



UK
FINANCE

DESIGNING INTEROPERABILITY FOR A POTENTIAL UK CBDC

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In association with:



pwc



UK Finance

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FOREWORD

The Bank of England (the Bank) and HM Treasury are currently considering whether the introduction of a UK retail central bank digital currency (CBDC) would be beneficial for the UK economy and the continued integrity of pound sterling in light of increasing use of digital money. This decision could have a significant impact on the way that the UK's financial markets operate and the ways in which consumers and businesses make payments on a day-to-day basis.

While the Bank has not yet made a decision on whether to introduce a UK retail CBDC, it has proposed that the launch of a UK retail CBDC would be done in collaboration with the private sector. In light of this, UK Finance and its members considered how the private sector might be mobilised to contribute to the collective challenge that is faced by industry and regulators in considering this important and strategic decision for the UK's financial ecosystem. As a result of this, we have worked with members throughout the first half of 2022 to understand how some of the key technical hurdles could be overcome by the market. Our members identified with us three areas that required particular investigation:

- The level of interoperability between a CBDC and other forms of money
- The potential commercial considerations of private firms offering CBDC services
- The impact of CBDC implementation on credit creation for the UK economy.

This paper is one of three reports developed with UK Finance members that helps to discuss the potential impacts of the issuance of a UK CBDC and reflects a synthesis of thought from our members, associates and other stakeholders. We encourage you to read the other reports in this series as they cover complementary implications of CBDC issuance for the UK economy.

UK Finance and its members remain in full support of the consideration by the Bank and HM Treasury of all work investigating the potential development of a CBDC for the UK market. The Bank and HM Treasury are currently considering the practical challenges of implementing and operating a UK retail CBDC, including the roles of the public and private sectors ahead of the proposed consultation in 2022 to help assess the case for a UK retail CBDC.

We firmly believe that this development process is a vital opportunity to cement the ability for public and private bodies to work collaboratively and openly to understand the technical concerns, operational benefits and public policy objectives that are all essential to answer through the development of a UK CBDC proposal. A CBDC could deliver to the UK a step change in the way that businesses and consumers use financial services and break off the boundaries imposed by legacy infrastructure while ushering in a new generation of innovation for the ecosystem. It is essential that both public and private bodies work together to ensure the potential of a CBDC can deliver these benefits.

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EXECUTIVE SUMMARY

In order to support the adoption of a CBDC and to reinforce the fundamental integrity of and confidence in Pound Sterling (GBP) our thinking has focused on two core and interconnected considerations:

- Fungibility – the ability of a CBDC to be exchanged at par with GBP held in other forms of money, including Bank of England bank notes, Royal Mint coins, commercial bank money and central bank money held in reserves and settlement accounts at the Bank of England.
- Interoperability – the ability of a system, party, or other mechanism to provide the means of exchange from one form of money to another. Given the number of payment systems operating in the UK market, the question of how a CBDC can be interoperable with other payment systems and other forms of money is a key one to answer.

This paper outlines how interoperability may be provided for a UK CBDC through investigation of some theoretical models for its implementation. These models are only indicative at this stage. There remain major variables to be resolved - such as how the CBDC ledger will work, what this means for interaction with existing payment systems and what CBDC payment services financial institutions might want to offer their customers. We expect, if a CBDC proceeds, the forthcoming consultation will shed much more light on these, and other issues, and then we look forward to taking the work to the next level of detail.

Currently both Financial Market Infrastructures (FMIs) and payment service providers provide services or systems supporting interoperability for the market. In the case of FMIs, these services are primarily provided to financial institutions while payment service providers (henceforth, we use the term Payment Interface Providers, PIPs)¹ provide services to consumers and merchants. In order to provide fungibility between two forms of money, we assume that financial institutions must have the means to fund or de-fund balances held in these different forms of money, and therefore must have the technical means to interact with an appropriate FMI, ledger or other service to effect this change.

We investigate a number of models to support this technical interoperability. The first is reliance on FMIs to provide interoperability and the second achieves this through PIPs. A third hybrid model enabling both FMIs and PIPs to provide interoperability is also investigated. Some of these models may be impacted by the mechanism that the Bank could use for the issuance of a CBDC, we explore this within the second annex.

Providing interoperability of a CBDC with other forms of money could drastically expand the availability of CBDC services and provide a clear pathway for broader market adoption. However, this paper outlines some of the significant infrastructure changes which may well be required to provide this interoperability, this of course is dependent on the eventual chosen model. While our investigation does not consider the interoperability of a CBDC with other forms of digital money, we note the work undertaken by industry to describe interoperability pathways.²

In conclusion, this paper considers that a model which provides flexibility to the market in providing CBDC services is most likely to provide the level of competition, innovation and access required to fulfil the Bank of England's objectives. Any infrastructure change cost necessary to enable firms to provide consumer services at a competitive price point must be considered. There remain unanswered questions concerning the level of interoperability required to support a CBDC. Foremost amongst these considerations are further details from HM Treasury and the Bank of England regarding the public policy objectives that a CBDC will fulfil for the UK economy over and above those outlined by G7 nations.³

¹ For this paper, we have adopted the nomenclature of the Bank of England's March 2020 Central Bank Digital Currency: Opportunities, challenges and design discussion paper of Payment Interface Providers (PIPs) to indicate financial institutions that provide CBDC services to the consumer (and that aren't FMIs). We assume that these PIPs may be already existing credit institutions, payment service providers or new CBDC providers. Where necessary, we use the term PIPs to indicate existing Payment Service Providers (PSPs).

² <https://arxiv.org/ftp/arxiv/papers/2109/2109.12194.pdf>

³ https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1025235/G7_Public_Policy_Principles_for_Retail_CBDC_FINAL.pdf

1. SCOPE AND ASSUMPTIONS OF ANALYSIS

1.1 Problem statement

The central problem statement this paper considers is the following:

CBDC interoperability: the ability of users to switch, without barriers or undue friction, between different forms of **sterling money and different payment services**. In a CBDC system, interoperability and fungibility exists between users of different digital wallets in the same coin and users of different coins and payment systems - at a reasonable or no cost to users.⁴

Through our investigation we considered how interoperability may be considered from the following angles:

- Business perspective: CBDC issuers can interact with other types of payment systems to offer end users a resilient digital payment infrastructure and efficient payment instruments which are open, standards-based, universally accessible, affordable, secure and always available.
- Technical perspective: CBDC systems leverage common messaging formats, protocols and/or identifiers which enable seamless payment transfers between users holding different digital currency types.
- Legacy perspective: Compatibility with legacy systems, taking into account the required transition period during which new systems will need to interact with the existing financial infrastructure, where value in the form of spendable assets exists today.
- Regulatory perspective: Regulatory interchange and consideration of (potentially) different regulatory guidelines between connected parties, with consideration of potentially limited risks to domestic interoperability.
- Future perspective: Compatibility with expected future developments, including enhancements to existing payments systems or the emergence of new payment services, such as stablecoins and smart contracts. Any design of CBDC would also need to allow users to interact between CBDC and financial system in a seamless fashion.

1.2 Scope definition

The scope of this paper considers:

- The interoperability of different forms of money denominated in GBP, including:
 - Commercial bank money
 - Bank of England bank notes
 - Royal Mint coins
 - Central bank money held with the Bank of England through reserve or settlement accounts
 - Electronic money (e-money)
 - CBDC issued to the public by the Bank of England through Payment Interface Providers.
- The interaction of the following parties:
 - Financial Market Infrastructure (FMI) – these institutions allow the clearing, settlement, and recording of financial transactions between different parties.⁵
 - Payment Interface Providers (PIP) - handle the interaction with end-users of CBDC and provide additional payments functionality through overlay services. We assume that these PIPs may be already existing, payment service providers or new CBDC providers.⁶
 - The CBDC ledger - provided by the Bank of England and the mechanism by which PIPs would record CBDC balances and process payments.⁷
 - Bank of England Reserves/Settlement accounts – accounts maintained by the Bank of England on behalf of connected participants. Reserves accounts are effectively sterling current accounts for participants in the Bank's Sterling Monetary Framework. Settlement accounts can be used to settle obligations that arise from participating in payments systems in central bank money. Reserves accounts can also be used as settlement accounts.

⁴ The definition excludes non-fiat money. Considerations relating to interoperability with other national CBDCs, for cross-border applications, are outside the scope of this analysis. This definition is derived from the Bank of England's New Forms of Digital Money discussion paper; <https://www.bankofengland.co.uk/paper/2021/new-forms-of-digital-money>

⁵ <https://www.bankofengland.co.uk/financial-stability/financial-market-infrastructure-supervision>

⁶ <https://www.bankofengland.co.uk/-/media/boe/files/paper/2020/central-bank-digital-currency-opportunities-challenges-and-design.pdf?la=en&hash=DFAD18646A77C00772AFIC5B18E63E71F68E4593> Section 4

⁷ Ibid

- We do not consider:
 - The technology systems involved in the issuance of a CBDC, nor the mechanisms by which participants in a CBDC ecosystem communicate with one another; our approach considers the interrelation of parties from a purely functional perspective.
 - The access requirements from a policy perspective of firms engaging with either an FMI or a CBDC environment.
 - The commercial models of FMIs or firms within a CBDC environment.
 - The relative benefits of interoperability from a policy perspective.⁸
 - The international interoperability between different CBDCs.
 - The potential implementation of a wholesale CBDC; however, some of the conclusions of this paper may be applicable to similar investigations of wholesale CBDCs.
 - The interaction of payment limits or other technical requirements of a CBDC that may be introduced by the need to answer other policy considerations in the design of a CBDC.
 - The explicit interaction of a CBDC with e-money, stablecoin, other form of digital money and asset, or any derivatives thereof; although the conclusions and analysis contained in this paper may be applicable to other functional discussions concerning these types of money.
 - The acceptance of CBDCs by merchants and/or their acquirers at point of sale. Interoperability with other forms of non-sterling digital money or Distributed Ledger Technology interconnects.
5. The prudential regulation of CBDC issuance is independent of an investigation of potential models for interoperability.
 6. The business models for PIPs and FMIs are independent of an investigation of potential models for interoperability.
 7. The technology used to launch a CBDC is independent of the functional investigation of potential models for interoperability.
 8. Any requirements for offline transactions will not have an impact on the requirements for interoperability between different forms of money.
 9. On issuance of a CBDC, consumers and businesses will continue to want to hold balances in CBDCs and existing forms of money, including commercial bank money, notes, coins, e-money and any other representation.
 10. CBDCs must be exchangeable at par for other forms of money, barring commercial arrangements such as transaction fees, account fees or other business charges which are considered out of scope of this investigation.
 11. A CBDC will operate principally through infrastructure independently of infrastructure providing for payments in commercial bank money.⁹
 12. A CBDC remains denominated in the currency Pound Sterling (GBP), however some operational requirements for payment schemes and internal accounting may require it to be denoted with an alternate flag to make sure that it can be distinguished from other commercial bank money denominated in GBP.¹⁰
 13. A CBDC will operate alongside other forms of new digital money.
 14. A retail CBDC could also be held by a financial institution.
 15. A retail CBDC could be held by foreign nationals and non-UK incorporated businesses.
 16. There are no functional differences between forms of money exchanged through different FMIs – all FMIs discussed in this paper are abstracted and fulfil their functions equally to payer and payee and process transactions regardless of the source of transaction.
 17. Firms providing CBDC services will require access to Central Bank money in order to fund or de-fund a CBDC balance. This may be through direct or indirect access to a reserves or settlement account at the Bank. PIPs without direct or indirect access to reserves or settlement accounts would be able to buy CBDC from existing holders using other forms of GBP.
 18. That all existing PSPs and new firms may become PIPs but not all PSPs will make a decision to provide CBDC services.

1.3 Key assumptions

Given the early development of the design of a UK CBDC, our work required us to make a number of assumptions about the design of a CBDC:

1. A CBDC will be developed under a public/private partnership between the Bank of England and industry.
2. A CBDC ecosystem will provide similar functionality and services (e.g. at point of sale and for transfers between accounts) as commercial bank money and other existing forms of digital money.
3. CBDCs will provide the same standard of service in relation to stability of value, robustness of legal claim and the ability to redeem at par in fiat when compared to that expected of commercial bank money.
4. A retail CBDC system will allow PSPs a reasonable degree of autonomy in choosing their respective technology platforms and interfaces for providing services to their customers.

⁸ Please see BIS paper CBDC – System design and interoperability, particularly page 11, for a more detailed review of the benefits of interoperability. https://www.bis.org/publ/othp42_system_design.pdf

⁹ Other implementation options for a CBDC are possible, beyond the parallel operation of infrastructure that this assumption predicates. We presume that a CBDC would be dependent upon infrastructure at the Bank of England separate to the existing settlement/reserves accounts. Infrastructure interacting, as we discuss in model A, with both settlement/reserves accounts and a CBDC ledger would need to be able to distinguish when transactions are being made against either (or both) of these distinct ledgers. Should alternative implementation choices for the introduction of a CBDC not require strict segregation between digital central bank liabilities within settlement/reserves accounts and a CBDC ledger then other interoperability solutions may become available to the Bank and wider industry.

¹⁰ We make this assumption in order to cover off situations where a CBDC is remunerated differently to commercial bank money (i.e. by the Bank of England rather than commercial banks) or retains intrinsic properties through the process of a transaction that requires special processing by PIPs or FMIs. If functional differences between a CBDC and commercial bank money become nominal to the functioning of payment services and account holding requirements (such as if a CBDC is offered as a separate product type to commercial bank money accounts) then requirements to keep CBDC and commercial bank money segregated during a payment (and, therefore, the need for any specific interoperability requirements) may no longer exist. We note that, commercial bank money payments ultimately achieve settlement through transfer of central bank liabilities.

1.4 Current state overview

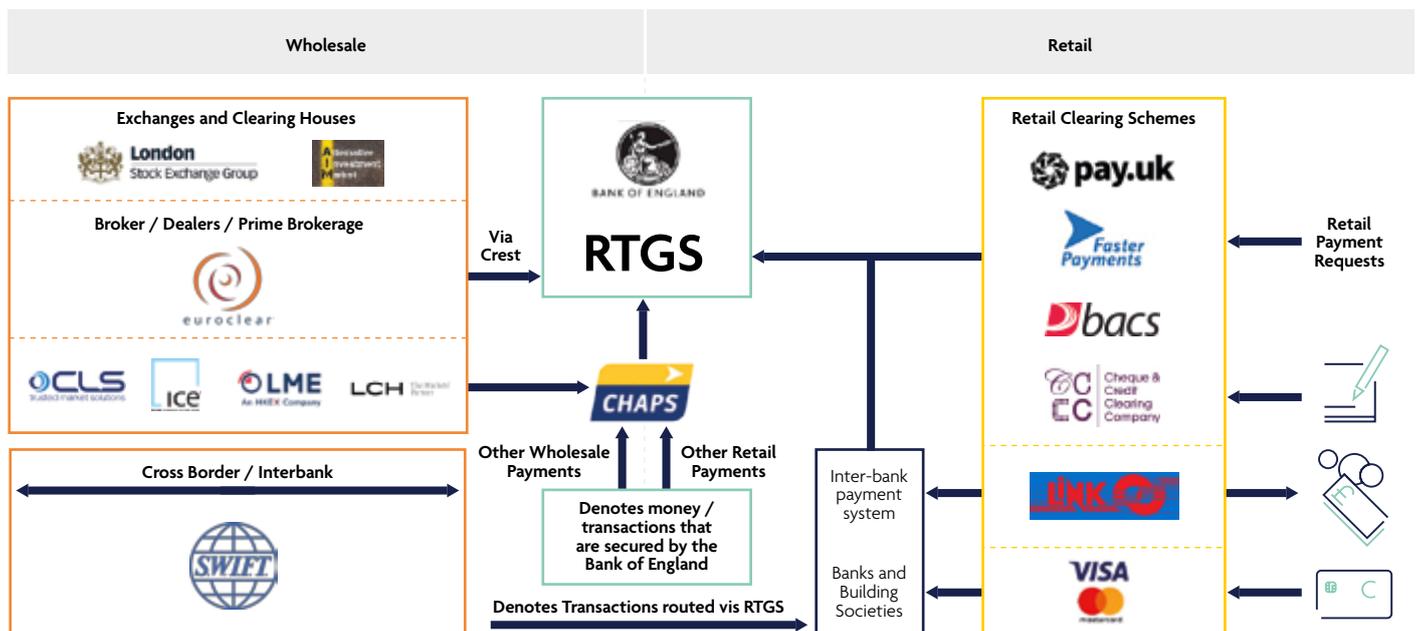
The distribution of GBP in the UK takes several different forms; from paper money, coins, commercial bank money, e-money and other representations. Given the distinctive characteristics of each of these forms of money, it is often necessary for market infrastructure or parties to provide the means of exchange between one form of money and another. For example, the transfer of commercial bank money into physical notes is often handled by infrastructure managed by LINK. It is clear that the potential scope for interoperability of a CBDC across the number of FMs operating in the UK is significant. This picture would be further complicated by the number of participants that connect to one or more of these FMs and provide payment or other financial services to the market. This is illustrated in the diagram below.

It is possible that firms will adopt business models or charging structures which will challenge the direct exchange of different forms of money with another. For instance, a PIP may decide to charge for exchange services from or to a commercial money account. While this form of business model may challenge the purported 1:1 relationship between different forms of GBP, we do not consider that it threatens the underlying principle of fungibility between these forms of money.

1.5 Fungibility and interoperability

In our investigation of interoperability, we considered that the fungibility of CBDC between different forms of money is a key policy decision that will be made during the implementation of a CBDC within the UK. We identified a distinction between the principle of fungibility between different forms of GBP and the technical interoperability provided by PIPs and FMs to enable exchange of one or more forms of money with another.

- Fungibility – the ability of a CBDC to be exchanged at par with GBP held in other forms of money, including Bank of England bank notes, Royal Mint coins, commercial bank money and central bank money.
- Interoperability – the ability of a system, party or other mechanism to provide the mechanism of exchange from one form of money to another form of money.



2. SUCCESS CRITERIA AND USE CASES

2.1 Success criteria

Within this context, an analysis of the Bank of England's New Forms of Digital Money discussion paper highlighted a number of assumptions concerning the interoperability of a CBDC with other forms of money. From these assumptions, we developed a number of success criteria against which potential models for interoperability could be judged.

Assumption	Success criteria
Interoperability is important for fostering competition in the provision of payment services.	The design of a CBDC ecosystem should encourage and promote competition within an open and commercial market.
Interoperability is important not only between users of different digital wallets in the same coin , but also between users of different coins and payment systems.	The design of a CBDC ecosystem should permit the exchange of CBDCs for other forms of GBP.
Interoperability should be provided at reasonable cost, or no cost, to users .	
It should be no more costly or complicated to make payments between digital coins and other payment systems than those involving commercial bank money .	The design of a CBDC ecosystem should not introduce disproportionate cost for firms providing interoperability between different forms of money.
Ideally, such payments should also be no more costly or complicated to make than those between users of the same digital coin .	
Any infrastructure would need to consider technology and data standards so that information could be exchanged seamlessly between the different systems involved.	The design of a CBDC should promote the adoption of common and consistent standards for market infrastructure.

Source: The Bank of England, New Forms of Digital Money, 2021

2.2 Interoperability use cases

To investigate the technical functionality that either a PIP or an FMI would need to provide, we outline below some of the use cases that users of a CBDC may expect to fulfil when transacting with a CBDC and other forms of GBP. These use cases helped to inform the functionality that PIPs and FMIs offering CBDC services may need to provide to the market.

#	Consumer	Payment Interface Provider (PIP)	Existing Financial Market Infrastructure (FMI)
1	Send money between CBDC wallets. ¹¹	Interface with the CBDC ledger to authorise transactions from customers to a CBDC account.	Provide technical access to a CBDC ledger for the market.
2	Send money from a CBDC account to another digital account holding commercial bank money and receive payments from an account holding commercial bank money – enabling the exchange of other forms of money to and from a CBDC within a single transaction.	Interface with the CBDC ledger and other commercial bank digital ledgers to provide point of interoperability between different forms of money.	Interface with the CBDC ledger to provide automatic transfer of commercial bank money (on existing platform) to CBDC.
3	Buy CBDC balances using other forms of GBP, and sell CBDC balances for other forms of GBP. ¹²	Able to exchange reserves with the Bank of England for CBDC, and trade CBDC for reserves.	No direct customer relationship – provide to a PIP the means to exchange reserves with the Bank of England for CBDC, and trade CBDC for reserves.

¹¹ While the transfer of CBDC from and to accounts denominated in a CBDC are not necessarily required to discuss the function of interoperability between a CBDC and other forms of GBP, we include it here for completeness.

¹² While this use case does not specifically answer any use case that a consumer or business may have in seeking interoperability between one form of GBP and another, we consider this process to be important in articulating the need for PIPs to provide the interoperability necessary when creating CBDC balances from other forms of money.

3. OUTLINE OF MODELS

To meet the industry’s demand for fungibility between CBDC and different forms of GBP, we consider that an organisation must have the ability to credit or debit balances in different forms of money in order to enable the transfer of funds between these separate systems. This is illustrated in the model below.

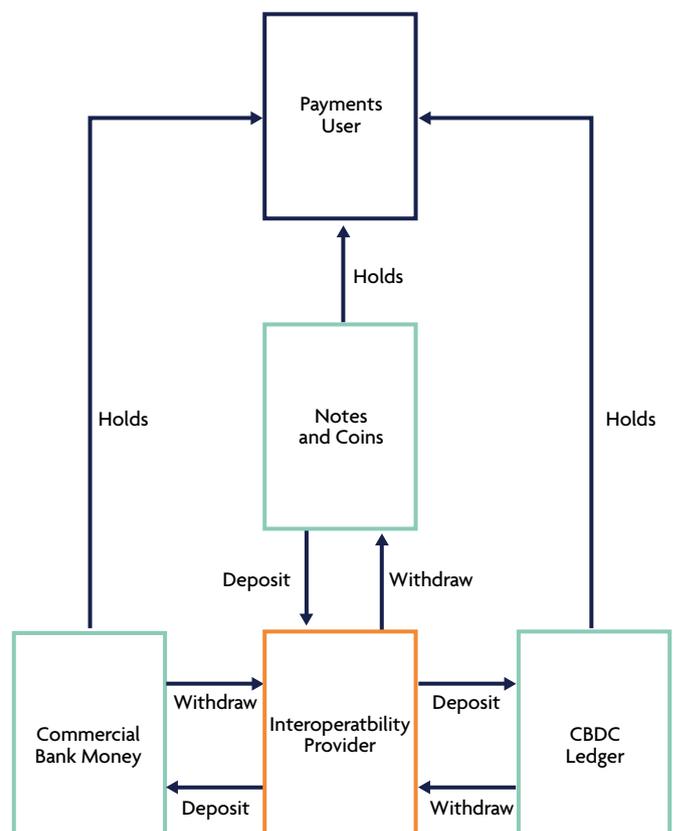
When a customer withdraws funds in one form of money, the interoperability provider must be able to provide a corresponding deposit in another form of money.¹³ A provider of interoperability may not wish to provide the full spectrum of interoperability to its customers, but at the lowest level it must provide interchange between two types of money.

Our investigation identified both PIPs and FMIs as having the ability to undertake this function for the market. By way of example, we consider that in the future, it may be possible for the UK’s New Payment Architecture (NPA) to interact with a CBDC ledger, authorise payments, and redeem or purchase CBDC balances for central bank money. If enabled concurrently with payments being made on behalf of a connected financial institution, the NPA could provide for payments being sent from commercial bank money accounts to a CBDC wallet. Similarly, we consider that, with the right reference data being provided in the transaction, a consumer could send CBDC balances to an industry hosted CBDC wallet to authorise the onward forwarding of commercial bank money funds. A similar process could be adopted by card networks and other payment networks. We explore this in the analysis of Model A.

Currently, consumer-facing organisations, PIPs, provide the primary mechanism for interoperability between multiple types of money for UK consumers and businesses. Under a CBDC ecosystem, a PIP may support a customer to pay and exchange money using commercial bank money, cash, cheques and (even) central bank money through the use of CHAPS; some of these may require connection with a specific FMI (e.g. for cash supply, a connection with LINK may be advisable). We outline this further in our analysis of Model B.

The pilot by the Riksbank of how to integrate a CBDC into existing PIP systems provides an indicative model for the type of technical connectivity that could be provided within a CBDC ecosystem. We presume that a technical design system, such as that articulated in their paper¹⁴ summarising the second phase of its pilot, could be adopted by a UK CBDC. We provide further assessment of this in the annex.

Finally, we investigate how enabling both consumer-facing organisations (PIPs) and market facing organisations (FMIs) would be able to provide interoperability to the market through a hybrid model.

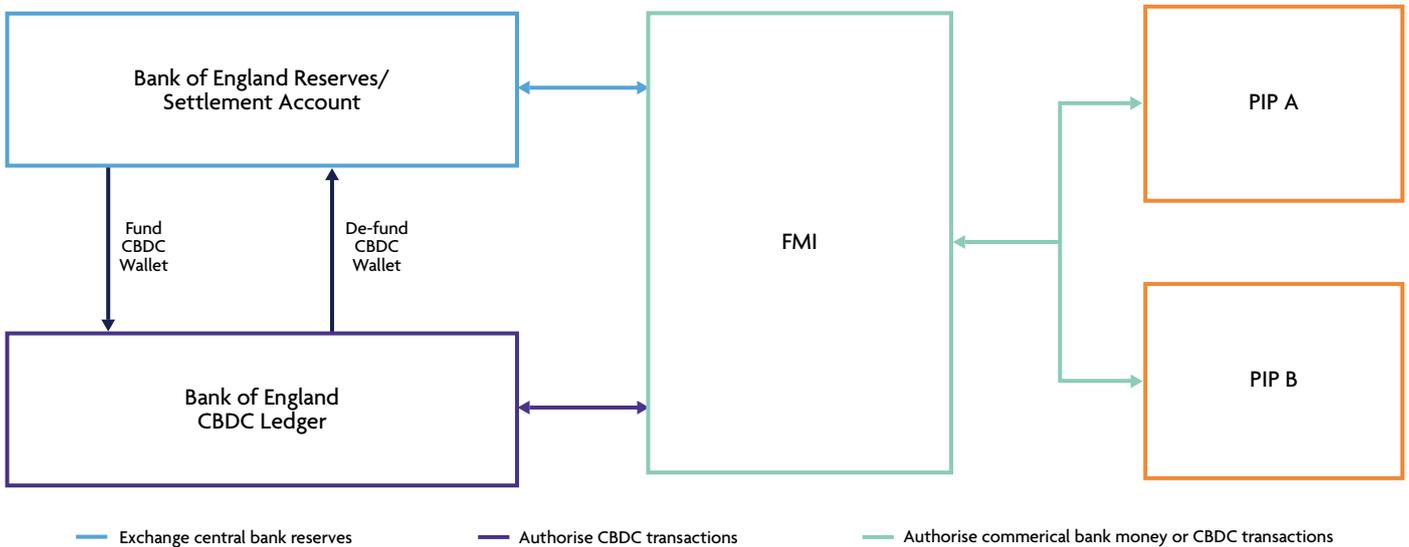


¹³ Note that common usage of terms is idiosyncratic due to the different conceptual status of various forms of money. Withdrawing cash refers to the increase in balance of cash holding while depositing cash often refers to exchange these for commercial bank deposits; the converse applies for digital balances.

¹⁴ <https://www.riksbank.se/globalassets/media/rapporter/e-krona/2022/e-krona-pilot-phase-2.pdf>

Model A – Interoperability through FMIs

Under this model, connectivity with an FMI would be the primary mechanism for the market to achieve interoperability between different forms of GBP. Existing FMIs could provide these services, or new FMIs could be introduced by the market to better enable competition and innovation.



N.B. PIP interaction with Bank of England Reserve/Settlement accounts not shown on diagram. PIP engagement with CBDC ledger for vanilla CBDC to CBDC transactions also not shown.

The diagram above shows how an FMI could provide to the market interoperability between a CBDC and other forms of GBP. This model is based on the assumption that user demand to send funds through an FMI to a CBDC account will incentivise existing FMIs to provide CBDC interoperability services to their customers. We have assumed, for the sake of illustration, that PIPs hold money in the Bank of England’s Reserves/Settlement accounts and that transactions are settled through these accounts as part of the FMI’s services to PIPs A and B. The FMI has direct access to both the Bank’s Reserves/Settlement account (on behalf of PIPs A and B) and authorisation to fund and defund these accounts as well as access to the CBDC ledger and authorisation to, at least, fund and, depending on design decisions, defund wallets.

Use case 1 – With the FMI able to fund and defund CBDC wallets on behalf of the customers of PIPs A and B, this model is able to support wallet holders to send CBDC between accounts. In order to meet this use case, the FMI would need authorisation to initiate transactions on the CBDC ledger on behalf of consumers that are customers of PIPs A and B. This use case does not mean that an FMI is required by PIPs to initiate CBDC transactions, just that this could be one of a suite of services offered by an FMI to its customers.

Use case 2 – The FMI would need to either have authorisation over a CBDC wallet to or from which CBDC balances could be sent. When CBDC balances are transferred to this wallet, it could then sell the balance to the Bank in exchange for reserves and credit these to the Reserves/Settlement account of the PIP servicing the destination account. The PIP would then credit the destination account the sum of the amount sent. The same operation would be undertaken in reverse to send another form of money through to a CBDC account.

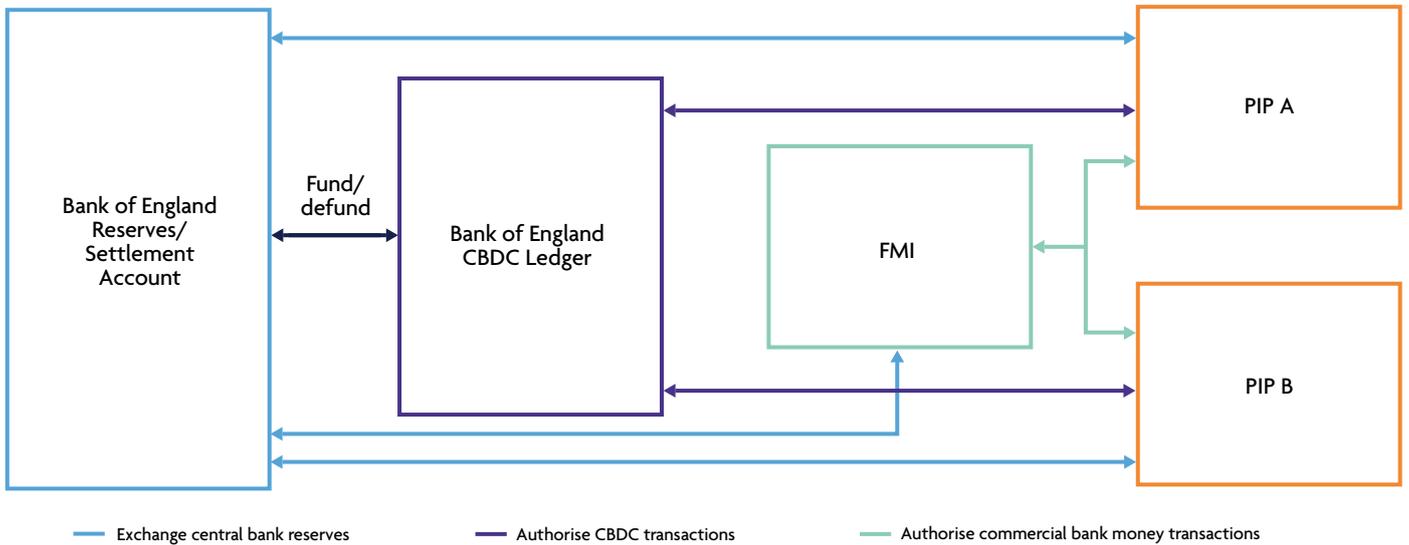
Use case 3 – The FMI would need to have authorisation to sell funds held by a PIP with the Bank of England in order to purchase CBDC. This could be credited directly to the required wallet or, alternatively, may need to pass through an intermediary account held by the FMI before being passed on to the destination account.

This model could deliver a number of advantages, principally that it achieves interoperability for a large number of PIPs through a clear single mechanism. In many ways, this model is similar to models proposed by industry to provide for interoperability between different forms of Distributed Ledger Technology based digital money.¹⁵

However, this change would not be without cost to the industry and it is unclear at this stage whether these changes would best be undertaken ‘centrally’ by an FMI and whether these changes would require change to existing customers of an FMI, introducing additional cost and complexity to the market. It is unclear whether this model would lower barriers, including cost and any infrastructure requirements, to entry into a CBDC ecosystem for existing or new PIPs. This model may also have an adverse impact on the level of competition in the market as it requires firms to connect to existing FMIs in order to provide the interoperability necessary for consumers, although it could also deliver market innovation through new FMIs creating new services to the market. The model would not necessarily ameliorate the cost for PIPs (both new and existing) as they would likely need to go through their own change programmes to take advantage of the FMI’s additional services, alongside funding the centralised change required by the FMI in question (whether that FMI operated as a for profit or a not-for-profit entity). In light of these costs and potential industry change, any mandated change programme may require significant industry preparation and investment. Giving firms commercial freedom to develop business cases and begin to offer CBDC services may be a suitable mechanism to gain market buy-in to a CBDC ecosystem.

Model B – Interoperability through PIPs

Under this model, connectivity of a PIP to multiple FMIs, the CBDC ledger and the Bank’s Reserves/Settlement accounts is the primary mechanism by which interoperability would be provided to the market.



We have assumed, for the purposes of this model, that connectivity with an FMI will be necessary for transactions in an alternative form of money to be transferred through to a CBDC wallet. By way of example, in order for a card payment from a consumer to a CBDC wallet held by a business to be made, the destination PIP must be capable of receiving a payment in order to subsequently update the balance on the respective CBDC wallet.

Use case 1 – The PIP is able to authorise CBDC transfers on behalf of its consumers, enabling them to send CBDC between different wallets.

Use case 2 – The PIP is able to send and receive money through an FMI as well as fund and defund CBDC balances. When it receives money destined for a CBDC account, the PIP can use the balances transferred to its Reserves/Settlement accounts held with the Bank of England to authorise the funding of a CBDC account. Conversely, if the PIP is able to authorise the selling of a CBDC balance in exchange for balances in a Reserves/Settlement account, it can use the balance to fund a transfer sent via the FMI in an alternative form of GBP.

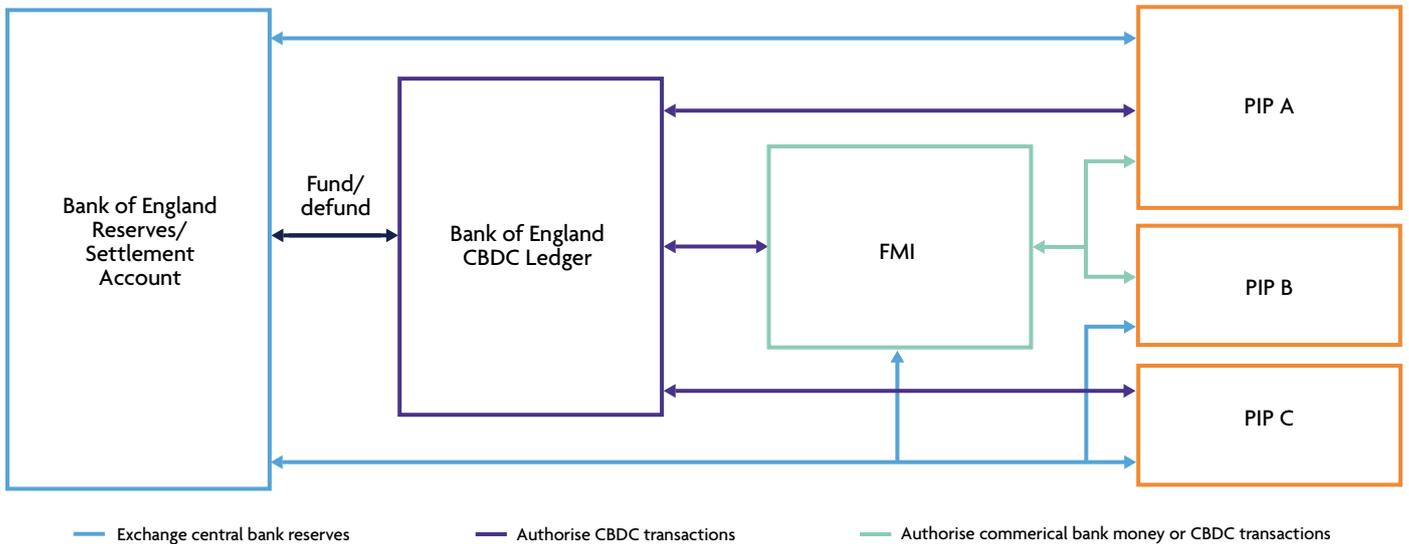
Use case 3 – Through access to a Reserve/Settlement account and permission to fund/defund CBDC accounts, the PIP will be able to exchange CBDC balances or central bank money on behalf of customers and sell or buy CBDC on their behalf.

Giving flexibility to PIPs as to the interoperability that they provide to the market (i.e. which forms of money they are able to provide

exchange between) will give freedom to different business models. This will ensure that ‘lighter’ financial services businesses are able to provide specialised offerings at a competitive price point while those adopting a more general service have the ability to engage with the appropriate FMIs, providing competitive differentiation between services. This flexibility could also reduce the need for any central change programmes to existing infrastructure. However, with no central mechanism to provide interoperability between different forms of money, the question of access may prove concerning for the industry as PIPs are required to develop multiple relationships with FMIs (or indirect providers) in order to provide a full suite of interoperability services to their customers. This concern is common across all three models considered.

Hybrid model

Our final model is a hybrid of both Model A and Model B and enables both PIPs and FMIs to provide a level of interoperability to their customers.



Granting capacity of both FMIs and PIPs to provide interoperability between different forms of money is illustrated in the above diagram. The variations between the interoperability mechanisms possible under this model are illustrated in the three PIPs on the right of the diagram.

PIP A operates as illustrated in Model 2 and provides interoperability to its customers by maintaining access to a relevant FMI, the Bank of England’s Reserves/Settlement accounts and the CBDC ledger.

PIP B operates as per Model 1 and provides interoperability to its customers by maintaining access to an FMI and maintaining relevant deposits at the Reserves/Settlement account level with the Bank of England.

PIP C does not interact with an FMI; however with PIPs A and B able to provide interoperability between a CBDC wallet and deposits in other forms of money, customers of PIPs A, B holding deposits in other forms of money would be able to exchange balances with customers of PIP C holding CBDC wallets only. This could be done either through an FMI providing the receiving/sending facility (and hosting the necessary intermediary CBDC wallet to receive and initiate CBDC payments) or through a PIP providing a similar intermediary facility. It should be noted that the business model for PIP C is also possible under both Models 1 and 2 and is shown here for completeness.

This hybrid model could provide the greatest scope for competition and innovation within a CBDC ecosystem. The number of firms able to provide exchange services between a CBDC and other forms of money would help to deliver better consumer outcomes through enhanced competition driving new service offerings and keeping costs controlled. Further, market participants would be able to best determine the optimal participation models to support their business models. On the other hand, the ability of this model to drive the adoption of common standards may be threatened given the diverse group of participants that would need to co-ordinate adoption and change programmes.

Providing for this model within the context of a commercially open market may provide flexibility for firms to invest in a CBDC ecosystem and arrange for their provision of CBDC services within the context of their own business models.

Summary of models

A summary of the ability of the different models to meet the success criteria is outlined below.

Success Criteria	Model A – FMI	Model B – PIP	Hybrid Model
The design of a CBDC ecosystem should encourage and promote competition within an open and commercial market.	Meets criteria.	Meets criteria.	Provides more opportunity for competition than models A and B.
The design of a CBDC ecosystem should permit the exchange of CBDCs for other forms of GBP.	Meets criteria.	Meets criteria.	Meets criteria.
The design of a CBDC ecosystem should not introduce disproportionate cost for firms providing interoperability between different forms of money.	FMI's able to provide interoperability to market at their discretion. Significant change programmes for FMI's and their customers may be required.	PIPs able to provide interoperability to their consumers at their discretion.	PIPs able to achieve interoperability through FMI's or direct integration with appropriate ledgers.
The design of a CBDC should promote the adoption of common and consistent standards for market infrastructure.	Adoption of standards driven by FMI's.	Common standards needed to ensure standardised adoption processes.	FMI's and PIPs able to drive out common standards for CBDC ecosystem.

4. SUMMARY AND QUESTIONS FOR FURTHER INVESTIGATION

Our analysis has highlighted the ability of both FMIs and PIPs to provide interoperability to users of CBDC. There is no doubt that other mechanisms could be used to create interoperability through the introduction of new entities to provide additional market services; however, at this stage in the analysis we consider that the introduction of such entities or market operators would be very similar to the operation of FMIs within this analysis.¹⁶

It should be said that the decisions by firms to integrate with new FMIs, to undertake internal change programmes to do so or for the industry to stand up new FMIs is not insignificant. By comparison, a 2020 estimation of the implementation costs of Open Banking by the nine firms caught under the CMA's Retail Banking Market Investigation Order put these costs at £1.5 billion. These are significant and commercially problematic costs that the UK industry must consider carefully when planning how to enable the interoperability required for a CBDC environment.

Further, there are variations of these models that will require more detailed investigation. First amongst this would be the mechanisms by which FMIs and/or PIPs allow for CBDC wallets to be credited with new CBDCs, in the event of creating new CBDC for their customers or receiving deposits of other forms of money into a CBDC wallet, or to sell CBDCs, in the event of selling CBDCs on behalf of their customers or sending their customers' CBDC balances to accounts holding other forms of money.

In order to fully understand the most optimal model for the industry to achieve interoperability between different forms of money, better clarification of the policy objectives of the launch of a CBDC will be required. We also recommend further investigation of potential models will be required before reaching any decisions.

In summary, we recommend that further consideration of the following questions will help to clarify some of the assumptions and unanswered questions from the analysis to date:

- How will the Bank's policy objectives impact the interoperability requirements for the industry? Will this change the relative merits of different success criteria?

- Will FMIs or PIPs be required through regulation to provide CBDC services to their customers or will this be left to the competitive market?
- How do PIPs undertake funding/defunding of CBDC wallets? Is direct connection to the Bank's RTGS or access to settlement/reserve accounts required? Would indirect connectivity to central bank money be sufficient for an indirectly connected PIP with direct access to the CBDC ledger to provide interoperability between different forms of GBP?
- How will an interoperability approach be constructed to manage flexibility in the supply and demand of CBDCs and CBDC services? Would controls and restrictions be introduced to manage the supply and demand of a CBDC and would this impact the level of interoperability that could, or should, be supplied to the market?
- How many FMIs or PIPs will need to deliver CBDC services in order to meet the Bank's objectives for CBDC coverage and interoperability? What cost impact will this have for the industry?
- If supply of CBDC is restricted in any way, will this have material impact on the fulfilment of payments? Will existing collateralisation of payments mechanisms be impacted by the issuance of a CBDC?
- Will FMIs and PIPs be permitted to hold balances of CBDC? Either permanently or on a temporary basis?
- How will deferred net-settlement payments interact with or interrupt the interoperability of different forms of money with CBDC balances? Will different retail clearing models result in some participants being unable to make immediate transactions of CBDC balances?
- Will the decision of an FMI or PIP to provide interoperability of a CBDC with another form of money be a commercial decision based on their business model? Will firms be mandated to provide CBDC services to the market? Will the type of CBDC issued to the market impact the ability, or willingness, for firms to provide interoperability?

¹⁶ It is possible that stablecoin providers, and systemically important stablecoin providers, could be considered as analogous to the operation of FMIs as discussed within this paper; however, further investigation of the precise operation of these entities would be required to draw substantive conclusions.

ANNEX 1

A NOTE ON FMI ABSTRACTION

There are a number of FMIs operating in the UK which may wish to provide a degree of interoperability of the types of money handled by existing products and CBDC. Many of these FMIs operate very different business models and support unique business models.¹⁷ It is not within the scope of this paper to assess the differences in services between these FMIs. In this sense, this paper abstracts the role of FMIs to the below process:

1. Consumer/business initiates payment with FMI customer
2. Debtor FMI customer receives payment request and updates balances
3. Debtor FMI customer makes request of FMI to process payment
4. FMI notifies Creditor PIP of the payment
5. Creditor PIP updates balances
6. FMI undertakes settlement with settlement agent

¹⁷ The greatest discrepancy exists between electronic payment systems and those supporting exchange of physical tokens (e.g. coins, notes and cash) with digital balances.

ANNEX 2

A NOTE ON ISSUANCE OPTIONS

Outline and assumptions

The precise method of issuance and associated mechanisms that will support a retail CBDC have yet to be articulated by the Bank and HM Treasury; these decisions, and the policy objectives of the Bank and HM Treasury, will have a significant impact on the mechanisms for interoperability that may be required by the market when providing a retail CBDC.

The analysis provided in this report is based on a large number of assumptions that we have done our best to document in our earlier section. There will inevitably be assumptions made in our assessment that have not been sufficiently documented and this analysis is provided on a 'best efforts' basis. The following discussion is a reflection of one of the core features of a CBDC as articulated by the BIS: that a CBDC is 'a digital form of central bank money that is different from balances in traditional reserve or settlement accounts'.

It is not the scope of the paper to provide a view on the mechanisms by which the Bank may consider the issuance of a CBDC to be suitable; however, at a high level, the range of options may vary between the creation of a central ledger by the Bank (similar to the existing mechanisms for providing reserves/settlement accounts), the creation of a distributed ledger solution, the creation of one or more entities that provide CBDC to the market or even the creation of new prudential backing requirements for specific product types issued by PIPs.

The CBDC ledger

What we believe is common through all of these issuing solutions is the need for the Bank and industry to have an agreed mechanism to track the amount of CBDC in the industry and which individuals or parties hold balances. We presume that a CBDC would have to be kept distinct from balances held in settlement/reserves accounts provided by the Bank. We express this in the models following in reference to a 'Bank of England CBDC Ledger' with the knowledge that this could be provided by any of, or other variations of, the issuance approaches noted above.

Understandably, some of the issuance mechanisms may have technical implications for the manner in which interoperability is achieved. For instance, if a CBDC is issued by a private third party on behalf of the Bank of England, their engagement with existing FMIs may be more akin

to the existing participation of FMI customers with their infrastructure. A diagram of such an arrangement would look quite different to the models we articulate in this paper. The mechanisms by which PIPs hold or represent CBDCs to their customers would need clarifying, as would the precise relationship of the third party provider of CBDCs to existing FMIs.

Distinguishing commercial bank money and CBDC

A further consideration to the above is our previous assumption that balances held in a CBDC would have to remain distinct from commercial money balances. This is a complex question to consider, particularly as it depends greatly on any policy decisions made by the Bank in any issuance of a CBDC. Some considerations indicate that a CBDC should be an instrument which is a direct liability of the Bank and that, therefore, PIPs can only provide custodial services for CBDC balances.

Under this construction, a CBDC therefore has intrinsically different properties to other forms of money; principally, its legal construct is that it is a liability of the central bank and not a private company. This could require its segregation from other forms of money throughout its lifecycle. Any transfer into other forms of money would require the exchange of a CBDC instrument with other money instruments between the originating firm and the Bank or another third party.

Therefore, CBDCs must always, and at every point in a payment journey, remain distinct and distinguishable from other forms of money. Interoperability with other forms of money could only be provided through the facilitation of the Bank, its appointed agent(s) or other third party. These requirements are reflected in the assumptions made in the description of the interoperability models in this paper and, on our assessment, would require the different CBDC and reserves/settlement ledger constructs that we outline.

Potential issuance options

Other issuance options are possible. For example, the Bank could achieve CBDC issuance to the market through the creation of another entity issuing CBDC products to the market and managing this issuance off the Bank's balance sheet. Under this issuance option, we presume that the CBDC instrument has different segregation requirements at different stages of its lifecycle.

While a CBDC instrument is held by a customer with a PIP, the CBDC is fully backed with reserves at the Bank (either held in a standard reserves/settlement account or a separate ledger) and the CBDC customer has special legal rights over the CBDC balance that satisfy the requirements for the CBDC to be a direct claim on the Bank. Under this approach, we assume that a ledger of some description will be required by the Bank or its appointed agent(s) to ensure that any CBDC offering in the market is appropriately backed with central bank reserves and that the correct legal controls are in place to provide the CBDC customer direct rights to those underlying central bank liabilities. Therefore, our presumption throughout this paper that separate ledgers between reserves/settlement accounts and a CBDC account appears to hold true.

For CBDC being processed as a transaction under this issuance model, the discussion may be more complicated. Most retail schemes operate on a deferred net-settlement model and, while these schemes are often supported by full backing of balances with the Bank, it is not clear how a net-settlement model would synchronise with the transfer of a CBDC, particularly if the CBDC in question was transferred in real-time. For a transfer of CBDC to other forms of money via another FMI, it may be that the CBDC liability is redeemed by the issuer of CBDCs and the balance transferred into the settlement account associated with the required FMI, and subsequently used to fund the transfer of another form of money through the relevant FMI.

For a transfer of another form of money into a CBDC account, the reverse would be true; the central bank liability settlement account funds are transferred to the CBDC provider and (presumably on completion of settlement) the reserve account liabilities are transferred to the CBDC ledger and credited to the destination account. In this discussion, the applicability of our Model A, as discussed later, may be of relevance, save that the described scenario would require the FMI and the issuer of CBDCs working in tandem to provide the necessary interoperability. It is not clear from this assessment whether that FMI would need to create additional legal parameters to support any required direct claim from a customer to central bank liabilities if their infrastructure is being used to support a CBDC transaction and whether such steps would be required if there was a need for the FMI to return funds to CBDC wallet, either due to an operational or business requirement.

The mechanisms by which the provider of CBDCs to the market arranges for transfers of CBDC to other CBDC accounts could presumably be covered by their operation as a de-facto FMI for the industry. If there were more than one provider of CBDCs to the market, then consideration may have to be given to the mechanism by which they synchronise payments and whether this could be achieved through existing FMI or new infrastructure introduced.

Summary

In summary, although the issuance options undertaken by the Bank and HM Treasury introduce additional complexities to the models that we introduce in this paper, the functional requirements of a CBDC and its legal or operational difference to other forms of money (as is currently articulated by documentation from the Bank and BIS) indicate that the broad requirement for separate ledgers to consider the various balances of different forms of money that are held by parties in financial services mean that this is a relatively safe assumption to make as a starting point in our consideration of how interoperability would work upon the issuance of a CBDC.

ANNEX 3

RIKSBANK PILOT AND INTEROPERABILITY

Sweden's central bank, the Riksbank, has completed phase two technical tests as part of its pilot and investigation as to how a CBDC, or Sweden's e-krona, might function offline, whether the performance of the tested solution is adequate, and how banks and other payment service providers could be integrated into an e-krona network. This integration was tested in collaboration with banks Handelsbanken and Tietoevry, also known as the pilot participants.

The second phase of the e-krona pilot began in February 2021 with the aim to continue developing and testing the technical solution on which the e-krona pilot is based and to investigate a potential legal framework around the e-krona. The distribution of e-krona is based on a two-tier model where it is distributed from the Riksbank to the general public via approved participants (banks or PSPs) in an e-krona network. Participants order e-krona from the bank which are debited from their reserves in the Riksbank settlement system, storing it in their digital vaults.

The work has shown how a parallel network could be integrated with participants' internal systems and enable the distribution of, and transactions with, e-krona. The Riksbank tested the integration of the e-krona network with a POS terminal, and demonstrated it was possible to update the software on a single POS terminal to support payment processing separate from traditional card payments. This would require the loading of discrete software onto the POS terminal that would interact with both the store and customer participant nodes to effect a transaction between them.

According to the Riksbank research, the Riksbank would be responsible for any software used for POS terminals, 'the certification of the terminal suppliers and the security solution for the terminals' and would require the Riksbank to sign contracts and certify terminal suppliers.

This solution to provide interoperability with card payment infrastructure requires a significant investment of a central bank to the POS environment and we consider that this could significantly change the scope and role of a central bank in providing payment services to a market.

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