

Central Bank Digital Currency

From the Philosophical to Practical in Global Adoption

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May 2022

Executive summary

The last year has seen interest rise sharply in central bank digital currency (CBDC), with the International Monetary Fund[1] reporting that approximately 100 member countries are now exploring CBDCs. This growth has been set in motion by:

- *The increased digitization of the global economy in the wake of a pandemic;*
- *the entrance of financial technology and social media firms into banking and finance;*
- *the growth in value and in popularity of stablecoins and cryptocurrencies.*

Cross-border payments are a top priority for central bankers, as the current process is often criticized as too expensive, too slow, and too opaque, making them a drag on global productivity. Remittances in particular are an area where financial technology could make a clear improvement in outcomes especially in countries where they account for a significant component to the GDP.

In April 2021, Digital Asset and Darrell Duffie of Stanford University published a white paper, [CBDC Principles for Technical Implementation](#), which addressed how the technology underpinning CBDC could address challenges, enable innovation, and support requirements and opportunities that have yet to be defined. The “pillars of CBDC” referenced in the paper have subsequently been echoed in statements by central banks and others, and include the need for interoperability, strict privacy controls, extensibility and finality of settlement. However, we believe that any discussion of technology must look beyond infrastructure to ensure that CBDC can be designed and constructed in a way that ensures its usability across a variety of use cases—from simple to complex, small to large, local to cross-border.*

CBDC promises solutions to persistent challenges of efficiency, security, and inclusion, but a majority of governments have indicated that they may still be years away from launching a digitized version of central bank money. With a number of pilot programs already underway, the CBDC discussion continues to advance with feedback and insight based on real-world examples. This report, co-authored by Dr. Giovanni Bandi, Fellow and [Regulatory Genome Project](#) Director at Cambridge University, and Digital Asset, explores key learnings from those initiatives—shifting from the philosophical to the practical by focusing on that which is achievable today and what we are learning about the future of CBDC in an international context.*

* Dr. Giovanni Bandi and Darrell Duffie received no compensation or other consideration for their collaboration on these papers.

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1.0 Introduction

Digital Asset is pleased to present further details on successful CBDC implementation, building on the key principles presented in [CBDC Principles for Technical Implementation](#). In that paper, we outlined the technology specifications and options that would enable CBDC goals to be achieved. However, we believe that any discussion of technology must look beyond infrastructure to ensure that CBDC can be designed and constructed in a way that ensures its usability across a variety of use cases—from simple to complex, small to large, local to cross-border.

Since publication, we have been involved in multiple, substantive discussions on how to design, pilot, or implement CBDC. We have also been privileged to participate in several pioneering market initiatives with organizations such as [Banque de France](#), the [Central Bank of Brazil](#), and [SETL for the Regulated Liabilities Network](#). These initiatives leveraged many of our stated technology principles and, as a result, we have collectively learned more about key regulatory and market model considerations.

Many of these initiatives have focused on cross-border use cases, as they best demonstrate the need for technical capabilities to manage multi-party workflows across existing and emerging platforms and highlight market model and design requirements. While these are among the most complex use cases, they also provide the best opportunity to identify and evidence core technology and regulatory principles.

In cross-border transactions, the ability of each country or market to operate its own digital currency with its own features, market rules, and regulations is a necessary condition and must be preserved. At the same time, that currency must be able to transact across a technology-enabled global economic network that safeguards privacy, provides security and scalability, and enables interconnectivity across different organizations and legacy technologies, with the flexibility to accommodate future, not-yet-defined use cases.

In this second report, we focus on the practical insight gained from these implementations and our ongoing discussions with policymakers, bankers, payment providers, and potential users worldwide.

1. **Regulatory considerations are paramount**, particularly with regard to cross-border use cases. These use cases have emerged as a priority for initial pilots or implementation since CBDC has the potential to remediate many historical challenges. We are fortunate to have insight from Dr. Giovanni Bandi, Fellow, Cambridge Centre for Alternative Finance on the evolving regulatory framework.
2. **How the specific challenges posed by CBDC create requirements for the underlying infrastructure**. Through real-world initiatives, the key principles we outlined in 2021 have been put to the test, augmenting our learning and expanding our knowledge of implementation requirements. One important learning is that interoperability becomes even more critical, as CBDC adoption will proceed at different speeds, and the greatest value and efficiencies accrue when one CBDC can interact with another. Given the number of CBDC initiatives that are expanding beyond a domestic-only focus to cross-border applications, interoperability is a foundational building block.

3. As the dialog continues and use cases proliferate, we continue to refine our understanding of CBDC from a technology perspective, including the **core pillars that will facilitate design, creation, and implementation**. These are based on specific examples from our experience testing the broad-scale usability of CBDC across complex, multi-party workflows involving different legacy technologies.

An initial wave of pilot projects has already demonstrated the viability of CBDC technology between Central Banks' payment systems. The current wave is focused on pilot programs and use cases that create efficiencies and address the shortcomings of current financial arrangements. This includes creative approaches by central banks to add their liabilities to a distributed ledger platform, allowing some of the benefits of CBDC to be realized today under current rules, regulations, and standard agreements. For example, the Regulated Liabilities proposed by Citi provides a starting point to achieve cross-border payment efficiencies within existing structures and regulations. While these initiatives do not achieve the full promise of CBDC, they are an important first step to lowering credit and liquidity risk and adding to financial stability.

2.0 The regulatory framework required for CBDC

Our initial exploration of CBDC focused on defining core benefits and key market requirements for digital currency, followed by an analysis of the technology framework that would be needed to support those. Now, as CBDC conversations increasingly shift from theoretical to practical, we focus on the real-world realities of market rules and controls, including the reporting, oversight, and supervision that will need to be fully addressed in any cross-border network.

2.1 The need for standards

As CBDC and digitized forms of central bank money emerge, countries and markets will be able to set the level of their participation in international trade and currency movements to a greater degree than otherwise possible. Failure to create a regulatory framework for CBDC could put one country and currency at risk of another's decisions and policies, which is not a tenable scenario. For example, currency substitution, which is already a concern in some economies, could potentially take on new dimensions in the event of widespread access to a strong digitized reserve currency. There must therefore be standards, underpinned by a common technology framework, which support individual market choices across the global economic network. Thankfully, there is a well-established precedent for this.

2.1.1 Standard-setting bodies

To understand the regulatory challenges in cross-border CBDC, it is necessary to be mindful of the jurisdictional requirements and supervisory powers adopted at a national level for a variety of financial regulations.

The similarities often seen in policies and comparable supervisory activities are no coincidence. Most regulators participate in a variety of international committees and supranational bodies commonly referred to as Standard Setting Bodies (SSB).[2] These entities are de-facto informed and lead by the same regulators who are adopting the

standards. Their goal is to promulgate international standards through the development of principles, guidance, and formulations to be adopted, at a national level, with a certain level of discretion.

A jurisdiction's application of rules related to implementation of CBDC frameworks such as AML, retail consumer protection, payments systems, or financial stability matters might differ at a level of national requirements. That does not mean that one jurisdiction is more or less stringent than another; regulatory standards are applied to financial systems over time, often constructed to encapsulate operational legacies and country-level regulatory specifications. It does, however, entail a problem in implementing the Financial Stability Board's ideal of applying relevant existing regulation to that activity or entity according to the "same-business, same-risks, same-rules" principle, as envisioned for stablecoin arrangements.[3] Given that national currency is a matter of national sovereignty, standards among governments issuing CBDC are agreed more broadly in terms of "do no harm" with relation to financial stability and cross border payments.[4]

2.2 An evolving regulatory framework

Evaluations of CBDC are not happening in a vacuum: Regulators and policy makers are undertaking this assessment as new regulations continue to come into force in financial markets worldwide. Any decision taken today on a CBDC regulatory framework will need to be flexible and adaptable enough to integrate new regulations as they are developed and enacted.

Beyond traditional markets, regulators are also evaluating cryptocurrency, tokenization, and stablecoins. For example, a recent study suggested that account-based retail CBDCs should be regulated similarly to wholesale digital funds transfers[5], more commonly identified as payment services acts or electronic money directives. Another comparative analysis on stablecoins by BIS-affiliated researchers identified that central bank infrastructures, like CBDCs or retail fast payment systems, with a role for private sector services built on top, could provide many of the opportunities of stablecoins more effectively[6].

The ability to continuously adapt and embed new regulatory requirements will be essential to maintain the integrity and usability of CBDC over the long term. This will require the ability to push changes out simultaneously, so that every participant in a network is operating with and according to the same set of updated requirements. Smart contract technology running on a distributed framework would provide one way to achieve this.

2.2.1 Different markets, different requirements

Appropriately, each central bank and market is charting its path to CBDC exploration and development based on their own national priorities. Since many focus on domestic use cases for CBDC, their local regulations are sufficient at the moment. Two examples illustrate the diversity of approaches:

1. CBDC legal tender status, at home and across borders

While digital currencies cases of CBDC have been already released in certain countries, the focus of legislators has been on enabling central banks to issue a digital currency and providing its legal tender status. However, policy and

supervisory frameworks have yet to be created. Most countries involved in CBDC pilots have committed to not jeopardizing financial stability and avoiding any sudden shifts to the structure of the financial system.

As one example, consider The Bahamas' Dollar Sand, for which the Central Bank of Bahamas Act was enacted in 2020. Its new definition of currency includes electronic money, and the Act specifically grants the Central Bank the power to issue currency in the form of "electronic money" and powers to prescribe "the framework under which electronic money issued by the Central Bank...may be held or used by the public." [7] However, regulations or policy decisions to extend Dollar Sand usage outside of The Bahamas have not been established.

2. Shifting from domestic to global payments

The stated policy of The Peoples' Bank of China is that the digital renminbi or e-CNY is intended to be used for domestic payments. Currently, more than a hundred million individual users and billions of yuan in transactions use e-CNY. However, it is anticipated that, at some point, China would wish to use e-CNY in global trade. Without a regulatory framework, currency controls might be the biggest challenge to cross-border CBDC, just as they are today. Although China is a leader in global trade, international transactions settled in renminbi account for less than two percent of international payments.

The decision on the international usage of a currency often resides with the legislature or executive branch of government. Once established, general alignment is desirable for key concerns such as ownership, controls, usability, privacy, and security. This highlights the need for a cross-border regulatory framework that can interact with, and respect, local regulations. Fortunately, while the specifics may differ, we see general alignment on key concerns such as ownership, controls, usability, privacy, and security. In addition, central banks are also understandably concerned about being able to extend CBDC and address new scenarios as markets continue to evolve, without having to begin anew or significantly retrofit capabilities that may already be in the market.

2.3 A call for CBDC interoperability, in regulatory terms

Recent studies published by the BIS point out the benefits and difficulties in developing CBDCs operating in cross-border, multi-currency environments. In a comprehensive summary, three interoperability models are identified as options for central banks:

- Using compatible standards, (e.g., similar regulatory frameworks, market practices, messaging formats, and data requirements)
- Interlinking systems via technical interfaces, common clearing mechanisms, or related schemes
- Establishing a single multi-currency payment system [8]

Ad-hoc surveys suggest that central banks prefer the second model, indicating that the upcoming cross-border framework may be a series of domestic CBDC systems connected to a foreign one [9].

From a regulatory point of view, this is probably the best solution, as it isolates national operations and requirements from those of other countries while implying some standardization at international level of the communications between different CBDCs.

However, this demands a CBDC framework that is interoperable, so that a country's CBDC can function at both national and international levels.

It is inevitable that private institutions will, at a minimum, interact with nationally managed CBDCs. The question of which institutions and what type of activities varies by country. What is clear, however, is that interoperability will be required in order to achieve this, and must be supported by the ability to clearly define rights and permissions of various actors. Ultimately, of course, the types of activities will determine regulatory obligations.

The same rationale has been described by the European Central Bank staff when researching regulatory and financial stability perspective on global stablecoins: Stablecoins could be classified under the current financial regulations, but regulatory gaps may exist depending on certain design features, impacting the regulatory requirements for the operators.[10]

2.3.1 Interoperability: A complex, but not unprecedented, regulatory challenge

Creating an interoperable, international system accommodating private institutions is a complex task. Countries will need to consider how they may want to restrict the movement of capital across borders and the risks that currency substitution may present. The ability to control CBDC on each jurisdiction's terms is a necessary consideration for CBDC. However, it is not the first of its kind.

There is a relevant precedent in defining interoperability in a regulatory context, namely that of central counterparties (CCPs) in clearing derivatives. Within the EU trading context, interoperability is defined as the agreement between two (or more) CCPs which allows a member of one CCP to use its "home" CCP to clear trades transacted with a member of another CCP, accessing multiple CCPs (possibly connected to different trading venues) but need only to become member of one.[11] It is the EU Commission who holds the decision on equivalence of the legal, supervisory and enforcement framework in third countries, if a number of conditions are met.[12]

It should be stressed that, even in the case of CCPs operating cross-border, "Access to central bank money for the settlement of payment flows might be more difficult, especially if the two CCPs are located in different currency areas and have different relationships with their respective central banks. It should, in addition, be noted that legal problems may arise if the two CCPs are located in different jurisdictions, and that regulatory coordination might be more complex to achieve, especially if either the CCPs' risk processes or the regulatory frameworks are not sufficiently harmonized. Interoperability may also increase the complexity of settlement arrangements which will take place in multiple locations." [13]

CCPs are able to facilitate cross border trade in securities markets despite a high level of idiosyncratic national regulations. Central Banks could facilitate cross border CBDCs using a similar model for foreign exchange (FX) market that has much less regulation.

Ultimately, the emergence of CBDCs and the development of digitized forms of Central Bank money will allow countries to set the level of their participation in international trade and currency movements to a greater degree than otherwise possible. This creates a number of

inherent challenges—nationally and cross-border—that must be addressed and will require CBDCs that are able to interact seamlessly with one another.

2.4 Prevention and protection: Cyber security, AML, and data protection

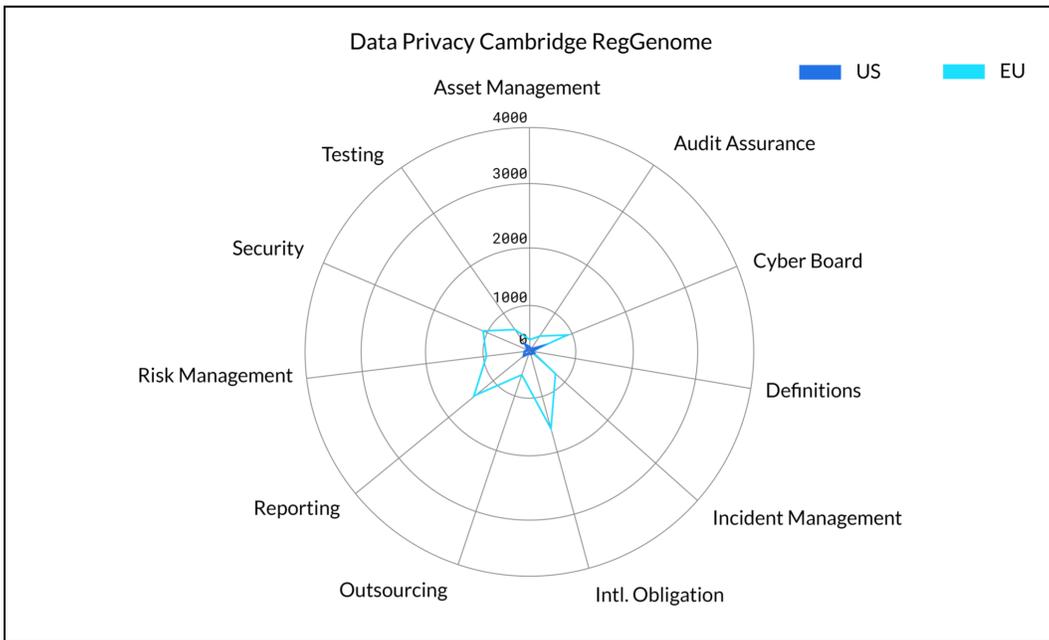
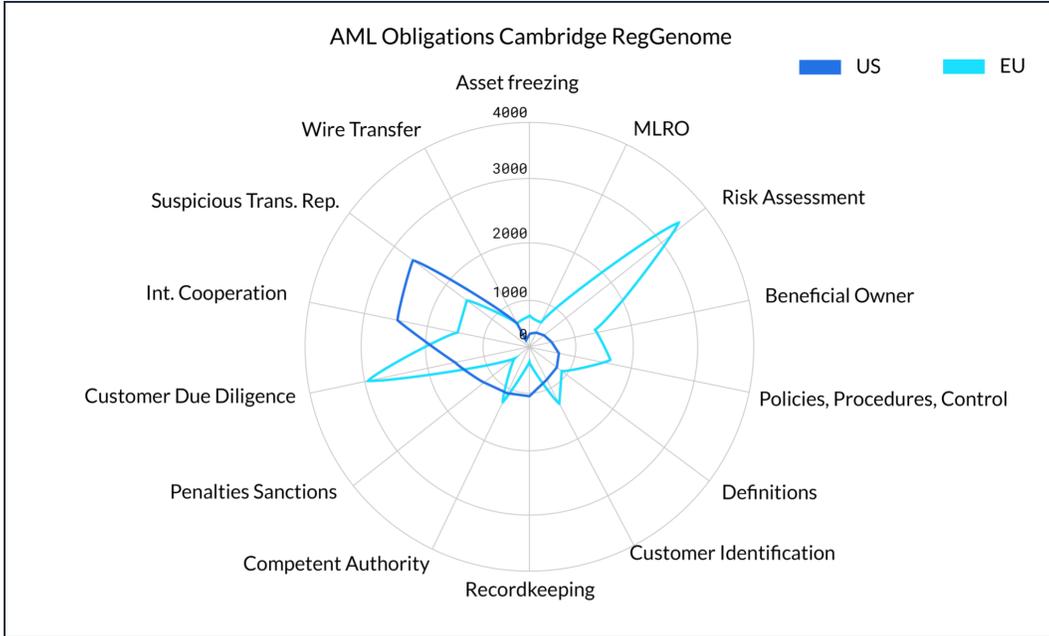
For certain risk stripes in international regulatory standards, and notably AML/KYC rules, the similarity of rules across borders indicates that for regulated entities and their clients the challenge for CBDC may be one of supervision more than new regulation.

As the responsible standard setting body (SSB), The Financial Action Task Force (FATF) is the watchdog for global money laundering and terrorist financing. Its policies include recommendations that obligate financial institutions to conduct customer due diligence, commonly called know-your-customer or KYC, which is part of every business for all regulated entities. FATF's interpretation of Recommendation 15 indicates that Countries should apply the relevant measures to virtual assets and virtual asset service providers alike.[14]

In the context of cross-border CBDCs, the BIS has pointed out that effective identification of users is crucial to every payment system as it “guarantees the system’s safety and integrity, by preventing fraud and bolstering efforts to counter money laundering and other illicit activities.”[15] While this leaves no room for interpretation, the same BIS report also stressed that the identification should occur “at some level” and that “Central banks participating in related CBDC arrangements may cooperate on know-your-customer (KYC) processes, AML/CFT monitoring, and, in a related manner, agree on the level of privacy granted to users when making/receiving cross-currency payments.”[16]

AML regulatory obligations are similar across jurisdictions. An analysis of the obligations through a common interpretative system, the Cambridge’s Regulatory Genome taxonomy, reveals that AML rules are substantially equivalent across jurisdictions. While the analysis reveals a divergent focus on AML sanctions for the US and on risk management for the EU, the requirements in relation to wire transfers and customer identification are very similar. The latter are central to CBDC cross-border transfers, and this commonality of rules implies greater homogeneity of requirements and potentially increased aptitude for interoperability.

The same analysis can be performed for data privacy rules. The output results from the Cambridge University’s Regulatory Genome taxonomy indicates quite a different result. The number of obligations between the two sets of rules are somehow different, raising an issue of conformity or even availability of information on a potential CBDC cross-border transaction. The visual representation in scale portrays the findings of the above study:



We can therefore expect that AML and data privacy standardization across jurisdictions should not be intended exclusively as having the same policies and regulatory reporting framework. In a truly interoperable system, the solution is linked to the interpretation of the regulatory requirements and their enforcement. A cross-border CBDC system ought to be supported by appropriate RegTech technologies rather than rely on a utopian vision of a global rulebook. Even with the precedents of regulatory interoperability discussed before, FATF's, and other SSBs' recommendations still apply, and they are inevitably different at the national obligation level. Hence, the pursuit of equivalencies between CBDCs can potentially use a system that identifies and enriches the required regulatory information.

3.0 Challenges faced in designing and implementing CBDC

Given the regulatory framework discussed above, this section explores the factors that CBDC studies and pilots must consider as they move from research through pilot to launch:

- Basic structural issues, for example, whether to use a tokenized or an account-based system of digital currency
- The types of technology, workflows, and legacy systems that a CBDC will need to connect to in order to be effective domestically and, ultimately, internationally
- The desired business and payment outcomes and efficiencies
- Required safeguards and controls
- The ability to scale with resiliency as volumes climb
- How to design CBDC to support monetary policy objectives
- How to proactively limit barriers to entry and increase adoption

3.1 The international development of digital currency

From a structural standpoint, central banks and policymakers have several options to consider, starting with the type of digital currency. Conversation currently focuses on stablecoins and tokens, which are privately issued, and central bank-issued digital currency aligned to the national currency. Cryptocurrency has largely been deemed unsuitable because the asset's entire history is attached in a way that is visible to every user.

3.1.1 Stablecoins and tokens

CBDC, as a new form of central bank money, should be endowed with special qualities. For example, it would be considered a high quality liquid asset (HQLA) when held by a commercial bank, the most liquid financial instrument, devoid of credit risk that is inherent to commercial bank money. From a regulatory, accounting, and legal viewpoint, CBDC would be a superior asset to hold compared to stablecoins or cryptocurrencies. And thanks to the use of smart contracts, public policy incentives and consumer protection safeguards may be addressed in CBDC.

Stablecoins transform fiat currency into a riskier asset class, for example adding the credit risk of the issuer, but they may also harness innovations in business applications that CBDC cannot. Where CBDC must serve a public good, stablecoins can target a narrow commercial need or address segments of the population. In fact, [Digital Asset is partnering with SETL](#) to tokenize securities as an initial component of the Regulated Liabilities Network proposed by Citigroup. It is conceivable that should stablecoin adoption reach significant levels, the risk of currency and payment fragmentation could impinge on monetary policy, and an international standard for stablecoin governance is not fully implemented.

In addition to the risk of misalignment between commercial incentives and public policy, a national currency should not be reliant on private actors. Currency, and the infrastructure that supports it, are too important to be managed by shadow central bank(s) or issuers who could be beyond the reach of regulators and able to disrupt financial systems. A central-bank-issued CBDC reduces such risks while still allowing other digital assets such as stablecoins and digital tokens to play a critical role in payments and capital markets.

3.1.2 Programmable money

One of the best reasons to develop CBDC is to address the current shortcomings of banking and traditional financial markets. Financial inclusion, sustainable development, and funding rural communities are high on the list of motivating factors for Central Banks.

One example of this is the [LIFT Challenge, sponsored by the Central Bank of Brazil](#), which is focused on tackling these shortcomings through a process where agricultural credits are being tokenized on a Daml platform to facilitate favorable terms of credit to smaller farms and for sustainable agriculture.

Brazil enacted banking requirements to ensure that lending to rural communities would meet a minimum targeted threshold. Repayment capacity and historic loan performance are strong amongst eligible farmers, yet the system struggled with operational difficulties and logistical complexity. Despite financial incentives to develop rural lending, liquidity remained trapped.

Working within the current regulatory framework, programmable money overcomes many of the logistical hurdles that traditional financial approaches could not. With smart contracts, the onboarding process is automated and connected via distributed ledger to a Daml marketplace linking private fund providers directly to the end users. As a result, farmers are no longer reliant on suppliers or local distributors for credit, and financial institutions can deploy their funds profitably, create and bid on loan portfolios, and more easily comply with lending targets.

Agricultural funding in the program can be designated for specific uses—petrol, seeds, fertilizers—so that the agricultural projects and funding requirements are fully aligned. Farm products used in sustainable production, according to ESG standards, may unlock better credit terms. Below-market rates on loans can also be set according to the size of the farm.

The policy ramifications go beyond the importance of the agricultural sector to the economy of Brazil. As a report by the Climate Policy Initiative has found, “After increases in municipal credit supply, rural producers shift their land use from less to more productive alternatives—specifically, pastures to croplands—and also result in an increase in forest areas.” The report notes that the central role played by rural credit in increasing productivity highlights “the ability to use this tool to rebalance agricultural and economic growth with greater protection of its natural resources”.[17]

This use case is replicable in many countries where the performance of rural lending faces similar challenges, where agriculture is an important part of the economy, or where micro credits are not available. The use of smart contracts could increase the possibility for financial inclusion as exemplified in making credit available directly to farmers where before there was none.

The rise of programmable money may strike some observers as a dangerous development. It is important to realize that incentives baked into CBDCs and the payment process would be those defined by national rules. Digital currency makes the existing rulebooks easier to implement, and makes payments and credit faster, cheaper, and smarter.

Most CBDC initiatives begin with the intent to align with naturally-occurring economic structures—both within nations and across borders—but improve outcomes. Based on our

involvement in various projects, we remain confident that CBDC has the potential to solve previously intractable problems. However, we believe even greater value can be created as individual CBDC initiatives plug into a network of interconnected distributed ledgers to create a decentralized, golden source of truth that is shared widely and boundlessly scalable.

This emerging ecosystem of interconnected networks is already being created. Digital Asset calls this the [Global Economic Network](#), where information and value are shared efficiently, and transactions occur seamlessly. Adding CBDC to this ecosystem will expand the value exponentially: Just as organizations are free to transact, unconstrained by organizational boundaries, so too will currency be more readily transferable across borders.

3.1.3 De-risking wholesale payments

To reduce credit and liquidity risk in payments. [Digital Asset and SETL are partnering to tokenize payments for the Regulated Liabilities Network \(RLN\), based on a concept paper issued by Citigroup](#). The RLN would connect a central bank, commercial banks, and payment processors on distributed ledger technology to create a network for their regulated liabilities. Through the RLN, transactions could be executed instantaneously by atomic swap and, for the purposes of payments, by making the liabilities fungible. This results in increased speed, greater transparency in the payments process, and the assured finality of payments.

By using shared ledgers and smart contracts, central banks, commercial banks, and payment processors have a common technology framework to conduct business. This significantly reduces the time to finalize transactions and manage the risk factors involved in payments. RLN maintains the legal certainty around the payment process and does not require new rules or functionality for any of the actors in the payment process.

In tokenizing payments for the RLN, Digital Asset and SETL are using current rules, regulations, and arrangements but managing them through new technologies to capture some of the promise of digital currency today and catalyze further development.

Ultimately the RLN could significantly improve cross-border transactions if it was linked with CDC and expanded, connecting two or more national RLNs into an international network of payments. In this case, the network of networks crosses national boundaries, allowing international transactions to transit between networks. With smart contracts and interoperable technology, different jurisdictions have the flexibility to manage their own privacy rights and protections.

3.2 The future of cross-border CBDC

Cross-border payments are widely regarded as too slow, too expensive, and too opaque. CBDC can make the transfer of money more straightforward, faster, and cheaper (whether peer to peer, customer to business, business to business, across banks, or internationally). To accomplish this, roles, rules, and permissions must be clearly defined for each participant and workflow. Those controls must be perpetuated as workflows extend to multiple parties, and are even more important for cross-border transactions where each central bank may have set different rules for how their currency can be used or transferred.

Digital Asset has been involved in several pilot programs that show, in practical terms, capabilities that should be built into future CBDC ecosystems, such as:

The Bank for International Settlement and the Hong Kong Monetary Authority

The Bank for International Settlement (BIS) and the Hong Kong Monetary Authority (HKMA) use of the extensible nature of Daml applications to provide greater access to financial and non-financial information.

SETL

In the UK and United States, Digital Asset is working with SETL to develop the [Regulated Liability Network](#) to reduce credit risk and liquidity risk in payments. The Daml distributed ledger solution allows commercial banks, payment processors, and the Central Bank to exchange fungible liabilities instantaneously.

Digital Dollar Project

As correspondent banks pull back from foreign markets, the costs and risk of sending money to smaller nations increases. As a member of the Digital Dollar Project, Digital Asset is focusing on cross-border remittances and programmable payments as an area where a Central Bank could foster innovation and better outcomes for its citizens. A central bank using CBDC could provide a low-cost alternative technology solution that both incumbent money transmitters and new entrants alike in order to lower such fees and improve the lives of millions of people.

3.3 Supporting monetary policy objectives

A government-sponsored CBDC would be exempt from the competitive pressures inherent in commercial institutions, such as monetizing users' data, making it ideally suited to serve the public good while prioritizing central bank policy objectives. With CBDC, the central bank can gain greater insight into the real-time impact of monetary policy decisions on the macro-economy, and can calibrate that policy more nimbly.

CBDC could improve the central bank's ability to manage reserves and oversee monetary policy while enhancing its ability to provide benefits to citizens. Examples include:

- Streamlined benefits administration through programmable money, providing citizens with greater convenience and certainty of receipt
- Direct lending to underserved communities
- Prioritized investments in certain sectors of the economy (agriculture lending) or geographic zones (for an emergency response)

CBDC can also improve the ability of a government to respond quickly to unanticipated use cases. For example, extraordinary government payments such as controlled stimulus payments could be distributed rapidly in the wake of natural disasters, stabilizing local economies and promoting recovery.

3.4 CBDC adoption: One size does not fit all

While CBDCs are being developed, there may be a period of hybrid cross-border usage when CBDCs and fiat currency, or CBDC and stablecoins are used as bridges for international payments. The role of the central bank, for developing countries in particular, could target improved outcomes for remittances. For example, using a DLT platform, a central bank could

issue domestic CBDC via bank cards, phone apps, or coupons in exchange for the reserve currency.

The pace of adoption for CBDC is likely to vary widely. A transitional period could see international payments co-existing or even interoperating in a hybrid state. During this phase, cross-border payments mechanisms will include regulated and less regulated methods:

- Cryptocurrencies (such as Bitcoin)
- Public blockchain (such as Ethereum)
- Stablecoins (over 90% are linked to the US dollar)
- Traditional banking rails (e.g., fiat currency)
- CBDC

Regulated cross-border payments during the hybrid phase may include links between a CBDC jurisdiction and fiat-based systems, or between regulated stablecoin and CBDC currencies.

Cross-border payments may ultimately become concentrated between sets of (two or more) national CBDC platforms. Many central bank tests have validated this wholesale banking functionality through CBDC projects such as Aber, Jasper, Jura, Ubin, and others.

What will distinguish CBDC from unregulated cross-border payment activity (stablecoins or cryptocurrency) are the use cases that improve the safety and soundness of the banking system or accomplish beneficial outcomes for society, such as financial inclusion or sustainable development.

In order to remove barriers to entry and facilitate adoption, it is essential that the technology underpinning CBDC be able to connect to different infrastructures, ledgers, and existing payment rails. Otherwise, we run the risk of creating new, different silos that do not deliver the desired benefits and efficiencies.

Early CBDC adopters should not need to significantly redesign or reinvest to extend their capabilities to different use cases, and those who implement CBDC later should not be forced into using the technology decided upon by another nation, just to participate. Rather, CBDC should exist as a network of networks, whereby each nation has control over their CBDC, and the data supporting the transactions, but the design and technology enables and improves both national and cross-border transactions.

4.0 Providing a strong foundation for CBDC

We believe a central-bank-issued CBDC is the better choice, as it delivers significant technological, legal, accounting, and operational benefits both for central banks and across the financial ecosystem. These include:

- **Risk management**, including reducing liquidity and credit risk through transaction finality, the avoidance of currency fragmentation that could come with multiple privately-issued stablecoins, and the reduction or elimination of depository risk.

- **Stability**, including finality of payment through atomic transactions and a reduction in the need for/use of third parties, and the ability to be used as benchmark or underpin interbank payment systems.
- **Growth and inclusion**, with the ability to provide easier access to financial services at lower cost and distribute benefits more efficiently.
- **Privacy and protections**, with embedded rights and permissions, observer roles that facilitate oversight, and the ability to limit data to stakeholders (rather than making it visible to the entire blockchain).

The first wave of experimentation with CBDC illustrated that stablecoins or tokens may have complementary benefits. Tokenized assets are useful for securities transactions (DvP) and trading objects such as non-fungible tokens (NFTs). In the short term, the more advanced state of stablecoins and tokens will allow improvements in targeted wholesale finance or certain retail apps.

However, CBDC is more secure and scalable when two forms of money are being exchanged (foreign exchange, cross-border, or other payment vs. payment exchanges), or for retail purchases and payments. As CBDC projects mature, a comprehensive deployment of a central bank-issued currency would provide a greater stimulus to the economy, as a regulated framework adding stability and confidence to better banking procedures.

4.1 The technology infrastructure

There are multiple options for digital currency, including distributed ledger options, centralized databases, and existing payment rails. As noted earlier, for regulatory reasons central banks favor the creation of systems that interlink via technical interfaces, common clearing mechanisms, or related schemes. In our view, this is the correct approach as it maximizes initial and future flexibility and allows each national CBDC initiative to proceed at its own pace, while preserving the ability for different CBDC programs to interact across a digital global economic network.

Employing a centralized database or locking into a specific ledger provider could restrict new solutions to a particular infrastructure or set of features even before they take shape. Creating a new technology silo could compromise adoption or future usability.

Rather, central banks will want to embed flexibility and interoperability from the start. The approach should be future-proof, allowing for the broadest possible set of uses and greatest flexibility to expand as opportunities arise. This includes looking downstream to equitable adoption by allowing users to choose how they interact with the CBDC. Central banks, counterparties, and payment providers should not have to commit to a particular (or the same) technology or be locked into their initial choice.

Over time, needs may change, necessitating a switch of ledger partners or the ability to work across multiple ledger partners. When and as that time comes, the work already done should be portable, maximizing reuse while minimizing additional investment or any interruption to functionality.

The following technology considerations are critical to successful design and implementation: Safeguards and controls; volume, scalability, and throughput; data privacy;

digital identities; cross-ledger atomicity; composable extensibility; and multi-ledger interoperability.

4.2 Safeguards and controls

The balance between privacy and the ability to retain necessary oversight to prevent illicit financial activity is one of the key challenges for CBDC; thus, technology and design must prioritize safety and privacy. Data must be limited to stakeholders while still allowing auditability and oversight for observers and regulatory bodies.

Privacy should be a key factor in determining the underlying technology on which CBDC is built and deployed.

- Privacy standards on most blockchains are underdeveloped, leaking information about transactions and individuals to the world. Some chains have addressed some, but not all, of the privacy concerns; however, they lack the ability to guarantee their privacy mechanisms across chains.
- While crypto markets and tokens have made efforts to improve privacy with add-on features, the asset's entire history remains attached in a way that is visible to every user.
- Stablecoins also suffer from an effective lack of privacy. Since all participants in the stablecoin network can inspect the history of transactions, data segregation is not achievable and only pseudo-anonymity can be achieved. This is not sufficient for a national digital currency.

A CBDC should feature privacy within, as well as across, ledgers. Therefore, privacy standards must be embedded at a foundational coding level. This is possible with smart contracts, which incorporate safeguards in the CBDC when it is created which can be updated over time as needed.

4.3 Volume, scalability, and throughput

CBDC must be scalable, secure, and able to meet rigorous performance standards. This includes being able to cope with ever-increasing transaction volume without any upper limit on the number of possible transactions—providing stability and reliability to maintain confidence and smooth market and payment operations; adapting to unforeseen circumstances or requirements; and supporting emerging use cases.

Here, not all blockchains are equal. Recently published tests by the Federal Reserve Bank of Boston [18] that focused on the payment engine capacity concluded that traditional blockchain architecture is not ideal for maximizing transaction throughput or settlement finality. Some estimates would see throughput (transactions per second, or tps) rising from the low thousands per second to the low millions.

Operating at the size of a national economy requires the right design and technology that can scale in a linear fashion. Decentralized distributed technology, combined with smart contracts, has attributes that limit the amount of data shared, making it a better option for CBDC:

- Data rights are determined on a need-to-know basis. This means that only the data essential to execute a transaction is shared with only the parties that require access to data.
- A decentralized distributed ledger improves network performance and resiliency as compared to traditional blockchain architecture where all information circulates.
- The network in aggregate maintains one single, golden source of truth, resulting in both a more sustainable network and better protected data.

Digital Asset has proven the ability of decentralized distributed ledger technology to manage high throughput, with the ability to scale to meet spiking volumes with resiliency. The production replacement for the [The Australian Stock Exchange's \(ASX\)](#) aging equities post-trade clearing and settlement solution demonstrates that this technology is capable of meeting the rigorous demands of systemically important infrastructure with uncompromising stability and performance.

4.4 Data privacy

A CBDC solution should feature privacy across, as well as within, ledgers. While every central bank will set their own standard, the technology should support stringent privacy protocols whereby:

- A central bank does not centrally hold the personal identity of CBDC holders or detailed transaction data.
- Individual users do not know the source and use of each CBDC. Parties to a transaction would only know that step of the transaction, and transactions would not be visible to those involved in preceding or following transfers, except as desired and arranged.
- Ownership is known and can be closely controlled or restricted, enabling conformance with know your customer (KYC), anti-money laundering (AML), countering the financing of terrorism (CFT), and other compliance requirements.
- Transactions can be audited and tracked, since data and contracts (to the lowest level of identification) are stored along with the history of each transaction. The set of observers for each smart contract can be customized to allow for more transparency and visibility.
- Data minimization enables the right to forget, enabling compliance with laws, regulations, and stringent standards, such as General Data Protection Regulation (GDPR).
- Strong and resilient governance and security can be achieved with a ledger that is updated in real time, auditable, and supports supervisory oversight.
- A component approach is used for data governance, workflow, data modeling protocols, and business interactions, preventing accidental data leakage, hacks, and break-ins.

Building privacy protocols into the sub-transactional level of a contract allows for separate “observer” roles that permit oversight without access to the user’s personal data or private aspects of the transaction. Confidential information resides with its owner (regardless of whether blockchain or traditional databases are used), and rights and permissions are set at a granular level to protect the “need to know” principle. This helps to limit the scope of data used, minimizing the potential for data breaches or other exposures of personal information

while still allowing authorities to monitor the legality of transactions.

This is particularly important for cross-border transactions such as remittances, where data is crossing multiple jurisdictions. It is critical that the underlying technology ensures that only the minimal set of required data is shared and only according to defined roles, rights, and obligations.

4.5 Digital identities

Digital identities are crucial for linking legal entities to their digital representations. Participants in the payments network must be able to identify who their counterparties are as well as their roles. Knowing the identity of your counterparty is such a crucial requirement that it must be captured within the solution.

Cross-border remittances preclude a centralized solution to digital identities since the transactions cross jurisdictions. The different participants of the network must be able to themselves define which source of information for digital identities they want to trust.

The need for a solution to span organizational (and national) boundaries reinforces interoperability as an imperative. For practical and equitable market access purposes, it cannot be assumed that all market participants would or could choose the same infrastructure. Yet in order to have a robust cross-border transaction flow, different market participants must be able to connect across different solutions.

4.6 Cross-ledger atomicity

With atomicity, every leg of a transaction must succeed for the transaction to complete. By ensuring atomicity, systems can achieve PvP and DvP without the risk of handing over goods when the payment leg fails and without the need for a depository institution or a central bank to act as an escrow.

Certainty of transfer and settlement is essential for cross-border remittance workflows. Enabling such transfers and settlements to be atomic—enabling direct transfers without requiring third party intermediation—would significantly improve the current process by eliminating fails and ensuring transparency throughout the transfer process.

4.7 Composable extensibility

Composable extensibility enables new applications to be added dynamically and supports connecting to other networks easily—from existing infrastructures to the most sophisticated emerging ledger solutions. Without composable extensibility, institutions will reinvent the wheel when future technologies arise or when there is a need to deploy future use cases to the same infrastructure. Since it is impossible to determine in advance all potential uses for CBDC, it must be easy to build new applications or add connections to other networks if CBDC is to be widely adopted and expanded.

Importantly, future use cases must not require changes to the initial implementation and must continue to provide frictionless transactions between parties. Extensibility is particularly relevant for cross-border remittances, as the implementations should not be looked at in isolation. A remittance solution should be leverageable in different or new workflows that emerge over time, without having to be rewritten or redesigned.

4.8 Multi-ledger, interoperable technology

This enables digital currency systems to be deployed and connected across disparate networks, regardless of the underlying IT infrastructure. It is the key to enabling compatibility with other CBDCs, since there will be no single master ledger, and because some CBDCs may not use DLT.

With Digital Asset's smart contract Daml application framework running on [Canton](#), an integrated, privacy-enabled distributed ledger, multi-ledger interoperability becomes attainable. Canton enables any Daml-based ledger to be distributed via participant nodes, with advanced synchronization protocols that ensure the participant's ledger remains in a valid state at all times.

This technology also removes the risk of locking into potential technology stacks or ledger providers before the full scope of CBDC requirements are defined. Applications built with Daml are fully portable and built on a framework that enables them to be kept as a standalone solution or expanded, extended or connected when and how the owner chooses.

While many CBDC use cases are initially and intentionally limited in scope, the broad applicability of a digital currency demands a high degree of flexibility and connectivity. Ensuring that a CBDC is compatible with other CBDCs is a critical first step to preventing the CBDC from hitting a dead end in cross-border applications.

5.0 Conclusion

The ongoing exploration of CBDC has shifted from philosophical to practical, with multiple pilot programs exploring different use cases within and across markets. We have been fortunate to be part of this initiative at multiple levels, and based on our experience, continue to refine our own thinking about CBDC.

While cross-border use cases may seem to be a complex initial use case to tackle, the ability to manage cross-border payments, remittances and currency flows is actually a natural and logical ground to test CBDC requirements and identify challenges.

Naturally, cross-border use cases bring questions of regulation into sharp focus. With CBDC and digitized forms of central bank money, countries will be able to set the level of their participation in international trade and currency movements to a greater degree than otherwise possible.

Most central banks prefer a model of interlinking systems via technical interfaces, common clearing mechanisms, or related schemes. This allows them to control the use and regulation of their own CBDC while still allowing it to transact with other CBDCs, as long as the rights and permissions of various actors can be clearly defined. Ultimately, the types of interaction will determine the regulatory framework needed.

The underlying technology must be able to support a regulatory environment that has a variety of standards for different types of transactions or asset classes and for different

jurisdictions or national priorities. Nonetheless, a clearer picture is emerging for CBDC design, which must:

- Be grounded in privacy with the roles, rights, and permissions of different actors clearly defined and full auditability and traceability.
- Provide the central bank with the ability to develop CBDC and define initial use cases, with the flexibility and interconnectivity to support future applications that may not yet be known or in scope.
- Assure transaction finality and certainty of settlement.
- Be scalable and resilient to support high transaction volumes that are likely to increase significantly over time.

The development of CBDC represents a generational opportunity to expand the central bank ledger to additional users, enabling important structural changes and accelerating innovation without disrupting existing payment rails. This report has focused on the regulatory and technical framework for CBDC, but there are other important conversations underway about implementation, particularly on the elimination of depository risk and the evolving role of banks.

Those conversations will continue even as pilot programs continue to progress. Collectively, these initiatives are the next steps towards a future. CBDC has the potential to deliver significant efficiencies and benefits that only grow as different CBDCs connect to one another, creating a global economic network where value and information flow freely.

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