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How to Design a CBDC? Remuneration, Collateral Haircuts and Quantity Constraints

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Central banks have initiated work to assess the potential issuance of central bank digital currency (CBDC) and gauge the macro-financial impact of different CBDC design parameters. We study the macroeconomic effects of CBDC, taking into account that, to steer the quantity of CBDC, the central bank can set the lending and deposit rates for CBDC as well as collateral and quantity requirements. In our dynamic general equilibrium model, timing and information frictions create a need for inside (bank deposits) and outside money (CBDC) to finance production. Less restrictive provision of CBDC reduces bank deposits. A positive interest spread on CBDC or stricter collateral or quantity constraints reduce welfare but can contain bank disintermediation, especially if the elasticity of substitution between bank deposits and CBDC is small. The first-best resource allocation in this set-up is characterised by CBDC being unconstrained by neither collateral requirements nor a quantitative cap and by the spread between the CBDC lending and deposit rate being zero.

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Introduction

The digital payments landscape has evolved rapidly over the past years and central banks cannot ignore these developments. Big tech companies' reflections on issuing private currencies and the emergence of crypto-assets have prompted concerns about related safety and data protection issues. As a response, central banks have started their own work programmes to assess the prospects of issuing central bank digital currency (CBDC) for retail transactions, see e.g. European Central Bank (2021).

Central banks' motivations for issuing CBDC emanate from its potential to provide a secure, efficient and universally accessible means of payment for everybody (European Central Bank, 2020; Bank for International Settlements, 2020). Beyond this primary motivation, however, the issuance of CBDC entails important implications for monetary policy implementation, monetary policy transmission and financial stability. These implications can originate from a substitution of bank deposits for CBDC that could erode a key component of commercial banks' funding base. A shift from deposits into CBDC could affect the bank-based transmission of monetary policy by increasing bank lending rates or curtailing bank credit provision, possibly hampering credit allocation and ultimately output and welfare. By influencing the share of credit that is intermediated through banks, a CBDC could also reduce bank profitability and affect the stability of the financial system in general.

Obviously, these effects depend on the specific design features of a CBDC, such as the interest rate at which CBDC balances are remunerated, holding limits on CBDC or the choice and the modalities related to assets held against CBDC. These parameters may be set by the central bank in a way that possible undesired consequences for monetary transmission and financial stability are mitigated (see e.g. Bindseil, 2020; Bindseil and Panetta, 2020). Little is known, however, about the effectiveness of these parameters in steering the demand for CBDC and the resulting macroeconomic outcomes. Specifically, the implications that variations of these parameters may have on equilibrium allocations and welfare have not been widely analysed or understood.

The model

We study these questions in a general equilibrium model with search and matching frictions that create a role for money as a means of payments which allows us to analyse the impact of different CBDC design parameters set by the central bank on credit allocation and welfare. Within this unified modelling framework, we consider three policy instruments to influence CBDC demand that have either been discussed in policy circles – such as a cap on CBDC holdings (European Central Bank, 2020; Bindseil and Panetta, 2020) – or that already exist in central banks' operational frameworks, such as interest rates on lending and deposit facilities for central bank money, or haircuts on the collateral pledged for lending at the central bank (see Sylvestre and Coutinho (2020) for the Eurosystem).

Our model comprises three markets that operate sequentially in one period: a settlement, a loan and an investment market. The centralised settlement market is needed to equalise allocations at the beginning of each period to make the model tractable (Lagos and Wright, 2005). In the settlement market banks, firms, and workers produce and consume a generic good and settle the borrowing contracts that they had entered into in the previous period. Entrepreneurs operate for one period only and are born during the loan market with an investment opportunity and a limited initial endowment. They receive an idiosyncratic investment shock that determines the optimal size of production and thereby the demand for capital goods. There are two types of workers who produce and sell two types of capital goods in the investment market: A "type-C" worker only accepts CBDC, whereas "type-D" workers only accept commercial bank deposits as payment against the capital goods they produce. To buy the capital required for production, an entrepreneur needs to borrow inside money

from a commercial bank and outside money (CBDC) from the central bank in the loan market. At the same time, entrepreneurs are obliged to pledge collateral (comprised of the initial endowment and a share of future output) against these loans. The central bank can use three tools to affect CBDC demand: It chooses the interest rate spread between the rate it charges on CBDC loans to entrepreneurs and the interest rate it pays on workers' deposits of CBDC; it can apply a haircut to future revenue posted as collateral for a loan; and it can set a limit on the size of each CBDC loan.

Results

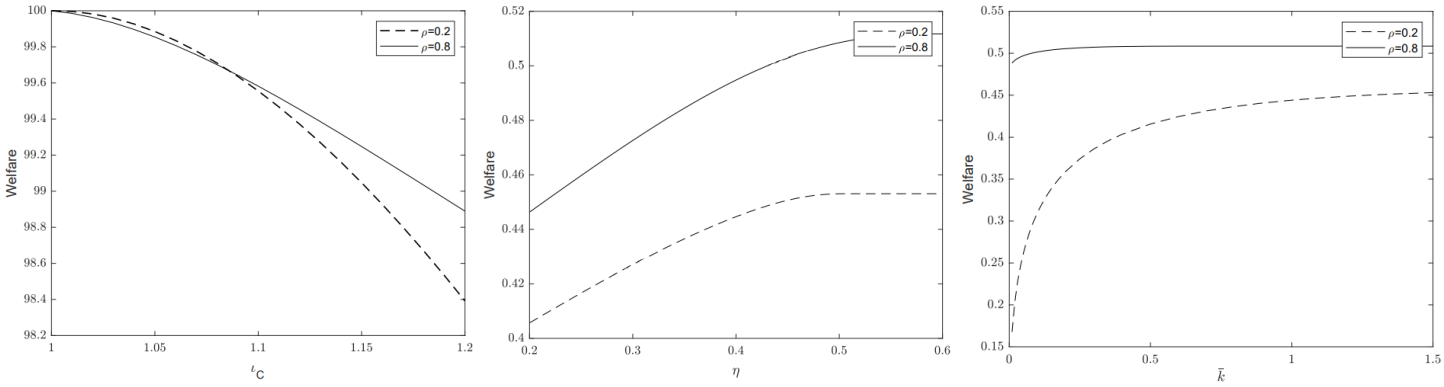
We find that the equilibrium allocation under the first-best solution is characterised by a CBDC lending spread of zero ($\iota_C = 1$) and CBDC provision being unconstrained by neither collateral requirements nor a quantitative cap. Once the central bank actively uses its policy tools to affect CBDC demand, output and welfare are diminished relative to the first-best solution. However, with the three policy tools the central bank can steer the demand for CBDC and thereby limit bank disintermediation. Figure 1 illustrates the welfare effects that arise from the use of these three tools. In these figures we show results for two different elasticities of substitution between CBDC and bank deposits, namely $\rho = 0.2$ (dashed lines) and $\rho = 0.8$ (solid lines). A high degree of substitutability between CBDC and bank deposits characterises a situation in which CBDC can be easily replaced by deposits in transactions whereas with a low degree of substitutability, this is not the case, e.g. because agents have strong preferences for either means of payment.

If the central bank imposes a positive interest rate spread between the CBDC lending and deposit rate, some investment projects that would otherwise be profitable at market interest rates are not financed, giving rise to inefficiently low investment and, consequently, production. This is depicted in Figure 1(a) for a lending spread that increases from zero ($\iota_C = 1$) to 20% ($\iota_C = 1.2$). Welfare declines because workers need to deposit CBDC received in the investment market with the central bank in order to transfer it into the next period's settlement market. If the entrepreneur borrows CBDC at a higher rate than the one that workers can earn on their deposits, the amount of CBDC in circulation will be too low to pay for the optimal amount of capital goods. While a higher interest rate spread on CBDC lending is effective in containing the demand for CBDC and mitigating bank disintermediation, especially when CBDC and bank deposits are easy to substitute, it thus also leads to lower output and decreases welfare.

While the interest rate on CBDC directly interacts with the limited commitment friction in the investment market, the collateral haircut and the cap on the size of CBDC holdings operate through the idiosyncratic investment shock that determines the optimal size of the entrepreneurs' projects. The larger the shock is an entrepreneur receives, the more likely she may face financing constraints that arise from collateral haircuts or a cap on CBDC holdings. When we simulate the model, we compute aggregate CBDC and deposit holdings over the whole support of the investment shock. Figures 1(b) and 1(c) show that welfare in the economy unambiguously increases with a larger share of pledgeable collateral (η) and a higher cap on CBDC ($\bar{l}_C$), independent of the degree of substitutability.

Figure 1.

Welfare as a function of the lending spread (ι_C), the share of pledgeable collateral (η), and the CBDC cap ($\bar{k}$) for different degrees of substitutability ρ



(a) Lending spread ι_C (b) Share of pledgeable collateral η (c) CBDC cap $\bar{k}$

As Figure 1 documents, restrictions on the supply of CBDC give rise to inefficiently low investment and production and thus reduce welfare. This result follows from production requiring an input that is produced by workers remunerated in CBDC and costly to substitute. Although entrepreneurs can substitute capital goods financed with CBDC by capital goods paid for with deposits, a less than perfect substitutability implies that investment will be lower than socially optimal if CBDC supply is restricted. Consequently, welfare gains from CBDC depend on the degree of substitutability of the production inputs paid for in inside or outside money. For increasing degrees of substitution between both forms of money, welfare gains from CBDC decline and approach zero if both types of money are perfect substitutes.

Besides the effects on capital allocation and welfare, we are interested in how CBDC design choices affect bank deposits, which we interpret as evidence of the potential of CBDC to disintermediate bank lending. With this notion we want to capture the so-called "structural" disintermediation resulting from the existence of CBDC (see Bindseil, 2020), i.e. the shift from bank deposits to CBDC in normal times, which is driven by different motives than runs out of bank deposits during a crisis. If the degree of substitution between commercial bank credit and CBDC is relatively high, a higher interest rate spread and a tighter cap for CBDC loans increase bank lending. If the degree of substitution is low, bank lending falls together with – although less than – CBDC demand as the latter is now more diffcult to replace by inside money. Allowing a larger share of future output as collateral unambiguously increases the demand for bank loans. An overview how the three policy parameters affect the bank lending depending on the degree of substitutability is given in Table 1. Overall, the central bank therefore can contain bank disintermediation by adjusting its policy parameters which, however, may lead to losses in output and welfare.

Table 1.
Impact of different CBDC design parameters on bank lending

Design parameter	High substitutability	Low substitutability
Larger interest rate spread on CBDC	↑	↓
Higher share of pledgeable collateral	↑	↑
Higher cap on CBDC	↓	↑

Conclusions

Overall, we find that policy parameters such as the interest rate spread between the lending and deposit rates for CBDC as well as collateral and quantity constraints are effective in curtailing the demand for CBDC. While unhindered provision of CBDC would be optimal from a welfare-maximising perspective, the unlimited supply of CBDC may decrease bank lending and thus lead to bank disintermediation. In our setup, the degree of substitution between CBDC and bank deposits is a key parameter that affects the impact of CBDC on output and welfare. In practice, the degree of substitutability between CBDC and deposits will be driven by non-pecuniary aspects of CBDC, such as the ease of access, the convenience of effecting transactions and potentially other services that are linked to this monetary asset.

In our model, we capture a setup where CBDC exists in equilibrium, as postulated by the need to obtain both bank deposits and CBDC in order to achieve optimal production. In contrast, we do not attempt to model the dynamics that may arise during the introduction of a CBDC and that may pose challenges on its own for credit allocation and financial stability.

Within the rapidly expanding literature on CBDC, our approach falls into a class of new-monetarist models assigning an essential role to money on account of search and matching frictions, as in Lagos and Wright (2005). Accordingly, our approach shares some important commonalities with the model by Keister and Sanches (2021) featuring perfectly competitive banks and credit frictions. CBDC is possibly interest bearing, might crowd out bank deposits, and leads to an increase in welfare by reducing credit frictions.

Yet, one important difference is that, while in Keister and Sanches (2021) the central bank fixes the price level by buying or selling goods against cash or CBDC, we assume that entrepreneurs borrow from the central bank and commercial banks. This approach allows us to focus on safeguards such as quantity or collateral constraints in addition to variations in the interest rate on CBDC.

In sum, we show that CBDC improves the overall allocation of resources and increases output and welfare (as long as production inputs are not perfect substitutes), as it always reduces frictions in credit provision. At the same time, the provision of CBDC can reduce commercial bank credit, thereby disintermediating banks to some extent. Increasing the interest rate spread on CBDC is effective in containing bank disintermediation, in particular if inside and outside money are close substitutes. ■

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