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Issuing a Wholesale Central Bank Digital Currency: Why and How

Although there are currently four retail central bank digital currencies in circulation, no central bank has yet issued the wholesale form of a central bank digital currency. There are good reasons to do so, however, and central banks have already conducted projects in this area. A wholesale central bank digital currency could be issued in different ways. This article presents two “polar” scenarios, with a restrained and an extensive use of the possibilities offered by recourse to distributed ledger technology. Their consequences for monetary policy are discussed, and some precautions for central banks that intend to launch a wholesale central bank digital currency are underlined.

A wholesale central bank digital currency (wCBDC) would be a form of central bank money that would be perfectly fungible with reserves, accessible only to a limited set of economic agents (at least those who currently have access to reserves, i.e. banks), and available in a distributed ledger technology (DLT) environment. These features distinguish wCBDC both from retail central bank digital currency (rCBDC),¹ which is accessible to the general public and is not necessarily supported by DLT, and from reserves, which are accessible only to banks, but not supported by DLT. The possibility of issuing a wCBDC has seldom been envisaged in the academic literature (however, see Pfister, 2019) and no wCBDC has yet been launched. Still, wCBDC has often been discussed by central bankers, especially in the recent past (see, e.g. Bowman, 2023; Jones 2023; Panetta 2021, 2022; Villeroy de Galhau, 2023), and central banks have conducted projects on wCBDC.

¹ Currently, rCBDCs circulate in the Bahamas, the Eastern Caribbean, Jamaica and Nigeria (Kosse and Mattei, 2023). Regarding the distinction between rCBDC and wCBDC, one can refer to Pfister (2019).

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Why issue a wCBDC?

This section first presents and discusses arguments against and in favour of wCBDC, before reviewing central banks’ projects related to wCBDC and the main lessons drawn from them.

Arguments against

A common argument against wCBDC is that it already exists, since reserves are central bank money in digital form that is available to banks for wholesale transactions, and therefore it would not need to be created (Bowman, 2023; Durfee et al., 2023; Panetta, 2021). However, central bankers who have positively envisaged the idea of issuing a wCBDC, as Jones (2023) and Villeroy de Galhau (2023), must have reasons to think that another form of reserves might need to be made available.

Another argument against wCBDC is that a bridge could be created between DLT platforms and central bank infrastructure, which would allow for settling the cash leg of transactions in central bank money without the need to launch a wCBDC. Two proposals in that direction have been made. They are both discussed in the framework of the New Technologies for Wholesale settlement – Contact Group (NTW-CG) established by the ECB (ECB, 2023), together with the Banque de France “full DLT” proposal (ECB-NTW-CG, 2023). The first proposal that avoids creating a wCBDC is the “trigger solution”, which was put forward by the Deutsche Bundesbank. It would be based on a technological bridge or interface between a conventional payment system and a DLT-based application. The second proposal has been suggested by the Banca d’Italia. It would use the existing Target Instant Payment

Settlement (TIPS) system and hashed timelock contracts (HTLC)² to synchronise the asset leg and the cash leg of transactions in tokenised assets. However, a coordination problem could arise if issuers and investors view the central bank's initiative to create a "bridge" as too timid, since this decision could easily be reversed. If this were the case, wCBDC might be essential for tokenisation to take hold, contrary to the view expressed by Durfee et al. (2023).

A further argument against is that the use of DLT would create risks and complexities for the central bank "because a shared ledger might allow central bank money to circulate on a platform that is not owned and operated by the central bank" (Bowman, 2023). However, this would not have to be the case (i.e. wCBDC could be designed to prevent such circulation). Furthermore, the project Helvetia Phase II demonstrated that it was both technically and, under Swiss law, legally feasible to issue wCBDC on a DLT platform operated and owned by a third party and even to delegate tasks related to wCBDC to the operator, provided that the central bank retains necessary wCBDC control and monitoring functions (BIS-SNB-SIX Group, 2022).

Arguments in favour

The main reason to issue a wCBDC would be to provide a perfectly safe and liquid settlement instrument that would be directly available in a DLT environment, thus preserving the anchoring role of central bank money (i.e. enabling the maintenance of parity between the different forms of money) in this environment (Pfister, 2019; Villeroy de Galhau, 2023). This would have two consequences:

First, it would increase financial stability, since other settlement instruments that are already available on DLT, such as stablecoins, bear credit and liquidity risk (Melachrinos and Pfister, 2021).³

Second, it would support the digitalisation of assets by allowing the straight-through processing of transactions in a DLT environment and explicitly demonstrating the central bank's support.

Other reasons to issue a wCBDC relate to "disintermediation" and "weaponisation".

2 A HTLC requires the beneficiary of a payment to acknowledge its receipt before a predetermined time or a preset deadline.

3 Stablecoins regulated, supervised, well-managed, and fully backed by central bank reserves would come very close to wCBDC, but it is doubtful that central banks would allow them, since they are likely to view such arrangements as tantamount to outsourcing the production of central bank money (Bindseil, 2023).

Disintermediation

The fact that wCBDC would not cause a loss of bank deposits, a so-called disintermediation, whereas rCBDC could (Pfister, 2019, 2022), while helping achieve objectives partly similar to those of rCBDC is one reason to consider issuing a wCBDC. This would notably be the case for cross-border payments, where interoperability between CBDCs could be arranged within different models (BIS-CPMI-IMF-WBG, 2022).

In particular, wCBDC could offer two major advantages for emerging and developing economies. The first one would be to remedy the drawbacks of correspondent banking by increasing the speed and lowering the cost of remittances, although other solutions such as the interlinking of fast payments systems could offer a similar result. The second advantage is that capital flow measures could be made more efficient (He et al., 2023). This could be achieved thanks to the automation of controls through recourse to smart contracts and to the organisation of these controls at the level of the CBDC architecture or that of the cross-border platform that connects the wCBDC rails.

Weaponisation

Another reason to issue a wCBDC relates to the weaponisation of money, or rather that of payment infrastructures, in particular the Swift messaging system. In the wake of war in Ukraine and the financial sanctions directed against Russia, more and more central banks are now envisaging a possible launch of a wCBDC in the coming years (Demertzis and Lipsky, 2023; Kosse and Mattei, 2023). This tends to show that issuing a wCBDC and making it interoperable with those of "friendly" economies is possibly envisaged in some countries as a way of evading potential sanctions.

Central banks' projects and main lessons drawn

Central banks have launched projects on the applicability of wCBDC for domestic payments, capital markets and cross-border payments (de Sèze, 2023).

Domestic payments have first been investigated.⁴ The idea was to assess the potential benefits of DLT technology to increase the efficiency of real-time gross settlement

4 Examples of early projects are: Project Stella by the ECB and the Bank of Japan in 2016, Project Jasper by the Bank of Canada in 2017, Project Ubin Phase 1 and Phase 2 by the Monetary Authority of Singapore in 2017, Project Khokha by the South Africa Reserve Bank (SARB) in 2018, and Project Inthanon Phase 1 by the Bank of Thailand in 2019.

(RTGS) systems widely used by central banks (BIS, 1997). Overall, the projects showed that it would be challenging for a DLT-based system to process domestic payments more efficiently than existing RTGS systems. However, wCBDC could increase financial system efficiency as a result of integration with the broader financial market infrastructure.

Regarding *capital market applications*, the results of projects were generally positive.⁵ However, a significant expansion of the scope of coverage of the ledger to include additional assets and the full trade and post-trade life cycle may be required to realise efficiency improvements. Also, instant gross settlement requires prefunding of the asset leg and the cash leg, which could require significant amounts of liquidity for settlement. On the other hand, the higher velocity of money allowed by DLT may reduce the need for liquidity, as well as counterparty, operational and market risks. Furthermore, as is already the case for RTGS systems, queuing arrangements could reduce the need for liquidity, although this would imply rejecting settlement risk at the periphery of the wCBDC platform, thus partly foregoing the potential security benefits of using central bank money for the final settlement of transactions.

The possibility of using wCBDC for *cross-border payments* is the area that has been most explored in recent years.⁶ It seems very promising, provided that central banks coordinate at the international level.

Central banks have so far mostly explored existing markets for which investments in proofs of concept were rather light. However, Jones (2023) notes that, other types of markets that stand to benefit from tokenisation are “greenfield markets that could develop rapidly by leveraging programmability and better informational transparency”. Examples he gives are those of nature-based markets like biodiversity or carbon credits, where underlying exposures are diverse, and data needs to be verifiable in real time to enhance trust. This could apply to “environmental, social and governance” (ESG) bonds, for which smart contracts could provide real-time information on the performances of the issuers on ESG grounds. This would allow both to adjust the yields and to help the market become more mature as investors could more easily compare performances. Of course, the DLT protocols that would enable such functionalities would have to be “environment-friendly”.

⁵ Early examples are Project Jasper Phase 3 by the Bank of Canada in 2018, Project Inthanon Phase 2 by the Bank of Thailand in 2019. See also Banque de France (2021).

⁶ Early examples are presented in Annex 6 of BIS-CPMI-IMF-WBG (2022).

How to issue a wCBDC?

The potential perimeter of the use of wCBDC, the consequences for monetary policy and precautions central banks should take are discussed in turn.

Perimeter

Should wCBDC circulate on a ledger (or several interconnected ledgers), together with other tokenised assets (deposits, securities and possibly also foreign currencies) or should it be used in all large-value transactions, instead of using deposited tokens or stablecoins?

The first possibility was initially formulated by McLaughlin (2021) and has been supported by a group of large U.S.-based financial corporations under the heading of the “Regulated Liabilities Network” (RLN), with the aim of enabling a financial system that is compliant with existing laws and regulations (The RLN, 2022). Applying this approach at a European level has also been supported by Villeroy de Galhau (2023). It would allow making settlements in different payment instruments, including wCBDC, when transacting in tokenised assets that are regulated.

By contrast, although this is not explicitly mentioned by the Bank for International Settlements, it seems that in the proposal that is put forward in its 2023 Annual Report (BIS, 2023), all transactions on the “unified ledger” would be settled in wCBDC. This would eliminate settlement risk, thus supporting financial stability, and eliminate any risk of “fragmentation” of the monetary system. However, it could also lead to a sharp increase in the demand for central bank money in the form of wCBDC, as clearing operations would disappear. On the other hand, the role of central bank money as the final means of settlement might be in question if participants in the unified ledger have the choice between using central bank money or not. From an operational perspective, it might also lead to higher volatility in demand for CBDC, thereby complicating the management of the monetary base by the central bank. However, monetary policy could still be implemented, in principle even in the extreme case in which there would be no demand for central bank money, although the central bank would then lose its seigniorage revenue and thus have to find alternative resources to cover its operating costs (Woodford, 2001).

Monetary policy consequences

The consequences of issuing wCBDC for the conduct of monetary policy are likely to be minimal as far as the monetary policy objective (price stability) and its trans-

mission mechanism are concerned. At most, by supporting tokenisation, wCBDC could contribute to slightly higher economic growth and productivity in the medium to long run, with positive effects on demand and consequences for inflation that are hard to predict, due to the opposite influences of demand and productivity on inflation (Pfister, 2023). However, the consequences for the monetary policy implementation framework could be more substantial. They are discussed below, in the context of two highly differentiated models, referred to as “reserves-on-ledger” and “central-bank-on-ledger”, with a restrained or an extensive use of the possibilities offered by recourse to DLT, respectively.

Consequences for the monetary policy implementation framework

Common features of both implementation models include the central bank and potentially all financial institutions participating on the wCBDC platform, and having an account with the central bank as a precondition for participation. Transactions would take place on a payment-versus-payment (PvP) basis, be validated through a consensus mechanism in which the central bank would not necessarily participate, although it would in all cases be entitled to block a transaction, and be settled “atomically”, thus eliminating settlement risk. Transfers between reserve accounts and wCBDC holdings would be immediate and could be free of charge, in order to eliminate any frictions and maintain the fungibility of the monetary base (cash plus reserves plus CBDC). The wCBDC could appear as an aggregate item in the balance sheet of the central bank.

The “reserves-on-ledger” model keeps the monetary policy instruments and procedures basically unchanged, using wCBDC mainly for “notary” purposes. The wCBDC platform, which would be fully owned and operated by the central banks, would thus appear as a mere extension of the existing central bank payment infrastructure (i.e. its RTGS system). In this model, wCBDC could only be created by transferring reserves onto the wCBDC platform and destroyed by converting wCBDC back to the reserve accounts. The wCBDC platform would operate only during central bank working hours. At the end of the day, there would be two possibilities: either wCBDC would remain “frozen” in the wCBDC platform, or it would be converted back into reserves. In the first case, wCBDC would have to be accounted for in the computation of reserve requirements if a required reserves system is in place. In the second case, either the central bank would automatically “sweep” all wCBDC onto central bank accounts (and the aggregate item “wCBDC” in the balance sheet of the central bank would be systematically void or would not

even appear), or the holders, who would be incentivised (e.g. if the wCBDC bears a zero-interest rate – see below), would realise the transfer.

The “central-bank-on-ledger” model aims to draw as much as possible on the offerings of the DLT, even if this might imply some amendments to the monetary policy instruments and procedures. In this model, wCBDC could be created directly by the central bank on the wCBDC platform, for instance by purchasing assets or by conducting refinancing operations on it. The wCBDC platform itself could be either operated and owned by the central bank or shared by the central bank and other stakeholders. Institutions (e.g., Fintechs or non-residents) could participate in the wCBDC platform, possibly without having an account with the central bank. In case a reserve requirement system is in place, wCBDC held by institutions that are subject to it could be considered as required reserves by priority and as excess reserves for the rest (Pfister, 2020a). The wCBDC platform would operate on a 24/7 basis. Possible consequences could be that an explicit market for intraday wCBDC might appear and that liquidity crises might occur when the central bank is closed. At some point, this could put pressure on the central bank to also operate 24/7.⁷ To the extent that reserves are remunerated at a non-zero interest rate, interest would then have to be paid at the same rate and same time as the payment of interest on reserves, in order to keep parity between wCBDC and reserves.

Of course, there could be many variants in between the “reserves-on-ledger” and the “central-bank-on-ledger” models. For instance, access could be enlarged and operating hours extended, starting from the “reserves-on-ledger” model.

The choice of the issuance model would have implications for the wCBDC remuneration. In the “reserves-on-ledger” model, wCBDC would not have to be remunerated, even if reserves are. This could obviously be the case if the central bank automatically “swept” wCBDC into banks’ accounts at the end of the day. In case it did not and reserves (including excess reserves) are remunerated, the lack of remuneration of wCBDC would give banks an incentive to convert their wCBDC back into reserves at any moment before the end of the day. However, for this incentive to work, interest rates on required and excess reserves would have to be positive or banks would have to need the reserves to fulfil their reserve requirement (assuming, which is reasonable, that the penalty for missing the reserve requirement is itself positive). This shows that,

⁷ For more on the possibility and the consequences of implementing a “real-time” monetary policy, see Pfister (2018).

in the “reserves-on-ledger” model, automatic “sweeping” by the central bank would most likely have to prevail when interest rates are negative. This notwithstanding, within the same model and to the extent that reserves are remunerated, interest could also be paid on wCBDC, through programmability, in case wCBDC would be “frozen” in the wCBDC platform at the end of the day, along the same modalities as in the “central-bank-on-ledger” model.

Finally, if both wCBDC and rCBDC are issued, and the central bank wishes to keep their circulations distinct, the remuneration of rCBDC and its possible individual holding limit would depend on the remuneration of wCBDC. In particular, in order to avoid that monetary policy counterparties hold rCBDC instead of wCBDC, if rCBDC bears a zero-interest rate, its individual holding would have to be limited when the policy rate is negative. For the same reason, the remuneration of rCBDC should be set below or equal to that of wCBDC when the policy rate is strictly positive.⁸ Of course, there could also be only one form of CBDC serving both as a rCBDC and wCBDC, but the risks of disintermediation by rCBDC would be higher, since wCBDC would have to bear the same interest rate as reserves to keep parity with them and interest rates are most of the time strictly positive (Pfister, 2019).

Precautions

Resilience refers to the ability to identify, protect against and recover from adverse shocks and other disruptive events. Due to their systemic role and to the reputation risk involved, wCBDC ecosystems should be secure (e.g. resist cyberattacks and fraud) and resilient to operational risks, such as loss of network communication, electrical outage, and natural disasters. In the case of cross-border transactions, resilience would also depend on arrangements used for interlinking CBDCs. The installation of a unified or regulated liabilities network or that of a “bridge” or the sharing of a common infrastructure at the international level could create concentration and a single point of failure risk.

The central bank’s reputation could also be seriously hurt in case of breaches of confidentiality. As exemplified in the projects carried out by the Banque de France, two main techniques, where transactions can be pseudonymous and the central bank has more visibility over transactions, can be implemented separately or in combination (Banque de France, 2021). The first technique is data encryption, where specific cryptographic keys are distributed in order to determine which participants can access which data and are required to decrypt and read these data. The sec-

⁸ On the remuneration of rCBDC and its consequences for monetary policy, see Pfister (2020b, 2023).

ond technique is data segregation, which implies that data is located on specific nodes of the blockchain. As a result, the transactions are stored only in relevant databases and made accessible to specific node owners, for instance the parties to a transaction. Overall, on the basis of the Banque de France experiments, it would appear that the use of data encryption on a public blockchain could ensure more confidentiality, while keeping traceability, albeit at a higher cost than using data segregation on a private blockchain or on a standard system.

Jurisdictions participating in a project to make cross-border payments using wCBDCs should at least agree on common standards making their wCBDC systems compatible.⁹ Provided governance issues are overcome, a higher degree of integration between wCBDC systems could be achieved by interlinking them through a common infrastructure, or even by creating a single wCBDC system where cross-border payments are settled by participating jurisdictions and multiple currencies are exchanged (BIS-CPMI-IMF-WBG, 2022). In all cases, coordination should preferably take place at an early stage, as making existing payment infrastructures compatible or interlinking them is costly and takes time, to the point that building entirely new infrastructures for that goal can be more economical and expeditious. At the same time, coordinating can be ambiguous since it can unwillingly serve the interests of a foreign country which has taken a technological lead. For instance, the People’s Bank of China (PBoC) has been actively exploring the possibilities of a cross-border use of CBDCs in recent years (BIS Innovation Hub, 2022). The PBoC has also been partnering in the work of the G20 on CBDC interoperability for cross-border payments (FSB, 2023). Through its participation in international projects and groups, China could play a disproportionate role, in comparison with the one played by its currency on the international stage, in the definition of international standards for CBDC (Pfister and de Sèze, 2023).

⁹ Compatibility is the minimal form of interoperability that presupposes the use of common standards for interacting, without the need for a common or a shared infrastructure.

References

- Bank for International Settlements (1997), Real-time gross settlement systems, Report prepared by the Committee on Payment and Settlement Systems of the central banks of the Group of Ten countries.
- Bank for International Settlements (2023), Blueprint for the future monetary system: improving the old, enabling the new, *BIS Annual Economic Report*, chapter III, 85-116.
- Bank for International Settlements, Committee for Payments and Market Infrastructures, International Monetary Fund and World Bank Group (2022), Options for Access to and Interoperability of CBDCs for Cross-Border Payments, Report to the G20.

Bank for International Settlements, Swiss National Bank, SIX Group (2022), Project Helvetia Phase II – Settling tokenised assets in wholesale CBDC.

Bank for International Settlements Innovation Hub (2022), Project mBridge: Connecting economies through CBDC.

Banque de France (2021), Wholesale Central Bank Digital Currency Experiments with the Banque de France.

Bindseil, U. (2023), The Implications of New Forms of Money for Financial Stability: Central Bank Digital Currencies and Stablecoins, *Revue d'économie financière*, 149, 207-224.

Bowman, M. (2023, 17 October), Responsible Innovation in Money and Payments, Speech at Roundtable on Central Bank Digital Currency, Harvard Law School Program on International Financial Systems, Washington D.C.

Demertzis, M. and J. Lipsky (2023), The Geopolitics of Central Bank Digital Currencies, *Intereconomics*, 58(4), 173-177, <https://www.intereconomics.eu/contents/year/2023/number/4/article/the-geopolitics-of-central-bank-digital-currencies.html> (11 January 2024).

De Sèze, N. (2023), Central Bank Digital Currencies: A Perspective on Initiatives and Experiments around the World, *Revue d'économie financière*, 149, 91-105.

Durfee J., J. L. Maniff and P. Slattery (2023, 8 September), Examining CBDC and Wholesale Payments, *FEDS Notes*.

European Central Bank, New Technologies for Wholesale settlement – Contact Group (2023), Scope of Eurosystem exploratory work and envisioned timeline, Presentation at NTW - CG meeting of 18 July 2023, Agenda item 1.

Financial Stability Board (2023), G20 Roadmap for Enhancing Cross-border payments, Priority actions for achieving the G20 targets.

He, D., A. Kokenyne, T. Mancini Griffoli, M. Miccoli, T. T. Olafsson, G. Söderberg and H. Tourpe (2023), Capital Flow Management Measures in the Digital Age (2): Design Choices for Central Bank Digital Currency, *IMF FinTech Notes*, 009.

Jones, B. (2023, 16 October), A Tokenised Future for the Australian Financial System, Speech at the Australian Financial Review Cryptocurrency Summit, Sydney.

Kosse, A. and I. Mattei (2023), Making Headway - Results of the 2022 BIS Survey on Central Bank Digital Currencies and Crypto, *BIS Papers*, 136.

McLaughlin, T. (2021), The Regulated Internet of Value, *Citi Treasury and Trade Solutions*.

Melachrinos, A. and C. Pfister (2021), Stablecoins: A Brave New World?, *Stanford Journal of Blockchain Law and Policy*, 4(2), 113-138.

Panetta, F. (2021, 18 November), The ECB's Case for Central Bank Digital Currencies, *Financial Times*.

Panetta, F. (2022, 26 September), Demystifying wholesale central bank digital currency, Speech at the Symposium on "Payments and Securities Settlement in Europe – today and tomorrow" hosted by the Deutsche Bundesbank, Frankfurt am Main.

Pfister, C. (2018), (Real-)Time Is Money, *Banque de France Working Paper*, 675.

Pfister, C. (2019), Central Bank Digital Currency: One, Two or None?, *Banque de France Working Paper*, 732.

Pfister, C. (2020a), Central Bank Digital Currency, Banque de France, https://publications.banque-france.fr/sites/default/files/media/2020/02/04/central-bank-digital-currency_cbdc_2020_02_03.pdf (19 December 2023).

Pfister, C. (2020b), Retail CBDC Remuneration: The Sign Matters, *SUERF Policy Note*, 205.

Pfister, C. (2021), Is the 100% Reserve Reform Finally Getting Topical?, *SUERF Policy Note*, 220.

Pfister, C. (2023), Monetary Policy and Digital Currencies, *Revue d'économie financière*, 149, 1-14.

Pfister, C. and N. de Sèze (2023), Who needs an e-Yuan?, *SUERF Policy Brief*, 716.

The Regulated Liabilities Network (2023), The Regulated Liabilities Network: Digital Sovereign Currency, Whitepaper, 15 November.

Villeroy de Galhau, F. (2023, 3 October), Wholesale CBDC: as decisive as Retail CBDC, and actively experimenting, Speech at the conference "Unveiling the potential of wholesale CBDC: what insights and prospects?", Paris.

Woodford, M. (2001), Monetary Policy in the Information Economy, in *Economic Policy for the Information Economy*, Jackson Hole Economic Policy Symposium Proceedings, Federal Reserve Bank of Kansas City, 297-370.