Central Bank Digital Currencies (CBDCs)

An update on rationales for issuance and systemic design considerations

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Abstract

This paper provides a late-2022 update on the state-of-play regarding the possible issuance of central bank digital currencies (CBDCs), focusing on higher-income economies with good electronic payments systems. We begin with a summary of the major rationales for CBDC issuance that appear to be finding favour in various jurisdictions. Based on the factors which could influence decisions to progress with issuance of CBDCs, we discuss some implications for, and constraints regarding, the design of CBDCs. We argue that the identification, assessment, and piloting of specific CBDC use cases will be an important element of CBDC research. Policy decisions regarding CBDC issuance and design should be based on use case categories that are assessed as being high priority for the jurisdiction in question, and technology selection can then be targeted to the intended use cases for CBDCs. It is quite possible that jurisdictions might decide to implement more than one form of CBDC, and we conjecture that 'wholesale' CBDCs – which could be important building blocks of the financial system of the future – might feasibly be implemented ahead of 'retail' CBDCs in some markets.

Introduction[1]

There has been a significant step-up recently in work on central bank digital currencies (CBDCs). Central banks of a few jurisdictions (the Bahamas, the Eastern Caribbean Central Bank, Jamaica and Nigeria) have introduced CBDCs for household and business use, with goals focused on payments modernisation and boosting financial inclusion, while the People's Bank of China has extended its pilot into some large cities and regions and is expected to proceed to full issuance. Most central banks in higher-income economies are actively researching and experimenting with CBDCs, but none has yet taken a decision to proceed with issuance.

This short paper provides a late-2022 update on the state-of-play regarding the possible issuance of CBDCs. It is not intended to serve as a comprehensive overview of CBDCs, but rather to provide our assessment on what can be learned to date from the huge amount of literature, discussion and experiments involving CBDC over the past five years or so. The focus of the paper will be on higher-income economies (like Australia) with good electronic payment systems, though in places we will also discuss the issues from the perspective of other jurisdictions.

We begin with a summary of the major rationales for CBDC issuance that appear to be finding favour in various jurisdictions and we also briefly point to some other suggested rationales for issuance that we do not expect will be particularly persuasive for central banks. Based on the factors which could influence decisions to progress with issuance of CBDCs, we discuss some implications for, and constraints regarding, the design of CBDCs. Finally, we review some of the technology choices that have been taken

[1] This paper was prepared for the 17th Central Bank Conference on the Microstructure of Financial Markets, Sydney, 8-9 December 2022. The authors are, respectively, Chair of the CBDC Steering Committee and Chief Executive Officer, at the Digital Financial Cooperative Research Centre. Contact details: info@dfcrc.com.

in some early CBDC experiments and implementations to date and we provide some thoughts about possible technology directions if there was to be broader issuance of CBDCs.

Background

While the paper will not provide a detailed introduction to CBDCs, there are a few important characteristics of CBDCs that are worth stressing as context for our paper. In particular:

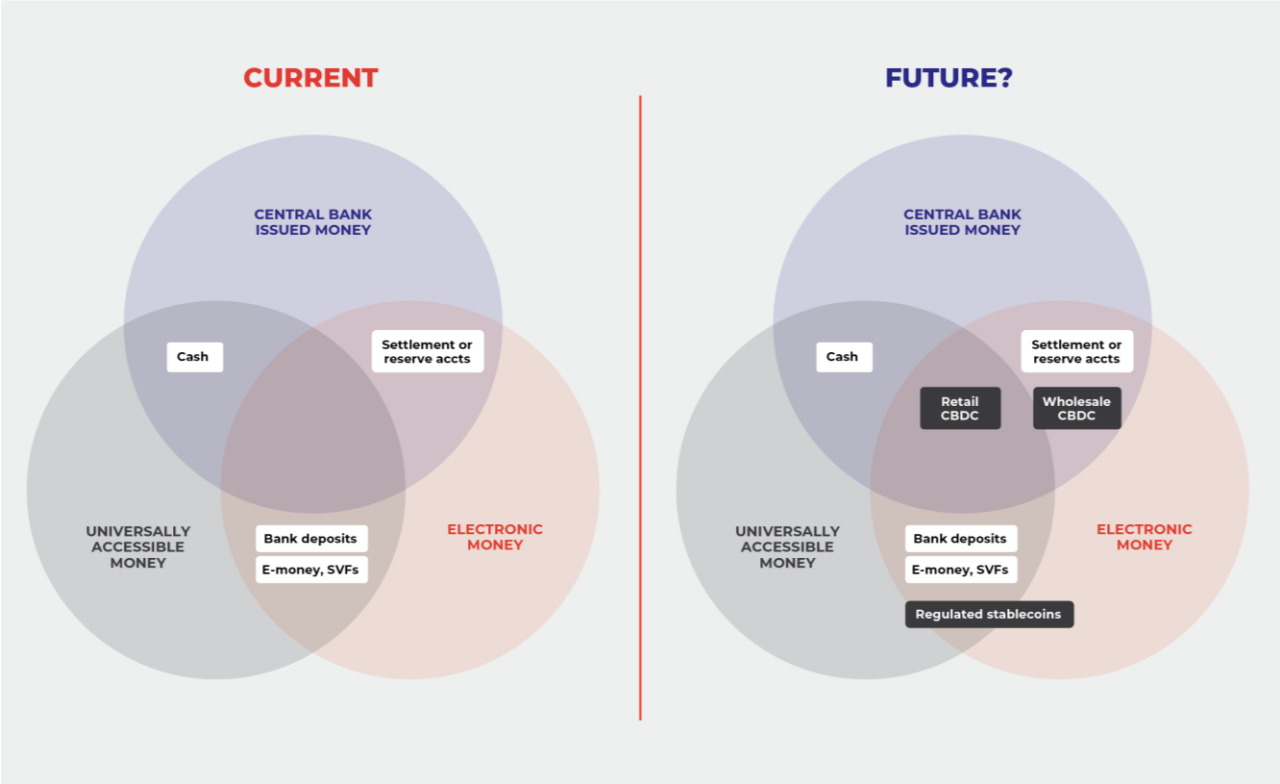
- CBDCs would represent new forms of existing sovereign/national/fiat currencies (e.g., the Australian dollar, US dollar or Euro), quite different to so-called cryptocurrencies. CBDCs would be exchangeable at par for other existing forms of national currencies and would presumably be explicitly specified to be a form of legal tender in their respective jurisdictions.
- CBDCs would be digital or electronic in nature (either an account balance or an electronic token) as opposed to being in physical form (like banknotes and coins). Issuance of CBDCs would presumably utilise insights from recent advances in cryptography and might draw on some of the technical building blocks of cryptocurrencies such as bitcoin, but (as we discuss below) it still very much an open question as to whether CBDCs would rely on distributed-ledger technology (DLT) and blockchains.
- CBDCs would be a liability of (or claim on) the central bank (like existing settlement or reserve account balances, and banknotes) as opposed to a liability of a commercial bank or other regulated deposit-taking entity.

This paper argues that an important element of the current evaluation of the case for CBDCs should be to establish what use cases are potentially to be serviced with CBDC, and then to consider what a fit-for-purpose CBDC could look like from the perspective of such use cases. If use cases and their requirements vary significantly, a central bank could issue different types of CBDC just as it currently issues different types of central bank money (see Figure).[2] These could potentially rely on different technologies and presumably would have differences in business rules (e.g., who could hold them, whether they earned interest, etc). Central banks could look to provide one or more of:

- A ‘retail’ or ‘general-purpose’ or payments-oriented CBDC for general use by households and businesses, where the central bank would presumably leave distribution and customer-facing activities to payment service providers; this would be a similar model to the distribution of banknotes in many countries today.
- A ‘wholesale’ or ‘institutional’ CBDC or new form of electronic claim for use by only a limited range of entities, largely in higher-value use cases; this could be like existing settlement or reserve account balances, but in a new form.
- Special-purpose CBDCs with properties specifically targeted at one or more use case categories, for example these could be categories like cross-border payments, atomic settlement in B2B marketplaces, regulated stablecoins, etc.

[2] A brief indication of magnitudes may be relevant. Bank deposits are by far the largest category of money in advanced economies, often 10 to 20 times larger than currency on issue. The size of settlement or reserve accounts varies significantly depending on institutional arrangements (including whether there are reserve requirements). In Australia, where there are no reserve requirements and where access to central bank accounts (known as exchange settlement accounts) is explicitly for settlement purposes, such balances were traditionally quite small until the recent expansion in the policy response to the pandemic.

FIGURE: Different forms of money



It is worth noting that new forms of private-sector retail payment instruments might conceivably be facilitated by the issuance of 'wholesale' CBDCs. For example, assuming that central bank access rules and the regulatory framework permitted it, wholesale CBDC could potentially serve as backing for stablecoins issued by private-sector entities to households and business. IMF researchers have proposed that such assets be called 'synthetic CBDC'.[3]

For the purpose of this paper, we do not consider any products issued as a claim against a commercial entity to be CBDC, even if they are enabled by CBDC held by the issuer (e.g., stablecoin provider). We adopt the assessment by the Bank for International Settlements and the G10 central banks that "these liabilities would not be a CBDC, as the end user would not hold a claim on the central bank. They are, essentially, a form of "narrow-bank" money."[4]

Finally, it might also be worth noting that most discussion of CBDCs in the everyday media is about retail CBDCs (e.g., China's e-CNY, or Sweden's potential e-krona) but the majority of the experiments and pilots that have been published by central banks to date have actually involved prototype wholesale CBDCs.

[3] See Tobias Adrian and Tommaso Mancini-Griffoli, 'The rise of Digital Money', IMF Fintech Notes, July 2019.

[4] See 'Central bank digital currencies: Foundational principles and core features', Bank for International Settlements, October 2020.

Likely rationales for CBDC issuance

No high-income country has yet taken a decision to issue a CBDC. The European Central Bank, which is following a very open and detailed process in its consideration, appears closest.[5] It took a decision to launch an 'investigation phase' in July 2021 and will prepare advice on a 'design and implementation plan' for its Governing Council to take a decision in September 2023 regarding whether to launch a 'realisation phase' which could take around three years, implying possible CBDC issuance around late 2026. In contrast, some other central banks appear much less convinced that a policy case exists for issuing a CBDC, with one US Federal Reserve Governor giving a speech in 2021 entitled 'CBDC - A Solution in Search of a Problem?'.[6]

Despite the absence of any decisions to move towards CBDC issuance in higher-income economies, the significant amount of material published by central banks allows us to highlight some of the rationales for CBDCs that we expect these jurisdictions may find reasonably persuasive in considering the case for issuance.

To help maintain the availability of central bank money to households in everyday life

Some central banks, most notably the European Central Bank and Sweden's Riksbank, have highlighted that central banks have long provided banknotes, a form of safe and universally available money, for use as a means of payment and store of value for households. They have noted that the provision of 'central bank money' (both currency and settlement balances) supports confidence in the use of 'private money' (accounts at commercial banks, other deposit-taking institutions or e-money providers) and in the financial system more broadly. However, with the ongoing shift to electronic payments, the declining use of cash is placing pressure on the economics of cash distribution in some countries, possibly leaving households with no alternative but to only use private money in their day-to-day lives. Accordingly, some central banks have indicated – notwithstanding the presence typically of deposit insurance schemes that safeguard households' holdings of private money – that they see a strong case for considering the issuance of retail CBDCs, a new form of safe and universally available money.

To promote competition and privacy in the payments market

A related concern for some central banks, particularly the European Central Bank, has been that the shift to electronic payments raises the risk of a reduction in competition in the payment services market, and growing market power for large banks, international payments schemes and technology companies. This reflects the tendency for a small number of players to dominate industries such as payments, where there are strong network effects. Such concerns were heightened by the proposed launch of the Facebook-backed Libra/Diem payment system in late 2019. By introducing CBDCs and associated rule-books, central banks could provide a new interoperable form of digital money that could potentially stimulate competition between different private-sector service providers, with appropriate safeguards for financial privacy.

[5] See 'Progress on the investigation phase of a digital euro', European Central Bank, September 2022.

[6] See Christopher J Waller, speech to the American Enterprise Institute, Washington, D.C., 5 August 2021.

As a response to possible adoption of alternative digital currencies

A number of central banks, in both higher-income and emerging economies, have pointed to the risks if there was to be a shift away from their domestic currency towards the use of alternative digital currencies – either CBDCs or stablecoins denominated in some other sovereign currency, or cryptocurrencies. Widespread substitution away from the domestic currency could in principle threaten a country's monetary sovereignty and reduce the ability of the central bank to influence domestic monetary conditions and to act as the lender of last resort if required. The argument is that by providing households and businesses with access to a new digital form of the domestic currency, it may be possible to reduce the likelihood of a shift to other forms of money. For example, this was one of the rationales cited by the Bank of Canada in announcing that it was planning to build the capacity to issue a retail CBDC if required.[7] A related rationale for CBDC cited by both the US Federal Reserve and European Central Bank is that it could help support the international role of their currencies.[8]

To improve the resilience of the payments system

The declining use of cash (and cheques, where they still exist) points to the growing importance of the resilience of the electronic payments, and the risks of outages from natural disasters, systems failures or cyber attacks. A number of central banks have pointed the possibility that the introduction of a CBDC, especially if it enabled offline use and relied on different technology to existing electronic systems, could improve resilience.

To improve financial inclusion

Even in some high-income economies, there may be a material proportion of the population who do not have good access to electronic payments, for example due to issues with establishing identity and opening banks accounts, or because of the cost of existing banking and payments services, or due to difficulties in using existing forms of electronic payments. Proponents of CBDCs argue some of these issues might be addressed with a CBDC that was supported by a user-friendly interface and low-cost payment services. The goal of improving financial inclusion and promoting the adoption of digital payments was recently highlighted by the Reserve Bank of India[9] and has been cited by some of those of jurisdictions that have already issued CBDCs.

To serve as a catalyst for innovation in the payments market

The growth of the cryptocurrency and DeFi sectors has pointed to a range of opportunities that arise from the use of new technologies in payments. Many central banks have noted the possible benefits to the real economy from issuing new tokenised forms of central bank money, including from the use of smart contracts to enable programmable or contingent payments.

To facilitate new means of settlement for transactions in tokenised assets

Similarly, there are potentially significant benefits in the financial sector from the issuance of CBDC. One obvious use case is the issuance of CBDCs to provide an alternative 'on-chain' settlement asset to private stablecoins and to facilitate 'atomic' and delivery-versus-payment settlement of transactions in tokenised

[7] See Bank of Canada, 'Contingency Planning for a Central Bank Digital Currency', February 2020.

[8] See for example 'Money and Payments: The U.S. Dollar in the Age of Digital Transformation', Federal Reserve Board, January 2022.

[9] See 'Concept Note on Central Bank Digital Currency', Reserve Bank of India, October 2022.

assets, thereby reducing systemic risk. Indeed, to date many of the CBDC experiments reported by central banks have involved wholesale CBDC in financial market applications. And a number of central banks, including the Reserve Bank of Australia and the Monetary Authority of Singapore have indicated that they see a stronger policy case for issuing wholesale CBDCs than retail CBDCs.[10] In Australia, examining the financial markets use cases for CBDC is a major focus for the new Digital Finance Cooperative Research Centre (CRC).[11]

To help improve cross-border payments

There has been increasing focus on CBDCs as a potential tool for improving cross-border payments, especially following the 2019 Libra/Diem stablecoin proposal, which was initially marketed largely in terms of bringing down the cost of remittances and other cross-border payments. Most of the focus for central banks has been on the use of wholesale CBDCs, based on their ability to improve cross-border interbank settlement given their likely 24/7/365 availability and potential to give access to central bank money to a wider group of entities, possibly including foreign banks.

Commentary

It should, of course, be noted that issuance of CBDCs would not be the only way to achieve some of these goals discussed above. Many of the improvements that could be enabled with CBDCs could potentially also be enabled by private-sector innovation centred around private money (commercial bank money, e-money or stablecoins) rather than central bank money or via regulation to encourage or prevent particular actions by private-sector providers. An observation that might be made in this regard is that those jurisdictions that have already taken the decision to issue retail CBDCs tend to be ones with payment systems that have not been meeting many of the needs of households, so that a CBDC was viewed as a way to significantly uplift the domestic payments system. More broadly, the periodic surveys of central banks conducted by the Bank for International Settlements have shown that CBDC issuance is considered significantly more likely in emerging economies than in higher-income economies.[12]

It may also be worth noting some potential rationales for CBDC issuance that are frequently mentioned, but which we do **not** consider will be significant drivers of CBDC issuance in higher-income economies.

- There is no evidence that advanced economies are considering introducing retail CBDCs as a precursor to the removal of cash. Central banks in numerous jurisdictions have indicated quite clearly that any CBDC would be introduced as a complement to cash and that they intend to ensure that cash remains available as a viable payment instrument as long as households have a need for it.[13] That said, we note that some emerging economies view the introduction of CBDC as a possible way to accelerate the shift from cash towards more efficient electronic payments. For example, the introduction of the Sand Dollar in the Bahamas was partly motivated by the high cost of moving cash around the nation's 700 islands.

[10] See e.g., Tony Richards, Chris Thompson and Cameron Dark, 'Retail Central Bank Digital Currency: Design Considerations, Rationales and Implications', Reserve Bank of Australia Bulletin, September 2020, and 'A Retail Central Bank Digital Currency: Economic Considerations in the Singapore Context', Monetary Authority of Singapore, November 2021.

[11] See https://dfcrc.com.au/.

[12] See Anneke Kosse and Ilaria Mattei, 'Gaining momentum – Results of the 2021 BIS survey on central bank digital currencies', Bank for International Settlements, May 2022.

[13] See, for example, Raphael Auer, Giulio Cornelli and Jon Frost, 'Rise of the central bank digital currencies: drivers, approaches and technologies', Bank for International Settlements, August 2020 who survey a large number of CBDC research efforts and conclude that "none of the designs we survey is intended to replace cash; all are intended to complement it."

- We do not see much evidence that central banks are considering CBDCs based on a range of rationales that might be described as 'improving the implementation of monetary policy'.[14] [15]
  - We see little evidence that central banks are seriously considering potential benefits from the possible ability to impose negative interest rates on CBDCs. While some academics have suggested this attribute could be useful in alleviating the 'zero lower bound' constraint to monetary policy,[16] we note that many central banks appear to be starting from a default position that retail CBDCs would carry the same zero interest rate as banknotes, and we expect that governments and legislatures would also be inclined to this position.
  - We do not expect that central banks will put any significant weight on some views that CBDCs could be implemented as a way to facilitate 'helicopter money drops' or other unorthodox monetary policies. Conventional fast payments systems (e.g., Australia's New Payments Platform) can already be used to make emergency real-time payments to households on a 24/7/365 basis.
  - More broadly, while some academics have viewed CBDCs as a way to reduce the effects of frictions in deposit or loan markets,[17] and some observers have embraced CBDC as a way to reduce the role of commercial banks in the financial system, this does not seem to be a consideration for central banks. Relatedly, we are also not aware of any evidence that central banks are viewing the introduction of CBDC as a device to increase seignorage income.
- Although some have suggested that issuance of CBDC could be a tool to allow central banks and other policymakers to get better data on aggregate spending and economic activity, this does not seem to be a factor that central banks are pointing to. As a number of jurisdictions have learned recently, including during the pandemic, it is already possible to collect much-improved high-frequency data on electronic transactions from large banks and/or payment schemes operating within their jurisdictions; it is unlikely that additional data from CBDC transactions would represent a sufficient additional improvement to justify the significant cost of implementing a CBDC.
- Finally, notwithstanding the concerns expressed by those with a 'libertarian' bent or who are mistrustful of the public sector, there is no evidence that central banks in advanced economy jurisdictions have any desire to introduce CBDCs to somehow enable visibility or control over the spending of citizens. As we discuss below, the two-tiered CBDCs that are being discussed by central banks in these economies quite simply contain no role for the central bank to see customer-level payment details.

Considerations, implications and constraints for CBDC design

The motivations for, and potential expected benefits from, CBDC are likely to vary significantly across countries. Different jurisdictions are likely to have different views as to which of the motivations discussed

[14] A discussion of these issues in 'Central bank digital currencies: foundational principles and core features' (a report by the BIS and G10 central banks) ends with "Monetary policy will not be the primary motivation for issuing CBDC."

[15] While some of these rationales might find favour with academic monetary economists, we do not expect that they would resonate in the broader community. They might also fall foul of the suggested Principle 3 in the 'CBDC Manifesto' recently released by a broad group of interested observers: "A CBDC should not be designed in a way to do harm to society, e.g., via very negative interest rates, or via so-called programmable money that restricts the use of money for specific types of expenditures (e.g., special food and beverages, computer games etc.) or that expires after a certain amount of time. A CBDC should be based on principles of self-determination and freedom."

[16] See e.g., Michael Bordo and Andrew Levin, 'Central Bank Digital Currency and the Future of Monetary Policy', NBER Working Paper No 23711, 2017.

[17] For an overview of theoretical modelling in this area, see Sebastian Infante, Kyungmin Kim, Anna Orlik, André F. Silva, and Robert J. Tetlow, 'The Macroeconomic Implications of CBDC: A Review of the Literature', Federal Reserve Board, November 2022.

above are the highest priorities for their payments systems and financial markets. These priorities should dictate the design of any CBDCs, with the implication that the design of CBDC systems might vary across countries where the intended outcomes of CBDCs differ.

Decisions about the design of possible CBDCs should also take account of evidence on proposed use cases for CBDCs from the projects that some central banks are currently undertaking. For example, in Australia, the Reserve Bank and the Digital Finance CRC are involved in a project which has called for entities in the payments industry to propose use cases that could leverage a CBDC and might not be feasible using existing payments infrastructure. A selection of these use cases will be invited to operate in early 2023 on a pilot platform with real CBDCs that are a claim on the Reserve Bank. Evaluating the potential impact of proposed CBDC use cases in such studies will both help establish whether an economic rationale for CBDC exists in the particular jurisdiction and should inform an assessment of which use cases would represent priority targets for a potential CBDC implementation. In turn, this prioritisation would help determining the parameters for a potential initial CBDC, targeted to priority use cases.

While we do not yet have any significant learnings from the RBA/DFCRC project, we attempt here to speculate about possible high-level design considerations for CBDC, based on the drivers for CBDCs discussed above and the pilots and experiments to date.

First, **jurisdictions might well decide to issue more than one form of CBDC**. Different types of CBDCs (presumably retail versus wholesale) would have different purposes and probably different interfaces and technologies, and different business (and access) rules. However, central banks would ensure that they would be exchangeable at par for each other and for other forms of domestic money.

It seems clear that **central banks in higher-income economies are all expecting that any retail CBDCs would use two-tier (or intermediated or platform) models**.[18] [19] That is, central banks would be responsible for 'minting' and for issuance of CBDCs to private-sector distributors (and depending on the technology used might also be involved in the settlement of transactions). These private-sector payment service providers (PSPs) would handle all the customer-facing activities such as distribution to households and businesses, account-keeping, and customer verification including know-your-customer (KYC) and anti-money laundering and counter-terrorism financing (AML/CTF) checks. Payment services could potentially be offered by a broader range of entities than currently; a two-tier model could facilitate new entrant PSPs which would not need a balance sheet of household deposits.

The default in any two-tier model would be that the central bank would not see customer-level details, even if it was involved in the settlement of transactions. So CBDCs could not be a device for central banks to monitor the transactions of households. For those readers who remain sceptical, the design of some of the recently introduced fast-payments systems might be instructive. For example, in Australia's New Payments Platform system, the Reserve Bank effects real-time settlement of every single transaction. However, the settlement message flow to the RBA contains only the payment amount and the two financial institutions involved. The clearing process requires financial institutions to exchange information about customer accounts between themselves, but this is not shared with the RBA.

[18] For example, page 13 of 'Money and Payments: The U.S. Dollar in the Age of Digital Transformation', the Federal Reserve Board, January 2022, indicates that the Fed is starting from this presumption.

[19] For wholesale CBDCs, however, the default would presumably be for a single-tier model, consistent with the way that central banks operate settlement or reserve account systems for commercial banks and similar entities.

To justify the effort of designing and implementing a CBDC, **the case to introduce CBDCs will presumably depend on them being able to at least match existing payment methods in many ways** (ease of use, speed, finality of transactions, etc) **but also to improve on them in some significant ways**.[20] We expect it will be particularly important for any general-purpose CBDC to be able to enable programmable/conditional payments, as well as offline and 'smart card' use, to ensure that it is remains possible to make electronic payments at times of power and network outages and in remote areas, as well as more broadly meeting the needs of current cash users.

Of course, it is not guaranteed that there would be significant demand for retail CBDC in jurisdictions where there already is a well-functioning retail payments system. Central banks would just be providing the 'raw' payment instrument and some back-end processing, with limited influence over the user experience (including any costs to users), which would be mostly in the hands of PSPs. More broadly, introducing a totally new payment method is never straightforward because it must be designed to be attractive to both sides of the market and must be made interoperable with various elements of the existing payments infrastructure. Accordingly, it may not be surprising that adoption has been very slow to date in some of the jurisdictions that have adopted retail CBDCs.[21]

However, with CBDCs presumably being denominated as legal tender and businesses potentially being under an obligation to accept CBDCs as a form of payment, the task of promoting CBDCs would presumably be made easier than otherwise. In addition, central banks may be able to influence payments providers by demonstrating what can be done with CBDCs in proofs of concept, via moral suasion/encouragement etc, or by relying on regulations or standards. For example, the European Central Bank is considering a payment scheme approach for a digital euro, involving a common rules-based framework for participants to develop their products, with the goal of facilitating a homogenous end-user experience and interoperability with other forms of the euro via standardisation.

However, if retail CBDCs are to be implemented, central banks will also be very mindful of the risks that would result from their new CBDCs being 'too successful' and resulting in unintended or undesired consequences. That is, central banks may be looking for a Goldilocks outcome – neither too little demand, nor too much.[22] We expect that central banks will be very careful that the introduction of CBDCs should not bring about major unintended changes to the structure of the financial system. In particular, there is the concern that the introduction of a CBDC could result in a significant reduction in commercial bank deposits, which could reduce the amount of financial intermediation (i.e. lending to households and businesses) in the economy.[23] With much larger balance sheets, central banks would also face the potentially thorny question of what assets they would invest in – for example, would they have to

[20] For example, in Australia, one of the goals of the CBDC pilot project underway between the Reserve Bank and the Digital Finance CRC is to investigate use cases that are not currently feasible with the current financial and payments infrastructure. Relatedly, Principle 1 of the recently announced 'CBDC Manifesto' states that "A retail central bank digital currency (CBDC) should have a strong value proposition (SVP) and tangible benefits for citizens. The decision process should start with identifying the problem(s) to be solved with CBDC and evaluating all alternative solutions. The CBDC option should be chosen only if it has a compelling value proposition relative to the best alternatives. If the CBDC option is chosen, SVPs to other digital forms of money are essential. To drive adoption, it is not sufficient to offer a new means of payment that has the same features as today's means of payment."

[21] For example, the balance sheet of the Central Bank of the Bahamas shows that more than a year and a half after the launch of the Sand Dollar, the amount of CBDC issued amounted to less than 0.1 per cent of currency (notes and coins) on issue.

[22] For example, Governor de Cos of the Banco de España spoke recently of the "the delicate balance between achieving our [payments] policy objectives and, at the same time, avoiding collateral damage, to the transmission of monetary policy and particularly to the stability of the financial system".

[23] We note that theoretical models suggest a range of outcomes from the introduction of CBDCs, and that with certain assumptions it is possible to obtain results with no disintermediation of banks. However, this does not seem like a plausible base case if a CBDC were to be widely used by households; we also note the opposition to CBDCs by commercial banks in a number of jurisdictions.

hold more government securities or lend funds back to the commercial banks? Alternatively, there is the possibility that there might be little demand for CBDC in normal times, but the risk of destabilising runs from the banking sector to CBDC in times of uncertainty.

The possibility of new financial stability risks or of major (and potentially unforeseeable) changes to the structure of the financial system suggests that policymakers will be cautious in any decisions to implement CBDCs. We expect that any such decisions will be explicitly in terms of CBDCs serving primarily as new payment or settlement instruments and not as stores of value. While it seems odd that central banks might be introducing a new product and then taking steps to ensure it is not 'too successful', some central banks are contemplating the possibility of some form of limits on (of other form of discouragement to larger) holdings for retail CBDCs. The European Central Bank has referred frequently to the possibility of quantity- or price-based tools applying to individuals, such as holding limits (€3000 per person has been frequently mentioned), 'overflow arrangements' whereby any larger CBDC payments received would have to instead flow into an account at a commercial bank, or tiered remuneration.[24] It appears also that most central banks have a presumption that a retail CBDC – like cash – would be non-interest-bearing so as to not compete directly with savings/term-deposit accounts at banks.[25]

As regards privacy and CBDCs, the hardest questions are probably the policy ones, rather than the technical ones. We note that financial privacy is something that some people feel very strongly about, and there is growing unease regarding the implications for privacy if large technology companies were to become more involved in payments. At the same time, privacy is less of a 'hot button' issue for many others, who are reasonably comfortable with existing arrangements that apply to electronic payments with their current payments provider. Accordingly, we expect that there are serious discussions still to be had about privacy and CBDCs, involving the community and numerous policy agencies beyond central banks. However, there has been significant research, especially in the cryptocurrency sphere, into how different levels of privacy can be incorporated into payments, so we conjecture that when there is agreement in principle as to what would be the appropriate degree of privacy for CBDC transactions, the technology will exist to implement it.[26]

For the time being, it is the European Central Bank that has provided the most guidance on its thinking regarding privacy and its position seems consistent with early indications from other central banks.[27] As noted above, the presumption in the higher-income economies appears to be that central banks would have no visibility over customer-level data, and that payment providers would be responsible for all customer-facing activity as is the case for electronic payments today. There seems to be general agreement that any CBDC would have to be designed to allow the ability for providers to monitor for serious financial crime such as money laundering and terrorism financing, and that a CBDC would therefore not fully match cash in terms of the ability to transact large values anonymously. However, some central banks have conjectured that it might be desirable to allow anonymity for small transactions below some threshold (probably subject to some ability to ensure that large payments were not broken into small transactions).

[24] See 'Progress on the investigation phase of a digital euro', European Central Bank, September 2022.

[25] See, for example, 'Contingency Planning for a Central Bank Digital Currency', Bank of Canada, February 2020.

[26] We note also that strong digital identity will be very important for any retail CBDC – as it will be for many other aspects of our increasingly digital lives. It seems unlikely that a central bank would launch a new retail payment instrument without being satisfied that identity issues had been uplifted significantly relative to the present.

[27] See pages 6-8 in 'Progress on the investigation phase of a digital euro', European Central Bank, September 2022.

Experimentation with wholesale CBDCs is more advanced than thinking about access issues and possible business rules. There have been many trials of various use cases for institutional use of CBDC and consideration of the possible benefits relative to existing settlement/reserve accounts at central banks. Many of these trials have focused on factors such as programmability, smart contracts and the ability to conduct atomic transactions in tokenised assets, as well as the possible benefits of 24/7/365 access to settlement in central bank money which could be particularly important for enhancing cross-border payments. Our overall sense is that the various pilots and experiments to date have generally been quite promising.

But there has been relatively little discussion from central banks (or academics) about possible eligibility and business rules that might apply for wholesale CBDCs. One possibility is that such CBDC might have remuneration and access arrangements broadly similar to current access policies for settlement/reserve accounts – i.e. interest bearing (say the policy rate less some spread), with supply determined by the central bank.[28] One important issue that is apparently yet to be discussed much is whether central banks would be comfortable with issuance of large amounts of wholesale CBDCs serving as backing for stablecoins (or deposits at 'narrow banks'); as with retail CBDCs, this would raise issues of disintermediation and also of what assets central banks would invest their larger balance sheets in. A broader point here is that policies and design decisions around CBDCs will presumably not be able to occur independently of consideration about the regulatory framework and possible future role for stablecoins (whether retail or wholesale).

There have recently been a significant number of experiments with wholesale CBDCs that could be promising for improving cross-border payments.[29] The Libra/Diem proposal envisaged that private 'retail' stablecoins could be used to enhance remittances and cross-border payments directly between households. However, experimentation by central banks using CBDCs for cross-border payments has focused on the possibility of institutions using wholesale CBDCs to facilitate interbank settlement, possibly via interoperability of different national CBDCs. There are still a range of possibilities for what interoperability might entail, ranging from common regulatory standards, to technology solutions that enable safe bridging across different CBDC platforms, to issuance of CBDC on common or multiple platforms, so they are native to each other (and have no bridging issues). It does not seem impossible that interoperability of wholesale CBDCs could play some role in cross-border payments by the time that the G20/FSB Roadmap's targets for reductions in the cost of cross-border payments are to be met at end-2027. However, it is important to remember there are a lot of other initiatives underway in this area, some of which – for example projects to link national fast-payments systems – may be more likely to yield near-term benefits.

Some initial thoughts on technology

It is obviously a truism that technology choices for CBDC systems should depend on the intended functionality of, and use cases for, those systems. Given that no higher-income economy has yet taken the decision to issue CBDC and set out its rationale and goals for doing so, we can do little more than speculate on possible technology choices for CBDCs in these economies.

[28] By contrast, the presumption seems to be that retail CBDC would in aggregate be supplied elastically (i.e., based on demand by households), subject to any limits on individual holdings.

[29] For example, Projects Ubin, Dunbar, Jura and Cedar by various combinations of central banks.

Discussions about possible CBDC technologies to date have focused to a significant extent on the likely volume of transactions and the speed of different systems, with blockchain technology generally considered more limited in transaction throughput. However, scalable solutions are being developed and proposed, based on new generations of blockchain technologies, or other approaches often using tokenisation.

Available technologies, including blockchain and DLT, provide a wide ranging and growing toolset for the implementation of CBDC and for transactions involving CBDC. And as discussed earlier, there are numerous possible motivations for CBDC, so the optimal technology solution will depend on the application context of CBDC; a one-size-fits-all solution is unlikely. Accordingly, we suggest that central banks' focus should be on identifying high-priority use cases for CBDC prior to deeper assessment and debate on technology choice.

Assessment of technology against the needs of use cases (and categories) will need to involve consideration of a range of factors, including:

- Transactional performance of a system in terms of throughput rates, as well as time to transaction finality.
- The degree of transparency (for external accountability and auditability) and transaction privacy (including for commercial reasons).
- Important non-functional issues such as system and operational resilience and security.
- The ability to interact with other tokenised or non-tokenised systems: for example, this includes the ability to do atomic transactions involving other ledgers (including delivery versus payment transactions).
- Where desired, the ability to program aspects or parameters of the CBDC itself, as well as its usage in transactions and contracts.

While we are probably still some time away from any decision to move towards issuance of a CBDC in any of the high-income economies, it may be instructive to look at some informative pilots/research efforts in some of the largest economies as well as the few actual CBDC implementations that have occurred.

- The wide range of experiments involving wholesale CBDC appear to have all used distributed ledgers, either private blockchains or private instances of public blockchains. This is not surprising given that these experiments have often involved using CBDC to settle transactions involving tokenised assets on some other ledger.
- Some early implementations of retail CBDCs (the Bahamas, the Eastern Caribbean Central Bank and Nigeria) are apparently on private, permissioned DLT platforms, although there is little in the public domain regarding the technologies used by their vendors. However, the retail CBDC launched in Jamaica is not based on DLT but instead is represented by digital certificates or digital bearer instruments which are issued by the central bank and passed between digital wallets.
- In the United States, retail CBDC research conducted by the Federal Reserve Bank of Boston and the Massachusetts Institute of Technology has also not been based on DLT.[30] Phase 1 of Project Hamilton looked at designing a core transaction processor that could meet the requirements of a large retail payment system. While the project has borrowed ideas from the blockchain industry, the work

[30] See 'Project Hamilton Phase 1: A High Performance Payment Processing System Designed for Central Bank Digital Currencies', Federal Reserve Bank of Boston and Massachusetts Institute of Technology Digital Currency Initiative, February 2022.

published in early 2022 – which achieved throughput of 1.7 million transactions per second – relies on more conventional database and distributed systems technology. The project report noted that blockchain was not required to enhance trust in a CBDC environment and also that consensus algorithms resulted in bottlenecks relative to other approaches.

- Relatively little is known about the specific technology behind the retail CBDC that is being trialled by the People's Bank of China.[31] However, it appears clear that it that it does not rely on DLT but rather on a centralised system.
- While the ECB has published significant material on its policy thinking regarding a digital euro, it is yet to share much detail about its experiments. However, there is no indication to date that it is envisaging the use of blockchain.

We think it is very likely that different technologies will be chosen to meet the needs of different CBDC systems. It seems quite possible that some wholesale CBDCs will use permissioned private DLT systems, whereas the results to date from Project Hamilton – the highest-profile research effort so far – indicate it is much less clear that DLT will be used in retail systems. We expect that the decisions that individual jurisdictions make on technology will borrow from the learnings in other markets. For example, it is not hard to imagine other economies borrowing from the open-source Project Hamilton if that research effort continues to show promise. Similarly, central banks are likely to take advantage of the project code that the BIS Innovation Hub is making available to its member central banks.

Conclusion

We conclude with a few observations and conjectures about developments in CBDCs in the period ahead.

The jurisdictions that have implemented CBDCs to date have mostly been smaller, lower-income ones adopting 'turnkey' CBDC solutions from fintech firms. We expect that there will be further adoption decisions along these lines, with payments modernisation and financial inclusion as prime motivations. China is obviously a very different case, and it seems likely to take a formal decision to issue the e-CNY after a very comprehensive pilot over an extended period.

Among the higher-income economies, central banks in a few jurisdictions – most notably the European Central Bank – appear to have a fairly strong presumption in favour of issuance and are therefore devoting more resources to their efforts. Other central banks are currently less convinced of the case for issuance and will presumably be happy to be fast followers – doing research into particular issues to help their own thinking and also contribute to the international knowledge base, and to also ensure they have the internal capability to assess developments elsewhere and then follow quickly if the policy case and developments in technology suggest that issuance is desirable.

Of course, decisions about CBDC issuance will not be based solely on payments considerations but will be made by governments and legislatures based on broader, whole-of-government considerations; developments in other jurisdictions may also be important. For example, the US Federal Reserve has indicated that any decision around issuance of a CBDC would be for the Congress, and the US Treasury and White House have both published reports on CBDC, while the European Central Bank is in active dialogue with the European Commission over a possible digital euro. Here in Australia, the

[31] See Jianguo Xu, 'Developments and Implications of Central Bank Digital Currency: The Case of China e-CNY', Asian Economic Policy Review 17 (2), 2022, pp235-250.

Commonwealth Treasury has joined the steering committee for the CBDC pilot project that the Reserve Bank and the Digital Finance CRC are conducting.

Based on where most jurisdictions currently are in terms of experimentation and policy thinking, and given the time it would take to complete a project to implement a CBDC that was interoperable with other accounts and payment methods, it seems unlikely that there will be actual issuance of **retail** CBDCs in higher-income countries anytime soon. For example, the European Central Bank's timetable would suggest possible issuance around late 2026 at the earliest. However, we conjecture that **wholesale** CBDCs could potentially be implemented sooner than that. This reflects a number of factors including: (i) conceptually, a wholesale CBDC would arguably represent only a modest technological modification to the settlement/reserve accounts that central banks currently provide;[32] (ii) wholesale CBDCs might be less of an issue politically than retail CBDCs; and (iii) there has already been significant experimentation involving wholesale CBDCs that gives some confidence that implementation could be feasible and not overly subject to significant risks.

We suggest three steps as priorities for central banks, to address the utility of CBDCs, to assess their systemic impact including risks, and to ensure a correctly sequenced path to potential implementation.

First, the various proposed high-level rationales for CBDC need to be rigorously tested, through identification and piloting of real CBDC use cases. Projects like the one underway between the Reserve Bank and the Digital Finance CRC should provide hard evidence on the possible benefits from the introduction of a CBDC. The key outcome of such exercises will be the identification of particular use cases, and use case categories, which would have large economic benefits and could suggest a case for CBDC issuance.

Second, use case categories with high impact potential need to be understood more deeply. Pilot projects in an actual commercial setting for these CBDC use cases will establish working relationships with the key stakeholders in such use cases, give a better understanding of actual requirements and implementation issues, and could lead to more effective implementation of any subsequent production CBDC. Working through these pilots will also highlight regulatory or policy issues they may raise, and which would have to be addressed.

Third, central banks will be able to make detailed technology assessment with the benefit of the learnings gained from the previous steps. When decisions are taken, it will be important that the use cases for CBDC help determine the choice of technology, rather than vice versa. We can imagine a decision framework that proceeds somewhat along these lines: a consideration of the key rationales for CBDC should lead to a consideration of possible high-level design choices for CBDCs and the broader monetary framework, which should lead to policy advice on CBDC issuance, which would lead to detailed system design, which should finally lead to choices about technology.

We conjecture that this process may well result in some degree of harmonisation of CBDC systems and technology across countries, but it will be more due to learning from each other than from an explicit desire to implement similar systems.

[32] See Fabio Panetta, speech on 'Demystifying wholesale central bank digital currency', Frankfurt, 26 September 2022.

On a forward-looking note, we observe that the issuance of CBDC and the broader digitisation of assets have the potential to result in new financial infrastructure and wider systemic change. So it will be important for central banks to think holistically about what the payments system, financial system and broader monetary framework might look like in the future.

There is already significant thinking about the possible role for retail CBDCs; the predominant thinking appears to be that they could be introduced to serve primarily as a new means of payment and not be intended to have a major store-of-value role, and some jurisdictions are talking about limits on individuals' holdings. This raises analogous questions about the possibility of limits, or access/eligibility controls, applying to holdings of **wholesale** CBDC if it is primarily viewed as a settlement asset provided by the central bank and not intended to serve as a longer-term store of value. In turn, this may have implications for the role of retail or wholesale stablecoins; perhaps they would have to be backed by government securities or high-quality private assets rather than wholesale CBDC.[33] This points to the need for thinking about CBDC to occur in conjunction with thinking about the possible role for other new instruments (regulated stablecoins) and possibly even new financial infrastructure (e.g. the proposed Regulated Liabilities Network).[34]

This project received grant funding from the Australian Government through the CRC Program.

[33] Here, there may be parallels with the question in the United States of whether so-called 'narrow banks' should have access to Federal Reserve accounts for investing their customers' deposits.

[34] See 'The Regulated liability network; Digital sovereign currency', White Paper, November 2022.