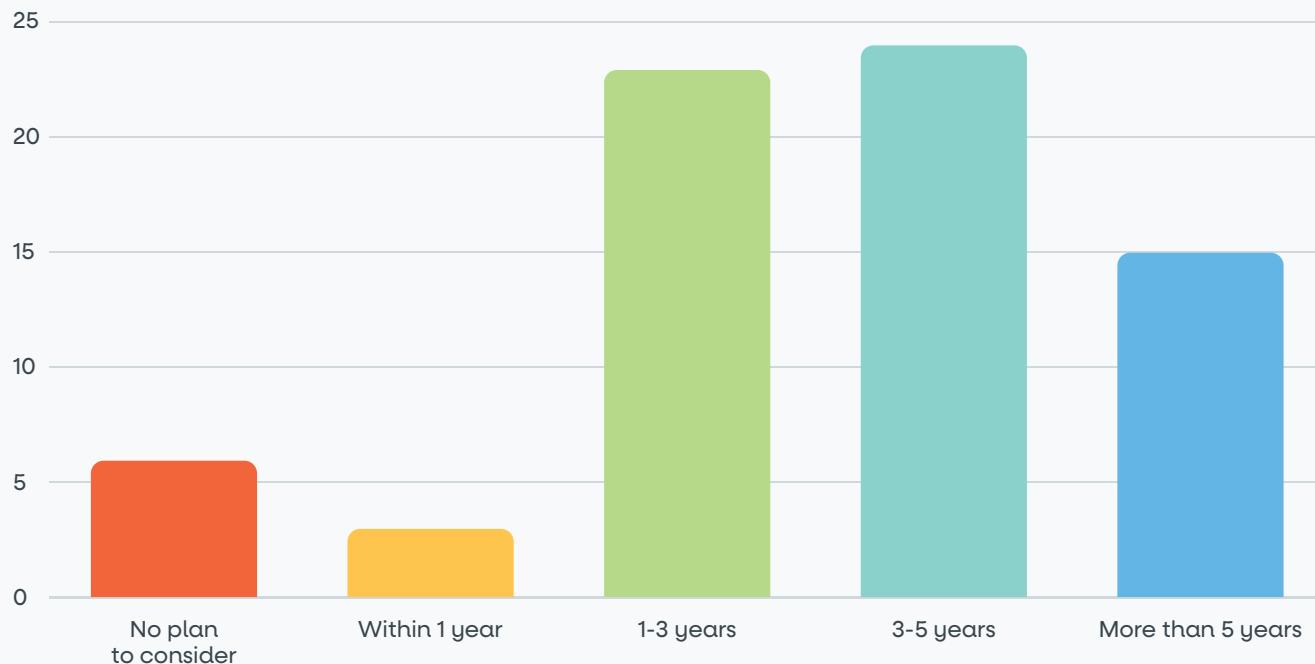


Figure 17

Source: Cambridge Centre for Alternative Finance. (2024, October). Regulator Knowledge Exchange social poll results.

There remains, however, several factors that may contribute negatively to the development of future wCBDC projects. Key among these include complexity of design choices (often itself relying on technology readiness) and absence of reliable solutions for the settlement of the cash leg of DLT transactions in central bank money.

In the CCAF survey, respondents also noted regulatory uncertainty as a primary concern, particularly in regions where the timeline for wCBDC implementation remains unclear. There is also notable apprehension about the potential disruption to financial institutions,

a concern that is more pronounced among those expecting wCBDCs to be considered within the next three to five years. These concerns reflect the possibility of upheaval in existing financial systems as wCBDCs, controlled by central banks, are introduced. Adverse regulatory developments (such as those recently introduced in the United States¹⁸) may further exacerbate innovation.

Some respondents raised additional concerns about missed opportunities. While wCBDCs hold promise for solving cross-border payment challenges and enhancing financial inclusion, there is concern that

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these benefits may not materialise if wCBDCs are not designed with these objectives in mind. Specific issues such as access to foreign currency and cybersecurity risks were also mentioned, though some see wCBDCs

as offering considerable potential to address challenges like de-risking, particularly in regions such as Africa.

What is your biggest concern regarding the issuance of a wholesale CBDC?

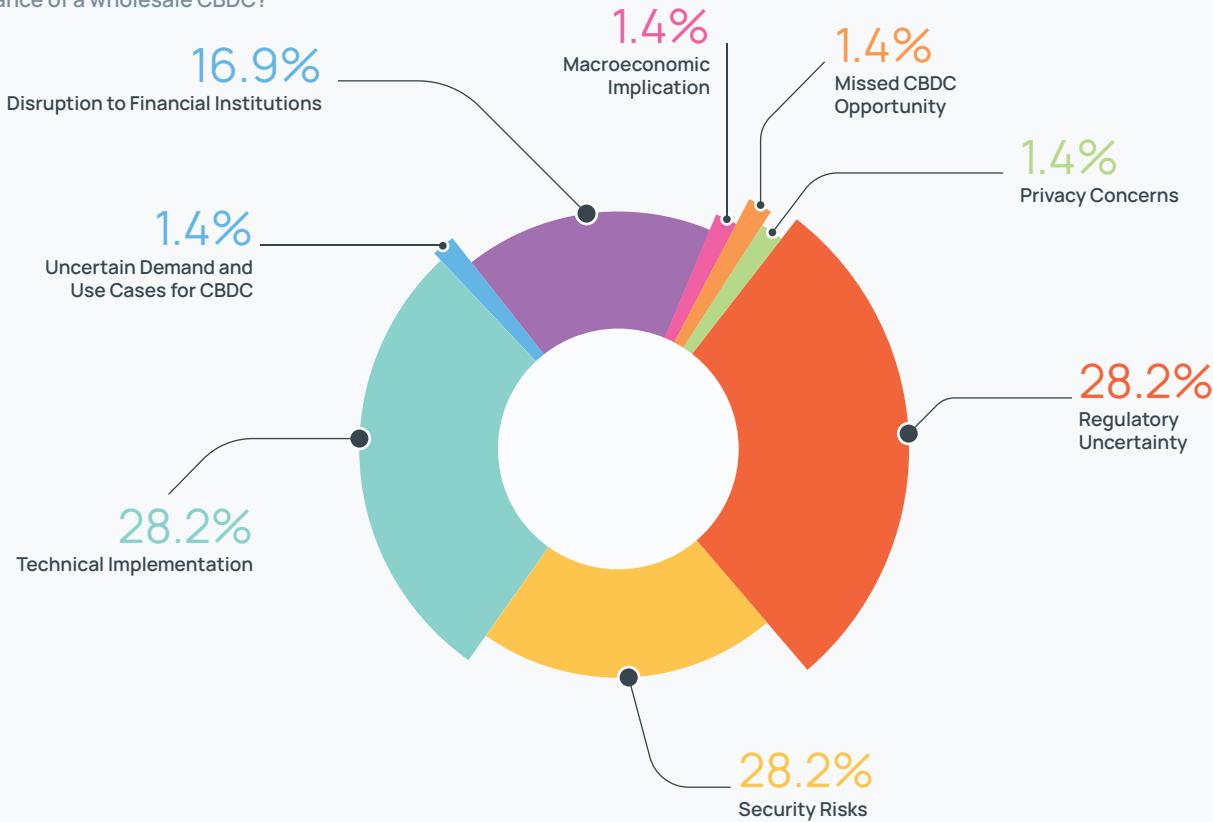


Figure 18

Source: Cambridge Centre for Alternative Finance. (2024, October). Regulator Knowledge Exchange social poll results.

For markets, the use of multiple DLT platforms, as well as the coexistence of DLT platforms with other infrastructures, creates a possibility for market fragmentation. Unless multiple platforms allow for seamless interoperability, it is difficult to see clear efficiencies in processing of transactions. As developments in payments markets have shown previously, developing industry standards will be important in this regard. However, avoiding fragmentation does not necessarily require shifting to a single platform; interoperability and harmonization can also be key factors.

From a central bank perspective, the use of smart contracts and 24x7 settlement capabilities of wCBDCs

may increase operational complexities, e.g. to ensure consistent remuneration across different forms of central bank money. This may warrant an in-depth consideration of new types of security risks, another aspect which respondents noted in their feedback.

The most important element, however, remains the absence of a clear business case for using DLT. For some projects (such as the BIS Project mBridge), this is more evident as compared to others, i.e. a clear business use case (PvP across borders; higher speed of payments and lower cost); and governance use case (where every central bank controls their node and can monitor the use of their CBDC in a decentralised manner) can be established. However,

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market participants noted that this is yet to be seen in practice. As also noted by the ECB, if existing inefficiencies are not technology-based, a change to a different technology may not be the appropriate solution – in such instances, moving RTGS to 24/7 would yield most benefits. We also note that some emerging market and developing economies have already decided to choose 24/7 processing, which may then better support, for instance, trigger solutions described in section 2.1.

Looking ahead, the case for change nevertheless appears evident. Participants in the survey identified several unique problems that wCBDCs could address, such as expanding PvP arrangements, creating a global settlement window, mutualising data across parties and tokenising credit risk-free settlement media. These insights suggest that wCBDCs are seen not only as a tool for improving the current financial system, but also as a means of innovating and resolving long-standing global financial challenges.

5.3 Legal Considerations

In this section, we examine potential legal issues that might arise on account of the development of wCBDCs in two areas: (i) legal status of a 'wholesale CBDC' under existing laws; and (ii) gaps in existing regulatory frameworks in relation to market activities.

5.3.1. Legal Status of wCBDCs

In general, the use of a different technology to record the ownership of the deposits or to transfer deposited funds should not alter the legal treatment of the tokens as ordinary deposits, assuming that wCBDCs and the central bank money created by existing RTGS systems are indistinguishable in their core economic characteristics. This is also required as deviation

between these two means of payment can also undermine the 'singleness' of money and result in the emergence of a twin-tracked monetary system.

Importantly, distributed ledgers can support both payment systems that maintain balances representing the assets held by identified users (i.e. 'account-based systems') and payment systems that allow assets in the form of tokens to be transferred between transacting parties (otherwise called 'token-based systems'). While the distinction between account-based and token-based systems is not entirely exclusive¹⁹, there are tangible benefits in this delineation in the absence of an alternative categorisation.

Distinction between account-based vs token-based payment systems.

The distinction between account-based and token-based currencies is helpful from a functional and legal viewpoint. In general, all accounts represent liabilities of one party to another. However, there is a category of tokens, such as Bitcoin, that do not represent liabilities. In contrast, all central bank digital currencies (CBDCs) and most stablecoins (i.e., cryptocurrencies that aim to maintain stability relative to fiat currencies or a specific asset basket) are liabilities. Accounts are a product of double-entry bookkeeping, where the account holder's credit balance corresponds to the bank's liability to the depositor. Tokens like Bitcoin are designed to eliminate intermediaries, so they do not rely on traditional bookkeeping systems. Specifically, account-based money—offered by banks and closed-loop payment systems—is tied to the identities of its users and depends on the performance of fiduciaries, whereas token-based money can function as bearer instruments.²⁰

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Tokens offer several advantages over traditional ledgers. Unlike traditional banking, which operates with batch processes and limited hours due to the non-availability of RTGS systems, tokenized money can be available 24/7. Tokens can also be programmable, enabling smart contracts to automate business processes. In addition, tokens have global potential, as they may overcome the national boundaries that constrain traditional financial systems, especially in the form of digital bearer instruments.

Tokens also support fractionalization, which is essential for new business models, such as the Internet of Things (IoT), that rely on micropayments. This fractionalization allows assets to be divided into smaller parts, with transactions settled automatically through smart contracts. Finally, tokens facilitate atomic settlement, where two assets are exchanged only if specific conditions are met, making the transfer of value instantaneous. This capability extends beyond money, with advocates pushing for the tokenization of all financial instruments, such as securities, to enable delivery versus payment (DVP) using atomic settlement between money tokens and security tokens.²¹

This distinction is important as the legal categorisation of CBDCs is generally discussed in account-based and token-based forms.²² For instance, Bossu et al. (2020) suggest that the distinction is fundamental in determining its legal status.²³

- If CBDCs are issued in an account-based form, their issuance can be supported by existing central bank laws in most jurisdictions, provided two conditions are met: (i) cash current accounts are offered to a limited group of institutions (typically the State, public entities, financial institutions, or banks); and (ii) central bank laws explicitly permit the opening of cash current accounts. In cases where explicit authorisation is missing, this authority may be inferred under the doctrine of implied powers.²⁴
- If CBDCs are issued in token-based form, the central bank's authority to permit its issuance (in the absence of explicit authorisation) would depend on the content and interpretation of existing central bank laws. Token-based CBDCs may be legally authorised if (i) the central bank law includes a broadly defined currency issuance power that allows the bank to issue domestic

"currency," or (ii) it explicitly refers to other forms of payment besides banknotes and coins. Issuance is also possible if the central bank law permits a broad currency issuance function without limiting it to banknotes and coins, provided there are no specific ancillary powers or indirect provisions restricting issuance to banknotes and coins.²⁵

- While this distinction is a feasible means to determine the legal status of a CBDC generally (and specifically for retail CBDCs), at the wholesale settlement level, distinguishing between account-based and token-based CBDCs may not be required, as this technical distinction does not alter the fundamental nature of a wCBDC.²⁶ This is also because wholesale CBDCs are de facto payment systems and would fall under standing powers/expectations of central banks to operate efficient payment systems (like RTGS and FPS) rather than under the laws that cover physical bills and notes.

Recent experiments such as BIS' Project mBridge has supported the approach to disregard this distinction and view the legal status of the wCBDC as a contractual matter. Besides, if wCBDCs are issued solely to current account holders within existing RTGS payment systems, issuing them in an account-based form may be legally more feasible.

Legality of asset tokenisation

The regulatory implications of tokenisation on existing legal framework and financial market infrastructure is another important area that requires comprehensive evaluation, more importantly since recent ECB settlement trials have spurred significant tokenisation activity.²⁷ In principle, asset tokenisation can be done via two mechanisms: (a) tokenised central bank money (which would be a direct liability of central bank),

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and (b) tokenised commercial bank deposits (i.e. commercial bank tokens).

In the first scenario, tokenised central bank money for wholesale settlement would be issued and redeemed for conventional money by the national central bank of each market participant. In the second instance, a tokenised commercial bank money would represent a liability of the issuing commercial bank and be subject to regulation. Legally, a tokenised commercial bank deposit would remain the same instrument—a form of private money issued by commercial banks as monetary liabilities payable on demand—but represented differently (i.e. under a new representation mechanism). Consequently, tokenised bank deposits could theoretically be viewed as part of the national currency system, subject to the

same protections and limitations as traditional bank deposits. This aligns with the current division of roles in the payment landscape, where commercial banks could offer their book money in tokenised form to meet the standards of modern payment methods.

Current experiments indicate that features such as token programmability via smart contracts, and the ability to free up collateral and reduce counterparty risk through the atomic exchange of money and assets on the same ledger, have been of significant interest to market participants. However, in these cases, the tokens are not intended to serve as instruments with independent legal significance (unlike, for instance, instruments such as checks). Instead, the tokens would act purely as a digital record of the deposit and a means to document ownership of the deposit.

US RLN PoC

In a mechanism like the RLN in the US, the wCBDC would facilitate the transfer of deposit liabilities associated with the relevant central bank on the ledger. These deposit liabilities would represent funds held by commercial banks in their wCBDC wallets at the central bank. When funds are transferred between participants on the central bank's ledger, the transferor's wCBDC wallet would be debited, while the transferee's wallet would be credited, updating the ledger to reflect the new deposit balance for the transferee. The wCBDC would not circulate; instead, it would represent deposits recorded on the central bank's ledger and could not exist separately or independently. In contrast, commercial bank tokens would serve as part of the mechanism for recording a commercial bank's deposit liabilities to its customers, which could be denominated in the currency of the country where the system operates.

The RLN PoC also showcases that while it is possible (though unlikely) to classify the deposit tokens as a “security” under US law, their legal characterisation in relation to private forms of money is nevertheless significant. The fact that the deposit tokens are exclusively used for facilitating fund transfers distinguishes them from tokens that can be delivered as payment or bearer instruments. However, it is conceivable that a participant could utilise the same tokens for purposes beyond their intended use in the payment network, which could lead to a different conclusion regarding the status of the deposit tokens.

5.3.2. Legal Requirements on Operators and Participants of the network

Another key legal consideration that could rise with issuance of wCBDCs relates to the legal treatment of the networks where wCBDCs are transferred. In this regard, this report considers the legal treatment on

three fronts: (i) transfer and redemption of wCBDCs in the payment network; (ii) regulatory status of the payment system in which wCBDCs operate; and (iii) considerations in relation to legal settlement finality.

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5.3.2.1. Transfer and Redemption of wCBDCs in the Payment Network

Generally, the legal basis for the issuance and redemption of wCBDCs would consist of an agreement governed under the applicable private law between the participants of the DLT platform and the issuer of a wCBDC (i.e. a central bank). As such, holders of wCBDCs would have a direct claim on the central bank.

Legally, if a wCBDC does not create a new form of claim against the central bank but serves only as an alternate representation of that claim through new technology, then existing legal frameworks should suffice. In this case, the wCBDC would simply function as a medium for payment instructions. Consequently, the parties would generally be free to define their respective rights and obligations concerning the wCBDC within the current established legal framework. However, if the token represents the holder's claim against the issuer rather than simply serving as an alternate representation, legislative changes may be necessary depending on the applicable law (as seen with the recent Swiss DLT legislation²⁸).

In case of a transfer of wCBDC, if all mandatory legal requirements for establishing ledger-based securities are met under domestic laws, it is possible to achieve a legally sound and final transfer of wCBDCs without significant changes to the regulatory framework as the token is unlikely to represent a legal title; it functions merely as an information carrier or a declaration of intent that can be transferred in accordance with the legal provisions governing payment instructions, without the need to adhere to specific formal requirements (such as physical transfer of possession or written assignment).

5.3.2.2. Regulatory status of the payment system in which wCBDCs operate

Depending on the design of the system, there would potentially be a need for payment systems regulatory framework to define the regulatory status, including the application of business registration/licensing requirements (as against a network such as SWIFT which does messaging but not settlement). This is crucial because the payment system operator has a core role in settling transfers and could potentially impact financial stability. Additionally, each participant and user within the system must consider any relevant regulatory frameworks that may apply based on their status, business activities, or assets, including considerations related to membership of a payment system as well as other applicable state or federal laws.

Without a dedicated legal framework regulating payment systems applicable to FMs, the regulatory status of an entity engaged in processing, clearing, or settling payments will hinge on several factors. These include the specific nature of its operations, the legal environment of the countries or states where it conducts business, and how much the payment system depends on access to other FMs or regulated systems. Additionally, jurisdiction-specific requirements must be considered; for example, in the US, this could involve regulations enforced by FinCEN or whether the system has been classified as systemically important under Title VIII of the Dodd-Frank Act.

Nonetheless, uncertainty persists regarding the regulatory classification of these arrangements, as it is possible that such arrangements may be deemed either custody services or involve dealing with a regulated financial product due to the handling of wCBDCs. Overall, the rise of new business models indicates that current regulatory requirements for entities offering regulated products and services using wCBDCs may need to be reassessed, since many of these models could change the nature of the risks involved in providing regulated financial services.

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RBA's CBDC Pilot Project (2022-23)

Following Reserve Bank of Australia's Project Atom (2020-21) which focused on a specific and narrow case of the use of wholesale CBDC for settling transactions in tokenised syndicated loans, the broader CBDC Pilot Project incorporated various use cases for transaction settlements involving different digital assets, including stablecoins and tokenised financial or non-financial assets.

Examples highlighted by the RBA involves use cases that illustrate the potential for CBDCs to facilitate atomic settlement of transactions directly between buyers and sellers in tokenised asset markets. This prompts questions regarding whether certain obligations outlined in the existing licensing and regulatory framework for CS facilities under current FMI laws are suitable for addressing the risks tied to business models that enable atomic settlement of transactions among customers in tokenised asset markets.

Finally, a core design question for wCBDC may relate to the platform on which wCBDC units are exchanged – specifically whether this is an infrastructure provided and controlled by the central bank or another entity.²⁹ If a central bank mints wCBDC units for exchange on third-party platforms, this may create a dependency on the operational resilience of such platforms. Given the current developments in legal frameworks globally, a solution that allows central bank money to remain in systems run, managed or closely monitored and controlled by the central bank may seem feasible in order to preserve stability, although existing central bank initiatives such as the Helvetia pilot and private solutions such as Fnality show that maintaining relevant controls and meeting desirable operational resilience requirements is possible.

"From a regulatory perspective, there are two broad questions: is the operator of a wCBDC based payment system a new type of FMI, given they perform different and often intermingled functions - clearing, settlement and payments systems, and whether the legal framework allows settlement to happen in a designated payment system?" Central bank

5.3.2.3. Legal settlement finality

Existing RTGS payment systems managed by central banks feature two essential risk-reducing attributes. First, settlement occurs at a central bank using central bank money – the ability to settle wholesale financial transactions in central bank money (specifically, reserves held by financial institutions at the central bank) helps mitigate risks to the financial system and bolsters financial stability and confidence in the currency. Second, obligations are discharged immediately upon their creation, preventing participants from accumulating credit risk while waiting for settlement. Collectively, this model, which was developed during the 1980s and 1990s, effectively eliminates settlement risk in high-value payment systems.

If the transition to a wCBDC-based infrastructure is made, wholesale CBDC legal frameworks would also need to recognise settlement finality and netting for payments.³⁰ While the legal assessment depends on the applicable law in each jurisdiction, any wCBDC connection must address the two key aspects highlighted above: (i) transactions should be settled in central bank money; and (ii) asset transfers must become irrevocable upon transaction completion. Additionally, the timing of legal finality established by the system's rules must align with the timing of technical finality. If a time lag exists between when a transaction achieves technical finality and when it is considered legally final, a scenario may arise where the payer has the legal right to revoke the payment instruction to the central bank, but is factually prevented from doing so, as the transaction has already reached technical finality.



5. Policy, Regulatory and Legal Aspects

wCBDC legal settlement finality in US (RLN), Switzerland (Project Helvetia) and South Africa (Project Khokha)

1. RLN (US) PoC: RLN PoC concluded that payments processed through the RLN would be governed by Article 4A of the UCC, ensuring that they are final and that payments made to fulfil an obligation effectively discharge that obligation at the point specified in the RLN rules. To fully cover payments made via the RLN under UCC Article 4A, the RLN would likely need to function as a funds-transfer system for transactions involving banks without accounts at a Federal Reserve Bank (FRB), or it could depend on a contractual agreement outlined in the RLN rules. Alternatively, the same outcome could be achieved through the establishment of a Federal Reserve regulation or operating circular.
2. The Helvetia pilot (Switzerland): Helvetia transfers are structured as a payment instruction pursuant to the Swiss Code of Obligations (Article 466 et seq). They are not structured as a ledger-based security (Article 973d).
3. Project Khokha (South Africa): For the settlement to be considered legally binding, the South African Reserve Bank would require adjusting the legal framework in order to 'designate' a wCBDC payment system. This is because legal settlement is defined in the National Payment System Act, 1998 as: "settlement [that] is effected in money or by means of entries passed through the SARB settlement system or a designated settlement system".

As is the case with any technological development, legal, regulatory and policy implications in case of wCBDCs depend on the design and scope of its use. The more transformative the proposed arrangements vis-à-vis the current RTGS system, the more likely it is that further consideration on its consequences would be required.



The case for change

06



6. The case for change

Based on interviews and desk research conducted by CCAF team, two success factors emerge: (i) having a clear business case that is built on market needs and provides evolutionary benefits over existing/improved RTGS mechanisms; and (ii) the ability of central banks to keep abreast with innovations in the market.

6.1 Wholesale Firm Motivations and the wCBDC Business Case

Our interviews demonstrated that there is broad support for wCBDC by wholesale firms, with many of those interviewed being part of multiple public/private collaborations such as Project Helvetia, Project Agorá, Project Guardian and RLN/RSN. This is especially true for firms at the vanguard of the tokenisation of financial markets. For EMDE countries collaboration in such initiatives also raises the possibility of leapfrogging traditional FMI setups in favour of new systems.

While it is clear that the potential to accelerate digitalisation throughout the economy persists and is identified as a key benefit, the further evolution of wCBDCs appears to be hampered by a 'chicken and egg' problem in terms of progressing wCBDC implementation: private market actors are refraining from investing in and committing funds to exploring tokenised assets and wCBDCs, while central banks seem to be waiting for more productive use cases. For instance, we observed a dichotomy as to (i) whether the growing scale of tokenisation of bonds, private assets etc. will by necessity pull wCBDC into existence, as central banks increasingly worry about settlement in non-central bank money, or (ii) whether concerted central bank and regulatory initiatives to set the direction (such as the ECB's progress to a 'European Ledger' to facilitate a digital CMU, or Project Agorá as a replacement of traditional correspondent banking by transforming nostro/vostro with a unified ledger approach) will be the driving force.

This leads to the critical question of what the business case is for a wCBDC, which from our research and interviews is clearly a very difficult question to answer. At an industry level, there are a limited number of estimates as to the cost savings associated with tokenised markets. For example, according to Cashlink "DLT based capital market infrastructures offer cost

saving potentials of up to 120.4 basis points in 2028 for bonds with a maturity of eight years, representing a decrease in costs of more than 85% within the middle and back-office processes compared to the existing capital market infrastructures without the usage of DLT. In addition, even today, as a report concludes, "there are cost saving potentials of up to 31.5 bps or 22.3%, respectively, depending on underlying scenario assumptions."³¹

For its part, GFMA estimates saving potential of ~US\$15-20 bn (USD) in annual global infrastructure operational cost savings facilitated by smart contract-driven process automation in areas such as settlement and corporate actions. They see the opportunities for savings are particularly concentrated in fixed-income and private market assets.³² It should be noted that these are estimates of cost reduction through fully tokenised markets rather than the benefits from use of a wCBDC for settlement.

Turning to the implementation costs for individual banks, estimating the cost to-achieve is very hard and depends on a number of factors, including the model by which a wCBDC is made available (trigger solution, distribution solution etc), the internal systems of individual banks, and the approach taken to integration etc.

In a fully tokenised wCBDC implementation, following the choices identified in the UK RLN experimentation phase, individual banks may elect to connect to a wCBDC implementation via a 'direct' model (integration between the token platform and the traditional ledger), an 'indirect' model (a separate account for token transactions in the traditional ledger) and a 'shadow' model (the traditional ledger tracks activity in the token ledger). Clearly each of these options will have different cost profiles.³³

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Anecdotally, interviewees stated that the trigger of synchronisation solution may be the least complicated to interface to. However, the details of wCBDC implementation, and integration approaches by individual banks makes the estimating of implementation cost very difficult and it essentially needs to be done on a bank-by-bank basis.

From the perspective of market participants, implementation costs are highly case-dependent and depend on a range of factors, such as legal costs (given the existing regulatory uncertainty regarding financial integrity aspects, licensing and supervision), business operations costs (i.e. resources to define the model, partnerships etc.), infrastructure costs and other cost factors such as human resourcing, design, operational resilience, etc.. One interviewee drew a strong comparison to ISO 20022 infrastructure upgrade and noted that the cost of overhaul could span somewhere close to that, given the extent of change needed to implement wCBDC solutions (i.e. anywhere between US20-50 million, depending on various scenarios, transactions and infrastructure considerations), with timescale of 3 years or more. Notably, for an institution

implementing a centralised payment system, the change to a wCBDC infrastructure could hit all major systems (sometimes comprising hundreds of applications) and therefore adoption can be a costly endeavour. Participants therefore highlighted the need for a strong business case as against existing (or improved) RTGS networks, which will be a strong factor in guiding market adoption.

In summary, whilst the need for a strong business case is clear, actually developing one at an individual bank level is challenging. Will the additional cost of integrating to a wCBDC result in a competitive advantage for banks and their revenue? And will it reduce the regulatory technology burden in the future? Banks have finite budgets and innovation capacities, and the number of current industry initiatives, combined with client pressure is putting both under significant strain for many firms. This combined with the need to support current technology stacks over multiple years in parallel with the cost of building new stacks for tokenised markets represents a significant challenge for the industry. At the end of the day, who pays?

6.2 The "Innovation" Gap

Market participants in our interviews who saw the potential for DLT in wholesale financial transactions note that this technology could significantly benefit existing segments that deem to be characterised by inefficiencies and constraints, such as international payments (cross-border, cross-currency and correspondent banking payments), which also complements results from a CCAF regulator survey. Besides, instruments currently not serviced by FMIs (such as over-the-counter traded securities or credit claims) could also be registered on DLT platforms, possibly making previously non-tradeable assets tradeable.

Accordingly, a clear case for change can be made on both public and private side, given the improvements in speed, availability and the efficiencies in liquidity management and transparency of registers. While the public and private sector majorly aligns on the key benefits, a substantial 'innovation gap' persists, and is evident from responses from interviewees on the question of perceived importance of wCBDC on a scale of 1 to 5. Responses indicate a distinct gap between market participants and FMIs on one hand, who rated importance as 4.5 and 4.3 respectively, and central banks on the other hand, at 3.7. The latter demonstrates a more cautious perspective on the part of central banks.

6. The case for change

Perceived importance of wCBDC (1-5)

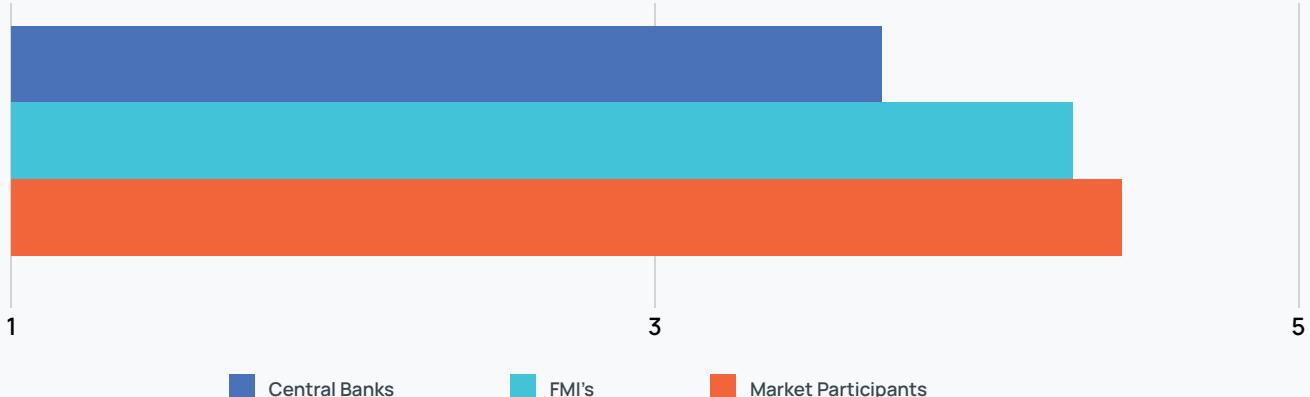


Figure 19

The diversity of opinion between public sector and private sector, central banks and commercial banks, on the question of wCBDC is also evident from the following quotes:

"I've never really received a kind of single coherent answer for where there is the one kind of nailed-on use case that you absolutely definitely could never replicate with kind of multi-legacy systems with additional functionality."
Central bank

"We need a truly native digital (wCBDC) asset; the distribution model is preferred." Market participant

While diverse views remain, public and private sector has witnessed some convergence and collaboration recently, with 35 commercial banks transacting in FX, treasury operations and inter-bank payments using mBridge, over 40 financial institutions engaged in Project Agorá, and 60 participants in the ECB-led wCBDC pilots and trials. However, our interviews showed that many still see an innovation gap between where the industry is vs where the central banks are in their thinking:

"Other solutions are appearing and are being used as a wCBDC is not yet available... e.g. tokenised cash enabling DVP on a private chain and an "explosion around stablecoins." Market participant

"There is frustration, Central Banks are moving too slowly, there is clear demand from asset managers." Market participant

"Regarding the gap; it's not a risk it's a fact!" Market participant

For EU banks, industry views have been further strengthened by a perceived (rightly or wrongly) lack of ECB commitment to any next phase, which may be addressed by updates from the ECB in the coming weeks and months:

"In my view the ECB is not completely convinced by wCBDC." Market participant

"Nobody knows how ECB will progress, not the slightest sign of what may be in production as a result." Market participant

For its part, the ECB has presented its vision for a future digital capital markets union in a recent speech by Piero Cipollone, member of the ECB's Executive Board. In his speech, Cipollone highlights the risks the ECB is focused on, i.e. the risk of fragmentation due to the possible proliferation of DLT platforms, the risk to the status of central bank money, and possible vulnerabilities of distributed ledger technologies.

Having said that, he also highlights a possible future state of a "European Ledger" following the Unified Ledger and RLN concepts: "there is a risk that relying on existing interoperability solutions over the long term could perpetuate inefficiencies in the post-trade environment given the ongoing lack of full harmonisation and standardisation. Such interim solutions are thus a stopgap measure to smooth the transition towards our long-term vision."³⁴

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Similarly, most central banks we interviewed believed more research and experimentation is needed to choose the right approach, and that there is no significant innovation gap:

"I don't see an innovation gap between industry and central banks—many market participants haven't started yet" [Central bank](#)

However, there are some exceptions:

"There is a risk indeed, private markets are accelerating, for example with stablecoins, so there is a risk of a gap" [Central bank](#)

"There is a risk of private sector settlement assets taking precedence over central banks if we don't move forward" [Central bank](#)

"The technology is not a self-fulfilling prophecy. We have not yet seen a killer activation that attracts all the other market participation. While wCBDC is important and central bank money is essential for wholesale financial markets, but the business case still needs to be worked out. There are no obvious pain points that need to be solved, so the costs to switch to a new platform should make sense as against the benefits and pain points." [Central bank](#)

Gap or no gap, the difference in views between industry participants and central banks further highlights the need for even more consultations and committed public/private collaboration in order to progress towards more efficient and safer markets.

An increased industry uptake for wCBDCs in wholesale financial transactions however also relies on the ability of central bank money to be used to settle cash leg of such transactions. It is evident that the market is already exploring use cases in alternative settlement assets in the absence of a DLT-compatible central bank money settlement solution. Given the potential risks associated with the use of such forms of money, including liquidity fragmentation and implications for financial stability, an evident case for exploration of wCBDC-based architectures can be made.

At the same time, interviewees also noted that involvement of central bank community is critical to the speed and success of DLT adoption. The ability to settle transactions in central bank money could be a requirement for certain market participants, preventing them from adopting DLT while a suitable central bank money settlement solution is not in place. Given the recent uptick in the wCBDC projects globally, the involvement of central banks of late is much welcomed as the industry unlocks the next frontier for innovation in financial services.

Conclusions

At the start of this report, we highlighted five key questions (amongst many others) that we wanted to shed light on. Based on desktop research and many interviews we have drawn the following conclusions on those five points.

1. What is a wCBDC?

High-level definitions between central banks tend to be fairly consistent, but analysis of the details reveal differences. We have explored how a full answer to this question needs to consider many factors such as questions of function vs form, how it is implemented, whether it lives (i.e. on a central bank operated platform or a third party), who can access it and how, the rules it needs to follow, what programmability is possible and so on. We also asked all our interviewees what was uniquely solvable by a wCBDC, which elicited several responses pointing to the benefits of true atomic settlement and facilitating a digital 'always-on' future of dynamic price-by-the-minute intraday FX swaps and repo. Whilst the many experiments by central banks and industry have shed significant light on the rationale for, and design pros and cons of, a wholesale CBDC, in our view further structured public/private collaboration is needed to define a clear and unambiguous definition at the necessary level of detail.

2. Is there a best approach for delivering a wCBDC?

We have reviewed multiple approaches to wCBDC implementation developed by a number of central banks, all of which have their advantages and disadvantages. Industry interviews point to a strong preference for atomic settlement to take place on a single shared ledger, either as in the Distribution Model or as in the Banque de France DL3S Model, but several interviewees recognise that a path to that ultimate goal may require a Trigger or Synchronisation model as an initial step towards a more strategic future state. Whilst market participant interviewees recognise the need for central banks to move carefully as regards wCBDC, there remains a risk given that tokenisation of markets may move significantly faster than central

banks' ability to deliver a satisfactory answer for wCBDC.

3. Is there an "innovation gap" between the industry and central banks, and is it widening?

Our interviews highlighted a significant difference in opinion on the market need for a wCBDC between central banks and market participants on this question. Many market participants told us they saw innovation being constrained by the slow progress in wCBDC and an increased use of tokenised deposits and stablecoins as settlement assets as market tokenisation continues to develop.

Again, the question points to the need for continuing and committed collaboration between public and private sectors and the need to balance the need of protecting the current two-tier financial system whilst facilitating the evolution to digital markets in a suitably controlled and safe way. Many banks' budgets and innovation capacities are limited which implies both central banks and market participants need to agree and select on what specific next steps are needed to bridge the gap, with clarity on anticipated outcomes. Initiatives such as the UK Digital Securities Sandbox, the DTCC's Industry Sandbox and similar initiatives are also welcome steps to help close gaps.

4. What are the risks of non-central bank money settlement assets growing?

Several of the interviewees referred to the use of tokenised deposits and stablecoins as settlement assets, whilst acknowledging a strong preference for moving to a wCBDC if one were available. By way of example, David Newns, CEO of SDX mentioned they had used tokenised assets as a settlement asset but feedback from participating banks demonstrated a strong preference to use a tokenised wCBDC as a risk-free settlement asset. Another interviewee talked about using the USDC stablecoin as a settlement asset, but practical use was constrained by credit limits.

Conclusions

Tokenisation is progressing at a slow pace, for example the website rwa.xyz currently states there are US\$13 billion Real World Assets on-chain, which is still a fraction of the trillions of dollars of tokenised assets anticipated to exist by 2030, as mentioned in the introduction. To some extent this mirrors the slow progress towards a wCBDC leading to whether this is a “chicken and egg” conundrum as discussed earlier. If wCBDC was available, would asset tokenisation speed up? Or if asset tokenisation accelerates will the risk to the foundational aspects of central bank money through settling in private assets drive further focus on wCBDC? This necessitates careful monitoring of the markets’ evolution as well as careful thought on the specific nature of future public and private sector collaboration.

5. What is the case for change regarding wCBDC?

Our analysis shows a significant appetite from many market participants for the availability of tokenised wCBDC, with a smaller number taking a more “wait and see” approach; whilst for many central banks, the

case for fully tokenised wCBDC as opposed to other approaches still has to be made.

A critical and as yet unanswered question for our research is identifying the specific business case for a wCBDC, and more broadly for tokenised markets.

Whilst we have highlighted some of the savings that could arise from tokenised markets, many of the trials and early implementations by market participants have been one-offs and manually implemented rather than tackling the thorny issue of integrating or upgrading core systems to support tokenised markets. If the migration cost to ISO20022 is any indication, such costs may be in the millions for each firm. The costs of such technology changes are further compounded by the need to maintain support for traditional markets for many years whilst the migration to tokenised market takes place. The role that wCBDC plays in this context is also critical. The ease and cost of integration to a central bank’s delivery model will be a key question for market participants, as well as the ability of the design in effectively supporting future always-on programmable tokenised markets.

Summary

In summary, there are three key takeaways from our report, which we hope will guide future discussion, as well as offer considerations for market participants and central banks.

What? The research and experiments undertaken by central banks and the industry have helped the mutual understanding of how wCBDC could be implemented, but more work is needed to develop specific solutions that meet both market and central banks requirements. This includes not only the exact definition of a wCBDC is, but how it can be delivered, used and implemented. A key example in this context is the resolution of the target technology infrastructure given the plethora of public and private initiatives and the shared sentiment of there not being “one ledger to rule them all”.

How? Private and public collaboration has significantly helped the industry plot its future evolution. Whilst this is very much a symbiotic relationship, bandwidths and budgets mean that future collaboration needs to be even more focused and structured to deliver outcomes that help the safe evolution to digital markets.

How much? The business case for tokenised markets and specifically wCBDC requires more analysis. It’s one thing to demonstrate the technical art of the possible in settling bonds with wCBDC, its quite another to work out with confidence the revenue and cost impact together with the cost to achieve for individual firms, as well as how the industry can fund the new FMI capabilities needed.

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Appendix 1: Interview Questionnaire

No.	Theme	Sample Questions
1	Context	<ul style="list-style-type: none">■ CCAF, in collaboration with NatWest Markets, a member of its Cambridge Digital Assets Programme are undertaking a research project into wholesale CBDC■ We aim to explore the rationale, benefits, risks and alternative approaches for this topic■ We are undertaking desk research and analysis on multiple wCBDC approaches, complemented by interviews of both industry participants, central banks and international organizations.
2	Views on the necessity/ motivations of a wCBDC	<ul style="list-style-type: none">■ On a scale of 1 to 5, how would you rate the importance of a wCBDC■ What markets do you see this as being most critical for wCBDC, both in geography and asset class?■ What use cases do you see as benefitting most from a wCBDC? Is it sufficient motivation to complement/replace traditional payments/banking infrastructure?■ What do you think may be uniquely solvable by wCBDCs and what, if any, deficiency do you perceive in the current system?■ Given the ongoing tokenisation of financial markets and the growth of non-CBDC settlement assets, is the risk that central banks will be too slow in launching a wCBDC low/medium/high?
3	What are the biggest benefits a successful wCBDC could bring?	<ul style="list-style-type: none">■ What is the business case to use wCBDC?■ What do you see as the key benefits of a wCBDC?<ul style="list-style-type: none">■ Atomic Settlement■ Reduced settlement costs■ As a route to reduced settlement risk■ International Payments■ How quickly would you expect wCBDC adoption to happen?

Appendix 1: Interview Questionnaire

4	What are the key challenges and risks that you would see a wCBDC facing?	<ul style="list-style-type: none">■ What challenges might exist for industry to adopt a wCBDC?■ What do you see as the main risks concerning a wCBDC implementation?
5	View on the different approaches	<ul style="list-style-type: none">■ What form of digital money do you see as most likely to be used for settlement – stablecoins, tokenised deposits or wCBDC?■ What network do you think wCBDC should be available on, privately operated networks like Canton and Fnality or Public e.g. Global Layer 1, Finternet etc ?■ There are multiple approaches being evaluated by central banks, including synchronisation and trigger solutions tied to RTGS, an integration model with a platform supporting both wCBDC and tokenised assets, a bridging model connecting a wCBDC to DLT platforms supporting other assets, and an interoperability model. What do you consider the most favourable approach and why■ Any other points that you think are important to consider for wCBDC implementation?

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 22. In case of the latter, tokens can be either issued directly or solely (as a standalone instrument) on new forms of ledger technology ('native tokens'), or they can digitally represent existing 'real-world' money and assets ('non-native tokens').
 23. 85% of central bank laws limit the power to open cash current accounts to a limited category of institutions, while a minority of central bank laws (10 central banks corresponding to 6% of the total) allow for the opening of current accounts to a broader public. 9% of central bank laws include some form of provision on the opening of current accounts. See Bossu, W. et al. (2020). Legal Aspects of Central Bank Digital Currency: Central Bank and Monetary Law Considerations. Available at: <https://www.imf.org/en/Publications/WP/Issues/2020/11/20/Legal-Aspects-of-Central-Bank-Digital-Currency-Central-Bank-and-Monetary-Law-Considerations-49827>. (Accessed: 23 September 2024).
 24. 61% of central bank laws limit the authority of issuance of currency to banknotes and coins. 23% of central bank laws allow directly for the issuance of currency in a digital format. 16% of central bank laws are unclear as to whether they authorise the issuance of a digital version of central bank currencies. See Bossu, W. et al. (2020). Legal Aspects of Central Bank Digital Currency: Central Bank and Monetary Law Considerations. Available at: <https://www.imf.org/en/Publications/WP/Issues/2020/11/20/Legal-Aspects-of-Central-Bank-Digital-Currency-Central-Bank-and-Monetary-Law-Considerations-49827>.

End Notes

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27. (NTW-CG):Listofmembersandobservers.Availableat:https://www.ecb.europa.eu/paym/pdf/ntw_cg_member_list.en.pdf (Accessed 9 November 2024).
28. In Switzerland, according to Article 973d, paragraph 2, of the draft CO for establishing wCBDC under the new DLT legislation, the securities ledger must fulfil the following requirements set forth by the newly introduced provisions of the CO: (a) the technological processes must grant the creditor, but not the obligor, power of disposal over the respective rights; (b) integrity must be ensured through appropriate technical and organizational measures, such as joint management by multiple independent participants, to protect against unauthorized modifications; © the content of the rights, the functioning of the ledger, and the registration agreement must be recorded in the ledger or linked accompanying data; and (d) creditors must have access to relevant information and ledger entries, allowing them to verify the integrity of the ledger contents pertaining to their interests without third-party intervention.
29. For example, in case of RLN in the US, an RLN FMI would operate a private, permissioned, shared ledger (RLN ledger) to effect and record the completion of payments between participants in the network.
30. For a discussion of legal settlement finality and legal risks in a DLT context, see sections 3.3.2 and 3.3.3: Bank of International Settlements (2017). Distributed ledger technology in payment, clearing and settlement: An analytical framework.,. Available at:<https://www.bis.org/cpmi/publ/d157.pdf>. (Accessed:2September2024). Settlement finality is the irrevocable and unconditional transfer of an asset or financial instrument, or the discharge of an obligation by the FMI or its participants in accordance with the terms of the underlying contract.
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