CBDC and the operational framework of monetary policy*

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Abstract

We analyze the impact of introducing a central bank-issued digital currency (CBDC) on the operational framework of monetary policy and the macroeconomy as a whole. To this end, we develop a New Keynesian model with heterogeneous banks, a frictional interbank market, a central bank with deposit and lending facilities, and household preferences for di□erent liquid assets. The model is calibrated to replicate the main monetary and financial aggregates in the euro area. Our analysis predicts that CBDC adoption implies a roughly equivalent reduction in banks' deposit funding. However, this 'deposit crunch' has a rather small e□ect on bank lending to the real economy, and hence on aggregate investment and GDP. This result reflects the parallel impact of CBDC on the central bank's operational framework. For relatively moderate CBDC adoption levels, the reduction in deposits is absorbed by an almost one-to-one fall in reserves at the central bank, implying a transition from a 'floor' system –with ample reserves– to a 'corridor' one. For larger CBCD adoption, the loss of bank deposits is compensated by increased recourse to central bank credit, as the corridor system gives way to a 'ceiling' one with scarce reserves.

Keywords: central bank digital currency, interbank market, search and matching frictions, reserves.

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tighter and tighter. As a result, the interbank rate is pushed against the ceiling of the corridor, such that the lending facility rate becomes the relevant policy rate (solid blue line, panel c). The operational framework then becomes a 'ceiling system', in which there is a structural lack of liquidity in interbank markets. According to our estimations, and absent any other policy intervention, the transition from a corridor to a ceiling regime happens for a CBDC take-up larger than 12% of GDP.

The total volume of households' assets, $\mathcal{W} = M + D + D^{DC}$, decreases almost linearly, by up to 0.5% of GDP as CBDC demand reaches 14% (panel e). In order to understand this effect, notice that the household's budget constraint (1) can be expressed as

$$C + \mathcal{W} \;\; = \;\; WH + R^{\mathcal{W}}\mathcal{W} + \textstyle\sum_{s=R,B} \Pi^s - T,$$

where $R^{\mathcal{W}} = R^D D/\mathcal{W} + M/\mathcal{W} + D^{DC}/\mathcal{W}$ is the *(weighted) average return on liquidity*. As the share of D^{DC} over total liquid assets increases, and given that its remuneration is zero, the return on liquidity would decrease, unless the return on deposits, R^D, increases enough to compensate for this. As shown in panel d of Figure 3, the deposit rate increases, for reasons explained below, but this increase is tiny (around 4.5 basis points for a CBDC demand of 14% of GDP) compared with the decline in the share of deposit over liquid assets (which falls by 4.5 pp, from around 95.7% in the initial pre-CBDC steady state). The decline in the return on liquidity explains why households save less on the aggregate, and hence the decline in total household assets $\mathcal{W}$.

The volume of household assets is ultimately linked, via the financial system, to the stock of physical capital operated by firms. The consolidated (steady-state) balance sheet of the financial sector, including the central bank, is[23]

$$K + B^G = \mathcal{W} + N. \tag{33}$$

[23]Notice that in the steady state the price of corporate claims equals $Q = 1$, such that bank holdings of those claims are $QK = K$.

For given bank equity N, a fall in household assets, $\mathcal{W}$, leads to a decline in bank lending to firms, K, as government debt outstanding B^G is assumed constant. This is amplified by the fact that bank equity is not constant, but also falls as CBDC take-up increases. To understand this, notice that in a floor system both borrowing and lending rates are close to the deposit facility rate, and hence $\omega^B \approx \omega^L$.[24] There is then a link between aggregate capital and bank equity (eq. 69), which, in steady state, simplifies to

$$\begin{aligned} K &= \phi\left[1-F\left(\omega^B\right)\right]N_t + \left[F\left(\omega^B\right)-F\left(\omega^L\right)\right](N+D)/(1-\psi) \\ &\approx \phi\left[1-F\left(\omega^B\right)\right]N. \end{aligned} \tag{34}$$

Thus the reduction in aggregate capital due to the fall in deposits also brings about a fall in bank equity (by a factor $\frac{1}{\phi[1-F(\omega^B)]} < 1$, which in our calibration is approximately 0.1) . The decline in capital and bank equity can be seen in panel f of Figure 3. The reduction in capital leads to an increase in its return, which in turn, lifts the deposit and interbank interest rates (panels c and d) in an almost linear fashion. As stated above, the increase in the deposit rate is too small to compensate for the fall in the average return on household savings. Finally, the lower stock of physical capital brings about a reduction in output (panel f), which decreases almost linearly, by up to 0.25% when demand for CBDC reaches 14% of GDP.[25]

Interestingly, the fall in bank equity follows an inverse hump-shape around the region in which the interbank rate lies in the middle of the policy rate corridor. This is because, when the central bank operates a corridor system, those banks that fail to find a match in the interbank market are forced to resort to the central bank facilities, where borrowing is more expensive (the lending facility rate is above the interbank rate) and deposits offer a lower remuneration (the deposit facility rate is below the interbank rate). This hurts banks' profitability and depresses the aggregate level of bank equity. This does not happen when the central bank operates a floor (ceiling) system, in which all lending (borrowing) banks find a partner in the interbank market and all borrowing (lending) banks that trade

[24] See Arce et al. (2020) for a proof of this result.

[25] At the same time, labor input H_t also decreases, although to a lesser extent, by 0.07%.

with the central bank do so at the same rate that prevails in the interbank market. The fall in bank lending and output when the central bank moves to a corridor system, however, is not as pronounced as the fall in bank equity, since it is partly compensated by a fall in ω^L, i.e. the fraction of banks that decide to lend their funds in the interbank market instead of investing in productive firms, reflecting the lower remuneration for lending orders that fail to find a match and thus end up at the central bank's deposit facility.

To further understand the effects of the introduction of CBDC on *bank intermediation*, Figure 4 depicts the response of the different components of banks' balance sheet. Panels a and b do so for the consolidated banking sector as a whole. For intermediate levels of CBDC adoption (of up to 6% of GDP), the fall in deposit liabilities is absorbed by an almost one-for-one reduction in reserves at the central bank. Crucially, this allows the banking system to preserve most of its lending to firms. From that point on, further decreases in deposit liabilities are matched one-for-one with increases in the recourse to the central bank's lending facility. Again, this allows banks to limit the impact of CBDC on their lending to the real economy.

This response in consolidated assets and liabilities, however, masks differing responses between borrowing and lending banks. Having no reserves to begin with, borrowing banks compensate their loss of deposits by borrowing more in the interbank market and, for sufficiently large CBDC adoption, also by borrowing more from the central bank (panel d). This allows them to preserve most of their lending to firms (panel c). By contrast, lending banks respond to their deposit loss (panel f) by reducing their central bank reserves; in fact, they do so by *more* than the actual fall in deposits, as they use part of their liquidity to increase their lending in the interbank market (panel e). For sufficiently large demand for CBDC, however, lending banks run out reserves, and additional deposit outflows are met with a cutback in interbank lending. It is at this point that borrowing banks start borrowing from the central bank lending facility, and that the tightening in the interbank market drives the transition from the corridor to the ceiling system.

Figure 4: Banks' balance sheet variables as a function of the demand for CBDC

Note: Demand for CBDC is varied by changing the parameter $_{DC}$ which determines the household's preferences for CBDC holdings. Units in the vertical axes are relative to total balance sheet size of each of the groups of banks in the baseline scenario without CBDC.