# Central bank digital currencies, supply of bank loans and liquidity provision by central banks

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A frequently voiced concern about a central bank digital currency (CBDC) is its potentially adverse effects on the supply of bank loans. We explore this concern in a setting where banks can create unlimited amounts of loans and deposits in their own books but must satisfy customers' outflows to other banks and cash. We show how the current stickiness of retail deposits allows banks to create lending volumes that are 10 or more times their own liquidity reserves. The CBDC may reduce the stickiness of these retail deposits and reduce the lending capacity of banks. However, central banks have tools to offset the effects of CBDC on the lending capacity of banks if so is deemed necessary.

## 1 Introduction and preliminaries

A frequently voiced concern about the issuance of a central bank digital currency (CBDC) is its potentially adverse effects on the supply of bank loans and thereby macroeconomic activity.[1] Some have therefore suggested that the demand for CBDC should be managed, for instance, via a time-varying interest rate spread between CBDC and the policy rate.[2]

This paper studies the effects of CBCD on the supply of bank loans in a setup where the demand for CBDC is not managed. CBDC is modelled as cash in an electronic form: it is non-interest-bearing and depositors can at will exchange their bank deposits for CBDC, exactly as they can exchange their bank deposits for physical cash in the current system.

The paper builds on a model of bank loan supply that is based on the actual practice of banking. In the model, banks can create potentially unlimited amounts of loans and deposits in their own books.[3] When banks give out loans and create deposits, they must also make sure that they can satisfy customers' outflows to other banks, cash or CBDC. To satisfy these outflows, banks need central bank reserves. For this purpose, banks hold a portfolio of central-bank-eligible collateral which can be exchanged for central bank reserves at the central bank's lending facility.

It is worth emphasising that the paper is conceptual in nature. No sharp policy conclusions on the actual effects of a CBDC on the supply of bank loans can be drawn from the paper. The sole purpose of different examples provided in the paper is to illustrate the underlying mechanisms. The paper also ignores the benefits of issuing CBDC and no attempt is made to weigh pros and cons of issuing a CBDC.

The rest of this paper is organised as follows. We start with a model that relates banks' supply of loans to potential outflows. Potential outflows are then linked to the savings rate,

* I would like to thank Carl Andreas Claussen, David Vestin, Carl-Johan Rosenvinge, Martin W Johansson, Vanessa Sternbeck-Fryxell, Olof Sandstedt, Jonatan Manfredini, Peter Sellin, Christoph Bertsch and Paola Boel for their valuable comments. The views expressed here are those of the author and are not necessarily shared by the Executive Board of Sveriges Riksbank.

1 This concern is especially well reflected in a speech by the general manager of BIS: 'Central bank digital currencies at the retail level have very serious consequences, and they are not easily tackled', see Carstens (2019).

2 See, for instance, Kumhof and Noone (2018). When the demand for CBDC is managed, the effects of CBDC on banks would be modest, see Juks (2018) and Bindseil (2020).

3 For an accessible primer for how banks create credit, see McLeay et al. (2014).

size of cash withdrawals and the magnitude of runs. CBDC is then introduced and its effects on potential outflows and hence on the supply of bank loans are discussed. Next, banks' measures to deal with increased outflows are discussed. Finally, it is discussed how central banks can offset potentially adverse effects of CBDC on the supply of bank loans.

# 2 Banks' loan creation with and without CBDC

## 2.1 A model of bank loan supply

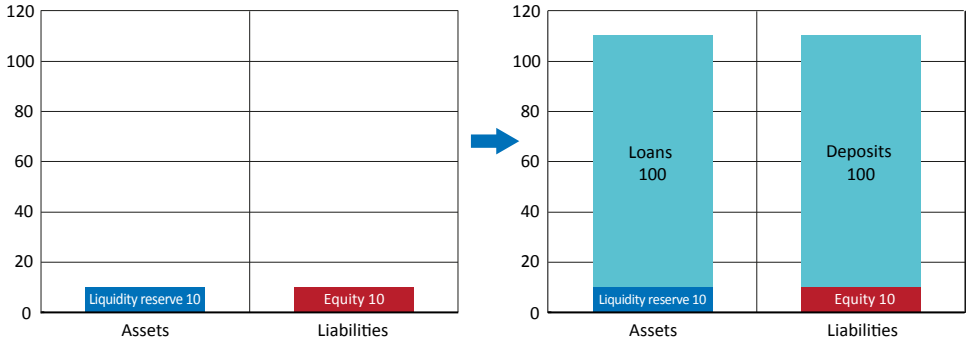
Consider a typical bank that is about to start its operations. The bank has some amount of own funds held in a liquidity reserve, that is, a portfolio of central-bank-eligible collateral. The bank can create unlimited amounts of loans and deposits in its book in a digital form.[4] However, when deposits are used for payments, outflows to other banks and to cash or CBDC, if available, may occur. These outflows can be only met in central bank reserves, giving rise to banks' demand for central bank reserves. The bank can lend and borrow reserves via interbank markets, but only on a secured basis using central-bank-eligible collateral.[5]

The central bank supplies central bank reserves against eligible collateral via its lending facility and exchanges reserves for cash or CBDC, if available, whenever the demand for these central bank liabilities arises.[6] The central bank also maintains the system of electronic payments, where banks can make payments between themselves in central bank reserves. Payments between banks arise whenever the clients of one bank make payments to the clients of other banks.

The setup outlined above allows the calculation of a bank's lending capacity as a function of its liquidity reserve and the size of potential outflows. To illustrate the mechanism of the model, consider a bank that has 10 units in its liquidity reserve (see Figure 1). The bank is assumed to operate in an environment where the size of potential outflows is estimated to be up to 10 per cent of deposits. In this environment, the bank has a capacity to create 100 units of loans. When the bank issues 100 units of loans, it simultaneously creates 100 units of deposits. These deposits can give rise to a potential outflow up to 10 units. Since the bank has 10 units in its liquidity reserve, it can borrow reserves from the central bank against its liquidity reserve and meet potential outflows stemming from deposits.

**Figure 1. A stylised example of a bank's lending capacity if the size of potential outflows of deposits is 10 per cent**

Units of money




4 Digital loan and deposit creation by banks nowadays can be compared with the issuance of banks' own notes and bills in 19th century Sweden. For more information on banks' issuance of notes and bills, see Sveriges Riksbank (2020). Note also that banks must comply with capital and many other regulations, something that is ignored in this model.

5 In practice banks can also borrow to some degree via unsecured interbank markets, but this source of borrowing is not available during times of distress.

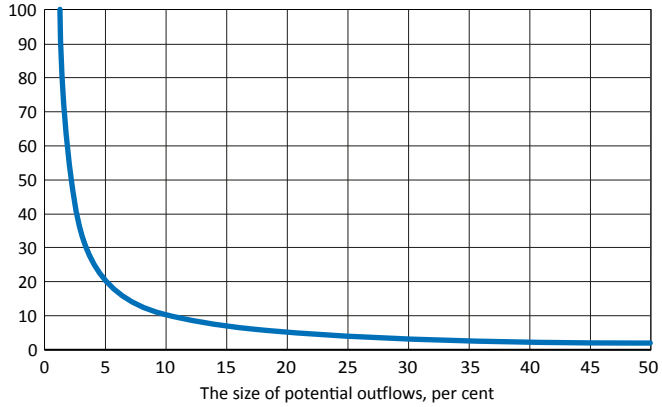
6 By applying interest rates on their deposit and lending facilities, central banks can influence the interest rates that banks apply on their deposits and loans.

A bank's lending capacity can be also expressed as a multiple of its liquidity reserve. For the bank in Figure 1, the lending capacity would be 10 meaning the bank can lend out 10 times its liquidity reserve. When the lending capacity is expressed as a multiple of the bank's liquidity reserve, the only remaining parameter that determines the bank's lending capacity is the size of potential outflows.

As illustrated in Figure 2, banks' lending capacity increases (decreases) exponentially as the size of potential outflows decreases (increases). When the size of potential outflows is below 5 per cent, banks' lending capacity is at least 20 times their liquidity reserves. When the size of potential outflows is between 5 and 10 per cent, banks' lending capacity is between 10 to 20 times their liquidity reserves. As the size of potential outflows approaches 100 per cent, banks' lending capacity reaches one. This case corresponds to a situation where banks lend out cash, but none of this cash ever returns to banks in the form of saving deposits.[7] We return to this case in the next section.

**Figure 2. Banks' lending capacity as a function of the size of potential outflows**

Lending as a multiple of liquidity reserve funded by equity




Note. Banks' capacity to lend is calculated as the inverse of the size of potential outflows.

## 2.2 Understanding the size of potential outflows from retail deposits

When banks create deposits by granting loans, all deposits are initially held for transaction purposes. Yet, after initial borrowers have used their deposits for various payments, other economic agents receive these deposits as an income. This income can be either consumed or saved. When income is consumed, deposits are used for transaction purposes. When income is saved, deposits are used to make financial investments. Below we explain in detail how outflows occur when deposits are used for either consumption or savings. Our focus is on retail deposits, that is, deposits held by households and small and medium-sized enterprises.

### 2.2.1 Outflows from retail deposits that are held for transaction purposes

When deposits are consumed and thus held for transaction purposes, depositors can choose between electronic demand deposits and physical cash. When depositors use cash as means of payment, outflows will occur. Banks will then need to buy more cash from the central bank against their liquidity reserve.

7 This case is similar to the loanable funds model where banks are assumed to be pure intermediaries rather than liquidity creators. For more information on the loanable funds model, see e.g. Jakab and Kumhof (2019).

When depositors use demand deposits for electronic payments, payments will occur between different banks. Whenever a client of one bank makes a payment to a client of another bank, the bank of the paying client sees an outflow while the bank of the receiving client sees an inflow. In other words, payments with demand deposits redistribute liquidity reserves between banks: banks that have more outgoing payments than incoming payments during a day see a daily outflow and hence reduction in their reserves while banks that have more incoming payments than outgoing payments during a day see a daily inflow and hence an increase in their liquidity reserves.

The amount of liquidity reserve that is needed to facilitate payments with demand deposits is small in relation to the stock of demand deposits. This result is partly driven by the fact that income is consumed gradually over time and only a fraction of all demand deposits held for transaction purposes are actually used every day. Another reason for this result is that incoming and outgoing payments during a day tend to be equal resulting in zero outflows for individual banks. This result holds naturally in a banking sector where banks are identical in terms of size, customer base and new lending. When banks differ in business models, structural outflows may occur for individual banks. Yet, these outflows are likely to be temporary in normal times since both reserve-losing and reserve-winning banks have incentives to actively adjust their activity.[8] Banks that experience frequent daily outflows see their liquidity reserves go down. To manage future potential outflows, these banks have clear incentives to reduce outflows for instance by temporarily slowing down new lending. Similarly, banks that experience frequent daily inflows see their liquidity reserves increase. Since holding more reserves than are needed weighs negatively on banks' profitability, these banks have an incentive to increase outflows, for instance, by increasing their new lending. In the end, these active choices reduce any structural imbalances between banks, allowing both groups of banks to achieve lending volumes that are large in relation to their liquidity reserves.

Even if demand deposits held for payment purposes generate close to zero daily outflows on average, individual banks would still need to hold some liquidity against demand deposits for two reasons. First, there is always some random volatility in outflows even if outflows on average are close to zero. Due to the law of large numbers, this volatility is naturally low when demand deposits are held by a large number of small retail clients, such as households and small and medium-sized enterprises. Second, demand deposits are subject to run risk. The amount of liquidity required to deal with runs is substantial even when referring to retail deposits. When mistrust against a bank or banks occurs, retail depositors may choose to move their funds away from the troubled banks. An outflow from retail deposits that is typically close to zero can in this case increase significantly for the banks concerned. In practice, it is this possibility of runs that makes banks hold a considerable amount of liquidity reserves against demand deposits held for transaction purposes.

### 2.2.2 Outflows from retail deposits that are used for savings

Some income that is received via deposits is saved rather than consumed. Depositors can use liquid demand deposits for savings, but most likely they would look for more attractive savings opportunities.[9] Typically, individual retail depositors use intermediaries to allocate their savings. When a few large asset managers receive a large pool of retail deposits, a large part of banks' retail deposit stock is converted into wholesale deposits controlled by a few actors. These wholesale deposits require larger liquidity reserves than retail deposits. However, instead of holding larger liquidity reserves, banks can manage outflows from these wholesale deposits by offering savings in term deposits and bonds. When these

8 In normal times, unsecured interbank markets may also work to some extent, reducing the need for banks to hold liquidity against random imbalances between incoming and outgoing payments.

9 If demand deposits are held for savings, banks would need to hold some liquidity against these demand deposits due to run risk.

wholesale deposits are invested in long-term funding instruments issued by banks, these wholesale deposits are stabilised and no outflows occur during the maturity of these funding instruments. In sum, banks have good opportunities to minimise outflows from saving-oriented retail deposits by offering them suitable saving products.

### 2.2.3 A numerical illustration of potential outflows from retail deposits

As explained previously, retail deposits are held for either transaction or saving purposes. Banks need to hold some liquidity against transaction deposits to cover potential outflows due to cash withdrawals and the risk of runs. To manage outflows from the saving part of retail deposits, banks can offer investments in stable funding instruments. Outflows from these deposits can therefore be considered to be zero since the maturity of stable funding instruments can be matched with the maturity of loans.[10] The total outflow factor for banks, in our example, can therefore be calculated as a product of the share of transaction deposits (i.e. the non-saving part of deposits) and the outflow factor attached to transaction deposits.

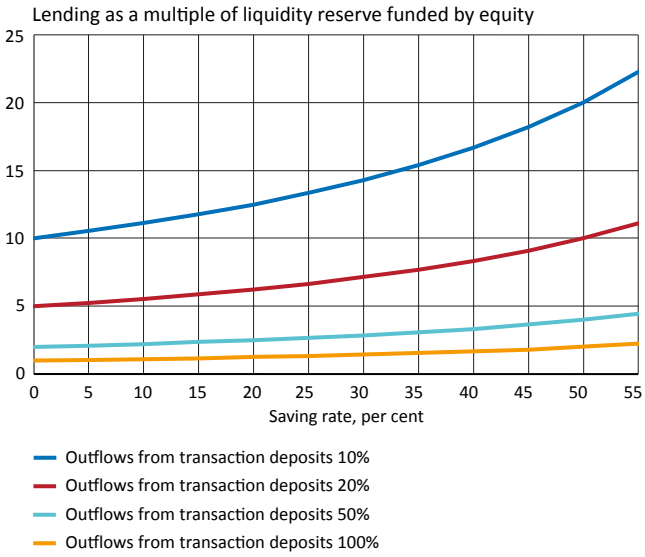
Figure 3 illustrates what different saving rates and outflow factors from transaction deposits (which themselves are driven by cash withdrawals and the risk of runs) mean for banks' lending capacity. The increased saving rate naturally increases banks' lending capacity since outflows from deposits held for saving purposes can be managed without holding any liquidity reserve, that is, these outflows can be managed via the issuance of long-term funding instruments (all lines are upward sloping in Figure 3). Increased outflows from transaction deposits naturally decrease banks' lending capacity for any given saving rate. As the risk of runs or withdrawals to cash increase, more liquidity must be held against every unit of deposits that is held for transaction purposes (see the downward shift in curves as outflows from transaction deposits increase).

There are two interesting cases presented in Figure 3 that are worth explaining in more detail. The first one is when outflows from deposits held for transaction purposes are 100 per cent and the second one is when the saving rate is zero.

The first case describes a world where loans are granted only in central bank money such as cash and where central bank money is used as the only means of transaction. In this world, banks' capacity to lend would entirely depend on the saving rate. With the saving rate of zero, banks will have 100 per cent outflows and banks' capacity to lend will be 1 (see the yellow line at the point of zero saving rate). In this world banks lend out cash, but none of this cash ever returns to banks in the form of transaction or saving deposits. Hence, banks cannot lend more than they have in their liquidity reserves. With the saving rate larger than zero, banks' lending of cash also generates an inflow of cash which in turn can be used to make additional lending so the total amount of bank lending will exceed that of banks' initial liquidity reserves.

10 This is a simplification. In practice, banks may not entirely match the maturity of their market funding with the maturity of loans. Also, some demand deposits may be held for saving purposes, which exposes them to the risk of run, thereby requiring the holding of liquidity reserve.

**Figure 3. Banks' capacity to lend for different combinations of saving rates and outflows from transaction deposits**




Note. The saving rate is used to divide deposits into two: saving and transaction deposits. The total outflow factor for all deposits can then be calculated as a weighted average of outflow factors for two types of deposits. The outflow factor for saving deposits is assumed to be zero, while the outflow factor for transaction deposits varies between 10, 20, 50 and 100 per cent. The total outflow factor is then used to calculate lending capacity as an inverse of the outflow factor, just like in Figure 2.

We can illustrate the lending process with the saving rate of 50 per cent (see the yellow line at the point when the saving rate of 50 per cent). In this case, banks' capacity to lend is 2, that is, banks can have a lending volume that is twice the amount of their own liquidity reserve. This lending can be created in a following way. First, banks lend out the amount of cash that is equal to their entire liquidity reserve. This initial lending then generates the need for savings that banks can satisfy for instance via term deposits. This means that after the initial lending, there will be an inflow of cash to banks that corresponds to 50 per cent of their initial lending. This inflow can be used for the second round of lending, which in turn generates an inflow of cash corresponding to 50 per cent of the second lending. The process continues until banks reach lending volumes that are twice the amount of their initial liquidity reserve. All these loans would be funded by 50 per cent of banks' own funds and 50 per cent of term deposits representing savings that were created in the economy.

The second case corresponds to a world where no depositor is willing to save in illiquid claims. In this world, all deposits created via lending will be held in the form of liquid demand deposits. In such a world, banks can still achieve high lending capacities provided that outflows from transaction deposits are relatively low. For instance, when the risk of runs and withdrawals to cash are estimated to be 10 per cent of these deposits, banks can still create illiquid bank loans that correspond to 10 times their liquidity reserves (see the interaction of the blue line with the y-axis). This case is a vivid illustration of how banks can fund some illiquid investments even when no-one in the economy is willing to hold illiquid claims.

## 2.3 The impact of a CBDC on the supply of bank loans

In the model, it is the size of potential outflows that determines banks' capacity to lend. Since banks can offer long-term funding instruments for retail deposits held for saving purposes, outflows stem mainly from retail deposits held for transaction purposes. While these deposits do not create any significant outflows in normal times, outflows can become significant in times of distress due to bank runs.

The introduction of a CBDC can affect banks' outflows in both normal as well as stressed times. In normal times, a CBDC can act as a natural competitor to a part of retail deposits held for transaction purposes. In stressed times, a CBDC can cause larger outflows than are possible currently, as a CBDC is more attractive competitor to bank deposits than physical cash is in times of systemic stress.

In this section, we consider the effect of a CBDC on outflows in distressed times. Our focus is on stressed times for two reasons. First, while a CBDC can also affect outflows in normal times, the effect of a CBDC on banks in normal times is likely to be insignificant. This is because bank deposits are interest-bearing, while a CBDC is not, giving banks a crucial advantage over a CBDC in normal unstressed times. Second, outflows in stressed times are larger than outflows in normal times. It is therefore the size of outflows in stressed times that is a binding constraint for banks. This result holds irrespective of whether there is a CBDC or not.

### 2.3.1 The current estimates of deposit outflows in stressed times

Banks' current holdings of liquid assets are regulated by the liquidity coverage ratio regulation (LCR). This regulation refers to a combined scenario of idiosyncratic as well as market-wide stress lasting for the period of 30 days. According to this stressed scenario, the cumulative net outflows of retail deposits under the period of 30 days are estimated to be between 3 per cent and 10 per cent of the stock (see BIS 2013). Therefore, banks must currently hold a liquidity reserve that is up to 10 per cent of their stock of retail deposits.

While it is not explicitly stated in the LCR regulation, there are good reasons to believe that the current estimates of outflows of retail deposit stem primarily from the actual cases of idiosyncratic rather than systemic runs. The reason is that a bank run in case of an idiosyncratic stress situation is straightforward: depositors can simply transfer their funds from a troubled bank to a healthy bank. This can be compared to a bank run in case of a systemic stress situation, when all banks are deemed risky. A bank run where depositors change banks makes little sense in this case. Depositors can buy government bonds or foreign currencies but the current owners of any safe assets will sell if they are appropriately compensated for exchanging these safe assets for risky bank deposits. In other words, the limited supply of these safe assets will leave any marginal depositor indifferent to buying or not buying these safe assets. While cash is supplied elastically by central banks, cash can be an inconvenient asset to run to due to its physical form.[11] A general lack of suitable assets to run to in systemic stress situations is likely to limit the actual magnitudes of runs of retail deposits in the existing financial system.

Note that retail deposit outflows in an idiosyncratic stress situation are lower than 100 per cent. One potential explanation is that some depositors are simply not informed. Another potential explanation is that depositors do not bother to run in the presence of a credible deposit guarantee scheme.

### 2.3.2 The change in deposit outflows when a CBDC is introduced

The introduction of a CBDC introduces an attractive run asset that allows retail depositors to run banks even in systemic crisis situations. If the potential size of runs in systemic stress situations is larger than the size of runs currently observed mostly in idiosyncratic stress situations, then a CBDC leads to an overall increase in potential outflows.

There are good reasons to believe that the magnitude of stress in systemic stress situations is likely to exceed the magnitude of stress observed in idiosyncratic stress situation. First, shocks may get more easily magnified via spillover effects in systemic stress situations as compared to idiosyncratic stress situations. Second, systemic crisis situations

11 In addition, the physical form of cash can make the actual supply of cash inelastic in the short-term. Banks may also have limits to how large daily withdrawals from deposits to cash can be.

typically persist longer than idiosyncratic crisis situations. This may increase media coverage, which in turn may increase the share of informed depositors in case of systemic as compared to idiosyncratic crisis situations. Finally, the credibility of any deposit insurance system may be weaker in case of systemic as compared to idiosyncratic crisis situations.

All in all, a CBDC may reduce the current stability of retail deposits by increasing the potential outflows of demand deposits during systemic stress situations.

# 3 Adjustments by banks in a world with a CBDC

In the previous sections we looked how the supply of bank loans depended on potential outflows and how CBDC affected the size of potential outflows. The size of banks' liquidity reserves and central bank policies for eligible collateral were taken to be given. In this section we allow banks to adjust to a world with a CBDC. Before the launch of a CBDC, banks can adjust their balance sheets in advance so that they are able to meet the new level of potential outflows.

To make the setup as concrete as possible, we assume that banks operate initially in the environment where the size of potential outflows is 10 per cent. This initial environment means that banks have created lending that is 10 times their liquidity reserve (see Figure 1). We then assume that the introduction of a CBDC is announced and the size of potential outflows is estimated to increase from 10 to 20 per cent.[12]

## 3.1 Balance sheet adjustments by banks with unchanged lending

We start by considering adjustments that banks can undertake without affecting their initial level or composition of lending. To achieve this, banks have essentially two choices in the new environment:

- find investors willing to exchange their central-bank-eligible securities for stable funding instruments issued by banks;
- find real sector depositors willing to convert their demand deposits into stable funding instruments issued by banks.

The first way banks can adjust is to increase their liquidity reserve so that the new increased level of liquidity reserve supports the initial level of lending[13] (see the upper graph in Figure 4.) Such an adjustment can be achieved by finding investors that are willing to exchange their central bank eligible securities for stable funding claims issued by banks.[14, 15] In practice, banks will first need to buy central-bank-eligible securities from willing investors. As a payment for these securities, investors will receive newly issued demand deposits. Banks can then convert these demand deposits into stable funding instruments when investors buy these funding instruments and pay with their demand deposits.

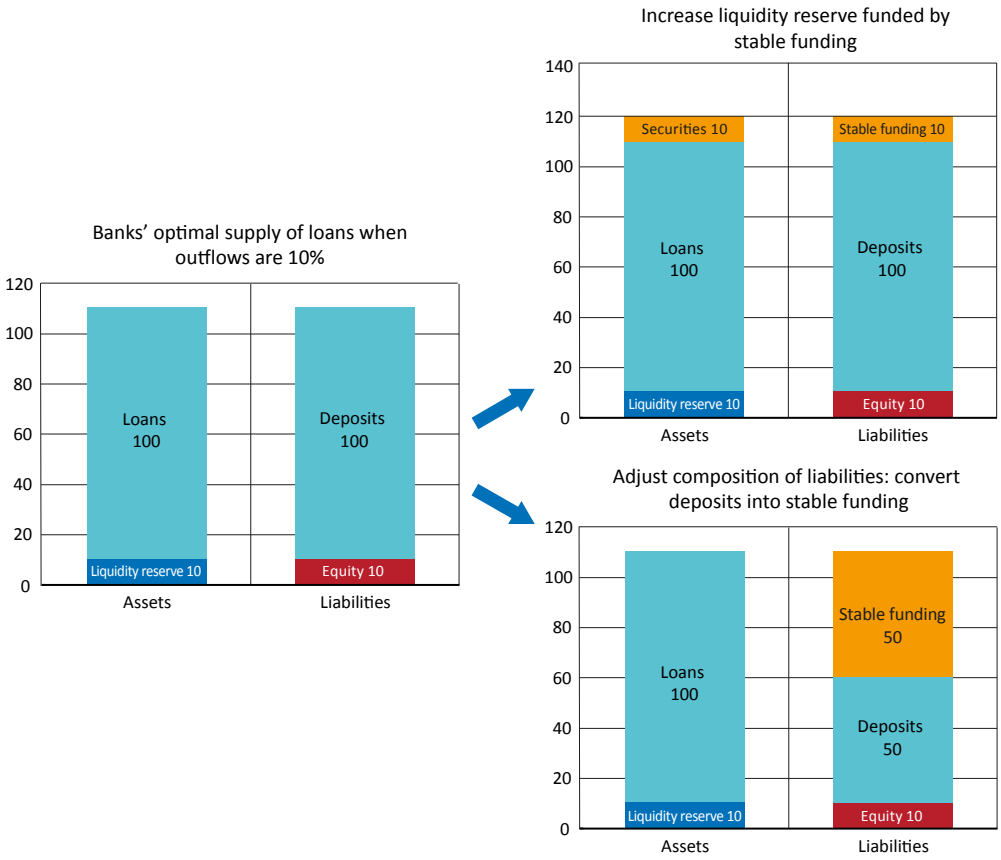
12 This increase in outflows can be motivated in many different ways. One possibility is to assume that all retail clients hold retail deposits even for saving purposes. Then, the size of potential outflows stems simply from the fact that a CBDC increases the size of bank runs from 10 to 20 per cent of demand deposits.

13 Here we keep the supply of central-bank-eligible collateral such as government bonds fixed. In practice, the supply of government bonds typically increases as the economy grows. When the government aims to keep its debt to GDP ratio constant over time, it must run a small deficit as the economy grows. When the government spends more than it receives, it funds this deficit first by borrowing overnight from the banks. Banks' balance sheets therefore increase as a result of the increased deficit: on the asset side, there is a larger loan to the government and on the liability side, there are increased deposits held by economic agents that received more than they paid to the government. The government can then exchanges its overnight bank loan for newly issued government bonds by selling these securities to banks. This natural increase in banks' liquidity portfolio facilitates the natural growth of banks' own supply of loans as the economy grows.

14 For an individual bank, it does not have to be central-bank-eligible collateral. If some non-central-bank-eligible collateral is accepted in money markets, the bank can draw in central bank reserves with this collateral from other banks. But looking from the perspective of the entire banking sector, outflows to a CBDC would create an aggregate shortage of central bank reserves in the banking sector. To manage this shortage, banks must acquire central-bank-eligible collateral.

15 Stable funding claims could also be in the form of equity. If so, banks would also become better capitalised and better capitalisation could in turn reduce the size of potential outflows from demand deposits. This second round effect is for simplicity ignored. It is also unclear to which degree can capital offset the risk of outflows from retail deposits.

**Figure 4. Banks' adjustments that keep banks' lending the same when outflows increase from 10 to 20 per cent**




As a result of these transactions, banks' liquidity reserves increase by the amount required to meet increased outflows. In our example, outflows increase from 10 to 20 per cent. This means that the liquidity reserve needs to increase by 10 units of central-bank-eligible collateral and on the liability side, there will be newly issued stable funding instruments in the amount of 10 units. With the help of these transactions, banks can adjust their balance sheets without affecting their initial supply of loans and deposits to the real sector.

The second way banks can adjust is to reduce the amount of potential outflows, for instance, by converting some demand deposits into stable funding instruments (see the lower graph in Figure 4). In practice, this means that banks will try to convert some of their existing demand deposits into term deposits. In our example, banks will need to convert half of their demand deposits into term deposits to survive in the new environment. Banks still have the same level of liquidity reserves as initially, but these reserves will be enough to meet outflows that fall due to a conversion of some demand deposits into term deposits.

Comparing the two adjustments presented above, it is clear that both adjustments imply an increase in illiquidity of the real sector. In the first adjustment, this increase in illiquidity takes place indirectly via intermediaries that become less liquid. These intermediaries may be willing to exchange their liquid assets against less liquid assets only if they are appropriately compensated for it. How much compensation they require depends on their own need for liquidity. In the second case, the increase in illiquidity is direct since some demand deposits held by the real sector are converted into term deposits. If the real sector holds these demand deposits for saving purposes, the cost of conversion will probably be low. However, if the real sector holds these demand deposits for transaction purposes, the cost of conversion will be high since the real sector will be unwilling to hold illiquid term deposits which cannot be used for transaction purposes.

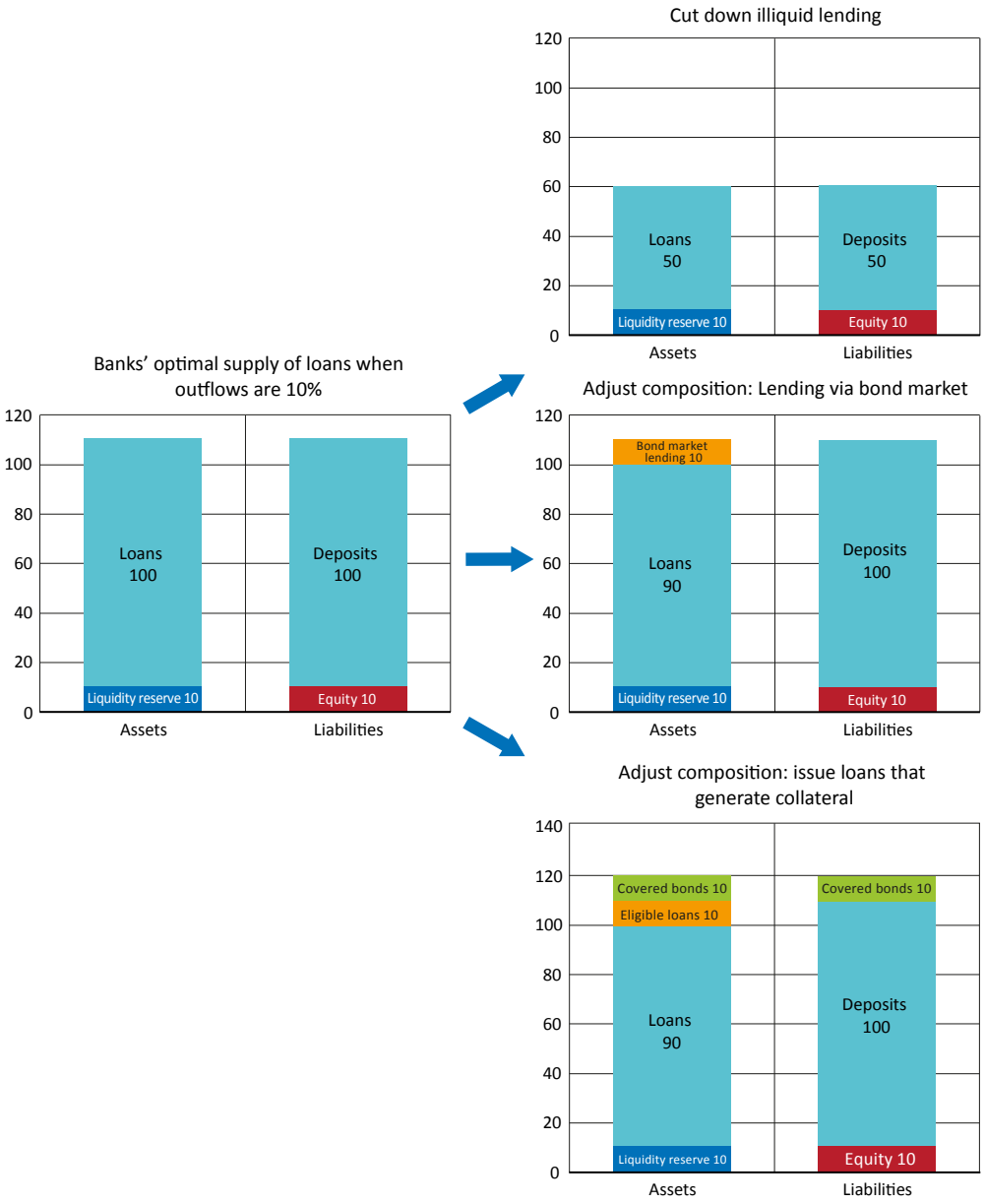
Both adjustments, even if feasible, will add to the cost of bank lending. The increased cost, once laid over to the initial stock of loans, will likely affect the demand for loans, leading to a lower level of bank loans in equilibrium. As a back-of-envelope calculation, assume a spread between government and senior unsecured bank bonds to be equal to 100 basis points. Then, an increase of outflows from 10 to 20 per cent implies an additional cost of existing bank loans of 10 basis points, if banks exchange their newly issued senior unsecured bonds for central-bank-eligible collateral in the form of government bonds.

## 3.2 Balance sheet adjustments by banks: level and compositional changes

In addition to the adjustments that allow banks to keep their initial level and composition of lending, banks can also respond by adjusting the level and composition of lending. The level adjustment can take place by banks not rolling over some of their maturing illiquid loans (see the upper graph in Figure 5). In our example, banks need to half their existing stock of loans to be able to adjust to the new environment. In practice, banks can also reduce illiquidity of loans by simply reducing the maturity of loans. In an extreme case, the maturity of loans may match that of the maturity of demand deposits. In the event of increased risk of deposit withdrawals to a CBDC, banks can simply call in loans which in turn will destroy deposits that can run to a CBDC.

Compositional adjustments can take place by banks cutting down the type of lending that cannot generate collateral and replacing it with loans that generate collateral. For instance, banks may start lending more via bond markets instead of issuing traditional illiquid loans (see the middle graph in Figure 5). By doing this, some illiquid real sector loans on banks' balance sheet are substituted for tradable bonds. This change in lending would enhance banks' liquidity position in case these tradable assets were accepted as central-bank-eligible collateral.

**Figure 5. Banks' adjustments via the level and composition of lending when outflows increase from 10 to 20 per cent**




Compositional adjustments can also take the form of banks tilting their lending policy towards loans that can be securitised (see the lower graph in Figure 5). In some countries retail mortgages with certain loan-to-value properties are eligible for cover pools that in turn can be funded by covered bonds. In case of an increased need for a traded security, banks can include loans currently funded by demand deposits into their covered pools and issue additional covered bonds. These newly issued covered bonds can then be retained by banks and used in central bank borrowing facilities as long as these traded securities are accepted as central-bank-eligible collateral.

Any changes in the level or composition of bank lending will lead to quantitative rationing of bank credit to some sectors. Credit rationing will lead to a contraction in macroeconomic activity in these sectors. In addition, there may be adverse effects on the prices of real assets that are heavily used in sectors that see their supply of banks loans decrease.

All the adjustments discussed above imply a reduced role of banks as liquidity creators for the real economy. Banks' adjustments will either increase the cost of existing bank loans or lead to a reduction in absolute level of bank lending to some sectors. The changed supply

of bank loans will in turn affect macroeconomic activity. The magnitude of macroeconomic effects will depend on the following factors:

- The size of a necessary adjustment. The larger the size of a necessary adjustment, the greater the macroeconomic cost associated with the adjustment. Banks are likely to follow a pecking order of adjustments starting with the least expensive: Banks may initially try to keep the existing volume and composition of their lending and work with acquiring more central-bank-eligible collateral and rolling-over demand deposits into term deposits. These first adjustments may however have their natural limits. If the supply of central-bank-eligible collateral is limited, finding willing investors to swap these securities for illiquid claims issued by banks will at some point be increasingly costly. Similarly, as banks try to roll over their liquid deposits into term deposits, they may at some point reach the point where no more existing depositors are willing to engage in trade, irrespective of the price offered. If these thresholds are hit, banks will need to cut their supply of illiquid loans which will have an increasing impact on macroeconomic activity.
- The length of an adjustment period. The longer the time period for banks and their borrowers to adjust, the lower potentially adverse transitory effects would be. Borrowers whose loans are not rolled over will need enough time to complete their investments. For instance, manufacturing companies will need to complete their production cycles and be ready with the sales of their final products before they can actually repay their maturing bank loans. Any rapid adjustment will inevitably increase stress for these firms, which in turn may lead to more adverse macroeconomic activity.
- Monetary policy response. When the adjustments go via rates rather than via quantities, central banks can reduce the macroeconomic impact via standard monetary policy tools. The necessary adjustments that go via costs will either increase bank lending rates in relation to the policy rate (e.g. lending margins) or reduce banks' profitability. If banks tried to increase their lending margins, monetary policy could react to offset increased margins. This policy measure is however limited if there is a natural limit in the form of a lower bound on the policy rate.

It is worth emphasising that other non-bank actors such as asset managers have only a limited capacity to compensate for the decreasing supply of bank loans. When the supply of bank loans contracts and bank loan rates increase, it may become more attractive for these other actors to step in and supply more credit. However, unlike banks, these other actors cannot increase their lending unless they first acquire more funds from existing depositors.[16] When existing depositors provide funds to these non-bank actors, they exchange their liquid demand deposits for less liquid claims. The end result is the re-distribution of liquidity from depositors to non-bank actors. Therefore, the capacity of non-bank actors to offset the decreasing supply of bank loans is directly comparable to banks' own ability to roll over their own demand deposits into term deposits or other forms of stable funding instruments. As explained above, there are natural limits to how much illiquidity can be pushed into the existing stock of demand deposits.

16 The only exceptions are non-bank actors that manage to create liabilities that are widely accepted as a means of payments by the general public.

# 4 Adjustments by central banks in a world with a CBDC

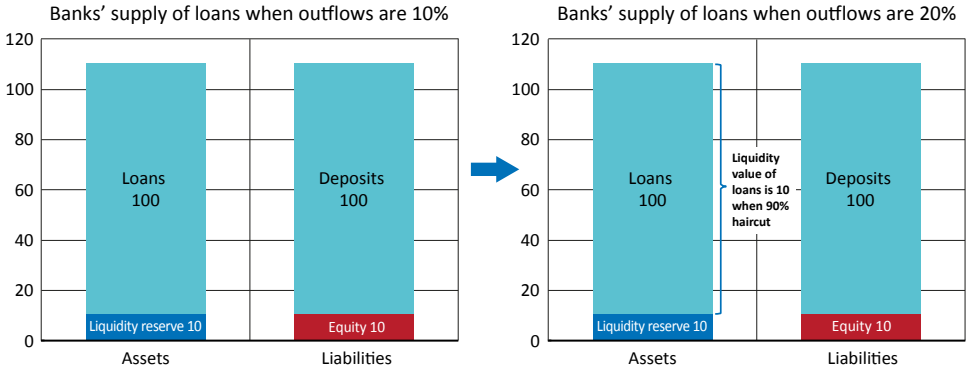
## 4.1 Adjusting the set of central-bank-eligible collateral

As described previously, the introduction of a CBDC may lead to increased outflows and thereby increase the demand for central bank reserves, especially in systemic stressed situations. When central banks accept only (high-quality) tradable securities as eligible collateral, the supply of central bank reserves may become constrained unless banks adjust their balance sheets ex ante. Adjustments by banks may however have adverse effects on the supply of illiquid bank loans, with potentially adverse effects on macroeconomic activity.

In this section we show how central banks can offset adverse effects of a CBDC on the supply of bank loans by accepting illiquid bank loans or simply raw loans as eligible collateral. When the extra liquidity value that stems from the eligibility of raw loans is large enough to cover an increase in potential outflows due to a CBDC, then banks' lending capacity can be kept unchanged even in the presence of CBDC.

To illustrate this result, consider the typical bank we have used throughout the paper (see Figure 6). Due to the issuance of a CBDC, the size of potential outflows increase from 10 to 20 per cent. It can be easily verified that if raw loans have a liquidity value of 10 per cent in central bank lending facilities (i.e. a haircut of 90 per cent), then the bank can still sustain its initial level of lending of 100 units. Lending out 100 would generate 100 units of demand deposits. When 20 per cent of these are converted into CBDC, the bank can use its initial liquidity reserve of 10 units plus the extra liquidity value of bank loans, which is 10 units, to meet the outflow.

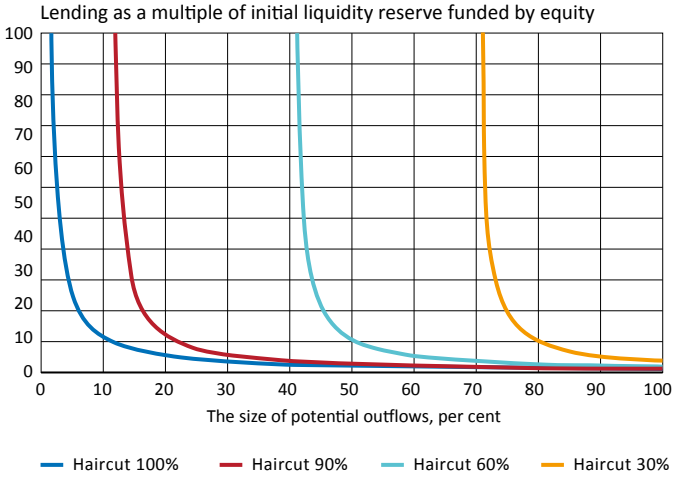
**Figure 6. An example of a bank's capacity to lend when raw loans are accepted as eligible collateral**




More generally, we can calculate banks' lending capacity by taking into account the eligibility of raw loans. This is illustrated in Figure 7. The dark blue line illustrates the initial situation where raw loans are not eligible. We can see that high levels of lending capacity can be achieved even in the environment with large potential outflows. For instance, banks would still be able to lend out 20 times their liquidity reserve when the size of potential outflow is 75 per cent. This would be possible if haircuts on raw loans were up to 30 per cent.

**Figure 7. A banks' capacity to lend as a function of the size of potential outflows when loans are eligible collateral**

Lending as a multiple of initial liquidity reserve funded by equity




The inclusion of raw loans to the set of eligible collateral is by no means an extraordinary step for central banks. The Federal Reserve, ECB, Bank of England and Bank of Canada have already collateral frameworks that allow pledging of raw loans in their credit operations. Haircuts that are applied vary from 5 per cent for low-risk loans such as high-quality retail mortgages to 80 per cent for high-risk loans such as unsecured consumer loans.[17] Some central banks do not accept raw loans directly, but they do so indirect by accepting asset-backed securities (e.g. Reserve Bank of Australia).

## 4.2 Increasing central bank reserves via outright purchases of assets from investors

In previous sections we looked at changes to the set of eligible collateral by central banks as a potential measure to manage adverse effects of a CBDC on the supply of bank loans. In this section we consider an additional measure that can be taken by central banks: the outright purchase of assets from investors (AP). The question we are interested in is whether AP can enhance banks' capacity to lend in an environment where banks' capacity to lend is hampered by the introduction of a CBDC.

To understand AP in the presence of a CBDC, we need first to specify who can hold central bank reserves. To ensure consistency with the rest of the paper, we stick to our initial assumption that only banks can hold central bank reserves but depositors can at will convert their deposits to the CBDC. This assumption allows us to think of AP as it is currently conducted in practice.

In this setup, AP will first lead to the creation of new central bank reserves as central banks need to pay for the purchased assets. These new central bank reserves will be held by banks, even if it is investors and not banks that sell the assets. Investors who sell their AP assets receive bank deposits as a payment for the assets sold. The investors can, however, convert their deposits into the CBDC, just like any other depositors.

To illustrate the setup, consider a case where the central bank buys 10 units of illiquid assets from investors. As a result of AP, banks experience an increase in central bank reserves that are funded with deposits held by the investors that sold their assets into AP (see the left graph on Figure 8). Investors are likely to take further steps. It is these additional steps taken by the AP investors that determine the impact of AP on banks' capacity to lend.

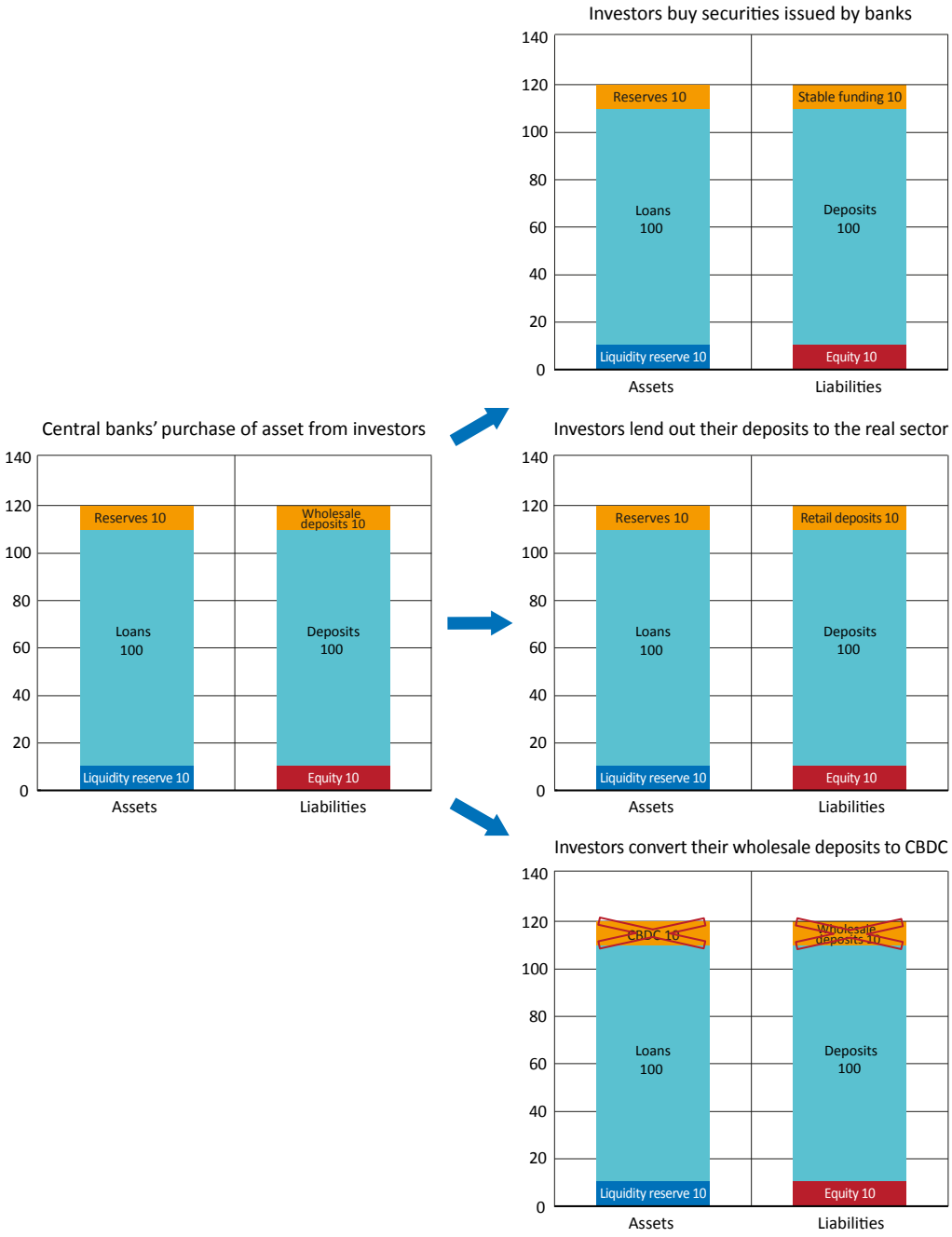
17 The Federal Reserve, ECB and Bank of Canada publish haircuts on individual loan types on their websites. Bank of England does not publish haircuts on individual raw loans, but states in its annual Report on the Bank's official market operations 2018–19 that haircuts in raw loans stayed in the interval of 14–52 per cent (see Bank of England 2019).

In non-stressed situations, investors would re-balance so that their exposure to illiquid assets was the same as it was before AP. In our context this means that investors would lend out their demand deposits at term, via either illiquid bonds or loans. The borrowers of these funds would be either banks via stable funding instruments or the real sector via illiquid loans (see the upper and middle graphs on the right-hand side in Figure 8). Irrespective of whether the funds were lent out at term to banks or to the real sector, banks' lending capacity would be enhanced as explained in more detail below.

If investors lent out funds directly to banks, AP would lead to an increased demand for stable funding instruments which in turn would mean reduced costs of term funding for banks. AP therefore reduces the cost that banks bear when they push illiquidity to investors in an attempt to adjust their balance sheets to the world of a CBDC (see also Figure 4).

If investors lent out funds to the real sector, AP would enhance banks' lending capacity by reducing the size of required adjustments that banks must take to manage the presence of a CBDC. As investors lent out their demand deposits to the real sector, deposits would move from investors to the real sector. If the retail deposits have an outflow factor than is lower than 100 per cent in the presence of CBDC, then the increase in central bank reserves due to AP is larger than the increase in outflows stemming from the increased retail deposits. All in all, this dynamic reduces the magnitude of adjustments that banks need to make to be able to cope with the world of a CBDC.

**Figure 8. Outright purchase of illiquid assets by central banks**




To illustrate this last point, consider again the setup where CBDC increases outflows from 10 to 20 per cent. Without AP, banks would need to find investors willing to swap 10 units of central-bank-eligible collateral with 10 units of stable funding instruments issued by banks (see also Figure 4). With the AP of 10 units, banks would obtain 10 units of extra central bank reserves. If investors rebalanced by lending out the received demand deposits to the real sector, banks would see an inflow of 10 units of extra retail deposits. These extra retail deposits would increase banks' outflow by 2 units. Thus, AP has given banks 10 units of extra central bank reserves, while outflows have increased by only 2 units. The extra 8 units of central bank reserves means that banks need only 2 units instead of the initial 10 units of central-bank-eligible collateral obtained via swaps from investors.

As shown above, AP can help banks to adjust to the world of a CBDC if investors do not themselves demand liquidity that is created by AP. However, there may be situations when

the demand for liquidity is high and investors absorb the extra liquidity created by AP. In such cases, investors would simply keep their extra liquidity in demand deposits (if they had trust in banks) or convert them directly into the CBDC (if they did not have trust in banks) (see the lowest graph on the right-hand side of the Figure 8). In these cases, AP would boost the overall supply of funds to the real sector via investors, but the effect of AP on banks' lending capacity would be weakened considerably.

In sum, AP represents an additional tool through which central banks can stimulate the supply of bank loans should the introduction of a CBDC lead to a contraction in the supply of bank loans. This tool however has its limits, especially when it is used in distressed times when the general demand for liquidity is high.

# 5 Conclusions

The introduction of a CBDC is often perceived to have an adverse effect on the supply of bank loans. We study this concern with the help of a model that is based on the actual practice of banking. In the model, banks can create unlimited amounts of loans and deposits in their own books. However, they must also satisfy customers' outflows to other banks and cash, and in the presence of a CBDC, also to the CBDC.

Banks can currently create lending volumes that are at least 10 times their own liquidity reserves. This lending capacity is possible because deposits created by lending generate only modest outflows. The two main drivers of outflows for retail deposits are withdrawals to cash and the risk of bank runs. In the current system, sizeable bank runs mostly take place in times of idiosyncratic stress situations when depositors can easily move their funds from a troubled bank or banks to healthy banks. In times of systemic stress, all banks may be deemed risky but outflows may nevertheless be limited. This is so because physical cash, the only available run asset with elastic supply in the times of systemic stress, is an unattractive asset to hold in the digital era. Since CDBC is digital, it can become superior to bank deposits, especially in times of systemic distress. CBDC can therefore expose banks to larger potential outflows than are currently observed.

To cope with larger potential outflows in the presence of a CBDC, banks can take different measures. Banks can for instance buy more central-bank-eligible collateral and fund these purchases by issuing stable funding instruments to the sellers. Banks can also try to convert some demand deposits into term deposits. Adjusting the composition and the supply of illiquid lending is another way for banks to adjust to a world with a CBDC. All these measures, especially if large enough, tend to reduce the supply of illiquid bank loans to the real sector, with potentially adverse effects on macroeconomic activity.

To offset the adverse effects of a CBDC on the supply of bank loans, central banks can increase the supply of central bank reserves. When raw loans are included into the set of eligible collateral, the issuance of new loans increases banks' liquidity reserves. When an increase in banks' liquidity reserves matches an increase in the size of potential outflows due to a CBDC, the effect of the CBDC on banks' lending capacity is neutralised fully. Central banks can also conduct an outright purchase of illiquid assets to stimulate banks' supply of illiquid loans. As central banks buy illiquid assets from investors, new central bank reserves will be created for banks. Investors who sell their illiquid assets are then likely to rebalance their portfolios, increasing the demand for illiquid assets and reducing the cost of illiquid term funding for banks.

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