



FINTECH

NOTES

Implications of Central Bank Digital Currencies for Monetary Policy Transmission

Mitali Das, Tommaso Mancini Griffoli, Fumitaka Nakamura, Julia Otten, Gabriel Soderberg, Juan Sole, and Brandon Tan

FINTECH NOTE

Implications of Central Bank Digital Currencies for Monetary Policy Transmission

Mitali Das, Tommaso Mancini Griffoli, Fumitaka Nakamura, Julia Otten,
Gabriel Soderberg, Juan Sole, and Brandon Tan

September 2023

©2023 International Monetary Fund

Implications of Central Bank Digital Currencies for Monetary Policy Transmission

Note 2023/010

Prepared by Mitali Das, Tommaso Mancini Griffoli, Fumitaka Nakamura, Julia Otten, Gabriel Soderberg, Juan Sole, and Brandon Tan*

Names: Das, Mitali, author. | Mancini-Griffoli, Tommaso, author. | Nakamura, Fumitaka, author. | Otten, Julia, author. | Söderberg, Gabriel, 1978- , author. | Sole, Juan, author. | Tan, Brandon Joel, author. | International Monetary Fund, publisher.

Title: Implications of central bank digital currencies for monetary policy transition / Mitali Das, Tommaso Mancini Griffoli, Fumitaka Nakamura, Julia Otten, Gabriel Soderberg, Juan Sole, Brandon Tan.

Other titles: Implications of CBDCs for monetary policy transition. | Fintech notes.

Description: Washington, DC : International Monetary Fund, 2023. | NOTE/2023/010. | Includes bibliographical references.

Identifiers: ISBN:

9798400252792 (paper)

9798400253126 (ePub)

9798400253157 (WebPDF)

Subjects: LCSH: Monetary policy—Technological innovations. | Finance—Technological innovations.

Classification: HG230.3.D3 2023

DISCLAIMER: Fintech Notes offer practical advice from IMF staff members to policymakers on important issues. The views expressed in Fintech Notes are those of the author(s) and do not necessarily represent the views of the IMF, its Executive Board, or IMF management.

RECOMMENDED CITATION: Das, Mitali, Tommaso Mancini Griffoli, Fumitaka Nakamura, Julia Otten, Gabriel Soderberg, Juan Sole, and Brandon Tan. 2023. "Implications of Central Bank Digital Currencies for Monetary Policy Transmission." IMF Fintech Note 2023/010, International Monetary Fund, Washington, DC.

Publication orders may be placed online, by fax, or through the mail:

International Monetary Fund, Publications Services

P.O. Box 92780, Washington, DC 20090, USA

Tel.: (202) 623-7430 Fax: (202) 623-7201

E-mail: publications@imf.org

bookstore.IMF.org

elibrary.IMF.org

*Brandon Tan and Mitali Das are the lead authors of this Fintech Note.

Contents

I. Introduction and Summary of Findings	2
II. Conceptual Framework	5
III. Design Features of CBDCs	6
IV. Impact on the Macroeconomic Environment	8
V. Tightness of Financial Conditions	13
VI. Transmission Channels of Monetary Policy	16
VII. Further Considerations on Operations, Regimes, and CBDC Designs	20
References	26

TABLES AND FIGURES

Figure 1. Conceptual Framework.....	5
Figure 2. Features of CBDCs.....	6
Figure 3. Impact of CBDCs on the Macroeconomic Environment	8
Figure 4. Static Partial Equilibrium Model–Based Analysis of Bank Disintermediation	10
Figure 5. Dynamic General Equilibrium Model–Based Analysis of Bank Disintermediation	11
Figure 6. Heterogeneous Households and Financial Inclusion	12
Figure 7: Level Effects on the Tightness of Financial Conditions	13
Figure 8: Main Channels of Monetary Policy Transmission.....	16
Figure 9: Impact on Transmission Channels of Monetary Policy.....	17
Figure 10: Interest Rate–Based Operational Frameworks	20
Figure 11: Monetary Policy Regimes	23

I. Introduction and Summary of Findings

The level of global interest in central bank digital currencies (CBDCs) is unprecedented. According to a 2022 survey from the Bank of International Settlements (BIS), 93 percent of central banks are exploring CBDCs, and 58 percent report that they are likely to or might possibly issue a retail CBDC in the short or medium term (Kosse and Mattei 2023). Indeed, more than 100 countries are exploring retail CBDC issuance. Several central banks have already launched pilots or even issued a CBDC.

The implications of CBDCs for monetary policy transmission is a topic of significant interest for IMF member countries. Monetary policy transmission plays a critical role in the overall functioning of an economy because it determines how changes in policy measures and interest rates implemented by central banks affect key economic variables such as investment, consumption, inflation, and employment. The proposed foundational principles for CBDCs stipulate that CBDC designs should align with central bank mandates to achieve price stability (low and stable inflation) and to help manage economic fluctuations (BIS, 2020).

CBDCs could bring both opportunities and challenges to monetary policy transmission. For some countries, enhancing monetary policy effectiveness is an important motivation for CBDC exploration; for others, motivations include modernizing the financial system, reducing future risks associated with rapid digitalization, and lowering the costs of person-to-person monetary transfers. At the same time, some countries view the potential for CBDCs to weaken monetary policy transmission as a risk.

This note provides a conceptual analysis of the implications of CBDCs for monetary policy. In particular, it focuses on the implications of a retail CBDC, which would be available to the general public and is the scale of access that most central banks are considering.¹ The baseline design considered in this paper is a non-remunerated CBDC with possible caps on individual holdings and accessible only in the issuing jurisdiction (the most common design among central banks adopting or piloting CBDCs thus far). The issuance of retail CBDCs can impact key parts of countries' macroeconomic environment. In turn, these changes in the macroeconomic environment may affect both the tightness of financial conditions (upon issuance) and the transmission of monetary policy through the main channels: the interest rate channel, bank lending channel, asset price channel, and exchange rate channel.

CBDCs may have an impact on countries' macroeconomic environment in several ways. CBDCs offer a safe store of value and efficient means of payment, which can increase competition for deposit funding, increase banks' share of wholesale funding, and lower bank profits. CBDCs also have the potential to bolster financial inclusion to the extent that they can address the barriers to inclusion for the unbanked. In dollarized or euroized economies, or in economies where the adoption of crypto assets is widespread, the introduction of CBDCs could also encourage a greater use of the local currency,

¹ BIS survey data show that central banks are particularly interested in retail CBDCs: all central banks conducting work on CBDCs either look at both wholesale and retail CBDCs or focus solely on a retail CBDC.

particularly in lieu of other forms of digital money denominated in foreign currency or crypto assets (that is, “de-dollarization/de-cryptoization”).

Changes in the macroeconomic environment could lead to either a tightening or a loosening of financial conditions. Increased competition for bank deposit funding, increased wholesale funding, and lower bank profits would tighten financial conditions. On the other hand, increased financial inclusion could loosen financial conditions. Decreasing dollarization/cryptoization has an ambiguous impact on financial conditions.

The central bank should closely monitor the effects of CBDC issuance on the macroeconomic environment so that it can react to maintain a given level of financial conditions, if needed. As it can with any other economic shock, the central bank can choose to adjust its policy instruments to achieve its objectives as the macroeconomic environment evolves. Given that the introduction of CBDCs could either tighten or loosen financial conditions, keeping a close watch over the macroeconomic environment related to monetary policy would be warranted. The central bank can offset the impact if necessary.

CBDCs have the potential to strengthen the channels of monetary policy transmission. De-dollarization/de-cryptoization is likely to amplify all transmission channels. Increased competition for bank deposit funding could strengthen the interest rate and bank lending channels. Increased wholesale funding would strengthen the bank lending channel. Higher levels of financial inclusion can strengthen the interest rate and asset price channels. There are unlikely to be additional effects on the exchange rate channel.

In general, the effects of CBDCs on monetary policy transmission are expected to be relatively small in normal times; however, these effects can be more significant in an environment with low interest rates or financial market stress. The strengthening of transmission channels via increased competition and wholesale funding relies on a significant substitution of bank deposits for CBDCs, which may not materialize. The impact of financial inclusion is also uncertain and constrained by the relatively small share in overall savings and lending of the financially excluded population, particularly in more advanced economies. The impact of de-dollarization/de-cryptoization may also be small if CBDCs do not effectively increase the attractiveness of local currency. Furthermore, most central banks exploring CBDCs are considering precautionary design features such as holding and transaction limits and tiering of interest rates. Such features will limit the potential flight from retail deposits or cash into CBDCs and are thus likely to ensure that the CBDC does not have a significant impact on monetary policy transmission. However, when policy rates are low and in times of financial market stress, the impact of CBDC on monetary transmission could be more significant. A non-remunerated CBDC could entrench the zero lower bound for interest rates. And when there is financial market stress, there is greater risk of a flight to safety from retail bank deposits into CBDCs.

The impact of CBDCs on monetary policy transmission will depend on both the design features of the CBDC and characteristics of the economy. This note is intended to give central banks a general framework to understand the likely impacts of CBDCs on monetary transmission. Practitioners can apply

the principles of this framework to the specific characteristics of their economies when considering the potential impact of CBDCs on monetary policy transmission. Doing so will also allow them to incorporate such considerations into the design of the CBDC.

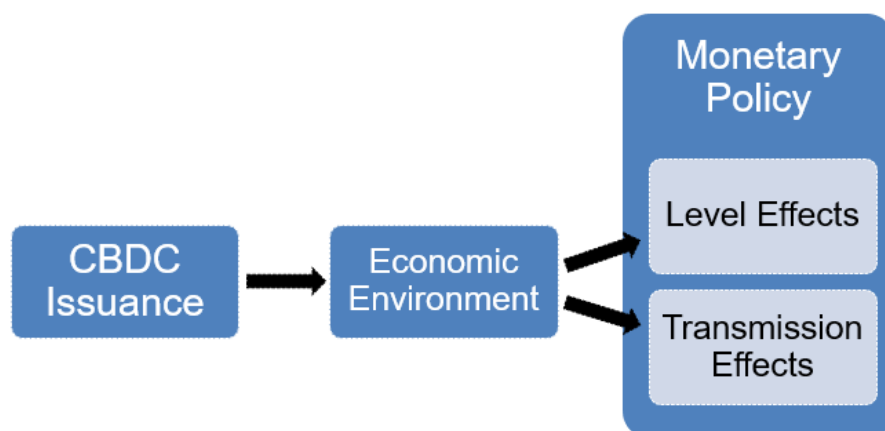
In the long run, CBDCs could help maintain the convertibility between private money and central bank money in jurisdictions where cash is becoming increasingly marginalized. The loss of such convertibility has uncertain implications for the basic trust in the monetary system. CBDCs could therefore potentially serve as a “monetary anchor” for the monetary system—and, by extension, also maintain the ability of the central bank to conduct monetary policy (Panetta, 2021).

The remainder of the note is organized as follows. Section II lays out a conceptual framework to analyze the implications of CBDCs on monetary policy transmission. Section III presents the baseline CBDC design considered in the analysis. Section IV considers the impact of CBDC on a country’s macroeconomic environment. Section V considers the CBDC’s impact on financial conditions. Section VI considers the CBDC’s impact on the transmission channels of monetary policy. Section VII discusses monetary policy operations, other monetary policy regimes, remunerated CBDC, and foreign CBDC.

II. Conceptual Framework

This section presents a conceptual framework for the analysis in this note, which also serves as a roadmap (Figure 1). In the framework, the implications of CBDC issuance on monetary policy are intermediated by its impact on key parts of the macroeconomic environment. The framework also makes a distinction between “level effects”—whereby the introduction of CBDCs could tighten or loosen financial conditions as a shock—and “transmission effects,” whereby CBDCs change the impact of a given monetary policy shock on output, employment, and inflation.

Figure 1. Conceptual Framework



Source: Authors.

Depending on how it is designed, the issuance of a CBDC could affect a country’s macroeconomic environment. A CBDC offers a safe store of value and efficient means of payment, which can increase competition for deposit funding, increase banks’ share of wholesale funding, and lower bank profits. CBDC also has the potential to bolster financial inclusion to the extent that it can address the barriers to inclusion for the unbanked. A CBDC could also increase the attractiveness of local currency and help reduce dollarization/cryptoization.

The impact on the macroeconomic environment in turn affects monetary policy. First, upon CBDC issuance, there will be a tightening or loosening of financial conditions from the changes in the macroeconomic environment (“level effects”). Second, changes in the macroeconomic environment can potentially strengthen or weaken the transmission channels of monetary policy (“transmission effects”). Transmission is said to be stronger (weaker) if a given change in the monetary policy stance has larger (smaller) effects on macroeconomic variables in an economy with CBDCs than in an economy without them, all else being equal. The “level effects” apply only during the CBDC’s introduction, whereas the “transmission effects” remain even after the CBDC has been fully integrated into the economy.

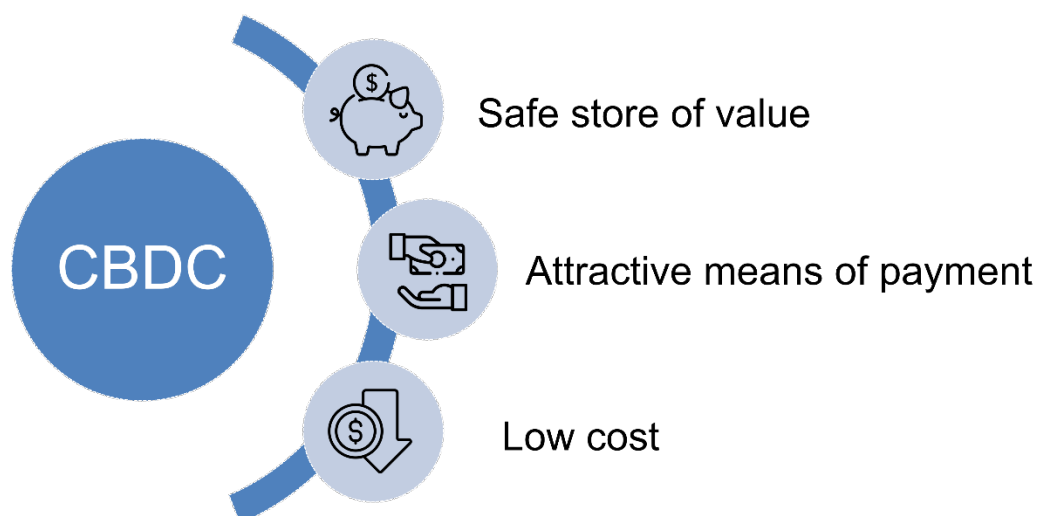
III. Design Features of CBDCs

This section outlines the baseline design and features of CBDC considered in this note: a non-remunerated retail CBDC that is accessible only domestically.

This note focuses on CBDCs designed for retail use, or retail CBDCs, which would be available to the general public. Central banks are considering both retail and wholesale CBDCs. Wholesale CBDCs refer to digital forms of central bank reserves whose access is limited to banks and other financial institutions. Retail CBDCs refer to digital forms of central bank money that can be widely held and used by individuals.

CBDCs have the potential to improve the payments and financial system by providing a new form of digital money with the following features (Figure 2):

Figure 2. Features of CBDCs



Source: Authors.

Note: CBDC = central bank digital currency.

- **CBDCs offer a safe store of value.** Unlike bank deposits and other liabilities of private financial institutions which are subject to credit and liquidity risk and the possibility of bank failures, CBDC would not carry such risks. As a direct liability of the central bank, CBDCs would be as safe and risk-free as physical cash.^{2,3}
- **CBDCs could provide an attractive means of payment** for use in person-to-person, person-to-business, and business-to-business transactions. Additionally, as an electronic means of payment, CBDCs would be on par with fast-payment solutions in overcoming the limitations

² While CBDCs are a safe store of value, as with cash, the level of inflation could decrease their purchasing power.

³ Caps on individual holdings of CBDC would limit its potential as a savings vehicle.

associated with cash use, such as the need to meet in person and to rely on networks of distribution such as ATMs, which may be particularly difficult in remote locations. Add-on features such as offline payments and programmability, which are being explored, would further enhance CBDCs' attractiveness for payments.

- **CBDCs could lower costs.** CBDCs could be offered through digital wallets on mobile devices, reducing the costs associated with maintaining physical bank accounts and transaction fees. Issuing and managing cash is expensive,⁴ with costs falling on banks, firms, and households. CBDCs may also reduce the price of cross-border (and potentially domestic) payments by reducing intermediaries in the normal transaction chain via closer connection or direct access to central bank settlement accounts.⁵ Transactions could be settled by directly transferring claims on the central bank's balance sheet. Although introducing and maintaining CBDCs would probably entail substantial fixed costs, marginal operational costs would likely be low.

The degree of adoption of CBDCs and their effect on the economy will ultimately depend on their design. Central banks are weighing the aforementioned benefits against the potential risks—in particular, the risk of banking disintermediation. They are therefore consciously exploring designs that would ensure that CBDC adoption would not create potentially large adverse effects on the economy. CBDCs specifically designed with this in mind will therefore be the focus of this note.

Most jurisdictions are considering issuing a non-remunerated CBDC, which is the focus of this paper. All CBDCs that have been launched or piloted thus far are non-remunerated, which is beneficial in limiting deposit migration. The monetary policy implications of remunerated CBDC will be discussed as an extension in Section VII.

Central banks are considering CBDC designs that cap individual holdings at a predefined maximum. The motivation is to limit the magnitude of the potential flight from retail bank deposits into CBDCs, which has implications for monetary policy. Effective limits on holdings would preclude large-scale adoption of CBDCs and, for instance, make digital bank runs into CBDCs impossible.⁶

This note mainly considers a CBDC that is legally accessible only in the issuing jurisdiction. The legal usage of a CBDC can be either restricted to the jurisdiction in which it is issued or opened to cross-border payments. Central banks that are currently in the process of launching or piloting CBDCs have largely focused on usage only in the issuing jurisdiction, even though featuring an international dimension in the design of CBDC could also be an important consideration.

⁴ Hasan, De Renzis, and Schmiedel (2013) estimate the cost to be 0.5 percent of GDP for the euro area, similar to the cost in Canada (Kosse and others 2017) and Uruguay (Alvez, Lluberas, and Ponce 2018). Even higher costs have been estimated in Albania (1.5 percent of GDP) and Guyana (2.6 percent of GDP; Banka 2018).

⁵ If a CBDC introduces competition in a monopolistic payment system, then overall costs could also be reduced.

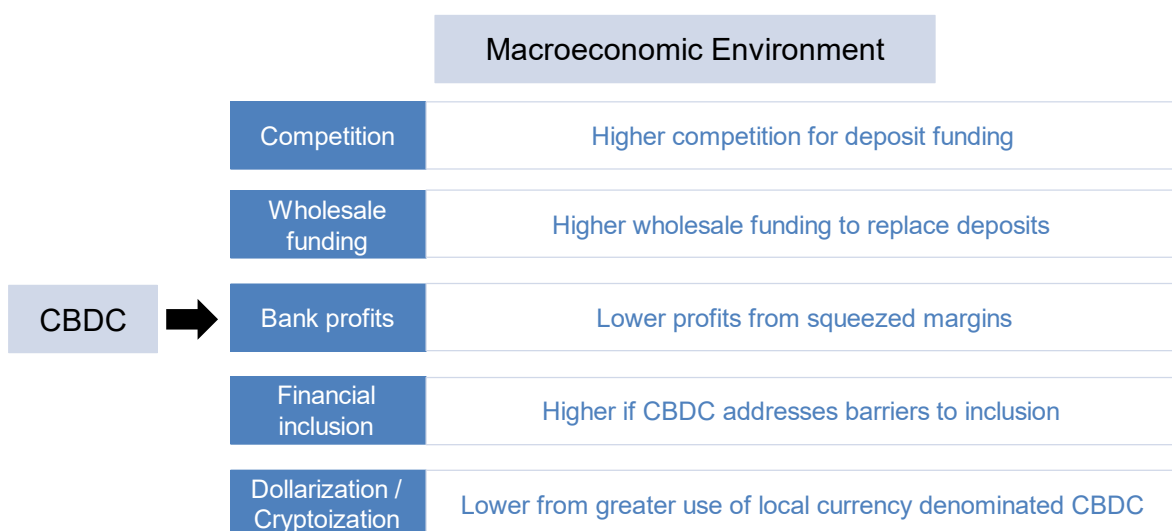
⁶ To promote financial inclusion, some central banks are considering so-called tiered digital wallets; wallets with higher caps would require more extensive customer identification (Bindseil 2020).

IV. Impact on the Macroeconomic Environment

This section provides an analysis of the impact of CBDCs on key parts of the macroeconomic environment that are relevant for monetary policy (Figure 3).

The baseline analysis is anchored in an inflation target monetary policy regime.⁷ In an inflation target framework, monetary authorities commit to maintaining inflation at a preannounced level or band. The main policy instrument is the policy interest rate, and monetary policy decisions are primarily guided by the deviation of forecasted inflation from its target level.⁸

Figure 3. Impact of CBDCs on the Macroeconomic Environment



Source: Authors.

Note: CBDC = central bank digital currency.

- CBDCs could raise competition for bank deposit funding.** By virtue of offering a safe store of value and an efficient means of payment, deposits may leave banks in favor of the CBDC, leading to a decrease in deposit funding available to banks (Bindseil 2020; Mancini Griffoli and others 2018).⁹ The magnitude of this impact depends on the extent to which the CBDC is an

⁷ Section VII also considers other monetary regimes.

⁸ Experience with the inflation target framework is relatively recent among the emerging markets, and they have had varying degrees of success (see Brandao Marques and others 2020).

⁹ This note focuses on the case of monopolistic competition in the banking sector as banks have some degree of market power in most countries.

attractive substitute for deposits.^{10, 11} Caps on individual holdings will also limit switching from deposits to CBDCs.

- **CBDCs could increase banks' share of wholesale funding.** To the extent that there is an outflow of deposits to CBDCs, banks could replace deposit shortfalls with wholesale funding.¹²
- **CBDCs could lower bank profits.** If banks raise deposit interest rates to compete with CBDCs or if funding costs increase from a shift toward wholesale funding, then bank profits will decrease to the extent that higher costs cannot be entirely passed through to higher lending rates.¹³
- **CBDCs could bolster financial inclusion.** Although not a silver bullet, CBDCs present opportunities for improving financial inclusion and expanding access to financial services for the unbanked (Lannquist and Tan 2023). CBDCs may serve as an initial entry point to a digital financial account that leads to the opening of bank accounts and credit access, especially when banks distribute CBDC in a two-tier system (Tan 2023b).¹⁴ The magnitude of effects depends on the extent to which a CBDC addresses the barriers to financial inclusion in a given country.
- **CBDCs could help de-dollarization or counter "cryptoization."** In dollarized or euroized economies, the introduction of a CBDC could encourage a greater use of the local currency by making it a more attractive means of payment. In particular, with the rise of other forms of digital money denominated in foreign currency (such as stablecoins), a CBDC can help prevent the local currency from being supplanted. However, a CBDC would not address deeper issues driving currency substitution related to a country's monetary policy framework and central bank credibility.

The impact of CBDCs on bank competition, wholesale funding, and profits is connected to the degree of bank disintermediation from CBDCs.¹⁵ In a static partial equilibrium model, the introduction of CBDCs draws deposits away from banks, leading to an upward shift in the deposit supply curve (Figure

¹⁰ The attractiveness of CBDCs relative to that of deposits would likely depend on the following design features: perceived safety, ease of access, convenience, technological innovation (such as programmability), cost of use, and privacy and anonymity. Merchant acceptance of CBDCs is also critical (see Tan 2023a).

¹¹ The impact will be greater on banks that rely more on deposit funding. As a result, this could potentially lead to differential effects across jurisdictions where banks have varying funding structures.

¹² The size of banks, the structure of the economy, and public acceptance are factors affecting the extent to which CBDCs could increase banks' share of wholesale funding.

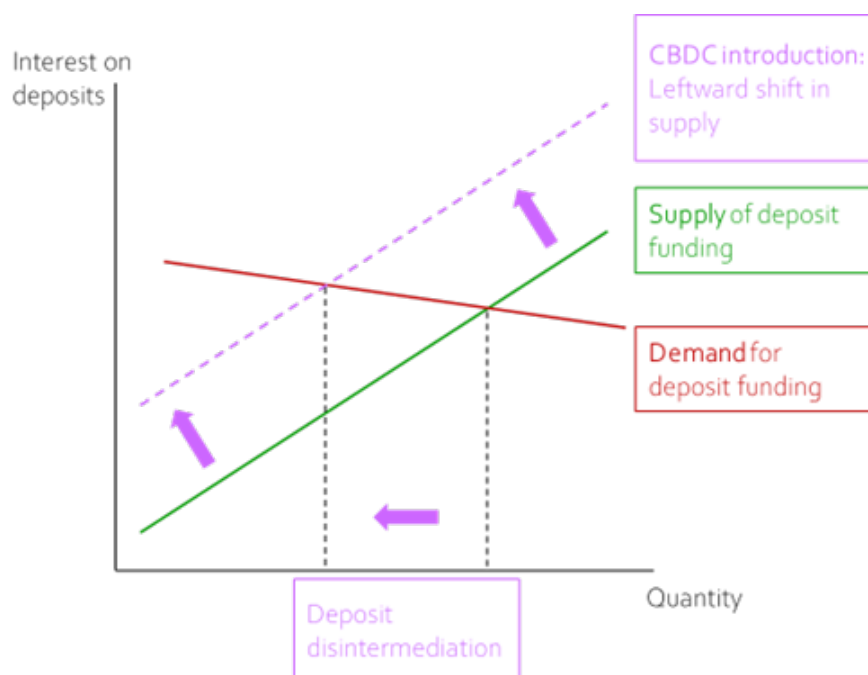
¹³ Although CBDC issuance will likely decrease bank profits through the channels described above, it could potentially have an offsetting positive impact on profitability in several other respects (Ahnert and others 2022). For instance, CBDCs could increase operational efficiency in the financial system, particularly in terms of payment processing and money transfers. Furthermore, greater financial inclusion would imply that more agents would be in the formal banking system, which could provide banks with new customers and new opportunities for lending and other services. On net, however, the effect is likely to be negative.

¹⁴ The account and transaction history in CBDC may be sent to credit providers or other financial product/service providers in place of collateral or more formal credit history for individuals and entities lacking them. In this way, it serves as an alternative data source for credit underwriting, enabling greater access to credit or other products/services needing financial data about a person or business. Ouyang (2021) shows that the use of Alipay in China for digital payments increases credit provision to its underserved users.

¹⁵ If a CBDC only replaces demand for cash, then there will be no impact on monetary policy via bank disintermediation.

4).¹⁶ Banks counteract some of the impact on their deposit bases by raising deposit interest rates, moving along the demand for deposit funding curve, but there is a decrease in total deposits.¹⁷ The reduction in deposits is greater if the CBDC is more attractive (a greater leftward shift of supply). When banks have more market power (reflected in the steepness of the demand for deposit funding curve), they can better insulate their loan volume, while banks with little market power adjust more aggressively in quantity, exhibiting a larger contraction in deposit and loan volume.

Figure 4. Static Partial Equilibrium Model–Based Analysis of Bank Disintermediation



Source: Authors, adapted from Mancini Griffoli and others (2018).¹⁸

Note: CBDC = central bank digital currency.

The introduction of a non-remunerated CBDC may not necessarily lead to a significant reduction in deposit supply—that is, the leftward shift in the supply of deposit funding curve may not be substantial. According to Li (2023), demand for a CBDC is largely determined by the degree to which it is remunerated, hence demand for existing unremunerated “e-money” (for example, in the United Kingdom and the European Union) has been low (BIS 2021). At the same time, CBDCs will be as safe as cash and might offer greater efficiency, hence possibly generating greater demand. So far, consumer adoption of non-remunerated CBDCs in countries that have launched them has been slow and limited. The reduction in deposits could be larger if the CBDC offers interest (a greater leftward shift of supply). Although some

¹⁶ The reaction from the issuance of CBDC could be different depending on the type of the deposits. For instance, households may be covered by deposit insurance, reducing their motives to convert deposits into CBDCs compared to firms. On the other hand, firms are more sensitive to interest rates than households, which means that the attractiveness of CBDCs to firms might be somewhat offset if the CBDC is non-remunerated.

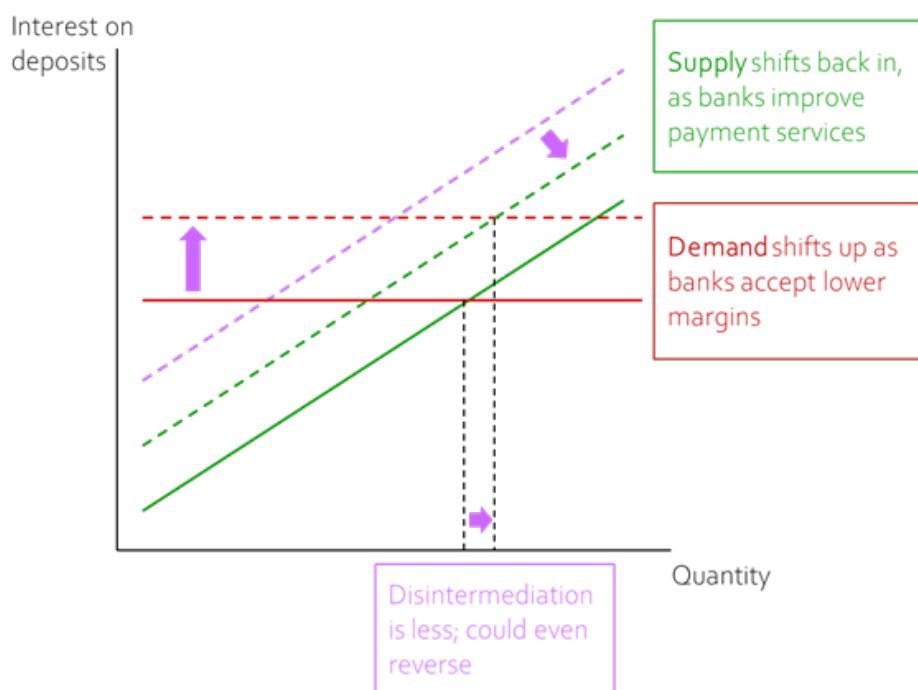
¹⁷ Banks could also respond by offering more and better complementary financial services.

¹⁸ See Agur, Ari, and Dell’Ariccia (2022) for a formalized version of this model.

literature provides an estimate of the magnitude of disintermediation, quantifying the potential impact is, in general, difficult, and the uncertainty is high.¹⁹

In a general equilibrium model where banks respond to the competitive pressures from CBDCs by accepting lower margins, the decrease in deposit quantities will be even smaller or could even turn positive (Figure 5).²⁰ The demand for deposit funding curve shifts upward as banks accept lower margins. As a result, the equilibrium quantity of deposits increases.

Figure 5. Dynamic General Equilibrium Model–Based Analysis of Bank Disintermediation



Source: Authors, adapted from Mancini Griffoli and others (2018).

Note: CBDC = central bank digital currency.

The central bank can act to limit the decline in bank deposits. The central bank can set or lower caps on individual CBDC holdings or discourage (such as through fees) convertibility from bank deposits to CBDCs. In addition, the central bank could lend the funds diverted from deposits back to banks.

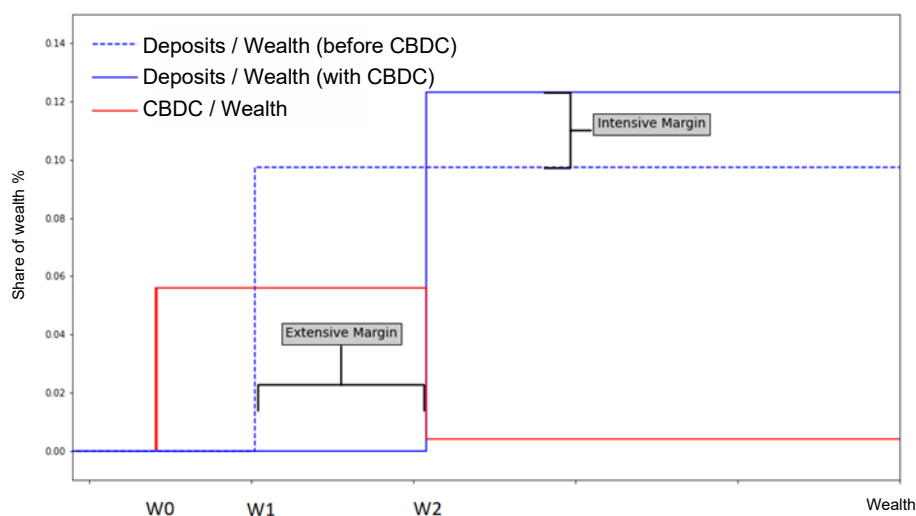
In a model with heterogeneous households, a CBDC increases financial inclusion by providing the unbanked access to the CBDC (Figure 6; see Chang and others 2023; Tan 2023b). Before CBDC issuance, the unbanked poor (wealth below W_1) hold only cash while the rich (wealth above W_1) hold

¹⁹ According to the results obtained from a static partial equilibrium model, the estimated change in deposits ranges from –10 percent for the UK (Chiu and Hill 2018) to –0.1 percent for Portugal (Canhoto 2004). Also, the changes in deposits rates are +17 basis points for the UK and +25 basis points for Portugal. It assumes a liquidity value of the CBDC of 50 basis points (which represents a possible lower bound to negative rates before deposits move to cash) and elasticities of deposit demand and supply to interest rate movements.

²⁰ Chang and others (2023), Chiu and others (2023), and Andolfatto (2021) show that it is possible for CBDCs to increase deposit quantities under imperfect competition in the banking sector.

cash and deposits. After CBDC issuance, the very poor (wealth below W_0) remain holding only cash, the middle class (wealth between W_0 and W_2) hold cash and CBDCs, and the very rich hold cash, CBDCs, and deposits (wealth above W_2). Financial inclusion improves as some unbanked poor households (wealth between W_0 and W_1) gain access to the CBDC. The disintermediation impact is composed of the extensive margin loss of deposits from those who switch from deposits to the CBDC (wealth between W_1 and W_2) and the intensive margin gain in deposits by those who continue to hold deposits because of higher deposit interest rates (wealth above W_2).

Figure 6. Heterogeneous Households and Financial Inclusion



Source: Authors and adapted from Chang and others (2023).

The potential margin for gains in financial inclusion is large, particularly in developing countries.

Globally, 1.4 billion adults (24 percent of adults) still lack access to a financial account.²¹ Women, the poor, the young, rural residents, and those outside the workforce all continue to have lower account ownership rates on average.²² Tan (2023b) finds that the financial inclusion impact of CBDCs can be particularly large in developing countries with large unbanked populations (intuitively, a large density of households between W_0 and W_1 in Figure 6). A calibration exercise for a representative developing economy suggests that there could be up to a 20 percentage points (as a share of population) boost to financial inclusion from the unbanked gaining access to a CBDC.²³

²¹ World Bank Global Findex 2021 database.

²² In 2021, the “gender gap” stood at 6 percentage points in emerging economies, where, globally, 74 percent of men have a financial account compared with 68 percent of women.

²³ Assuming a liquidity value of the CBDC of 50 basis points and a 20 percent reduction in costs to access the CBDC compared to that of a bank account (Tan 2023b).

V. Tightness of Financial Conditions

Upon CBDC issuance, there will be “level effects” on the tightness of financial conditions from the changes in the macroeconomic environment (Figure 7). The introduction of a CBDC could alter deposit and lending rates. Changes in these interest rates affect the aggregate demand of the economy through households’ consumption-saving decisions (intertemporal substitution effect) and households’ and firms’ investment decisions by way of changing the marginal cost of borrowing. Additionally, CBDCs could change the volume of deposits as well as credit provisioning, both of which also affect financial conditions.

Figure 7: Level Effects on the Tightness of Financial Conditions

	Level Effect on the Tightness of Financial Conditions
↑ Competition	Tightening
↑ Wholesale funding	Tightening
↓ Bank profits	Ambiguous
↑ Financial inclusion	Loosening
↓ Dollarization/ Cryptoization	Ambiguous

Source: Authors.

Increased competition for bank deposit funding would tighten financial conditions. Banks will raise deposit interest rates to counteract some of the impact on their deposit bases and offset the additional liquidity value of the CBDC.

Increased wholesale funding would tighten financial conditions.²⁴

- **Increased wholesale funding would be more expensive.** Deposit insurance and implicit government guarantees allow banks to fund themselves with deposits at a lower cost than with other instruments (Drechsler, Savoy, and Schnabl 2021). External financing through wholesale funding is costly (Kashyap and Stein 1995). Hence, switching away from deposits could result in

²⁴ See Bouis and others (2023) for the implications of CBDC issuance for financial stability.

higher lending rates to preserve margins. The magnitude of the effect may not be very large, though, given that most of the value of deposits in most banking systems is uninsured.

- **Increased wholesale funding could increase market discipline, decreasing credit provision to the economy.** Relatedly, discipline stems from banks facing higher costs of funding or a drop in deposits as they take more risks (Berger 1991). Insured depositors do not impose the same level of discipline on banks since they do not bear the consequences of the risks they undertake.²⁵ Following the introduction of a CBDC, market discipline could increase as banks rely more on uninsured wholesale funding—thus shrinking lending.
- **Increased wholesale funding may be less stable.** Retail depositors are more stable sources of funding than wholesale depositors (Huang and Ratnovski 2011; Gertler, Kiyotaki, and Prestipino 2020). Banks might have to hold more liquid assets to meet regulatory requirements or cut back on lending.
- **The quantitative impact is uncertain and depends on the expected decrease in deposit quantities.** Whited, Wu, and Xiao (2023) estimates that bank lending falls by one-fourth of the drop in deposits as banks partially replace lost deposits with wholesale funding.²⁶ However, in general equilibrium, the lending impact approaches zero and could turn positive if there is an increase in deposit quantities.

Lower bank profits have an ambiguous impact on financial conditions. Banks may tighten their lending standards or increase interest rates to compensate for reduced profitability; however, it is possible that some banks might increase risk taking to make up for reduced profits.

Increased financial inclusion could loosen financial conditions.

- **Financial inclusion could lead to savings mobilization among the previously unbanked and underserved populations,** to the extent that a CBDC leads to the opening of bank deposit accounts. Increased savings can provide a stable pool of funds for greater lending; however, even if the CBDC induces a large share of the unbanked population to open bank accounts, the amount of savings mobilized may be small, as the unbanked own a small share of overall wealth in the economy. Furthermore, the poor have a much lower savings rate than do the rich, implying that the poor's contribution to the increase in overall deposit can be limited (Fagereng and others 2019).²⁷

²⁵ There is some debate on the conditions under which there is a disciplining effect, as Irish banks that were highly reliant on wholesale funding in the run-up to the global financial crisis nevertheless built up very high levels of risk.

²⁶ This implies an estimated change in lending ranging from –2.5 percent for the UK to –0.03 percent for Portugal, based on the partial equilibrium model described in Chiu and Hill (2018) and Canhoto (2004). See Davoodalhosseini (2021), Keister and Monnet (2022), Keister and Sanches (2023), and Niepelt (2020) for other relevant quantitative work.

²⁷ According to Anand and Thampi (2016), the top 10 percent of households hold 51.6 percent of entire wealth, while the bottom 10 percent hold only 0.2 percent of wealth in India.

- **The use of CBDC transaction histories as an alternative data source for credit underwriting could reduce credit-risk information asymmetry, lowering lending interest rates, and expanding access to credit.**²⁸ According to Ouyang (2021), adopting Alipay cashless payments in China increases the probability of getting credit access by 56 percent, and a 1 percent increase in cashless payment flow results in a 0.41 percent increase in the credit line. If CBDC data can be shared with lenders, one might expect effects of a similar magnitude; however, as before, if the CBDC expands lending among primarily low-income and underserved populations, then the aggregate impact will be small, as these groups make up a relatively small share of total lending.

Decreasing dollarization/cryptoization has an ambiguous impact on financial conditions. De-cryptoization itself could loosen financial conditions, similar to financial inclusion, since it could potentially lead to an increase in the supply of deposits. Given that deposits are the cheapest funding source, banks have room to reduce lending rates due to the decline in funding costs. On the other hand, the effects coming from de-dollarization are ambiguous because they depend on the difference in interest rates between the domestic and foreign currency. For example, if the domestic interest rate is higher than the foreign one, the decline in dollarization leads to tightening.

The central bank should monitor the macroeconomic environment closely to prevent any undesired loosening/tightening of financial conditions. As is the case with any other economic shock, the central bank should closely monitor the macroeconomic environment, which is relevant to monetary policy operation, and choose to adjust its policy instruments to achieve its objectives of maintaining price stability and managing economic fluctuations. If financial conditions tighten (loosen) from the issuance of a CBDC, the central bank can lower (increase) the policy rate to offset the impact and communicate its rationale to the public.

²⁸ Appropriate privacy protections and safeguards, including attaining user consent and adhering to country-specific regulations and legal frameworks, should be put in place to protect user data. In countries that prioritize privacy and data protection in their financial transactions, the extent to which data can be recorded and shared with financial service providers may be more limited.

VI. Transmission Channels of Monetary Policy

This section analyzes the impact of the changes in the macroeconomic environment induced by CBDC issuance on the transmission channels of monetary policy. Transmission is said to be stronger (weaker) if a given change in the tightness of financial conditions has larger (smaller) effects on macroeconomic variables in an economy with a CBDC than in one without CBDCs, all else being equal.

The main channels of monetary policy transmission are (Figure 8):

Figure 8: Main Channels of Monetary Policy Transmission

Transmission channels	
Interest rates	Real deposit, lending, capital market rates → intertemporal substitution
Bank lending	Bank balance sheets → wholesale funding costs
Asset prices	Borrower balance sheets (NPV) → funding costs & wealth effects
Exchange rates	Borrower balance sheets, asset prices, net exports

Source: Authors.

Note: NPV = net present value.

- The interest rate channel:** Monetary transmission through the interest rate channel occurs when changes in the policy rate induce changes in the overall level of interest rates in the economy, and those in turn affect the overall level of aggregate demand through their effects on the demand for credit and the available income of borrowers. Changes in interest rates alter the marginal cost of borrowing, inducing households and firms to rebalance investment and consumption between the future and the present, especially if exposed to interest-sensitive borrowing and saving instruments.
- The bank lending channel:** Monetary transmission through the bank lending channel occurs when banks' cost of funds changes in response to changes in the policy rate. Changes in the policy rate and its expectation affect bank balance sheets, profits, and ultimately their creditworthiness. These changes affect their non-deposit funding costs and their ability to supply credit. In response, banks adjust their lending rates and standards.²⁹

²⁹ See Bernanke (2007) and references therein for a full description of the bank lending channel. Older versions of this channel, originating in a period with higher reserve requirements and credit market segmentation, suggested that a higher supply of reserves increased deposits—loanable funds—and hence bank lending.

- The asset price channel:** Monetary transmission through this channel occurs when changes in the policy rate affect asset prices in the economy (in particular, equity or the value of collateral). A tightening would erode the balance sheet quality of borrowers by reducing their net worth— affecting their creditworthiness and costs of borrowing. This induces changes in consumption and investment through the wealth effect and the financing cost of investments.
- The exchange rate channel:** Monetary transmission through the exchange rate channel operates through the effect of the policy rate on the exchange rate, which, in turn, affects net exports. When monetary policy is tightened, domestic real interest rates rise and domestic deposits become more attractive relative to foreign deposits. Uncovered interest parity dictates that this will lead to capital inflows and, in the short run before prices adjust, a real appreciation of the currency and a contraction of net exports. This trade channel is complemented by a financial channel for countries that have high foreign-currency balance sheet exposure. In this case, an appreciated exchange rate leads to a wealth shock and looser financial conditions, boosting consumption and counteracting the trade channel.

Changes in the macroeconomic environment induced by CBDC issuance can potentially strengthen the transmission channels of monetary policy (Figure 9).

Figure 9: Impact on Transmission Channels of Monetary Policy

	Transmission Effects			
	Interest rate	Bank lending	Asset price	Exchange rate
↑ Competition	+	+		
↑ Wholesale funding		+		
↓ Bank profits	+/-			
↑ Financial inclusion	+		+	
↓ Dollarization / Cryptoization	+	+	+	+

Source: Authors.

Note: +/- indicates a strengthening/weakening of the transmission channel.

Increased competition for bank deposit funding could strengthen the interest rate and bank lending channels. The pass-through from policy rates to deposit rates is stronger when banks have less market power, as banks exercise market power to widen net interest margins. Thus, all else equal, the interest rate channel of transmission is more potent with greater competition in the banking sector (see also Drechsler, Savov, and Schnabl 2017). Consequently, bank lending rates also would become more sensitive to the policy rate.

Increased wholesale funding would strengthen the bank lending channel. Wholesale funding costs tend to be more sensitive to the central bank's policy rate than retail deposits, which are relatively insensitive to interest rates. Further, when a bank relies more on wholesale funding, changes in its balance sheet can have a larger effect on its total funding costs. Uninsured wholesale funding markets are more sensitive to changes in a bank's balance sheet.

Lower bank profits may have an asymmetric but relatively small effect on the interest rate channel. Banks may have larger incentives to raise interest rates when the policy rate is increased to maintain already small profit margins—thus strengthening transmission. The opposite is likely to occur when policy rates are lowered. However, this effect is likely to be relatively small.

Higher levels of financial inclusion can strengthen the interest rate and asset price channels. Greater financial inclusion implies that more households would be sensitive to monetary policy to the extent that a CBDC boosts access to interest-sensitive borrowing and saving instruments—for instance, if the use of CBDC payments data to build financial histories expands credit access among the unbanked or if the CBDC serves as an initial entry point to a digital financial account that leads to the opening of bank accounts. This leads to a greater share of the economy making intertemporal consumption and saving decisions guided by interest rates, which strengthens monetary transmission through the interest rate and asset price channels (Mehrotra and Nadhanael 2016). However, the aggregate impact of financial inclusion is limited by the relative contribution of the financially excluded population to overall saving and borrowing.

Increased monetary autonomy as a result of lower levels of dollarization or cryptoization will amplify all transmission channels. In dollarized or euroized economies, the introduction of a CBDC could encourage a greater use of the local currency, in lieu of dollars or euros, by making the local currency a more attractive means of payment. Thus, the CBDC could also help maintain monetary sovereignty and sustain the demand for central bank money. With greater monetary autonomy, monetary policy transmission will be stronger through all channels.

There are unlikely to be additional effects on the exchange rate channel. The basic relationship between interest rates and the exchange rate, as captured by the uncovered interest parity condition, is expected to remain unaffected.

Box 1. Lessons from the US Overnight Reverse Repurchase Agreement Facility

The Overnight Reverse Repurchase Agreement (ON RRP) facility in the United States provides nonbank financial firms direct access to the central bank balance sheet. The ON RRP facility offers US Treasury-backed repos to money market funds, allowing them to deposit funds overnight with the Fed.

The ON RRP facility offers returns close to the policy rate. The administered rate is set at the bottom of the target range for the federal funds rate, below the rate on balances held at the Federal Reserve Banks (IORB).

This arrangement has similarities to a CBDC. The ON RRP facility has the potential to disintermediate banks and reduce the supply of deposits by providing a safe and risk-free alternative investment to a broad base of money market investors. However, it is not a retail facility directly available to the general public, like a retail CBDC would be.

Bank deposits interest rates do not seem to be more sensitive to the policy rate since the introduction of ON RRP. The overall impact on the banking sector so far has not led to a significant contraction in bank deposit supply. However, the facility can crowd out private repo (Anderson and Kandrach 2017; Infante 2020).

VII. Further Considerations on Operations, Regimes, and CBDC Designs

This section studies the impacts of a CBDC on the operational aspects of monetary policy in more detail and considers other monetary regimes as well as two extensions to the baseline CBDC design. While so far, this note has covered the impact of a CBDC in a typical inflation-targeting setup, this section takes a closer look at implications at the operational level and considers alternative monetary policy regimes. It also considers the implications of a remunerated CBDC as well as the case of a foreign CBDC being available to domestic residents.

Monetary policy operations

Interest rate–based operational frameworks can be designed as corridor or floor systems (Figure 10). For a corridor system, the discount rate is set above the target interest rate, and the interest rate on reserves is set below it. Open market operations can be used to achieve the target rate. Alternatively, the policy rate can be attached to a central bank instrument that is offered on a full allotment basis. In a floor system, bank reserves are remunerated at the policy rate.³⁰

Figure 10: Interest Rate–Based Operational Frameworks

Mid-corridor, market rate	Calibrated OMOs to hit target rate
Mid-corridor, central bank rate	Full allotment lending of reserves at policy rate
Floor rate	Remuneration of excess reserves

Sources: Authors.

Note: OMOs = Open Market Operations

- In a mid-corridor system targeting a market rate (Regime 1), CBDC demand is an autonomous factor that might complicate the forecasting of liquidity necessary to optimize open market operations.** A careful forecast of banks' reserve needs is used to calibrate the reserves that central banks lend through open market operations. CBDCs could complicate liquidity estimates given the potential jaggedness and novelty of demand for the new payment instruments. Volatility of demand might increase more during crisis times. Central banks would learn to forecast more accurately over time and have tools to absorb forecasting errors. Central

³⁰ See King and Mancini Griffoli (2018) for more details.

banks could also temporarily switch to a full-allotment regime if needed (see Afonso and others 2021 for past examples).³¹

- **Otherwise, monetary policy operations could continue largely unchanged with CBDCs.** Central banks should be able to affect term spreads through communication as before, such as by releasing and discussing their interest rate projections. Central banks should be able to retain control of interest rates on reserves. As long as banks demand reserve balances to pay each other—ultimately, as long as banks intermediate payments—the central bank should be able to set their marginal price.

The size of the central bank balance sheet could grow considerably if the CBDC replaces deposits to a large extent.³²

- **Central banks' demand for government bonds is likely to increase to balance the increase in their CBDC liabilities.**³³ While this increase is likely to have price impacts that can affect the yield curve, available evidence suggests they would be marginal.³⁴ Naturally, in countries with much smaller government bond markets, the impact of a CBDC on the yield curve could be greater.
- **There would be implications for seigniorage revenue—the income from holding assets with a return higher than the cost of liabilities.** Bindseil (2016) argues that a large balance sheet increases seigniorage; however, Hall and Reis (2015) points to the risks (interest rate, foreign exchange, and default) from a larger balance sheet, which boils down to higher leverage. Losses could undermine the central bank's independence (Ishi, Fujita, and Stone 2011). If a CBDC is nonremunerated, seigniorage could be expected to grow.³⁵

Although the effect on monetary policy transmission is expected to be relatively small in normal times, a CBDC could potentially have more significant implications for monetary policy transmission in an environment of low interest rates and in times of financial market stress.

³¹ In floor systems, forecasting may still be needed for central banks to keep the size of outstanding reserves just above what banks require to settle transactions or as safety buffers.

³² The balance sheet of a central bank expands as CBDCs replace deposits when it offsets the reduction in reserves using open market operations (see Armas and Singh 2022; Bouis and others 2023).

³³ However, the impact on the size of the central bank balance sheet will be smaller if the CBDC partially replaces banknotes in circulation. The same is true if deposits are substituted by the CBDC, leading to an exchange of central bank reserves for the CBDC, given that banks still hold sufficient reserves at the central bank.

³⁴ The estimated effects of quantitative easing equal to 1 percent of GDP on 10-year US Treasury yields typically lie in the neighborhood of 4 to 5 basis points (see Williams 2011). However, given that purchases to balance CBDC liabilities would presumably fall heavily on shorter maturity instruments, the effects on yields would likely be much smaller.

³⁵ In the case of a remunerated CBDC, the impact is ambiguous and would depend on the differential between assets (typically government bonds) and the rate of reserve remuneration. The likely shift away from non-interest-bearing cash to an interest-bearing CBDC, though, would contribute to lower seigniorage.

An unremunerated CBDC could entrench the zero lower bound for interest rates.^{36,37} In case of an unremunerated CBDC without holding limits, there could be no other asset with a negative interest rate (Jamet and others 2022). CBDC would not bear the storage costs that apply to physical cash, raising the effective lower bound (Armelius and others 2018). While central banks have been able to set interest rates at negative levels for prolonged periods, given the high costs of storing physical cash, they could well be impeded if households start holding CBDCs in unlimited quantities.

Under financial market stress, there is greater risk of a flight to safety from retail bank deposits into CBDCs. This would strengthen the impact on monetary policy transmission from increased competition for bank deposit funding, increased wholesale funding, and lower bank profits.

It may be hard to gauge how low the policy rate can be set before the risk of broad-based disintermediation from the banking system becomes significant. Central banks are likely to be particularly wary of these risks, given that runs can evolve rapidly due to new technologies and social media in recent years (for example, Silicon Valley Bank).³⁸

These concerns, however, would be significantly reduced if effective limits are placed on how much CBDC can be held.

A CBDC, if not well designed and properly operated, could undermine the credibility of the central bank—with implications for the effective transmission of monetary policy. Technical failures, cyberattacks, loss of user funds, or breaches of confidential user data could pose reputational risks for the central bank. Central bank credibility directly impacts public expectations of future inflation. A central bank that is perceived as credible in its commitment to maintaining price stability helps anchor inflation expectations, making it easier for the central bank to achieve its inflation targets.

Type of monetary policy regime

This subsection discusses the extent to which the monetary policy effects of CBDCs are different for other regimes (Figure 11).

Under an exchange rate management framework, the central bank stabilizes the nominal exchange rate vis-à-vis a base (or “anchor”) country using interest rates and foreign exchange intervention, often in combination with sterilization, to achieve its target. A well-known implication of this framework is some loss of independent monetary policy, with a strict peg fully sacrificing independent monetary policy when there is no restriction on cross-border capital flows.

³⁶ A remunerated CBDC that allows for negative interest rates would not necessarily entrench the zero lower bound.

³⁷ Relatedly, CBDC has the potential to increase the reversal interest rate (Abadi, Brunnermeier, and Koby 2023) via lower bank profits.

³⁸ CBDCs could make bank runs both more likely and quicker, as they might present a more convenient vehicle to shift funds into than cash. There are, however, ways to mitigate these risks with improved information sharing, redesigned deposit contracts, and central bank asset-side policies (Chapman and others 2023).

In a monetary targeting framework, the central bank targets the quantity of a specific monetary aggregate whose rate of growth is linked to long-run inflation. The quantity target in turn is achieved principally by using interest rates or reserve requirements. In practice, the efficacy of monetary targeting relies on clear and consistent communication with the public to guide inflationary expectations.

Figure 11: Monetary Policy Regimes³⁹

	Objective	Intermediate target	Operational target	Instrument
Inflation targeting	Inflation stability	Expected inflation	Short term interest rate	OMO, reserve remuneration
Exchange rate management	FX stability	FX rate/ volatility	FX rate/ volatility	FX interventions, OMO, reserve requirements
Monetary targeting	Inflation (credit) stability	M2 growth	M0 growth	OMO, reserve requirements

Source: Authors.

Note: FX = foreign exchange; OMO = Open Market Operations.

CBDC could inject instability in the velocity of money, which could lead to challenges in pursuing monetary targeting. A monetary targeting regime relies on a stable relationship between M0 growth, which the central bank controls through open market operations and reserve requirements, and the growth rate of broader aggregates (M2). For instance, CBDC adoption could stimulate financial innovation, which in the past has been connected to increased velocity of money (Anderson, Bordo, and Duca 2016). Also, if CBDCs replace cash handling associated with high costs, it could lead to households being able to make more frequent transactions. Other factors such as interest rates and the economic outlook likely will be more decisive however and CBDC issuance is unlikely to have a significant effect (Wen and Arias 2014).

There is likely no significant effect on the ability to undertake FX interventions in a managed exchange rate regime. Only if CBDCs lead to a more open capital account— by making it easier for foreigners to hold domestic currency and vice versa— will the effectiveness of FX interventions be undermined.

Remunerated CBDCs

This subsection briefly discusses the monetary policy implications of remunerated CBDCs.

Although at present the majority of central banks are exploring non-remunerated CBDCs, they could in the future also consider remuneration. A few central banks are already considering the possibility of remuneration. This subsection focuses on the unique aspects of interest-bearing CBDCs, beyond the fact

³⁹ In an exchange rate management regime, some central banks also use the policy rate to achieve their targets.

that remuneration can amplify the impact of previously discussed mechanisms by increasing the attractiveness of CBDCs.

A remunerated CBDC introduces a risk-free and highly liquid overnight government debt instrument.

- **The issuance of remunerated CBDCs could help meet the demand for short-duration safe assets.** This would reduce the convenience yield of such assets and raise the neutral rate of interest, r^* , which could reduce the incidence of zero lower bound episodes (Gorton and Ordoñez 2022).
- **Remunerated CBDCs could boost capital market development by providing a new overnight asset to financial actors.** More developed capital markets would strengthen the interest rate and asset price channels of monetary policy transmission, given greater household and firm exposures to interest-bearing savings. In addition, greater capital market development could strengthen the exchange rate channel by allowing more fluid cross-border currency arbitrage.

An interest-bearing CBDC with a variable interest rate could serve as an additional policy tool to potentially strengthen monetary policy transmission.⁴⁰ A CBDC that is remunerated at a rate linked to the policy rate could have a larger impact on monetary transmission as it will be a closer substitute to deposits. The resulting higher degree of disintermediation might force banks to react more strongly to changes in the policy rate—by changing deposit rates, lending rates, and credit supply—making transmission more efficient.

Interest-bearing CBDCs could also support a negative interest-rate policy to enlarge the policy space. In periods of low interest rates, it could allow for the setting of a negative policy rate, provided that the public cannot shift into large holdings of zero interest-rate assets, such as cash (Armelius and others 2018). Frictions associated with acquiring and storing large amounts of cash, however, could still provide leeway even if a negative interest-rate CBDC exists in parallel with cash.⁴¹

Foreign CBDC

There could be a significant impact on monetary policy and autonomy if a foreign CBDC were available domestically, but this could be alleviated with restrictions on foreign CBDC usage, such as holding or transaction caps.

⁴⁰ Interest on CBDC interacts with traditional monetary policy tools, and they should be coordinated to effectively achieve policy goals (see Jiang and Zhu 2021).

⁴¹ Negative interest rates could also help reduce competition with cash if the central bank is concerned that CBDCs would crowd out cash (Agur, Ari, and Dell’Ariccia 2022).

Foreign CBDCs could increase the risk of currency substitution. If a foreign CBDC becomes widely adopted and individuals or businesses in a country opt to hold and use it rather than the domestic currency for transactions or as a store of value, then the effectiveness of monetary policy would be severely limited. This is a key issue for smaller developing countries, where there are concerns over domestic currency stability and inflation.

CBDCs can also amplify the international spillover of shocks and increase international linkages (Ferrari, Mehl, and Stracca 2022).⁴² The issuance of a CBDC by a foreign nation can weaken monetary policy transmission and autonomy to an economically significant extent, forcing the central bank to react more strongly to the stronger international spillovers caused by the CBDC. Capital flow management measures might be warranted in this case (He and others 2023).

If a domestic CBDC could be held in large quantities abroad, then the domestic central bank balance sheet could be subject to large fluctuations connected to changing external demand. These fluctuations may have potential effects on market liquidity and the availability (and price) of domestic safe assets, which could undermine the policy conducted by the monetary authority. Further complications to financial stability and central bank operations could also follow (He and McCauley 2010).

⁴² The existence of a cross-border CBDC creates a new arbitrage condition that links together the interest rate differential, the exchange rate, and the remuneration of the CBDC. This leads to stronger exchange rate movements in response to shocks in the presence of a CBDC.

References

- Abadi, Joseph, Markus Brunnermeier, and Yann Koby. 2023. "The Reversal Interest Rate." *American Economic Review* 113 (8): 2084–120.
- Afonso, Gara, Marco Cipriani, Adam Copeland, Anna Kovner, Gabriele La Spada, and Antoine Martin. 2021. "The market events of mid-September 2019." Federal Reserve Bank of New York Staff Reports 918, Federal Reserve Bank of New York, NY.
- Agur, Itai, Anil Ari, and Giovanni Dell'Ariccia. 2022. "Designing Central Bank Digital Currencies." *Journal of Monetary Economics* 125: 62–79.
- Álvez, Marcelo, Rodrigo Lluberas, and Jorge Ponce. 2018. "The Cost of Using Cash and Checks in Uruguay." Working Paper 004-2019, Central Bank of Uruguay, Montevideo.
- Anand, Ishan, and Anjana Thampi. 2016. "Recent Trends in Wealth Inequality in India." *Economic and Political Weekly* 51: 59–67.
- Anderson, Richard G., Michael Bordo, and John V. Duca. 2016. "Money and Velocity During Financial Crises: From the Great Depression to the Great Recession." NBER Working Paper 22100, National Bureau of Economic Research, Cambridge, MA.
- Anderson, Alyssa, and John Kandrak. 2017. "Monetary Policy Implementation and Financial Vulnerability: Evidence from the Overnight Repurchase Facility." *Review of Financial Studies* 31 (9): 3643–86.
- Andolfatto, David. 2021. "Assessing the Impact of Central Bank Digital Currency on Private Banks." *The Economic Journal* 131 (634): 525–40.
- Ahnert, Toni, Katrin Assenmacher, Peter Hoffmann, Agnese Leonello, Cyril Monet, and Davide Porcellacchia. 2022. "The Economics of Central Bank Digital Currency." ECB Working Paper 2713, European Central Bank, Frankfurt am Main, Germany.
- Armas, Adrian, and Manmohan Singh. 2022. "Digital Money and Central Banks Balance Sheet." IMF Working Paper 2022/206, International Monetary Fund, Washington, DC.
- Armelius, Hanna, Paola Boel, Carl Andreas Claussen, and Marianne Nessén. 2018. "The e-Krona and the Macroeconomy." *Sveriges Riksbank Economic Review* 3: 43–65.
- Bank for International Settlements (BIS). 2020. "Central Bank Digital Currencies: Foundational Principles and Core Features." <https://www.bis.org/publ/othp33.htm>.
- Bank for International Settlements (BIS). 2021. "Central Bank Digital Currencies: Financial Stability Implications." https://www.bis.org/publ/othp42_fin_stab.pdf.
- Banka, Holti. 2018. "Initial Findings from the Implementation of the 'Practical Guide for Measuring Retail Payment Costs.'" World Bank Blogs, May 28. <https://blogs.worldbank.org/psd/initial-findings-implementation-practical-guide-measuring-retail-payment-costs>.

- Berger, Allen. 1991. "Market Discipline in Banking." Proceedings of the 27th Conference on Bank Structure and Competition, Federal Reserve Bank of Chicago, Chicago, IL.
<https://econpapers.repec.org/paper/fipfedhpr/328.htm>.
- Bernanke, Ben. 2007. "The Financial Accelerator and The Credit Channel (Speech 296)." Speech presented at the Board of Governors of the Federal Reserve System (US).
<https://ideas.repec.org/p/fip/fedgsq/296.html#author-abstract>.
- Bindseil, Ulrich. 2016. "Evaluating Monetary Policy Operational Frameworks." Federal Reserve Bank of Kansas City. https://www.kansascityfed.org/documents/7036/BindseilPaper_JH2016.pdf.
- Bindseil, Ulrich. 2020. "Tiered CBDC and the Financial System." ECB Working Paper 2351, European Central Bank, Frankfurt am Main, Germany.
- Bouis, R., G. Gelos, P. Miettinen, F. Nakamura, E. Nier, and G. Soderberg. 2023. "Central Bank Digital Currencies and Financial Stability: Scenarios and Policy Choices," Forthcoming.
- Brandao Marques, Luis, Yi Xue, R. G. Gelos, Ratna Sahay, and Thomas Harjes. 2020. "Monetary Policy Transmission in Emerging Markets and Developing Economies." IMF Working Paper 2020/035, International Monetary Fund, Washington, DC.
- Canhoto, Ana. (2004). "Portuguese Banking: A Structural Model of Competition in the Deposits Market." *Review of Financial Economics* 13 (1–2): 41–63.
- Chang, Huifeng, Lucyna Gornicka, Federico Grinberg, Marcello Miccoli, and Brandon Tan. (2023). "CBDC and Banking Disintermediation in A Portfolio Choice Model." Forthcoming IMF Working Paper.
- Chapman, James, Jonathan Chiu, Mohammad Davoodalhosseini, Janet Jiang, Francisco Rivadeneyra, and Yu Zhu. 2023. "Central Bank Digital Currencies and Banking: Literature Review and New Questions." Bank of Canada Staff Discussion Paper 2023-4, Bank of Canada, Ottawa.
- Chiu, Jonathan, Seyed Davoodalhosseini, Janet Jiang, and Yu Zhu. 2023. "Bank Market Power and Central Bank Digital Currency: Theory and Quantitative Assessment." *Journal of Political Economy* 131 (5): 1213–48.
- Chiu, Ching-Wai (Jeremy), and John Hill. 2018. "The Rate Elasticity of Retail Deposits in the United Kingdom: A Macroeconomic Investigation." *International Journal of Central Banking* 14 (2): 113–58.
- Davoodalhosseini, Seyed Mohammadreza. 2021. "Central Bank Digital Currency and Monetary Policy." *Journal of Economic Dynamics and Control* 142: e104150.
<https://doi.org/10.1016/j.jedc.2021.104150>.
- Drechsler, Itamar, Alexi Savov, and Philipp Schnabl. 2021. "Banking on Deposits: Maturity Transformation without Interest Rate Risk." *The Journal of Finance* 76 (3): 1091–143.
- Fagereng, Andreas, Martin Blomhoff Holm, Benjamin Moll, and Gisle Natvik. 2019. "Saving Behavior across the Wealth Distribution: The Importance of Capital Gains." NBER Working Paper 26588, National Bureau of Economic Research, Cambridge, MA.
- Ferrari, Massimo Minesso, Arnaud Mehl, and Livio Stracca. 2022. "Central Bank Digital Currency in an Open Economy." *Journal of Monetary Economics* 127: 54–68.

- Gertler, Mark, Nobuhiro Kiyotaki, and Andrea Prestipino. 2020. "A Macroeconomic Model with Financial Panics." *Review of Economic Studies* 87 (1): 240–88.
- Gorton, Gary, and Guillermo Ordoñez. 2022. "The Supply and Demand for Safe Assets." *Journal of Monetary Economics* 125 (C): 132–47.
- Hall, Robert E., and Ricardo Reis. 2015. "Maintaining Central-Bank Financial Stability under New-Style Central Banking." NBER Working Paper 21173, National Bureau of Economic Research, Cambridge, MA.
- Hasan, Iftekhhar, Tania De Renzis, and Heiko Schmiedel. 2013. "Retail Payments and the Real Economy." European Central Bank Working Paper 1572, European Central Bank, Frankfurt am Main, Germany.
- He, Dong, Annamaria Kokenyne, Tommaso Mancini Griffoli, Marcello Miccoli, Thorvardur Tjoervi Olafsson, Gabriel Soderberg, Herve Tourpe. 2023. "Capital Flow Management Measures in the Digital Age (2): Design Choices for CBDC" IMF Fintech Note Forthcoming, International Monetary Fund, Washington, DC.
- He, Dong, and Robert McCauley. 2010. "Offshore Markets for the Domestic Currency: Monetary and Financial Stability Issues." BIS Working Paper 320, Bank for International Settlements, Basel, Switzerland.
- Huang, Rocco, and Lev Ratnovski. 2011. "The Dark Side of Bank Wholesale Funding." *Journal of Financial Intermediation* 20 (2): 248–63.
- Infante, Sebastian. 2020. "Private Money Creation with Safe Assets and Term Premia." *Journal of Financial Economics* 136 (3): 828–56.
- Ishi, Kotaro, Kenji Fujita, and Mark R. Stone. 2011. "Should Unconventional Balance Sheet Policies Be Added to the Central Bank Toolkit? A Review of the Experience So Far." IMF Working Paper 2011/145, International Monetary Fund, Washington, DC.
- Jamet, Jean-François, Arnaud Mehl, Cyril Max Neumann, and Fabio Panetta. 2022. "Monetary Policy and Financial Stability Implications of Central Bank Digital Currencies." VoxEU Column, Monetary Policy, April 13, 2022. <https://cepr.org/voxeu/columns/monetary-policy-and-financial-stability-implications-central-bank-digital-currencies>.
- Jiang, Janet, and Yu Zhu. 2021. "Monetary Policy Pass-Through with Central Bank Digital Currency." Staff Working Paper 21-10, Bank of Canada, Ottawa.
- Kashyap, Anil K., and Jeremy C. Stein. 1995. "The Impact of Monetary Policy on Bank Balance Sheets." *Carnegie-Rochester Conference Series on Public Policy* 42:151–95.
- Keister, T. and Monnet, C. (2022), "Central Bank Digital Currency: Information and Stability", *Journal of Economic Dynamics and Control* 142: 104501.
- Keister, Todd, and Daniel Sanches. 2023. "Should Central Banks Issue Digital Currency?" *Review of Economic Studies* 90 (1): 404–31.

- Kosse, Anneke, Heng Chen, Marie-Hélène Felt, Valéry Dongmo Jiongo, Kerry Nield, and Angelika Welte. 2017. "The Costs of Point-of-Sale Payments in Canada." Bank of Canada Staff Discussion Paper 2017-4, Bank of Canada, Ottawa.
- Kosse, Anneke, and Ilaria Mattei. 2023. "Making Headway: Results of the 2022 BIS Survey on Central Bank Digital Currencies and Crypto." BIS Paper 136, Bank of International Settlements, Basel, Switzerland.
- Lannquist, Ashley, and Brandon Tan. 2023. "CBDC's Role in Promoting Financial Inclusion." Forthcoming IMF Fintech Note.
- Li, Jiaqi. 2023. "Predicting the Demand for Central Bank Digital Currency: A Structural Analysis with Survey Data." *Journal of Monetary Economics* 134: 73–85.
- Mancini Griffoli, Tommaso, Maria Soledad Martinez Peria, Itai Agur, Anil Ari, John Kiff, Adina Popescu, and Celine Rochon. 2018. "Casting Light on Central Bank Digital Currencies." IMF Staff Discussion Notes 2018/08, International Monetary Fund, Washington, DC.
- Mehrotra, Aaron, and G. V. Nadhanael. 2016. "Financial Inclusion and Monetary Policy in Emerging Asia." In *Financial Inclusion in Asia*, edited by S. Gopalan and T. Kikuchi, 93–127. London: Palgrave Macmillan.
- Niepelt, Dirk. 2020. "Reserves for All? Central Bank Digital Currency, Deposits, and Their (Non)-Equivalence." *International Journal of Central Banking* 16 (3): 211–38.
- Ouyang, Shumaio. (2021). "Cashless Payment and Financial Inclusion." Working Paper.
- Panetta, Fabio. 2021. "Central Bank Digital Currencies: A Monetary Anchor for Digital Innovation." Speech delivered November 5, 2021, at the Elcano Royal Institute, Madrid. European Central Bank. <https://www.ecb.europa.eu/press/key/date/2021/html/ecb.sp211105~08781cb638.en.html>.
- Tan, Brandon. 2023a. "Central Bank Digital Currency Adoption: A Two-Sided Model." IMF Working Paper 2023/127, International Monetary Fund, Washington, DC.
- Tan, Brandon. 2023b. "Central Bank Digital Currency and Financial Inclusion." IMF Working Paper 2023/069, International Monetary Fund, Washington, DC.
- Wen, Yi, and Maria A. Arias. 2014. "What Does Money Velocity Tell Us about Low Inflation in the U.S.?" On the Economy Blog, Federal Reserve Bank of St. Louis, September 1. <https://www.stlouisfed.org/on-the-economy/2014/september/what-does-money-velocity-tell-us-about-low-inflation-in-the-us>.
- Whited, Toni, Yufeng Wu, and Kairong Xiao. 2023. "Central Bank Digital Currency and Banks." Working Paper.
- Williams, John C. 2011. "Unconventional Monetary Policy: Lessons from the Past Three Years." Presentation to the Swiss National Bank Research Conference, Zurich, Switzerland, September 23. <https://www.frbsf.org/our-district/press/presidents-speeches/williams-speeches/williams-speeches/2011/september/williams-unconventional-monetary-policy/>.



PUBLICATIONS

Implications of Central Bank Digital Currencies for Monetary Policy Transmission
NOTE/2023/010