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Central bank digital currency and European banks' balance sheets

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Contents

Abstract

The aim of this paper is to look at possible scenarios of demand for a retail-only euro central bank digital currency and assess their impact on bank's balance sheets, to explore potential effects on bank's intermediation capacity and financial stability. The European Central Bank, in the context of the Eurosystem investigative exercise, has tackled this issue by proposing a set of illustrative scenarios for the adoption of a Euro CBDC (see Adalid et al., 2022 and discussion therein). We expand their analysis to include more detailed results at country level by making use of individual banks data. For each demand scenario, we estimate the potential shock on deposits making use of MS-level data. We then apply these shocks at individual bank level and compare them to a set of alternative adjustment channels, including free reserves, wholesale funding and assets (deleveraging) to obtain a distribution of the ratio of shocks to different channels. Results show that per capita demand scenarios around 3 thousand euro do not seem to present risks for financial stability in the aggregate, though they present asymmetric impacts and could give raise to shifts in the structure of balance sheets and interbank markets.

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The authors acknowledge useful comments and suggestions from Matteo Salto, Guillaume Cousin, Mario Bellia, the participants to the informal working group on Central Bank Digital Currencies and to the Joint JRC-ECFIN seminar. Any remaining errors or omissions remain our own.

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1 Introduction

In 2021 the Eurosystem launched an investigative exercise to ensure its readiness to issue a digital currency if needed.

The project started with a planned duration of two years, and has been accompanied by a parallel set of exercises by the European Commission, including the establishment of an informal working group on Digital Currencies, the creation of an Inter Service Steering Group, and the drafting of an Impact Assessment of a Euro Central Bank Digital Currency (CBDC).

This paper is a contribution to the work of the Inter Service Steering Group and the Impact Assessment. The aim of this paper is to look at possible scenarios of demand of a retail-only euro central bank digital currency and assess their impact on bank's balance sheets, to explore potential effects on bank's intermediation capacity and financial stability.

One of the key questions to determine the potential impact of a Euro CBDC on banks is its potential extent of adoption, and in particular the extent to which CDBC is going to be used in place of deposits for payment and store of value purposes.

A large substitution of deposits in favour of CDBC could have consequential impacts on the balance sheet of banks, forcing banks to decrease assets, potentially leading to a contraction of lending to the real economy, or to an increase of wholesale funding, with possible implications for financial stability.

Take-up of a CBDC in turn depends on a wide variety of technical, legal, policy, social and economic characteristics of both the currency and the environment in which it is released. This is therefore an extremely challenging issue to tackle.

The European Central Bank, in the context of the Eurosystem investigative exercise, has tackled this issue by proposing a set of illustrative scenarios for adoption of a Euro CBDC (see Adalid et al., 2022 and discussion therein).

These scenarios are all predicated on the assumption that a Euro CBDC would be limited, at least for the time being, to Retail Transactions within the Euro area. Additionally, scenarios are also including limits to individual take-up of Euro CBDC.

In order to keep consistency with the work already performed by ECB, in this work we will strive to limit as much as possible variations from the scenarios and assumptions proposed by ECB, concentrating instead on expanding analysis using individual banks' balance sheets in place of aggregates.

The rest of the work is organised as follows: section 2 looks at background and the definition of scenarios; section 3 describes the methodology, adjustment channels considered and data employed; section 4 presents results; and section 5 concludes.

2 Background and scenarios on a Euro Central Bank Digital Currency

The ECB document (Adalid et al., 2022) looks at two main illustrative demand scenarios with unlimited supply, and a scenario of maximum take-up in the context of different supply limits.

We present here a quick recap of the main characteristics of each scenario. Full details are available in section 2 of the document cited above.

The first scenario refers to a "moderate demand for retail payments only", in this scenario Euro CBDC is mainly substituted for banknotes and a limited part of the transaction value of payment cards. The second scenario refers to a "large demand" scenario, where Euro CBDC is intensively used both for payments and as a store of value, both by households and NFCs. In the third scenario, supply of Euro CBDC is limited to a maximal fixed amount per individual, and its availability is limited to physical persons who reside in the Euro Area.([1]) This scenario is built around a limit of Eur 3000 for every resident,([2]) with an uncertainty analysis involving both higher and lower alternative maximum supply levels.

In terms of total demand and quantities of deposits substituted for CBDC:

1. the moderate demand scenario foresees a total demand of Eur 470m, of which 120m from foreign demand, and the remainder equally substituting domestic banknotes and deposits.
2. the large demand scenario foresees a total demand of Eur 7.2tn, of which 5.1tn domestic demand. Almost 85% of this demand would be substituting for deposits.
3. the capped supply scenario at Eur 3000 foresees a maximal total demand of Eur 1.15tn, of which about Eur 1tn domestic demand, almost 60% of which substituting for deposits. In this scenario, individuals are going to substitute about 50% of their banknotes, and cover the remaining part by swapping CDBC for deposits. Alternative maximum supply levels of 2, 4, 5 and 10 thousand Euro are also considered by ECB.

In the current work, we mainly work on reproducing the last set of scenarios. This is mainly due to the fact that these are feasible to implement on a bank-by-bank and country-by-country basis, they can be calibrated to reproduce a total demand that corresponds to the moderate and large scenarios, and we lack data to differentiate total demand at country and bank level depending on whether this comes only from households or also from the NFC sector.

We therefore proceed as a first step to the construction of a set of scenarios at MS level for different levels of maximum supply of funds. In all scenarios, in line with ECB, we assume that up to half the current amount of cash held by individuals is substituted for CBDC, before starting to exchange deposits for CBDC.

In order to translate these scenarios in demand scenarios for each MS in the European Union([3]), we retrieve data on the number of households, the share of households with deposits, and the average number of people per household from ESTAT, data on deposits from households and NFCs from ECB, and on cash holdings from ESTAT.

We build scenarios for take-up limits of 1, 2, 3, 4, 5 and 10 thousand euro. A total demand of substitution of deposits equivalent to the moderate scenario is obtained in correspondence of a limit of 1.6 thousand euro per person, and a total potential demand of substitution of deposits equivalent to the large scenario is obtained for a limit of 14 thousand euro. The demand is termed potential, as this limit, if fully exhausted, would correspond to most cash and deposits for some banking sectors.

As per the original report by ECB, given data limitations, it is not possible to take into consideration the fact that some households will have deposits or cash holdings which are smaller than the potential demand for substitution for CBDC (i.e. even if the limit of substitution is larger than the cash and/or deposit holdings of some households, the demand for substitution will be fully counted for every household). When this methodology is

([1]) Visitors would be allowed temporary accounts.

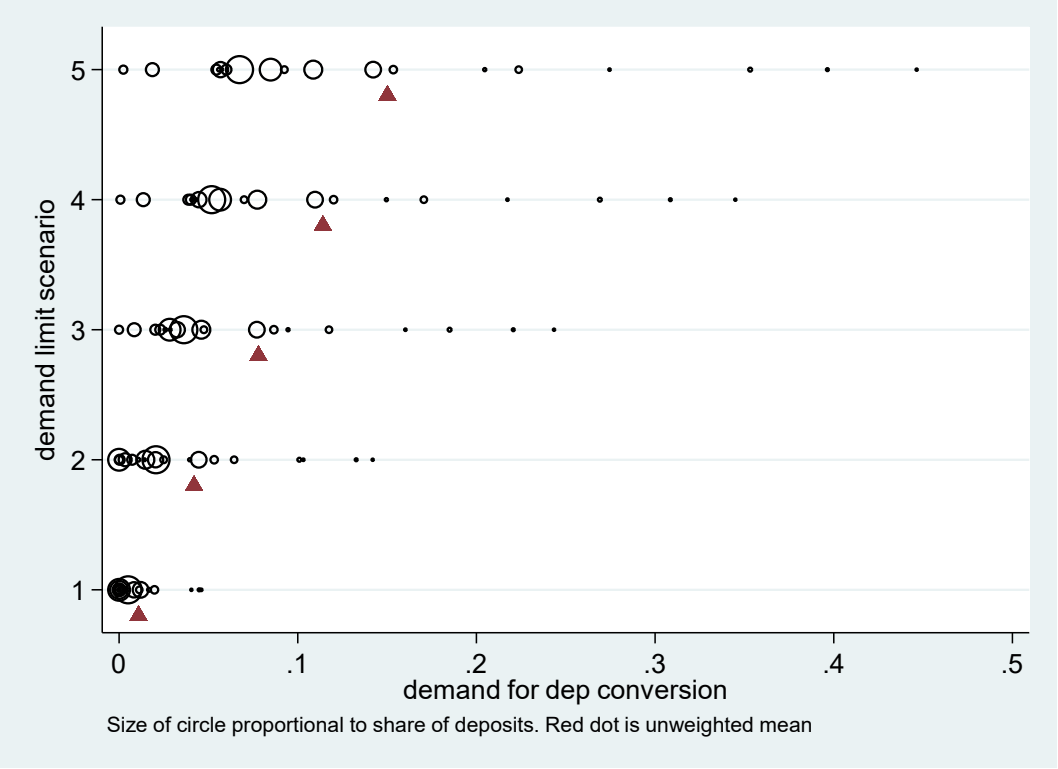
([2]) This limit is considered to be fully exhausted by every resident, irrespectively of status, age or effective availability of cash or deposits, in order to build a "maximum take-up" given the chosen limit.

([3]) This is done also for non-EA MS in order to produce counterfactual scenarios, as described in the introduction.

employed at individual MS and bank level, it can deliver substantial over-estimates for the impacts in jurisdictions or banks with large numbers of small deposits. ([4])

Results for each scenario up to the demand limit of 5 thousand euro are presented in Figure 1.

Figure 1: demand for deposit conversion in various scenarios



Source: JRC, based on data from ECB, EUROSTAT, NSOs, NCBs.

From the figure it can be seen that, for the Eur 3k cap scenario, the maximum possible impact is moderate for most national banking systems. Impacts start increasing in the 4k and 5k scenarios, and can start being relevant for a limited number of MS (keeping in mind some of the results for jurisdictions with smaller banking systems and average deposits per capital might be over-estimated as described above). ([5])

([4]) Several attempts at working around this limitation were performed, but the potential gain in precision did not seem to compensate the inevitable increase in estimate bias due to the introductions of assumptions. Moreover, deviating from the original ECB set-up would make results harder to interpret and compare without offering substantial qualitative gains.

([5]) A "what if" scenario for non-Euro area members has also been calculated. These results represent a "comparative static" exercise of what could happen in the country if they would be a member of the Euro area at the time of CDBC adoption without any additional change to the current exchange rate, bank balance sheet structure or national economic structure. These "what if" scenarios shows somewhat larger average impacts (subject to the caution remark that the methodology is prone to yield over-estimates in jurisdictions with lower income and deposits per capita), but overall no difference in maximal impact across scenarios. These "what if" scenarios are a purely hypothetical exercise and do not represent under any circumstance a potential impact of the adoption of a euro CBDC on non-EA MS banking sectors under current conditions.

3 Methodology and data

In this section, we look at the possible impacts of the demand of deposits for substitution with a CBDC on bank's balance sheets. Deposits are nominally short term liabilities for banks (though they are de facto the most stable source of bank funding), and banks can react to this reduction on the liability side by taking into consideration three possible mechanism (see also Adalid et al., 2022).

1. Decreasing assets without affecting the lending function, by reducing cash and non-mandatory central bank reserves. This channel does not require any changes in the relationships between the aggregate balance sheet of the banking sectors and that of other sectors (apart from the reduction in deposits from households) as it simply reduced the asset side in parallel with the reduction in deposit liabilities;
2. Increasing liabilities by increasing wholesale funding, either intra-group, on the interbank market, or with the Central Bank (in this report due to data limitations we consider total wholesale funding only). At the aggregate level, any increase in wholesale funding will imply an increase in liabilities to compensate the shock to deposits, and will need to be financed by another sector, either other financial corporations, non-financial corporations, or the central bank. ([6])
3. Decreasing assets by affecting the lending function, by reducing loans to customers and/or debt securities (excluding those held short term or for trading or hedging purposes). In particular, we focus on a "worst case scenario" for the real economy where the reduction is entirely conducted by decreasing customer loans. In the short term, these assets can be either not rolled over or sold to other sectors or to the central bank, with the proceedings used to reimburse depositors.([7])

Additionally, we always consider a fourth adjustment mechanism, employed directly by households and which does not affect the balance sheet of banks

4. Exchanging cash for CDBC, which is always considered to happen up to 50% of cash reserves of households.

For each demand scenario described above, we estimate the shock on deposits at individual bank level by applying the overall shock calculated above at country level to customer deposits for each bank. Relative to total deposits, we thus obtain an identical shock for each bank in any given MS. We then translate this shock in absolute monetary amounts, and compare it to the amount of the variable involved in each adjustment channel, again at individual bank level. Finally, we plot a distribution of the ratio of the shock to the potential adjustment channel size.

3.1 Data

To analyse the impact of deposit substitution on individual banks, we obtain balance sheet data from Moody's Analytics Bankfocus. ([8])

Our sample include banks classified in Bankfocus as savings banks, commercial banks, and cooperative banks. After data and consistency checks, we exclude other specialisations, especially bank holding companies and investment banks.

The data includes data for consolidated and unconsolidated balance sheets. Often, multiple balance sheets are presented for the same entity, and we make sure that at most one consolidated and one unconsolidated samples are retained (excluding in most case the C* and U* special purpose balance sheets). This however does not completely eliminate the issue of having multiple sub-consolidated entities with overlapping boundaries within the same group, especially in some jurisdictions. For this reason, further cleaning is conducted for Consolidated balance sheets in order to keep only the highest possible consolidation level within groups.

([6]) This funding might need to be covered by collateral. We do not have data on collateral availability, but ratios of the shocks to assets can be used as a rough guideline. The ratios to lending assets are developed in the third channel assessment. ECB calculations show that at the aggregate level unencumbered collateral is more than enough to cover the overall shortfall. See Chart 5 in Adalid et al. (2022)

([7]) Thus, the last two channels do not exactly coincide with the channels illustrated in the ECB report. In the ECB report, the second channel focuses exclusively on increased lending from the Central Bank, while the third channel focuses on asset sales to the central bank. We do not investigate the option where banks sell to the Eurosystem assets from other sectors.

([8]) https://www.moodysanalytics.com/product-list/bankfocus.

Finally, rather than trying to have the largest possible sample in terms of total assets and names covered by mixing consolidated and unconsolidated data, we retain two separate sub-samples, as consolidated balance sheets often reflect consolidation across borders and/or do not allow to observe some features of intra-group structures.

Our final sample (see Table 1) at consolidated level covers about 80% of banking sector assets reported by ECB in their statistics, while the unconsolidated sample covers about 50% of reported assets.

We mostly concentrate on using individual data to produce EA level estimates rather than country level aggregations. Unconsolidated samples, while less populated, are more faithfully representing the division of impact across boundaries. The comparison between results in the two cases can offer insights on differences in impact between groups and individual subsidiaries and independent banks.

Table 1: Sample representativeness

	solo			consolidated		
MS	N	Sample TA	% of ECB total	N	Sample TA	% of ECB total
BE	14	8.38E+08	75%	12	1.13E+09	101%
DE	700	4.33E+09	48%	21	5.71E+09	64%
EE	1	7321900	21%	7	3.96E+07	115%
IE	21	3.09E+08	22%	7	5.62E+08	41%
EL	5	2.10E+08	62%	7	3.61E+08	107%
ES	70	2.20E+09	76%	38	3.81E+09	132%
FR	57	5.96E+09	57%	22	8.75E+09	83%
IT	51	1.35E+09	35%	32	2.87E+09	75%
CY	24	5.51E+07	85%	11	4.88E+07	75%
LV	13	2.01E+07	84%	10	1.97E+07	82%
LT	4	2.76E+07	70%	4	2.77E+07	70%
LU	38	3.20E+08	26%	7	2.08E+08	17%
MT	9	2.50E+07	62%	4	2.32E+07	57%
NL	14	1.82E+09	72%	13	2.16E+09	85%
AT	126	5.75E+08	60%	20	7.76E+08	81%
PT	19	3.09E+08	75%	11	3.61E+08	87%
SI	9	3.71E+07	80%	6	3.87E+07	84%
SK	7	7.41E+07	79%	5	7.08E+07	76%
FI	9	5.03E+08	72%	8	8.26E+08	118%
Total	1191	1.90E+10		245	2.78E+10	

As described above, for each bank in our sample, we multiply total customer deposits by the share of total deposits substituted in the national banking sector. This yields and estimate of the demand for deposit substitution at each individual institution. While this approach will imply errors in the estimation of demand at individual estimation level, it will also imply that overall demand at MS and aggregate level will be correct, and errors will tend to average out, providing correct estimates of averages, totals and shares. This approach of course also implies that demand as a share of deposits, by construction, is identical for each bank within a single country.

3.2 Descriptive statistics of balance sheet structure

In the following we provide some brief descriptive statistics for the sample.

We start by presenting some box plots of structural balance sheet indicators for different classes of liabilities. This allows to assess the relative importance of different funding channels across different countries, size, and consolidation classes for banks.

Figure 2: Balance sheet structure indicators for EA MS over consolidation classes

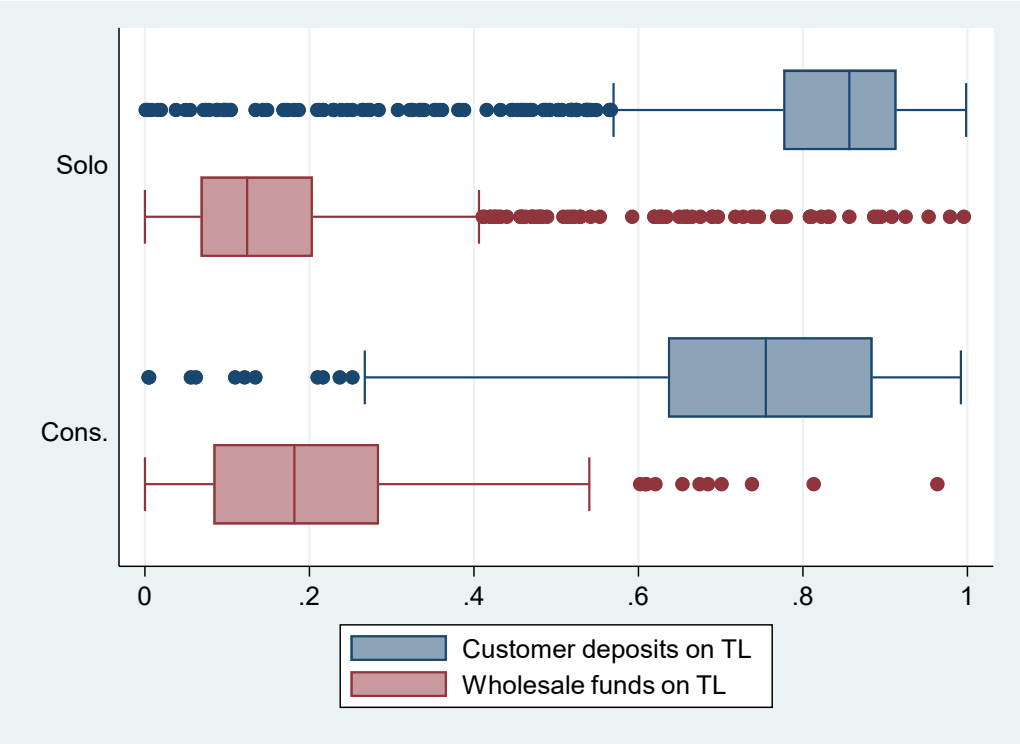


Figure 3. Box plots of customer deposits for EA MS, Unconsolidated balance sheets.

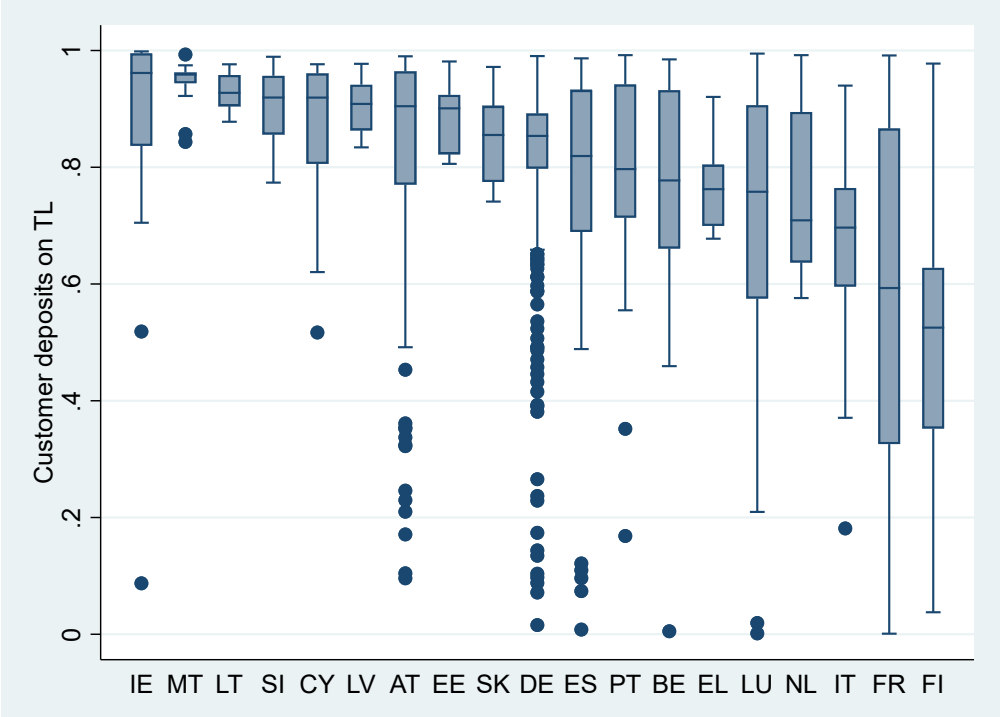


Figure 4: Balance sheet indicators for EA MS banks, by size class, for unconsolidated balance sheets

In terms of the structure of liabilities, the box plots above show that the median of deposits funding across the whole sample for EA MS is around 85% for unconsolidated balance sheets, and 75% for consolidated balance sheets, pointing to a smaller role of deposits at group level and/or for larger banks funding.

The mirror image holds for wholesale funding, with median at unconsolidated level at 10% and at consolidated level at about 20%

While the average structure of liabilities sees a preponderance of deposits, the dispersion is quite high.

When looking at individual EA countries, it is possible to see that there is non-trivial variability between countries, and in some cases also within countries.

Similarly, when looking at banks by size class (within EA MS), it is possible to see that larger banks seem to rely less on deposit funding than smaller banks, with a median of about 65%, versus a median of about 80% and 90% for medium and small sized banks (size assessed at consolidated level).

This seems to point to a “hub and spoke” structure where wholesale funding is handled preferentially by larger banks and group heads, who then redistribute it to smaller banks and/or to individual subsidiaries within groups.

This possible duality of roles for individual banks and subsidiaries is also confirmed by looking at distribution curves for the main liabilities and free reserves. It is possible to see that concentration is markedly higher when looking at solo entities than when looking at consolidated balance sheets.

4 Results

4.1 Shocks compared to Total Liabilities

Before looking at possible individual adjustment channels, we want to explore the potential overall impact of a shock to deposits compared to the size of the balance sheet of the banks. In order to do so, we compare the size of the shocks to the total liabilities of each bank.

The first figure (Figure 5) shows the cumulative distribution of banks compared to the Total liabilities/deposit conversion shock ratio in different demand scenarios.

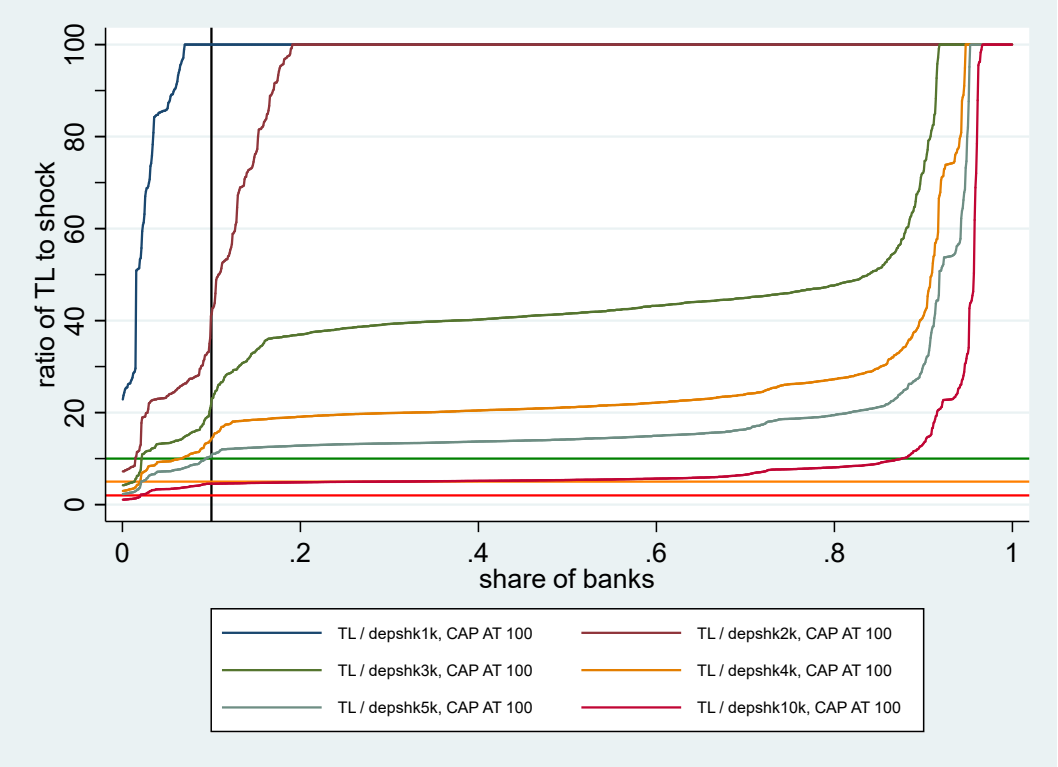
Each scenario (1 to 5, and 10 thousand demand limits) is represented by an individual curve. On the horizontal axis, we can find the share of institutions in the sample (not weighted by size), while on the vertical axis we can find the ratio of Total Liabilities to the conversion shock. For readability, ratios are capped at 100.

To aid in reading the graph, three horizontal lines are drawn at ratios of 2 (red line, the shock is 50% of total liabilities), 5 (orange line, the shock is 20% of total liabilities) and 10 (green line, the shock is 10% of total liabilities). A vertical line is drawn in correspondence to 10% of all banks.

Each point on a line indicates the share of banks that have a certain ratio or lower in the given scenario.

How to read the graph: in the 3k€ demand scenario (dark green line), total liabilities amount to less than 20 times the deposit shock for 10% of banks while 90% of banks have total liabilities of over 20 times the deposit shock. This is equivalent to saying that the deposit shock represents less than 5% of total liabilities for 90% of banks.

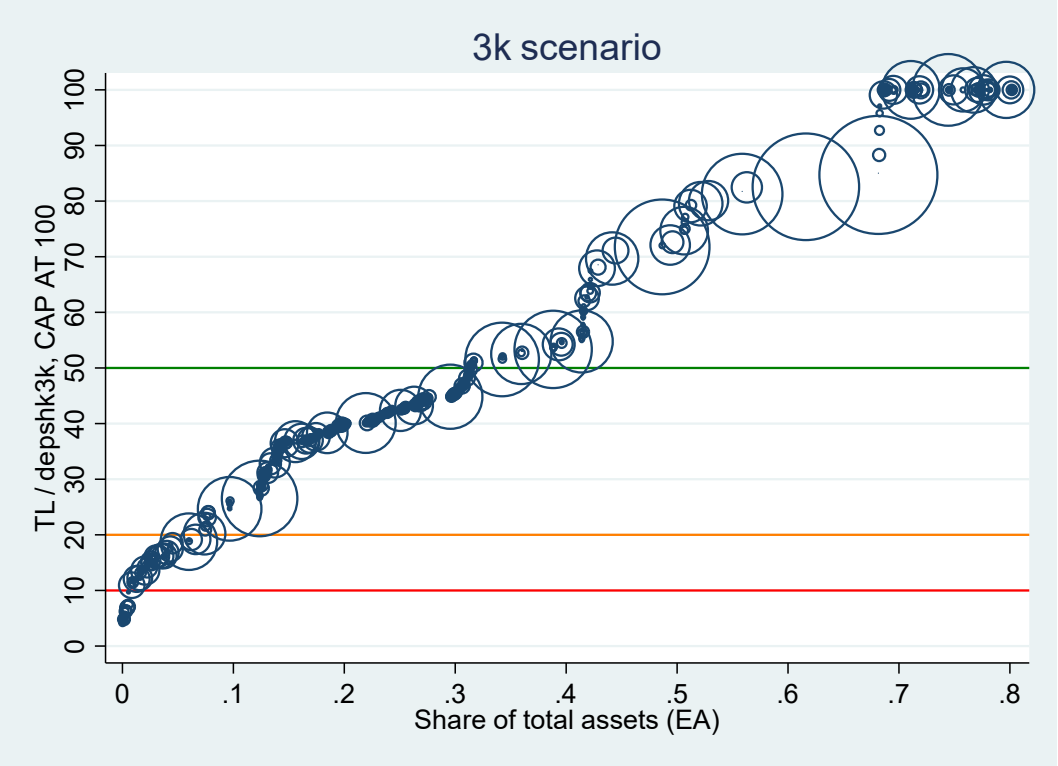
Figure 5: Distributions of the Ratio of Total Liabilities to deposit conversion shock in different scenarios, EA, as a share of the number of banks in sample, unconsolidated Balance Sheets



Looking at all scenarios, it is possible to see that, for the 1k shock, only about 5% of all banks in the EA would face a shock equal to at least 1% of their total liabilities (ratio of TL to shock above 100). For the 3k scenario, only 10% of banks would face a shock equal to at least 5% of liabilities (a ratio of 20). For the 5k and 10k scenarios, 10% of banks would face a shock bigger then 10% and 25% of their TL (ratios of 10, and 4, respectively), and in the latter scenario, only about 10% of all banks would face shock less than 10% of TL (ratio of 10).

The distribution can also be plotted in terms of Total Assets held by banks in sample, rather than in terms of number of banks. In other words, each bank can be weighted by its size when calculating the distribution. We plot such a distribution in Figure 6 for the 3 thousand euro limit scenario.

Figure 6: Distribution of the Ratio of Total Liabilities to deposit conversion shock in the 3k scenario, EA, as a share of Total Assets in sample, unconsolidated Balance Sheet



This chart shows the cumulative distribution of euro-area banks' total assets compared to their Total liabilities/deposit withdrawals ratio in the 3k demand scenario. Each bank is represented as a circle whose size is proportionate to the bank's total balance sheet size.

The horizontal lines represent three different thresholds in terms of total liabilities (10 times, 20 times and 50 times the deposit shock, equivalent to 10%, 5% and 2% shocks as a share of total liabilities, respectively).

How to read: banks representing around 10% of euro-area banks' total assets have liabilities of less than 20 times the deposit shock that would occur in a 3k€ demand scenario. In another way, in the 3k€ demand scenario, the shock to banks' deposits would represent more than 5% of total liabilities for banks representing less than 10% of euro-area banks' total assets.

Also, banks potentially facing a shock to deposits which is equivalent to over 10% of their total liabilities hold less than 1% of total assets in the banking sector in the sample considered, while banks potentially facing a shock between 5% and 10% hold less than 10% of all total assets in the sample.

When looking at the distributions on a MS basis (not shown here), it is possible to see that banks facing larger shocks seem to be relatively concentrated in a small number of countries, though result might also be driven by the application of the same shock as a share of deposits to all banks in each country and by assumption which might be favouring over-estimation of the shocks in certain jurisdictions (see Section 2, above).

These results point to the fact that, for scenario close to the central scenario, the potential shock to deposits should be small compared to total liabilities for the vast majority banks, though it could be non-negligible in certain, rather limited, cases.

4.2 Free reserves adjustment channel

The first adjustment channel considered is the use of free reserves. ([9]) Free reserves can be used to reduce the asset side of the bank without having to increase funding from other banks or ultimately other sectors, or liquidating longer term assets such as loans and securities. It should be note that these figures are based on current values of reserves, but balance sheet structure could change under changes to monetary policy environment under inflationary pressures.

Figure 7 shows the cumulative distribution of banks compared to the Free reserves/deposit conversion shock ratio in different demand scenarios.

Each scenario (1 to 5, and 10 thousand demand limits) is represented by an individual curve. On the horizontal axis, we can find the share of institutions in the sample (not weighted by size), while on the vertical axis we can find the ratio of Free reserves to the conversion shock. For readability, ratios are capped at 10.

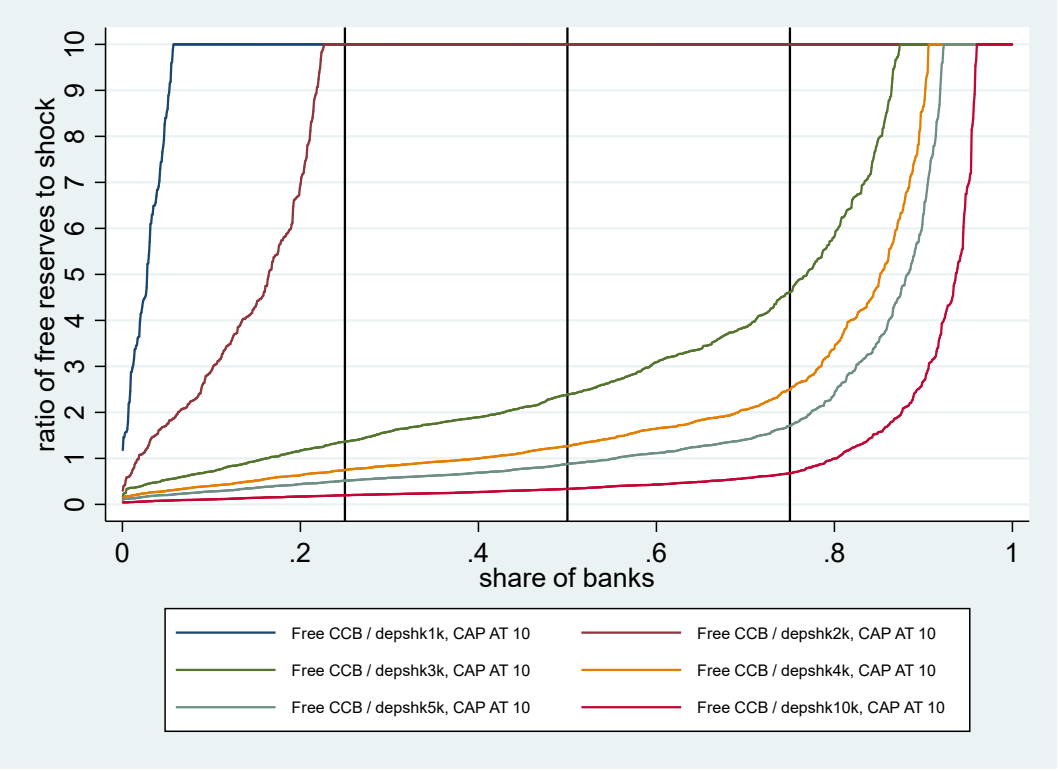
Three vertical lines identify the points corresponding to 25%, 50% and 75% of banks in the sample.

Each point on a line indicates the share of banks that have a certain ratio or lower in the given scenario.

How to read the graph: in the 3k€ demand scenario (dark green line), Free reserves amount to less than 2 times the deposit shock for 40% of banks while 60% of banks have free reserves of over 3 times the deposit shock. About 15% of banks have free reserves which are less than the amount of the shock.

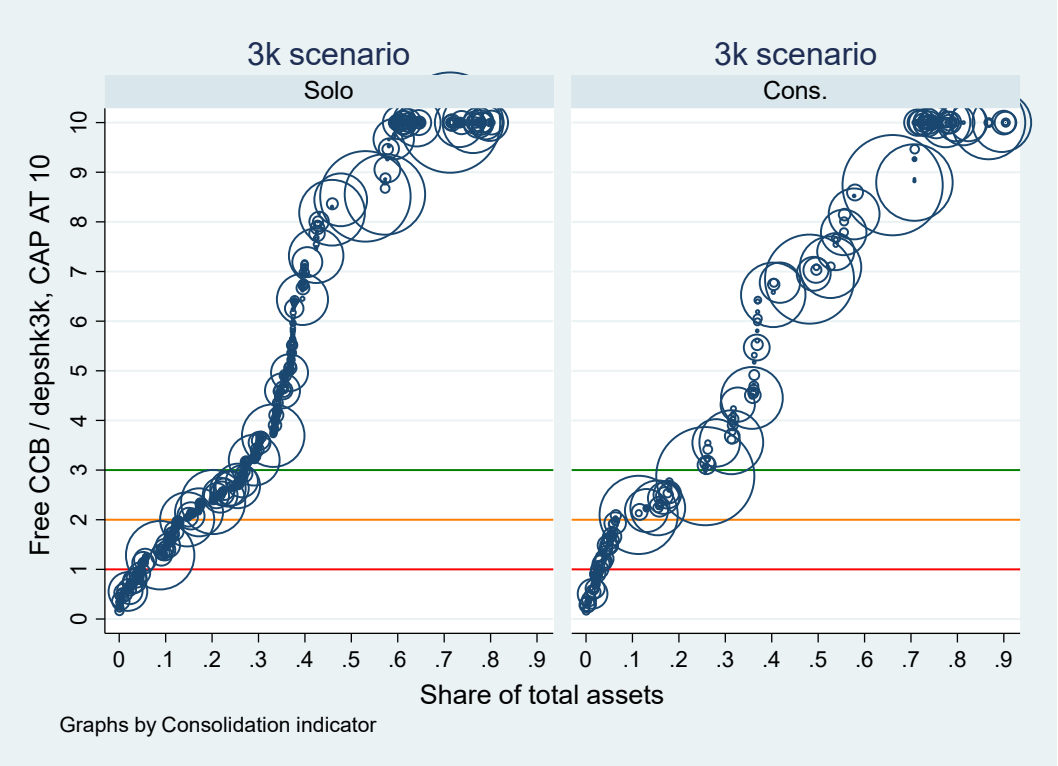
For the 4k scenario, almost, or over, 75% of banks would have reserves than twice the shock, while for the 5k scenario about half of all banks would have free reserves lower than the shock.

Figure 7: Distributions of the Ratio of Free Reserves to the deposit conversion shock in different scenarios, EA, as a share of the number of banks in sample, unconsolidated Balance Sheets



([9]) Free reserves are calculated as total cash and reserves with the central bank, less 1% of customer deposits and 15% of interbank deposits.

Figure 8: Distribution of the Ratio of Free reserves to deposit conversion shock in the 3k scenario, EA, as a share of Total Assets in sample, consolidated and unconsolidated Balance Sheets



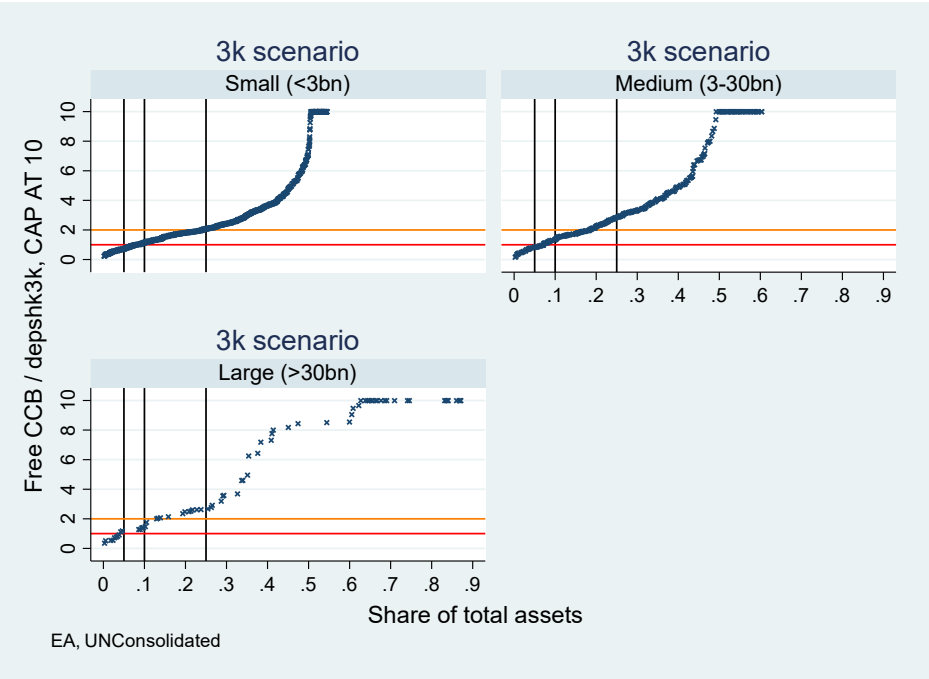
In Figure 8, the two graphs look again at the 3k shock scenario, but uses a the distribution in terms of share of Total Assets rather than share of number of banks. This chart shows the cumulative distribution of euro-area banks' total assets compared to their Free Reserves/deposit withdrawals ratio in the 3k demand scenario. Each bank is represented as a circle whose size is proportionate to the bank's total balance sheet size.

How to read: looking at "solo" (unconsolidated) balance sheets, only banks representing around 5% of total assets in the sample would not be able to cover the shock with free reserves. Also, banks representing about 15% of total assets in the sample would have less than twice the shock in reserves. This figure improves when considering consolidated balance sheets. So under the assumption that banks would be able to freely allocate assets within groups, adjustment with reserves could be relatively easier.

Figure 9 again uses a distribution in terms of share of total assets for the 3k scenario, but divides banks by size class (using unconsolidated balance sheets). Vertical lines show the position of 5%, 10%, 25% and 50% of total assets within each class. The graph seems to confirm that larger banks are better placed in terms of reserves. By way of example, small banks holding 25% of all assets held by small banks have less than twice the amount of the shock in free reserves, while banks representing only less than 10% of assets held by large banks have less than twice the shock in reserves.

When looking at the distributions on a MS basis (not shown here), it is also in this case possible to see that banks facing larger shocks seem to be relatively concentrated in a small number of countries. Also in this case the result might also be driven by the application of the same shock as a share of deposits to all banks in each country and to factors driving potential over-estimation of the shocks for certain jurisdictions.

Figure 9: Distribution of the Ratio of Free reserves to deposit conversion shock in the 3k scenario, by bank size class, EA, as a share of Total Assets in sample, unconsolidated Balance Sheets



4.3 Wholesale funding adjustment channel

The second adjustment channel considered is wholesale funding. Wholesale funding can be substituted for deposits in case of a withdrawal shock. An increase in wholesale funding has the likely effect of increasing bank funding costs (and their variability) and increasing the interconnectedness of the financial system.

Wholesale funding increases will also require, in the aggregate, to be financed from other institutional sectors such as the Central Bank/Eurosystem, other financial corporations, or non-financial corporations. On the other hand, increases in wholesale funding leave the total balance sheet of the banking sector constant.

Figure 10Figure 7 shows the cumulative distribution of banks compared to the Wholesale funding/deposit conversion shock ratio in different demand scenarios.

Each scenario (1 to 5, and 10 thousand demand limits) is represented by an individual curve. On the horizontal axis, we can find the share of institutions in the sample (not weighted by size), while on the vertical axis we can find the ratio of Free reserves to the conversion shock. For readability, ratios are capped at 10.

Three vertical lines identify the points corresponding to 25%, 50% and 75% of banks in the sample.

Each point on a line indicates the share of banks that have a certain ratio or lower in the given scenario.

How to read the graph: in the 3k€ demand scenario (dark green line), about 20% of banks in the sample would need to increase wholesale funding by less than 10% of the current level to entirely cover the shortfall due to the shock (ratio of wholesale funding to shock of 10 or more). 50% of banks would need to increase it by less than 20% of the current level (a ratio of wholesale funding to shock of 5) and 25% of banks would need a large increase of more than 50%.

For the 4k scenario, almost 75% of banks would need to increase wholesale funding by more than 20% the current level (a ratio of 5), while for the 5k scenario 75% all banks would need to increase wholesale funding by at least a third of the current level (a ratio of 3).

Figure 10: Distributions of the Ratio of Wholesale funding to the deposit conversion shock in different scenarios, EA, as a share of the number of banks in sample, unconsolidated Balance Sheets

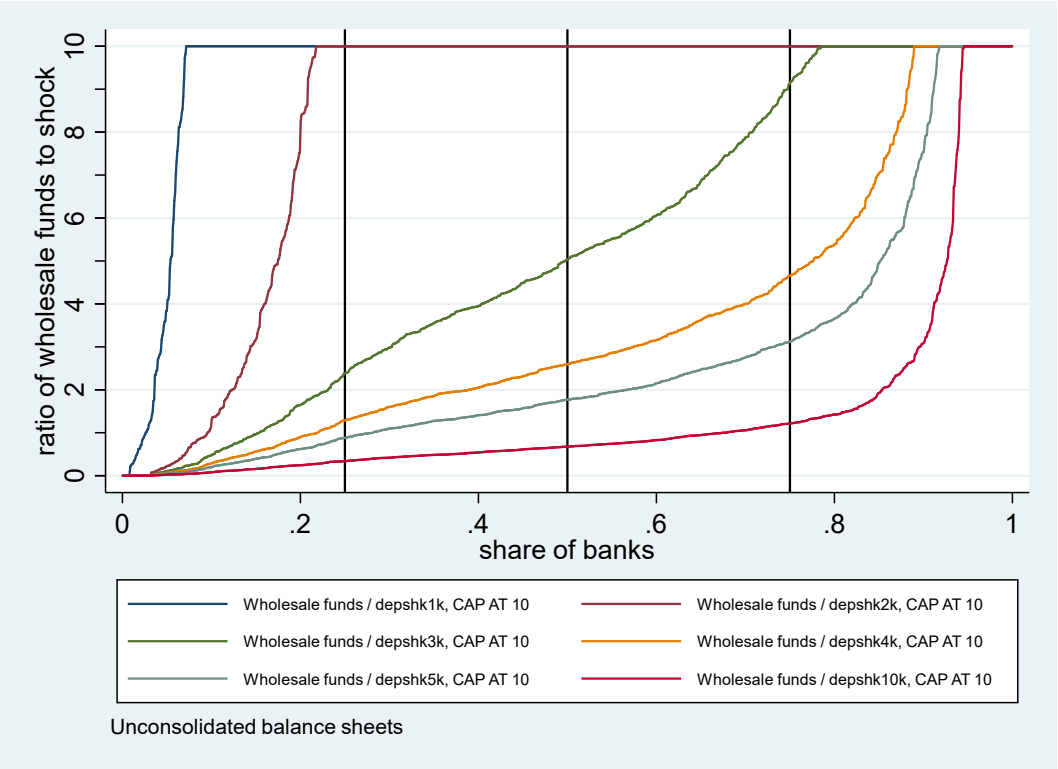
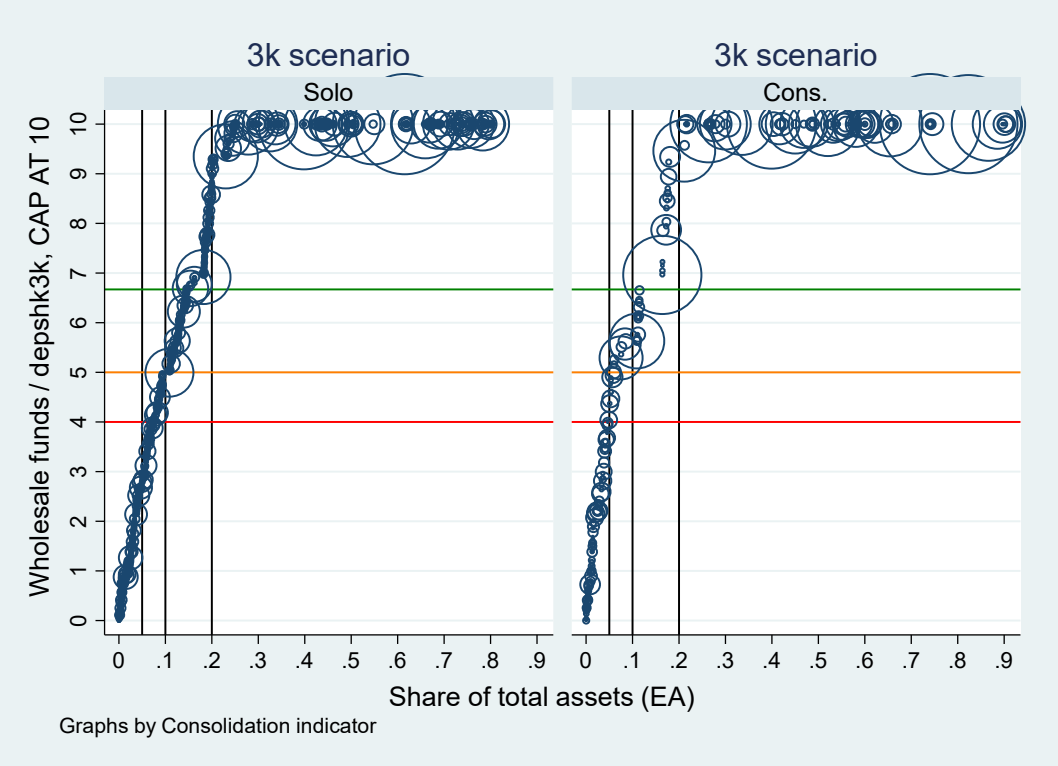


Figure 11: Distribution of the Ratio of Wholesale funding to deposit conversion shock in the 3k scenario, EA, as a share of Total Assets in sample, consolidated and unconsolidated Balance Sheets



In Figure 11 the two graphs look again at the 3k shock scenario, but uses at the distribution in terms of share of Total Assets rather than share of number of banks. This chart shows the cumulative distribution of euro-area banks' total assets compared to their Wholesale funding/deposit withdrawals ratio in the 3k demand scenario. Each bank is represented as a circle whose size is proportionate to the bank's total balance sheet size.

Three vertical lines identify the points corresponding to 5%, 10% and 20% of total assets in the sample. Three horizontal lines identify the points corresponding to a ratio of 4, 5 and 6.66 (corresponding to an increase in wholesale funding of 25%, 20% and 15%, respectively).

How to read: looking at "solo" (unconsolidated) balance sheets, banks needing to increase wholesale funding by more than 20% (a ratio of 5) represent about 10% of total assets in the sample at unconsolidated level, and 10% at consolidated level, and appear to be on the lower side of the size distribution.

The improvement when moving from the unconsolidated to the consolidated side seems to point to an asymmetric distribution of wholesale funds within groups.

As stated also in the first part of this chapter, increases in wholesale lending could need to be accompanied by coverage with collateral. ECB shows (Adalid et al., 2022, Chart 5) that available collateral would be more than sufficient to cover the shortfall. We do not have data on collateral quality and encumbrance at individual bank level, but the calculations of the next section illustrate the ratio between lending assets and deposits shortfalls.

When looking at individual MS level (not shown here), the disparity between MS is again quite marked. Both these results were to be expected given the likely structure of the interbank market as a hub-spoke network.

In the aggregate these results point to the fact that wholesale funding would be sufficient to absorb the shock at aggregate level, but due to the uneven distribution of shocks vis-à-vis the availability of reserves and collateral, it could also lead to an increase in inter-bank and intra-group connectivity in terms of wholesale funding relationships. In case an increase in interbank lending would not be feasible or desirable, wholesale funding could represent a more limited option for absorbing the shock, unless the central bank could be available to increase its financing directly to each individual institution.

4.4 Lending assets adjustment channel

The last adjustment channel considered is reduction of the asset side by deleveraging and reduction of lending to the real economy. In particular, we concentrate on lending to customers, which represent only a part of total lending to the real economy. This is due to data issues in some sub-samples, so that these results can be considered a "worst case scenario" if the whole accommodation is conducted via decrease in customer lending rather than via the sale or missed roll-over of other lending assets such as debt securities.

The reduction of the asset side can be achieved via missing roll-overs or, more likely, by the sale of assets to other institutional sectors such as the Eurosystem, other financial corporations or non-financial corporations. This adjustment channel entails a reduction in the balance sheet of banks, and a reduction in the volume of bank credit.

Figure 12 shows the cumulative distribution of banks compared to the Customer Loan/deposit conversion shock ratio in different demand scenarios.

Each scenario (1 to 5, and 10 thousand demand limits) is represented by an individual curve. On the horizontal axis, we can find the share of institutions in the sample (not weighted by size), while on the vertical axis we can find the ratio of Customer Loans to the conversion shock. For readability, ratios are capped at 10.

Three vertical lines identify the points corresponding to 1%, 5% and 10% of banks in the sample.

Each point on a line indicates the share of banks that have a certain ratio or lower in the given scenario.

How to read the graph: in the 3k€ demand scenario (dark green line), over 70% of banks in the sample have a ratio of customer loans to withdrawal shock of 10 or above, and would thus need to reduce lending by less than 10% to cover the shock. Slightly less than 10% of banks have a ratio of around 5, needing to reduce customer lending by 20% to absorb the shock fully, and less than 5% of banks in the sample have a ratio lower than 2.

When considering the lending adjustment channel, it is possible to see that, with a few exceptions, for the 2k-4k scenarios the shock would represent less than 10% of lending for over 90% of banks in most EA countries. There are however some countries for which the shocks would represent larger shares of lending to customers.

For the 4k and 5k scenarios, 60% and 50% of banks have ratios of 10 or above, respectively. In the 4k and 5k scenarios, about 20% of banks have a ratio lower than 3 (33% reduction needed).

The numbers look much better when considering the distribution in terms of total assets rather than in terms of number of banks.

Figure 12: Distributions of the Ratio of Customer Loans to the deposit conversion shock in different scenarios, EA, as a share of the number of banks in sample, unconsolidated Balance Sheets

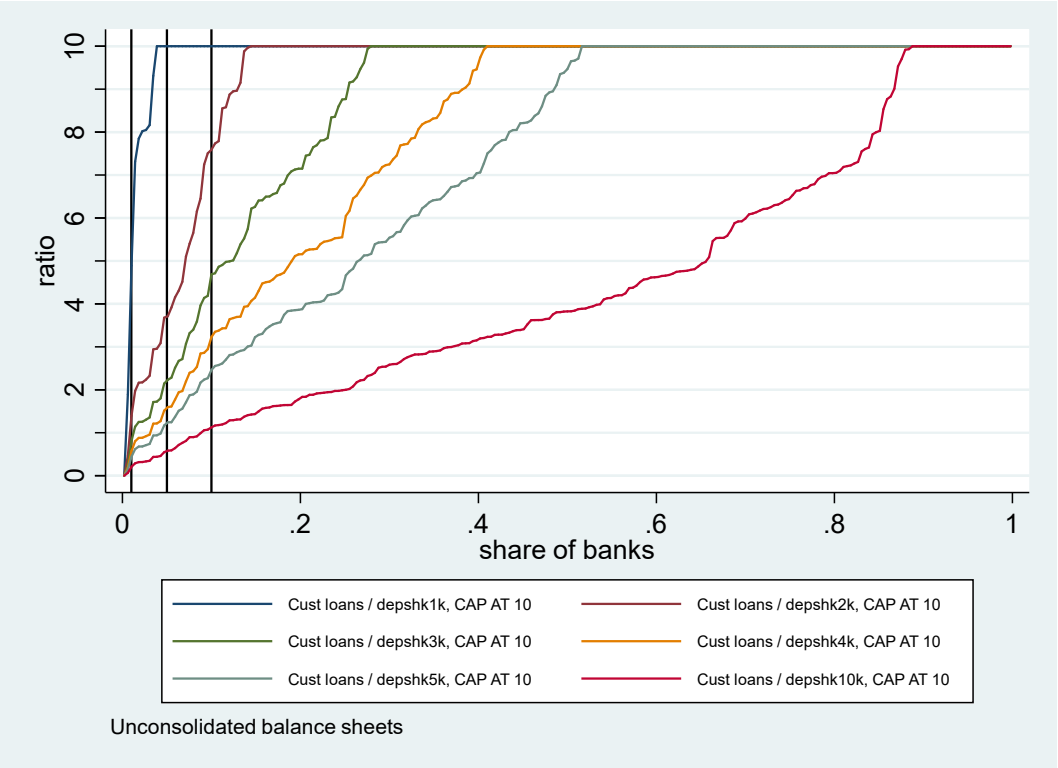
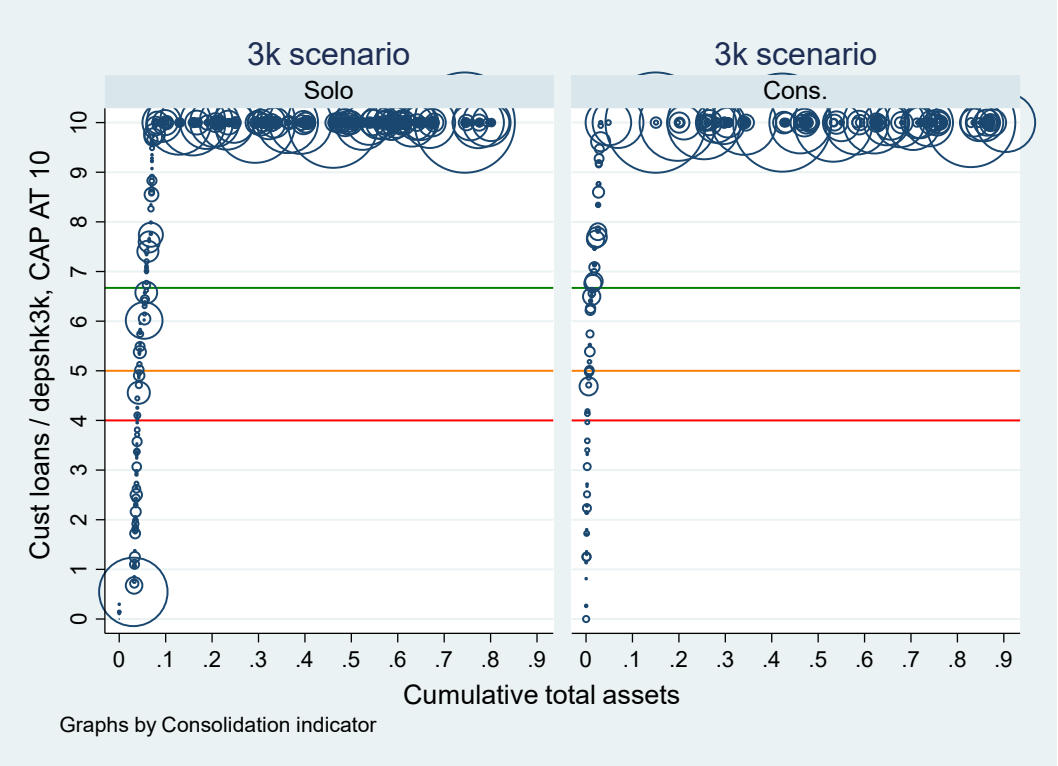


Figure 13: Distribution of the Ratio of Customer Loans to deposit conversion shock in the 3k scenario, EA, as a share of Total Assets in sample, consolidated and unconsolidated Balance Sheets



In Figure 13Figure 11 the two graphs look at the 3k shock scenario, but uses at the distribution in terms of share of Total Assets rather than share of number of banks. This chart shows the cumulative distribution of euro-area banks' total assets compared to their Customer Loans/deposit withdrawals ratio in the 3k demand scenario. Each bank is represented as a circle whose size is proportionate to the bank's total balance sheet size.

Three horizontal lines identify the points corresponding to a ratio of 4, 5 and 6.66 (corresponding to a decrease in customer lending of 25%, 20% and 15%, respectively).

How to read: looking at "solo" (unconsolidated) balance sheets, the total assets of institutions for which the shock would represent more than 15% of customer loans (green line) seems lower than 3% at consolidated level, and lower than 10% at solo level.

The improvement when moving from the unconsolidated to the consolidated side seems to point to an asymmetric distribution of customer loans within groups.

When looking at individual MS level (not shown here), as in the other cases, the disparity between MS is marked, again subject to the usual caveats illustrated above.

In the aggregate, the lending channel seems therefore able to absorb the shocks relatively easily, even when only considering customer loans, while possibly implying some intra-group adjustment.

5 Conclusions

It seems that, at an aggregate level, the three channels considered would be able to allow the banking sector to absorb shocks to deposits in the 2-5k per capital demand range. The analysis nonetheless points to heterogeneity that increases along the range across institutions, bank size classes and countries.

While the overall shock could not be large, the full dynamic effect of a change in the liability side to shocks following the introduction of a CBDC could thus be nuanced and complex than the first round impacts, leading to the formation of position rents and the exchange of income streams across banks in different size classes or countries.

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List of abbreviations and definitions

CBDC	Central Bank Digital Currency
EA	Euro Area
EC	European Commission
EU	European Union
HHs	Households (institutional sector)
IA	Impact Assessment
ISSG	Inter Service Steering Group
MFIs	Monetary Financial Institutions (institutional sector)
MS	Member State
NFCs	Non Financial Corporations (institutional sector)
WG	Working Group

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