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Digital currencies in financial networks☆

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ABSTRACT

We introduce a central bank digital currency (CBDC) in the network of financial accounts. Simulating a shift of deposits by both households and non-financial corporations from the banking sector to the central bank, we model the different responses of the affected institutional sectors. We find that the introduction of CBDC generates funding shortages in banks, which may propagate to other sectors. In addition, significant adjustments in the balance sheets of all sectors trigger large moves in securities prices and induce changes in the financial network structure. Finally, we extend the analysis to the introduction of a crypto financial asset (stablecoin) issued by either a domestic or a foreign entity.

1. Introduction

Digital currencies have the potential to shape the future of banking and financial intermediation. Whether the provision of a digital currency is provided by the public sector (central bank digital currency, CBDC) or a by a private initiative (referred to in this paper as a stablecoin), the eventual rollout of such new instruments is likely to provide a significant boost to the retail use of digital assets. At the same time, financial innovations may create new risks and vulnerabilities whose implications should be thoroughly assessed. This paper analyses the introduction of digital currencies in the network of financial accounts. We identify key channels through which the effects of these novel instruments materialise in the network, and we reveal significant direct and indirect consequences for most parts of the financial system.

The starting point of our paper is the introduction of a digital currency in the financial accounts. We consider a CBDC as a deposit scheme similar to existing central bank deposit facilities, but with an extended list of counterparties, including non-financial agents. Armed with these definitions, we build on the work by Castrén and Kavonius (2013) and Castrén and Rancan (2014) and incorporate the new financial assets into the "Macro-Network", a network of bilateral exposures among the institutional sectors of the economy. We model the introduction of a digital currency as a deposit shift out of commercial banks to the central bank. Then, we introduce a set of rules in which the banking sector rebalances its accounts. Following these rules, the heterogeneous portfolios of financial assets held by the various sectors imply that the set of tradable assets that one sector may have to offload is not the same as the set of assets that another sector may be willing to acquire. Price adjustments are then required to allow the markets to clear.

Retail deposits are the cheapest and most stable source of funding for commercial banks (Stein, 1998). We observe that even a relatively limited loss of deposits is sufficient to generate significant funding gaps for the banking sector, requiring major adjustments in balance sheets. We analyse several alternative strategies for banks to cover the funding gaps and find that, in all cases, the outcome is inferior to the status quo either in terms of price or stability of funding. We also identify multiple channels through which the effects from the introduction of the CBDC may propagate from banks to the other sectors of the economy. When the banking sector chooses to liquidate debt securities, corporate bonds may suffer a significant drop in prices, causing funding difficulties for non-financial corporations. Differently, in the case in which the commercial banks decide to redeem loans, households may experience significant funding constraints. Finally, by invoking network centrality measures, we observe changes in the relative importance of

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the individual nodes of the network (the institutional sectors). In this way, by changing the shape of the macro-network, the introduction of a digital currency may also affect the network's stability properties. Our findings therefore also support the view that the introduction of digital currencies should take into account wider effects than merely the immediate counterparty exposures. We then extend our framework to the case of the stablecoin, a digital currency issued by the private sector, either domestic or foreign. The introduction of a stablecoin enhances the relevance of the private issuing sector in the macro-network and generates different relative price adjustments in the markets for financial assets. In case of a mixed scenario with both a CBDC and a stablecoin, the ultimate impact will depend on the relative importance of the public and private initiatives and their specific designs.

Our paper contributes to a rapidly growing literature on digital currencies. Theoretical models include among others Andolfatto (2021), Agur et al. (2022), Brunnermeier and Niepelt (2019), Chiu et al. (2019), Kim and Kwon (2019), Keister et al. (2019) and Fernández-Villaverde et al. (2021). These authors investigate the effects of various digital currency designs on bank lending, banks' deposit market power, cost of funding and aggregate welfare, with sometimes conflicting results. Other papers contribute to the conceptual debate on digital currency as instruments in models of monetary exchange and currency competition (Brunnermeier et al., 2019) or by providing a framework to categorise digital monies (Adrian and Griffoli, 2019; Bullmann et al., 2019). Other works introduce CBDC in DSGE models (Ferrari et al., 2020; Barrdear and Kumhof, 2021). While we do not use a general equilibrium model, our paper provides a comprehensive framework to simulate the economic impact of the introduction of a digital currency covering several possible scenarios and including the full range of institutional sectors. On the one hand, we build on the literature on financial networks (Castrén and Kavonius, 2013; Castrén and Rancan, 2014). On the other hand, we resort to the literature of banking models, where retail deposits constitute the cheapest and most stable source of funding, and investigates the implications of funding shocks or fire sales in various contexts (see,e.g., Allen and Gale, 1994; Holmström and Tirole, 1998; Shleifer and Vishny, 1997; Hanson et al., 2015; Drechsler et al., 2018).

Our paper shares some features with Kumhof and Noone (2018) and Bindseil (2020). Using financial balance sheets, Kumhof and Noone (2018) study the introduction of CBDC and derive a set of "core principles" that could prevent runs from retail deposits to CBDC. Bindseil (2020) analyses the system-wide impact of both a CBDC and private digital currencies and argues that a two-tiered remuneration system may be sufficient to mitigate the risk of retail deposit runs to the CBDC. In both works, shocks to individual sectors' asset and liability positions are immediately rebalanced by offsetting shifts in homogeneous asset and liability items. These models implicitly assume that there is only one type of financial asset that can be exchanged in the account rebalancing process. With respect to these papers, our framework accounts for the existing heterogeneity in the portfolios of the different sectors and quantifies the impact to the financial system under various designs of the digital currency, including the risk of disintermediation of the banks' lending activities.

The rest of this paper proceeds as follows. Section 2 presents the data used for the simulations. Section 3 introduces the theoretical framework and the macro-network approach to modelling financial interlinkages. Section 4 describes the main results from the introduction of the CBDC. Section 5 analyses the cases in which a digital currency is issued by a private entity, either domestic or foreign. Finally, Section 6 discusses the main implications and concludes.

2. Data

We use data on sector-level financial accounts – often referred to as flow of funds – from the Euro Area Accounts (EAA), published jointly by the ECB and Eurostat. In the EAA, the analytical grouping of economic agents into institutional sectors and transactions follows the methodological framework established in the European System of Accounts 2010 (ESA2010, the European application of the 2008 System of National Accounts, SNA2008). Ten distinct institutional sectors are considered: households, including non-profit institutions serving households (HH), nonfinancial corporations (NFC), banks (MFI), the central bank (CB), insurance companies (INS), pension funds (PF), other financial intermediaries (OFI), non-money-market-fund investment funds (INV), general government (GOV), and the rest of the world (ROW). Owing to the inclusion of the rest of the world sector, the asset and liability items also include instruments originating from foreign counterparties. Together, these sectors cover the complete financial accounts of the domestic economy, and, by including the ROW sector, the system is closed, i.e. each financial asset item that is held by a sector has a counterparty item on the liability side of some other sector.[1] The categories of financial instruments that constitute the sector-specific balance sheets are distinguished in the ESA2010 and are classified according to liquidity factors and legal characteristics. The analysis in this paper covers the following instrument types: currency, deposits, debt securities, loans, and investment fund shares. The EAA provide who-to-whom tables, i.e. the cross-sector bilateral financial exposures, for all these instruments categories from Q1 2015 to Q1 2021.[2]

Despite the potential for digital currencies to play an important role in the future of banking and finance, allocating these instruments within the system of financial accounts, or in regulatory or accounting standards, is not a straightforward task. At the time of writing, the debate on the treatment of digital currencies in national accounts remains inconclusive (see, e.g., IMF, 2018; OECD, 2018). In order to allocate CBDC, we make the working assumptions that CBDC is a deposit instrument similar to existing central bank deposit facilities but with an extended list of counterparties, including non-financial agents.[3]

3. Introducing digital currency in macro-networks

3.1. The financial system

This section sets up the model, which we then fit to the EEA data, introduced in Section 2. The financial system consists of n institutional sectors i, $i = 1, \ldots, n$, with $n = 10$. The liability side of the balance sheet of sector i in time t, $L_{i,t}$, encompasses X items, including quoted and unquoted equity shares (EQ), deposits, credit (loans) and debt securities and loans (DD), other items (OI)[4] and net wealth (NW), where the latter is defined as total assets minus total liabilities. Formally, we have:

$$L_{i,t} = EQ^L_{i,t} + DD^L_{i,t} + OI^L_{i,t} + NW^L_{i,t}$$

where the superscripts L denote liability items and $DD^L_{i,t} = D^L_{i,t} + B^L_{i,t} + C^L_{i,t}$ is a portfolio of debt items deposits (D^L), bonds (B^L) and credit (C^L). Each liability item can be represented as $\sum_j^n \omega^{X^L}_{i,j,t} X^L_{i,t}$ with weights

[1] Note that, in the financial accounts, the ROW sector is not a "residual" sector; rather, it has its own sources and accounts that are calculated independently, as in the case of any other sector, describing both domestic residence units' assets and liabilities abroad or foreign residence units' assets and liabilities in the domestic economy. The EAA data are non-consolidated, which means that they include financial links not only between the sectors but also within the sectors in the system.

[2] Data are available on the ECB Statistical Data Warehouse.

[3] Instead we assume that a private stablecoin is an investment fund share issued by the investment funds sector (see Section 5).

[4] The largest items in the "Other Items" category are liabilities associated with insurance companies (pre-paid insurance premiums), pension funds (paid pension liabilities), as well as money market and investment fund shares. The counterparty sectors to the first two types of items on the asset side are mainly households and non-financial corporations, and for the latter items households and MFIs.

ω, that are sector-, items- and time-specific. The asset side of sector i is defined as:

$$A_{i,t} = EQ^{A}_{i,t} + DD^{A}_{i,t} + OI^{A}_{i,t}$$

where superscripts A denote asset items and $EQ^{A}_{i,t}$, $DD^{A}_{i,t}$ and $OI^{L}_{i,t}$ are portfolios of equity, debt and other assets issued by all sectors j, including sector i itself. Each asset item can be expressed as $\sum_i^n \omega^{X^A}_{i,j,t} X^A_{i,t}$. At the financial system level, with the rest of the world sector, we have:

$$\sum_{i=1}^{n} L_{i,t} = \sum_{i=1}^{n} A_{i,t} \text{ and } \sum_{i=1}^{n} NW_{i,t} = 0$$

The latter condition means that even if the net wealth positions may be positive or negative at sector level, they cancel out at the financial system level. If the domestic sectors in aggregate show a positive (negative) net wealth position, this will be reflected by an offsetting current account surplus (deficit) position *vis-à-vis* the rest of the world.[5]

3.2. The macro-network

Following Castrén and Kavonius (2013) and Castrén and Rancan (2014), we model the EAA data, introduced in Section 2, as a macro-network. The macro-network consists of a set of bilateral links between the main institutional sectors, which constitute the nodes of the network. The links of the network are the EAA who-to-whom statistics for the different financial instruments. Formally, $\omega^X_{i,j,t} X_{i,t}$ corresponds to links from sector i to sector j at time t, for instrument X. Separate macro-networks are drawn for the different financial instruments. The macro-network allows us to model the financial system as an intertwined set of agents that is particularly suitable for analysis of shock propagation and feedback effects.[6]

Fig. 1 shows the status quo macro-networks of two separate instrument categories, deposits (Panel A) and debt securities (Panel B). The directions of the links between the nodes (the sectors) show the direction of a claim (from liabilities to assets). In the case of deposits, the households (HH), the non-financial corporates (NFC), and the rest of the world (ROW) sectors hold deposit claims that are issued mostly by commercial banks (monetary financing institutions, MFI). The network is incomplete and dominated by strong links between a small number of sectors. By contrast, the network of debt securities is much more complete, as the issuance and holdings of these instruments are more evenly distributed across the sectors.[7]

3.3. The issuance of a digital currency

Next, we assume that at time $t+1$, the digital currency is issued, depending on the specific design and institutional classification of the scheme, by the central bank (CB), the investment funds sector (INV), or the rest of the world sector (ROW). The introduction of the digital currency implies a funding shock ϵ in the form of a switch of deposits by both households (HH) and non-financial corporations (NFC) from MFI to the sector y that is issuing the digital currency, with $y \in \{CB, INV, ROW\}$. Formally:

$$L_{MFI,t+1} = EQ^{L}_{MFI,t+1} + (DD^{L}_{MFI,t} - \epsilon) + OI^{L}_{MFI,t+1} + NW^{L}_{MFI,t+1}$$

and

$$L_{y,t+1} = EQ^{L}_{y,t+1} + (DD^{L}_{y,t} + \epsilon) + OI^{L}_{y,t+1} + NW^{L}_{y,t+1}$$

If we assume that the sectors will not absorb the shock in their net wealth positions, i.e. $NW_{i,t+2} = NW_{i,t+1} = NW_i$, then, at $t+2$ we have, for sector y:

$$A_{y,t+2} = EQ^{A}_{y,t+2} + (DD^{A}_{y,t+2} + \epsilon) + OI^{A}_{y,t+2}$$

We assume that, to offset the increase in its deposit liabilities, the sector issuing the digital currency may choose one of the following options:

(i) $A_{y,t+2} = EQ^{A}_{y,t+2} + (DD^{A}_{y,t+1} + \delta D) + OI^{A}_{y,t+2}$
(ii) $A_{y,t+2} = EQ^{A}_{y,t+2} + (DD^{A}_{y,t+1} + \delta B) + OI^{A}_{y,t+2}$
(iii) $A_{y,t+2} = EQ^{A}_{y,t+2} + (DD^{A}_{y,t+1} + \delta C) + OI^{A}_{y,t+2}$

With $\delta D = \delta B = \delta C \equiv \epsilon$. Option (i) means that sector y redeposits the funds with the commercial banks (MFIs). Under option (ii), sector y purchases debt securities to offset its increase in investible funds. Under option (iii), the sector issuing the digital currency treats the deposits as loanable funds and extends credit (loans). On the other hand, to offset the reduction in its deposit liabilities, the MFI sector will choose between the following non-exhaustive set of options:

(i) $L_{MFI,t+2} = EQ^{L}_{MFI,t+2} + (DD^{L}_{MFI,t+1} + \delta) + OI^{L}_{MFI,t+2} + NW_{MFI,t+2}$
(ii) $A_{MFI,t+2} = EQ^{A}_{MFI,t+2} + (DD^{A}_{MFI,t+1} - \delta) + OI^{A}_{MFI,t+2}$
(iii) $A_{MFI,t+2} = EQ^{A}_{MFI,t+2} + (DD^{A}_{MFI,t+1} - \delta) + OI^{A}_{MFI,t+2}$
(iv) $L_{MFI,t+2} = EQ^{L}_{MFI,t+2} + (DD^{L}_{MFI,t+1} + \delta) + OI^{L}_{MFI,t+2} + NW_{MFI,t+2}$

The response by the MFI may be in the form of (i) an increase in the deposit liability portfolio (receiving re-deposited funds from sector y), (ii) a reduction in the bond asset portfolio, (iii) a reduction in the bank credit asset portfolio, or (iv) an increase in the bond liability portfolio with new issuances. Note that MFI could completely offset the funding shock ($\delta = \epsilon$) only if there are no financial frictions or transaction costs. However, in practice this is not the case ($\delta < \epsilon$). Indeed, retail deposits are considered both the cheapest and most stable source of funding for banks (Allen and Gale, 1994; Stein, 1998).

Crucially, even if the magnitudes of the various portfolio shifts by MFI are similar to the portfolio shifts experienced by sector y, the compositions of the asset portfolios are different. Depending on the specific re-balancing strategies followed by the various sectors, the assets sold/liabilities issued by MFI and the assets purchased by sector y are not identical, and the transactions may therefore require price adjustments to allow the markets to clear.[8] Moreover, the changes in bilateral exposures at $t+2$ may trigger further adjustments in the

[5] The domestic sectors that typically show negative net wealth positions (i.e. they are net borrowers in the system) are the government and the non-financial corporate sectors. Households constitute the main surplus, or creditor, sector. The financial sectors are mostly financial intermediaries and tend to have nearly balanced net wealth positions.

[6] There is now an extensive body of literature on financial networks. In their study of bank runs, Allen and Gale (2000) demonstrated the different contagion effects implied by complete versus incomplete network structures. Several papers study contagion effects across financial institutions, using interbank loans as financial links (see, e.g., Upper and Worms, 2004; Gai and Kapadia, 2010; Mistrulli, 2011; Glasserman and Young, 2015). Some authors have considered a broader set of interlinkages between banks, both on the asset and the liability side, with the aim of better characterising how financial institutions are connected to each other (Aldasoro and Alves, 2018; Poledna et al., 2015; Bargigli et al., 2015; Caccioli et al., 2014). Papers that investigate network structures, their properties, and the implications for financial stability include Craig and Von Peter (2014), Peltonen et al. (2014) and Roukny et al. (2018). Departing from the micro-level analysis, some authors treat the network nodes as more aggregate entities, such as countries (see, e.g., Kali and Reyes, 2010) or industries (see, e.g., Acemoglu et al., 2016). Stolbova et al. (2018) apply a framework similar to the macro-network to assess the economic impact of climate policies.

[7] Note that because the data from Euro Area Accounts are non-consolidated, they include intra-sector exposures. For the clarity of the presentation, the intra-sector links are not shown in the graphs, but they are always accounted for in the calculations.

[8] While we do not explicitly model prices, our analysis below provides insights about the sectors whose securities will be most affected in various scenarios. See Greenwood et al. (2015) and Adrian and Shin (2010) for papers that investigate financial fragility considering fire sales and leverage targeting.

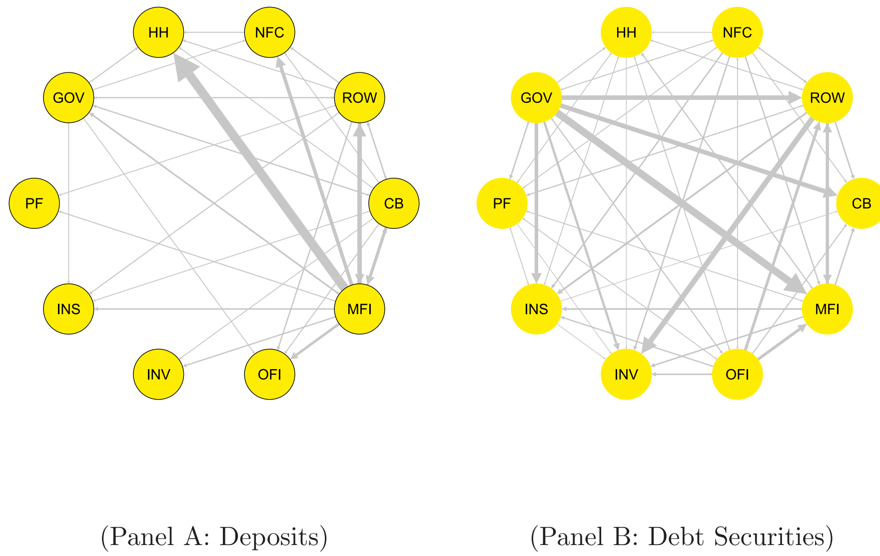


Fig. 1. Examples of macro-networks in two categories of financial instruments. Panel A: Network of deposits; Panel B: Network of debt securities. Arrows run from liabilities to assets.

system (e.g. the sector that loses bank financing under MFI options (ii) and (iii) at time $t+2$ could cover the funding gap by issuing its own debt securities which would have to be absorbed by the other sectors). Several additional rounds of rebalancing could be considered to incorporate more periods into the analysis. Since our focus is on the immediate effects of the introduction of a digital currency, we limit the contagion analysis to only the first stages of the process and the most relevant transactions between sectors, which are sketched in Fig. A.12 in Appendix.[9]

4. Central bank digital currency

4.1. Scenario analysis

To illustrate the introduction of the CBDC, as baseline we consider the EAA data described in Section 2 using the asset and liability items of each institutional sector as of Q1 2021.

The launch of the CBDC creates an initial funding shock, defined as a withdrawal of 20% of the MFI deposits by both households and firms. Fig. 2 illustrates the impact of the introduction of the CBDC at $t=1$, step-by-step. Starting from the network of deposits before the introduction of the CBDC (depicted in Fig. 1, Panel A), in Panel B, private non-financial-sector depositors have withdrawn 20% of their commercial bank (MFI) deposits (the light blue arrows show the "weakened" deposit links after the withdrawals). This amounts to a decrease in overall MFI deposits of roughly 9%.[10] In Panel C, the deposits withdrawn from the commercial banks have been placed in accounts with the central bank, so that households and firms now hold direct claims against the central bank (the dark blue arrows).

As explained in Section 3.3, the shifts in deposits trigger wider changes in the affected sectors' balance sheet aggregates at $t=2$. We consider a non-exhaustive list of four alternative scenarios – each of which describes a set of actions independently taken by the relevant agents – that are sufficient to complete the process.

(i) *Scenario A.* The CB redeposits the funds with the commercial banks (MFIs) to offset the increase in its deposit liabilities;
(ii) *Scenario B.* The MFI sells debt securities (assets) to offset the reduction in its deposit liabilities; the CB purchases debt securities to offset the increase in its deposit liabilities;
(iii) *Scenario C.* The MFI redeems loans (assets) to offset the reduction in its deposit liabilities; the sector which loses bank financing replaces loans (on the liabilities side) by issuing its own debt securities; the CB purchases debt securities to offset the increase in its deposit liabilities;
(iv) *Scenario D.* The MFI issues debt securities (liabilities) to offset the reduction in its deposit liabilities; the CB purchases debt securities to offset the increase in its deposit liabilities.

As a result of all these transactions, the central bank's balance sheet expands while the commercial banks' balance sheet either shrinks (in Scenarios B and C) or remains unchanged (in Scenarios A and D). This does not have to be the case, however. The central bank could also decide to offset the increase in its liabilities by using the CBDC as a substitute for other liability items, for example by retiring banknotes. We now analyse each scenario separately.

Scenario A. Fig. 3 displays Scenario A. The re-depositing of the funds by the CB to the commercial banks (MFI) is shown by the blue arrow. In practice, the transaction is a monetary policy operation whereby the banks tap the central bank repo financing facility to cover their funding gap. Although, in terms of balance sheet items, the loans from the central bank fully offset the banks' funding gap, there are other characteristics that make the positions heterogeneous. First, in terms of pricing, the banks' funding has now shifted from cheaper retail deposits to more expensive central bank repos. Second, central bank repo financing is collateralised, which means that a relevant share of the banks' securities portfolios will become encumbered. Third, central bank financing is short-term and has to be rolled in the absence of alternative funding sources. In contrast, retail deposits, although in theory mostly callable on demand, are in practice the most stable source of bank funding (Gropp and Heider, 2010).

Scenario B. Here, the rebalancing occurs solely through the actions of the commercial banks instead. The process involves transactions in debt securities (bonds) rather than deposits, and the relevant macro-network considered is the one drawn on the former instrument category. The main holding sectors of bonds are investment funds, banks and, as a result of the Eurosystem's extensive QE policies, the central bank. Given that the banks' securities portfolios consist of bonds issued by several other sectors, including the MFI itself, it is necessary to introduce some order according to which the various types of bonds

[9] Notice that the time gap between $t+1$ and $t+2$ can be considered infinitely short in the case of transactions between the CB and the MFI.

[10] We further explore this point in Section 4.2.1.

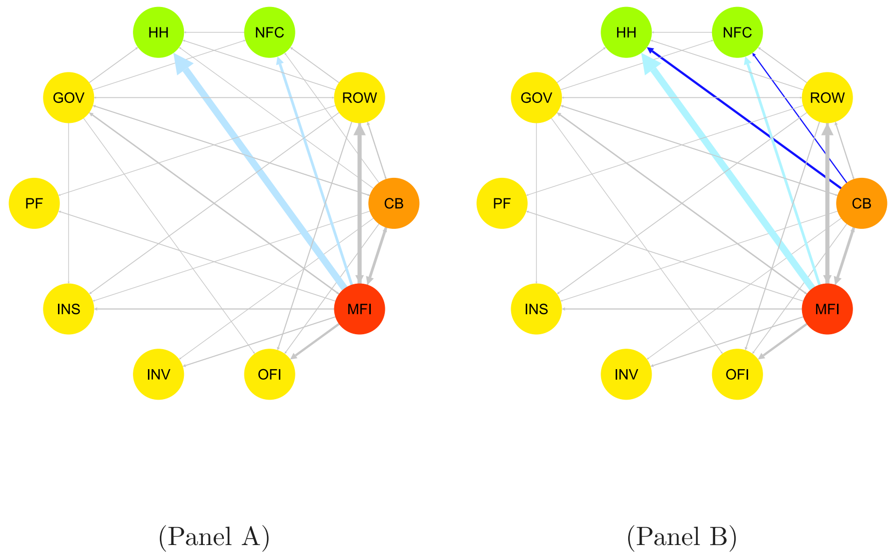


Fig. 2. Central bank digital currency: Network of institutional sectors, instrument deposits, $t = 1$. Panel A: Network of deposits after NFC and HH have withdrawn 20% of their deposits; Panel B: Network of deposits after NFC and HH have invested funds in CBDC. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

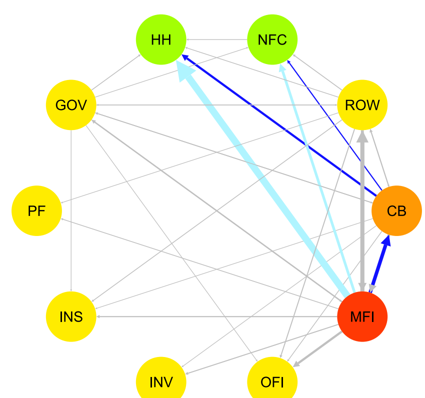


Fig. 3. Central bank digital currency: Network of institutional sectors, instrument deposits, Scenario A. Network of deposits after CB redeposits funds at MFI in $t = 2$. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

will be disposed of. Following previous literature (see, e.g., Greenwood et al., 2015), the banks are assumed to sell bonds in proportion to their existing holdings, in order to cause minimal changes to their existing portfolio structures.[11]

This, however, has a price impact on the debt securities market, represented in Fig. 4, and affects the funding positions of other sectors. We assume in the analysis that the central bank uses the resources it receives from the introduction of the CBDC to increase its holdings of debt securities by purchasing bonds according to its existing holdings.[12]

Overall, the differences in portfolio structures and rebalancing strategies between commercial banks and the central bank mean that, in the rebalancing process, the bonds that are subject to bids and those that are offered are not the same. The heterogeneous compositions of the commercial banks' and central bank's bond portfolios mean that some bonds will be subject to excess demand, while an excess of supply will occur for others, and market clearing will consequently require price adjustments. The graph illustrates the resulting imbalance between the supply of and demand for bonds, by sector. In the cases where supply from the commercial banks (the red bars) exceeds the demand from the central bank (the blue bars), the bond prices will fall, and vice versa in the cases where demand exceeds supply. Under the rules invoked in this stylised exercise, the bonds facing upward price pressure would be those issued by the GOV and NFC sectors. Conversely, the bonds facing downward price pressure would be those issued by the OFI, MFI, and ROW sectors. Commercial banks are large holders of foreign debt instruments, while the CB usually refrains from such purchases in operations other than dedicated foreign exchange interventions. The excess supply of foreign bonds is thus likely to contribute both to a fall

[11] However, one could easily imagine alternative strategies. For example, the order in which the bonds are sold could instead be stipulated by their risk characteristics. In this case, the bonds with the lowest ratings and/or the highest risk weights (such as high-yield corporate bonds) would be offloaded first, whereas the bonds with the lowest risk weights (those issued by the government sector, with zero risk weight) would be the last to be sold. Another strategy would be to sell the most liquid bonds first, an approach that would typically be deployed in emergency, or fire-sale, situations. In this case government bonds and credit issued by larger, higher rated corporates would be at the top of the sales list.

[12] An alternative strategy would be akin to QE purchases, where acquisitions are made according to a pre-announced plan for various types of bonds; it is not unreasonable to assume that CBDC-related purchases would also follow some plan that the central bank could decide to make public.

in their price and to a depreciation of the foreign currency vis-à-vis the domestic currency. Besides of the price impact on debt securities, the MFI rebalancing strategy may also cause funding constraints in some sectors. By computing the ratio between the bonds issued by sector i that are sold by the MFI and the total outstanding amount of bonds issued by sector i, we find that OFI, MFI and ROW with a ratio of around 10% would be significantly affected.

Scenario C. In this scenario the commercial banks redeem loans to offset the loss of deposits. In the network of loans, the MFI, ROW and OFI sectors are the key nodes. The baseline assumption in such a "deleveraging scenario" is that loans are also redeemed proportionally according to the existing stocks of loans extended by the banks to the other sectors (including interbank lending within the MFI sector itself).[13] We compute the ratio between the loans extended by banks to sector i but redeemed following the shock and the total outstanding amount of loans extended to sector i, to get a measure of the loan-funding gap for each sector (in the absence of new lending by some other sector in the system). Table 1 shows that, after such proportional redemptions by the commercial banks, HH and INV sectors are the most strongly affected sectors, with a reduction of loans by more than 10%, followed by the GOV and NFC sectors for which the reduction amounts to 6%. The debtor sectors that lose part of their bank funding now face the choice of either shedding assets or seeking alternative funding sources. The latter can be either new loans extended by some other sector or debt securities issued by the sector itself. We assume that the sectors with access to debt capital markets – mainly the Government, NFC and ROW sectors – choose to issue new bonds, while the households sector reduces its existing bond holdings (assets) to offset the loss of bank financing. Fig. 5 shows the supply–demand imbalances that arise in this case. Note that the demand side for debt securities remains the same as in Fig. 4, because the central bank again rebalances its portfolio proportionally, given its existing mix of bond holdings. However, on the supply side, there are now both the debt securities sold by HH, which are bonds issued mainly by the GOV and MFI sectors, and the debt securities newly issued by mostly the NFC, OFI, ROW and GOV sectors. Combining the behavioural responses of all sectors, the bonds experiencing upward price pressure are those issued by GOV, while the bonds now facing the most downward price pressure are those issued by the corporate sector. The significant deterioration of the non-financial corporate sector funding situation in this case comes from two distinct sources. First, firms in the euro area rely heavily on bank loans as a funding source, and they are therefore strongly affected by the deleveraging of the commercial banks. Second, according to its portfolio structure, the central bank purchases only a relatively small portion of the non-financial corporate bonds that the firms issue to substitute for the reduced lending by the commercial banks. The price of the NFC bonds then has to fall to make it attractive for the other sectors to absorb the increased supply.

Scenario D. Fig. 6 demonstrates the impact when rebalancing takes the form of the commercial banks issuing new bonds and the CB increasing its bond holdings (different colours of the bar on the left side indicate the sector that could buy the newly issued bonds according to the current preferences). Because the entire supply of debt securities now consists of bank bonds, while the demand side is again split across various issuers according to the CB's current portfolio, market clearing requires a meaningful drop in the price of MFI bonds. According to the baseline rule of proportional purchases, the CB would absorb less than 12% of the newly issued bank bonds, while, based on its portfolio structure, it would have the strongest demand for government bonds (71%).[14] In this scenario, the commercial banks therefore not only lose deposits to the CBDC in $t = 1$ but they also see an increase in their cost

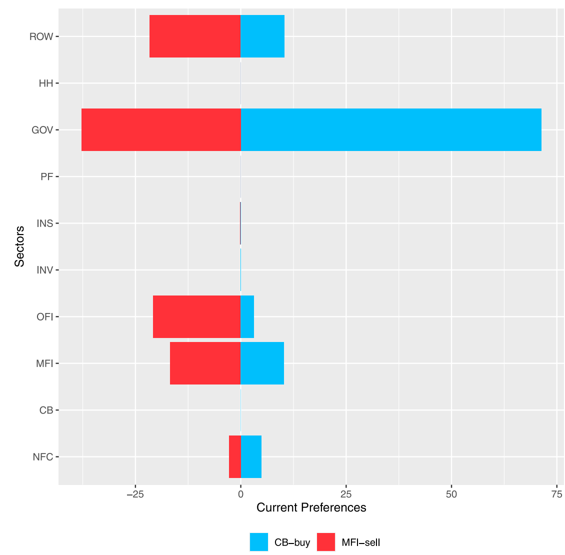


Fig. 4. Impact on debt securities, Scenario B. The graph shows the supply–demand imbalance in debt securities across individual sectors for CBDC, Scenario B. Red bars represent the debt securities that MFI would sell to keep its exposures constant and blue bars represent the debt securities that CB would buy to keep its exposures constant. All values are normalised and expressed in percentage terms. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

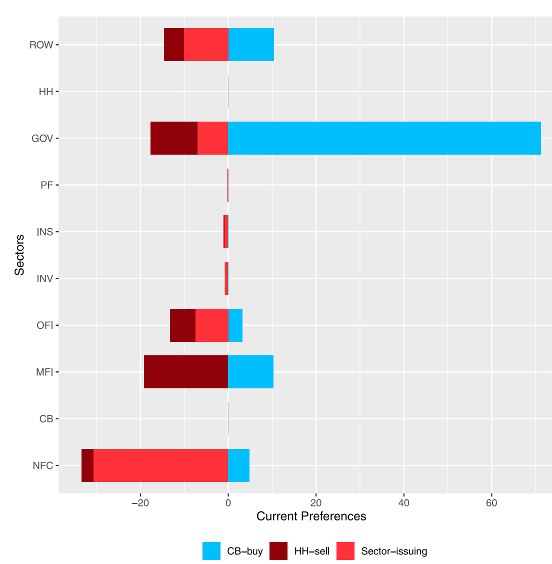
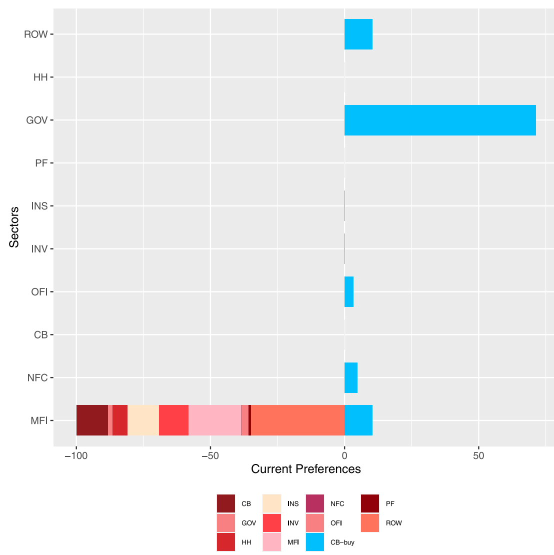


Fig. 5. Impact on debt securities, Scenario C. The graphs show the supply–demand imbalance in debt securities across individual sectors for CBDC, Scenario C. In Panel B dark red bars represent the debt securities that HH would sell, red bars represent the amount of new debt issuance to offset MFI redemption of loans, and blue bars represent the debt securities that CB would buy to keep its exposures constant. All values are normalised and expressed in percentage terms. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

[13] However, plausible alternative scenarios can be envisaged in this case as well: for example, redemption decisions could be based on the risk characteristics of the loans. In that case, consumer credit and corporate SME loans would typically be redeemed first, owing to their higher historical loss characteristics.

[14] In the case of the Eurosystem, the Asset Purchase Programme (APP) has skewed the CB securities portfolio heavily in favour of government bonds. In addition, as regards MFI bonds, the Eurosystem rules currently allow purchases of covered bonds only. Other sectors, including the ROW, insurance companies,



(a)

Fig. 6. Impact on debt securities, Scenario D. The graph shows the supply–demand imbalance in debt securities across individual sectors for CBDC, Scenario D. Blue bars represent the debt securities that CB would buy to keep its exposures constant. The bar on the left corresponds to the new debt issuance by MFI, split according to the sectors holding the existing MFI bonds. All values are normalised and expressed in percentage terms. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Funding gap: CBDC, Scenario C. The table shows the funding gap defined as the amount of loans redeemed by the MFI after a shock ($\varepsilon = 20\%$) and the total loans of sector i. Values are expressed in percentage terms.

Sector	Funding-gap
NFC	6.17
CB	–
MFI	–
OFI	3.11
INV	10.5
INS	4.28
PF	3.08
GOV	6.52
HH	13.76
ROW	4.57

of market-based funding in $t = 2$, due to the limited capacity of the other sectors to absorb new MFI issuance.[15]

4.2. Comparative statics

In this section, we provide further analysis of the contraction of banks' balance sheets (Section 4.2.1) and changes in the network structure (Section 4.2.2) that are caused by the introduction of the digital currency.

4.2.1. Funding gap

Retail deposits are a stable source of funding for commercial banks (MFI), generally less sensitive to changing market conditions and a given bank's financial performance. It is therefore important to evaluate the broader impact on banks of the deposit shift triggered by the introduction of a digital currency. For this, we define $Funding-gap_{MFI}$ as the ratio between the amount that is withdrawn by corporate and household depositors (the funding shock ε) and the total amount of deposits held by all sectors with commercial banks. Fig. 7, provides a quantification of the funding gap under different levels of ε and δ, considering a funding shock originated by HH and NFC (white–yellow surface) or by HH, NFC and ROW (white–red surface). Starting from the case in which $\delta = 0$, under the baseline scenario where the private non-financial sectors each withdraw 20% of their bank deposits, the negative impact on the overall MFI deposit stock is limited to around 9%, with household depositors as the main contributor. When the size of the deposit shock increases, the funding gap of commercial banks also increases. For example, setting the shock at 70% of both NFC and HH deposits would cause a loss of 32% of all commercial bank deposits. Such a large outflow would require a more significant rebalancing effort. In a scenario where the ROW sector also shifts a share of deposits to a digital currency (white–red surface), the overall funding shock for MFI would raise to almost 42%. While it might be unreasonable to expect shifts of such magnitude to occur in a short period of time, the exercise nevertheless highlights the importance of the potential shifts in market shares in deposits. Furthermore, the frictions in the funding markets complicate the banks' efforts to raise alternative funding. The graph shows that the funding gap is close to 0 if CB redeposits the funds with the commercial banks (Scenario A). However, this is the case only if $\delta \simeq 100$, otherwise commercial banks' deposits still shrink significantly. Indeed, central bank repos are of short maturity, collateralised, and usually more expensive than retail deposits. In Scenario D, where the banks tap the wholesale funding market, access may be limited, especially for smaller, low-rated or riskier institutions (Goncharenko et al., 2021; Rixtel et al., 2015; Camba-Mendez et al., 2014). Also, empirical results show that for European banks new bond issuance is often difficult in periods of market tensions or crisis (Rixtel et al., 2015), and the amount raised is limited by high levels of government debt due to a crowding-out effect (Rancan et al., 2022).

Under Scenarios B and C, commercial banks transfer the funding gap to other sectors, thus weakening their funding positions. Also in these cases, when ε increases, the funding shortages may become significant and challenging to offset with alternative sources of funding. Empirical evidence with U.S. data show that bank-dependent firms are not always able to find alternative sources of financing (Supera, 2021) and even for those firms that rely on the bond market their abilities to raise funds are influenced by macroeconomic conditions (Erel et al., 2012). Moreover, compared to the U.S. corporate bond market, the European market is significantly smaller and less mature, with only a limited number of generally large and listed firms issuing (Altunbaş et al., 2010).

Overall, therefore, depending on the scenario, the introduction of a digital currency may create funding shortages either for the commercial banks or some other sectors.

4.2.2. Changes in the macro-network structure

We now turn to an investigation of how the structures of the macro-networks change with the introduction of the CBDC. To do this, we introduce closeness, a network centrality measure that allows us to quantify the changes in the networks that are triggered by the introduction of the digital currency and the rebalancing process that follows it. Measures of network centrality quantify the position of a given node in the network and provide insights into contagion and diffusion processes. They have been used to investigate the effect of the global financial crisis on the interbank market (Affinito and Pozzolo, 2017), the dynamics of the global banking network (Minoiu and Reyes, 2013), and the relationship between international trade linkages and stock market returns (Kali and Reyes, 2010).[16] We apply closeness

pension funds, investment funds and households, are the largest buyers of unsecured MFI bonds.

[15] Note that the drop in bank bond prices that is necessary for the markets to clear implies an increase in yield, thus adding to the periodic coupon payments both on new debt and on the outstanding stock of debt.

[16] Other applications include analysis of venture capital firms and fund performance (Hochberg et al., 2007), the effect of CEOs' social connections on M&A outcomes (El-Khatib et al., 2015), and other corporate finance policy decisions (Fracassi, 2017).

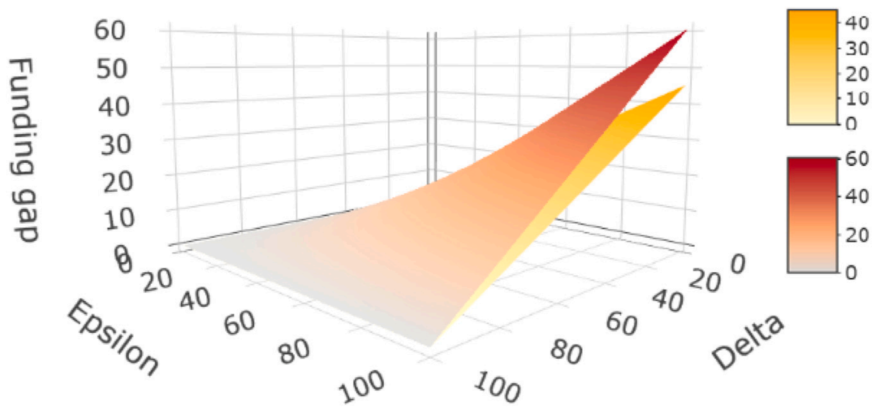


Fig. 7. Banks funding gap. The graph shows the MFI funding gap (y-axis) and the size of the initial shock ε (x-axis) over the size δ of CB redeposits with MFI (z-axis) for CBDC, Scenario A. The white–yellow (white–red) surface considers the case of a withdrawn by the NFC and HH sectors (NFC, HH and ROW sectors). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

as a measure of how "close" a node is to all the other nodes in the network. Even if the macro-networks considered here consist of only 10 nodes (institutional sectors), closeness can provide an indication of how the importance of each sector in the system changes.[17] We consider Scenario A, which is the simplest one for MFI. Drawing from the network of deposits, Fig. 8 shows how the closeness measure of MFI and CB varies with the size of the shock in the case of a CBDC (Panels A and B) across the various simulation stages. Following the introduction of the CBDC, the graphs show the growing centrality of the central bank at the expense of MFI centrality in $t = 1$. CB centrality then decreases with increase in the shock size after rebalancing at time $t = 2$, but it does not reach the pre-shock level; as a result the centrality of the MFI sector is lower at $t = 2$ than at $t = 0$. These changes are magnified by an increase in the shock size. Importantly, this proves that even in the most conservative scenario, where the MFI borrows the lost deposits back from the digital currency issuing sector, the relative importance of the various sectors and the structure of the "steady state" macro-network change.[18]

5. Alternative digital currency designs

Our framework is general enough to encompass alternative designs where the digital currency may be issued by an entity different from the central bank. The digital currency issuer can be a private entity, operating as part of the investment funds sector (Section 5.1). Alternatively, the stablecoin issuer can be a foreign entity located in the "rest of the world" sector but with part of its global reserve fund assets denominated in the domestic currency (Section 5.2). The vehicle controlling the domestic fraction of the reserve fund would then typically be a locally licenced and supervised subsidiary within the domestic investment funds (INV) sector. Within the system of financial accounts, we assume that private stablecoins are instruments akin to investment fund shares.

5.1. A domestic stablecoin initiative

Digital currencies come in a wide variety of forms. Here we focus on the special case of instruments that are 100% backed either by fiat currencies or assets that are close substitutes for fiat currencies. Such private initiatives have been launched globally mainly as domestic payment projects that operate under a single jurisdiction, or in a single currency area.[19] In our framework the stablecoin issuer is incorporated into the investment funds sector (INV). In Fig. B.14 in Appendix, the deposits that shift out of the commercial banks (the MFI sector, Panel B) are now directed to the investment funds sector as "non-MFI deposits" (Panel C). At $t = 2$ the deposit shift again triggers a rebalancing process. Like the CBDC, alternative scenarios can be considered with the main difference being that the sector disrupting the status quo is now the stablecoin issuer (INV sector). Specifically, INV can either redeposit the funds received from the sales of the stablecoins with the MFI sector (Scenario A) or it can purchase short-term debt securities and place them in its reserve fund to match the increase in its deposit liabilities (Scenarios B–D).[20]

Scenario A is captured by Fig. 9. The domestic stablecoin, which is part of the INV sector, redeposits the funds with the commercial banks, as shown by the dark blue arrow now connecting the two sectors. The stablecoin reserve fund then consists of 100% commercial-bank deposits, and the rebalancing occurs without any further action required by the MFI sector. As a result, the INV sector becomes a key node in the network of deposits. The re-depositing of funds by the stablecoin issuer with the commercial banks raises some questions, however. For example, there is no a priori way of guaranteeing that the banks that lost deposits at $t = 1$ are the same as those that will receive deposits from the stablecoin at $t = 2$. In the cases where rebalancing takes the form of actions initiated by the commercial banks instead, the behavioural responses are similar to those with the CBDC (see scenarios B–D Section 4.1). However, since the ultimate buyer of the debt securities is now the stablecoin issuer (the INV sector), the purchases are made in proportion to its portfolio stock of assets. However, alternative rules could be considered, too. For example, the stablecoin issuer may want a reserve fund consisting of only cash-like securities, making the structure akin to a money market fund. The network of debt securities thus changes when the stablecoin issuer (INV sector) rebalances its accounts by purchasing bonds in proportion to the reserve fund's existing holdings. Fig. 10 shows the resulting

[17] We use the weighted version of closeness to take changes in the intensity of the financial linkages into account properly.

[18] We obtained similar insights using betweenness as an alternative measure of centrality, which approximates the extent to which a particular node lies "between" the other nodes in the network. Fig. A.13 in Appendix shows the betweenness for the MFI and CB in $t = 1$ when the size of the shock increases.

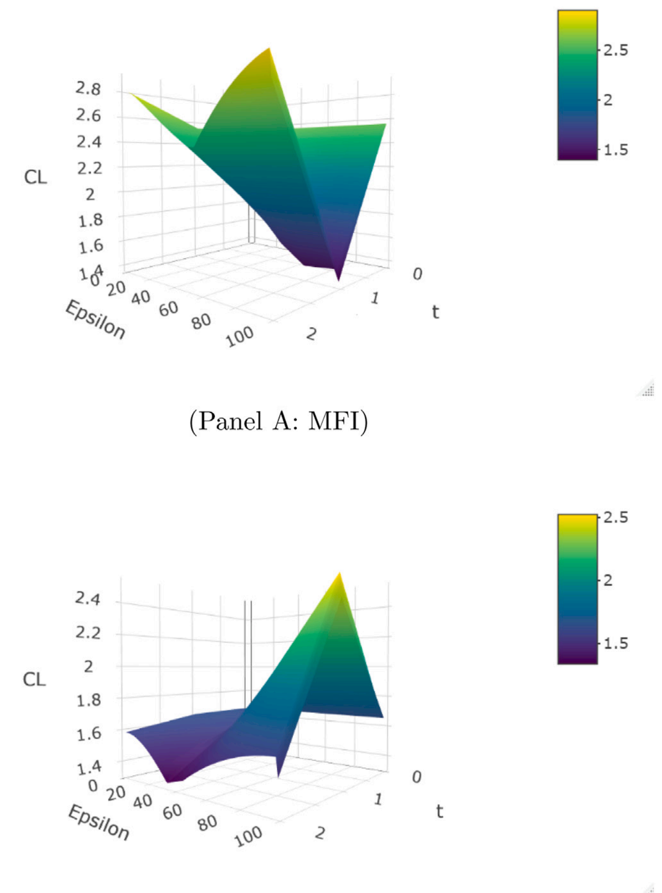
[19] These projects range from small local payment operators to vast and near-dominant players in digital payments, such as AliPay and WeChat in China. The natural advantage for tech companies in this area is their ability to combine a proprietary payments rail with existing online platforms that provide large user bases and the potential for significant network effects.

[20] Another possibility is that the INV sector lends part of the new deposits directly to the non-financial sectors. Then, it would be important to evaluate whether this may lead to an efficient allocation of credit, but such analysis is beyond the scope of the present paper.

supply/demand imbalances in the bond market. The prices of GOV, OFI and MFI debt securities will face downward pressure, while the prices of ROW and NFC bonds will experience upward pressure.[21] Notice that while, demand for government bonds exceeds the amount that would be sold by commercial banks in the case of CBDC, under a stablecoin we may face a very different outcome because of the different preferences for debt securities of the digital currency issuing sector.[22] This implies that, depending on the digital currency design different sectors may face funding difficulties.

5.2. A global stablecoin initiative

Digital currency can also be set up as a global stablecoin initiative. The difference compared to a purely domestic model is that the ROW sector now plays a key role, with the relative importance of the domestic investment funds sector depending on the weight of the domestic economy in the stablecoin issuer's global reserve fund. Some observers have suggested that a global stablecoin whose reserve fund is denominated in a (mix of) foreign currencies could be considered a currency board type arrangement (see Anderson and Papadia, 2020). For the analysis below, adopting this analogy would make no difference in theory, but since currency boards are not a concept that is included in either the national accounts or the regulatory classifications, we consider the global private digital currency/stablecoin a non-MFI deposit scheme. Fig. B.15 in Appendix illustrates this case, with Panel A showing the network of deposits after 20% MFI deposit withdrawals by the HH and NFC sectors. In Panel B, the funds are transferred to the ROW sector where the global stablecoin issuer vehicle resides. Panel C shows the final step at $t = 1$, where the global stablecoin vehicle moves a share of γ of its globally acquired deposits from the ROW (its home jurisdiction) back to the domestic financial system (the host jurisdiction from the global stablecoin's perspective), where γ denotes the weight of the domestic currency in the stablecoin's global reserve fund. In the simulations, it is assumed that this weight equals 30.93%, which is the current weight of the EUR in the IMF's SDR basket. The rebalancing process must now take into account that the funds withdrawn from the commercial banks' deposit accounts are split between two sectors. A share of γ will go to the global stablecoin's domestic subsidiary in the domestic financial system (placed in the INV sector), whereas the share of $1-\gamma$ will move to the ROW. The familiar Scenarios A to D for rebalancing are now somewhat different. Under Scenario A the domestic INV sector first redeposits its share of γ with the domestic commercial banks (the MFI sector), leaving the MFIs with a remaining funding gap of $1-\gamma$. The ROW sector goes through its own rebalancing process, but at the end of the day, it will hold $1-\gamma$ worth of surplus EUR denominated funds, which it will deposit at the host country's central bank (the eurosystem). In the case of the eurosystem balance sheet these funds would go under the balance sheet item "EUR denominated deposits by non-euro area residents". The domestic (host country, from the perspective of the stablecoin issuer) commercial banks then borrow these funds from the central bank in its repo operations to cover their remaining funding gap.



(Panel A: MFI)

(Panel B: CB)

Fig. 8. Sector centrality measure at different simulation stages. The graph shows closeness (normalised) computed for the macro-network of deposits at different the simulation stages of CBDC, Scenario A. Panel A refers to MFI and Panel B to CB. The $x-axis$ measures the size of the shock. The $y-axis$ depicts the scale of the centrality measure closeness. The $z-axis$ shows t the simulation stages of CBDC.

Scenarios B–D are similar to those described in Sections 4.1 and 5.1, with the difference being that if, for example, the MFI sector issues new bonds, these bonds cannot be purchased by the ROW sector, since the latter will not acquire euro area assets in excess of its share of $1-\gamma$. However, given that, in a closed financial system, the ROW sector ultimately redeposits its share of $1-\gamma$ with the domestic central bank, in scenarios B to D the securities purchases are made jointly by the CB and the INV sectors, with the relative shares determined by the size of γ. Fig. 11 shows the ratio between demand and supply in debt securities for Scenario B as a function of γ, with $\gamma = 0$ corresponding to the CBDC framework and $\gamma = 1$ to the domestic stablecoin initiative. The graph highlights that, as γ changes, the price impact varies for bonds issued by all sectors, with the GOV and INS sectors showing the highest variation.

6. Discussion and conclusion

This paper applied the financial accounts network to study the implications of the introduction of digital currencies. We demonstrated the now well-documented deposit shifts and their potential to generate large funding gaps for commercial banks. We stressed the negative consequences for the commercial banks of replacing cheap and stable deposit funding with collateralized, expensive and short-maturity funding from the central bank or from the wholesale market. We also illustrated the propagation of the funding stress to the non-financial sectors along the links of the network. Moreover, the network approach

[21] If the stablecoin reserve invested solely in cash-like assets, the GOV bonds would rise in price, whereas the prices of bonds issued by all other sectors would fall.

[22] Under Scenario C downward price adjustments will now be prevalent for the NFC, MFI, OFI, and GOV debt securities, while upward adjustments are limited to foreign (ROW) issued bonds. Concerning Scenario D the bond issuance of the banking sector is offset by the purchases of the stablecoin only for 8% (INV would have the strongest demand for foreign bonds) and the resulting excess supply of bank bonds will only be absorbed by the other sectors if prices fall. This drop in prices of MFI bonds would be more substantial if the stablecoin issuer had a mandate only to purchase government issued securities.

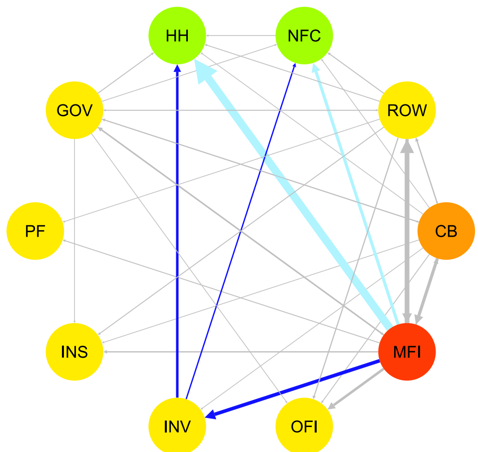


Fig. 9. Domestic stablecoin initiative: Network of institutional sectors, instrument debt securities, Scenario A, $t = 2$. Network of deposits after INV redeposits funds at MFI in $t = 2$. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

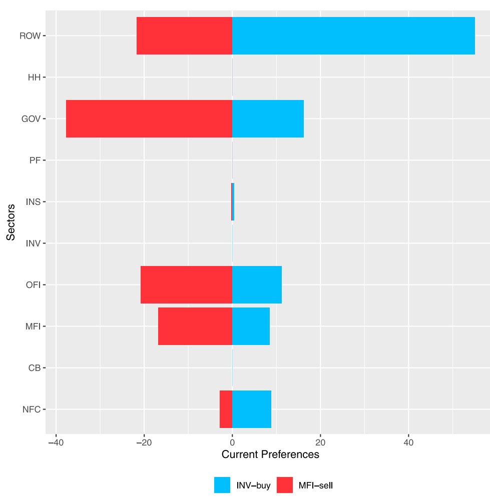


Fig. 10. Impact on debt securities: Domestic stablecoin initiative, Scenario B. The graph shows the supply–demand imbalance in debt securities across individual sectors for Scenario B. Red bars represent the debt securities that MFI would sell to keep its exposures constant and blue bars represent the debt securities that INV would buy to keep its exposures constant. All values are normalised and expressed in percentage terms. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

allowed us to unearth another risk from the introduction of a digital currency, which is the price adjustment in financial assets that is triggered by the rebalancing process following the shifts in deposits.

In terms of policy recommendations, the following sequence of key points summarises our findings. (i) Design: how the digital currency scheme is established (public or private issuer and the statistical/accounting/regulatory classification) makes a difference to the issuing sector, the banking sector, the retail users/depositors and the monetary/regulatory authorities. Specific circumstances may favour certain designs over others. (ii) Reaction: how the affected parties adjust to the introduction of the digital currency by shifting deposits and rebalancing their accounts depends not only on (i) but also on the incentives and constraints/mandates that they face. There may be ways to shape these incentives through mechanism design and public policy. (iii) Third parties: given that the financial system is a network of exposures, third parties will be affected by the introduction of a digital currency and the rebalancing that follows it. The identity of these third

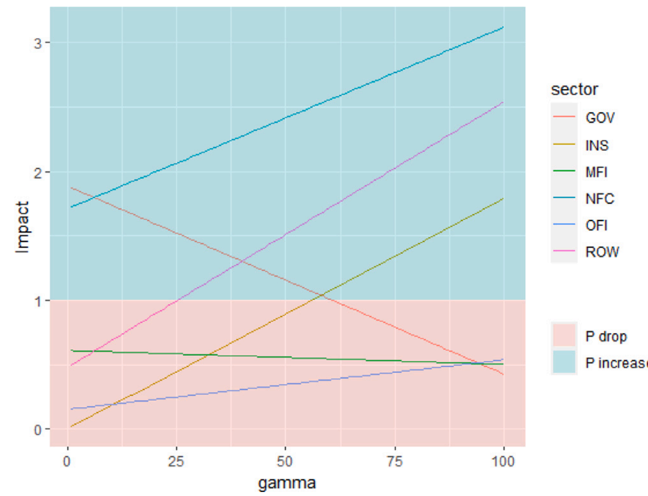


Fig. 11. Impact on debt securities as a function of gamma. $y-axis$ represents the ratio between demand and supply in debt securities for each sector varying γ ($x-axis$). The case represented is Scenario B, MFI sell debt securities, and CB purchases debt securities ($\gamma = 0$) or INV buy debt securities ($\gamma = 1$). In the blue (red) area prices undergo an upward (downward) pressure. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

parties and the impact they experience may differ depending on how (i) and (ii) play out. Maximum effort should be taken to identify the relevant links and mitigate any potential collateral damage ex ante.

Our study also highlighted the strong cross-border links in financial networks. Large scale domestic digital initiatives may have important repercussions on the international financial system by replacing cross-border exposures with a higher concentration around the domestic providers. On the other hand, successful digital currencies established in major currency areas may become popular in other countries, contributing to the loss of monetary sovereignty, as has been highlighted in the literature. Some reallocation of exposures in the macro-networks has already been taking place over the past decade (the importance of the central bank has increased sharply in countries where large-scale central bank asset purchases have been taking place). Opening up the central bank balance sheet to non-financial depositors would not quantitatively increase the aggregate exposures, unless the central bank also assumed the role of creating new credit for the non-financial sectors, which, however, would trigger a re-allocation of funds in the network with uncertain consequences. Such a reform may raise not only regulatory and financial stability issues but also distributionary concerns, as well as other fundamental issues related to integrity of data, competition, and public versus private provision of essential financial services. Our results underline the importance of the full network implications of innovations in financial intermediation. Any shock to the system that causes shifts in the financial balance sheets has the potential to trigger a redistribution of financial linkages and force adjustments in financial asset prices. These features may not be properly captured by analysis that does not cover the full network of interlinked exposures present in the financial system.

Data availability

Data used in the paper are available at the ECB Statistical Data Warehouse.

Appendix A

See Figs. A.12 and A.13.

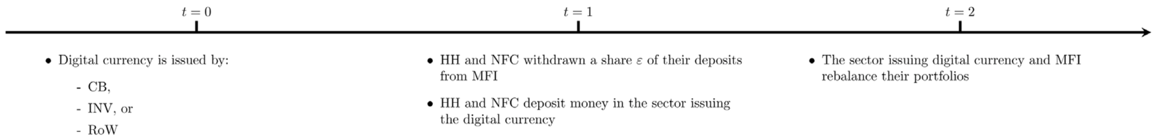


Fig. A.12. Introduction of digital currency in the macro-network.

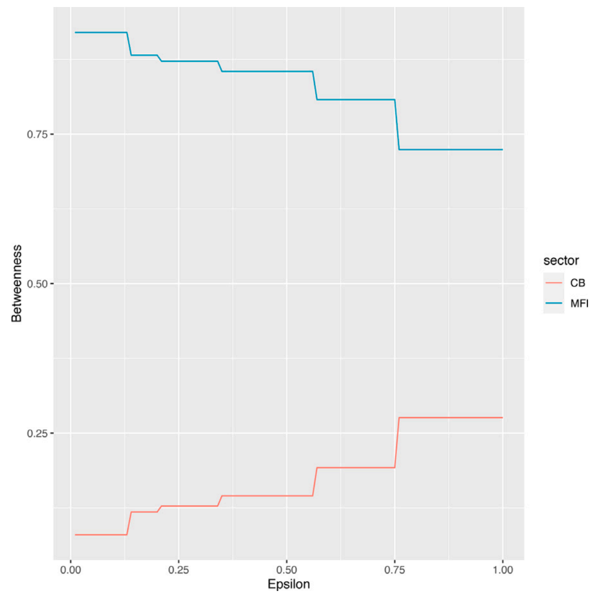


Fig. A.13. CBDC: Sector centrality measures. The graph shows the values of betweenness (normalised) for the MFI (blue) and CB (orange) over ε. The network under investigation is the one of deposits at time $t = 1$ after NFC and HH have withdrawn from MFI a percentage ε of their deposits. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Appendix B

This appendix includes the graphs of institutional sectors to show the changes in the macro-network in:

- a domestic stablecoin initiative (Fig. B.14);
- a global stablecoin initiative (Fig. B.15 for $t = 1$, and Fig. B.16 for $t = 2$).

Appendix C

This appendix shows the effects of the introduction of a digital currency over time. The time series covers the period for which data from the who-to-whom accounts are available, i.e. from Q1 2015 to Q1 2021. The timing of the introduction of the digital currency could be relevant as the funding gap determined by the deposit withdrawal is time-varying. Similarly, the funding shortage for the various sectors of the economy, caused by MFI rebalancing strategies, also vary and should be taken into account by policy makers and regulators.

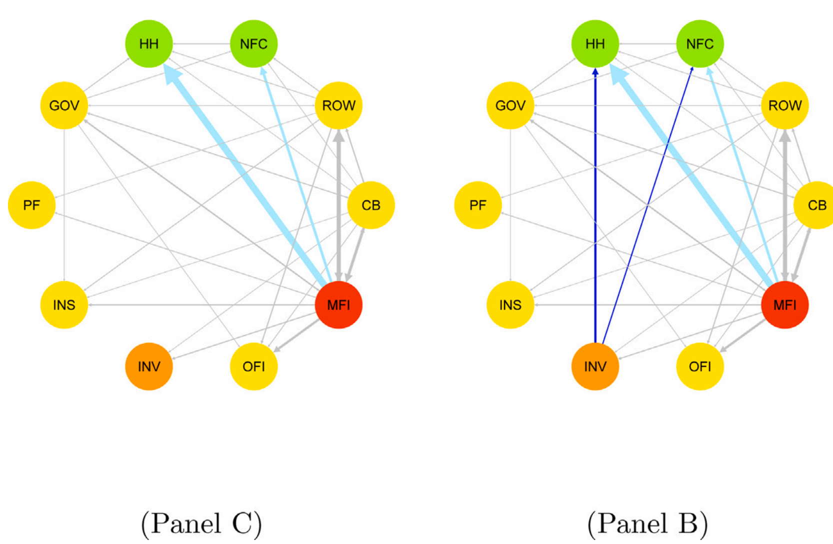
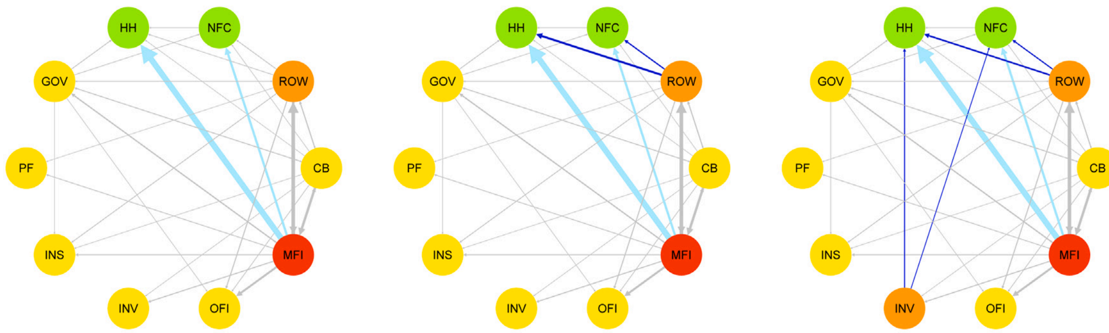
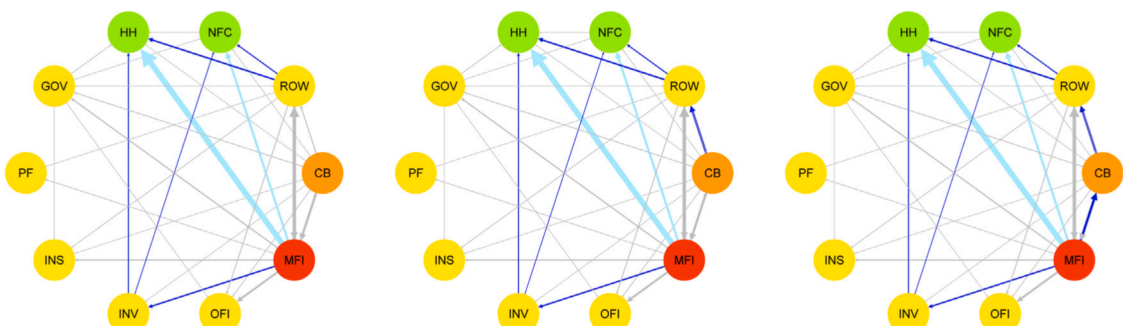


Fig. B.14. Domestic stablecoin initiative: Network of institutional sectors, instrument deposits, $t = 1$. Panel A: Network of deposits after NFC and HH have withdrawn 20% of their deposits; Panel B: Network of deposits after HH and NFC have shifted the deposits to an INV (domestic stablecoin).



(Panel A) (Panel B) (Panel C)

Fig. B.15. Global stablecoin initiative: Network of institutional sectors, instrument deposits, $t = 1$. Panel A: Network of deposits after NFC and HH have withdrawn 20% of their deposits; Panel B: Network of deposits after the deposits withdrawn have been moved to the ROW sector (the foreign home sector); Panel C: Network of deposits after the global stablecoin has re-invested a share γ of its global funds in the euro area investment funds sector (the domestic host sector).



(Panel A) (Panel B) (Panel C)

Fig. B.16. Global stablecoin initiative: Network of institutional sectors, instrument deposits, $t = 2$, Scenario A. Panel A: Network of deposits after INV has redeposited a share γ of the funds with the MFI sector; Panel B: Network of deposits after ROW has deposited a share of $1 - \gamma$ with the domestic CB; Panel C: Network of deposits after the MFI has borrowed $1 - \gamma$ from the CB to cover the remaining funding gap.

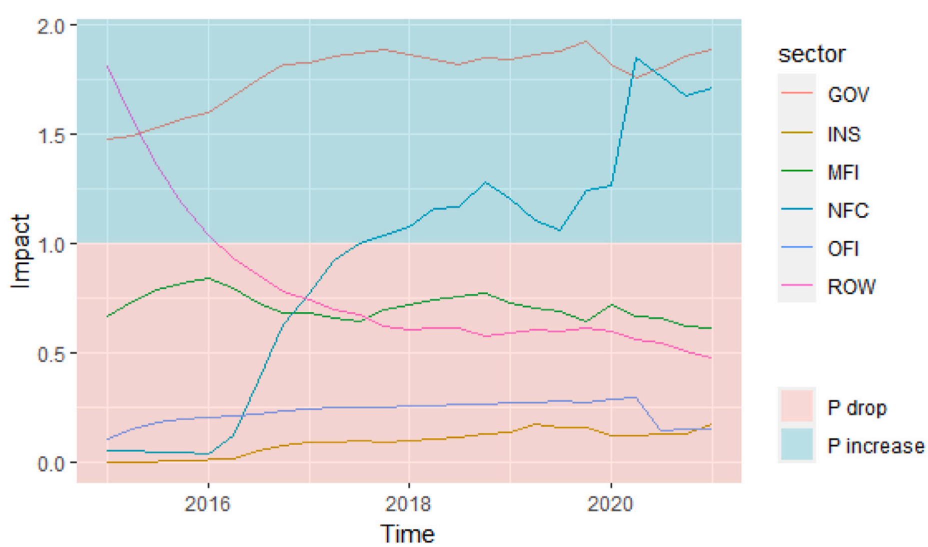
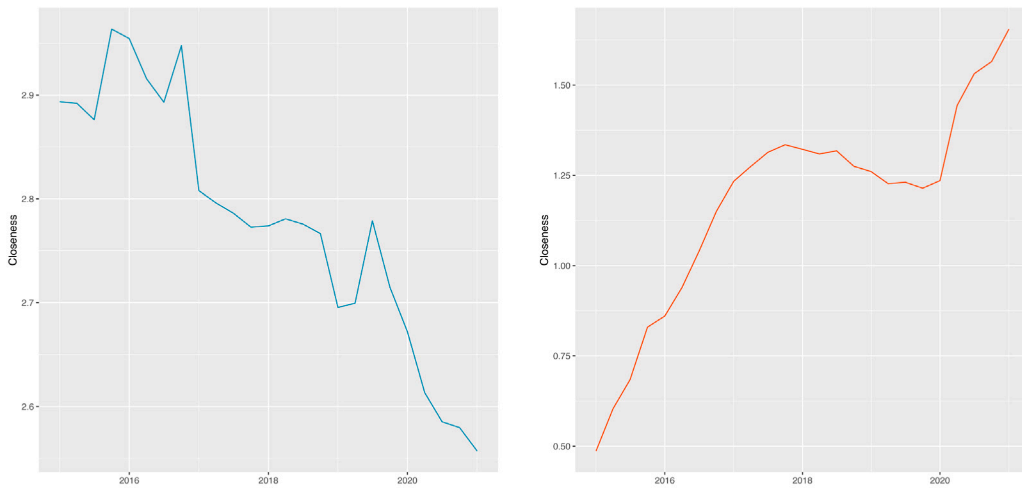


Fig. C.17. Price impact on debt securities over time. The graph shows the price impact in case of CBDC, Scenario B (MFI sell debt securities and CB buy debt securities based on their existing portfolio compositions). $y - axis$ represents, over time, the ratio between demand and supply in debt securities for each sector. Period Q1 2015–Q1 2021. In the blue (red) area prices undergo an upward (downward) pressure. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)



(Panel A: MFI) (Panel B: CB)

Fig. C.18. Sector centrality measures over time. The charts show the values of closeness for the MFI (Panel A) and CB (Panel B) over time. The network under investigation is that of deposits, the centrality measure is closeness (normalised). Period Q1 2015-Q1 2021.

Another important feature varying over time is the impact on the various segments of the debt market. We plot in Fig. C.17 the pattern over time of the ratio between demand and supply in debt securities for the CBDC, Scenario B. It shows that, as exposures of MFI and CB differ over time, different impacts in term of downward and upward price pressure can be foreseen. The blue (red) area highlights prices that undergo an upward (downward) pressure. At the beginning of the sample period corporate bonds could have suffered a decline in price, while since Q3 2017 their prices would have increased, with an accelerating trend towards the end of the sample thanks to the Eurosystem asset purchase programmes also targeting corporate bonds.

Finally, network centrality measures illustrate the evolution over time of the shape of the macro-network. Fig. C.18 focuses on the dynamic pattern of centrality of MFI and CB sectors that in the network of deposits at $t = 0$ were the most central. While the centrality of the MFI sector has decreased over time, the centrality of the central bank has increased dramatically throughout the sample period, reflecting the Eurosystem asset purchase programmes. Network structures may therefore change significantly even over a relatively short period of time, which means that “time 0”, when the digital currency is to be launched, could indeed matter. This is because, as was shown earlier in this paper, the ultimate impact of the introduction of a digital currency and the rebalancing that follows it are dependent on the underlying network structures. At certain times and under certain conditions, a digital currency could therefore be more disruptive.

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