



BUILDING CENTRAL BANK DIGITAL CURRENCY

GROWTH OPPORTUNITIES AHEAD FOR CENTRAL
AND COMMERCIAL BANKS

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FOREWORD

Despite the crypto winter, central bank digital currency development and experimentation continues to gain momentum. In this paper, we look at the design and implementation of central bank digital currencies (CBDCs) around the globe and consider real-world implications for retail, commercial, and central banks in terms of strategy, business models, organizational structure, and technology.

While some crypto and decentralized finance organizations offer novel – some would say revolutionary – approaches to the digital currency space, we view CBDC as but one of many elements fueling evolutionary digital ecosystem transformation. Therefore, we explore CBDC and possible related financial market developments through the lens of existing banking organizations and financial infrastructure providers.

A number of professionals working today on central bank digital currency projects and potential financial market infrastructure changes have contributed to this report. The true scope of change ahead is hard to predict, and our aim is to present a balanced, business-focused view on possible developments: we offer hypotheses on the trajectory of CBDC developments and implications for commercial banking, rather than one hard and fast pronouncement on what the future of CBDC and financial markets will be.

Please read on. We hope you find the information and points of view presented here to be useful and thought provoking, and we'd welcome the opportunity for dialogue about your perspectives.

Sincerely,

Nilesh Vaidya

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CBDC: BUILDING THE FUTURE OF DIGITAL MONEY

Central bank digital currency (CBDC) generates broad public- and private-sector attention these days. However, attempts to digitize fiat money to transfer value or to pay for goods and services are not new. US computer scientist David Chaum set out to create an electronic currency that maintained anonymity when he founded DigiCash¹ in 1989. The DigiCash concept and its intent were similar to today's public, decentralized ledger-based Bitcoin. However, DigiCash operated for less than a decade, as Chaum unsuccessfully tried to convince banks to adopt its technology.

What distinguishes CBDC today is momentum. Digital currency ecosystems have benefited from the mass adoption of digitalization during and after COVID-19. And as its infrastructure and technology mature, governments, individuals, and private companies are working together to innovate and develop CBDC policies.

What differentiates CBDC from other forms of money?

As the concept is relatively new and reference terms are evolving at warp speed, a simple way to define CBDC is to compare it with other current, modern forms of money:

- Cash - banknotes and coins
- Digital or virtual money - currencies, stablecoins, commercial bank money

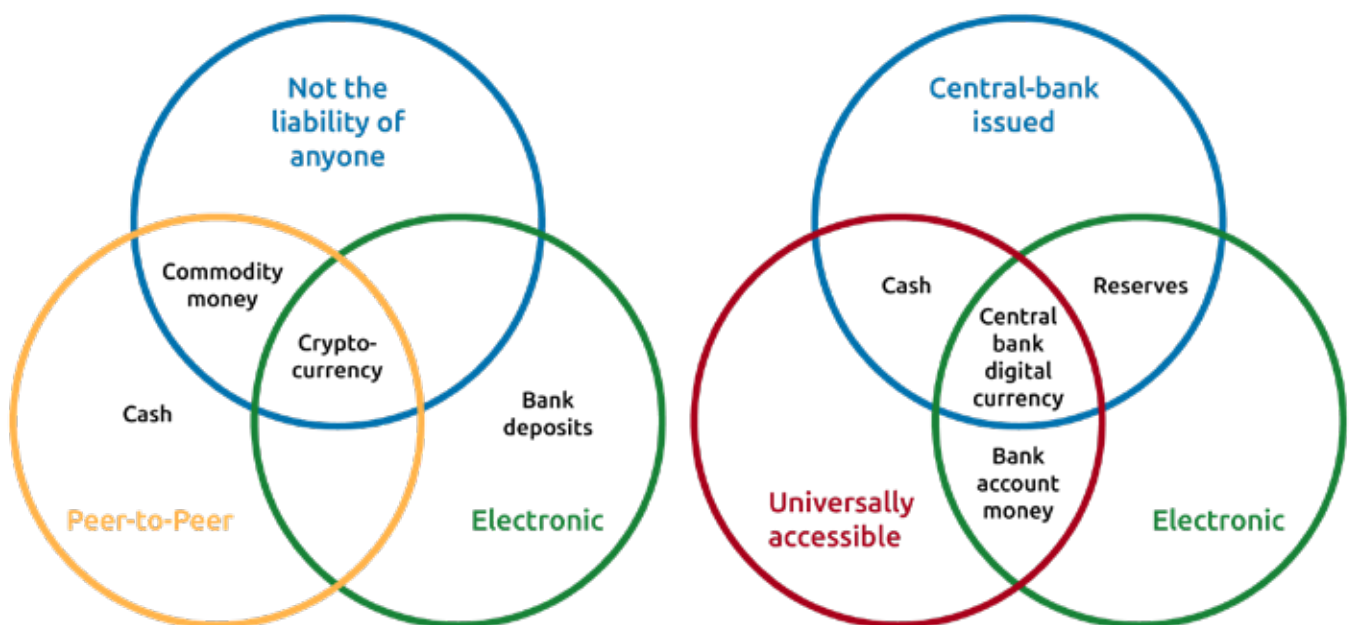
What differentiates the digital currency of a central bank is that a CBDC represents its market's fiat money in electronic form. The central bank makes it universally available to individuals and institutions. And as a digital liability of a central bank, CBDC is backed by central bank reserves. Hence, monetary, trade balance, or foreign accounts directly impact its value.

CBDC differs from other forms of virtual money, such as cryptocurrency or stablecoin, from value, access, and issuance perspectives:

- Cryptocurrency is issued/minted by the private sector and generally is not backed by any underlying asset – its value is contingent upon supply and demand.
- Stablecoins are private-sector currencies with value backed by a regulated or recognized asset (fiat currency, commodity, etc.).

We have illustrated differences between the various forms of digital currency through three criteria – universality, issuance, and form – in Figure 1 below.²

Figure 1: Differences between cryptocurrency and CBDC



Source: Bank for International Settlements (BIS).

Key CBDC dimensions, definitions, and principles

In 2020, the Bank of International Settlement (BIS) published guidelines³ for central banks looking at structuring CBDC for their fiat currencies, and included discussion of core CBDC features. We have grouped these features into five key dimensions:

1. **User experience:** As with cash, CBDC should handle all types of payments and transactions – individual to individual, business to business – conveniently and instantly at any time. Offline payments should be available when connections are lost or unavailable.
2. **Inclusion:** The CBDC system should be accessible to everyone, everywhere.
3. **Affordability:** For individuals or institutions, CBDC transaction fees should be low or without charge.
4. **Safety:** Personal information and CBDC transactions should be encrypted, ensuring data remains private and secure. Also, the CBDC system should be able to prevent cyber-attacks and counterfeiting.
5. **Resilience:** Operating models and infrastructures should enable rapid recovery from unexpected or unknown conditions, such as operational failure or natural disaster.

Current central bank experimentation and development is looking at the development of two distinct kinds of CBDC: retail CBDC will enable digital money exchange between public/private institutions and individuals, or person to

person. On the other hand, the launch of wholesale CBDC enables settlement of cash or other financial instruments between financial institutions (such as commercial banks, pension funds, insurers) and/or large corporations.

- **Retail use cases** aim to improve financial exchanges between individuals. Retail CBDC supports faster and safer payments through performance attributes such as transaction speed, further inclusion, laser-focused economic stimulus or policies (helicopter money), or social benefits, such as contactless digital payments during the pandemic.
- **Wholesale use cases** aim to significantly improve interbank financial systems by boosting performance and building interoperability between financial ecosystems (e.g., end-to-end trade finance tokenization.)

The convergence of retail and wholesale models might be on the mid-to-long-term horizon as central banks envision a unified payment infrastructure able to process multiple assets and instruments in several markets. Please refer to the accompanying retail and wholesale use case examples for further details of how these can work.

RETAIL CBDC USE CASE

China is a CBDC development frontrunner. The People's Bank of China (PBoC) has been testing its e-Yuan CNY digital currency since 2014. The Renminbi (RMB, ¥) backs the centralized digital currency. E-Yuan's primary function is to provide domestic retail payments for public transport and shopping. Travelers are allowed to hold e-Yuan via registering an e-Yuan wallet through authorized traditional banks and online banks in China. In addition, consumers make e-Yuan transactions via payment platforms, such as WeChat, an e-CNY app launched by PBoC. A significant e-Yuan feature is that small-amount transactions are entirely anonymous. However, large-amount transactions must be traceable. Following two years of pilots in an increasing number of cities across China, 13.61 billion of e-CNY were in circulation at the end of 2022, representing 0.13% of the total central bank money in circulation.

WHOLESALE CBDC USE CASE

Hong Kong, China, Thailand, and the UAE entered a pilot phase for CBDC developments in Q3 2022 via the Project mBridge trial platform, a DLT-based platform to support real-time cross-border payments. The project is among the first multi-CBDC efforts to initiate and settle real-time cross-border transactions on behalf of corporates. Today, 20 commercial banks from four different jurisdictions have processed more than 160 payments and foreign exchange (FX) transactions via Payment-versus-Payment (PvP), with a total value of HKD 171 million (USD 218 million).

Project mBridge participants include 20 commercial banks, the BIS Innovation Hub Hong Kong Centre, the Hong Kong Monetary Authority (HKMA), the Bank of Thailand, the Digital Currency Institute of the People's Bank of China, and the Central Bank of the United Arab Emirates.

In addition to retail versus wholesale CBDC differences, CBDC development objectives to date have also revolved around either domestic payments or cross-border payment needs. Use cases around the globe have often opposed domestic experiments aimed at domestic local payment rails enhancement in favor of wholesale cross-border use cases to mitigate pain points arising from global interbank transactions.

- **Domestic CBDC** facilitates digital payments between payer and payee within the same region only.
- **Cross-border CBDC** is all about digital payments between payer and payee based in at least two different countries.

However, most experiments are often complementary and can be conducted in succession to integrate domestic and international payment flows, which correspondent banking and foreign exchange controls disconnect. Please refer to the accompanying domestic and cross-border use case examples for further detail.

Whether retail/wholesale or domestic/cross-border, proponents say central banks can achieve multiple key and important objectives by establishing central bank digital currency:

Maintain financial stability. CBDC provides a safe and secure platform for end users to place money. A national reserve backs CBDC, which mitigates bankruptcy or default risks. Moreover, information stored within the CBDC blockchain network is encrypted to reduce cyberattack threats while retaining sovereignty.

Lower transaction and operational costs. CBDC reduces cross-border payment transaction costs, such as exchange fees. In addition, the price of printing and storing bank notes and coins will shrink.

Improve payment efficiency. CBDC payments are instant, regardless of type, boosting payment efficiency and encouraging cross-border transactions.

DOMESTIC CBDC USE CASE

In October 2020, the Central Bank of The Bahamas (CBoB) launched Sand Dollar, a CBDC backed by Bahamian dollars. CBoB leverages Sand Dollar for retail and wholesale transactions. However, it is available exclusively for use by Bahamians. Business travelers and foreign tourists can transact and hold Sand Dollars by registering for a Tier 1 Sand Dollar wallet while visiting the Caribbean Islands nation. The governor of the Central Bank of the Bahamas backed the Sand Dollar, aiming for financial inclusion in an archipelago country where about 20% of citizens lack bank accounts, especially in some of the more remote islands, partly because banks are reluctant to open isolated branches.

Commercial banks act as an intermediary between the Central Bank and end users to undertake the CBDC onboarding process and perform know your customer/anti-money laundering procedures. Commercial banks also sponsor Sand Dollar digital wallets but do not keep a ledger of individual holdings. Users can integrate Sand Dollar accounts with private bank accounts where traditional-channel cross-border payments are available. However, by late Q1 2022, the International Monetary Fund⁴ reported that Sand Dollars accounted for less than one-tenth of 1% of the money in circulation in the Bahamas.

CROSS-BORDER CBDC USE CASE

High cost and slow transaction time drive cross-border CBDC settlement development. A precursor to Project mBridge, Project Inthanon-LionRock⁵ was a corridor network launched in 2019 to connect CBDC blockchains between the Hong Kong Monetary Authority (domestic payment network developed under project Lionrock) and the Bank of Thailand (domestic project network developed under project Inthanon) to test cross-border payments at the wholesale level via a PoC platform. It was an ambitious attempt to facilitate a connection between two central banks/authorities to enhance transparency, efficiency, and compliance when operating a digital corridor from the Thai Baht (THB) / Hong Kong Dollar (HKD) cross-border payment network. As a result, participating banks in Thailand and Hong Kong can transfer international funds and foreign exchange (FX) transactions in real time. In its second phase, Project Inthanon-LionRock reported that the network reduced transaction time to two to 10 seconds from three to five days. The prototype also reduced FX risk, exchange fees, compliance, and treasury operation costs. The initiative evolved into Project mBridge with the addition of the UAE and China, led by Chappuis Halder & Co., now part of Capgemini Invent.

Any widescale adoption of CBDC will begin with stakeholder trust and confidence, which depends on global financial ecosystems demonstrating several overarching principles. These are discussed below, and each of these motivational objectives are country- or jurisdiction-agnostic.

Cybersecurity, scalability, and operational resilience

CBDC ecosystems must be secure and resilient to cybercrime, fraud, and other operational risks to achieve trust, safety, and durability as a digital payments foundation. They must be scalable to accommodate large transaction volumes to support mass adoption.

Legal, governance, and data privacy and monetary stability

Rigorous confidentiality standards are required to protect user data in compliance with jurisdictional law, including open banking frameworks where applicable. Security measures must be transparent, as with governance and accountability frameworks. Enhanced fraud and know-your-customer (KYC) processes will improve efficiency and accuracy globally. Designs should support the fulfillment of public policy objectives and cause no harm to the international monetary and financial system, including the sovereignty and stability of individual jurisdictions.

Cross-border functionality and digital economy and innovation

Where relevant to fiscal policy, CBDC should enhance cross-border payments to improve efficiency and open access to safer and more cost-effective payment methods with a commitment to mitigating global crime. Central bank digital currency should support and catalyze responsible digital economy innovation and ensure interoperability with existing and future payment solutions. If fragmented, CBDC will be as inefficient as disjointed fiat currencies.

Competition

CBDC should coexist with existing means of payment and should operate in an open, secure, resilient, transparent, and competitive environment that promotes choice and diversity in payment options.

Environmental and Social Governance

CBDC infrastructure energy use should efficiently support international net-zero economic commitments. In addition, CBDC should contribute to financial inclusion and provide access to payment services for those excluded from or underserved by the existing financial system. Relief organizations could leverage digital currency to support international development and humanitarian aid via the rapid, safe, and secure release of global funding to distressed areas.

CBDC and central bank activity today

As of the start of 2023, 11 geographies had launched production-mode CBDC initiatives, including Nigeria, the Bahamas, Jamaica, Anguilla, Montserrat, Dominica, St. Lucia, St. Vincent, and Grenada. In addition, China plans to expand its pilot nationwide in 2023, giving 1.5 billion individuals access. As of December 2022, all G7 economies (Canada, France, Germany, Italy, Japan, the UK, the United States, and the European Union) had moved into phased CBDC development.

The New York Federal Reserve's multiphase research effort to develop a technical framework for a wholesale CBDC, Project Cedar⁶, is propelling the United States forward from research to phased development. In 2023, over 20 countries will take significant steps to pilot a CBDC; Australia, Thailand, Brazil, India, South Korea, and Russia are among those that have said they will continue or begin 2023 test pilots.

Please refer to this report's Appendix for a regional CBDC maturity grid.



CBDC operating model design

While it is true that CBDC development initiatives are extremely varied and in many different stages of development, three distinct operating designs underlie all currently evolving architectures – direct, indirect, and hybrid.

Direct or single-tier model

In the direct or single-tier CBDC model, central banks exclusively conduct all tasks and bear all responsibilities. This architecture enables central banks to issue and redeem CBDC while assuming all responsibility for system capabilities and operations (BIS 2021).

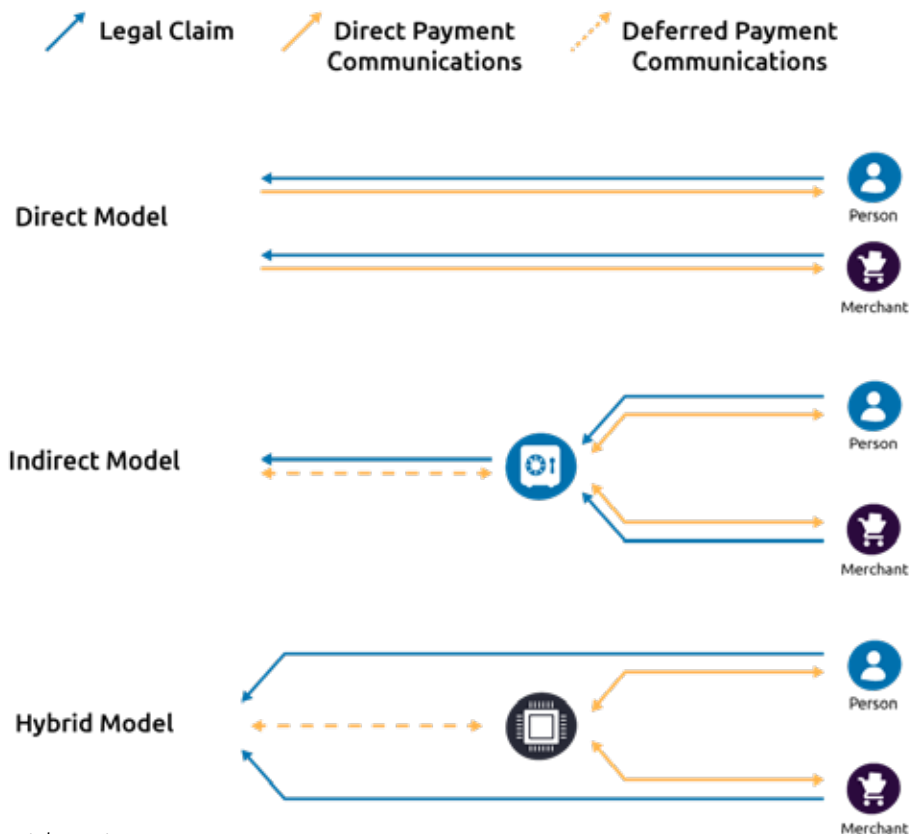
This model may seem lean and efficient, but recent central bank experiences show that industrializing this model in the short term may be highly unrealistic. Intermediaries, such as commercial banks, play a significant role in driving innovation in end-to-end financial processes. In addition to creating a single point of failure, the model implies that central banks have the vision, knowledge, and resources to support the entire financial system.

Indirect or two-tier model

The indirect CBDC model is a two-tier financial system in which the central bank outsources some tasks to payment interface providers (PIPs) or commercial banks. Intermediaries back indirect CBDCs and provide cash-like liability to retail consumers through their existing pool of CBDC in a central bank. Central banks can delegate roles and tasks according to the private sector’s strength and each geography’s financial maturity and needs.

In this model, which is the basis of our current financial model, intermediaries handle all types of communication with retail or wholesale clients. Arguably, it is the more popular design.

Figure 2: Three primary CBDC operating designs



Source: Capgemini Financial Services, 2023.

INDIRECT MODEL USE CASE

Project Aurum is a retail central bank digital currency (CBDC) prototype developed by the Bank for International Settlements (BIS) Innovation Hub, the Hong Kong Monetary Authority, and the Hong Kong Applied Science and Technology Research Institute. It consists of a wholesale interbank system and a retail e-wallet. The e-wallets use an intermediated retail CBDC, and the interbank system uses CBDC-backed stablecoins. The CBDC is a direct liability of the central bank, while the stablecoins are liabilities of the issuing bank. Aurum's unique validator system prevents bank over-issuance and user double redemption.⁷

Hybrid or intermediated model

The hybrid or intermediated model combines direct and indirect designs through which central banks and PIPs issue digital dollars fully backed by the central bank. This model allows for gradual change in consumers' habits and offers choice options, and the hybrid model has the most potential for product and service diversity.

For example, the digital yuan, or e-CNY token issued by the Bank of China, could be a hybrid CBDC. Commercial banks and payment service providers also handle the digital yuan's public interface by developing fund transfers, payments, and settlement services applications.

The choice of a CBDC operating model depends on the design pros and cons and the social and technological circumstances of the region or market. Trade-offs that may not be apparent nor easy to measure – such as considerations for resilience, security, and functionality – will be necessary. Therefore, given the implications of today's financial industry – and the centralization of power and risk – a direct single-tier CBDC model may be unrealistic.

The two-tier model is closer to what society is used to today, allowing intermediaries and consumers to interact with central banks. On the other hand, if we look at progression and flexibility, a hybrid model might be the first step for society to adapt to CBDC, yet also see the benefits of a direct liaison.

The emerging role of Big Tech in CBDC

The initial announcements of previously denominated Libra (now Diem) by Meta/Facebook, making it the first Big Tech to propose a global permissioned blockchain-based stablecoin payment system, demonstrated the ambitions of Big Tech to become a vital protagonist of a decentralized finance future. This move by the social media giant has increased governmental and regulatory scrutiny worldwide on DeFi, accelerating research and experiments on CBDC.

The European Central Bank (ECB) invited Amazon to collaborate on a digital euro user interface prototype based on its e-commerce expertise. While European sovereignty remains top of mind, Big Techs' user-base depth and infrastructure maturity make them valuable resources in building universally accessible, interoperable, and seamless CBDC ecosystems – ensuring quicker mass adoption and better outreach. The ECB prototyping exercise aimed to test how well the technology behind a digital euro integrates with prototypes developed by companies.

Amazon, Meta/Facebook, or Google would also be relevant actors in identifying the best use cases and showcasing the benefits of integrating CBDC into ecosystems such as e-commerce. Of course, it will be the role of central banks and regulators to ensure this contribution to the future of monetary systems guarantees a fair, competitive environment for smaller players, to benefit all users.

LAUNCHING A CBDC: ONE SIZE DOES NOT FIT ALL

Guiding principles and trade-offs

A CBDC designer must consider geography, the economic situation, policies, payments, identity infrastructure, risks, and, most importantly, trade-offs between traditional and digital monetary systems. When developing a CBDC infrastructure, wholesale or retail, central banks must first consider design implications. The design will affect business, technical, legal, policy, and regulatory angles and necessitates a balanced approach. The following principles have been devised to act as a guiding framework for central banks in CBDC development.

<p>Value vs. risks</p>	<p>The implementation of new technologies – such as consideration of DLT use and public versus private deployments – should be assessed regularly for benefits versus risks, and adopted only after looking carefully at potential performance, scalability, data security, and privacy concerns. Central banks must uphold monetary policies when integrating new currencies such as CBDC into payment ecosystems to ensure financial security, stability, and sustainability.</p>
<p>Operating model vs. liability Accessibility vs. legitimacy</p>	<p>Multiple operating models come under consideration when designing CBDC infrastructure. For example, the central bank will have to decide who owns the liability, how many intermediaries it will onboard, and how much control it will cede to private sector partners. Any CBDC introduction must ensure that all citizens and corporations can access this digital currency. Offline CBDC requires a protocol to handle potential disputes related to double spending or transaction data reconciliation.</p>
<p>Identity vs. privacy Transaction times vs. volatility</p>	<p>Know your customer (KYC) considerations are significant for regulators and central banks in regards to CBDC end users. Regulators must agree upon a base level of customer identity needed for security while limiting privacy intrusion. CBDCs promise near-instant settlement times between parties. However, cash movement, especially in bulk, requires regulation to ensure that sudden liquidity changes don't impact markets and the global economy.</p>
<p>Upgrades vs. feasibility</p>	<p>While advanced features such as programmability and smart contracts can add CBDC versatility, banks adopting technology should consider how end users will access CBDCs without requiring special hardware or software.</p>
<p>Coexistence vs. complexity Accountability vs. decentralization</p>	<p>New approaches should be compatible with the current systems to ensure synergies. CBDCs can complement, rather than replace, existing payment rails. The payment rails of multiple geographies will be a consideration when developing cross-border CBDC infrastructure. New systems should be able to enact a robust governance model with clearly defined participant roles and responsibilities. Decentralization should not come at the cost of a lack of accountability. Regulators must ensure sovereign control over the system.</p>
<p>Interoperability vs. standards</p>	<p>CBDC platforms must be interoperable (with existing and other CBDC systems) to ensure they function across geographies, regulations, and jurisdictions. Therefore, standards and interoperability are critical considerations when adopting a platform to develop a design from scratch.</p>
<p>Fail safes vs. security</p>	<p>While developing fail safes for CBDC systems used by a vast population, regulators must ensure robust governance and compliance checks to recover lost funds or damaged wallets without risking victim identities.</p>

Design considerations

Considering the trade-offs mentioned above, CBDC implementation designs are critical. The operating design – direct, indirect, or hybrid/intermediated model – underlying the architecture is a critical decision for CBDC implementation. Decisions will differ based on central bank involvement. For complete oversight, a central bank can adopt a single-tier (direct) model that performs all tasks – from issuing and distributing a CBDC to running wallets. Alternatively, in a multi-tier (indirect or intermediated) model, the central bank issues and redeems the CBDC, with distribution and payment services delegated to the private sector – like the e-Rupee strategy the Reserve Bank of India is exploring.

- **In a direct operating model**, the central bank issues CBDC directly to end users and operates a ledger that records all transactions. Central banks own the CBDC infrastructure, implementation, and distribution, allowing maximum control. However, constrained resources can be the trade-off.
- **In an indirect model**, the central bank issues CBDC through intermediaries (commercial banks). The

intermediary manages end-user claims, and the central bank handles wholesale payments to intermediaries. As in traditional (physical) currency management systems, commercial banks distribute notes to the public and verify transactions. They also manage account-keeping and comply with KYC, anti-money laundering, and counter-terrorism regulations.

- **A hybrid (intermediated) model** allows the central bank to maintain CBDC sovereignty, where there is a direct claim on the central bank. The central bank maintains a wholesale ledger, while commercial banks handle retail transactions. The arrangement would help the central bank mitigate some risks with a resilient infrastructure supported by intermediaries. Most CBDC pilots use this model today because it is less disruptive than a single-tier configuration.

Incentives for external players are critical to the design of a multi-tier CBDC ecosystem. The business model should factor in revenue from fees, interest rates, cross-subsidization, and controllable fixed and variable costs.



CBDC technology building blocks

While central banks have conducted considerable CBDC experimentation, only limited production examples exist. As a result, the overall book of knowledge on best-fit technology choices for CBDC is still evolving. Adding complexity is potentially differing design choices and operating models in different countries. Capgemini has been working with ANZ Bank, SWIFT, Visa, several central banks, and financial management information systems (FMIs) to gain valuable insights. What we can share is that all CBDC infrastructure development requires universal building blocks, often associated with DLT use; discussion of those key components follows:

Ledger

A ledger is a shared, immutable register that facilitates recording transactions and tracking tokens/assets in a business network. In the context of DLT, a ledger is often associated with blockchain technology characteristics.

Consensus

Central banks will have multiple consensus mechanisms, each providing a different calibration of speed, scalability, and finality. When selecting the ledger, it is essential to consider the consensus mechanism(s) it offers and ultimate trade-offs based on use cases, e.g., transaction volume versus transaction value versus security.

Smart contracts

CBDC solution programmability depends on smart contracts. Therefore, the CBDC technical platform must provide a robust mechanism for maintaining smart contract integrity, consistency, and availability, including constructs to upgrade/change the contracts without affecting the global state.

Privacy and confidentiality

Privacy is fundamental to building end-user trust, and banks must consider it within the design. Privacy and ID verification systems will differ based on account vs. token-based approaches. However, some central banks aim to offer the same level of privacy and anonymity to CBDC transactions as are available via cash transactions.

Security

The ledger should be able to upgrade its cryptographic algorithms as more secure quantum-resistant algorithms come along in the future. Cryptography protects ownership and non-repudiation characteristics, and ensures that banks can upgrade safety elements over time.

Interoperability

Interoperable networks are required to ensure seamless operations among CBDC systems and between CBDC and fiat-currency systems. However, interoperability remains a work in progress.

- SWIFT and Capgemini are working to achieve interoperability between CBDC–fiat and CBDC–CBDC networks. CBDC–fiat interoperability can ensure

coexistence, while CBDC–CBDC interoperability might be essential for seamless cross-border payments.

- Interoperability may be necessary for an indirect CBDC setup where the retail CBDC is a token-based system on a specific ledger. Meanwhile, the wholesale CBDC might be account based using a different ledger.
- Alternatively, Algorand’s State Proofs and Inter-Blockchain Communication⁸ (IBC) protocol can be applied to secure interoperability between heterogeneous ledgers without a trusted intermediary.

An essential aspect of CBDC is encapsulating the rich payment context of ISO20022 within the solution. Therefore, the ability to rapidly evolve interoperability is a significant consideration – particularly regarding current features and the future roadmap.

Wallets

Wallets are the primary interface for end users and custodians to manage and control token holdings.

Security: Wallets require incredibly high security; and protocols have evolved considerably from the paradigm of hot storage, cold storage, hardware wallet, etc., to techniques such as multi-party computation. CBDC proponents say these contemporary techniques can be more secure than fiat when combined with confidential computing.

Recoverability: A recoverability mechanism is critical if a device is lost, etc. Protocols must be safe and quick to earn the confidence of the vast numbers of CBDC users. Wallet infrastructure service providers must balance security, user experience, and asset recoverability.

Access: While banks conceptualize CBDC wallet infrastructure, wallets can also hold tokenized assets (tokenized bonds, digital identity tokens, etc.). Agile wallets will consider access beyond CBDC.

Account-based and token-based design

Irrespective of architecture, an account- or token-based design can be adopted. These two models have different economic implications and ramifications that designers must carefully consider. The design choice will depend on how much authority the central bank will retain regarding consumer identities.

- Account-based design will require end-user ID verification where the central bank can keep track of all transactions. While this can increase financial inclusion, it comes at the cost of complex governance and infrastructure issues.
- Token-based design enables anonymity because the bank records only issuance and redemption. However, end users can transfer ownership through public/private key pairs without being documented in a database. A token approach can reduce central bank bureaucracy; however, the decentralized nature of the network can cause cybersecurity issues.

Orchestrating a CBDC ecosystem

While central banks decide on the operating model and the type of CBDC to introduce, they must also partner with many stakeholders to develop CBDC infrastructure within a country or geography and ensure its connectivity at the global level. This collaboration is already happening at domestic and international levels.

Central banks partner with retail banks, FinTechs, and other technology providers beginning even at the exploratory phase to share learnings to ensure ecosystem readiness and streamline the adoption journey. In addition, central banks collaborate with multiple banks and regulators to ensure seamless CBDC cross-border payments. As but one example, Project mBridge is a collaboration between banking authorities in Hong Kong, Thailand, China, and the UAE to develop a blockchain for multi-currency cross-border CBDC payments.

When working together on CBDC solutions, ecosystem partners typically play the following roles:

- **Central banks** will formulate regulations and act as a stakeholder that owns CBDC liability. They can handle all operational aspects of a CBDC program or delegate to intermediaries as appropriate.
- **Retail banks** form a distribution layer to end consumers and can drive innovation through CBDC value-added services. Retail banks and FinTechs might see CBDC as an additional revenue stream through payments, safekeeping, exchange, and loyalty-type services.

- **Technology partners** work with central banks and intermediaries to develop platforms required for CBDC adoption. Necessary expertise includes security, infrastructure, data, compliance, and, most critically, integration into existing core systems and processes.
- **Consumers** – Typically, end users for retail CBDC will be individuals; and for wholesale CBDC, end users might include institutional investors, corporate and investment banks (CIBs), or other asset-servicing firms. How and when consumers consider using CBDCs against digital or fiat currencies will drive CBDC adoption.
 - Cultural shifts and education and training will be essential to CBDC consumer engagement.
 - In institutional markets, we expect buy-side asset management firms to seek exposure to digital assets denominated and traded in CBDC and CIBs, acting as issuers and market makers for these asset classes. Moreover, large asset-servicing banks that provide custody solutions for digital assets will also become significant users for CBDC.

Other essential ecosystem partners are regulators that create and maintain legal and security frameworks and merchants – large and small – who will assess the reliability of CBDC value propositions before investing in ancillary technology and equipment.



CBDC DEVELOPMENTS AND IMPLICATIONS FOR COMMERCIAL BANKING

Given local, regional, and global agendas – mandates, authorities, objectives, motivation, technology, and central bank processes – let us agree that a CBDC initiative may take multiple approaches, shapes, and timelines.

Monarchies and sovereign states have issued currencies from time immemorial. When upstart crypto firms had similar aspirations, it was time to plan a sovereign alternative. The sovereign option supports efficient monetary policy transmission and the general welfare of citizens. The CBDC concept involves retaining sovereign control while enabling the banking system with next-generation technology.

Talk of banking system disintermediation or replacement with crypto upstarts is without merit. CBDC will not compete with commercial banks. It is part of the historical progression from minted precious metals, to paper currency, to electronic currency transactions.

- CBDCs have to provide an effective alternative for the peer-to-peer payment offered by cryptocurrency yet retain most of the characteristics of the current fiat currency. In addition, the anonymity of cryptocurrency transactions is overrated. The FBI traced transactions to resolve cryptocurrency thefts. These considerations will drive the design of retail CBDC.
- Reducing friction in international payments – including trade finance, cross-border payments, and remittances – drives wholesale CBDC design. Further, wholesale CBDC is a competitive arena for increasing the use of sovereign currencies. It is similar to the competition among fiat currencies in the current environment.
- In addition to functional considerations, CBDC will support existing anti-money laundering and currency control goals. Moreover, governments could use CBDC to collect taxes, make benefit payments, and pay bills.

Given this inclusive definition, does CBDC compete with current payment systems – and is cannibalization possible? It is unlikely that CBDC will compete with fiat, and the system we know will continue to exist and grow. However, introducing central bank digital currency gives citizens a viable alternative to cash and often risky unregulated crypto and private tokens. The objective of the CBDC is not to replace regulated banks, but to give citizens a safe option. As media headlines expose the failures of private digital currencies erroneously touted as centralized and secure, central banks are stepping up to offer government-backed legal tender that instills public trust.

CBDC, banks, and payments

It does not make sense for central banks to act as deposit-taking institutions and offer retail banking services and payments: it is the commercial banks that have hundreds of years of experience. Moreover, commercial banks are regulated, so replicating what already exists wastes scarce investment dollars, especially given know your customer/ anti-money laundering concerns and various regulatory frameworks. Further, banking and payments are competitive

markets, and end users already have choices among incumbents and FinTech challengers to benefit from price and service. Therefore, CBDC design becomes critically important.

CBDCs will not be interest-bearing assets. And commercial banks will propagate monetary policy. Primarily, CBDC will offer a safe and stable alternative to cryptocurrencies. Banks will accept and process CBDC as fiat. Of course, cryptocurrencies as speculative assets can have a life of their own. CBDC may supplant stablecoins underpinned by a fiat currency.



CBDC and retail payments

We envision a world where CBDC coexists with existing digital fiat currency; it will provide a universally available option for digital payments in a country. It can accelerate the push to a cashless economy while providing everyone with a digital payment alternative. As a result, the embedded payments ecosystem can rapidly accelerate. An increase in low-value payments will raise the bar on commercial banks' approach to processing payments cost-effectively. Current archaic payment architecture may have to be radically simplified to support CBDC payments.

CBDC will enable simple payment processes to settle digital transactions like cash operations versus credit cards or payment mechanisms. Commercial banks will accept and process CBDC as fiat while offering a safe, stable crypto alternative. Let's review a number of CBDC use cases:

- **Peer-to-peer payments:** Central bank digital currency should allow direct P2P payments without fees from individuals' bank accounts. We envision a world where CBDC harmonizes with existing digital fiat currency. CBDC can provide a universal domestic option for digital payments. Strictly speaking, we don't need a CBDC for P2P payments. Schemes supporting account-to-account transfers are sufficient and already used in some countries. Players charging fees for payment transfers may challenge a CBDC that attempts this use case. It is not a technology challenge, and a technology solution cannot bring resolution. Only a national authority can enforce change. Besides the political challenge, an increase in low-value payments will raise the bar on the commercial bank's approach to processing payments cost-effectively. The current archaic payment architecture needs radical simplification to support these CBDC payments.
- **Financial inclusion:** In mid-2022, the World Bank⁹ reported that 1.4 billion individuals remained unbanked globally. However, it noted that 76% of adults worldwide had an account in 2022, up from 51% a decade ago. In the United States, unbanked adults say they cannot meet minimum balance requirements, do not trust banks, have privacy concerns, or do not want to pay high banking fees.¹⁰ While CBDC is not essential for financial inclusion, it can lead to significant inclusion.
 - In the cashless economy, CBDC can substitute cash. For instance, unbanked individuals can access electronic payment processes at commercial establishments. Governments could directly provide subsidies through CBDC. The underlying smart contracts can direct how the receiver spends the money. This change has the potential to simplify many welfare and social security schemes. However, we won't delve into the smart contract aspect of CBDC in this paper. A government-to-population, direct subsidy transfer can bring people closer to consumer financial products such as credit cards and savings accounts. Banks need to find

the appropriate changes to serve this population segment cost-effectively.

- Not surprisingly, financial inclusion often goes hand in hand with digital inclusion. Individuals on the periphery of mainstream society may not have internet access or lack the confidence to begin. Therefore, CBDC educational programs and offline CBDC should be considered.
- **Direct-to-citizen government subsidy:** Most countries have complex government mechanisms to provide subsidies and welfare payments to citizens. There are layers of businesses involved in delivering subsidies and welfare payments. A CBDC smart contract could eliminate process complexity.
- **Crowdsourced lending:** Although highly touted, decentralized finance (DeFi) is still nascent. It can offer limited crowdsourced lending without the judicious credit-decision protocols banks use. However, recent crypto firm debacles have demonstrated that self-regulation is grossly insufficient. Attempting crowdsourced lending with CBDC would be even more difficult. Therefore, we don't anticipate adoption at scale anytime soon.

These use-case examples indicate that while CBDC can address some pressing needs, other viable options can deliver similar outcomes. Moreover, each use case needs a concurrent resolution of different challenges. National authorities must drive industry-wide transformation along with CBDC for these use cases. Commercial banks also need significant investments and technological change to support many areas.

Cross-border peer-to-peer payments seem the most viable use case. Demand for P2P will likely spark industry change. However, other use cases may have a long journey ahead.

CBDC and wholesale payments

While incumbent commercial banks and payment processors have to shoulder much investment for the public good in the case of retail CBDC, the situation is different for wholesale. Commercial banks may readily support the adoption of wholesale CBDC due to potential revenue generation and cost reduction opportunities. In addition, cross-border payments and trade finance transacted with CBDC may potentially resolve operational issues around reconciliation and reporting.

Correspondent banks and the need for human intervention for reconciliation impede cross-border payments and increase costs. Anti-money laundering and combating terrorism financing (AML and CTF) add operational processing. CBDC, with verifiable first-party information, can address many of these challenges. SWIFT changes that support CBDC transactions on existing payment rails (a [SWIFT-Capgemini project](#)) and architectural simplifications to provide transaction traceability through intermediaries can simplify operational challenges and reduce reconciliation.

CBDC and sustainability impacts

If CBDC becomes a digital fiat for decentralized finance and applications such as cross-border payments, its potential to support sustainability is tangible. The case is especially valid if central banks don't undertake token burns or consensus mechanisms to create a digital currency.

And because central banks underwrite the legitimacy of CBDC, it does not need to prove authenticity through technological structure. Therefore, CBDC does not require the energy-intensive consensus or mining mechanisms a cryptocurrency uses, and its energy consumption is lower than a credit card system. CBDC designers can leverage various solutions, including real-time gross settlement (RTGS), DLT, or a combination. Careful deliberation to meet objectives and implications will be necessary and significant, as CBDC can catalyze financial innovation.

Opportunities and challenges for commercial banks

Let's assume that indirect and hybrid models are the most likely way forward, given the potential impact of CBDC on overall financial stability and monetary policy transmission. In hybrid models (in which central and commercial banks can both issue interest-bearing CBDC to end customers), the environment could challenge access to retail bank deposits and weaken balance sheets – thus threatening the ability to lend.

However, given the direction of most central banks so far and the realization of the impact of intermediation, we believe that amid checks and balances, commercial banks can leverage this new paradigm to promote product innovation and enhance customer experience.

Financial Product	Strategy/Business Model	Organizational Structure	Technology
Retail payments	<ul style="list-style-type: none"> • CBDC raises electronic payment volumes while decreasing card volumes • Banks compensated for their distribution role alone • CBDC initiatives may likely open distribution to newcomers and increase competition • The accelerated shift from cards to account-to-account will impact cards' interchange revenue 	<ul style="list-style-type: none"> • Fiat currencies and CBDC are not fungible • Firms will need to duplicate account management and payment rails 	<ul style="list-style-type: none"> • CBDC built on top of existing commercial payment services and cash • Only at banks that decide to leave some parts of the market, CBDC may not offer rationalization opportunities
Wholesale payments	<ul style="list-style-type: none"> • Reduced costs will encourage new entrants and threaten the position of historically-dominant correspondent (intermediary) banks • Disintermediation as FIs may no longer require intermediaries for cross-border payments 	<ul style="list-style-type: none"> • Increased efficiency will shrink Nostro¹¹ reconciliations and FinCrime/AML¹² costs 	<ul style="list-style-type: none"> • Streamlined E2E to link domestic and cross-border payments; impacts to SWIFT, ACH/RTGS expected
Lending	<ul style="list-style-type: none"> • As some consumer deposits move into CBDC, commercial bank deposits may shrink • Lending capacity is affected (Basel III)¹³ • Credit bundled to card payments must be re-bundled in the new context • Credit card business models reinvented 	<ul style="list-style-type: none"> • CBDC will reduce lending volumes based on commercial deposits • Banks will do less transformation and resell their assets into the market (or European Central Bank) 	<ul style="list-style-type: none"> • Changes limited to asset and liability management and asset distribution

Trade finance & supply chain	<ul style="list-style-type: none"> • CBDC may be one of the most relevant strategic areas in terms of DLT/ DeFi innovation • It presents opportunities to integrate fragmented/costly value chains with CBDC ecosystems to digitize end-to-end from documentation to issuance or settlement • CBDC will enable banks' existing trade finance products (LCs, guarantees) to be distributed to a more extensive customer base thanks to inclusion in trade ecosystems • Lower barriers to financial inclusion can bridge the finance gap for SMEs via better outreach and cost-effective loans 	<ul style="list-style-type: none"> • CBDC will encourage more transversal product teams across business and technology 	<ul style="list-style-type: none"> • Banks will need to review their end-to-end trade finance and supply chain financing ecosystems and build interoperability in a highly-fragmented industry
Liquidity & treasury	<ul style="list-style-type: none"> • Corporations have long sought solutions giving them 360-degree views of their global cash pools and fast cross-border treasury management • For instance, JP Morgan allows corporate subsidiaries to leverage JPM coin¹⁴ for treasury management, enabling near-instant liquidity management at the global level and real-time cross-border payments • CBDC (especially interest-bearing CBDC) might also increase competition in attracting deposits and affect access to liquidity and the ability to provide financing 	<ul style="list-style-type: none"> • CBDC could impact the way banks manage overall liquidity from a risk perspective 	<ul style="list-style-type: none"> • Connectivity to local and international financial systems and market infrastructure to be reimagined under CBDC architecture
FX transactions	<ul style="list-style-type: none"> • Some emerging cross-border CBDC platforms aim to embed FX markets and liquidity mechanisms (e.g., mBridge), enabling new entrants to become market-makers 	<ul style="list-style-type: none"> • Delivery versus payment (DVP)¹⁵ will remain as a method to mitigate counterparty risk (CLS) • Handling by correspondent banks will continue as CBDC remains in its jurisdiction • The emergence of cross-border payment rails linked directly with domestic rails could drastically reduce the need for Nostro/Vostro reconciliations¹⁶ – and how banks manage liquidity • CBDC will also affect the governance of overall international flows (e.g., the correspondent banking model) 	<ul style="list-style-type: none"> • Connectivity to local and international financial systems and market infrastructure may be reimagined

There are several areas in which CBDC might boost commercial bank revenues. From a wholesale perspective, integrating end-to-end financial chains and interoperability will drive CBDC adoption. If commercial banks industrialize current cross-border experiments to facilitate market-making activities on CBDC FX transactions, they could generate revenues currently concentrated on US dollar flows and correspondent banking.

- Additionally, banks that embrace novel digital models by participating in new ecosystems can access a broader customer base. This opportunity is especially significant in trade and commodity finance or supply-chain financing, where several initiatives are maturing (shipping, digital LCs, insurance, etc.). Adding CBDC-based settlements (the last missing building block) could integrate the complete value chain.
- Some commercial banks that are at advanced stages of developing similar innovations with stablecoins (e.g., JPM coin) could direct investments toward connectivity with domestic or cross-border CBDC infrastructures and propose their platforms as Banking-as-a-Service.

From a retail perspective, CBDC could help forge new customer relationships beyond the scope of traditional deposit/lending banking activities. It could help foster financial inclusion and access untapped customer segments in geographies with significant unbanked populations without needing a bank account (such as the retail CBDC experiment in Nigeria).

Central bank digital currency could pave the way for wallet innovations or CBDC custody by providing super-apps giving access to a broad range of integrated financial and non-financial services, leveraging Web3 capabilities. For instance, banks could leverage digital currency's programmability features to distribute rewards spendable under certain conditions (via specific outlets or to particular populations). It would enable user experience enhancements in payments with frictionless, instant payment transactions.



IN CONCLUSION: WATCH THIS SPACE

Even in the near term, future developments in central bank digital currency are hard to predict. It may be that we are closer than ever to a world in which CBDC is built, fully launched, and gains real traction in the marketplace – and as a result helps reshape the global banking industry and how it operates. But CBDC critics and naysayers also abound.

- Although each market has its own societal and economic challenges, it seems almost all central banks want to explore the CBDC opportunity and not be left behind: indeed, 114 countries – representing 95% of global GDP – are engaged in CBDC research and development, pilots, or actual digital currency launches. However, it is incumbent upon central bankers to collaborate with ecosystem partners to ensure they do not replicate fiat inefficiencies within new digital currencies.
- For commercial and retail banks, CBDC may reduce transaction and operational costs, simplify cross-border transactions, and improve overall payment system efficiency. It may offer a viable alternative to cash and often risky, unregulated crypto currency options; and even new revenue-making opportunities may arise.
- And for wholesale and individual bank consumers, widespread adoption of CBDC will begin with stakeholder trust and confidence. Security, resiliency, and accessibility are but a few of the key promises that CBDC needs to deliver on.

The continuing CBDC journey bears attention and is definitely one worth following. Stay close to continuing developments, and see what opportunities CBDC may offer for you.

PARTNERING WITH CAPGEMINI ON CBDC

Capgemini draws on its deep payments expertise and experience in global blockchain technology implementation to strategize, design, and pilot central bank digital currency use cases. Since 2021, we have delivered various CBDC programs globally, covering retail, wholesale, hybrid, and interoperability scenarios, in partnership with central banks, commercial banks, FinTechs, and other technology partners.

We offer support in two CBDC development essentials:

- 1. Strategy, design, and road mapping:** When it comes to CBDC, one size doesn't fit all. Hence, we offer a tailored, concentrated, insightful consulting engagement solution to accelerate CBDC journeys or validate strategy through an objective lens. We provide market research and benchmarks, engage stakeholders through use case exploration workshops, support business case development, and coordinate ecosystem engagement with regulators, commercial banks, and technology providers. In short, we help participants make critical trade-off decisions during CBDC strategizing and create a line of sight from ideation to roadmap.
- 2. Pilots and enterprise enablement:** We bring CBDC strategy to life through this offer. Capgemini's tested approach identifies qualified technology and data partners, builds and nurtures sandbox environments, and connects with third parties through application programming interfaces (APIs). A tech-focused squad and industry expertise lead to CBDC pilot deployment. Then, we provide post-deployment support and communication, industry showcases, and points of view with frameworks that capture critical learnings. Our offers leverage cloud, dApps, SWIFT TMP messaging, open APIs, and custody. And they are fully integrated, so the CBDC may be piloted and tested in real-world enterprise scenarios.



Capgemini CBDC case studies

Central bank digital currency has broad implications, from monetary policy to financial inclusion. Therefore, many of our case studies are confidential, so we encourage you to contact us. However, the illustrative examples below showcase the breadth and depth of our CBDC value proposition.

CBDC Type	Case Study
<p>Retail</p>	<p>Global retail CBDC challenge – Monetary Authority of Singapore (MAS)</p> <p>In partnership with Australia and New Zealand Banking Group (ANZ Bank) and other ecosystem participants, we supported the development of retail CBDC scenarios through the National Integrated CBDC Ecosystem solution (NICE). The Capgemini solution was among the top 15 featured in the 2021 Global CBDC Challenge report¹⁷ published by MAS.</p> <p>We worked with a set of ecosystem partners to assist the bank in developing use cases and user journeys for a two-tier retail CBDC model connected to the National ID. Through NICE, we demonstrated offline transactions, programmable wallets, atomic settlement, and faster consumer-to-government (C2G) and government-to-consumer (G2C) payments.</p>
<p>Wholesale</p>	<p>Wholesale CBDC use cases</p> <p>A large central bank in APAC was embarking on a multi-year strategic CBDC program to test feasibility and experiment with wholesale CBDCs for payments and settlements between central banks’ regional commercial banks in both pull and push models. Capgemini partnered with digital finance consortium R3 to demonstrate CBDC use cases for the central bank, engaged the broader banking ecosystem in the region, and built pilots around wholesale CBDC use cases.</p> <p>The program’s objectives were to unleash CBDC potential, align use cases to policy objectives, and prepare a roadmap to accommodate a broader ecosystem.</p>
<p>Cross-border</p>	<p>CBDC-2-CBDC transactions between DLT networks</p> <p>SWIFT and Capgemini achieved CBDC-to-CBDC transactions between distributed ledger technology networks based on Quorum and Corda technologies, fiat-to-CBDC flows, and a real-time gross settlement system. Further, our experiment proved that we could link the blockchain networks for cross-border payments through a single gateway.</p> <p>Additionally, SWIFT’s new transaction management capabilities could orchestrate all inter-network communication. As a result, 14 central and commercial banks are collaborating in a testing environment to accelerate the path to full-scale deployment.</p>

EXECUTIVE PERSPECTIVES ON CBDC

How will CBDC change banking?

“Our observation from being deeply embedded in central bank pilots across our extensive network is that the next 2–3 years is likely a ‘sprouting’ phase as central banks accelerate CBDC exploration and proofs of concepts. Material-scaled infrastructure will likely take more time. And we anticipate multi-CBDC interoperability to mature over the next few years.”

Weikai August Phang, Executive Director, Digital Currency Products, Standard Chartered, Singapore

What are the near- and long-term effects of CBDC on commercial/universal banks? Will CBDC draw deposits away from banks?

“The impact of CBDC on banks will vary depending on the CBDC issued by central banks. If it’s a wholesale CBDC, the effects on commercial banks will be less significant as they can operate similarly as before and issue bank-grade stablecoins as commercial money on blockchains. Therefore, commercial banks could benefit from reduced settlement costs and increased efficiency.”

Daniel Coheur, Co-founder & Chief Commercial Officer, Tokeny, Luxembourg

Potential benefits of CBDC?

“The potential digital euro would fill a missing block in the European single-market objective. This new pan-European digital payment system could materialize into a strategic opportunity for the payments industry used in international trade, in coexistence with other jurisdictions’ digital currencies. It represents a new payments ecosystem, built in collaboration with the whole community of stakeholders, in a very challenging timeline.”

Sylvie Calsacy, Head of Public and Regulatory Affairs, Worldline Global, Paris, France

Distributed ledgers could digitalize securities’ DVP by bridging both transaction legs with the same or interoperable technologies. Financial institutions could cut costs and reduce potential DVP-related risks because settlement time would be swift. Wholesale CBDC could be an innovation game-changer for securities settlement based on DLT. Given that wholesale transactions raise fewer regulatory issues than retail – and regulators would already supervise wholesale CBDC users – it would be easy for central banks to conduct wholesale CBDC experiments.”

Stéphane Blemus, Secretary General of Forge by Société Générale

Have you participated in strategic forums about design processes and use cases?

“We are working with the Eurosystem on designing the digital euro for the Euro Area. Cross-border use of the digital euro is not a priority, although the design considers Central and Eastern European and EEA citizens to have access in subsequent releases.”

Petia Niederländer, Director of Payments, Risk Monitoring, and Financial Literacy, Austrian National Bank (OeNB)

How should banks prepare for the commercial launch of CBDC?

"Digital currencies can potentially make cross-border payments cheaper, faster, safer, and smarter. This has prompted most of the world's central banks to explore or start developing CBDC. At the same time, commercial banks can also reap similar benefits by offering commercial bank money in a digital form to customers. At Onyx by J.P. Morgan, we have been at the forefront of this journey since 2014. And today, we offer deposit accounts on our blockchain platform that enable our financial institution and corporate customers to reap the benefits of real-time 24/7 payments across borders and with smart programmability features."

Naveen Mallela, Global Head of Coin Systems, Onyx by J.P. Morgan

How should CBDC be offered to customers? Describe the last-mile experience.

"Regarding the digital euro, there are current conversations that merchants shouldn't have access. So there will be some impact, but not much because, as you're aware, payments are not the most profitable product banks provide."

Executive from a large European bank

"Last-mile connectivity will embark on existing channels and be managed carefully for a smooth transition to mobile-based. Initially, there will be a need for CBDC in cards. Consumers are used to cards, and they will not disappear soon – and merchants' terminals can't be replaced at once. So the value to merchants will be key to achieving CBDC success."

Gerard Hartsink, Chairman of the Industry Advisory Board of the Digital Trade Standards Initiative
International Chamber of Commerce, Netherlands

Privacy concerns?

"No. In democratic societies, CBDC should not spark privacy concerns, and participants must enact appropriate guardrails and policies to prevent surveillance. These policies should be enforced in the technologies used – to alleviate privacy concerns further."

Jonathan Dharmapalan, CEO, ecurrency, San Francisco Bay Area

"Collecting data on users is a design consideration. When a digital asset is issued, tracking is possible but not required. Most CBDC-issuing governments are designing CBDC to act like cash, so they will not track users. There is some nuance to this question, however. One benefit of a digital currency is that it can alert authorities to bank runs before they become complete system shocks. So collecting data at a very high level (not at the individual level) can make a system more stable."

Gagan Jain, Global Partnerships Director, R3, New York

Will a single-data CBDC dashboard aid data gathering and cleansing, which will support administering monetary policy?

"Yes, blockchain is resilient by redundancy, which means it is not efficient per se. However, it solves problems of trust. For example, in the case of CBDC, issuance is restricted to the central banks, which resolves the trust issues – alternatively, financial market stability is endangered."

Petia Niederländer, Director of Payments, Risk Monitoring, and Financial Literacy, Austrian National Bank (OeNB)

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APPENDICES

The CBDC maturity index

MARKET/ REGION	MATURITY STAGES				KEY PROJECTS	SUMMARY STATUS
	RESEARCH	DEV	PILOT	LIVE		
UNITED STATES	Wholesale & retail				Projects Hamilton & Cedar, Digital Dollar	The FED has not formally decided to proceed with CBDC but is accelerating the exploration of benefits and risks from various projects and research over 2023.
CANADA		Wholesale & retail			Project Jasper and MIT partnership	BoC has not confirmed a plan to release a CBDC but has advanced research and development work since 2017 and, in late 2022, launched a public consultation process .
CHINA			Wholesale & retail		mCBDC Bridge Digital Currency Electronic Payment (DCEP)	In progress: advanced domestic and cross-border payment network pilots via digital currencies. China began its e-CNY pilot in 2019. As of December 2022, there were 13.61 billion e-CNY in circulation , worth ~USD 2 billion in Q1 2023.
HONG KONG			Wholesale & retail		Projects Stella & Aurum, eHKD /e-CNY mCBDC Bridge	The Hong Kong Monetary Authority is involved and well-progressed in retail and wholesale CBDC use cases through its e-HKD and mBridge projects.
JAPAN		Wholesale & retail			Project Stella	Bank of Japan is developing a retail CBDC PoC and undergoing functionality testing in 2023. BoJ is involved in cross-border research through its work with the European Central Bank on Project Stella.
SINGAPORE		Wholesale & retail			Projects Ubin & Dunbar, Jasper, Onyx/Multiple wCBDC, Project Mariana, MAS Digital ID	A project and pilot leader: MAS's Project Orchid report outlines a path for CBDC development in 2023 and 2024, including use cases and ledger technology recommendations.
EUROZONE		Wholesale & retail			Digital euro, Projects Stella & Mariana	The European Commission is to publish a digital euro bill in May. The European Central Bank has not decided whether to issue a CBDC ; however, the commission said new laws might be required to assert a digital euro's status as legal tender and to set AML rules.
GREAT BRITAIN	Wholesale & retail				Participation with BIS	The Bank of England finished its research and exploration phase of a potential CBDC in Q1 2023. BoE concluded that Great Britain would need a digital pound ultimately. Phase II may take two to three years, after which BoE will decide whether or not to begin building CBDC infrastructure. BoE says Bitcoin could be ready by 2030.
AUSTRALIA			Wholesale & retail		Projects Atom & Dunbar	In collaboration with the Digital Finance Research Cooperative Research Centre, the Reserve Bank of Australia outlined technical and policy requirements and a pilot of retail CBDC planning in early 2023.

MARKET/ REGION	MATURITY STAGES				KEY PROJECTS	SUMMARY STATUS
	RESEARCH	DEV	PILOT	LIVE		
NEW ZEALAND	Retail only					The Reserve Bank of New Zealand (RBNZ) published commentary on its CBDC strategy following a 2021 feedback period - no decision as of September 2022.
INDIA		Wholesale & retail			Domestic with nine national banks Q4 22	RBI outlined the features and objectives of the Digital Rupee and launched a wholesale CBDC pilot program in partnership with nine national banks.
BAHAMAS				Retail only	Sand Dollar	Fully live, the Sand Dollar is the digital version of the Bahamian dollar (B\$) issued by the Central Bank of The Bahamas through authorized financial institutions (AFIs).
JAMAICA				Retail only	eCurrency Mint	In May 2022, the BOJ announced a phased roll-out of the JAM-DEX .
SOUTH AFRICA	Wholesale & retail				Project Khokha	South Africa has made no formal CBDC decision or official plan. However, the South African Reserve Bank is researching and exploring potential benefits and risks.

CBDC principles and trade-offs for central banks

Value vs. risks	New technologies must be assessed regularly for benefits versus risks and adopted after carefully considering performance, scalability, data security, and privacy to ensure the system's safety, stability, and sustainability. E.g., DLT vs. non-DLT considerations, public vs. private deployments.
National policy vs. stability	Integrating newer forms of currencies into existing payment ecosystems should ensure that all monetary policies set out by a central bank are adhered to so that financial stability never comes into abject risk scenarios as the system adopts CBDCs.
Operating model vs. liability	Multiple operating models come under consideration when designing CBDC infrastructure. The central bank must decide who owns the liability, how many intermediaries they want to onboard, and how much control they want to cede to private-sector partners.
Accessibility vs. legitimacy	Any CBDC introduction to a system must ensure that every citizen and corporation can access this digital currency. In the case of offline CBDCs, safeguards must handle disputes related to double spending or transaction data reconciliation.
Identity vs. privacy	KYC considerations are a significant factor for regulators and central banks regarding end users of CBDCs. Regulators must agree upon a base level of customer identity for security while not intruding on privacy.
Upgrades vs. feasibility	While advanced features such as programmability and smart contracts can bring more features to CBDCs, technology adoption should also consider the feasibility for end users to access CBDCs with minimal technical and non-technical barriers. E.g., the need for special hardware, software.
Coexistence vs. complexity	New approaches should be compatible with current systems to ensure synergies. CBDCs can complement, rather than replace, existing payment rails. Cross-border CBDC infrastructure will need to consider payment rails of multiple countries.
Interoperability vs. standards	CBDC platforms must be interoperable (with existing and other CBDC systems) to ensure they function across geographies, regulations, and jurisdictions. Therefore, central banks must consider standards and interoperability when adopting a platform for developing a new system.
Transaction times vs. volatility	CBDCs promise near-instantaneous settlement times between parties. However, faster transaction times are mostly optimistic because rapid cash movements, especially in bulk, must be regulated to ensure that sudden changes in liquidity do not impact the markets and the economy.
Fail safes vs. security	While developing fail safes for CBDC systems that a vast population will use, regulators will have to ensure robust governance and compliance checks for recovering lost funds or damaged wallets without risking the identity of the affected parties.
Accountability vs. decentralization	New systems should be able to enact a robust governance model with clearly defined roles and responsibilities for each participant. Decentralization should not come at the cost of a lack of accountability. Regulators must ensure sovereign control over the system and allocate roles and responsibilities for all participants.
Scalability vs. performance	Widespread adoption of CBDCs in a country means that any systems developed need to be scalable. Therefore, the infrastructure must be robust enough to grow in size to handle increased volumes and various transactions while maintaining a high degree of performance.
Sustainability vs. efficiency	Design decisions should ensure that adopting new technology involves energy-efficient consensus mechanisms and governance models to mitigate the drawbacks of conventional systems while not conflicting with the sustainability agenda.

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