



Options for access to and interoperability of CBDCs for cross-border payments

Report to the G20

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Executive summary

In October 2020, the G20 endorsed a roadmap to enhance cross-border payments, developed by the Financial Stability Board (FSB) in coordination with the Bank for International Settlements' Committee on Payments and Market Infrastructures (CPMI) and other relevant international organisations and standard setters. The G20 cross-border payments programme aims to address long-standing challenges in the cross-border payments market, including high costs, low speed, limited access and insufficient transparency. This programme comprises the necessary elements of a globally coordinated response in the form of a set of 19 building blocks (BBs), based on a CPMI report to the G20 (CPMI (2020a, 2020b)). BB 19 is tasked with factoring an international dimension into central bank digital currency (CBDC) design to explore how CBDCs could potentially enhance cross-border payments. As mandated under Action 1 of this building block, in July 2021 the CPMI, BIS Innovation Hub, International Monetary Fund and World Bank published a stocktake of provisional domestic CBDC designs and experimentations and their potential to enhance cross-border payments (CPMI et al (2021)).

The current report is a response to Action 2 of BB 19 and presents different options for access to and interoperability of CBDC systems to facilitate cross-border payments. It assesses these options based on five criteria: do no harm, enhancing efficiency, increasing resilience, assuring coexistence and interoperability with non-CBDC systems, and enhancing financial inclusion. Also, leveraging experiences from existing CBDC projects, the report discusses the key implementation challenges of each of the access and interoperability options. Central banks have different motivations for exploring or developing CBDC systems, and the demand for improved cross-border payment rails differs across jurisdictions. Therefore, this report serves as a tool for central banks to assess different cross-border CBDC design options given their objectives.

When identifying access options, the report distinguishes between, on the one hand, access by foreign banks and other payment service providers (PSPs) to wholesale CBDC (wCBDC) systems and retail CBDC (rCBDC) systems in case of a two-tier model, and, on the other hand, access to rCBDCs by non-residents. Access by PSPs may be *indirect* (ie via an intermediary) or *direct* (ie without an intermediary). These models are similar to the access models of traditional payment systems as discussed in BB 10 of the G20 cross-border payments programme (CPMI (2022b)). In a third model – *closed access* – only domestic PSPs are granted access to the CBDC system. The discussion on access to rCBDCs by non-residents focuses on whether and under what conditions (eg transaction and holding fees and limits) non-residents are granted access.

Well calibrated access to CBDCs by foreign PSPs and non-residents may facilitate cross-border payments, though it is not a silver bullet. A complementary approach is ensuring interoperability between CBDC systems. Building on the BB 19 Action 1 work, the current report presents three ways to achieve this: compatibility, interlinking and a single system. *Compatibility* refers to individual CBDC systems using common standards, such that the operational burden on PSPs for participating in multiple systems is reduced. *Interlinking* refers to establishing a set of contractual agreements, technical links, standards, and operational components between CBDC systems allowing participants to transact with each other without participating in the same system. Similar to the interlinking of traditional payment systems (see CPMI (2022c)), CBDCs could be interlinked via different models – via a single access point, bilateral link or “hub and spoke” model. A *single system* refers to an arrangement that uses a single common technical infrastructure hosting multiple CBDCs.

Each of the CBDC access and interoperability models has different implications in terms of macro-financial risks, efficiency, resilience, coexistence and interoperability with non-CBDC systems, and financial inclusion. At the same time, as with traditional cross-border arrangements, CBDC cross-border arrangements raise a number of implementation challenges, which differ depending on the type of access

and interoperability model used. A number of CBDC projects have been completed as one-off experiments and others are still in an exploratory stage (see Annex 6). Yet, these initiatives provided useful insights for the analysis of cross-border CBDC access and interoperability options. Potential challenges of broader access to CBDC systems range from governance, decision-making and risk management to operational, technical and financial aspects. Many of these are fairly similar to the challenges of broadening access to traditional payment systems (see CPMI (2022b)). Each interoperability model also faces different challenges, eg in terms of investment and maintenance cost, scalability, legal and regulatory frameworks and governance.

There is no “one size fits all” model for access to and interoperability of CBDC systems. For example, while compatibility might be the least costly form of interoperability, it may not achieve similar efficiency benefits to interlinking multiple systems or developing a single system. Combining compatibility with a direct access model would go a long way, but given the challenges of achieving direct access, such a solution might be difficult to realise in the short run. Similarly, while interlinking via a single access point may not necessarily require direct access or the establishment of new technical components, it has scalability limitations. Overall, interlinking of CBDC systems through a hub and spoke or single system might bring more improvement to the cross-border payments market than compatibility or single access points, and the same holds for direct access models compared to closed or indirect access. Yet, given the elevated challenges of these solutions, they are most likely to be implemented where the benefits of enhanced cross-border payments exceed the challenges, such as between countries with large trade volumes, or between countries with similar CBDC objectives and designs. This inherently might entail the risk that the interoperability and access models with the highest potential to alleviate current cross-border payment frictions are not implemented for the use cases that are currently heavily impacted by these frictions, such as remittances.

For CBDCs to enhance cross-border payments, jurisdictions working on a CBDC must take the cross-border functionality into account at an early stage to avoid unintended barriers later. CBDCs are new to all, and those central banks who choose to explore one need to go through design and development phases. Although each jurisdiction is likely to be bound by certain constraints when designing a CBDC, eg in terms of ensuring coexistence and interoperability with current systems and complying with existing legal and regulatory frameworks, many design features are still undecided which allows central banks to start with a “clean slate”. To use this opportunity, international cooperation and coordination is needed in the early stages of CBDC design. More structured and broader international coordination on domestic CBDC designs would be beneficial to lower barriers to cross-border compatibility and could serve as a launching pad for interoperability. In addition, jurisdictions must keep in mind to build CBDC ecosystems that are flexible enough to account for different forms of interoperability and coexistence as well as inclusivity and accessibility needs – both with the payment methods we have today and with potential future types of money. Other considerations that are relevant to the design of cross-border CBDC solutions and that may warrant coordination include ensuring compliance with rules on anti-money laundering (AML) and combating the financing of terrorism (CFT) while safeguarding privacy and promoting competition.

To avoid domestic CBDC work unintentionally creating barriers to cross-border CBDC payments, further work is required in the short-term within the central bank community to identify the stages of domestic CBDC planning and development when decisions should be taken on cross-border CBDC access and interoperability models. Further work is also required on the standards to which domestic CBDC designs would need to adhere to support cross-border payments. Even jurisdictions not planning to issue a CBDC ought to be involved in this work as they will still be part of this new potential cross-border payments landscape. To inform such work, further technology experimentation on cross-border payments between rCBDCs is essential, since to date, most cross-border CBDC experiments have focused on wCBDCs. Also, it would be beneficial to broaden the diversity of countries involved in the CBDC experiments and dialogues, especially to better understand the implications and requirements to enhance currently underserved cross-border corridors. To the extent that cross-border use of CBDCs for these corridors relies on the quality of and features in national payment system infrastructures, it is essential to

continue dedicating resources to improving and strengthening these infrastructures and regulatory, supervisory, and oversight practices. More work is also required on the trade-offs between different assessment criteria and between different access and interoperability models. Macroeconomic implications, eg of limiting CBDC holdings to certain participants and of large-scale issuance to non-residents, would also require further consideration.

While CBDCs can enhance cross-border payments in various ways, eg by extending the availability of central bank money settlements around the clock and by eliminating the need for PSPs to act as liquidity providers, they will come with implementation challenges. Some of these are common to all types of money or traditional payment systems, yet some are specific to CBDCs, eg in terms of the required legal authority to issue CBDCs, macro-financial implications, controlling and monitoring CBDC holdings, and, depending on the technology used, different technical and operational challenges. The “clean slate” advantage of CBDCs, however, will allow central banks to address these challenges at an early stage.

Other building blocks of the G20 cross-border payments programme focus on measures to improve existing payment systems, eg via extended operating hours, broader access, interlinking of fast payment systems or adoption of harmonised message formats. Improvements in these areas could complement and in some cases (eg facilitating comprehensive application of AML/CFT rules) also be directly beneficial to improve cross-border payments with CBDCs.

1 Introduction

1.1 Background

In October 2020, the G20 endorsed a roadmap to enhance cross-border payments, developed by the Financial Stability Board (FSB) in coordination with the Bank for International Settlements' Committee on Payments and Market Infrastructures (CPMI) and other relevant international organisations and standard-setting bodies. The G20 cross-border payments programme aims to address long-standing challenges in the cross-border payments market, including high costs, low speed, limited access and insufficient transparency. This programme comprises the necessary elements of a globally coordinated response in the form of a set of 19 building blocks (BBs), based on a CPMI report to the G20 (CPMI (2020a, 2020b)).¹

BB 19 is tasked with factoring an international dimension into central bank digital currency (CBDC) design to explore how CBDCs could potentially enhance cross-border payments. As mandated under Action 1 of this building block, in July 2021 the CPMI Future of Payments Working Group (FoP) published a stocktake of provisional domestic CBDC designs and central bank experimentations and their potential to enhance cross-border payments (CPMI et al (2021)). This report also provided a conceptual framework for how CBDCs could be connected via multi-CBDC (mCBDC) arrangements and an analysis of international macro-financial implications of cross-border CBDC use.²

The current report constitutes a response to BB 19 Action 2 of the G20 cross-border payments programme, which invited the CPMI in collaboration with the BIS Innovation Hub (BISIH), the International Monetary Fund (IMF) and the World Bank to identify and analyse options for access to and interlinking of CBDCs that could improve cross-border payments, covering different CBDC design, access and interlinking options, including interoperability with non-CBDC payment arrangements. Access and interlinking are two key features through which CBDCs can be made available to banks and other payment service providers (hereafter collectively referred to as PSPs) from different systems or jurisdictions and through which end users can seamlessly transact with each other regardless of their geographic location or choice of PSP.³ In addition to covering interlinking options, the report takes a broader approach by considering interoperability options in general.

The remainder of Section 1 provides the definitions used in this report and summarises the potential role of CBDC in improving cross-border payments. Section 2 presents five evaluation criteria for assessing different cross-border CBDC arrangements taking the CBDC principles defined by the Group of Central Banks (2020) and the G7 (2021) as a starting point. Section 3 presents potential options for access to and interoperability, including interlinking, of CBDCs and maps completed and ongoing CBDC projects accordingly. Section 4 assesses the identified options against the five evaluation criteria and discusses their implementation challenges based on lessons from existing CBDC projects. Section 5 concludes and presents recommendations for future work.

¹ The 19 building blocks are arranged into five focus areas, four of which (focus areas A to D) seek to enhance the existing payments infrastructure. Focus area E, comprising BBs 17 (multilateral platforms), 18 (stablecoins) and 19 (CBDCs), is more exploratory and covers emerging payments infrastructure and arrangements. See FSB (2020a) for an overview of the G20 roadmap to enhance cross-border payments.

² See also Auer et al (2021) for more details on the conceptual mCBDC arrangements.

³ The CPMI report on best practices for jurisdictions and payment system operators conducting a self-assessment with the aim of expanding access to key payment systems (CPMI (2022b)) also refers to payment infrastructures, beyond banks and non-banks, as possible payment system participants. In the current report we consider non-banks and payment infrastructures, and also other central banks, as part of "other PSPs".

1.2 Definitions and scope

CBDC has generally been defined as central bank money in a digital format, denominated in the national unit of account, that is a direct liability of the central bank and can be used for retail payments and/or wholesale settlement.⁴ Based on this definition, traditional central bank reserve or settlement accounts currently held by commercial banks and certain other financial institutions at the central bank can also be seen as CBDC. As an analysis of these traditional accounts is out of the scope of this report, we apply a narrower definition of CBDC by defining it as *a new form of central bank money* in a digital format, denominated in the national unit of account, that is a direct liability of the central bank. This report will consider both retail and wholesale CBDCs. *Retail CBDCs* (rCBDCs) are meant to be held and used by individuals and firms for day-to-day transactions, including purchases of goods and services, whereas *wholesale CBDCs* (wCBDCs) are held by eligible financial institutions only and used for financial market payments (eg interbank payments and the settlement of securities and currency transactions).⁵ Financial institutions with access to wCBDC can, however, offer retail services to individuals and firms that build on the wCBDC, such as cross-border transfers of non-CBDC money. Further, a CBDC relies on many different components to be circulated. This report considers a *CBDC ecosystem* to encompass the underlying payment system, information and communications technology (ICT) infrastructure, governance and business arrangements, and participants involved in CBDC payments. Participants in CBDC ecosystems may include different service providers, such as payment interface providers onboarding customers and offering wallets. Further, the term cross-border CBDC arrangement is used in this report to refer to the design choices made regarding access and interoperability.

Cross-border CBDC payments, as described in this report, cover the following cases: (i) a payment between residents, including resident financial institutions, of two separate jurisdictions where at least one entity is using a CBDC; or (ii) a transfer of a CBDC by a resident or non-resident of the issuing jurisdiction to a wallet or account maintained in another jurisdiction or vice versa. Many, but not all, are also cross-currency payments where the payer and payee are respectively debited and credited in different currencies (see Box 1). As such, cross-border CBDC payments could also include payments made by tourists and business travellers, either when they use their home country's CBDC when abroad or when they acquire the CBDC of the country they are visiting. For the purpose of this report, cross-currency cross-border payments will be in focus.⁶

Interoperability refers to technical, semantic and business compatibility that enables a system to be used in conjunction with other systems. Interoperability allows PSPs from different CBDC systems to make payments across systems without participating in multiple systems (Boar et al (2021)). As discussed in Section 3, for CBDCs, interoperability could be achieved between different CBDC systems.

1.3 How can CBDC mitigate challenges and frictions in cross-border payments?

Cross-border payments face four particular challenges: high cost, low speed, limited access and insufficient transparency. These challenges arise from a series of frictions, including fragmented and truncated data formats, complex processing of compliance checks, limited operating hours, legacy technology platforms, long transaction chains, high funding costs, and weak competition. Legal, technical and commercial

⁴ See eg BIS (2021b). This definition also applies to currency unions, as long as the CBDC is a liability issued by a central bank that is in its own currency (ie where it does have the monetary authority), such as a digital currency issued by the European Central Bank.

⁵ In line with our definition of CBDC and the approach used in CPMI-MC (2018), a wCBDC is defined as a new form of digital central bank money that is different from balances in traditional central bank reserve or settlement accounts. For one of the first papers on wCBDCs, see www.mas.gov.sg/-/media/MAS/ProjectUbin/Cross-Border-Interbank-Payments-and-Settlements.pdf.

⁶ Cross-border payments within a monetary union typically encounter fewer challenges and frictions. Therefore, cross-border payments between jurisdictions using the same CBDC will not be a focus of this report.

changes are necessary in a number of areas to overcome these frictions. These changes include harmonisation of regulatory, supervisory and legislative frameworks (eg for anti-money laundering and combating the financing of terrorism (AML/CFT); see also Box 2 in Section 2), improvements in existing payment infrastructures and arrangements (eg operating hours, participation requirements, funding and interlinking arrangements) and harmonisation of market practices and standards (eg messaging standards; see FSB (2020a)). There are ongoing projects to relieve the traditional cross-border payment system of some of these frictions, such as the introduction of a common messaging standard. However, such improvements on an already existing and complex structure can be costly and difficult.

Box 1

Currency conversion – a vital element of cross-currency payments

Cross-currency payments are payments where the payer's and payee's accounts are respectively debited and credited in two different currencies. Hence, a vital element of cross-currency payments is the currency conversion: somewhere along the payments chain, the currency of the payer has to be converted into the currency of the payee.

The currency conversion can be provided by different entities; typically, it could be provided by the PSP of the payer, by the PSP of the payee or by an intermediary which stands in between both PSPs, such as an international bank or even a central bank. If it is the payer's PSP doing the conversion, the payer basically purchases the foreign currency (B) from its PSP against the home currency (A) prior to sending it to the payee. By contrast, if the payee's PSP is offering the exchange, it is the payee who purchases currency (B) from its PSP against currency (A) after receiving it from the payer. In the intermediary example, the payer's and payee's PSPs sell and buy, respectively, the two currencies to and from the intermediary.

To enact a cross-currency payment, the entity responsible for the conversion must have sufficient balances of the different currencies. The treasury departments of the involved entities monitor their holdings of each currency and determine when they must buy and sell currencies to cover their transactions. They do so at the foreign exchange (FX) market. These FX transactions are ideally settled on a payment-versus-payment (PvP)⁷ basis to reduce settlement risk. Major currencies are commonly settled on a PvP basis, eg via CLS, whereas other, eg emerging market currencies are more often settled on a non-PvP basis. BB 9 of the G20 cross-border payments programme is about facilitating increased adoption of PvP.⁸

CBDCs can help to enhance cross-border payments in various ways. First, as with any new system, one key advantage of both retail and wholesale CBDC is the opportunity to start with a "clean slate". CBDC is new to all, and those central banks who choose to explore one must go through design and development phases. This provides an opportunity for central banks to take the cross-border dimension into account when designing their domestic CBDCs. Cross-border payment markets are bound by a number of issues, including the structure of existing domestic payment systems, currency exchange issues, the demand for cross-border payments, and the legal and regulatory aspects of these payments. As such, each jurisdiction will face certain constraints when designing a CBDC, eg in terms of ensuring coexistence and interoperability with current systems and complying with existing legal and regulatory frameworks. Nevertheless, many design features and technical specifications are still undecided, which allows central banks to start with a "clean slate". For example, CBDC infrastructures could be made available 24/7, allowing for instant cross-border settlement and overcoming mismatches of operating hours between different jurisdictions.⁹ More broadly, the fact that a significant number of central banks are now simultaneously looking into the issue of CBDCs (see Kosse and Mattei (2022)) allows them to increase their coordination efforts and to achieve interoperability between their CBDCs from the outset. Interoperability of CBDC systems could facilitate cross-border CBDC payments between financial institutions, corporates

⁷ A settlement mechanism that ensures that the final transfer of a payment in one currency occurs if and only if the final transfer of a payment in another currency or currencies takes place.

⁸ For full details of the actions under BB 9, see FSB (2020a, Annex 1).

⁹ See CPMI (2022a) for a discussion on extending operating hours to enhance cross-border payments.

and consumers by reducing the costs for PSPs and shortening transaction chains, which might eventually result in a higher transaction speed and lower end user fees.¹⁰ Achieving interoperability once systems have been fully designed and employed can be more complicated.¹¹

Second, cross-border CBDC arrangements would improve the safety of cross-border payments because payments are made using a direct liability of the central bank, which is the safest and most liquid settlement asset (especially when compared to stablecoins and other cryptoassets). Moreover, since CBDCs are a direct liability of the central bank, there is no need for PSPs (as wallet providers or payment validators) to act as liquidity providers, which could increase the number of PSPs. However, those PSPs acting as FX providers must have CBDC accounts with the central banks to hold and transact both currencies. A common FX trading venue could enhance competition and bring additional benefits. An increased number of PSPs and direct access to central bank money could then shorten cross-border transaction chains, simplify processes and address current frictions in cross-border funding arrangements.

Third, CBDCs, as a new means of cross-border payment, are commonly meant to coexist with and complement existing cross-border payment options. In this case, CBDCs would increase payment diversity, thereby stimulating resilience, competition and efficiency in a cross-border context. The potential programmability features of CBDCs enabled by smart contracts and APIs could facilitate faster and better interoperability with other CBDCs and non-CBDC systems. This would allow payments to be tightly linked to business processes enabling self-triggered and conditioned transactions, leading to vast improvements to payment speed, and hence promote efficiency. CBDCs could also specifically be designed to improve individuals' and businesses' access to affordable cross-border payment products and services, for example through simplified onboarding allowing remote registration or electronic know-your-customer (e-KYC) processes and through low-cost and easy-to-use instruments, especially when these aspects are explicitly taken into account in the domestic design of CBDCs.

Measures to improve cross-border payments in general and involving other types of money are discussed in other building blocks of the G20 payments programme. Improvements in these areas could complement the effort to ensure interoperability of CBDC systems for cross-border payments.¹² Moreover, there might be circumstances where the desired interoperability requirements for improving cross-border payments conflict with those for achieving domestic interoperability. In such a case, jurisdictions might face a trade-off between making their CBDC interoperable with existing domestic payment infrastructures and achieving international interoperability with other CBDCs. These and other challenges will be discussed in Section 4.

2 Evaluation criteria for analysing cross-border CBDC arrangements

The establishment of a new CBDC ecosystem allows jurisdictions to take the cross-border dimension into account at an early stage. There are several aspects to consider when designing a cross-border CBDC arrangement and different ways in which these can be accommodated. This section presents five

¹⁰ See Boar et al (2021) for a discussion of the benefits and trade-offs of interoperability between payment systems across borders and Oliver Wyman and J.P. Morgan (2021) for an estimation of the transaction cost implications of moving from traditional correspondent banking arrangements to an mCBDC solution.

¹¹ For example, BB 13 of the G20 cross-border payments programme is currently working on interlinking existing payment systems (see eg CPMI (2022c)).

¹² Indeed, harmonisation of regulatory, supervisory and legislative frameworks is not only important for facilitating cross-border payments through existing systems but would also be important for cross-border CBDC payments. Such harmonisation requires concrete legal changes and strong international cooperation. Important work on this is being done in BBs 4 (regulatory, supervisory and oversight frameworks) and 5 (AML/CFT) of the G20 cross-border payments programme, which aims to align regulatory, supervisory and oversight frameworks for cross-border payments and to further harmonise the application of AML/CFT rules among countries.

evaluation criteria that will be used in Section 4.1 to analyse the potential options for access to and interoperability of CBDCs which will be identified in Section 3.

The five evaluation criteria below are based on the CBDC principles developed by the Group of Central Banks (2020)¹³ and the G7 (2021).¹⁴ When designing their CBDCs, central banks may want to ensure that all these principles are properly observed for cross-border CBDC transactions. Some of these principles have a direct impact on the way in which central banks achieve their mandated objectives, eg do no harm to macro-financial stability or interoperability and coexistence of payment systems. By contrast, other principles require central banks to comply with prevailing laws, rules and guidelines developed outside of their usual remit, eg AML/CFT regulations (see Box 2 at the end of this section and Annex 3) and provisions regarding data and privacy protection. In this report, we assume that CBDC ecosystems are developed in accordance with all these relevant laws, rules and guidelines. The analysis in Section 4.1 will focus on those principles that commonly fall within the mandate or public policy objectives of central banks. For the purpose of this report, we have grouped these into five overarching criteria: do no harm, enhancing efficiency, increasing resilience, assuring coexistence and interoperability with non-CBDC systems, and enhancing financial inclusion. For each of these, the remainder of this section describes its relevance in the context of cross-border CBDC payments. The potential challenges faced when complying with the prevailing rules and regulations will be further discussed in Section 4.2.

2.1 Do no harm

Do no harm in the context of CBDCs refers to designing CBDC ecosystems that support public policy objectives and do not impede central banks' ability to carry out their mandates (Group of Central Banks (2020), G7 (2021)). For example, apart from the benefits discussed above, cross-border use of CBDCs could increase macro-financial risks (G7 (2021), IMF (2020)). First, cross-border availability of CBDCs can foster currency substitution in countries with weaker economic fundamentals. Second, capital flows could increase, leading to the benefits of increased market integration, but also increasing synchronisation and intensification of global financial cycles and contagion risks, and potentially also heightening capital flow volatility. Both currency substitution and increased capital flow volatility and synchronicity could have negative implications for financial stability and the ability of countries to conduct independent monetary policy.¹⁵ While most of these risks are more pronounced for recipient countries, swings in the external demand for a CBDC could also affect the implementation of monetary policy of the issuing country if its financial markets are relatively small or shallow. Third, cross-border payments with CBDCs could help circumvent existing capital flow management measures (CFMs), which could undermine countries' efforts to maintain macro-financial stability. However, CFMs could also be an integral part of CBDC design, directly embedded into the CBDC software, for instance by ensuring that digital wallets have caps on how many cross-border transactions a user can make in a certain time period. This could increase CFMs' efficiency.¹⁶ Finally, cross-border availability of CBDCs may in some cases contribute to a reconfiguration of reserve currency holdings, which, while not a risk, could require a change in regional and global backstops (eg a change in multilateral lenders and regional FX reserve pooling arrangements).

¹³ The Group of Central Banks (2020) outline three common foundational principles for domestic retail CBDC issuance: do no harm, coexistence, and innovation and efficiency. In addition, they discuss several core features that support these foundational principles, eg convertibility, convenience, resilience, interoperability, availability, low cost, security, instant settlement, scalability, flexibility and robust legal framework.

¹⁴ The G7 (2021) discuss 13 principles for retail CBDCs: monetary and financial stability, legal and governance frameworks, data privacy, competition, operational resilience and cyber security, illicit finance, spillovers, energy and environment, digital economy and innovation, financial inclusion, payments to and from the public sector, cross-border functionality, and international development. A comparison shows that most of the G7 principles were also covered by either the three common foundational principles or the core features of the Group of Central Banks (2020).

¹⁵ For more on this, see IMF (2020) and CPPI et al (2021).

¹⁶ See He et al (forthcoming) on CBDC and CFMs.

Many of these risks, such as currency substitution, are not new, but the availability of CBDCs across borders could reinforce them and their impact, including by making it more difficult to implement monetary policy and capital control measures. Therefore, it is crucial for cross-border CBDC arrangements to be designed in such a way that negative spillovers to the macroeconomy and risks to financial stability are limited, in both the domestic and cross-border context. Examples of design features that could be employed for this purpose may include restrictions on holdings of CBDCs by non-residents, caps and fees on flows, and specific risk monitoring systems.

2.2 Enhancing efficiency

Efficient payments, both wholesale and retail, are characterised by low cost and high speed, without compromising other relevant aspects, such as ease of use, accessibility, availability and safety. CBDC ecosystems could enhance efficiency in the overall payments market by adopting cutting-edge technology compared to legacy systems, and fostering a level playing field and competition, for instance through increased product diversity and enhanced interoperability (see also Section 2.4) between other means of payment in a domestic and cross-border context (Group of Central Banks (2020), G7 (2021)).

Efficiency sits at the core of the G20 cross-border payments programme that aims to address the challenges of high costs, low speed, limited access and limited transparency. For CBDCs to promote efficiency in the broader payments market, it is crucial that CBDC payments themselves are as efficient as possible. Encouraging broad-based private sector participation and the supply of innovative payment services as well as technologies and technical standards/procedures that minimise risks and lower costs in CBDC ecosystems would be essential in achieving efficiency in CBDC payments. Several design choices will also have an impact on the efficiency of CBDC payments, such as choices related to fee structure, access policy and interoperability arrangements.

2.3 Increasing resilience

Resilience is the ability to identify, protect against and recover from adverse shocks and other disruptive events. An ecosystem can be said to be resilient at the system level if weaknesses of its individual participants do not undermine the resilience of the entire ecosystem. CBDC ecosystems with their own payment instruments and infrastructures could provide an independent alternative to existing payment instruments and systems, contributing to the general resilience of the overall payment landscape in the domestic and cross-border context (Group of Central Banks (2020), G7 (2021)).

The ability of CBDC ecosystems to contribute to the resilience of the overall payment landscape would depend crucially on interlinkages with existing payment systems as well as the overall resilience of these ecosystems. CBDC ecosystems should be secure (eg resist cyber attacks and fraud) and resilient to operational risks, such as loss of network communication, electrical outage, and natural disasters (Group of Central Banks (2020)). The resilience of CBDC ecosystems would also depend on the resilience of arrangements used for interlinking CBDCs, the presence of a sufficient number of intermediaries to reduce risks from single points of failure and the cross-border coordination and supervision of resilience-related activities and policies. There are several international sets of guidance that would be relevant to ensure resilience of cross-border CBDC arrangements, such as the CPMI-IOSCO guidance on cyber resilience for financial market infrastructures (CPMI-IOSCO (2016)), the CPMI report on reducing the risk of wholesale payments fraud related to endpoint security (CPMI (2018)), and the FSB report on regulatory and supervisory issues relating to outsourcing and third-party relationships (FSB (2020b)).

2.4 Assuring coexistence and interoperability with non-CBDC systems

Different types of central bank money – new (CBDC) and existing (banknotes and balances in reserve or settlement accounts) – should complement each other and coexist in a wider payment landscape that

supports public policy objectives and includes and supports private money (just like commercial bank accounts and cash issued by central banks currently coexist; see Group of Central Banks (2020)). In addition to coexistence, interoperability between the different forms would enable end users to seamlessly transact with each other regardless of their geographic location, choice of PSP or type of money and support the convertibility at par.

CBDC systems that coexist and are interoperable with domestic as well as other cross-border transfer arrangements avoid fragmentation and inefficiencies in payment systems (eg the need for separate card acceptance terminals for CBDC payments), ensure competition and facilitate adoption of CBDCs. Given that the payments market is constantly changing, a cross-border CBDC system should also be flexible enough to interoperate with future payment services, systems, schemes and arrangements. This requires carefully considered design choices, eg regarding the involvement of foreign PSPs or the type of interoperability model used.

2.5 Enhancing financial inclusion

Financial inclusion means that individuals and businesses have access to affordable financial products and services that meet their needs – transactions, payments, savings, credit and insurance – delivered in a responsible and sustainable way. CBDCs should not impede and, where possible, should enhance access to payment services for those currently excluded from or underserved by the existing financial system, while also complementing the important role that will continue to be played by cash (G7 (2021)).

Financial inclusion aspects explicitly factored into the domestic designs of CBDC ecosystems may also enhance financial inclusion in a cross-border context. CBDCs could be designed to ensure access to a basic, trustworthy means to pay and store value in situations where PSPs do not offer transaction accounts that effectively meet the needs of the unbanked and/or have failed to instil trust (CPMI-WB (2020)). As part of CBDC design, the use of third-party agents, person-to-person payments at little or no cost, different user interfaces, simplified KYC and e-KYC processes, offline payments and cross-border interoperability, among others,¹⁷ can address multiple barriers related to geography, institutional factors or market structure. These design features can contribute to meeting the needs of specific groups, such as those without ID credentials or international migrants. While these features are not unique to CBDCs, the opportunity to deploy them through one public sector-led initiative may present a unique and novel approach for tackling financial exclusion going forward (BIS-WB (2022)).

¹⁷ For instance, time-tested measures such as simplified KYC and e-KYC, accessible, low-cost and easy-to-use payment instruments and extended access points to and from cash could facilitate individuals' access to cross-border CBDC arrangements (eg for making and receiving remittances and cross-border e-commerce payments).

AML/CFT compliance in cross-border CBDC arrangements

Illicit activity undermines financial integrity, national security and economic development. As with any value transfer system, CBDCs could be used by criminals and terrorists for illicit activity. An important part of global efforts to combat illicit finance is national implementation of sound anti-money laundering and combating the financing of terrorism (AML/CFT) regimes in line with the international standards set by the Financial Action Task Force (FATF). Central banks are expected to design CBDCs in line with AML/CFT requirements.¹⁸

The exact financial integrity implications of a CBDC arrangement will vary depending on the design choices taken. In particular, central banks, in coordination with relevant AML/CFT bodies, should consider the following aspects when designing a CBDC arrangement:

- **CBDC ecosystem and scope:** While a wide and varied user base may be desirable for a CBDC, the number and jurisdiction of residence of users will affect money laundering and terrorism financing (ML/TF) risks. Similarly, the number, type and location of intermediaries involved in the issuance, distribution and use cases of the CBDC will have regulatory and supervisory implications, particularly as service providers may be located abroad in the context of a cross-border arrangement.
- **Level of intermediation and allocation of AML/CFT responsibilities:** In a one-tier model (see Section 3.1.2), the central bank would have a direct relationship with end users, and, as a result, would have AML/CFT obligations. This model could create conflicts of interest if the central bank is also the AML/CFT supervisor. In a two-tier model, AML/CFT obligations would remain with intermediaries. Ensuring that all relevant actors are subject to the AML/CFT regime and supervised would be key in this model.
- **User identification and due diligence:** A critical component of AML/CFT is identifying the customer and source of funds. Due diligence challenges might differ between account-based or token-based CBDC arrangements,¹⁹ and as with traditional financial services, these challenges are likely to be magnified in a cross-border context. Some rules pertaining to “traditional” financial transactions (eg the wire transfer rule) may require further thought in the context of a CBDC arrangement.
- **Oversight of AML/CFT compliance:** The evolution of new service providers and/or services may require adaptation of AML/CFT laws and regulations, supervisory models, and organisational structures of AML/CFT supervisors. Coordination with other key AML/CFT agencies as well as foreign counterparts (in the case of cross-border arrangements) will also be important.

As with the traditional forms of money and financial services, the implementation of AML/CFT measures for CBDCs will be more challenging in a cross-border context, calling for global harmonisation and collaboration.

See Annex 3 for further elaboration and discussion of the key design considerations.

3 Potential options for access to and interoperability of CBDCs

The potential uptake and use of CBDCs for cross-border transactions strongly depend on the access and interoperability choices made by central banks when designing their CBDCs. There are two main ways to enable cross-border payments using CBDC. First, national CBDCs can be made available to non-residents (for rCBDCs) and to foreign PSPs (for both rCBDCs and wCBDCs) for direct use. Second, cross-border CBDC transactions can be facilitated through interoperability between different countries' CBDC systems.

¹⁸ See FATF (2020, Annex B) for further information on CBDCs in the AML/CFT context.

¹⁹ Account-based and token-based CBDC arrangements are not always fully distinct from each other and, indeed, many CBDC arrangements are hybrid systems. For the purpose of this discussion, the critical distinction is whether authentication is primarily focused on the user or the object of payment.

3.1 Options for access to CBDCs

3.1.1 Access to wCBDC by foreign PSPs

When designing a wCBDC, central banks must decide whether and how foreign PSPs can access the system and use their wCBDCs. In general, the following choices can be made (see Graph 1):²⁰

- *Closed access – domestic PSPs only:* only domestic institutions can access, hold and use the wCBDC. In this model, central banks issue (redeem) wCBDCs to (from) the participants upon receiving (transferring) central bank reserves from (to) them in their traditional settlement accounts, or upon receiving (transferring) collateral, similar to the issuance of central bank reserves. In this model, foreign PSPs are not direct or indirect participants in the wCBDC system. Yet, the wCBDC could still be used in a cross-border setting through various interoperability and/or interlinking arrangements as discussed in Section 3.2 (see Table A.1 in Annex 4 and projects HSBC, Jasper-Ubin, Prosperus, MAS and Aber in Annex 6).
- *Indirect access – foreign PSPs can access the wCBDC network via an intermediary.* As with indirect access to traditional payment systems, indirect access to wCBDC systems may take various forms. For example, foreign PSPs might be required to rely on a direct (domestic) participant for payment instruction, clearing and settlement. In this case, the direct participant transacts on the wCBDC ledger on behalf of the foreign PSP. An alternative indirect access model would be one in which foreign PSPs are allowed to hold a wCBDC directly and to submit their own transactions, but still rely on a direct (domestic) participant for the onboarding and possibly also transaction processing. Project Dunbar Phase I (Annex 6.9) is an example of a wCBDC using such an indirect access model.²¹ This report focuses on forms of indirect access that are formalised in the system rules and that dictate some or all of the terms of such access. Thus, correspondent banking is not considered a formal indirect access model.
- *Direct access – foreign PSPs can directly hold and transact in wCBDC issued by a central bank without an intermediary participant.* In this model, foreign PSPs, upon satisfying certain access criteria, can hold and transact directly without the need for an intermediary (see Table A.1 in Annex 4 and projects Helvetia Phase II, mBridge and Jura in Annex 6). This model would generally require mutual reliance by the central banks on the supervision of these entities by their home supervisors.²²

Each of the above options will have different implications, eg in terms of efficiency (length of transaction chain, processing speed, costs and fees), competition and innovation (barriers to entry, creation of level

²⁰ The access choices presented in this report are similar to the access options for non-CBDC systems presented and discussed by the CPMI as part of the work conducted under BB 10 of the G20 cross-border payments programme (CPMI (2022b)). The BB 10 report distinguishes between direct access, indirect access and agent-only access. Since there is some variation in agent access models and the types of entities that may use or offer them (such as payment infrastructures or non-bank PSPs) depending on the settlement needs of the participant, agent access models may be considered direct or indirect access depending on the jurisdiction and the perspectives of the system operators. Therefore, in the current report, we only distinguish between direct and indirect access.

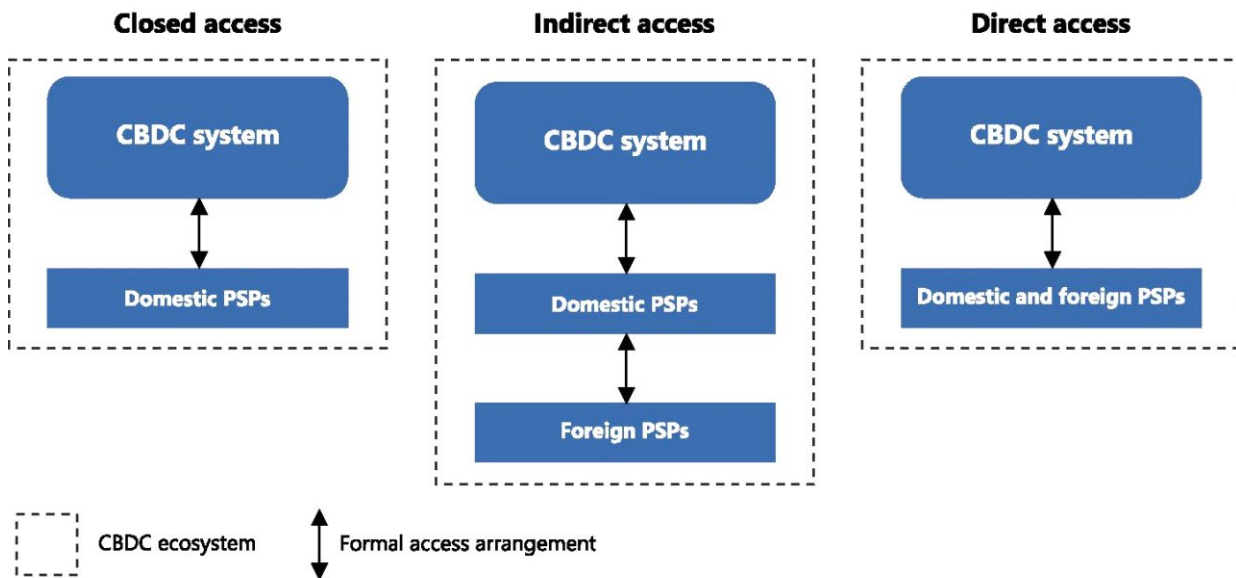
²¹ Prototypes were developed to flexibly support both indirect and direct access models. In jurisdictions where the regulatory frameworks allow direct access to the CBDC by non-resident banks, approval routing to “sponsoring” banks could be disabled to move from a sponsored to direct CBDC access model.

²² Even if foreign PSPs are given direct access, central banks might limit the issuance (redemption) of CBDCs to domestic PSPs. In this case, foreign PSPs would have to buy (sell) the CBDC in the secondary market from (to) domestic PSPs. So the provisioning of direct access to wCBDC raises the question of how to issue wCBDC to non-local banks or other PSPs. While most wCBDC projects propose the issuance of wCBDC through the RTGS system, another option proposed by BISIH, SIX and SNB would be for the central bank to issue wCBDC via monetary policy operations, such as standing facilities, directly on the wCBDC network (see project Helvetia Phase II in Annex 6.5).

playing field), resilience (settlement/liquidity/credit risks, concentration risks) and financial inclusion. Also, the challenges and feasibility of each access option differ. These will be discussed in Section 4.²³

High-level options for access to wCBDC systems by foreign PSPs

Graph 1



This report does not consider a correspondent banking arrangement as a formal access model. Yet, in each of the CBDC access models presented here, direct and indirect participants could establish correspondent banking relationships with other PSPs that are neither direct nor indirect CBDC system participants. Such arrangements might especially occur in a cross-border arrangement based on closed access and in which interoperability with other CBDC systems is achieved via compatibility.

Source: Authors' elaboration.

3.1.2 Access to rCBDC by non-residents and the role of PSPs

When designing an rCBDC, central banks will also have to find an answer to the following two questions, each of which will impact the flow of cross-border CBDC transfers:

- *Who will be able to hold and transfer rCBDCs and under what conditions?* A key issue is to what extent non-residents of the issuing jurisdiction will be granted access to the rCBDC. There is a spectrum of options, starting with granting access to tourists and business travellers visiting the country. Broadening this out somewhat, access could also be granted to refugees, asylum seekers, foreign entrepreneurs, and resident branches of foreign corporates, as well as to expatriates and relatives living abroad so that they could use the rCBDC to send and receive remittances and cross-border transfers. The flow of cross-border rCBDC payments can further be influenced by

²³ On top of determining who can access wCBDC, central banks will have to decide which rights each of the participants will have in the system. In case of, for example, a DLT, the various options might differ depending on the type of DLT used, but generally speaking the role of participants in such a network might vary from validating transactions within the network, to reading and writing information (ie submitting transactions) to reading own transactions only. These choices too will have different implications.

the conditions set for holding and using rCBDCs. CBDC holdings and payments by non-residents, when allowed, could be limited through caps or fees.²⁴

- *If access to rCBDC is allowed for non-residents, how will they be able to access it?* For rCBDCs to be accessible to non-residents, either when visiting the issuing country or when abroad, they would need to be able to open and hold an rCBDC account. This requires the rCBDC ecosystem to be designed such that rCBDCs can be acquired by non-residents through transfers or in exchange for their home currency. As with the distribution of domestic rCBDCs, these account and exchange services can be provided either directly by the issuing central bank (one-tier rCBDC model) or indirectly via private sector intermediaries (two-tier rCBDC model).²⁵ One- and two-tier architectures might have different implications, both in terms of the five criteria discussed in this report and in terms of their implementation challenges. However, as most central banks are considering a potential domestic rCBDC architecture that involves a role for the private sector (see Kosse and Mattei (2022)), this report focuses on two-tier architectures.

If non-residents are not allowed to hold rCBDCs, one way to still transact using them is for the end user to have a non-CBDC account with an intermediary who has access to rCBDC and who can make an rCBDC transfer on the end user's behalf. However, from the end user's perspective, this would constitute a claim on the PSP even if the rCBDC would still be a liability of the central bank. Alternatively, if multiple CBDC systems are interlinked (see Section 3.2), non-residents, provided that they have access to a domestic CBDC, could still make CBDC payments to someone in another CBDC system in the presence of an intermediary PSP acting as a CBDC conversion provider. Similar to the wCBDC access options presented in Section 3.1.1, foreign PSPs may be granted access to the rCBDC using an indirect or direct access model.

3.2 Options for interoperability of CBDC systems

As mentioned earlier, cross-border payments with CBDC can also be enabled through ensuring interoperability between different CBDC systems as well as between CBDC and non-CBDC systems. In this section, we explore different types of interoperability, while accounting for the fact that somewhere along the payments chain, one currency (regardless of its form, whether CBDC or non-CBDC) must be exchanged for another, just like traditional cross-currency transactions (see Box 1).²⁶ Domestic interoperability between a jurisdiction's CBDC and non-CBDC systems will be briefly discussed in Section 3.3.

There are three broad models of mCBDC arrangements that can be used to achieve interoperability (see CPMI et al (2021)²⁷ and Graph 2):

- *The compatible model* – refers to individual CBDC systems that use common standards, such as message formats, cryptographic techniques, and data requirements, that reduce the operational burden on PSPs for participating in multiple systems. Hence, compatibility might be achieved, for example, through the use of common messaging standards and data formats, such as ISO

²⁴ Remuneration is another tool that central banks could use to influence holdings and use of rCBDC (see eg Bindseil (2020)), which could be considered as a negative fee.

²⁵ In a two-tier model, the issuing central bank and trusted private sector intermediaries would work together in a complementary way (see Auer and Boehme (2021)). The central bank could focus on issuing the CBDC, providing the core CBDC infrastructure, and ensuring its stability and security, whereas the majority of the operational tasks and consumer-facing activities would be delegated to the intermediaries. These intermediaries could be located either within or outside the country of issuance depending on the jurisdiction's policy and regulation.

²⁶ As is the case with traditional cross-currency transactions, foreign currency providers for cross-border CBDC transactions must hold enough balances in the respective currencies. This requires them to hold CBDCs either directly or indirectly and necessitates domestic interoperability between the CBDC systems and traditional central bank reserves. This type of interoperability to facilitate FX transactions is out of the scope of this report's analysis.

²⁷ The three models of mCBDC arrangements were first presented in Auer et al (2021).

standards.²⁸ Cross-border CBDC payments in the compatible model could be achieved with the various access models presented in Section 3.1. If a CBDC system allows for direct access, a foreign PSP could directly access the system to facilitate a cross-border payment using that CBDC. In that case, the foreign PSP would likely have to obtain the currency of the CBDC system on its own accord. Alternatively, a foreign PSP could access the CBDC system via a direct participant that probably performs the currency conversion (see Graph 3).

Although the compatible model does not link different CBDC systems, it has the potential to improve current cross-border payments by enhancing efficiency of payment processing and compliance protocols and by facilitating participation in different systems and different jurisdictions. Depending on the access model, some frictions may however remain, such as the need for individual PSPs to establish correspondent banking relationships. See project Helvetia Phase II (Annex 6.5) for an example of a compatible model with direct access.

- *The interlinked model* – links different CBDC systems with a set of technical and contractual agreements that not only facilitate communication and exchange of data, but could also facilitate compliance, foreign currency provision and settlement.²⁹ These common arrangements would allow participants in the interlinked CBDC systems to transact with each other without the need to become a direct participant in each of them or to establish bilateral arrangements with an intermediary for each of them. Interlinking arrangements could include common technical functionalities between CBDC systems (such as PvP settlement) and a common set of currency providers connected via a common trading venue. For the interlinked model, a question is how exactly the CBDC systems involved are linked. Work on interlinking of non-CBDC payment systems is being taken forward under BB 13 of the G20 cross-border payments programme (see eg CPMI (2022c)). For the purposes of this report, we build our analysis on the ways of interlinking systems identified in that work, which can also be applied to CBDC systems (see Graph 3):
 - *A single access point* – where participants in one system have access to another system through a single “gateway” entity, such as a PSP acting as a single correspondent bank for all and participating in both systems. This model differs from the compatible model above in that the single gateway entity is a formalised part of the arrangement and acts as a gateway to all other participants;
 - *A bilateral link* – where two individual CBDC systems are directly linked so that participants in one system can directly transact with participants in the foreign system (see projects HSBC and Jasper-Ubin in Annex 6);
 - *A hub and spoke solution* – where a common hub connects two or more separate CBDC systems of participating jurisdictions. The hub can be a payment system in itself, but does not necessarily have to be.³⁰
- *The single system model* – refers to CBDCs that use a single common technical infrastructure and potentially also a common rulebook.³¹ While the rulebook over the platform will apply to all participants, the rulebook for each CBDC might still differ between jurisdictions with regard to, for example, holding and transaction limits, participation requirements, and issuance and redemption of CBDCs. Hence, this model is not connecting separate CBDC systems, but rather

²⁸ There could be trade-offs between promoting international interoperability of CBDCs using commonly implemented standards and achieving domestic interoperability with existing forms of money within jurisdictions; this should be carefully assessed.

²⁹ The BIS Innovation Hub’s Project Nexus is an example of an interlinked model applied to fast payment systems. This project provides a blueprint for a scalable cross-border payment network that would connect fast payment systems in multiple countries. Detailed information about the project is available at www.bis.org/about/bisih/topics/fmis/nexus.htm.

³⁰ Project Nexus is an example of a hub and spoke model even if not focused on CBDC. See nexus.bisih.org/.

³¹ A single system model may qualify as a “common platform” and a “multilateral platform” as defined by BBs 13 (interlinking) and 17 (multilateral platforms) of the G20 cross-border payments programme.

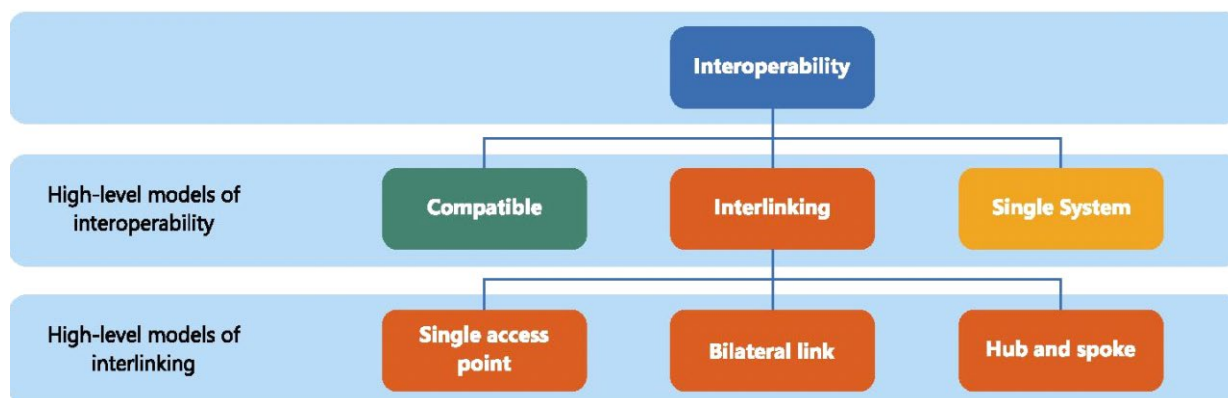
establishing a common platform to achieve interoperability between CBDCs. The single system model may offer the same services as the interlinked model (eg PvP functionality and common currency trading venue), but could also establish common participation requirements for all jurisdictions involved. If establishing such requirements, the single system model could bring additional benefits as compared to the interlinked model by further stimulating competition (see Graph 3 and projects Prosperus, MAS, Aber, Dunbar, mBridge and Jura in Annex 6).

The design of the interlinked model and the single system model raises the question of which entities provide the common services. For instance, central banks could act as common settlement agents or foreign currency providers, but these services could also be left to the private sector. The role of the public sector in that case could be to specify requirements for private actors to offer certain common services. Currency providers could in principle be anyone that is willing to engage in currency exchange, but if they are not themselves settlement agents in the respective CBDC systems, they would have to rely on common settlement agents. Common technical functionalities allowing for PvP settlement would eliminate credit risk exposures in the settlement process. This would stimulate competition in the provision of these intermediary services, as PSPs in different systems could act as settlement and foreign currency providers to each other without exposure to credit risks in the settlement process.³²

All models described in this section can be implemented with different access options and using different technical solutions. When analysing the different access and interoperability arrangements in the remainder of this report, we remain agnostic regarding the technical solutions used. Moreover, it should be noted that the interoperability and interlinking options presented above should be taken as stylised models that aim to facilitate our understanding of the high-level distinctions and key considerations. In practice, hybrid solutions may arise that have characteristics of different models. Also, systems may be classified in multiple ways depending on their reach and access criteria. For example, a single system implemented by a group of countries could act as a hub to other countries outside this group.

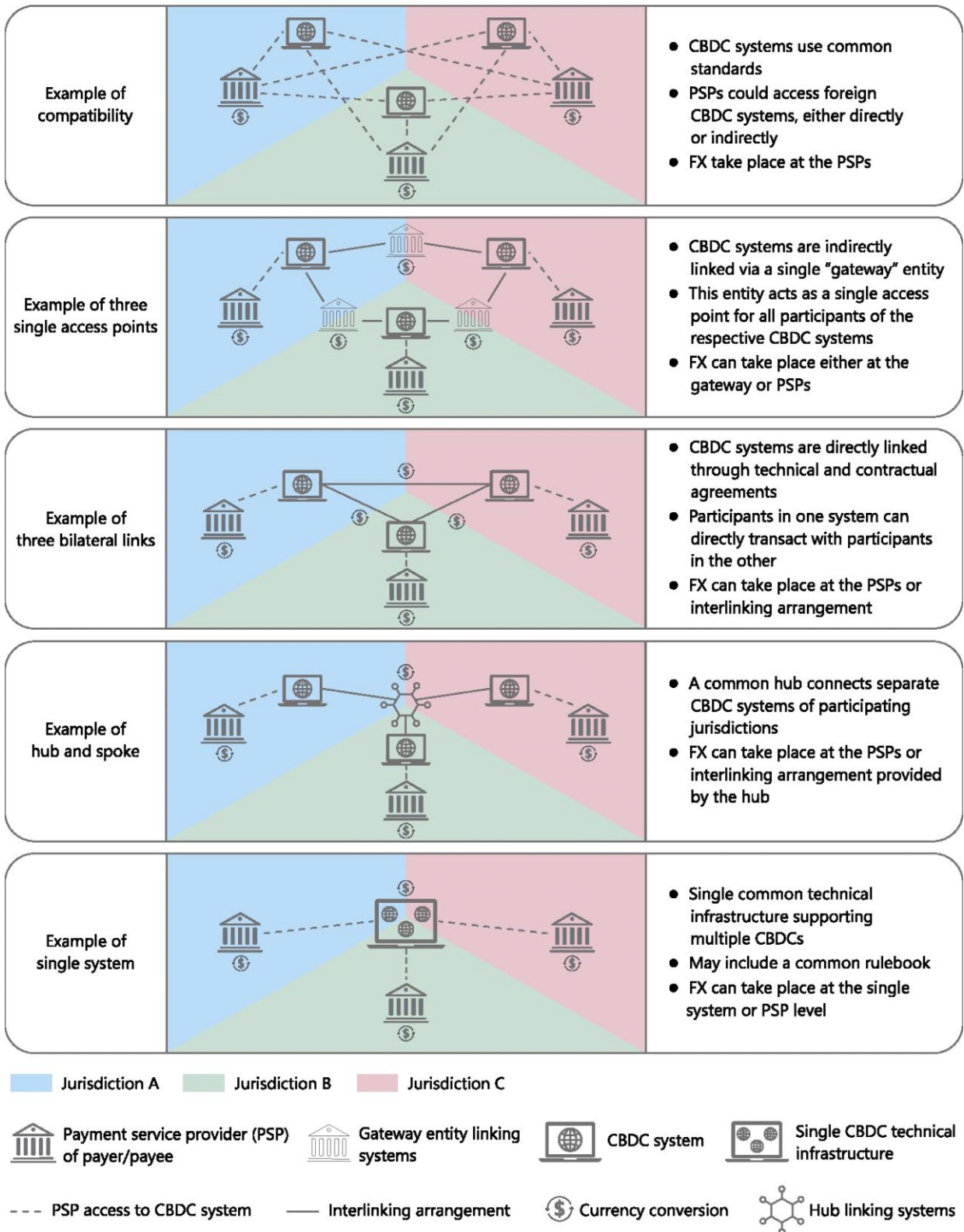
High-level models of interoperability and interlinking of CBDC systems

Graph 2



Source: Authors' elaboration leveraging CPMI et al (2021) and CPMI (2022c).

³² Payments from one CBDC system to the other would in this case involve two payments as in the compatible model where one intermediary is acting as settlement agent and currency provider. As a first step in cross-border payment, a domestic PSP would enter into a foreign currency trade via a common trading venue. After the foreign currency exchange rate is established via the foreign currency trade, the cross-currency payment would be settled by two synchronised payments in respective currencies. The foreign currency provider (or its settlement agent) would settle the payment to the ultimate receiver in the currency of the receiver, while the originating PSP would settle the payment to the foreign currency provider (or its settlement agent) in the domestic currency.



The PSP access to the CBDC system could be based on any of the models discussed in Section 3.1.1.

Source: Authors' elaboration leveraging CPMI et al (2021) and CPMI (2022c).

3.3 Interoperability of CBDC and non-CBDC systems

Interoperability between CBDC and non-CBDC systems, such as fast payment systems, RTGS systems or other (future) systems, is key to ensuring that end users can seamlessly transact across borders regardless of the payment instrument chosen. For example, arrangements among wCBDC systems might require linking to the non-CBDC systems in each jurisdiction to facilitate cross-border transfers and wCBDC arrangements could act as the settlement system for linked domestic retail payment systems. In addition, there might be cases in which a payer wants to send money using a CBDC to a country without a CBDC.

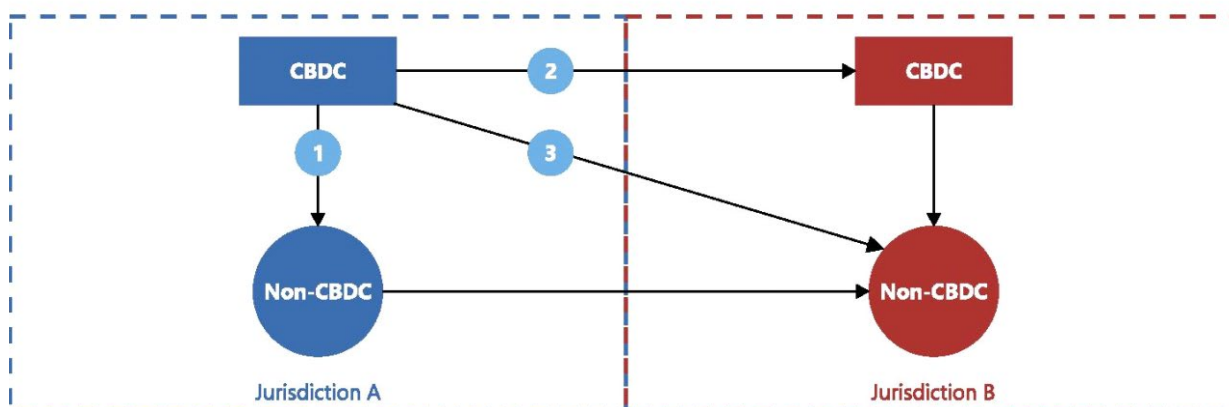
To achieve interoperability between CBDC and non-CBDC systems, it should be considered at an early stage – both within and between jurisdictions. There are three general options to attain such “universal” interoperability. As an illustration, let us consider the example where someone in Country A would like to use a CBDC account to transfer money to someone in Country B who does not have a CBDC account. Such a payment could, in principle, take three different routes (see Graph 4):

1. From the CBDC system to the non-CBDC system in Country A and then to the non-CBDC system in Country B via a cross-border interoperability arrangement between the two non-CBDC systems;
2. From the CBDC system in Country A to the CBDC system in Country B using the cross-border interoperability arrangement between the two CBDC systems and subsequently to the non-CBDC system using domestic interoperability between the CBDC and non-CBDC systems in Country B;
3. From the CBDC system in Country A directly to the non-CBDC system in country B via a cross-border interoperability arrangement between the domestic CBDC and foreign non-CBDC systems.

The first two routes are similar in the sense that they both build on domestic interoperability between a CBDC and non-CBDC systems and a cross-border arrangement connecting two systems of the same type. However, the first option would rely on the traditional cross-border arrangement, whereas the second would rely on a CBDC cross-border arrangement, which could be more efficient, for example for the reasons mentioned in Section 1. The third route only requires one type of interoperability, ie cross-border interoperability. Provided that more than one cross-border connection exists, different routes would be available for end users. Factors such as cost and speed will then influence the selected route, which in turn will be affected by which of the interoperability models from Section 3.2 is used for each “link”.

Interoperability of CBDC systems with non-CBDC systems

Graph 4



Source: Authors' elaboration.

4 Analysis of access and interoperability options

4.1 Analysis of access and interoperability options for meeting the criteria

Tables A.1 and A.2 in Annex 4 map a selection of completed and ongoing CBDC projects against the access and interoperability options identified above. The majority of the wCBDC projects have been completed as one-off experiments, while a few are still in an exploratory stage (see Graph A.1 in Annex 4). Regardless of their status, most cross-border wCBDC projects use a single system to facilitate CBDC transactions between jurisdictions, and all except one apply a closed or direct access model. This might suggest that central banks perceive these interoperability and access options either to have the highest potential to add value in the long run or to be the easiest to start from in the short run. In this section, we analyse the access and interoperability options identified in Section 3 through the lens of the five criteria presented in Section 2 (see also Graph 5 at the end of this section for a summary).

4.1.1 Do no harm

As discussed in Section 2.1, macro-financial risks of cross-border use of CBDCs derive mainly from potential capital volatility and currency substitution. Thus, limiting harm in this context implies maintaining the option of implementing CFMs to control flows. Cross-border use of CBDC will require an interface, such as a digital wallet, to access and transfer the CBDC. This interface could be exploited to control flows regardless of the interoperability model used. Control measures could also be applied directly to the connection between CBDC systems. In this case, the implementation of such controls depends on the different choices regarding interoperability of and access to CBDCs.

At the interface level, different access controls and limits can be used to mitigate risks. Here it is relevant to distinguish between rCBDC and wCBDC. For rCBDC, controls could potentially be “hard-coded” in the wallet to limit the amount of foreign holdings or the size and frequency of cross-border transactions. The access choice will set the scope for such controls. Allowing non-residents, such as tourists, access to rCBDCs when physically within the borders of the issuing country probably has limited macro-financial consequences compared to allowing access to non-residents who are not physically in the issuing country. Controls such as GPS geolocation and transaction limits could be used to limit the use and holdings of rCBDC by non-residents after leaving the issuing country. Similarly, for wCBDC, controls could be applied to the foreign intermediaries’ accounts. If the issuing country allows indirect access (see Section 3.1.1), the account held by indirect participants may be set up in such a way that transactions related to foreign banks are flagged, which would allow for real-time reporting to both domestic and foreign central banks – assuming that they are cooperating on surveillance flows – and for potential blocking of foreign transactions. Control at the interface level could thus be used with any interlinking option. It would, however, require: (i) effective KYC procedures; (ii) wallet design that allows control parameters to be set; and (iii) close cooperation among central banks, as the wallet issuer or overseer (ie the issuing central bank) must be willing to set those parameters to take international effects into account. Compliance of all actors involved would also be key for effective controls.

In the compatible model, countries would rely primarily on regulation and supervision of the domestic financial service providers providing the connection between jurisdictions. This would be similar to the current CFMs setup, in which financial intermediaries are responsible for implementing controls. Both the model for cross-border payments and the method to control them would thus be an updated version of the present system. Effects of increased use of digital money on the possibility of enforcing regulation and CFMs need to be analysed, and possibly updated for the digital age.

Both the interlinked model and the single system model allow the system operators to monitor and control transaction flows more directly, as flows are channelled through either a single access point, a bilateral link, a central hub, or a single system. However, a key challenge with these models is the governance of the link, hub or system, especially if there are competing country requests for controls and

stops on flows. Governance must allow for a process to resolve different requests and, at the very least, provide the option of detaching unilaterally from the cross-border arrangement if the control of flows would not meet the needs of a certain jurisdiction.

4.1.2 Enhancing efficiency

The efficiency implications of different access and interoperability options depend on a large number of factors, such as the number of systems or intermediary PSPs involved, the development and maintenance costs of the arrangements, and whether such factors result in speedier and cheaper payments. All else equal, the single system model with common infrastructure and a single rulebook may lead to shorter transaction chains and hence speedier transactions than a single access point, bilateral link or hub and spoke model, as the latter involve multiple systems.

Also, integrating currency trading platforms and technical PvP functionalities in different interlinking solutions or in a single system may generate efficiency improvements, as such arrangements would reduce principal and currency exchange risks and potentially increase competition in the FX market. The compatible model would rely on policies and design to ensure an increase in competition. There is a risk that this model could be dominated by a few large PSPs for whom it is viable to participate in multiple CBDC systems and act as a currency provider and settlement agent.

Although the compatible model, the single access point model and bilateral links model can be established with relatively low costs, the adoption of a hub and spoke or single system would allow the costs of a technical solution for CBDCs to be shared among multiple participating jurisdictions. This would facilitate low fees and the internalisation of network effects that would bring added benefits to the users. Both aspects are crucial for encouraging sufficient adoption and private sector participation. At the same time, adopting a single system would save the costs of establishing and maintaining separate links or hubs necessary in the interlinking options. A single system (if operated on a cost-recovery basis similar to traditional payment systems operated or governed by the public sector) may be especially attractive in regions with smaller jurisdictions that may otherwise lack the scale that is required to sufficiently lower the unit cost of CBDC payments. Achieving low fees is especially important in the context of remittances and other low-value cross-border payments.

The use of a common rulebook may further increase the efficiency of a single system, as this may lead to additional harmonisation of payment messages, compliance and data processing. This in turn could result in faster payment processing, eg due to faster pre-checks and compliance. It could also promote harmonisation among other payment systems, especially if the CBDC system interoperates with other, domestic, payment systems. A single system with a common rulebook may also contribute to lowering legal uncertainty around settlement finality, and hence increase speed. This is particularly important in the context of time-critical large-value cross-border payments.

CBDC systems which would offer direct access to a broad range of institutions could contribute to efficiency. This could enhance competition, reduce risk and shorten transaction chains, but as highlighted elsewhere, it could also bring changes to the risk profile of the direct participants, potentially undermining the integrity of the existing settlement process (see eg CPMI (2022b)). Provided that risks relating to the direct access policy can be controlled, this policy could further enhance efficiency in cross-currency payments.

4.1.3 Increasing resilience

Resilience as defined in Section 2.3 is a broad term that covers the management of various risks. In addition to implementing general guidance on resilience, the different arrangements used for connecting CBDCs may have varying implications for resilience. Implications may differ according to how centralised or decentralised arrangements are. Both can offer potential advantages and disadvantages for resilience.

As the single system model is centralised, consequences could be large if it is disrupted. However, such a system would allow pooling of knowledge and resources from multiple jurisdictions, which could

support more extensive measures, such as mirroring of crucial components and sophisticated cyber security measures, and more extensive incident management and reporting.

The resilience of the compatibility model depends on the access model implemented. An indirect access model might result in a few large domestic PSPs through which foreign PSPs access multiple CBDC systems. By contrast, compatible models allowing for direct access might increase resilience by reducing concentration of risk in a single or a few crucial entities.

The various interlinking models also differ in terms of their potential resilience. In the bilateral link or single access point model, a disturbance to the link or gateway entity between two jurisdictions would disrupt all transactions between the two respective jurisdictions, but not that of other countries. However, multiple jurisdictions could be connected through bilateral links or single access points which could increase resilience through redundancy: if the link between country A and B is disrupted but both countries also have a link to country C, then payment between A and B could potentially be rerouted via C. Similarly, in a hub and spoke model, a disturbance to one jurisdiction's link to a hub would only disrupt the transactions to and from this jurisdiction, while leaving transactions between other spokes unaffected. However, disruptions to the hub would affect all payments in the system, similar to a disruption of a single system and thus increase concentration risk.

While a bilateral link model could reduce the concentration risk of a hub and spoke or single system, maintaining a high level of resilience for all links and systems could be costly. Using a hub and spoke or a common platform, in contrast, allows pooling of resources (eg knowledge and budgets) that could be employed for increasing resilience compared to a more decentralised approach.

The choice of interoperability model might also have longer-term implications for development of resilience, as entities develop strategies to cope with risks. More centralised models might entail larger resources to develop new risk management tools. But on the other hand, a compatible model – provided that sufficient competition can be achieved – could provide a diversity of experimentation with new approaches, as different actors strive to adapt to changing risk landscapes, which could benefit the development of resilience.

Overall resilience of cross-border payments would also depend on the resilience of the individual CBDC systems. To protect domestic CBDC systems from operational failures of individual intermediaries or third parties (eg wallet providers or critical service providers), strict eligibility and compliance requirements for participants (eg sufficient operational and technical ability, sound risk management) could be established. A jurisdiction would have greater autonomy in establishing regulatory compliance requirements and supervising intermediaries with a less integrated model. However, establishing a common rulebook between jurisdictions would probably increase resilience, since everyone would abide by the same rules which would minimise the risks arising from divergent or inconsistent requirements. This is especially important if access is broadened to foreign PSPs that are not under the purview of the domestic regulator. In this case, some degree of coordination between the different jurisdictions is needed (eg to exclude a participant from the arrangement in case of misconduct or insolvency).

4.1.4 Assuring coexistence and interoperability with non-CBDC systems

To promote coexistence with other forms of money and payment instruments and a reasonable level of adoption of CBDC, interoperability with non-CBDC systems, both domestically and cross-border, is fundamental. Users benefit from having a choice of different payment methods. To fully achieve this, users must have the ability to effortlessly go from one method to another.

For end users to make and receive rCBDC payments, they must be able to domestically exchange CBDC to cash or commercial bank money. One way to achieve this is to use a two-tier model in which PSPs are allowed to hold and transact the rCBDC. Extending this to a cross-border setting, PSPs could be allowed to hold and transact both domestic and foreign CBDC and commercial bank money. In such an arrangement, an access model giving PSPs direct access to both the CBDC and non-CBDC systems would

be the best option to enhance interoperability across borders as it would reduce the number of intermediaries involved.

Coexistence with non-CBDC systems is best promoted via a level playing field. Ensuring that different forms of public money (eg cash and traditional reserves) and private money (eg commercial bank accounts and e-money) can coexist and sustain sound business models is best achieved by access models promoting competition between PSPs and payment types. Establishing interoperability between different forms of payment types across borders would promote coexistence as it provides users with more options.

Section 3.3 presents three potential routes for connecting a domestic CBDC system with a foreign non-CBDC system. The first route (utilising domestic interoperability and then non-CBDC cross-border arrangements) requires improvements in non-CBDC payment infrastructures and arrangements (eg messaging standards, opening hours, participation requirements, funding and interlinking arrangements) and domestic interoperability between CBDC and non-CBDC. For the second route (connecting domestic and foreign CBDC systems and then utilising domestic interoperability in the foreign country), the CBDC connection could be established using either compatibility, interlinking, or a single system model. The third route (connecting a CBDC system directly with non-CBDC systems) would be important in cases where a recipient country does not have a CBDC. Potentially, all the models of interlinking could be used to link a domestic CBDC to a foreign non-CBDC system.

4.1.5 Enhancing financial inclusion

As noted in Section 2, simplified onboarding (eg via remote registration), ease of use, and access through a wide range of interoperable access points are likely to have a direct impact on how a CBDC supports financial inclusion objectives. These aspects largely depend on domestic CBDC design choices. Furthermore, the greater the level of harmonisation of regulations and alignment of technical standards and business practices, the broader the range of potential CBDC use cases supported and the greater the potential impact on financial inclusion. It is also worth noting that financial inclusion also depends to a great extent on the domestic arrangements of each jurisdiction. Factors such as foreign exchange policies, and the level of development of ICT infrastructure could dramatically affect the ability and willingness of users to use formal channels to send and receive remittances.

Access options to wCBDC are relevant to financial inclusion insofar as they may have a bearing on the ability of PSPs to serve a wide range of customers, including segments that most incumbents may consider unprofitable or difficult to reach. wCBDC systems act as a bridge for the PSPs' customers to transfer funds among themselves. Although customers will not hold CBDCs, the wCBDC could be used to switch, clear and settle customer transfers initiated from non-CBDC systems. Options that facilitate direct access to wCBDC accounts by foreign PSPs would appear to be most supportive of financial inclusion objectives, as foreign PSPs might have a better traction with certain customer segments like diaspora and their families. An indirect access model would make foreign PSPs reliant on domestic banks acting as correspondents, and closed access models would be the least supportive. Cross-border CBDC arrangements could be well placed to replace the existing correspondent banking relationships provided there is a large number of direct participants, thereby cutting down the number of intermediaries and multiple steps that weigh on costs and disproportionately affect small-value payments such as remittances (BIS-WB (2022)).

Cross-border CBDC arrangements that have small local and regional banks as direct participants would enhance micro, small and medium-sized enterprises (MSMEs)' access to cross-border payments (WTO et al (2021)). MSMEs – both as exporters and importers – could benefit from greater access to international markets and from digital tools and services for furthering their business. These opportunities are dependent on MSMEs having access to cross-border payment services. As MSMEs tend to be served by smaller local or regional banks, the de-risking phenomenon affecting these banks' correspondent banking relationships may result in hindering their ability to connect MSMEs to cross-border markets. Cross-border CBDC arrangements could provide or restore this connection. Another aspect of relevance is MSMEs' limited access to trade finance facilities, where new approaches based on technologies such as

blockchain and tokenisation could be relevant. Such approaches could integrate better with CBDC-based payment services.

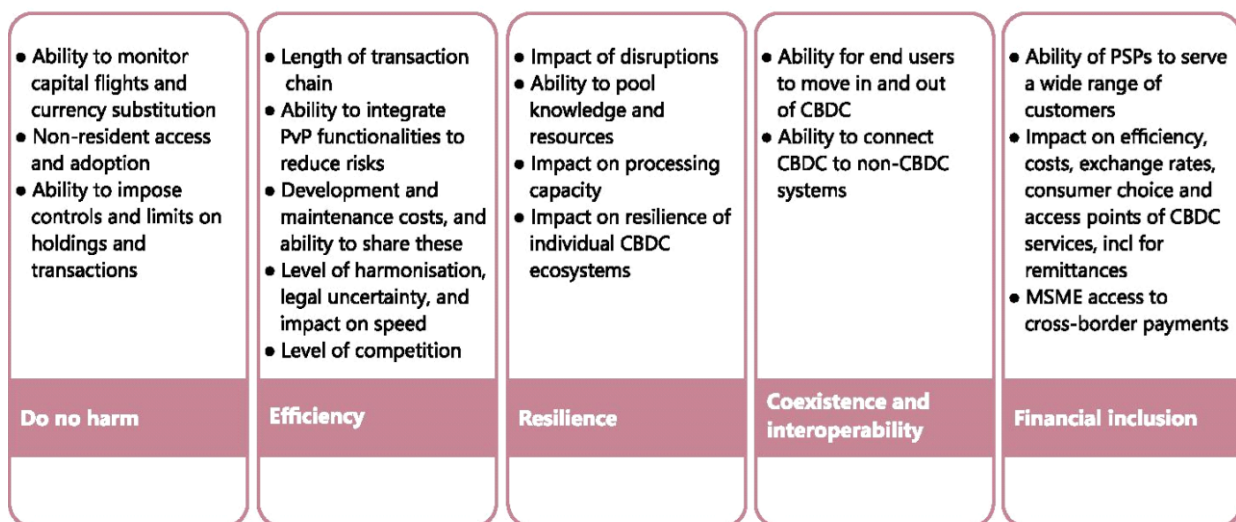
Allowing carefully calibrated non-resident access to domestic CBDC ecosystems may enhance financial inclusion, eg by enabling citizens working abroad to transfer funds to their family members' CBDC accounts domestically. This would have a positive impact on financial inclusion, both domestically and across the border, if it leads to a higher adoption and use of formal payment accounts. However, risks associated with, for example, currency substitution would increase.

In addition to access policies, the specific cross-border CBDC interoperability models may also have implications for financial inclusion insofar as greater levels of harmonisation may contribute to greater efficiency, lower end user costs, increased consumer choice or better access points. However, there may be certain trade-offs between harmonisation and the prerequisites for a model:

- CBDC cross-border arrangements based on a compatible model could be the least complex way to achieve cross-border interoperability. However, for compatibility to enhance financial inclusion, there should be strong harmonisation on such aspects as fee structure, speed of payment processing, AML/CFT arrangements, exchange rates and dispute resolution.
- For interlinked models, it would be the role of the system operators to ensure alignment. Compared to the compatible model, interlinking will typically reach a higher degree of harmonisation, and thus enable financial institutions and users to select among a larger (or common) set of providers, possibly leading to fewer fees and better services.
- The single system arrangement in principle provides the governance to ensure the highest degree of alignment across several aspects of CBDC operations. However, some jurisdictions may lack the incentives or eligibility criteria to participate in a common governance arrangement.

Factors that influence the impact of access and interoperability models on each of the five assessment criteria

Graph 5



Source: Authors' elaboration.

4.2 Assessment of implementation challenges

4.2.1 Challenges of interoperability of CBDC systems for facilitating cross-border payments

While CBDC cross-border arrangements could provide an advantage compared to the traditional cross-border arrangements, several challenges are common to all types of payments.³³ For example, in order to be successful, interoperability options for CBDC systems need to address challenges related to investment and maintenance cost, scalability, legal and regulatory frameworks, governance, AML/CFT and privacy protection, technology standardisation, risk management, operational and information-sharing concerns. In addition, other issues arise, such as network governance arrangements, data warehousing and choice of custody model, as CBDC business model questions remain to be answered. However, novel technologies, for instance DLT, potentially open up new options (eg subnetworks, control of nodes)³⁴ for addressing some of these challenges. Some of these challenges are universal across the different interoperability models, while others are more specific and should be taken into account in evaluating interoperability options (see Annex 5).

Investment and maintenance cost

Cost sharing and incentive mechanisms are key to the sustainability of all interoperability models. The compatible model, the single access point model and bilateral links can be established with relatively low costs. With the hub and spoke model, a hub must be set up from scratch, with the costs varying depending on the functions offered. A single system with a common platform requires a fully fledged mCBDC system and would be the costliest upfront, inter alia because of the importance of ensuring operational resilience and to avoid having a “single point of failure”. However, once the hub or common platform was in place, costs could be shared among a larger number of participants, and the marginal cost on an ongoing basis could be the lowest.

The initial and ongoing investment might cover system software development, hardware infrastructures, system operation and maintenance, business monitoring, etc. For hub and spoke models and single systems with a common platform, it is essential to weigh who shoulders the development work, how to build it, who maintains it and how to ensure business sustainability in an international cooperative context.

Scalability

The compatible model using common standards would result in extensive scalability if the common standards truly removed country-by-country variation. However, its scalability would be limited if different detailed standards were still permitted. Despite simplicity in terms of having fewer attributes to harmonise and low costs, the single access point model and bilateral links have obvious scalability limitations compared with the hub and spoke model or the single system using a common platform. This is because a multitude of bilateral links between single access points, payment systems and other systems results in complex processes and requires a myriad of interoperability arrangements to be maintained. By design, a hub or common platform could more easily accommodate new participants and, by limiting the number of access points, reduce the costs associated with accommodating each new participant.

Legal and regulatory framework

Divergent, restrictive and not sufficiently harmonised legal and regulatory frameworks can pose challenges for mCBDC arrangements. Rules and regulations like CFMs, tax and payment laws, data-sharing and privacy treatment differ across jurisdictions. Interlinkage between infrastructures located in different

³³ BBs 10 (access), 13 (interlinking) and 17 (multilateral platforms) of the G20 cross-border payments programme address in more detail interlinking and access questions for traditional payment systems.

³⁴ See Annex 6 for a technical overview of how interoperability and access questions are being addressed in current experiments.

jurisdictions may therefore be regulated by divergent regulatory frameworks, which could result in important legal uncertainties. However, legal certainty is necessary in terms of applicable laws. Legal certainty is also required for any financial market infrastructure (CPMI-IOSCO (2012)), whatever the interoperability model chosen. However, complexities could increase in a bilateral link model, because there are a multitude of links. The hub and spoke model and the single system with a common platform would bring added complexity upfront, as they require broader legal and regulatory policies to be determined, to which the platform and its participants must adhere. Yet, after such consensus is reached among the participating jurisdictions, the hub and spoke model and single system with a common platform would show greater efficiency in terms of accomplishing compliance duties on an ongoing basis and could reduce the aforementioned legal uncertainty. Finally, it is important that the issuance of CBDC is legally feasible in the issuing country³⁵ and that issued CBDCs are fully recognised as currency by recipient countries' laws.

Governance arrangements

Cross-border CBDC arrangements require governance structures and frameworks, such as system rules, clear goals, effective decision-making processes, risk management policies and procedures, and clear rights and obligations – as with any interoperability arrangement. While traditional governance aspects and agreement on a rulebook are complex issues in all the interoperability models, challenges could be even more difficult for a single system with a common rulebook, since all participants would in essence have to accept the same rulebook and the risk of dissension increases with the number and heterogeneity of the participants. However, this single system model could potentially be less challenging in the longer term once the rulebook is agreed upon. How a governance model would fit with multiple central banks that share a common mCBDC platform and involve multiple commercial stakeholders remains a key consideration. Individuality that allows a sufficient level of autonomy and control has to be balanced with universality and standardisation. To address this challenge, governance structures and decision-making frameworks could be designed.³⁶

Domestic versus cross-border interoperability

As discussed in Section 3.3, ensuring domestic interoperability would also be crucial in a CBDC ecosystem. As CBDC efforts progress in each jurisdiction, potential trade-offs might arise between promoting international interoperability of CBDCs using commonly implemented standards on the one hand and achieving domestic interoperability with existing forms of money on the other. For example, creating a single system and rulebook for cross-border CBDC payments could shift the interoperability challenge from between CBDCs (internationally) to between CBDCs and other forms of payment (domestically). This could impact the different priorities of central banks.

The balance between addressing illicit finance and privacy protection

Regardless of the model chosen, an mCBDC arrangement requires strong coordination among participating central banks to address illicit finance and to strike a balance between protecting privacy and combating illegal activities. AML/CFT processes are more challenging in a cross-border context. Different jurisdictions might have different thresholds to identify significant transactions that require enhanced due diligence. In a single mCBDC system, participants may collectively agree to adopt the lowest threshold to comply with the most stringent regulatory requirements, and, in the specific case of sanctions screening, this model as well as hub and spoke could facilitate the implantation of automated verification of sanction enforcement. However, it might be complex to agree on a single set of rules that allows individual countries to have the variations tailored to their ML/TF risk profile and other country-specific contexts (see also Box

³⁵ Kosse and Mattei (2022) show that 26% of the 81 respondent central banks have the legal authority to issue a CBDC and another 10% of jurisdictions are currently changing their laws to allow for it.

³⁶ See BIS (2021a, Section 6) for considerations related to the governance structure and conceptual decision-making framework of a common CBDC platform.

2). Customised privacy solutions that satisfy AML/CFT requirements also should be determined, eg who can access which parts of a cross-border transaction and under what circumstances.

Technology standardisation

One challenge relates to technological coordination. Insufficient technical standardisation in areas such as message formats, data elements, cryptographic algorithms and numbering and coding systems would cause frictions and inefficiencies when attempting to achieve interoperability between CBDC systems. Adopting the same technical standards requires high initial effort in each interoperability model. Another aspect relates to technological infrastructure and implementation. Greater challenges would appear in the steady state phase because remaining differences between systems would create inefficiencies. With a single system with a common platform, it would be easier to have baseline technological compatibility. In addition, a common platform model could enable greater technological efficiency for settlement and other processes.

Risk management, operational and information-sharing challenges

Given the currency conversion involved in most cross-border CBDC payments, challenges arise with respect to the choice of entities to provide the conversion service and bear the associated FX risk, and the choice of a reasonable exchange rate determination mechanism that minimises the risk of FX arbitrage. A single system with a common platform has the potential to streamline the payment process by performing both FX trading and settlement on the platform.³⁷

Market and liquidity fragmentation issues could be less challenging for a hub and spoke or single system model considering that liquidity would be centralised on one platform for several jurisdictions. If central banks were to issue CBDCs on several platforms, this could induce liquidity and market fragmentation, unless it is feasible to seamlessly transfer funds across systems or platforms.

From a cyber security perspective, it would be essential to ensure the resilience of all the systems and models. However, the hub and spoke and single system models would require greater protection against cyber attacks and extreme conditions due to the “single point of failure” problem.

Other questions related to data warehousing rules³⁸ and custody models³⁹ should also be carefully considered to ensure data safety. Data warehousing would be complex to address in hub and spoke and single system models, because data localisation requirements could prove challenging to implement. One solution is to store data with a mutually trusted party. For the compatible, single access point and bilateral link models this would be easier to handle, since data can be stored within each jurisdiction’s borders if necessary. The custody relationships would depend on the CBDC system design.

4.2.2 Challenges related to access to wCBDC by foreign PSPs

The potential challenges of broadening access to wCBDC systems are the same as those for broadening access to traditional RTGS systems.⁴⁰ These range from governance, decision-making, and risk management to operational, technical and financial aspects. In addition, as a new tokenised financial ecosystem emerges that brings increased market choice and competition, specific challenges related to CBDC system adoption might arise.

³⁷ For example, automated market-making protocols could be deployed on the common platform.

³⁸ For example, what countries’ data and privacy rules apply? Do geographic data warehousing rules apply?

³⁹ For example, who actually owns the CBDC, the end user or the PSP? What is the custody relationship? Can it be different across countries?

⁴⁰ See CPMI (2022b) for a discussion on access to non-CBDC systems for cross-border payments.

Governance, decision-making and risk management

Broader access can entail greater challenges in terms of governance, decision-making and risk management practices. A closed model would be the least challenging due to the familiarity with governing the participating PSPs. An indirect access model would pose a challenge for commercial models and incentives for PSPs to take on the role of direct/indirect participant. The direct model would be the most challenging as the system could be opened up to many new types of participants. As mentioned above, this could be especially challenging upfront if paired with the single system model, as there could easily be disagreements during the development phase over what types of PSPs to allow, or it could be viewed as difficult to implement due to the need for harmonisation of and changes in regulation. Although the question of direct access is more complex in a single system model and requires further study to understand the specific differences, their consequences and the actual regulatory changes that might be required, it also has the highest potential to unlock efficiency gains.

Operational and technical scalability aspects

More direct access may increase the operational burden on the system, as it is essential to ensure that it can handle the increased load of participants. From a technical scalability perspective, there may be a limit to the optimum number of financial entities allowed to connect directly to the network. A large number of participants may affect network performance and scalability. Tiering of system access is a possible option for resolving this issue. Also, expanding access may raise pressure on central banks' and payment system operators' resourcing needs. It could also increase reputational risks in the event of a problem with an entity that had been granted access.

Adoption

To be truly successful for cross-border payments, a cross-border CBDC arrangement would need to attract a sufficiently large mass of end users, PSPs, countries and currencies. Adoption challenges would be larger where there are already well functioning alternatives in place. Arrangements with broader PSP access would probably be adopted more easily, because end users would be more likely to already be a customer of one of the participating PSPs. At the same time, a challenge of an indirect access policy may be its commercial viability from the perspective of the domestic PSPs on whom the indirect participants would rely. The willingness to take on such a role and the potential fees charged for it may vary depending on the roles and responsibilities required from these direct participants.

4.2.3 Challenges related to access to rCBDC by non-residents

While many of the challenges related to access options for rCBDC systems overlap with the ones for wCBDC systems, identity management and enabling offline payments would be specific to an rCBDC system.

Identity management

In order to facilitate cross-border payments, there two options for identity management: either jurisdictions develop and use a coordinated identification (ID) system or they each accept the ID systems of the jurisdictions of their foreign participants. Identification is important for the implementation of AML/CFT, as well as for the enforcement of any caps or limits imposed on payers and/or account holders (see also Box 2). Passport information can be gathered from non-resident visitors to the domestic country, but non-residents while abroad may not have the appropriate ID documents to be properly onboarded – this might be especially relevant in case of massive population displacement caused by war, political instability or a natural disaster. Getting agreement on the appropriate ID requirements will be less challenging for the more decentralised interoperability models. The single system model would be the most challenging, as it would require agreement across all countries involved, which could lead to a sense of unfairness if the requirements are set too high for some jurisdictions.

Offline payments and technology

Many countries are pursuing the possibility of enabling domestic offline payments, for example for crisis scenarios (often paired with lower ID requirements). This could pose potential challenges, especially if they also want the CBDC in general to be open to foreign use. Unfettered use of an offline payment system outside the issuing jurisdiction could pose risks of currency substitution and heightened money laundering (if the offline system also enables anonymity), while at the same time it could prove challenging to restrict offline use to domestic users only.

5 Conclusions and considerations for future work

5.1 Conclusions

Many central banks around the world are currently exploring, both conceptually and technically, the possibility of issuing a CBDC, either in retail or wholesale form or both. Most of this work focuses on exploring or developing a CBDC to meet domestic policy objectives, such as improving domestic payments efficiency, financial inclusion or payments resilience (Kosse and Mattei (2022)). Yet, various CBDC experiments have also been conducted with the aim of making cross-border payments faster, cheaper and more efficient. For CBDC to be an effective enhancer of cross-border payments, international collaboration is needed to coordinate and incorporate cross-border functionalities at an early stage, so as to avoid unintended barriers later. Although each jurisdiction may be bound by certain constraints when designing a CBDC, eg in terms of ensuring coexistence and interoperability with current systems and complying with existing legal and regulatory frameworks, many design features are still undecided, which allows central banks to start with a "clean slate".

To use this opportunity, the central banking community should work closely together from the outset of CBDC explorations in order to make timely decisions around cross-border access and interoperability. Concrete steps for central banks could take different shapes, such as agreements on common standards for clearing and settlement, identification, and data and messaging, as well as interlinking of different CBDC systems or even developing a single system for cross-border CBDC payments. This could build on, or consider the role of, existing institutional arrangements for regional integration and cooperation. More structured and broader international coordination on domestic CBDC designs would be beneficial to lower barriers to cross-border access and compatibility and may serve as a launching pad for interoperability. With the right design and governance structure, as well as international collaboration, CBDCs for cross-border payments could provide a basis for further competition and innovation in this market.

Central banks have different motivations for exploring or developing CBDCs. Also, the demand and need for improved cross-border payment rails differ across jurisdictions. Central banks are therefore likely to adopt different CBDC designs, and jurisdictions may take different decisions as to how to arrange cross-border payment flows between them. This report presents several options for access to and interoperability of CBDCs for cross-border payments and evaluates these options based on five criteria: do no harm, enhancing efficiency, increasing resilience, assuring coexistence and interoperability with non-CBDC systems, and enhancing financial inclusion. By doing so, the report serves as a tool for central banks to assess different options given their objectives.

This report presents three general ways to achieve interoperability between two or more CBDC systems: via compatibility, interlinking or a single system. Compatibility of CBDC systems, eg via common standards, might be easiest and least costly to implement in the short run. In fact, at a minimum, compatibility is required to enable cross-border payments. However, interlinking of CBDC systems, and even more so a single system, might deliver larger benefits, for example as it could allow for PvP settlement and centralised FX services which may yield additional efficiency benefits. Given the governance challenges

and relatively high upfront costs of the interlinking and single system models, it is likely that such solutions will only be implemented in the long run, and there where the benefits of enhanced cross-border payments exceed the challenges, for example between countries that currently have large bilateral or multilateral trade volumes, or that have similar CBDC objectives and designs. This inherently might risk that the interoperability and access models with the highest potential for alleviating current frictions in cross-border payments are not necessarily implemented for the use cases that currently face large cross-border payments frictions, such as remittances.⁴¹ Importantly, the three models of interoperability need not mutually exclude each other. For instance, some countries might develop a single system with primary trading partners, while still promoting cross-border payments to other countries using the compatible model.

Interoperability of CBDC systems is one way to enhance cross-border CBDC payments – another and complementary way is to broaden access to CBDC systems by foreign PSPs and to allow non-residents to use rCBDCs. The challenges of broadening access to CBDC by foreign PSPs are similar to those of broadening access to traditional large-value systems (BB 10 of the G20 cross-border payments programme). When identifying different cross-border CBDC access options for PSPs, this report presents three stylised models: closed access, indirect access and direct access. Allowing for direct access would reduce the number of intermediaries and shorten the transaction chain. The discussion on access by non-residents focuses on who will be able to transfer and hold CBDCs, and under what conditions. A key decision is to what extent non-residents are granted access and whether such cross-border access will be subject to certain conditions, eg in the form of transaction and holding fees and limits. Challenges and risks related to access by non-residents could be more uncertain than those related to access by PSPs and require careful consideration. This further underlines the need for international coordination and cooperation.

Implementation of new payment systems takes time, while digital innovations are accelerating faster than ever. This, even when collaborating and coordinating on the design of their CBDCs, requires jurisdictions to build a CBDC ecosystem that is flexible enough to account for different forms of interoperability – interoperability and coexistence with the payment methods we have today, such as cash and commercial bank money, as well as interoperability with potential future types of public or private money, such as properly regulated and well designed stablecoins. Any CBDC ecosystem must be built with the flexibility to adapt to a changing future. Other relevant considerations in the design of cross-border CBDC solutions, which may warrant cross-sectoral coordination, including ensuring compliance with AML/CFT rules, while safeguarding privacy and promoting competition.

Other building blocks of the G20 cross-border payments programme focus on measures to improve existing payment systems, eg via extended operating hours, broader access, interlinking of fast payment systems, or adoption of harmonised message formats. These work streams could complement and in some cases (eg facilitating comprehensive application of AML/CFT rules) also be directly beneficial to improve cross-border payments with CBDC.

5.2 Considerations for future work

The “clean slate” advantage of CBDCs has an expiry date. By the end of 2021, more than a quarter of central banks were developing or running concrete CBDC pilots. To help central banks in the planning and development of their CBDCs and to make sure that cross-border functionalities are considered in time, the central bank community should identify the stages in the design process when access and interoperability decisions must be taken. Having open and regular dialogues between central banks about their CBDC journey and experiences so far would be instrumental here. Further work is also required on the standards to which domestic CBDC designs would need to adhere to support cross-border payments.

⁴¹ See Project Prosperus (Annex 6.3) for an encouraging example of a CBDC project focusing on the use of CBDC for remittance transfers.

Even jurisdictions not planning to issue a CBDC ought to be closely involved in this work as they will still be part of this new potential cross-border payments landscape.

While many central banks are exploring rCBDC issuance, presently most cross-border experiments involve wCBDC.⁴² The BISIH conducted a deep-dive into the experience gained across its mCBDC projects, focusing on key functional and technological considerations, and lessons learnt for using wCBDC for settling across borders (BISIH (2022)). While many lessons from wCBDC experiments could apply to CBDCs more generally, an rCBDC is different in that it contains an additional set of participants, consumers and businesses, and that retail systems will likely process and settle a larger number of payments, which has implications for which technology can be used. Further work focusing on rCBDCs is essential to better understand the implications of such a cross-border CBDC arrangement.⁴³ Different rCBDCs could also be connected through wCBDC cross-border payment arrangements, and the interaction between retail and wholesale CBDC should therefore be further explored. Also, the opportunities and implications of offline capabilities for cross-border payments require further analysis.⁴⁴

The analysis in this paper has pointed out several potential trade-offs between criteria and between choices of different cross-border CBDC arrangements. For example, there could be a trade-off between offering freedom to access CBDC cross-border services and minimising negative spillovers from capital outflows or currency substitution. Going forward, central banks ought to consider how to manage such trade-offs. However, at least in principle, technological advances make it possible to embed some CFMs in the design of CBDCs and allow central banks to strike a balance between efficiency gains and risk reduction.

While current experiments can help provide insight into technological feasibility, questions remain about their viability and the challenges of moving from a prototype to a production setting. Further assessment of the non-technological dimensions, such as legal, regulatory (eg AML/CFT compliance), governance, and policy issues is essential. In addition, actions to broaden the diversity of countries involved in CBDC experimentations and dialogues would be beneficial, especially to better understand the implications and requirements of cross-border CBDC arrangements to enhance the currently underserved cross-border corridors.

More work is also required regarding the macroeconomic implications of CBDCs. This report has highlighted potential risks, such as increased currency substitution and heightened capital flow volatility. In addition, some jurisdictions might choose to impose holding limits on rCBDCs in order, for example, to mitigate risks to monetary and financial stability from high rCBDC holdings, eg the risk of runs from the banking system into rCBDC. However, such holding limits might hamper the ability of PSPs to perform the currency conversion in cross-border CBDC payments if they are expected to do so. Such issues, in addition to the macroeconomic and monetary policy implications of potentially issuing CBDC to a large set of non-domestic participants, should be studied further.

⁴² Kosse and Mattei (2022) show that central banks presently perceive wCBDC to be more capable of addressing cross-border frictions than rCBDC and that enhancing cross-border payments is a more important motivation for wCBDC than for rCBDC. See also Bank of France (2021) and the BIS Innovation Hub (BISIH) website (www.bis.org/about/bisih/projects.htm) for an overview of several wCBDC projects.

⁴³ A two-tier rCBDC distribution model is being studied in Project Aurum, run by the BIS Innovation Hub Centre in Hong Kong SAR and the Hong Kong Monetary Authority (HKMA) in collaboration with the Hong Kong Applied Science and Technology Research Institute. More details are available at www.bis.org/about/bisih/topics/cbdc/rcbdc.htm.

⁴⁴ The BISIH, via Project Polaris, is about to embark on work on this, to provide a deeper and holistic insight into the design, architecture and infrastructural requirements of offline payments as well as the operational impacts.

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Annex 1: Glossary

Access: As used in this report, this means households' and businesses' access to payment services and the ability of banks, other PSPs and, where relevant, other market infrastructures to use the services of a CBDC system.

Application programming interface (API): a set of rules and specifications for software programs to communicate with each other that forms an interface between different programs to facilitate their interaction.

See www.bis.org/bcbs/publ/d486.pdf

Central bank digital currency (CBDC): a new form of central bank money in a digital format, denominated in the national unit of account, that is a direct liability of the central bank and can be used for retail payments and/or wholesale settlement.

Central bank money: A liability of a central bank which can be used for settlement purposes. The widespread use of central bank money for large and critical settlements is pivotal to the functioning of the global financial system, offering safety, availability, efficiency, neutrality and finality.

See www.bis.org/cpmi/publ/d101a.pdf

Clearing: The process of transmitting, reconciling and, in some cases, confirming transactions prior to settlement, potentially including netting of transactions and establishment of final positions for settlement.

See www.bis.org/cpmi/publ/d101a.pdf

Correspondent banking: An arrangement whereby one bank (correspondent) holds deposits owned by other banks (respondents) and provides those banks with payment and other services. Correspondent banking networks are critical for firms and households that conduct business or send payments internationally.

See www.bis.org/cpmi/publ/d147.htm

Distributed ledger technology (DLT): DLT refers to the processes and related technologies that enable nodes in a network (or arrangement) to securely propose, validate and record state changes (or updates) to a synchronised ledger that is distributed across the network's nodes. In the context of payment, clearing, and settlement, DLT enables entities, through the use of established procedures and protocols, to carry out transactions without necessarily relying on a central authority to maintain a single "golden copy" of the ledger.

See www.bis.org/cpmi/publ/d157.pdf

Financial inclusion: Universal access to, and frequent use of, a wide range of reasonably priced financial services, in particular transaction accounts.

See www.worldbank.org/en/topic/financialinclusion/brief/achieving-universal-financial-access-by-2020 and www.bis.org/cpmi/publ/d191.pdf

Fragmented and truncated data formats: Data standards and formats vary significantly across jurisdictions, infrastructures and message networks and the amount of data that is carried in most cross-border messages is extremely limited. This prevents high rates of automated "straight through processing", leads to delays in processing and releasing cross-border payments, and increases technology and staffing costs.

See www.fsb.org/wp-content/uploads/P090420-1.pdf

Interoperability: The technical, semantic and business compatibility that enables a system or mechanism to be used in conjunction with other systems. Interoperability allows participants in different systems to conduct, clear and settle payments or financial transactions across systems without participating in multiple systems.

See www.bis.org/publ/bisbull49.pdf

Payment versus payment (PvP): A settlement mechanism that ensures that the final transfer of a payment in one currency occurs if and only if the final transfer of a payment in another currency or currencies takes place.

See www.bis.org/cpmi/publ/d101.htm

Retail CBDC (rCBDC): A CBDC for use by the general public.

See www.bis.org/publ/arpdf/ar2021e3.pdf

Settlement: The discharge of an obligation in accordance with the terms of the underlying contract.

See www.bis.org/cpmi/publ/d101.htm

Settlement account: An account containing money and/or assets that is held with a central bank, central securities depository, central counterparty or any other institution acting as a settlement agent, which is used to settle transactions between participants or members of a commercial settlement system.

See www.bis.org/cpmi/publ/d101.htm

Settlement asset: An asset used for the discharge of obligations as specified by the rules, regulations or customary practice for a financial market infrastructure.

See www.bis.org/cpmi/publ/d101.htm

Settlement finality: Settlement finality is defined as the point when the irrevocable and unconditional transfer of an asset occurs. Final settlement is a legally defined moment.

See www.bis.org/cpmi/publ/d101.htm

Smart contract: Protocol or code that self-executes when certain conditions are met.

See www.bis.org/publ/qtrpdf/r_qt2003i.pdf

Wallet: Electronic wallets are payment arrangements that enable end users to securely access, manage and use a variety of payment instruments issued by one or more PSPs via an application or a website. The electronic wallet may reside on a device owned by the holder, eg a smartphone or a personal computer, or may be remotely hosted on a server but still under the control of the holder.

See www.bis.org/cpmi/publ/d191.pdf

Wholesale CBDC (wCBDC): A CBDC for use by financial institutions (wholesale transactions). A wCBDC is a new form of digital central bank money that is different from balances in traditional bank reserves or settlement accounts.

See www.bis.org/publ/arpdf/ar2021e3.pdf

Annex 2: Acronyms and abbreviations

AML	anti-money laundering
API	application programming interface
BB	building block
BIS	Bank for International Settlements
CBDC	central bank digital currency
CFM	capital flow management measure
CFT	combating the financing of terrorism
CPMI	BIS Committee on Payments and Market Infrastructures
DLT	distributed ledger technology
FATF	Financial Action Task Force
FSB	Financial Stability Board
FX	foreign exchange
G7	Group of Seven
G20	Group of Twenty
ICT	information and communications technology
ID	identification
IMF	International Monetary Fund
IOSCO	International Organization of Securities Commissions
IP	intellectual property
IPS	instant payment system
KYC	know-your-customer
LVPS	large-value payment system
MC	Markets Committee
mCBDC	multi-CBDC
MSMEs	micro, small and medium-sized enterprises
PSP	payment service provider
PvP	payment versus payment
rCBDC	retail central bank digital currency
RTGS	real-time gross settlement
wCBDC	wholesale central bank digital currency

Annex 3: AML/CFT compliance in cross-border CBDC arrangements

Illicit activity undermines financial integrity, national security and economic development. As with any value transfer system, CBDCs could be used by criminals and terrorists for illicit activity. An important part of global efforts to combat illicit finance is national implementation of sound anti-money laundering and combating the financing of terrorism (AML/CFT) regimes in line with the international standards set by the Financial Action Task Force (FATF). While AML/CFT requirements may not be the primary motivation for central banks to issue a CBDC, central banks are expected to design CBDCs in line with AML/CFT requirements.⁴⁵

The exact financial integrity implications of any given CBDC arrangement will vary depending on the particular design choices taken. Regardless of the design choices made, countries must: assess and mitigate the money laundering and terrorism financing (ML/TF) risks associated with a CBDC; ensure that relevant CBDC activities (eg the exchange of assets, transfer of value, and management of assets) are regulated and supervised for AML/CFT purposes; and pursue criminal cases involving CBDC. In particular, central banks, in coordination with relevant AML/CFT bodies, should consider the following aspects when designing a CBDC arrangement:

- **CBDC ecosystem and scope:** While a wide and varied user base may be desirable for a CBDC and many countries identify financial inclusion and cross-border payments as motivation for CBDC development, the number and jurisdiction of residence of users will affect ML/TF risks that need to be managed. For example, wCBDC arrangements that can only be accessed by eligible PSPs will probably present fewer ML/TF risks than a retail arrangement widely available to users from multiple countries. Similarly, the number and type of intermediaries involved in the issuance, distribution and use cases of the CBDC will have regulatory and supervisory implications, particularly in the cross-border context where service providers may operate outside of the issuing jurisdiction.
- **Level of intermediation and allocation of AML/CFT responsibilities:** In a one-tier model (see Section 3.1.2), the central bank would have a direct relationship with the end user. This necessitates central banks assuming AML/CFT obligations that are currently generally assigned to intermediaries and with which central banks are likely to have limited experience or expertise. This model could potentially create conflicts of interest if the central bank has AML/CFT obligations (and is therefore a regulated entity) and at the same time is a supervisor overseeing implementation of these obligations. A two-tier model would preserve the current structure – in which intermediaries have AML/CFT obligations – but might be more difficult to supervise. Regardless of the model chosen, gaps should not exist in the implementation of AML/CFT preventive measures, such as customer due diligence, monitoring of transactions and business relationships, record-keeping, and reporting of suspicious transactions. The cost of AML/CFT compliance may offset some of the purported benefits accrued to CBDCs in a cross-border context, including speed, lower cost, and convenience. However, these trade-offs are necessary to ensure the integrity of the financial system and the reputation of the CBDC.
- **User identification and due diligence:** Critical components of AML/CFT include identifying the customer and source of funds. Due diligence is an important part of ML/TF prevention. Additional preventive measures include transaction monitoring, suspicious transaction reporting, and implementation of targeted financial sanctions. This consideration would be particularly important in a retail context, as users in the wholesale context would be regulated financial institutions. In a CBDC arrangement that has more account-based attributes, identification of parties and transaction authentication naturally arise as part of account management. User

⁴⁵ See FATF (2020, Annex B) for further information on CBDCs in the AML/CFT context.

identification⁴⁶ is not inherent in a pure token-based system,⁴⁷ in which case the necessary due diligence would probably have to be built into a precondition to receiving the token, for instance at the stage of wallet opening. Regardless of the model chosen, countries must consider how fulfilment of AML/CFT obligations, including due diligence, will be carried out within the particular CBDC system. Uncertainties as to how to apply some rules relating to “traditional” financial transfers (eg the wire transfer rule, whereby information on both parties to a transaction must be obtained/held by service providers on both ends) will have to be answered. Key considerations, such as how and when due diligence will be conducted, who will be responsible for carrying out due diligence, and whether the legislative and institutional frameworks require an adjustment, should occur prior to a CBDC launch and keep up with the evolution of the CBDC system. In terms of user identification, a well advanced digital ID system could be a mitigating measure.⁴⁸ As with traditional financial services and products, due diligence challenges (eg knowing your customer and understanding a customer’s business, identifying and verifying the beneficial owners and accounts) are likely to be magnified in a cross-border context.

- **Oversight of AML/CFT compliance:** The evolution of new service providers and/or services/products may require adapting of AML/CFT laws and regulations, supervisory models, and organisational structures of AML/CFT supervisors. Any new supervisors would have to develop the requisite expertise and avoid any conflicts of interest that may arise. Coordination with other financial sector supervisors and key AML/CFT agencies (such as financial intelligence units and law enforcement) will also be important. Supervisors should keep in mind that overseeing entities located in a different jurisdiction could pose challenges (eg conducting on-site inspections).

As with the traditional forms of money, financial services and activities, the implementation of AML/CFT measures for CBDC is difficult in a cross-border context, from the perspective of both service providers/other regulated entities, and competent authorities. To facilitate the provision of cross-border services and supervision of such activities and to prevent regulatory arbitrage, harmonisation of AML/CFT frameworks at a global level would be vital. Information-gathering and -sharing may require common technological solutions to be developed between countries. Competent authorities will have to stay abreast of developments and ensure that they are able to adjust their policies and frameworks to account for changes in the financial landscape.

⁴⁶ User identification refers to customer due diligence measures to identify a customer and verify their identity through independent and reliable sources, not to the extrapolation of other identifying information on users, such as IP addresses.

⁴⁷ Account-based and token-based CBDC arrangements are not always fully distinct from each other and, indeed, many CBDC arrangements are hybrid systems. For the purpose of this discussion, the critical distinction is whether authentication is primarily focused on the user or the object of payment.

⁴⁸ For further information on digital ID in an AML/CFT context, see: www.fatf-gafi.org/media/fatf/documents/recommendations/Guidance-on-Digital-Identity.pdf.

Annex 4: Access and interoperability choices in existing CBDC projects

Tables A.1 and A.2 map a selection of completed and ongoing CBDC projects against the access and interoperability options identified in the report. Annex 6 provides for a more detailed description of some of the projects. Table A.2 contains the rCBDCs which are, at the time of writing, circulating among the public, either as a “live” CBDC or in the form of a pilot. While these rCBDCs are mainly developed for domestic purposes, their designs shed light on the choices made regarding their use by non-residents. Table A.1 maps existing cross-border wCBDC projects. It also contains non-CBDC cross-border arrangements that provide useful insights into how different combinations of access and interoperability options can be employed for cross-border payments. The majority of wCBDC projects have been completed as one-off experiments, while a few are still in an exploratory stage (see Graph A.1). Regardless of their status, most of these wCBDC projects use a single system to facilitate CBDC transactions between jurisdictions and, all except for one, apply a closed or direct access model. This might suggest that central banks perceive these interoperability and access options either to have the highest potential to add value in the long run or to be easiest to start from in the short run.

Mapping of existing cross-border wCBDC projects and non-CBDC arrangements¹ Table A.1

	Compatibility	Interlinking			Single system
		Single access point	Bilateral link	Hub and spoke	
Closed access			HSBC Jasper-Ubin <i>Directo a Mexico</i>	<i>Nexus REPS</i>	Prosperus MAS Aber Buna
Indirect access					<i>TIPS Dunbar²</i>
Direct access	Helvetia Phase II	<i>euroSIC</i>			mBridge Jura

The font type of the project name indicates whether it is a wCBDC (**bold**) or a non-CBDC arrangement (*italic*).

¹ See Annex 6 for the descriptions of the wCBDC projects indicated in bold. ² In jurisdictions where the regulatory frameworks allow direct access to CBDC by non-resident banks, approval routing to “sponsoring” banks could be disabled to move from an indirect to direct CBDC access model.

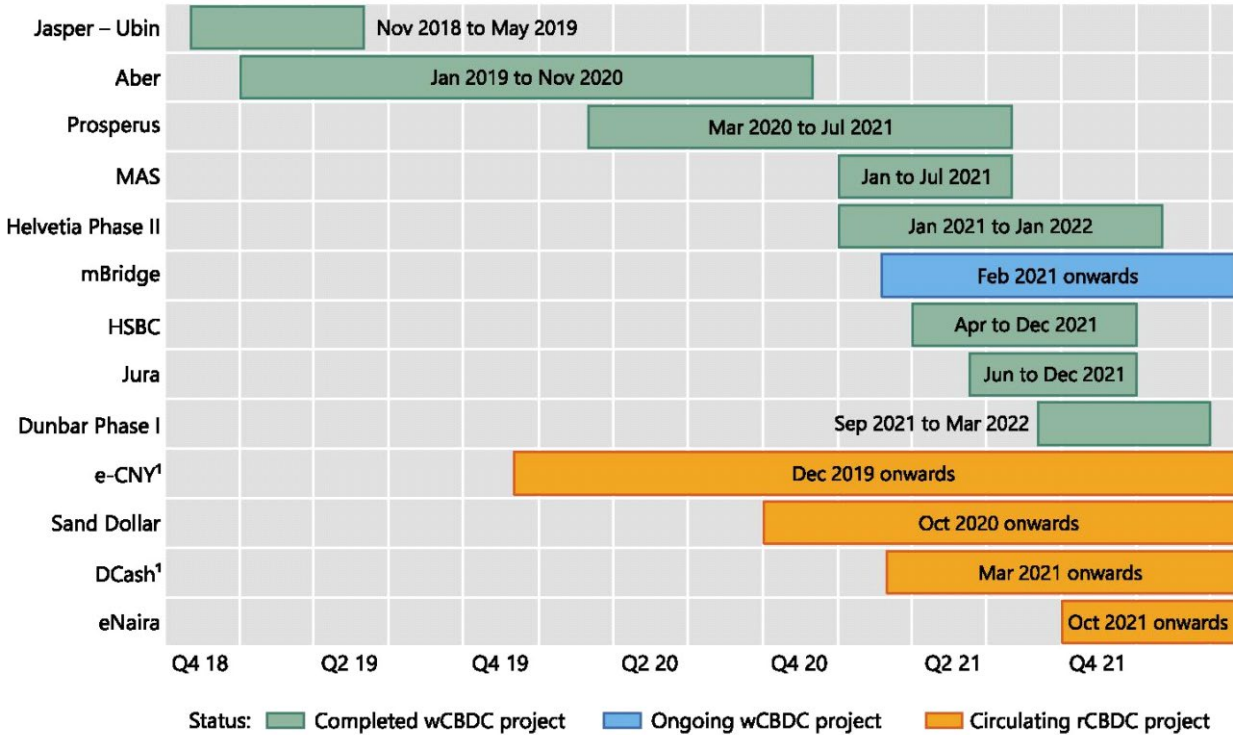
Source: Authors’ elaboration.

Mapping of the current status of circulating rCBDCs¹ Table A.2

	No caps or fees on transactions or holdings	Caps or fees on transactions	Caps or fees on holdings	Caps or fees on transactions and holdings
Domestic residents only				eNaira DCash
Non-residents visiting the country				Sand Dollar e-CNY
Non-residents when also abroad				

¹ These are either formally issued or circulating as a pilot. As they progress, restrictions might be added or removed. See Annex 6 for descriptions of the rCBDC projects.

Source: Authors’ elaboration.



¹ The project is still ongoing in the form of a pilot.

Source: Authors' elaboration.

Annex 5: Summary of challenges of high-level interoperability options

Interoperability options for CBDC systems for facilitating cross-border payments

Challenges related to:

Table A.3

	Compatibility	Interlinking			Single system
		Single access point	Bilateral link	Hub and spoke	
Investment and maintenance cost	Relatively low cost	Relatively low cost	Relatively low cost	Costs vary depending on functions offered	Costliest upfront; requires a fully fledged system
Scalability	Extensive scalability if common standards truly remove country-by-country variation; limited if different standards are still permitted	Limited scalability; would require multitude of links	Limited scalability; would require multitude of links	Extensive scalability	Extensive scalability
Legal, regulatory and oversight frameworks	Complex	Complex	Increased complexity if it requires multitude of links	Added complexity upfront to determine a clear delineation of jurisdictional boundaries, adherence to regulatory policies of different jurisdictions; less challenging on an ongoing basis	
Governance arrangements	Complex	Complex	Increased complexity to manage multitude of links	Increased complexity in a system with additional integration	Added complexity on how a common ownership and governance model would fit with multiple central banks in individual but overlapping dimensions
Domestic vs cross-border interoperability	Potential trade-offs might arise between promoting international interoperability of CBDCs using commonly implemented standards and achieving domestic interoperability with existing forms of money				
Balance between addressing illicit	All models require strong coordination among participating central banks to address illicit finance and to strike a balance between protecting privacy and combating illegal activities				

finance and privacy protection					
Technology standardisation: technical coordination vs technical infrastructure and implementation	High complexity for technical coordination; added challenges for technical implementation if systems are different	High complexity for technical coordination; added challenges for technical implementation if systems are different	Increased complexity if it requires multitude of links for both technical coordination and requirements	High complexity for technical coordination; added complexity for technical implementation if different systems are permitted	High complexity for technical coordination; low complexity for technical implementation
FX model	Challenges arise with respect to the choice of entities to provide the conversion service and bear the associated FX risk, and the choice of a reasonable exchange rate determination mechanism that minimises the risk of FX arbitrage				Potential to streamline the payment process by performing both FX trading and settlement on the platform; automated market-making protocols could be deployed on the common platform
Resilience	Essential to ensure the resilience of all the systems and models			Would require greater protection against cyber attacks and extreme conditions due to the "single point of failure" problem	
Market and liquidity fragmentation	Not applicable as liquidity stays on the home account	Potentially more fragmentation	Potentially more fragmentation	Less fragmentation considering that liquidity is centralised on one platform for several jurisdictions	Less fragmentation considering that liquidity is centralised on one platform for several jurisdictions
Data warehousing	Easier to handle, as data can be stored within jurisdiction border if necessary	Easier to handle, as data can be stored within jurisdiction border if necessary	Easier to handle, increased complexity in case of multitude of links	Complex to implement; data localisation requirements could prove challenging to implement	Complex to implement; data localisation requirements could prove challenging to implement
Custody model	Depends on the CBDC system design				

Annex 6: Descriptions of existing CBDC projects

6.1 Jasper-Ubin (project completed in May 2019)⁴⁹

6.1.1 Context

The Jasper-Ubin project was an experiment to test and explore the benefits of distributed ledger technology (DLT) for cross-border payments. This work undertakes a line of enquiry emanating from the paper "*Cross-border interbank payments and settlements*," authored by the Bank of Canada, the Bank of England, the Monetary Authority of Singapore, HSBC and a group of other commercial banks in the United Kingdom, Canada and Singapore.⁵⁰ Jasper-Ubin explores the architecture of token-based wCBDC proposed in the paper by building a cross-border payment proof of concept solution.

6.1.2 Participants

The experiment was led by the Bank of Canada (BoC) and Monetary Authority of Singapore (MAS) in collaboration with Accenture and JP-Morgan as technology partners.

6.1.3 High-level design of the experiment

The Jasper-Ubin solution was based on different DLT networks in different jurisdictions, without requiring any trusted entity (but replacing it with trust in the technical solution), with the intention of reflecting a potential future world of heterogeneous networks aimed at increasing the efficiency of and reducing risks for cross-border payments. The cross-border (between Canada and Singapore), cross-currency (CAD and SGD) payment use case was implemented by building and linking two DLT platform networks (using R3's Corda for Canada and ConsenSys' Quorum for Singapore).

The hash time-locked contracts (HTLC) protocol was used to connect the two networks and allow an atomic PvP settlement transaction without the involvement of a trusted third party acting as an intermediary. HTLC is a reliable way of passing messages between the two systems and the distributed ledger platforms used supported the basic constructs of HTLC: locking or encumbering the asset to be transferred, secret disclosure to the counterparty to complete the acceptance process, and a timeout mechanism to release the encumbrance should the counterparty fail in its acceptance process. The project successfully demonstrated atomic transactions between two different DLT networks.

6.1.4 Key considerations around interoperability and access

In terms of interlinking, each country managed their own DLT-based RTGS network and interoperability was achieved by implementing the HTLC protocol in both networks. HTLC performed well to achieve atomic PvP settlement. However, there were rare circumstances where challenges and some complications arose, especially when large numbers of networks or jurisdictions were assumed.

With regard to access, commercial banks in each of the jurisdictions had access to their local network and were able to settle multicurrency cross-border wholesale payments with their counterparties in the other jurisdiction without the need for a trusted intermediary. The central bank in each jurisdiction was in full control of access criteria for its local commercial banks. Commercial banks did not need direct access to both platforms to fully use the system. After the project, the BoC and MAS declared that it remains to be seen whether they will eventually use blockchain technology for high-value cross-border payments.

⁴⁹ See www.mas.gov.sg/-/media/Jasper-Ubin-Design-Paper.pdf.

⁵⁰ See www.mas.gov.sg/-/media/MAS/ProjectUbin/Cross-Border-Interbank-Payments-and-Settlements.pdf.

6.2 Aber (project completed in November 2020)⁵¹

6.2.1 Context

The aim of the initiative was to study, understand, and evaluate the feasibility of a single dual-issued wCBDC as an instrument for domestic and cross-border settlement between two countries.

6.2.2 Participants

The experiment was a cooperation between the Saudi Central Bank (SAMA), the Central Bank of the United Arab Emirates (CBUAE) and six commercial banks (three from each jurisdiction).

6.2.3 High-level design of the experiment

The participants agreed upon the following three key principles that guided the execution of the project:

- Commercial banks had to be active participants, running local nodes on the network, and be fully engaged from a technical and business perspective throughout the lifecycle of the project.
- Real money was used in the project. This was important because it forced greater consideration of the non-functional aspects, including security and the interaction of the system with existing payment systems, such as the domestic RTGS system.
- The project sought to explore how such systems can leverage the unique characteristics of DLT to drive greater levels of distribution.

The project was structured into three distinct phases or use cases:

- Cross-border settlement between the two central banks;
- Domestic settlement between three commercial banks in each country;
- Cross-border direct transactions between the participating commercial banks.

6.2.4 Key considerations around interoperability and access

Since Aber is an interbank payment system, its requirements were naturally derived from the features of traditional RTGS systems but extended to cover cross-border payments. The main difference with the traditional implementation was its decentralised nature. The system allowed payment and settlement between commercial banks without the central bank(s) nodes being available. The key property of irrevocable transactions can be achieved as long as transaction validity requires a quorum of participants that do not necessarily include the central bank(s).

The commercial banks had complete knowledge of their own nodes and transactions, but did not know about other nodes (ie their overall DLT balances) or transactions between other nodes. The two central banks had visibility on everything regarding the nodes and transactions in their own jurisdictions. In addition, they also knew about all cross-border transactions. As a result, the central banks did not know the overall DLT balances and the domestic transactions of participants in the other jurisdiction. However, central banks had full visibility on the money supply, including of the digital currency issued to the other country.

The project confirmed that a cross-border dual-issued CBDC was technically viable and that it was possible to design a distributed payment system that offered the two countries significant improvement over centralised payment systems in terms of architectural resilience. The project also confirmed the viability of DLT as a mechanism for both domestic and cross-border settlement.

⁵¹ See www.sama.gov.sa/en-US/News/Documents/Project_Aber_report-EN.pdf.

6.3 Prosperus (project completed in July 2021)⁵²

6.3.1 Context

Project Prosperus covered the issuance and distribution of EUR wCBDC and usage rights to operate near real-time remittance transfers between individuals from France to Tunisia.

6.3.2 Participants

The experiment involved the Bank of France (BdF) and the Central Bank of Tunisia (BCT) in collaboration with a group of private sector firms comprising ProsperUs, the French bank Wormser Frères, the Tunisian bank BIAT and its French subsidiary BIAT France.

6.3.3 High-level design of the experiment

In this experiment, the cross-border funds transfer for a customer in Tunisia was operated from a French bank to the BCT. The payment flow contained details about the sender, the beneficial owner and his Tunisian banking coordinates. While the design is similar to the scenario in which the BCT acts as the remittance EUR correspondent bank for all Tunisian banks, it has the benefit of a near immediate release of funds to the remittance recipient.

The process relied on both central banks' infrastructures: T2 and TOPAZE for the BdF, and the BCT's core banking system. To bridge them, the distributed ledger Instaclear allowed the creation of "wallets" to enable the receipt of EUR CBDC and EUR CBDC "usage right". This ledger, although it is not a blockchain, allows its administrators to authorise and supervise participants and transactions. The experiment allowed the BdF to issue intraday EUR wCBDC on Instaclear against blocked balances on a central bank's technical account in T2. The BdF had exclusive rights to create and destroy the EUR wCBDC.

The experiment showed that wCBDC is an effective means to lower remittance costs while also reducing the delays in crediting the remittance recipient's bank account. Although other experiments had already demonstrated all or some of these basic functionalities, the Prosperus experiment showed that a DLT involving central banks could be a viable core system of a remittance channel.

6.3.4 Key considerations around interoperability and access

Interlinking was achieved by using a common technical distributed platform, Instaclear, which relies on an account-based system that grants each institution a node. Each node's parameters, including whether it could hold, mint, transfer or destroy a wCBDC token, were set up by a trusted authority.

In terms of access, any T2 participant is eligible to access EUR wCBDC as long as it operates a node in the system. Although the BCT is not a T2 participant, it has a EUR central bank money account with the BdF and therefore was able to operate a node. In addition, any Tunisian commercial bank can set up a node and be informed, through the BCT and within the Instaclear platform, of an incoming credit to its account at the BCT and therefore credit its clients' balances accordingly.

⁵² See www.banque-france.fr/en/communique-de-presse/banque-de-france-cooperation-banque-centrale-de-tunisie-successfully-conducts-experiment-use-central.

6.4 MAS (project completed in July 2021)⁵³

6.4.1 Context

The MAS experiment covered cross-border payment and cross-currency PvP transactions in EUR wCBDC and SGD wCBDC issued and exchanged on a single corridor network.

6.4.2 Participants

The experiment involved the Bank of France (BdF) and Monetary Authority of Singapore (MAS) in collaboration with JPMorgan as technology partner.

6.4.3 High-level design of the experiment

In the shared corridor network, the BdF and MAS are jointly controlled operators. They share the management of the rulebook and the governance arrangements. Additionally, commercial banks are admitted to the network as participants.

Fictitious commercial banks located in France and Singapore settled multicurrency cross-border wholesale payments. This included a cross-border payment with currency conversion, and settlement of an FX trade in PvP. In order to reduce intermediaries and optimise costs, these cross-border transactions were managed by smart contracts, one for order orchestration, and the other for the automatic liquidity and FX rate management.

Automated market-making (AMM) and liquidity management capabilities were incorporated into the overall design. The use of AMM could seemingly be a viable alternative to traditional order book infrastructures. AMMs allow permissionless and automatic ways of trading digital assets and use liquidity pools instead of a traditional market with buyers and sellers.

6.4.4 Key considerations around interoperability and access

In terms of interlinking, each country maintained only a single connection to a shared common platform for cross-border features. In practice this experiment involved the respective central banks issuing their CBDC tokens to the commercial banks' wallets. The commercial banks could then initiate transactions on the network if they had sufficient CBDC tokens for such transactions.

The single DLT platform reduced the complexity of bank-to-bank integration and simplified the business process through a single standardised governing rulebook.

With regard to access, the experiment used the principle of sharing data on a need-to-know basis. The CBDC balance of each commercial bank was known only to itself and the central bank issuing the CBDC token. To achieve this, at the node level, the state database is split into a public state and a private state. A public state is always in sync across the network through the consensus algorithm. The private state is updated based on the private transactions that a node is part of, and thus is unique only to that node. This also means that the private state will be divergent across nodes.

⁵³ See www.banque-france.fr/sites/default/files/media/2021/11/15/bdf-mas-onyx_liquidity_management_in_a_multi-currency_corridor_network_vfinal_-_12112021_0.pdf.

6.5 Helvetia Phase II (project completed in January 2022)⁵⁴

6.5.1 Context

Helvetia Phase II looks towards a future with more tokenised assets and DLT-based financial market infrastructures. It addresses the question of whether and how settlement in central bank money would be feasible in such infrastructures.

The Helvetia Phase II experiment covers domestic and cross-border DvP and payment settlement in wCBDC issued and exchanged on a private permissioned DLT platform. Use cases are investigated end to end, ie from entering the settlement instructions, via the matching and settlement on the DLT platform to booking and reconciliation in core banking systems.

6.5.2 Participants

Helvetia Phase II is a joint project by the BIS Innovation Hub Centre in Switzerland, the Swiss National Bank (SNB) and SIX. It leverages the DLT-based central securities depository (CSD) of SIX Digital Exchange (SDX), a subsidiary of the main Swiss financial market infrastructure provider SIX. Five commercial banks participated in the experiment: Citi, Credit Suisse, Goldman Sachs, Hypothekarbank Lenzburg and UBS.

6.5.3 High-level design of the experiment

The solution design consists of three components: (i) the SDX test platform; (ii) the Swiss RTGS test system; and (iii) the core banking test systems of commercial banks and that of the SNB. Interoperability across these systems is achieved through ISO messaging. This form of integration is compatible with existing core banking systems and back office processes of commercial banks and central banks.

The wCBDC in Helvetia is designed to be a tokenised form of central bank money. Access criteria, remuneration and the value date rules of wCBDC are identical to those for reserve balances held in today's RTGS system. Furthermore, the central bank retains similar control and monitoring capabilities over wCBDC as over reserve balances.

6.5.4 Key considerations around interoperability and access

In Helvetia Phase II, eligible resident and non-resident financial institutions have direct access to wCBDC, facilitating cross-border DvP and payment settlement in wCBDC. The wCBDC can either be issued through the one-to-one conversion of RTGS balances into wCBDC or monetary policy transactions on the DLT platform, ie the direct issuance of wCBDC by the central bank. The latter approach could be one way to provide direct access to wCBDC to financial intermediaries without access to the RTGS system.

Helvetia Phase II investigates single-currency cross-border settlement. Cross-currency settlement and currency conversion would require some form of compatibility with arrangements outside the DLT platform. As shown in Project Jura, the solution design of Helvetia could be broadened to a single system with direct access to multiple wCBDCs.

⁵⁴ Links to report and video: www.bis.org/publ/othp45.pdf and www.youtube.com/watch?v=R5TF3xB5J88.

6.6 mBridge (project ongoing)

6.6.1 Context

The mBridge project aims to build a prototype for an mCBDC platform for cross-border payments. Earlier versions of mBridge⁵⁵ have shown that using a CBDC arrangement for cross-border payments can be cheaper, faster and more transparent than today's existing systems.

6.6.2 Participants

The project involves the BIS Innovation Hub Centre in Hong Kong SAR, the Hong Kong Monetary Authority, the Digital Currency Institute (DCI) of the People's Bank of China, the Central Bank of the United Arab Emirates, the Bank of Thailand and private sector partners.

6.6.3 High-level design of the experiment

In the current iteration of the project built on mBridge Ledger, all central banks can issue their respective CBDCs on the platform. All commercial bank participants can receive this issued CBDC in return for reserves and transact directly with each other regardless of jurisdiction.

The currencies issued on the mBridge platform are the Hong Kong dollar, renminbi, Thai baht and UAE dirham. They are settled using a single logical ledger. The leading use case of the current pilot is to settle cross-border payments for international trade. Advanced atomic PvP, liquidity management and privacy features are all in scope. The consensus model is inspired by the "HotStuff" consensus protocol. The participants share encrypted messages peer-to-peer and use RocksDB for persistent storage.

6.6.4 Key considerations around interoperability and access

Several key considerations around interoperability and access options still need to be decided for the current iteration of the project. The project is currently gathering requirements to provide connectivity with other DLT-based CBDC systems, RTGS and traditional payment integrations.

Access to the platform as a private DLT is achieved by successfully completing the onboarding process. The onboarding criteria for each jurisdiction are the responsibility of the corresponding central bank. The technical platform onboarding is still in discovery. The project aims to onboard a few commercial banks for a pilot to better understand these requirements. With respect to platform controls, each issuing central bank can control which participants are allowed to have custody of its currency, the maximum custody and transaction limits. All issuing central banks can see transaction and balance sheet details for all banks within their jurisdiction. Commercial banks can only see their own custody and transaction details.

⁵⁵ See www.bis.org/publ/othp40.htm.

6.7 HSBC (project completed in December 2021)⁵⁶

6.7.1 Context

The HSBC PoC was designed to cover an end-to-end transactional lifecycle, covering eBonds (issuance, ISIN dissemination, DvP across primary issuance and secondary trading, coupon payments), CBDCs (issuance and allocation), and foreign exchange between two CBDCs (pricing and PvP).

6.7.2 Participants

The experiment involved the Bank of France (BdF) and HSBC in collaboration with IBM as a technology partner.

6.7.3 High-level design of the experiment

In this experiment, a virtual issuer sold a virtual eBond to HSBC on the primary market. This transaction was settled in EUR CBDC. HSBC then sold the asset in EUR CBDC to one of its corporate clients (DvP). A coupon was paid to HSBC and cascaded to its client in EUR CBDC. The corporate client converted the EUR CBDC into another CBDC (XXX, a fictitious currency from a simulated central bank X).

The experiment tested a novel PvP/cross-border model. To achieve this, two main use cases were explored: (1) interoperability between systems using different DLTs (Fabric and Corda); and (2) control of the usage of the CBDC by the issuing central bank through programmability features.

The technical interface ("Bridge") developed as part of the experiment allowed for interoperability, transfer of data and information and exchange of assets. The experiment leveraged on four multi-chain technologies: (1) DLT for the settlement of securities transactions and their cash legs on the primary market (DL3S); (2) DLT where T2 participants and their clients can use EUR CBDC to settle specific transactions in a secure way (Euro-NET); (3) DLT where participants in a simulated central bank and their clients can use CBDC in a secure way (XXX-NET); and (4) DLT custody platform (HSBC Vault).

6.7.4 Key considerations around interoperability and access

The interlinking of both CBDCs and the fictitious digital bond was conducted in a multi-cloud environment that incorporated public and private clouds. For the wholesale CBDCs to circulate, two issuer nodes on each subnetwork – controlled by the BdF for EUR wCBDC and by the simulated central bank for XXX wCBDC – allowed for the issuance of tokens on the DLT test platforms. Each issuer node had sole and exclusive rights to create and destroy the respective type of wCBDC. In this experiment, the CBDCs issued by the BdF and the other central bank were intraday.⁵⁷

In terms of access criteria, the experiment made no assumptions on the rules and usage rights the simulated central bank would establish for its participants. On the BdF side, under specific usage protocols managed through programmability, the experiment extended the use of CBDC to non-T2 participants.

⁵⁶ See www.banque-france.fr/en/communique-de-presse/banque-de-france-has-successfully-completed-first-tranche-its-experimentation-programme-central-bank.

⁵⁷ An intraday wCBDC means that there is a mandatory conversion of wCBDC into reserve balances before the value date change in the RTGS system.

6.8 Jura (project completed in December 2021)⁵⁸

6.8.1 Context

Project Jura explored DvP and Pvp use cases between euro and Swiss franc wCBDCs and a tokenised French commercial paper (CP) in a near-real setting.

6.8.2 Participants

The experiment involved the Bank of France (BdF) and the Swiss National Bank (SNB) in collaboration with the BIS Innovation Hub and a group of private sector firms comprising Accenture, Credit Suisse, Natixis, R3, SIX Digital Exchange and UBS.

6.8.3 High-level design of the experiment

The experiment took place over three days and explored two use cases: (1) settlement of EUR-CHF FX transactions with EUR and CHF wCBDC between French and Swiss financial institutions; and (2) issuance and redemption of a tokenised French CP and settlement of the tokenised CP with EUR wCBDC between French and Swiss financial institutions (cross-border) and Swiss financial institutions (offshore).

On the technical side, Jura explored a new approach including subnetworks and a dual-notary signing mechanism. The cross-border settlements conducted used three subnetworks on a single privately operated DLT platform developed under Corda technology: one subnetwork dedicated to the French tokenised asset, one dedicated to the EUR wCBDC and one dedicated to the CHF wCBDC. The dual-notary signing capability allowed tokens to be exchanged atomically while residing on different subnetworks and jurisdictions.

Having sub-networks on a single platform with dual-notary signing validation involves fewer institutions in the payment process, which could improve efficiency and reduce cost, while enabling transparent pricing and a simplified fee structure. Settlement speed is likely to be increased.

6.8.4 Key considerations around interoperability and access

Project Jura combined the advantages of the model where two platforms are linked (BIS model 2) and the single platform model (BIS model 3). The project also explored the interlinking between traditional infrastructures (RTGS systems, Target2 and SIC) and DLT (SDX testing platform).

The EUR and CHF wCBDCs in Jura had two key access features: they were intraday, and directly available to non-resident banks. In the experiment, the BdF and SNB provided direct access to intraday wCBDC for regulated financial institutions domiciled in France and Switzerland which had access to reserves at the respective domestic central bank. Subnetworks on the SDX test platform allowed the central banks to maintain control over who had access to their wCBDCs. While having direct access to hold and transact the wCBDC, non-resident regulated financial institutions that did not have access to the RTGS relied on correspondents to make the RTGS funds transfers – a prerequisite for the issuance of wCBDC.

⁵⁸ See www.bis.org/publ/othp44.htm.

6.9 Dunbar (Phase I completed in March 2022)⁵⁹

6.9.1 Context

Project Dunbar enabled international settlements on a common platform that enabled issuance of multiple CBDCs by different central banks.

6.9.2 Participants

The experiment involved the BIS Innovation Hub Centre in Singapore, the Reserve Bank of Australia, the Central Bank of Malaysia, the Monetary Authority of Singapore and the South African Reserve Bank, in partnership with R3, Partior, DBS Bank, JP-Morgan, Temasek and Accenture.

6.9.3 High-level design of the experiment

Project Dunbar developed two prototypes of an mCBDC shared settlement platform on the Corda and Quorum DLTs. The prototypes proved the technical feasibility of implementing a shared mCBDC platform. With respect to governance, the common platform guarantees autonomy for participating central banks in the issuance of their CBDC, within a framework of uniformly applied rules.

On this common shared platform, multiple central banks issue their CBDCs, which can be used by participating commercial banks for payments. Participating commercial banks will be able to hold and transact in the CBDCs issued. This includes CBDCs in local as well as foreign currencies. Banks that are connected to the domestic payment system can exchange their central bank balances for CBDCs. Non-local banks (banks licensed as banks in other jurisdictions, but not in the local jurisdiction) which are not connected to the domestic payment system can exchange CBDCs with other banks.

6.9.4 Key considerations around interoperability and access

In this common platform participants transact using common functions (smart contracts on DLT) and messaging formats. Interlinking with legacy systems was not part of the experimental scope.

In designing the access framework, two models were explored: direct and indirect (sponsored/hybrid) CBDC access. A "sponsored" indirect CBDC access model is applied that allows banks to hold CBDCs from jurisdictions where they do not have a presence. With this CBDC model, non-local banks hold CBDCs representing a direct liability of the issuing central banks. The banks that have direct access and on which the indirect participants rely are called "sponsoring" banks. These banks are subject to local regulations and perform customer due diligence processes on the non-local banks. This includes onboarding and know-your-customer (KYC) processes as well as suspicious transaction monitoring and AML/CFT processes. This allows application of control processes without the need for changes to existing regulatory policies. While the need for an intermediary is eliminated in the settlement process, intermediaries, in the form of "sponsoring" banks, continue to play a role for control processes such as KYC and AML/CFT. This represents a limitation on the efficiency gains of eliminating intermediaries and poses a challenge with regard to commercial models and incentives for banks to play such "sponsoring" roles. Various possibilities exist, including reciprocal arrangements, obligations imposed as conditions of access, and fees, and require further evaluation. Dunbar's prototypes were developed to flexibly support both sponsored and direct access models. In jurisdictions where the regulatory frameworks allow direct access to CBDC by non-resident banks, approval routing to "sponsoring" banks could be disabled to move from a "sponsored" to a "direct" CBDC access model.

⁵⁹ See www.bis.org/about/bisih/topics/cbdc/dunbar.htm. Phase II of the project is being scoped.

6.10 e-CNY (project ongoing)⁶⁰

6.10.1 Context

E-CNY is the digital version of fiat currency issued by the People's Bank of China (PBC). It is designed mainly for domestic retail usage, and aims to improve efficiency, the resilience of the central bank payment system and financial inclusion.

6.10.2 Participants

The PBC, eligible commercial banks, PSPs, telecoms operators and end users.

6.10.3 High-level design of the experiment

The e-CNY project has adopted a two-tier model, whereby the PBC issues e-CNY to authorised operators, including eligible commercial banks, PSPs (in the name of their commercial bank arms) and telecoms operators (grouping with commercial banks). The authorised operators are responsible for providing exchange and circulation services to the general public. With the two-tier model, the general public can still access e-CNY through traditional financial intermediaries, which would not be crowded out in the process of digitalisation of the fiat money.

In terms of design features, the system provides tiered wallets with different thresholds in order to achieve synergies between anonymity, risk reduction and financial inclusion. Following the principle of "anonymity for small value and traceable for high value", wallets with lower thresholds allow greater anonymity. As a result, e-CNY can more easily be rolled out into rural or disadvantaged areas where identification can be difficult. Wallets with higher thresholds follow respective customer due diligence procedures that ensure AML/CFT compliance. The e-CNY does not pay interest on its holdings because of quantitative restrictions, but also to avoid competition with bank deposits and to foster financial inclusion.

In terms of technology, the project uses a "hybrid architecture" with both distributed and centralised design, which enhances the resilience and scalability of the system and supports rapid growth in e-CNY transactions. Also, it has adopted a "long-term evolution" approach without any prescriptive technology path in advance, so new technological features can continuously contribute to the system. In terms of legal foundations, a general revision of the People's Bank of China Law (draft) stipulates that Chinese currency includes both physical and digital forms, and thus will confirm the legal tender status of the e-CNY.

6.10.4 Key considerations around interoperability and access

The e-CNY system broadens the accessibility of payment services, providing fiat money for a large population in various scenarios. Offline payment capacity and hardware-based wallets facilitate access for the underbanked population as well as foreign visitors.

The project is being carried out primarily with a view to domestic considerations, while the PBC also explores how CBDC can be used for enhancing cross-border payments. To this end, the PBCDCI⁶¹ has partnered with the BISIH and three other central banks in the mBridge project (see Annex 6.6). The PBCDCI is also exploring interlinking with the fast payment system in Hong Kong SAR, in order to facilitate cross-border consumption of both mainland and Hong Kong SAR residents. As emphasised by the PBCDCI, cross-border payments should involve interoperability across domestic CBDCs or domestic CBDCs and incumbent payment systems, and domestic CBDCs should be converted to other currencies as payments cross borders, so as to avoid potential adverse macroeconomic implications such as currency substitution.

⁶⁰ See www.pbc.gov.cn/en/3688110/3688172/4157443/4293696/2021071614584691871.pdf.

⁶¹ The Digital Currency Institute of the PBC, which undertook the e-CNY project.

6.11 Sand Dollar⁶²

6.11.1 Context

The Sand Dollar was launched in October 2020 as the world's first CBDC, issued by the Central Bank of The Bahamas (CBB). Its main policy goals are financial inclusion, improved access to payments, efficiency of payments, resilience, and to reduce illicit use of money. In late 2021, the number of users of the Sand Dollar was around 20,000, or roughly 5% of the population. It is continuously being developed, and new functions are being added.

6.11.2 Participants

The CBB, supervised financial institutes including banks, credit unions, money transmission businesses, PSPs and end users.

6.11.3 High-level design

The Sand Dollar is issued by the CBB and circulated in a network consisting of private sector intermediaries that interact with the end users of Sand Dollars. The intermediaries develop and operate electronic wallets where end users store their Sand Dollars and the graphical interface that they use to make and receive payments. They also carry out the required KYC controls but do so using a common infrastructure that is operated by the central bank.

Technologically, the Sand Dollar makes use of DLT. Intermediaries offer end users wallets that are available with different caps on transactions and holdings. This arrangement is intended to relieve bank deposits from competition from CBDC and thus mitigate the risk of both bank disintermediation and digital bank runs. The lower tier wallets do not require formal proof of identity in order to ensure ease of access in areas in which identification can be difficult. Basic user information including a phone number is necessary, however. With higher caps the need for identity and KYC/AML compliance increases.

Recently, the CBB finished connecting the Sand Dollar to its banking sector, which allows payments from Sand Dollar wallets to bank accounts. The connection also enables automatic transfers between a Sand Dollar wallet into a linked bank account in case money transferred to the wallet exceeds the cap.

6.11.4 Key considerations around interoperability and access

The Sand Dollar does not currently have a cross-border function, but the CBB has stated that it intends to explore its international usage in the coming years.

⁶² See <https://www.sanddollar.bs>.

6.12 DCash⁶³

6.12.1 Context

DCash is the CBDC issued by the Eastern Caribbean Central Bank (ECCB) in the context of a pilot. The pilot started in March 2021 in some countries of the Eastern Caribbean Currency Union (ECCU) and will progressively extend to all countries. The pilot is expected to last at least until the summer of 2023, one year after the last country is planned to join the pilot. DCash is designed mainly for retail use, with the aim to improve efficiency and resilience of the payment system and financial inclusion. No decision has been made regarding a launch of the CBDC after the pilot ends.

6.12.2 Participants

The ECCB, financial institutions and end users (for the latter two, voluntary participation).

6.12.3 High-level design of the experiment

DCash uses a two-tier CBDC distribution model. The ECCB issues, redeems, and validates transactions, as well as updating the ledger. The CBDC is distributed through the banking system, which performs the onboarding of customers (KYC/AML/CFT), manages users' data and provides customer service. Currently, the ECCB offers banks a ready-made application for users to interact with DCash, but the expectation is that, in a formal launch, banks would develop their own applications.

In terms of design features, DCash does not bear interest, and there are quantitative limits to DCash holdings in place. These were put in place to limit the potential disintermediation of the banking system. The ECCB also wanted to keep control of the overall amount of DCash issued, by setting an aggregate limit on issuance. This, however, has not been put in place yet. To manage the trade-off between anonymity/financial inclusion and AML/CFT compliance, the system offers a tiered selection of wallets with different levels of thresholds. Wallets with lower limits allow for greater anonymity.

The ECCB has been relying on third-party vendors for the technology. The system is based on a DLT, considered by the central bank secure and apt for its needs. In terms of legal foundations, the ECCB has prepared a draft amendment to its central bank act. This will extend the definition of "currency" to "digital currency" and clarify the central bank's sole right to issue digital currency. The amendment also gives the status of legal tender to digital currency.

6.12.4 Key considerations around interoperability and access

As the ECCU consists of eight different nations,⁶⁴ DCash is the first example of a cross-border CBDC, even though it is not cross-currency. Still, the focus for DCash has been on improving payments efficiency both within a country and across the countries forming the currency union. Further, the ECCB looks favourably on the possibility to use CBDC for cross-border payments with other countries, given the importance of trade and overseas remittances for ECCU countries. While the main priority for the ECCB is ensuring that DCash works smoothly for domestic purposes, it has begun discussions with other regional central banks regarding interoperability with legacy payment systems and platforms to enable remittances and trade in the region.

⁶³ See www.eccb-centralbank.org/p/what-you-should-know-1.

⁶⁴ The Eastern Caribbean Central Bank (ECCB) is the monetary authority of a group of eight island economies: Anguilla, Antigua and Barbuda, Dominica, Grenada, Montserrat, St Kitts and Nevis, St Lucia, and St Vincent and the Grenadines.

6.13 eNaira⁶⁵

6.13.1 Context

The eNaira is the Nigerian CBDC issued by the Central Bank of Nigeria (CBN). It was launched as the world's second CBDC on 25 October 2021. The CBN lists several domestic policy goals for CBDC, including ensuring financial inclusion, improving the availability of and access to central bank money, and making payment systems more efficient and resilient. But the eNaira is also intended to improve cross-border payments and make remittances to Nigeria cheaper.

6.13.2 Participants

The CBN, financial institutions (FIs), end users, and government ministries, departments, and agencies (MDAs) (for receiving and making payments to citizens).

6.13.3 High-level design

eNaira uses a two-tier CBDC distribution model. The CBN administers the eNaira through the Digital Currency Management System (DCMS) to issue and mint the eNaira. The eNaira platform hosts the eNaira wallets for different participants. The eNaira stock wallets, which belong solely to the CBN, serve as the warehouse for all minted eNaira. FIs maintain a treasury eNaira wallet for holding and managing eNaira on the DCMS using the FI Suite. The FI Suite is the primary application the FIs use to manage their digital currency holdings, requests, and redemptions with the CBN. FIs may create eNaira Sub-Treasury Wallets for branches tied to them and fund them from their single eNaira treasury wallet with the CBN. An FI may also create an eNaira branch sub-wallet for its branches and fund them from the treasury eNaira wallet. There are also eNaira Merchant Speed Wallets used solely for receiving and making eNaira payments for goods and services, and eNaira Speed Wallets, which are available for end users to transact on the platforms.

Technologically, the eNaira relies on permissioned DLT, in which the intermediaries make up nodes in the network. The FIs also carry out onboarding of customers and AML/CFT controls. Users of eNaira are subject to a tiered structure of KYC requirements based on transaction and balance limits. Legally, the CBN is empowered to issue eNaira based on its mandate under the Central Bank of Nigeria Act and other financial institutions acts.

6.13.4 Key considerations around interoperability and access

Universal access to eNaira is a key goal of the CBN, and new forms of digital identification are being issued to the unbanked to help with access. The CBN also reports that the eNaira has been designed with international interoperability in mind. The eNaira, according to the CBN, could thus lead to cheaper remittances to Nigeria, and also improve cross-border payments in general, which could facilitate trade.

The individual and merchant wallets of the eNaira have different caps on daily transaction limits and the amount of eNaira that can be held in them, depending on their customer due diligence tier. The wallets with lower caps can be held by individuals that do not have a bank account, but a bank account is necessary to hold a wallet with higher caps. The caps are explained by the CBN as intended to ensure that the eNaira is primarily used for smaller retail payments and that competition between eNaira and bank deposits is limited. Similarly, the CBDC has been designed with a 0% interest rate, which is also intended to avoid competition with bank deposits. When it comes to anonymity, the CBN has opted to not allow anonymity even for lower-tier wallets. At present, a bank verification number is required to open a retail customer wallet, and going forward anyone whose identity can be verified at least with a phone number will be able to open lower-tier wallets.

⁶⁵ See enaira.gov.ng/ and www.cbn.gov.ng/Out/2021/FPRD/eNairaCircularAndGuidelines%20FINAL.pdf.

Annex 7: Composition of the Future of Payments Working Group (FoP)

Chair of the Working Group and Lead of the BB 19 drafting team

Sveriges Riksbank	Cecilia Skingsley
Bank of France	Valérie Fasquelle [until February 2022]

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** The access of the Central Bank of the Russian Federation to all BIS services, meetings and other BIS activities has been suspended.