NBER WORKING PAPER SERIES

BANK LIQUID ASSETS, THE PORTFOLIO MOTIVE, AND CAPITAL REQUIREMENTS

René M. Stulz
Alvaro G. Taboada
Mathijs A. van Dijk

Working Paper 30340
http://www.nber.org/papers/w30340

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
August 2022, Revised December 2024

We are grateful for excellent research assistance from Jonas Elenskis, Byungwook Kim, and Leandro Sanz. We thank Mike Wittry for useful discussions. We are grateful to Viral Acharya, Allen Berger, Mark Carey, Darrell Duffie, Gene Fama, Mark Flannery, Stefan Lewellen, Steven Ongena, Raluca Roman, Til Schuermann, Jeremy Stein, Kairong Xiao, Andrew Winton, and participants at the Virtual Corporate Finance seminar, the 2023 Financial Intermediation Research Society conference, the 2024 Carnegie-Penn State-Pitt Conference, and seminars at Columbia University, De Nederlandsche Bank, Erasmus University Rotterdam, Ohio State University, Tilburg University, University of Amsterdam, University of Chicago, University of Texas at San Antonio, and University of Zurich for comments. Stulz is at times retained by financial institutions or their attorneys as a consultant or as an expert. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Bank Liquid Assets, the Portfolio Motive, and Capital Requirements
René M. Stulz, Alvaro G. Taboada, and Mathijs A. van Dijk
NBER Working Paper No. 30340
August 2022, Revised December 2024
JEL No. G21, G28

ABSTRACT

Banks hold large amounts of liquid assets. These amounts grow sharply for the largest banks after the global financial crisis (GFC). The standard transaction and precautionary motives for holding liquid assets cannot explain the size and evolution of bank liquid asset holdings. Motivated by the deposit view of banks, we introduce a portfolio motive such that banks hold more liquid assets when they have poorer lending opportunities, making loans and liquid assets substitutes. We find support for the portfolio motive and for its prediction that capital requirement increases help explain the post-GFC growth in the largest banks' liquid asset holdings.

René M. Stulz
The Ohio State University
Fisher College of Business
806A Fisher Hall
Columbus, OH 43210-1144
and NBER
stulz@cob.osu.edu

Mathijs A. van Dijk
Rotterdam School of Management
Erasmus University
P.O. Box 1738
3000 DR Rotterdam
The Netherlands
madijk@rsm.nl

Alvaro G. Taboada
Mississippi State University
College of Business
310-H McCool Hall, P.O. Box 9580
Mississippi State, MS 39762
ataboada@business.msstate.edu

1. Introduction

Banks hold large amounts of liquid assets. At the end of 2019, banks, in aggregate, held 25.4% of their balance sheet in liquid assets (defined as assets with minimal credit risk that can be sold rapidly with little price pressure), compared to roughly 10% for non-financial firms. The importance of liquid assets for banks changes sharply over time. In particular, the growth of liquid assets of the banking system was roughly fifty percentage points lower than the growth of deposits in the eleven years before the global financial crisis (GFC), so that during those years liquid assets fell as a percentage of bank assets. In contrast, the growth of liquid assets was roughly fifty percentage points higher than the growth of deposits in the eleven years after the GFC. As a result, liquid assets increased sharply from just before the GFC to just before the COVID crisis, but mostly for large banks (those with assets greater than $50 billion in 2018 dollars) as their liquid assets increased on average from roughly 13% to 26% of bank assets over that period while they increased from roughly 17% to 18% of bank assets for other banks. A large literature explains empirically the liquid asset holdings of non-financial firms using the transaction and precautionary motives for holding liquid assets (Keynes, 1936). There is no equivalent literature for liquid asset holdings of banks, even though these holdings are generally higher than bank holdings of loans to businesses, are important for financial stability, and impact the effectiveness of monetary policy. Consequently, despite their importance for banks and for the financial system, we have little understanding of why bank liquid assets are so high, vary so much across banks and across time, and increase so much after the GFC. In this paper, we address this gap in the literature.

We find that the transaction and precautionary motives for holding liquid assets cannot explain the time-series and cross-sectional patterns in liquid asset holdings of banks. We introduce a portfolio motive for holding liquid assets for banks and show that it helps make sense of these patterns. With this motive, banks are profitable because they can invest deposits at a higher rate than the rate they pay on deposits. When a bank runs out of profitable lending opportunities, investing deposits in liquid assets can be the most advantageous use of these deposits. Our empirical work provides support for the portfolio motive. It also demonstrates that post-GFC increases in capital requirements that reduce the profitability of holding loans relative to holding liquid assets help explain why bank liquid assets are much higher after the GFC for the largest banks.

The traditional view of banks is that they make loans funded with deposits (Diamond and Dybvig, 1983). We call this view the lending view of banks. From this perspective, banks have transaction and precautionary motives to hold liquid assets. Specifically, banks require a buffer of liquid assets to cope with unexpected cash outflows since the other assets of a bank are largely illiquid. A bank can fail if it does not have enough liquid assets to pay off depositors because it may be unable to sell illiquid loans in time or at prices near their fundamental value (Diamond and Kashyap, 2016).

An alternative view is that banks gather deposits and find ways to earn an income on the funds raised through deposits. These deposits provide liquidity services that are valuable, so that banks can create value on the liability side of their balance sheet even if they do not create value on the asset side (DeAngelo and Stulz, 2015; Hanson, Shleifer, Stein, and Vishny, 2015). We call this view the deposit view. Supporting the deposit view is evidence showing that deposit-taking is a more important source of value creation for banks than lending (Egan, Lewellen, and Sunderam, 2022). With the deposit view, banks have transaction and precautionary motives to hold liquid assets as with the lending view. However, in addition, banks may choose to hold more liquid assets than required for the transaction and precautionary motives because investing in liquid assets is the best use of the funds raised through deposits after they have made all the positive net present value (NPV) loans available to them.

In Hanson et al. (2015), traditional banks "create money-like claims by holding illiquid fixed-income assets to maturity." These illiquid fixed-income assets can be loans or securities. To understand holdings of liquid assets, we take a broader view of bank balance sheets than Hanson et al. (2015) in that we explicitly consider that banks also invest in liquid assets. Unless liquid assets are strictly dominated by illiquid assets, banks will hold both liquid and illiquid assets. This broader portfolio view dates at least from Klein (1971). In Klein (1971), banks invest in different asset classes such that, at the margin, they earn the same risk-adjusted expected return from each asset class. In such a model, if loans become less profitable, banks hold more other assets, including liquid assets, so that loans and liquid assets are substitutes. We call this the portfolio motive for holding liquid assets. Loans can become less profitable because the demand for loans falls or because it becomes more expensive to make and hold loans. One reason that it can become more expensive for banks to make and hold loans is a tightening of regulations that affect lending. For instance, an increase in capital requirements for loans that leaves capital requirements on liquid assets unchanged increases the relative cost of lending and makes investments in liquid assets relatively more attractive for banks.

With the lending view of banks, liquid assets and loans are complements. As loans increase, banks have to hold more liquid assets to facilitate the transactions resulting from new loans. If loans shrink, we expect a bank to hold fewer liquid assets. As a result, the lending view implies that a bank's balance sheet shrinks if lending becomes less advantageous. In contrast, the deposit view of banks implies that liquid assets and loans are substitutes. If a bank's lending opportunities improve, it will reduce its liquid assets as long as the transaction and precautionary motives are not binding. With the deposit view, a bank's balance sheet does not shrink if lending opportunities worsen as long as the deposits can be invested profitably in liquid assets. Further, the deposit view implies that when monetary policy leads to deposit outflows (Drechsler, Savov, and Schnabl, 2017), banks with ample liquid assets will reduce liquid assets rather than loans, so that monetary policy is less effective when banks have ample liquid assets (Kashyap and Stein, 2000).

Our evidence supports the deposit view of liquid assets and loans as substitutes. We find that banks with better lending opportunities hold fewer liquid assets across different panel regression specifications, different subsamples, different subperiods, and different estimation approaches. When we proxy the change in lending opportunities with the change in loans, we show that the relation is robust when we instrument the change in loans using a Bartik-like instrument (Bartik, 1991). With our framework, we expect that when banks with good lending opportunities (and thus low liquid assets holdings) experience an increase in deposits, they use the additional resources to lend more. In contrast, when banks with poor lending opportunities (and thus more liquid assets) experience an increase in deposits, they invest relatively more of the new funds in liquid assets. We corroborate this conjecture in panel regressions that include an interaction term of instrumented deposits with an indicator variable for banks with low liquid asset holdings or with an indicator variable for banks with high past lending growth.

With the portfolio motive, we expect banks to hold more liquid assets than required for the transaction and precautionary motives when their deposits are large compared to their profitable lending opportunities. If deposits grow and lending opportunities do not change, banks invest the new funds from deposits in other assets, including liquid assets. With this baseline model, we show that, from 2010 to 2020, large banks (those with assets greater than $50 billion) experience a greater increase in liquid assets than other banks, while there is no differential evolution in the liquid assets of large banks compared to other banks before the GFC. This differential increase in the growth rate of liquid assets of large banks compared to other banks after the GFC corresponds to 12.7 percentage points of assets by the end of 2020.

The most logical candidate for an explanation of this divergence in liquid asset growth between small and large banks in the 2010s is the plethora of regulatory changes taking place after the GFC. These regulatory changes involve an increase in capital requirements that advantages liquid assets at the expense of loans and the introduction of liquidity requirements that affect large banks more than other banks. There is anecdotal evidence of this effect since the CEO of JPMorgan Chase, Jamie Dimon, ordered at least one large part of the bank to decrease its use of risk-weighted capital in response to the increase in capital requirements (Zeissler, Ikeda, and Metrick, 2019). More systematic evidence is provided by Gropp, Mosk, Ongena, and Wix (2019), who find that treated banks in the 2011 EBA capital exercise chose to increase capital ratios by reducing risk-weighted assets. Using a difference-in-differences design with 2013 as the year when there is a treatment effect from the regulatory changes, we find evidence that large banks (with assets greater than $50 billion) and especially the largest banks (with assets greater than $250 billion) increase their liquid assets post-treatment. Such an increase could be consistent with an impact of the introduction of the liquidity coverage ratio requirement, the LCR requirement, which is the main new quantitative liquidity regulation during our sample period, but it could also result from increases in capital requirements when liquid assets have lower capital requirements than loans.

To distinguish between the effect of the LCR regulation and that of capital requirement increases, we use triple interactions to investigate whether the liquid assets increase more for treated banks that have a lower LCR before treatment and are affected (the large banks) or are most affected (the largest banks) by the LCR regulation. We find no evidence that banks with a low LCR before treatment that are affected or are most affected by the LCR increase their holdings of liquid assets more than other banks. However, when we investigate whether liquid assets increase more for banks with a low Tier 1 ratio before treatment, we find that the largest banks with a low Tier 1 ratio increase liquid asset holdings more. Banks with a low Tier 1 ratio can satisfy the higher risk-based capital requirements by reducing their holdings of loans and of illiquid credit-risky assets and replacing them with safe liquid asset holdings. Consequently, our results indicate that the change in capital requirements helps explain the increase in liquid assets of the largest banks relative to the other banks after 2012. We also find evidence that the regulatory changes decrease holdings of loans by the largest banks, which we would expect to be the case if banks decrease their holding of riskier assets to satisfy increased capital requirements. Perhaps not surprisingly, we find that large banks experience a sharp decrease in risk-weighted assets. An important caveat is that very few banks have assets greater than $250 billion. However, we provide extensive robustness checks for our results and they support our conclusions.

The Federal Reserve controls the aggregate amount of reserves and the rate that they earn. Our measure of liquid assets includes reserves.[1] Though aggregate reserves are under the control of the Federal Reserve, liquid assets of individual banks are not directly under the control of the central bank. Our approach is based on the view that banks choose the amount of liquid assets they want to hold. We also find support for the portfolio motive if we consider only non-reserve liquid assets. Specifically, we find that banks hold fewer non-reserve liquid assets when they have better lending opportunities.

During the post-GFC period, the Federal Reserve increased reserves through quantitative easing programs. Though these programs may have forced banks in the aggregate to hold more reserves and, as a

[1] Call reports do not provide details on banks' reserves. Our proxy for reserves is "balances due from Federal Reserve Banks."

result, increased deposits of large banks (Acharya and Rajan, 2023), increased the cost of loans (Diamond, Jiang, and Ma, 2021), and changed the composition of lending (Darmouni and Rodnyansky, 2017; Chakraborty, Goldstein, and McKinlay, 2020), there is no a priori reason why these programs would have increased the ratio of liquid assets to assets for banks in the aggregate. Reserves are a fraction of aggregate bank liquid assets. At their peak, reserves are 37% of aggregate liquid assets. Banks could have sold non-reserve liquid assets to keep their holdings of liquid assets unaffected by the increase in reserves. In any case, during the period from the end of 2009 to the end of 2020, the ratio of banks' aggregate reserves to assets increased by 5 percentage points while the ratio of liquid assets to assets increased by 14 percentage points.

Our paper is related to several literatures. There is a vast literature on corporate liquid asset holdings (for recent surveys, see Almeida, Campello, Cuhna and Weisbach, 2014, and Denis and Wang, 2024). However, this literature focuses on non-financial firms and papers in that literature typically exclude banks from their sample because they are heavily regulated. Our paper adds to that literature by examining liquid asset holdings of banks. While there is a large literature in banking on the risks to banks and to the financial system of having too few liquid assets, this literature is focused mostly on crisis episodes. We add to our understanding of bank liquid asset holdings by providing an explanation for why these holdings are large, why they vary in the cross-section, and why they are higher after the GFC than before. A recent literature empirically examines liquidity transformation by banks (Berger and Bouwman, 2009; Bai, Krishnamurthy, and Weymuller, 2018). Everything else equal, a bank that holds fewer liquid assets engages in more liquidity transformation, but a bank's level of liquidity transformation does not have a one-to-one correspondence to its holdings of liquid assets. We therefore shed light on the size of one component of liquidity transformation. This component is important in itself but further it helps explain why banks can be large even when banks have poor lending opportunities. As Buchak, Matvos, Piskorski, and Seru (2024) show in a contemporaneous paper, the increase in holdings of securities by banks over the last sixty years is the mirror image of a decrease in the importance of information-sensitive loans by banks. Hence, understanding better the composition of the assets of banks is critical in understanding how the role of banks is evolving.

A growing literature examines the impact of post-GFC regulatory reforms on bank balance sheets. These reforms interact with each other (Cecchetti and Kashyap, 2016). Related papers examine the impact of the liquidity regulations introduced after the GFC. The liquidity regulations target a ratio called the liquidity coverage ratio, or LCR. There is not a one-to-one relation between the LCR and the ratio of liquid assets to total assets. Roberts, Sarkar, and Shachar (2019) show that the LCR reduces bank liquidity transformation in part by reducing lending. Like Sundaresan and Xiao (2024), we find that the treatment effect of the post-GFC regulatory reforms increases bank holdings of high-quality liquid assets (HQLA).[2] However, while they attribute this effect to the LCR, we find evidence that increases in capital requirements caused an increase in the ratio of high-quality liquid assets to total assets. The key difference between the two studies is one of focus. Sundaresan and Xiao (2024) mostly focus on the growth rate of the dollar amount of HQLA, while we focus on the change in the ratio of liquid assets to total assets. An increase in the growth rate of HQLA does not imply an increase in the ratio of liquid assets to total assets as the growth rate of HQLA can increase because of an increase in the growth rate of assets and a bank can increase its HQLA simply by reallocating its portfolio of liquid assets towards assets that are more highly weighted in the LCR.

The large literature on the impact of the post-GFC capital requirement changes is also related to our paper. It does not appear to investigate the impact of the capital requirement changes on holdings of liquid assets of banks. Various papers find that banks decrease lending in response to the increased capital requirements (e.g., Berrospide and Edge, 2016, and Gropp, et al., 2019). We show that the increase in capital requirements helps understand the increase in liquid assets of banks.

The paper is organized as follows. In Section 2, we define bank liquid assets and show how they evolve over time. In Section 3, we develop a conceptual framework for holdings of liquid assets by banks that

[2] Banerjee and Mio (2018) find a similar results for the implementation by the UK of a regulation similar to the LCR in 2010.

includes the portfolio motive. In Section 4, we provide evidence supportive of our framework using panel regressions. In Section 5, we show that large banks experience a greater increase in liquid asset holdings after the GFC than can be explained by our baseline model and investigate why this is so. We explore the robustness of our findings in Section 6. We conclude in Section 7.

2. Bank liquid assets: Definition and evolution over time

Liquid assets are assets with minimal credit risk that can be sold rapidly with little or no price pressure (Grossman and Miller, 1988). We obtain the data for liquid assets from the Reports of Conditions and Income (Call Reports).[3] Our measure of liquid assets includes bank cash holdings, US Treasuries, US government and government-sponsored agency obligations, and mortgage-backed securities issued or guaranteed by GNMA, FNMA, or FHLMC.[4] We define bank cash holdings as vault cash, cash items in the process of collection, balances due from depository institutions, and balances due from Federal Reserve Banks (our proxy for reserves). All traded assets we include in the definition trade in liquid markets, have little or no credit risk, and can easily be used for repurchase agreements. As discussed earlier, Hanson et al. (2015) focus on banks holding loans and securities. Liquid asset holdings include a subset of securities held by banks, but they do not include assets such as ABS, stocks, non-agency RMBS, and CLOs that banks hold as securities either because these assets are not liquid or because they have material default risk.

We compute the liquid asset holdings quarterly from March 1984 to December 2020 for all US-chartered commercial banks (charter type 200) with assets in excess of $2 billion. We drop banks with missing data on assets and those with a negative book value of equity. In the following, all dollar amounts are in constant 2018 dollars (using the CPI deflator), except for those amounts set by regulations. We have 1,282 unique banks. At times, we divide banks between large, medium, and small banks. We define large banks to be banks with assets in excess of $50 billion dollars. Medium banks have assets between $10

[3] We obtain call report data using a modified code from Drechsler, et al. (2017) and follow that study to form consistent time-series data.
[4] Securities are measured as the sum of the amortized cost of held-to-maturity securities and the fair value of available for sale securities. We exclude trading assets in our baseline definition of liquid assets.

billion and $50 billion. Small banks have assets between $2 billion and $10 billion. Small and medium banks form the category of "other banks." We refer to banks with assets greater than $250 billion as the "largest banks." We have 324 banks in 1984. The lowest number of banks is 288 in 2010. In 2020, we have 405 banks.

Figure 1 shows the evolution of the aggregate liquid assets-to-assets ratio (the LAR in the following). The aggregate LAR is computed by summing liquid assets for all banks in the sample and dividing them by the sum of assets for all banks. The aggregate LAR hovers around 20% until the early 1990s, when it increases to a pre-GFC peak of 24% in December 1992. After the pre-GFC peak, it falls to reach a trough of 12.4% in the first quarter of 2008. After that trough, the aggregate LAR doubles to reach 25.4% in December 2019 before the COVID crisis and 33.2% at the end of our sample period. We show in the same figure the percentage of assets represented by loans. The aggregate loans-to-assets ratio is computed by summing loans across banks and dividing them by the sum of assets.[5] The fraction of the balance sheet of the banking sector corresponding to loans falls for most of our sample period, but it increases slightly between 2015 and 2019 before falling again in 2020. The peak aggregate loans-to-assets ratio before the GFC is 65%. The trough aggregate loans-to-assets ratio is 47.3% at the end of the sample. Before the COVID crisis, the trough of aggregate loans-to-assets is 49.4% in the third quarter of 2011.

The increase in liquid assets after the GFC is not simply due to the increase in aggregate reserves. For banks, liquid assets are the sum of cash and non-cash liquid assets and the cash component includes reserves that do not earn interest before the GFC. Figure 1 shows the evolution of these two components of liquid assets. We compute the aggregate cash-to-assets ratio, which is the sum of cash holdings of sample banks scaled by the sum of assets of sample banks. The aggregate cash-to-assets ratio falls dramatically from 16% in 1984 to a low of 4.1% in 2006. This fall can be attributed to technological improvements in cash management at banks. The aggregate cash-to-assets ratio increases sharply starting with the bankruptcy of Lehman. After the GFC, cash is mostly reserves that earn interest. At the end of our sample period, the ratio

[5] The results are similar if we net out inter-bank loans.

stands at 15.2%. However, the aggregate non-cash liquid assets-to-assets ratio increases starting with the GFC as well. While the ratio is 7.8% just before the bankruptcy of Lehman, it reaches 18% at the end of our sample period, which is more than three times its value at the beginning of our sample period. It follows that the growth in the aggregate LAR cannot be explained by the increase in reserves alone.

To get a sense of how liquid asset holdings differ in the cross-section over time, we divide our sample into largest, large, medium, and small banks and show the equally-weighted LAR for these four classes of banks in Figure 2. The LAR differences between the bank size classes are substantial at times. At the beginning of our sample period, the LAR of the largest banks is more than nine percentage points lower than the LAR of small banks. The peak difference between the LAR of the smallest banks and of the largest banks is 20.3 percentage points in the second quarter of 1993. Just before the COVID crisis, the LAR of the largest banks is 12.4 percentage points higher than the LAR of small banks. The time-series evolution of the LAR differs greatly across bank size classes. The LAR of the largest banks is more than twice as large at the end of our sample period than at the beginning. In contrast, the LAR of small banks is smaller at the end of the sample period than at the beginning.

Lastly, it is instructive to compare holdings of liquid assets by banks to those of non-financial firms. We only have data for non-financial firms that are public. Consequently, for a meaningful comparison, we compute the LAR of public banks and nonfinancial firms with assets greater than $10 billion in constant dollars. The average LAR for banks in this sample is 22%. In contrast, the ratio of liquid assets to assets for non-financial firms is 8.3%. Liquid assets are much more important on average for banks than non-banks.

We have seen in this section that the ratio of liquid assets to assets is large for banks compared to non-banks. The ratio for banks exhibits substantial variation over time. For banks in the aggregate, it is much larger after the GFC. Before the GFC, large banks have a lower ratio than small banks. After the GFC, large banks have a much higher ratio than small banks.

3. Why do banks hold liquid assets?

In this section, we first briefly discuss the role of the transaction and precautionary motives for bank liquid asset holdings. We next introduce the portfolio motive. We then discuss the role of regulation and reserves. We conclude with a summary of empirical predictions that we examine in the remainder of the paper.

3.1. The precautionary and transaction motives

There is a vast literature that examines theoretically and empirically the determinants of liquid asset holdings of non-financial firms. This literature focuses much on the transaction and precautionary motives of liquid asset holdings. Part of this literature relates holdings of liquid assets to firm characteristics that proxy for these motives (Opler, Pinkowitz, Stulz, and Williamson, 1999). We show in Internet Appendix Table A1 that these variables are not helpful in explaining bank holdings of liquid assets.

From the literature, the main concern that precautionary holdings of liquid assets of banks address is the risk of unexpected cash outflows. A bank run is an extreme case of such outflows. Everything else equal, we expect the risk of a run to be lower if a bank has more liquid assets. With this view, we expect liquid assets to be higher if the bank has more demand deposits. In general, however, deposit accounts are insured directly up to some amount, and the excess over that amount is viewed as insured implicitly at least to some extent. Banks have other runnable or short-maturity liabilities (Duffie, 2010), on and off their balance sheets, which do not benefit from implicit government insurance. The risk of loss on such liabilities is less of a concern if the bank holds more equity. We therefore expect that banks with more equity, everything else equal, require lower precautionary holdings of liquid assets. Given a bank's leverage, we expect a bank with more loans to require more precautionary holdings of liquid assets as it is more likely to experience losses that could reduce its equity buffer and lead to a run on its deposits. Consequently, liquid assets and loans should be complements (in dollar terms, not necessarily as a fraction of bank assets). If a bank increases its loans, it should increase its amount of liquid assets. Banks with more commitments, such as non-drawn credit lines, are expected to hold more liquid assets because they have to be able to honor these commitments. We therefore expect liquid assets to increase with commitments and derivatives.

Banks also hold liquid assets for the transaction motive. Holders of deposit accounts use them for transactions, and the bank has to be in a position to honor the payments they make through their accounts. These payments affect the liquidity position of banks (Li, Li, and Sun, 2021). The best liquid asset for the transaction motive is cash, which generally means reserves held at the Federal Reserve. Reserves are also the liquid asset that is most easily usable if the bank has an unexpected demand for payments. Large banks have a large demand for reserves to manage intra-day flows (Copeland, Duffie, and Yang, 2024). We, therefore, expect that the precautionary and transaction motives involve holdings of cash first. Other liquid assets have to be converted into cash, so that they do not have proceeds that are instantly usable.

The precautionary and transaction motives for holdings of liquid assets for banks have a key prediction that we will show does not hold in the data. If banks hold liquid assets only because of the precautionary and transaction motives and the holdings of liquid assets are therefore an increasing function of the loans made by the bank, then holdings of liquid assets should be higher for banks that make more loans.

3.2. The portfolio motive.

In this section, we present our theory of the portfolio motive of liquid asset holdings for banks. The starting point is that there is much evidence in the literature that banks face a downward-sloping demand for loans. For instance, Degryse and Ongena (2005) show that banks charge less for loans to firms that are farther away from them, which is consistent with an inelastic demand for loans that enables banks to price discriminate. Therefore, we assume, as is frequently done since Klein (1971), that banks face a downward-sloping demand curve for loans. The demand for loans varies across banks and over time. When the demand is relatively high, the average profitability of loans is greater, and a bank underwrites more loans. However, even then, a bank may have a surplus of investable funds. A bank can invest these funds in liquid assets, illiquid securities, and trading assets. Consequently, a bank may have a portfolio motive to hold liquid assets. Specifically, the bank may allocate part of its portfolio of financial assets to liquid assets because it is advantageous for it to do so from the perspective of investing that portfolio optimally. In other words, liquid assets may offer a risk-return profile that is attractive for the bank's overall portfolio. These assets may be attractive because of their diversification benefit, because they offer relatively attractive risk-adjusted returns, because of the flexibility they provide, and/or because of the low cost of monitoring a portfolio of liquid assets.

When facing a low demand for loans, a bank could shrink its balance sheet. This would make sense for the bank if its marginal cost of funding were persistently higher than the marginal expected return on the funds it invests. In general, banks earn more than the marginal cost of deposits on liquid assets up to some level of deposits. A bank, therefore, optimally chooses to issue deposits up to the level where the return on liquid assets equates the marginal cost of deposits. Further, even if the marginal expected return on the funds a bank invests were particularly low at a given time, it might not want to chase away deposits as it might benefit from them when the marginal expected return on the funds it invests in increases, for instance because of an increase in the demand for loans.

To analyze the determinants of the portfolio motive, it is useful to think about a risk-neutral bank with a balance sheet that has loans, liquid assets, deposits, and equity. For simplicity, we first ignore the transaction and precautionary motives for holding liquid assets. Let's assume that deposits, D, and equity, E, are fixed. The assets are funded at a cost of r per dollar. Investments in liquid assets have an expected return of r^*. The supply of liquid assets to the bank is perfectly elastic, so that there is a constant expected marginal revenue curve for liquid assets at r^*, as shown in Panel A of Figure 3. If $r^* > r$, the bank could be profitable by just investing in liquid assets.

Consider now the demand for loans the bank faces. Let L be the demand of loans for the bank. We assume that the demand for loans is negatively related to the expected return on loans, r_L, so that we write $L(r_L)$. The expected return on loans is the rate the borrower promises to pay minus the expected credit losses and minus the expected cost of making and managing loans. As a result, the demand for loans is downward-sloping as shown in Figure 3. With a downward-sloping demand curve, the marginal revenue curve, $L'(r_L)$, is downward-sloping as well. The bank sets the amount of loans, L, at the point where the expected marginal revenue from loans equals the expected marginal revenue from investing in liquid assets. If $L < D + E$, the bank does not invest all its internal funds in loans. Instead, it invests some in liquid assets. In contrast, if the loan demand is high, then $L = D + E$, and the bank does not invest in liquid assets. It follows that a decrease in the demand for loans that moves the demand curve to the left causes the bank to invest more in liquid assets. Similarly, an increase in the expected return on liquid assets causes a decrease in the quantity of loans made by the bank. In other words, liquid assets and loans are substitutes under the portfolio motive.

The model discussed in the previous paragraph has the key implication of our theory of the determinants of liquid asset holdings: banks hold liquid assets for the portfolio motive as long as the demand for their loans is not so large that loans always dominate liquid assets as investments for the bank. In the model above, we ignore the deadweight costs of financial distress. In general, however, sufficiently adverse outcomes have deadweight costs. With deadweight costs of adverse outcomes, corporations find it optimal to manage their risk (e.g., Smith and Stulz, 1985; Froot, Scharfstein, and Stein, 1993). In this case, the precautionary motive provides another reason to invest in liquid assets.

To account for the transaction and precautionary motives in our model, we include in the expected return from liquid assets the benefits these assets give the bank to facilitate transactions and reduce risk. With this approach, the marginal expected return on liquid assets decreases as the amount of liquid assets increases because each additional dollar of liquid assets has a lower benefit for the transaction and precautionary motives. If, at some point, an additional dollar of liquid assets has no benefit for the transaction and precautionary motives, then the expected net return on liquid assets is r^*. If the intersection of the marginal revenue curve from loans is on the flat part of the marginal revenue curve from liquid assets as in Panel B of Figure 3, then the quantity of liquid assets does not depend on the transaction and precautionary motives.

If the portfolio motive is sufficiently strong, the marginal dollar of liquid assets is held for the portfolio motive, not the transaction and precautionary motives. In this case, to a first-order approximation, the amount of liquid assets held by the bank fluctuates because of changes in the portfolio motive rather than because of changes in the transaction and precautionary motives. The key prediction implied by our framework is that, when $L < D + E$, holdings of liquid assets are higher when the demand for loans is lower. This prediction implies that an increase in the demand for loans causes a decrease in holdings of liquid assets. We investigate this prediction in Section 4.

Now suppose that the demand for deposits increases so that the bank can have a larger amount of deposits for the same rates, everything else equal. In this case, the bank's assets increase. The loan amount is unchanged because the demand for loans is unchanged. As a result, the increase in the demand for deposits results in an increase in holdings of liquid assets. We show this in Panel C of Figure 3. With this figure, if the marginal revenue curve for loans were to intersect the marginal revenue curve of investing in liquid assets on its upward-sloping part, an increase in deposits would increase loans. Hence, for a bank with strong lending opportunities, an increase in deposits causes an increase in loans. We investigate these predictions in Section 4 as well.

3.3. Reserves and liquid asset holdings

The marginal reserve requirement for our sample period is 10% of net transaction accounts until March 2020 when it goes to zero. As discussed in Bennett and Peristiani (2002), reserve requirements become less important over time because banks use sweep accounts to reduce the size of net transaction accounts. Starting with the GFC, the Federal Reserve expands its balance sheet massively, so that it creates excess reserves that the banking system has to hold. The expansion of the Federal Reserve balance sheet raises the question of how the creation of excess reserves affects bank holdings of liquid assets. At the bank level, the aggregate amount of reserves is not relevant as a bank chooses its amount of excess reserves. An individual bank can choose the composition of its liquid assets as it pleases, as long as it satisfies regulatory requirements (the reserve and capital requirements throughout the sample period and the liquidity requirements after the GFC). However, prices have to adjust so that reserves as a whole are held by the banks. Before the GFC, since reserves do not pay interest, banks attempt to minimize reserves. The situation is more complicated after the GFC. When reserves pay interest, banks' willingness to hold excess reserves increases with the interest rate they pay. To address the concern that aggregate reserves are determined by the Federal Reserve, we consider separately reserve liquid assets and non-reserve liquid assets in some of our analyses.

3.4. Regulation and bank liquid asset holdings

Banks are subject to capital requirements and liquidity requirements. We consider these requirements in turn. In practice, banks hold more capital than is required. This does not mean that capital requirements are not binding. If, as is generally believed, a bank chooses to hold a buffer of capital above the regulatory minimum capital requirement, any change in capital requirements affects its target holdings of capital. For simplicity, suppose that the minimum capital requirement that is binding for a bank can be formalized as the requirement that the equity-to-assets ratio is equal to or greater than x. If the bank has an equity-to-assets ratio equal to y, which is greater than x, we say that the bank is not constrained by capital. An unconstrained bank can expand its balance sheet without raising equity. In contrast, a constrained bank cannot expand the balance sheet without raising equity. We distinguish between constrained and unconstrained banks. For simplicity, we assume that raising capital is not possible in the short run. This reflects the well-known reluctance or difficulty that banks have in raising equity. With this assumption, the deposit view of banks implies that a binding increase in capital requirements decreases the value of banks as they must decrease their balance sheet and hence offer fewer deposits (DeAngelo and Stulz, 2015).

Suppose that a bank is required to hold more capital to support a dollar of loans than a dollar of liquid assets. This is the case with the risk-based capital requirements. With risk-based capital requirements, an unconstrained bank can become constrained if capital requirements increase. However, this bank can again become unconstrained by replacing loans with liquid assets. Consequently, capital requirements affect a bank's optimal holdings of liquid assets. Capital requirements increase substantially after the GFC (Walter, 2019). With our framework, one way that a bank can at least partly accommodate an increase in risk-based capital requirements is by replacing loans with liquid assets. It follows from this that a bank that targets its regulatory capital ratios so that it has a margin of safety over the required ratios benefits from substituting liquid assets for loans if capital requirements increase.

We turn now to the liquidity regulations. The US did not have such regulations before the GFC. After the GFC, it implemented new liquidity regulations. Consider a regulation that requires a bank to have liquid asset holdings such that the LAR has to be equal to or greater than k. Suppose that the same bank wants to have liquid assets of m as a fraction of assets for the precautionary motive. These liquid assets have to be in excess of k as the bank cannot use the liquid assets held for regulatory reasons.[6] Consequently, the bank wants a LAR at least equal to $k + m$. Before the implementation of the regulation, the bank has LAR > m, so that the marginal dollar is not held for the transaction and precautionary motives. If the new regulation is such that LAR > $m + k$, the bank can keep holding its liquid assets and does not need to change anything. However, suppose that LAR < $m + k$. In this case, the bank does not have enough liquid assets. The bank can shrink its balance sheet or it can acquire liquid assets. In particular, the bank could build its holdings of liquid assets by decreasing the size of its loan book through loan sales or through loan repayments.

Panel D of Figure 3 shows the impact of a liquidity requirement. The liquidity requirement means that some fraction of the balance sheet has to be immobilized in liquid assets. Now, the liquid assets held for the precautionary motive come in addition to the required liquid assets, so that the intersection between the marginal revenue curve for loans and the marginal revenue curve for liquid assets moves from L to L^* and the expected net return on loans increases from r^* to r^{**}. The imposition of a liquidity requirement reduces loans and makes loans more expensive.

3.5. Summing up and hypotheses

Figure 3 summarizes the interaction of the various motives we have discussed in the simplified case where a bank's assets are only loans and liquid assets and where its liabilities are only deposits and equity. The figure neglects many complications. Most importantly, it neglects that banks have assets other than liquid assets and loans and that they have other liabilities besides deposits. However, there is no reason to

[6] In principle, banks could choose to let their liquid assets drop below the LCR when under stress. However, banks seem unwilling to do so as evidenced by the events of March 2020 (Nelson and Waxman, 2021; Basel Committee on Banking Supervision, 2022).

believe that our main empirical predictions do not hold if we take these complications into account. For instance, we still expect an increase in the demand for loans to decrease other assets held by banks. Perhaps more importantly, we ignored that deposits are endogenously determined by banks (e.g., through adjustments of the deposit rate). We expect the supply curve of deposits to the bank to be upward-sloping (Drechsler, et al., 2017). With the portfolio motive, deposits would be such that the marginal return on each class of assets would equal the marginal cost of deposits, where returns and costs are all-inclusive. If banks are mostly institutions that make loans, then deposits mostly increase as loans become more advantageous and fall as loans become less advantageous. It follows that, in a model that allows for more types of assets and endogenous deposits, the key predictions are:[7]

1) With the lending view of banks, deposits, loans, and liquid assets all increase if the demand for loans increases. Liquid assets increase because a bank with more loans and more deposits requires more liquid assets for the transaction and precautionary motives of holding liquid assets. However, to the extent that the marginal benefit of holding liquid assets for the transaction and precautionary motives decreases as the dollar amount of liquid assets increases, liquid assets increase less than proportionately than loans or total bank assets, so that the LAR does not increase as loans increase. With the lending view of banks, liquid assets and loans are complementary assets.
2) With the deposit view of banks, loans increase and liquid assets fall when the demand for loans increases. With the deposit view of banks, liquid assets and loans are substitute assets.
3) With the lending view, an increase in the supply of deposits to the bank decreases its deposit rate and increases the bank's holdings of loans on the balance sheet.
4) With the deposit view, an increase in the supply of deposits to the bank increases the bank's holdings of liquid assets, especially for banks that do not have good lending opportunities. In this case, the marginal cost of deposits does not change as it is determined by the return of liquid assets because of the portfolio motive.

[7] For simplicity, when we consider the deposit view of banks, we assume that the bank holds some liquid assets because of the portfolio motive. Otherwise, the deposit view and the lending view are not distinguishable.

5) With the lending view, an increase in the cost of holding loans on the balance sheet reduces holdings of liquid assets because the bank's balance sheet shrinks as it holds fewer loans.
6) With the deposit view, an increase in the cost of holding loans on the balance sheet increases holdings of liquid assets because holdings of loans fall. For instance, an increase in capital requirements that increases the cost of holding loans but not the cost of holding liquid assets causes an increase in liquid assets.
7) A liquidity requirement increases a bank's liquid asset holdings only if the requirement plus the bank's holdings of liquid assets to meet the transaction and precautionary motives exceeds the liquid assets the bank would hold absent the requirement. With the deposit view, if a liquidity requirement increases a bank's liquid asset holdings, it decreases a bank's holdings of loans. Note that, because of the portfolio motive, the liquidity requirement is more likely to bind with the deposit view for banks that have good lending opportunities.

To sum up, with the lending view, banks hold liquid assets for the transaction and precautionary motives, so that the dollar amount of liquid assets increases with the dollar amount of loans. However, the dollar amount of liquid assets does not increase more than the dollar amount of loans, so that the LAR does not increase. An increase in deposits is funneled into new loans if profitable loans are available and otherwise the bank reduces the deposit rate to decrease its deposits. In contrast, with the deposit view, the dollar amount of liquid assets and the LAR increase if the dollar amount of loans falls. An increase in deposits is funneled into liquid assets and/or illiquid securities if the bank does not have profitable loans available.

4. The portfolio motive and bank holdings of liquid assets

In this section, we present empirical support for the portfolio motive for bank holdings of liquid assets. With this motive, banks hold more liquid assets when they have fewer valuable lending opportunities. This motive results directly from the deposit view of banks. We proceed in three steps. First, we assess the determinants of liquid assets implied by the role of the portfolio motive in the deposit view of banks in contrast to the determinants of liquid assets implied by the lending view of banks. Second, we consider the relation between liquid assets, deposits, and loans using exogenous variation in deposits and loans through instrumental variables. Third, we test a key prediction of our model, which is that banks with good lending opportunities invest less in liquid assets than other banks when they experience an increase in deposits.

4.1. The determinants of liquid asset holdings

In this section, we first examine regressions of the bank-level liquid assets at time *t* on determinants observed at *t*-1. We use quarterly data. This approach is similar to a widely used approach in the literature on liquid assets for non-financial firms (e.g., Opler, et al., 1999). In Panel A of Table 1, we regress the LAR at *t* of bank *i* in state *s* on variables that proxy for the transaction, precautionary, and portfolio motives determined at *t*-1. The regressions use state-time fixed effects and bank fixed effects. With the portfolio motive, banks with better lending opportunities, which translate into a higher ratio of loans-to-assets, have a lower LAR. We regress the LAR on previous quarter log assets, loans-to-assets, demand deposits-to-assets, other deposits-to-assets, equity-to-assets, net income-to-assets, ROA volatility, and an indicator variable for whether the bank has trading assets:

$$LAR_{ist} = c + \beta_{LA} Log\ Assets_{ist-1} + \beta_{L} Loans/Assets_{ist-1} + \beta_{DD} Demand\ deposits/Assets_{ist-1} + \beta_{OD} Other\ deposits/Assets_{ist-1} + \beta_{E} Equity/Assets_{ist-1} + \beta_{NE} Net\ income/Assets_{ist-1} + \beta_{ROA} ROA\ volatility_{ist-4,t-1} + \beta_{TA} Trading\ assets_{ist-1} + \gamma_{st} + \delta_{i} + \varepsilon_{ist} \quad (1)$$

We show the estimates in Panel A of Table 1. The detailed definitions of the variables are given in the Appendix. We estimate regressions for the whole period, the pre-GFC period, and the post-GFC period. The coefficient on *Loans-to-assets* is negative and roughly similar for the whole sample period and for the two shorter periods. The magnitudes of the coefficients suggest that a decrease of one percentage point in *Loans-to-assets* is associated with an increase in LAR of roughly half a percentage point. We then show coefficients for *Demand deposits-to-assets* and *Other deposits-to-assets*. These coefficients are mostly insignificant. The coefficient on *Equity-to-Assets* is significantly negative. This finding is consistent with the precautionary motive. With the precautionary motive, we expect the volatility of ROA to have a positive significant coefficient, but it does not.

We estimate additional regressions but report the results only in the Internet Appendix (Table A2). First, in Panel A, we estimate the regressions using individual loan categories instead of overall loans-to-assets. These categories are C&I loans, real estate loans, and consumer loans. The coefficients are significantly negative for each type of loan. Second, in Panel B, we re-estimate the regressions adding *Other securities-to-assets*. The inferences are similar. *Other securities-to-assets* has significant negative coefficients. Third, in Panel C, we re-estimate the regressions adding *Non-deposit liabilities-to-assets*. The coefficient for the pre-GFC period is positive and significant. The other coefficients are insignificant. Fourth, in Panel D, we re-estimate the regressions adding *Wholesale funding-to-assets*, *Commitments-to-assets*, and *Derivatives-to-assets*.[8] *Commitments* corresponds to the total unused commitments of the bank. The coefficient on *Wholesale funding-to-assets* is positive and significant for the pre-GFC period but insignificant otherwise. The coefficient on *Commitments-to-assets* is insignificant for the whole sample period and for the pre-GFC period but is significantly positive for the post-GFC period. For *Derivatives*, we use the fair value of derivatives. The coefficient on *Derivatives-to-assets* is insignificant for the whole sample period and for the post-GFC period, but significantly negative for the pre-GFC period. In Panel E, we use an indicator variable for the bank having derivatives instead and we observe a positive and significant coefficient for the post-GFC period, but the coefficient is insignificant otherwise. The addition of these variables does not change our inferences about the coefficients on *Loans-to-assets*. None of the coefficient estimates on these additional variables supports the view that, at the margin, the LAR is determined by the precautionary and transaction motives of liquid asset holdings.

A plausible concern is that the negative coefficient on *Loans-to-assets* in Panel A of Table 1 could be mechanical since an increase in loans-to-assets at t leaves less balance sheet room for liquid asset holdings.

[8] Derivatives data are only available since 1995. In these regressions, our sample period is from 1995-2020.

Because we include the lag of *Loans-to-assets*, there is no direct mechanical relation in that a given level of *Loans-to-assets* at *t-1* is consistent with any level of the LAR at *t*. In other words, the relation between the LAR and one-quarter lagged *Loans-to-assets* could be anything. This is even more the case when we lag *Loans-to-assets* by four quarters, which we do in Internet Appendix Table A2, Panel F, and find that results are unchanged. We nevertheless also estimate regressions that include no balance sheet ratios as independent variables. Instead, these regressions use a proxy for lending opportunities, which is the lagged eight-quarter average growth for loans. For deposits, we use the four-quarter volatility of deposits-to-assets. Our other independent variables are the log of assets, net income-to-assets, ROA volatility, and the indicator variable for trading assets. The regressions include state-time and bank fixed effects. We estimate the following regression using quarterly data:

$$LAR_{ist} = c + \beta_{LA} Log\ Assets_{ist-1} + \beta_{L} Loan\ growth_{ist-8,t-1} + \beta_{D} Deposit\ volatility_{ist-4,t-1} + \beta_{NI} Net\ income/Assets_{ist-1} + \beta_{ROA} ROA\ volatility_{ist-4,t-1} + \beta_{TA} Trading\ assets_{ist-1} + \gamma_{st} + \delta_{i} + \varepsilon_{ist} \quad (2)$$

We focus on the variables that are specific to the framework developed in the previous section. We expect a negative sign on *Loan growth* and a positive sign on *Deposit volatility*. We see in Panel B of Table 1 that *Loan growth* has a negative coefficient in all the regressions. Turning next to *Deposit volatility*, we see that *Deposit volatility* has a positive significant coefficient for the whole sample period and for the pre-GFC period, but not for the post-GFC period. It follows that we find support for our prediction of a negative relation between holdings of liquid assets and lending opportunities. The evidence on the precautionary motive for deposits is consistent with such a motive for the pre-GFC period, but not for the post-GFC period. One possible explanation for this finding is weaker lending opportunities post-GFC, such that, at the margin, liquid asset holdings tend not to be determined by the precautionary motive in this period.

Another possible concern with Panel A of Table 1 is that aggregate reserves have to be held by banks. We address this issue by looking separately at cash holdings, which are mostly reserves, and non-cash holdings. With the portfolio motive, we expect non-cash holdings to be lower when a bank has better lending opportunities at least for the pre-GFC period when reserves did not pay interest. We estimate the regressions of Panel A of Table 1 separately for cash holdings of liquid assets and non-cash holdings of liquid assets and report the results in the Internet Appendix (Panel G of Table A2). The coefficient on *Loans-to-assets* is negative in all regressions. We further find that the coefficient is greater in absolute value for non-cash liquid assets. When it comes to demand deposits, we see that the coefficient on *Demand deposits-to-assets* is positive for the cash holdings regressions and negative for the non-cash holdings regressions. This is consistent with the transaction and precautionary motives applying to cash holdings of liquid assets but not to non-cash holdings. Lastly, the negative coefficient on *Equity-to-assets* observed in Panel A of Table 1 seems to be due to a negative relation between equity and holdings of non-cash liquid assets. If more equity allows a bank to hold fewer liquid assets for the precautionary motive, this effect should be present for cash holdings, but it is not. The negative relation may be explained by the fact that if loans and non-cash holdings are substitutes, a bank that has more non-cash holdings of liquid assets has lower capital requirements.

Our main hypotheses are about changes in holdings of liquid assets. In the regressions used so far, the dependent variable was the LAR, which is a portfolio weight for the bank's assets. We now use instead the change in liquid assets normalized by the beginning of period of assets. These regressions are in the spirit of Almeida, Campello, and Weisbach (2004) and assess how changes in bank resources are allocated to liquid assets. These regressions relate contemporaneous changes in the dollar amount of liquid assets to contemporaneous changes in loans and assets. With these regressions, changes in the dollar amounts of liquid assets and loans do not have a mechanical relation since both could grow as a bank's balance sheet grows. We scale the dollar changes in these and other bank balance sheet variables by lagged total assets to circumvent issues with non-stationarity, outliers, and inflation that could arise when using variables expressed in dollar terms. We also control for lagged net income, scaled by lagged assets, for the lagged change in ROA volatility, and the lagged change in the indicator for trading assets. As in Panel A, we have state-time and bank fixed effects. We estimate the following model:

$$\Delta Liquid\ assets_{ist}/Assets_{ist-1} = \beta_L \Delta Loans_{ist}/Assets_{ist-1} + \beta_A \Delta Assets_{ist}/Assets_{ist-1} + \beta_{ROA} \Delta ROA\ volatility_{ist-1} + \beta_{NA} \frac{Net\ income_{ist-1}}{Assets_{ist-2}} + \beta_{TA} \Delta Trading\ assets_{ist-1} + \gamma_{st} + \delta_i + \varepsilon_{ist} \quad (3)$$

In this regression, the dependent variable is the change in liquid assets for bank *i* in state *s* from *t-1* to *t* normalized by assets at *t-1*. The independent variables are constructed in the same way. It is important to note that regression (3) is not a differenced version of regression (1) and that the regression coefficients from regression (3) are not directly comparable to the regression coefficients from regression (1). First, regression (1) uses lagged values of the independent variables, so that a differenced version would have lagged changes instead of contemporaneous changes. Second, regression (1) focuses on the equivalent of portfolio weights, whereas regression (3) focuses on dollar changes. To see the difference, note that for the LAR to stay constant when assets increase, holdings of liquid assets have to increase as assets increase. Therefore, an increase in holdings of liquid assets does not imply that the LAR increases. The LAR only increases if holdings of liquid assets increase more than assets.

In Panel C of Table 1, we show estimates of regression (3). As expected from Panel A, we find significant negative coefficients on *ΔLoans/Assets*. In other words, when the dollar amount of loans increases, the dollar amount of liquid assets falls, so that loans and liquid assets are substitutes rather than complements. We find that *ΔAssets/Assets* always has a positive significant coefficient. These coefficients suggest that if resources flow into a bank, a substantial share of these resources will be held as liquid assets.

We show additional regression estimates in the Internet Appendix. We add lagged changes to the regressions of Panel C (Panel H of Table A2). Doing so leads to two conclusions. First, the results we report in Panel C do not change. Second, the coefficients on the lagged changes are generally small in absolute value and typically insignificant. The adjusted R-squareds are essentially unchanged when we add the lagged changes. We further estimate the regressions of Panel C adding *ΔCommitments/Assets*, *ΔWholesale/Assets,* and *ΔDerivatives/Assets* (Panel I of Table A2). The coefficients on changes in loans, assets, and net income are not meaningfully different from the coefficients for the same variables in Panel C. *ΔCommitments/Assets* has positive significant coefficients for the whole sample period and the pre-GFC period, but an insignificant coefficient for the post-GFC period. The same is true for the coefficients on *ΔWholesale/Assets*. Lastly, *ΔDerivatives/Assets* has significant negative coefficients for each period.

Finally, we use a different specification for changes. Instead of using dollar changes, we use growth rates as in Chakraborty et al. (2020). The results using that approach, reported in the Internet Appendix (Panel J of Table A2), are similar to the results using the dollar change specifications. In these regressions, controlling for the growth rate of loans, a higher growth rate of assets is associated with a higher growth rate in liquid assets. Such a result is opposite to results in the liquid asset holdings literature for non-financial firms and to predictions of models for transaction holdings of liquid assets. It is consistent with Figure 3 when a bank experiences an increase in balance sheet size but no change in the demand for loans. Note that we estimate these regressions with and without deposit growth as an independent variable. The coefficients on loan growth do not seem to depend on whether deposit growth is included in the regression.

Overall, the evidence in this section supports the role of the portfolio motive for bank liquid asset holdings in that we find a negative relation between liquid assets and lagged loans-to-assets, between liquid assets holdings and lagged lending opportunities, and between changes in liquid assets and changes in loans. We find that these results hold for non-cash liquid assets as well as for cash. These results are inconsistent with the view that holdings of liquid assets are complements to loans held on the balance sheet because of the transaction and precautionary motives and instead suggest that they are substitutes.

4.2. Liquid assets and exogenous variation in loans and deposits

A concern with the results reported in Table 1 is that loans and deposits are both chosen by banks. That concern is especially acute in Panel C of Table 1 because it uses contemporaneous changes for all variables. In this section, we investigate the relation using exogenous variation in loans and deposits.

We instrument the change in loans from *t-1* to *t* (normalized by assets at *t-1*) with a Bartik-like instrumental variable (Bartik, 1991; Blanchard and Katz, 1992; Goldsmith-Pinkham, Sorkin, and Swift, 2020). Bartik-like instruments have been used before in banking, for example, in Schiantarelli, Stacchini, and Strahan (2020), Greenstone, Mas, and Nguyen (2020), and Diamond et al. (2021). The approach uses as an instrument for loan changes at a bank the (predetermined) exposure of that bank to each type of loan times the aggregate loan changes for each type of loan for the type of bank at the national level. We distinguish between three types of banks: small, medium, and large. We proceed in the same way for the change in total deposits, i.e., the sum of the change in demand deposits and other deposits (normalized by assets at *t-1*), which we denote by *ΔDeposits/Assets*.

Specifically, our Bartik instrument for the change in loans is constructed as follows:

$$Bartik_{ct} = \sum_k w_{ck} g_{kts} \tag{4}$$

where w_{cks} is bank *c*'s share of loan type *k* in bank *c*'s assets (loans type *k*/total assets) for the first available quarter in a five-year rolling window ending in the current quarter. We focus on the following five loan types (*k*): commercial and industrial (C&I) loans, real estate (RE) loans, personal loans, agricultural loans, and other loans. g_{kts} is computed as the aggregate growth in loans of type *k* from *t-1* to *t*, where aggregate numbers are computed across all banks in size bucket *s* except for bank *c*. We use three size buckets (small banks with assets from \$2 billion to \$10 billion; medium banks with assets from \$10 billion to \$50 billion; and large banks with assets above \$50 billion).

We construct our Bartik instrument for the change in deposits similarly. Specifically, our Bartik instrument for changes in deposits is constructed using equation (4) above, where w_{cks} is bank *c*'s initial share in each of four deposit types *k* (demand deposits, time deposits, savings deposits, and other deposits) as of the first available quarter in a five-year rolling window ending in the current quarter, g_{kts} is the aggregate growth deposits of type *k*, from *t-1* to *t*, where aggregate numbers are computed across all banks in size bucket *s,* excluding the bank of interest.

We report the results in Table 2. In the following, we call the second-stage model of Table 2 our benchmark model. The regressions use bank fixed effects, but not state-time fixed effects since the Bartik instrument has a common time-varying component for all banks. We add changes in the Fed funds rate, the default spread (measured as the yield difference between BBB-rated and AAA-rated corporate bonds), the interest rate on reserves, and the ratio of aggregate reserves to aggregate bank assets to control for macroeconomic conditions. We first show the first-stage regressions where we regress *ΔLoans/Assets* on our Bartik instrument for the change in loans, our Bartik instrument for the change in deposits, the change in the other bank characteristics we use in the regressions of Panel C of Table 1, and the variables that control for macroeconomic conditions. We report the first-stage results for *ΔLoans/Assets* for the full sample period and the pre-GFC and post-GFC periods in Columns (1) through (3). In Columns (4) through (6), we estimate the same regressions, but now the dependent variable is *ΔDeposits/Assets*. We find that the corresponding Bartik instruments (i.e., the instrument for loans in the loan regression and the instrument for deposits in the deposit regression) are significant in all first-stage regressions.

Columns (1) through (6) of Table 2 show strong first-stage results, so that our Bartik instruments are relevant. Consequently, the first stage captures the impact of differential exposures of banks to loan types on a bank's loans and the impact of differential exposures to deposit types on a bank's deposits. These differential exposures are not affected by the aggregate variables as they are observed five years before the changes in the aggregate variables. The additional control variables capture changes in macroeconomic conditions, so that these changes can affect holdings of liquid assets directly rather than potentially through their impact on the instruments.

We now turn in Columns (7) through (10) to the second-stage results. Again, these models have bank fixed effects. We show OLS estimates of the same regressions in the Internet Appendix (Table A3) estimated over the same period. All OLS coefficients on the change in loans and the change in deposits are significantly different from zero. For the two-stage least squares results, we find a strong negative coefficient on the instrumented *ΔLoans/Assets* for all three periods and a strong positive coefficient on the instrumented *ΔDeposits/Assets* for all three periods. The Sanderson-Windmeijer (2016) multivariate *F*-test of excluded instruments rejects the null of weak instruments strongly based on the Stock and Yogo (2005) weak ID F-test critical values. These results support the role of the portfolio motive. In addition, in Column (10), we instrument the change in aggregate reserves using the instrument from Lopez-Salido and Vissing-Jorgensen (2023). They argue that reserves are not exogeneous because they increase in response to reserve demand shocks when take-up of the overnight reverse-repo facility is not zero. With their reasoning, the sum of reserves plus the overnight reverse-repo facility take-up is exogenous, so that it is a suitable instrument for reserves. This instrument is only available for the 2010-2020 subperiod. We see that instrumenting the change in reserves does not change our inferences. We estimate the regressions reported in Table 2 without control variables in the Internet Appendix (Table A13). The results are similar to the results reported in Table 2.

We assess the robustness of our results by estimating shares w_{cks} in the Bartik instruments using a ten-year instead of a five-year rolling period in the Internet Appendix (Table A4). The results are similar, except for the pre-GFC period, where the coefficient for instrumented *ΔLoans/Assets* is negative but insignificant. We also estimate Table 2 adding the VIX (Table A5), which shortens the sample period. We find that the coefficients on loans and deposits are similar except for the pre-GFC period, in which case the coefficient for instrumented *ΔLoans/Assets* is negative but insignificant. This latter finding may be due to the shorter sample period as it obtains as well on the shorter sample period if we do not include the VIX. We also obtain similar results when we compute the aggregate growth in loans and deposits not by bank size buckets, but across all banks (Table A14).

Inspired by Cohen, Diether, and Malloy (2007) and Gelman and MacKinlay (2024), we further consider alternative instruments for changes in loans and deposits that distinguish between changes that are demand-driven vs. supply-driven by comparing changes in quantities to changes in prices, as follows. For each bank, we create a demand-driven indicator variable for increases (decreases) in loans that is equal to one if the bank experienced an increase (decrease) in loans from quarter *t*-1 to quarter *t* that is not accompanied by a decrease (increase) in the loan rate (defined as interest income on loans, scaled by total loans). Similarly, we create a supply-driven indicator variable for increases (decreases) in deposits that is equal to one if the bank experienced an increase (decrease) in deposits from quarter *t*-1 to quarter *t* that is not accompanied by an increase (decrease) in the deposit rate (defined as interest expense on domestic deposits, scaled by total deposits). We then rerun the regressions in Table 2, where, in the first stage, changes in loans and deposits are instrumented with demand-driven loan increases and decreases as well as supply-driven deposits increases and decreases (we focus on demand-driven loan changes and supply-driven deposit changes as those are exogenous to the bank). The second-stage results are very similar to those in Table 2 (Internet Appendix Table A15).

One possible concern about Table 2 is that instrumented changes in loans and instrumented changes in deposits could be highly correlated, possibly hampering inferences from the second-stage regressions. For the baseline specification, the full-sample correlation between instrumented loan and deposit changes is substantial but not dramatic, at close to 50%. Nonetheless, in Internet Appendix Table A16, we show that we obtain similar second-stage results when we run separate first-stage regressions for loan changes on the Bartik instrument for loans and for deposit changes on the Bartik instrument for deposits.

4.3. Do banks with better lending opportunities invest more in liquid assets following an increase in deposits?

In Section 3, we showed that a bank with good lending opportunities has a lower LAR than one with poor lending opportunities. Hence, the portfolio motive implies that banks with the lowest LAR should use an increase in deposits to increase holdings of liquid assets less than banks with a higher LAR because the latter banks have poorer lending opportunities. We proceed as in Section 4.2. using the Bartik-like instrument for the change in loans and the change in deposits. In this section, however, we are interested in whether banks with low liquid assets behave differently. If banks with low liquid assets are liquidity-constrained banks, we expect them to use additional deposits to invest more in liquid assets. Alternatively, if banks with low liquid assets are simply banks that have good lending opportunities, we expect them not to invest more in liquid assets out of additional deposits. If banks with low holdings of liquid assets do not increase their holdings of liquid assets when their deposits increase, this would be consistent with the portfolio motive but not with the view that these banks have abnormally low liquid asset holdings because they are constrained in accumulating such assets.

We consider a bank to have low liquid asset holdings at t if its holdings of liquid assets are in the bottom decile of liquid assets of banks at *t*-2. We lag the measurement of the low liquid assets indicator by two quarters so that it can be reasonably treated as predetermined. We add an indicator variable for whether a bank has liquid assets holdings in the bottom decile (*Bottom LAR*) to our regressions in Table 2, together with an interaction of that variable with the instrumented *ΔLoans/Assets* and *ΔDeposits/Assets*. The results of the second-stage regressions are in Table 3. The corresponding OLS results are shown in the Internet Appendix (Table A3). We show results for the whole sample period and the two subperiods in Table 3, columns (1) to (3). We find, as expected, that banks with a low LAR invest much less of an increase in deposits in liquid assets than other banks. To address the concern that having a bottom decile LAR might be due to other reasons than having great lending opportunities and the concern that using the lagged LAR to construct the indicator variable may not resolve endogeneity concerns, we use loan growth as a measure of lending opportunities. Specifically, we construct an indicator that is equal to one if a bank's loan growth in the previous eight quarters is in the top decile of loan growth across banks. We then use the indicator for good lending opportunities instead of the *Bottom LAR* indicator in regressions (4) to (6). We find that banks with good lending opportunities invest less of an increase in deposits in liquid assets than other banks.

In the Internet Appendix (Table A6), we report the regression estimates of the same analysis using a ten-year rolling window and find similar results. The results are similar for the full sample period and for the post-GFC as well if we add changes to the VIX as an independent variable, which shortens the sample period. We also omit bank fixed effects. When we do so, the estimated coefficients in the second-stage on the variables of interest are significant, but the null of weak instruments is rejected more strongly.

5. The post-GFC period

In Section 4, we provided supportive evidence for the role of the portfolio motive in explaining banks' holdings of liquid assets. In this section, we first examine the remarkable growth in liquid asset holdings of large banks after the GFC in light of our benchmark model. We show that our benchmark model with instrumented loans and deposits estimated in Table 2 underpredicts the increase in the LAR of large banks after the GFC. We then turn to explain why the LAR grows more for large banks than other banks after the GFC.

5.1. The benchmark model and the post-GFC growth in liquid assets of large banks

To better understand the evolution of bank liquid assets after the GFC, it is useful to compare the 11-year period from 2010 to 2020 to the 11-year period from 1996 to 2006. From 1996 to 2006, the growth of aggregate bank loans is 87.6% and the growth of aggregate deposits is 92.4%, so that the growth of loans is almost equal to the growth of deposits. During that period, bank liquid assets grow by 50.9%. Turning to 2010 to 2020, the growth of deposits is 108.3% in contrast to a growth of loans of only 36.7%. With such a high growth of deposits and low growth of loans, we expect liquid assets to grow at a high rate. They grow by 163.7%. Figure 4 shows that the cumulative growth rate of aggregate bank loans since 1984 is close to the cumulative growth rate of aggregate deposits for banks in the aggregate until the GFC, but afterwards the two cumulative growth rates differ sharply. The aggregate growth of liquid assets is driven by the growth of liquid assets of large banks as these banks represent a large share of the banking system. We showed in Figure 2 that the LAR for large banks and for the largest banks increases substantially relative to the LAR of the other banks after the GFC.

For a more formal examination of whether our benchmark model explains the increase in the LAR of large banks after the GFC relative to the LAR of other banks, we re-estimate our benchmark model of Table 2 but allow for a differential change in liquid assets holdings for large banks. We show the results in Table 4. We re-estimate the second-stage regressions of Table 2 for the two sub-periods with the addition of an indicator variable that takes a value of 1 for the large banks (*Large*). For the post-GFC sub-period, in columns (2) and (3) we instrument reserves as we do in the last column of Table 2. We find that the coefficient on the *Large* indicator variable has a coefficient of zero that is insignificant for the period 1984-2006. In contrast, the coefficient has a magnitude of 0.003 and is significant at the 1% level for the period 2010-2020. A coefficient of 0.003 is economically large as it implies a greater growth of the LAR for large banks that is 0.3% higher per quarter than for the other banks. The cumulative effect from 2010 to 2020 corresponds to 15.5 percentage points.

A concern already discussed in the introduction is that the increase in reserves resulting from quantitative easing could have a differential impact on large banks. We allow for such a differential impact in the regression estimated in Column (3). In that regression, we add an interaction between the *Large* indicator variable and instrumented *Aggregate reserves*. We find that the coefficient on this interaction is positive and significant. However, it does not change the estimate of the coefficient on the *Large* indicator variable. Consequently, changes in reserves do not explain the differential increase in holdings of liquid assets of large banks relative to other banks.

5.2. Why did liquid asset holdings grow more for large banks?

As shown in Section 5.1, liquid asset holdings grow more for large banks than other banks after the GFC. We now investigate whether the regulatory changes after the GFC can explain the increase in liquid asset holdings of large banks relative to the liquid asset holdings of smaller banks after the GFC.

Regulatory capital requirements for US banks increase after the GFC because of the Basel III Accord and the Dodd-Frank Act. As explained by Walter (2019), the increase in capital requirements was higher for large banks that were viewed as systemically important. The final rules for the increase in capital requirements were promulgated in July 2013. These rules explicitly increased the risk weights for some riskier assets and increased the minimum capital requirements.[9] The risk-based capital ratio Tier 1 is the

[9] See Davis Polk, US Basel III Final Rule: A visual memorandum, April 30, 2015, for a detailed summary of the changes in capital requirements resulting from Basel III.

ratio of Tier 1 regulatory capital to risk-weighted assets. The risk weights on loans are typically 100%, which is a multiple of the risk weights for liquid assets. Treasuries have weights of zero. Consequently, by reducing loans and increasing liquid assets, a bank increases its Tier 1 risk-based capital ratio. The minimum risk-based capital requirements were increased more for global systemically important banks (GSIBs) through a GSIB surcharge and for all US banks using advanced approaches for risk estimates through a countercyclical buffer. The rules also introduced a leverage ratio that is higher for GSIBs and for banks using advanced approaches. With these rules, the largest banks are subject to substantially higher capital requirements. In addition, the banks with assets greater than $50 billion are subject to stress tests.[10] Stress tests effectively impose capital requirements on banks as they require banks to be well-capitalized based on adverse economic scenarios. These adverse scenarios generally do not affect liquid assets but affect loan provisions. As a result, stress tests favor liquid assets over loans.

The higher increase in capital requirements for large banks means that, for the same loan, a large bank generally must hold more capital than a small bank, so that in our framework, the risk-adjusted demand curve for the loans of a large bank shifts to the left relative to the risk-adjusted demand curve for the loans of a smaller bank.[11] Consequently, the portfolio motive implication of an increase in capital requirements for large banks is that they lend less and hold more liquid assets. With the framework presented in Section 3, banks do not issue equity. As a result, an increase in capital requirements forces the bank to decrease the size of its balance sheet. However, a bank will necessarily increase its LAR in this situation as liquid assets become more attractive than loans at the margin. To see this, if loans and liquid assets have the same net expected return, the bank would prefer the liquid asset as it could have a larger balance sheet. Finally, note that this analysis does not require that banks hold exactly the required amount of capital. In general, banks

[10] On May 24, 2018, Congress adopted the Economic Growth, Regulatory Relief, and Consumer Protection Act (EGRRCPA). This Act led to regulatory relief for banks with assets lower than $250 billion as of November 1, 2019. With our sample, the period during which banks are affected by this Act is too short to be used to test further the implications of liquidity requirements.

[11] As explained earlier, with the deposit view, regulatory capital has a cost. Because of the greater capital costs, the bank has to charge a higher yield on loans to receive the same risk-adjusted expected return that it received before the increase in capital costs.

hold more than the required amount of capital as they hold a capital buffer that enables them to deal with unexpected shocks without being short of regulatory capital. Consequently, the bank will be directly affected by the increase in capital requirement because it will shrink its capital buffer.

Before the GFC, there are no liquidity requirements for banks. Basel III introduces these requirements in 2010 and participating countries implement these measures in the following years. The final version of the LCR in the US applies to bank holding companies with assets in excess of $250 billion starting from January 1, 2015, but with full implementation in 2017. Banking organizations with assets greater than $50 billion are subject to a modified LCR starting in 2016. As part of enhanced supervision, these banking organizations are also subject to regulation YY that requires them to have a liquidity risk management framework and to conduct liquidity stress tests. These risk management requirements are more onerous for the largest banks, those with assets greater than $250 billion, in part because of the constraints they put on the management of intra-day liquidity (Copeland et al., 2024).

A formal examination of the impact of the regulatory changes faces some obstacles. First, this is not a situation where banks have one liquidity policy until the changes are implemented and another one when the changes are implemented. Banks get ready for the implementation of new regulations. The second obstacle is that there are multiple regulatory changes. The LCR requirement is not the regulatory change that preoccupies bank CEOs the most in the early years after the GFC. They focus much more on the increase in capital requirements and the stress tests.[12] Third, it is not clear when the banks thought that they knew enough about the regulatory changes to fully adjust their policies. As Berrospide and Edge (2016) document, the evolution of capital requirements involved proposals that increased capital requirements more than the final version. Fourth, the banks most affected by the regulatory changes are the largest banks, but there are few of those. After excluding foreign banks and trust banks, there are seven banks with assets

[12] For instance, we reviewed the CEO's letter to shareholders for JP Morgan Chase for 2013 and 2014. There is almost no discussion of the LCR, but considerable discussion of the various new capital requirements and changes in capital requirements.

in excess of $250 billion. Fifth, the complexity of the changes makes it impossible for researchers to attempt to measure the capital requirements and liquidity requirements directly.[13]

By 2013, both the capital requirement changes and the details of the liquidity requirements are generally known. The Federal Reserve and other bank regulators publish key documents that year.[14] The final version of the LCR is published in 2014. Capital requirements and liquidity requirements are implemented over time. We show results of difference-in-differences (DiD) regressions where we take 2013 to be the treatment year. Figure 5 shows that the parallel trends assumption holds. As shown in the Internet Appendix Table A7, most of these results hold if we take 2014 to be the treatment year. However, when 2014 is the treatment year, the parallel trend condition no longer holds for the largest banks, as shown in Internet Appendix Figure A1.

We now turn to a more detailed examination of how 1) the LAR, 2) Tier 1 equity-to-assets, 3) risk-weighted assets-to-assets, 4) loans-to-assets, and 5) high-quality liquid assets (HQLA)-to assets are affected by the regulatory changes. We expect the banks affected the most by the regulatory changes to increase the LAR, increase the Tier 1 capital ratio, decrease their risk-weighted assets, increase HQLA, and decrease their loans. The banks that are affected the most are the banks with assets greater than $250 billion. Banks with assets between $50 and $250 billion were also affected, but to a lesser extent than the largest banks. We therefore implement DiD regressions using quarterly data that distinguish between banks with assets between $50 billion and $250 billion and banks with more than $250 billion of assets.[15] The non-treated banks are the other banks in our sample. The treatment year (*year 0)* is 2013. We classify banks into size groups based on their status the year before treatment (*year -1*, as of the fourth quarter of 2012). We focus on a seven-year window [*year -3*, *year +3*] around the treatment year and estimate the regressions over the period 2010 to 2016.

---

[13] In its 2014 letter to the shareholders, the CEO of JPMorgan Chase states that the bank has 27 different capital requirements and more than 500 requirements for liquidity (see page 23 of the Annual Report for 2014 of JPMorgan Chase Co.).
[14] See Basel Regulatory Framework, Recent Updates, Board of Governors of the Federal Reserve System, https://www.federalreserve.gov/supervisionreg/basel/basel-default.htm.
[15] Our results hold if we estimate the regressions using annual data.

We show our DiD estimates in Table 5. We include interactions between indicators for our treatment groups, *Largest* stands for the largest banks and *Large* for the large banks, respectively, and an indicator, *Post*, which equals one starting in the first quarter of 2013. All regressions use bank fixed effects and time fixed effects.[16] The regressions have the same control variables as the regressions in Table 1, Panel A. However, to avoid the bad control variable problem (Angrist and Pischke, 2009), we only use control variables for the year before the treatment year, so that the control variables are not affected by treatment. The regressions interact these controls with the *Post* indicator variable. In Column (1), we find an estimate of an increase in LAR of 9.0 percentage points for the largest banks and of 3.8 percentage points for large banks. The increase in LAR for large banks is only significant at the 10% level while the increase for the largest banks is significant at the 1% level. Note that an increase in LAR is not evidence of an impact of the LCR on holdings of liquid assets. Specifically, the LAR could increase because of an increase in capital requirements alone. Hence, our DiD evidence is that the regulatory changes as a whole cause the large banks and the largest banks to increase their holdings of liquid assets relative to other banks. To put this treatment effect in perspective, from the start of 2010 to the end of 2019, the LAR of the largest banks increases relative to the LAR of the smallest banks by 10.4 percentage points. As a result, the treatment effect appears to explain most of the relative increase in the LAR of the largest banks.

We now turn in Column (2) of Table 5 to the treatment effect on the Tier 1 ratio. We expect this ratio to increase for the largest banks and large banks relative to other banks. We find that the Tier 1 ratio of the largest (large) banks increases by 2.7 (1.6) percentage points. As discussed, the increase in the Tier 1 ratio makes it more expensive for banks to hold assets with high risk-weights, such as loans. In Column (3), we show that the ratio of risk-weighted assets to assets, the RWA ratio, falls by 9.6 (8.2) percentage points for the largest (large) banks. Because loans and liquid assets are substitutes and because capital requirements increase more on loans than liquid assets, we expect loans to fall. Column (4) shows a significant drop in the loans to assets ratio of 6.4 percentage points for the largest banks and an insignificant drop of 2.6

[16] State-time fixed effects are questionable when we focus on the largest banks that are global in nature.

percentage points for large banks. Lastly, in Column (5), we show a large increase in HQLA-to-assets of 7.2 percentage points for the largest banks but no significant increase for large banks. The increase in HQLA does not, by itself, indicate an impact of the LCR requirement because an increase in liquid asset holdings mechanically increases HQLA even in the absence of the LCR requirement.

If the LAR increases because of the LCR requirement, we expect the LAR to increase more for banks with a low LAR or a low LCR before treatment. There are two difficulties with this argument, however. First, as discussed, a bank can increase its LCR without increasing its LAR. Evidence of the rather loose relation between the LCR and the LAR is that the correlation between these two ratios for our sample of banks in 2012 is only 40%. Second, it is impossible to compute the LCR ratio exactly with data publicly available (Ihrig, Kim, Vojtech, and Weinbach, 2019), so that one has to make assumptions in estimating the ratio. Specifically, the problem in computing the LCR ratio with public data is estimating the net cash outflows used in the denominator. We follow Hong, Huang, and Wu (2014) to compute the denominator and Yankov (2020) in computing the numerator from public data.[17]

In Column (6) of Table 5, we add an indicator variable for whether a bank has a low LAR, *Low LAR*, and interact that indicator variable with the interactions of *Post* and the *Large* and *Largest* indicator variables. *Low LAR* is defined at the size class level and is equal to one for the banks in the bottom quartile of the distribution of LAR at the end of 2012. We find that the triple interactions are not significant, but the interaction of *Low LAR* and *Post* is positive and statistically significant. In Column (7), we use an indicator variable for a low LCR, *Low LCR*, constructed and used similarly to the *Low LAR* variable. Surprisingly, the triple interaction for the largest banks is significantly negative (at the 10% level). Note that a low LCR bank could increase its LCR by replacing its assets with low weights in the HQLA computation by Treasuries which have the highest weight. In that case, the LCR would increase without the bank changing its LAR. A bank could also change its funding so that the potential outflows that are used for the denominator of the LCR become smaller, which increases the LCR even though the bank does not change

[17] We thank Vladimir Yankov for providing us with the code used in Yankov (2020) to compute HQLA.

its LAR. Next, in Column (8), we use the *LCR gap* of Sundaresan and Xiao (2024) instead of the *Low LCR* indicator. The *LCR gap* is the difference between 100% and the LCR pre-treatment for the banks with assets in excess of $250 billion pre-treatment and the difference between 70% and the LCR pre-treatment for the banks with assets between $50 billion and $250 billion. The coefficient for the largest banks is insignificant and the coefficient for the large banks is negative. It follows that the LCR gap is not helpful in explaining the increase in liquid assets for the large and largest banks.

Sundaresan and Xiao (2024) conclude from their evidence that the LCR regulations increased the holdings of HQLA and increased the LCR for the affected banks. Their evidence is not necessarily inconsistent with what we find. There are three important differences between our DiD analysis and theirs. First, their sample is different. They include foreign banks and investment banks in their sample. We do not because we are focused on banks for which the deposit view potentially applies. Second, their focus is on regressions where the dependent variable is the growth rate of the dollar amount of HQLA. Instead, our dependent variable is the level of the LAR, which is a balance sheet ratio. Note that HQLA grows if a bank grows. Banks that grow faster but do not change the composition of their balance sheet will experience faster HQLA growth. Our study is focused on the LAR as we examine the portfolio motive that considers how banks allocate their assets across different asset classes, including liquid assets. We would not expect the LAR to have a non-zero growth rate in steady state since if it did a bank would eventually only have liquid assets. With the regulatory changes, we expect the LAR to increase until it reaches a level where the full effect of the regulatory changes has been incorporated in the balance sheet and then change because of the portfolio motive and not because of the regulatory changes. As a result, using the growth rate of the LAR as our dependent variable would not be appropriate for our purposes.[18] Finally, while we explore the

[18] We implement our DiD analysis on the sample of LCR banks used by Sundaresan and Xiao (2024) and show in Appendix Table A8 that our results hold if we use their sample. We used alternate methods to compute the LCR and our results do not change. We also replicate their results on their sample and our sample. We found their results for their sample. The results for our sample are consistent but weaker, presumably because of the smaller number of banks. However, the smaller number of banks cannot explain the difference when we use the LAR as the dependent variable because the *LCR gap* has a significantly negative coefficient rather than positive.

differential evolution of LAR between large (LCR) banks and other banks, Sundaresan and Xiao (2024) focus on the effects of LCR regulation on the HQLA of LCR banks.

If the LAR increases because of the increase in capital requirements, we expect the LAR to increase more for banks with a low Tier 1 ratio. In Column (9) of Table 5, we use an indicator variable *Low Tier 1* for banks that have a Tier 1 ratio in the bottom quartile of the distribution of the Tier 1 ratio in their size class. We use the *Low Tier 1* indicator in the same way that we use the *Low LAR* indicator variable. In contrast to our results with *Low LAR* and *Low LCR*, we find a very strong coefficient on the triple interaction for *Low Tier 1*. The coefficient has a magnitude of 7.4 percentage points and is significant at the 1% level. The triple interaction for the large banks has a positive, but insignificant coefficient.

As discussed, there are few banks with assets in excess of $250 billion. However, the health of the banking system depends crucially on these banks and they represent a large share of the assets controlled by banks. While finance research often looks at samples of large banks, these samples are not focused on the banks with assets in excess of $250 billion and hence cannot speak to the impact of regulations on these banks. Because there are few such banks, it is important to check especially carefully that the results are robust. We do so in Table 6 and in the Internet Appendix. In Columns (1)-(4) of Table 6, we re-estimate our triple interaction regressions but now use the median of the size class as the dividing line to construct the samples of *Low LAR*, *Low LCR*, and *Low Tier 1*. We see that our results hold. In Columns (5) through (7), we re-estimate the regressions, but now we use all LCR banks. This sample includes trust banks and banks that are not primarily deposit-taking banks. We see again that our results are maintained. Lastly, we use the period 2011-2017 instead of 2010-2016 to estimate our regressions. Once more, the results hold.

Our DiD analysis suggests that the regulatory changes help explain the increase in liquid asset holdings of the large and largest banks relative to other banks. However, our analysis does not show an effect of the liquidity regulations. The increase in capital requirements made holding loans more expensive relative to holding liquid assets especially for the largest banks. Hence, to the extent that liquid assets and loans are substitutes, as they are with the portfolio motive, we expect an increase in capital requirements that makes holding loans more expensive to increase holdings of liquid assets relative to holdings of loans and to do so especially for the largest banks. This is exactly what we find.

6. Robustness

We examine the robustness of our results to alternative definitions of LAR and alternate samples extensively. We report the results in the Internet Appendix. Panel A of Figure A2 shows the evolution of the aggregate LAR for the alternate definitions. We see that the evolution through time of our different measures of LAR is largely similar. We also add to the figure the HQLA ratio. The HQLA ratio is smaller than the LAR but evolves similarly. We see that the evolution of the LAR is similar if we exclude Treasuries or include reverse repos.

In our extensive robustness analysis, we specifically find:

1) Our conclusions generally hold if we use bank holding company (BHC) data and restrict our sample to bank holding companies. Results using BHC data are in Tables A9-A11 of our Internet Appendix.
2) Our conclusions generally hold if we include Fed funds and reverse-repos in our definition of liquid assets (Panels A-C of Table A12 of our Internet Appendix). The use of reverse-repos substantially increases the level of the LAR but does not materially change the time-series evolution of the LAR.
3) Our results are not explained by changes in the outstanding amount of Treasuries over time. Specifically, our results hold if we remove Treasuries from the definition of the LAR (Panels D-F of Table A12 of our Internet Appendix). Panel B of Figure A2 in our Internet Appendix shows the evolution of the Treasuries held as a percentage of liquid assets holdings. Interestingly, Treasuries were a larger component of the LAR in the early 1990s than after the GFC.

7. Conclusion

Banks hold large amounts of liquid assets. These liquid assets are important for the financial strength of banks and for the stability of the financial system. Given the importance of these liquid assets, we would expect financial economists to have produced much empirical research to help us understand the magnitude and the evolution of bank liquid asset holdings, but this is not the case. In this paper, we present a theory of bank liquid asset holdings, provide support for it in our sample period from 1984 to 2020, and show that it helps understand why banks (especially large banks) hold more liquid assets after the GFC.

We contrast the lending view of banks to the deposit view of banks. With the lending view, banks hold liquid assets for the transaction and precautionary motives. They hold more liquid assets if they have more loans, so that liquid assets and loans are complementary. With the lending view, bank assets shrink when a bank lacks lending opportunities. With the deposit view, banks create value from deposits, so that if they do not have positive NPV loans available, they invest their funds in other assets than loans, including liquid assets. As a result, bank assets do not shrink when a bank has fewer positive NPV loans available and liquid assets are substitutes for loans. We find much evidence that liquid assets and loans are substitutes. The deposit view implies that when holding loans on a bank balance sheet becomes more expensive relative to holding liquid assets, banks will increase their holdings of liquid assets and decrease their holdings of loans. Consequently, the deposit view provides a useful lens through which to examine the impact of the post-GFC increases in capital requirements as these increases make holding liquid assets relatively more advantageous relative to holding loans and especially so for the large and largest banks. We show that the differential increases in capital requirements for the largest and large banks relative to other banks help explain the differential increase in holdings of liquid assets for these banks compared to other banks. In contrast, the liquidity regulations put in place after the GFC do not appear to explain the increase in liquid assets of the banks that are most exposed to the regulatory changes. A possible explanation for this finding is that there are many different ways for banks to satisfy the LCR requirement, so that if banks are holding large amounts of liquid assets for other reasons than the liquidity regulations, the LCR requirement may not play an important role as a determinant of bank holdings of liquid assets.

Our analysis shows that using the deposit view helps understand the role of liquid asset holdings for banks. This is because with the deposit view banks hold liquid assets for the portfolio motive. The extremely large increase in liquid asset holdings of the largest banks relative to other banks after the GFC cannot be explained if banks hold liquid assets only for precautionary and transaction motives. The portfolio motive for holding liquid assets explains why the largest banks increase their holdings of liquid assets so much after the GFC compared to other banks. This is because they experience a greater increase in capital requirements than other banks and this increase affects holdings of loans much more than holdings of liquid assets. The post-GFC increase in capital requirements appears to have increased holdings of loans outside of the banking sector and increased holdings of liquid assets inside the banking sector, thereby reducing the role of banks in the economy.

References

Acharya, Viral V., and Raghuram Rajan, 2023. "Liquidity, liquidity everywhere, not a drop to use: Why flooding banks with central bank reserves may not expand liquidity." NBER working paper 29680.

Almeida, Heitor, Murillo Campello, Igor Cunha, and Michael S. Weisbach, 2014. "Corporate liquidity management: A conceptual framework and survey." *Annual Review of Financial Economics* 6, 135-162.

Almeida, Heitor, Murillo Campello, and Michael S. Weisbach, 2004. "The cash flow sensitivity of cash." *Journal of Finance* 59, 1777-1804.

Angrist, Joshua D., and Jörn-Steffen Pischke, 2009. *Mostly Harmless Econometrics*. Princeton University Press.

Bai, Jennie, Arvind Krishnamurthy, and Charles-Henri Weymuller, 2018. "Measuring liquidity mismatch in the banking sector." *Journal of Finance* 73, 51-93.

Banerjee, R.N. and Mio, H., 2018. "The impact of liquidity regulation on banks." *Journal of Financial intermediation 35*, 30-44.

Bartik, Timothy J., 1991. *Who benefits from state and local economic development policies?* W.E. Upjohn Institute for Employment Research.

Basel Committee on Bank Supervision, 2022. "Buffer usability and cyclicality in the Basel framework." Bank for International Settlements.

Bennett, Paul, and Stavros Peristiani, 2002. "Are U.S. reserve requirements still binding?" *Economic Policy Review* 8, 1-16.

Berger, Allen N., and Christa H. S. Bouwman, 2009. "Bank liquidity creation." *Review of Financial Studies* 22, 3779-3837.

Berrospide, Jose M., and Rochelle M. Edge, 2016. "The effects of bank capital requirements on bank lending: What can we learn from the post-crisis regulatory reforms?" Unpublished working paper.

Blanchard, Olivier, and Lawrence Katz, 1992. "Regional evolutions." *Brookings Papers on Economic Activity* 23, 1-75.

Buchak, Greg, Gregor Matvos, Tomasz Piskorski, and Amit Seru, 2024. "The secular decline of bank balance sheet lending." Unpublished working paper.

Cecchetti, Stephen G., and Anil K. Kashyap, 2016. "What binds? Interactions between bank capital and liquidity regulations." Unpublished working paper.

Chakraborty, Indraneel, Itay Goldstein, and Andrew MacKinlay, 2020. "Monetary stimulus and bank lending." *Journal of Financial Economics* 136, 2806-2853.

Cohen, L., Diether, K.B. and Malloy, C.J., 2007. "Supply and demand shifts in the shorting market." *Journal of Finance* 62, 2061-2096.

Copeland, Adam, Darrell Duffie, and Yilin (David) Yang, 2024. "Reserves were not so ample after all." *Quarterly Journal of Economics*, forthcoming.

Darmouni, Olivier, and Alexander Rodnyansky. 2017. "The effects of quantitative easing on bank lending behavior." *Review of Financial Studies* 30, 3858-3887.

DeAngelo, Harry, and René M. Stulz, 2015. "Liquid-claim production, risk management, and bank capital structure: Why high leverage is optimal for banks." *Journal of Financial Economics* 116, 219-236.

Degryse, Hans, and Steven Ongena, 2005. "Distance, lending relationships, and competition." *Journal of Finance* 60, 231-266.

Denis, David J., and Luxi Wang, 2024. "Corporate cash holdings." *Handbook of Corporate Finance*, Edward Elgar Publishing, forthcoming.

Diamond, Douglas, and Phil Dybvig, 1983. "Bank runs, deposit insurance, and liquidity." *Journal of Political Economy* 91, 401-419.

Diamond, William, Zhengyang Jiang, and Yiming Ma, 2021. "The reserve supply channel and unconventional monetary policy." Unpublished working paper.

Diamond, Douglas, and Anil K. Kashyap, 2016. "Liquidity requirements, liquidity choice, and financial stability." *Handbook of Macroeconomics*, vol. 2, 2263-2303, Elsevier.

Drechsler, Itamar, Alexi Savov, and Philipp Schnabl, 2017. "The deposits channel of monetary policy." *Quarterly Journal of Economics* 132, 1819-1876.

Duffie, Darrell, 2010. "The failure mechanics of dealer banks." *Journal of Economic Perspectives* 24, 51-72.

Egan, M., S. Lewellen, and A. Sunderam, 2022. "The cross-section of bank value." *Review of Financial Studies 35*, 2101-2143.

Froot, Kenneth A., David S. Scharfstein, and Jeremy C. Stein, 1993. "Risk management: Coordinating corporate investment and financing policies." *Journal of Finance* 48, 1629-1658.

Gelman, M. and MacKinlay, A., 2024. "Open to all comers: How unsought deposit inflows affect banks." Unpublished working paper.

Greenstone, Michael, Alexandre Mas, and Hoai-Luu Nguyen, 2020. "Do credit market shocks affect the real economy? Quasi-experimental evidence from the great recession and "normal" economic times." *American Economic Journal: Economic Policy* 12, 200-225.

Goldsmith-Pinkham, Paul, Isaac Sorkin, and Henry Swift, 2020. "Bartik instruments: What, when, why, and how? *American Economic Review* 110, 2586-2624.

Gropp, R., Mosk, T., Ongena, S. and Wix, C., 2019. "Banks response to higher capital requirements: Evidence from a quasi-natural experiment." *Review of Financial Studies 32*, 266-299.

Grossman, Sanford J., and Merton H. Miller, 1988. "Liquidity and market structure." *Journal of Finance* 43, 617-633.

Hanson, Samuel G., Andrei Shleifer, Jeremy C. Stein, and Robert W. Vishny, 2015. "Banks as patient fixed-income investors." *Journal of Financial Economics* 117, 449-469.

Hong, Han, Jing-Zhi Huang, and Deming Wu, 2014. "The information content of Basel III liquidity risk measures." *Journal of Financial Stability* 15, 91-111.

Ihrig, Jane, Edward Kim, Cindy M. Vojtech, and Gretchen C. Weinbach, 2019. "How have banks been managing the composition of high-quality liquid assets?" *Federal Reserve Bank of St. Louis Review* 101(3), 177-201.

Kashyap, Anil K., and Jeremy C. Stein, 2000. "What do a million observations on banks say about the transmission of monetary policy?" *American Economic Review* 90, 407-428.

Keynes, John Maynard, 1936. *The General Theory of Employment, Interest and Money*. Macmillan.

Klein, Michael A., 1971. "A theory of the banking firm." *Journal of Money, Credit and Banking* 3, 205-218.

Li, Ye, Yi Li, and Huijun Sun, 2021. "Bank credit and money creation on payment networks: A structural analysis of externalities and key players." Unpublished working paper.

Lopez-Salido, David, and Annette Vissing-Jorgensen, 2023. "Reserve demand, interest rate control, and quantitative tightening." Unpublished working paper, Federal Reserve Board.

Nelson, Bill, and Brett Waxman, 2021. "Bank Treasurers' views on liquidity requirements and the discount window." Bank Policy Institute.

Opler, Tim, Lee Pinkowitz, René M. Stulz, and Rohan Williamson, 1999. "The determinants and implications of corporate cash holdings." *Journal of Financial Economics 52,* 3-46.

Roberts, Daniel, Asani Sarkar, and Or Shachar, 2019. "Bank liquidity creation, systemic risk, and Basel liquidity regulations." Federal Reserve Bank of New York Staff Reports, no. 852.

Sanderson, Eleanor, and Frank Windmeijer, 2016. "A weak instrument F-test in linear IV models with multiple endogenous variables." *Journal of Econometrics* 190, 212-221.

Schiantarelli, Fabio, Massimiliano Stacchini, and Philip E. Strahan, 2020. "Bank quality, judicial efficiency, and loan repayment delays in Italy." *Journal of Finance* 75, 2139-2178.

Smith, Clifford W., and René M. Stulz, 1985. "The determinants of firms' hedging policies." *Journal of Financial and Quantitative Analysis* 20, 391-405.

Stock, James H. and Motohiro Yogo, 2005. "Testing for weak instruments in linear IV regression." In D.W.K. Andrews and J.H. Stock, eds. *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg*. Cambridge: Cambridge University Press, 2005, 80-108.

Sundaresan, S., and K. Xiao, 2024. "Liquidity regulation and banks: Theory and evidence." *Journal of Financial Economics*, forthcoming.

Walter, John, 2019. "US bank capital regulation: History and changes since the financial crisis." *Economic Quarterly of the Federal Reserve Bank of Richmond* 105, 1-40.

Yankov, Vladimir, 2020. "The liquidity coverage ratio and corporate liquidity management." FEDS Notes.

Zeissler, Arwin G., Daisuke Ikeda, and Andrew Metrick, 2019. "JPMorgan Chase London Whale A: Risky Business." *Journal of Financial Crises* 1, 40-59.

Table 1. Determinants of liquid asset holdings of banks

This table shows results from regressions to explain bank liquid asset holdings using quarterly data. The sample consists of US-chartered commercial banks with assets that exceed $2 billion (in constant 2018 dollars). In Panels A and B, the dependent variable is the liquid assets ratio, *LAR* – the sum of cash holdings and non-cash liquid assets, scaled by total assets. In Panel C, the dependent variable is *ΔLiquid assets-to-assets* – the change in liquid assets for bank *i* from *t-1* to *t* normalized by assets at *t-1*. The sample period is 1984-2020. We show results using three periods: the full sample period, the pre-GFC period, and the post-GFC period, respectively. Independent variables include *Log(assets)*, the natural log of book value of assets; *Loans-to-assets*, total loans scaled by assets; *Demand deposits-to-assets,* demand deposits scaled by assets; *Other deposits-to-assets,* total deposits minus demand deposits scaled by assets; *Equity-to-assets*, total book value of equity scaled by assets; *Net income-to-assets*, net income scaled by assets; *ROA volatility*, the standard deviation of return on assets (ROA) over the prior four quarters, and *Trading*, an indicator variable equal to one for banks with trading assets as of the prior quarter-end. In Panel B, independent variables also include *Loan growth* – lagged eight-quarter average growth for loans, and *Deposit volatility*, the standard deviation of deposits-to-assets over the prior four quarters. Controls in Panel C include *Net income*$_t$*-to-assets*$_{t-1}$; all other controls in Panel C are measured as changes from *t-1* to *t* normalized by assets at *t-1*, except for *ΔROA volatility*, and *ΔTrading assets*, which are measured as changes from *t-1* to *t*. We report *t*-statistics based on standard errors clustered at the bank level in parentheses. Bank and state-year fixed effects are included in all regressions. All variables are defined in the Appendix. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Determinants of LAR

	(1)	(2)	(3)
Dependent variable:	LAR	LAR	LAR
Sample period:	1984-2020	1984-2006	2010-2020
Log(assets)$_{t-1}$	-0.004	-0.005	-0.018***
	(-0.82)	(-1.14)	(-2.96)
Loans-to-assets$_{t-1}$	-0.509***	-0.444***	-0.602***
	(-17.23)	(-15.40)	(-15.20)
Demand deposits-to-assets$_{t-1}$	0.098	-0.046	0.077*
	(1.57)	(-0.95)	(1.67)
Other deposits-to-assets$_{t-1}$	0.001	-0.037	0.056
	(0.03)	(-1.36)	(1.38)
Equity-to-assets$_{t-1}$	-0.338***	-0.343***	-0.323***
	(-4.96)	(-5.51)	(-3.23)
Net income-to-assets$_{t-1}$	0.028	0.709*	-1.143***
	(0.10)	(1.94)	(-2.95)
ROA volatility$_{t-1}$	-0.785*	-0.314	0.450
	(-1.65)	(-0.63)	(0.63)
Trading assets$_{t-1}$	-0.008**	-0.007**	-0.002
	(-2.44)	(-2.09)	(-0.56)
Intercept	0.621***	0.641***	0.876***
	(8.60)	(7.95)	(8.66)
Observations	47,322	29,656	13,921
Adjusted R^2	0.815	0.825	0.893
Bank fixed effects	Yes	Yes	Yes
State-time fixed effects	Yes	Yes	Yes

Table 1. Determinants of liquid asset holdings of banks – continued

Panel B. Determinants of LAR: Loan growth and deposit volatility			
	(1)	(2)	(3)
Dependent variable:	LAR	LAR	LAR
Sample period:	1984-2020	1984-2006	2010-2020
$Log(assets)_{t-1}$	-0.003	0.001	-0.027***
	(-0.41)	(0.20)	(-2.86)
$Loan\ growth_{t-8,t-1}$	-0.114***	-0.098**	-0.137**
	(-3.00)	(-2.12)	(-2.16)
$Deposit\ volatility_{t-1}$	0.168***	0.227***	-0.189*
	(2.91)	(3.62)	(-1.83)
$Net\ income\text{-}to\text{-}assets_{t-1}$	-0.468	-0.148	-2.127***
	(-1.16)	(-0.28)	(-3.60)
$ROA\ volatility_{t-1}$	-0.378	-0.826	3.118***
	(-0.58)	(-1.15)	(3.02)
$Trading\ assets_{t-1}$	-0.010**	-0.003	-0.010
	(-2.22)	(-0.62)	(-1.31)
Intercept	0.268**	0.209**	0.646***
	(2.50)	(2.22)	(4.37)
Observations	47,207	29,616	13,873
Adjusted R^2	0.715	0.752	0.830
Bank fixed effects	Yes	Yes	Yes
State-time fixed effects	Yes	Yes	Yes

Panel C. Determinants of changes in liquid asset holdings			
	(1)	(2)	(3)
Dependent variable:	$\Delta Liquid\ assetst\text{-}to\text{-}assets_{t-1}$		
Sample period:	1984-2020	1984-2006	2010-2020
$\Delta Loans_t/assets_{t-1}$	-0.444***	-0.346***	-0.760***
	(-19.96)	(-14.29)	(-15.50)
$\Delta Assets_t/assets_{t-1}$	0.472***	0.412***	0.677***
	(27.83)	(21.60)	(20.89)
$Net\ income_{t-1}/assets_{t-2}$	-0.127*	-0.071	-0.214*
	(-1.85)	(-0.68)	(-1.70)
$\Delta ROA\ volatility_{t-2,t-1}$	0.075	0.015	0.260
	(0.51)	(0.08)	(0.87)
$\Delta Trading\ assets_{t-2,t-1}$	-0.001	-0.001	0.003*
	(-0.67)	(-1.34)	(1.65)
Intercept	0.001***	0.000	0.002***
	(3.55)	(0.63)	(4.25)
Observations	44,831	27,967	13,288
Adjusted R^2	0.479	0.424	0.695
Bank fixed effects	Yes	Yes	Yes
State-time fixed effects	Yes	Yes	Yes

Table 2. Exogenous variation in loans and deposits and bank holdings of liquid assets

This table shows first- and second-stage results from 2SLS regressions using quarterly data to explain changes in bank liquid asset holdings with instrumented changes in loans and deposits. The sample consists of US-chartered commercial banks with assets that exceed $2 billion (in constant 2018 dollars). We instrument Δ*Loans-to-assets*$_{t-1}$ and Δ*Deposits-to-assets*$_{t-1}$ using Bartik-like instruments. The approach uses as an instrument for loan (deposit) changes at a bank the predetermined exposure of that bank to each of five loan types (four deposit types) times the aggregate growth in loans (deposits) for each type of loan (deposits) for all other banks of the same type at the national level. Predetermined exposures (loan or deposit shares) are chosen for the first available quarter in a five-year rolling window ending in the current quarter. We distinguish between three types of banks: small, medium, and large; five loan types: Commercial and industrial (C&I) loans, real estate (RE) loans, agricultural loans, personal loans, and other loans; and four deposit types: demand deposits, time deposits, savings deposits, and other deposits. When instrumenting Δ*Loans*$_t$*-to-assets*$_{t-1}$ (Δ*Deposits-to-assets*$_{t-1}$), we use the aggregate growth in loans (deposits) of type *k* from *t*-1 to *t*, where we aggregate across all banks in group size *s*, excluding the bank of interest. We show first-stage results in Columns (1)-(6) and second-stage results using Δ*Liquid assets-to-assets* as the dependent variable in Columns (7)-(10). The sample period is 1984-2020 and we show results for three periods: the full sample period, the pre-GFC period, and the post-GFC period, respectively. Independent variables include *Net income*$_t$*-to-assets*$_{t-1}$; Δ*ROA volatility;* Δ*Trading assets;* Δ*Fed funds rate;* Δ*Default spread;* Δ*Interest on excess reserves*, and Δ*Aggregate reserves-to-assets.* In column (10), we show results in which we instrument aggregate reserves with reserves + ONRRP (overnight reverse repurchase), following Lopez-de-Salido and Vissing-Jorgensen (2023). Specifically, Δ*Aggregate reserves-to-assets* is instrumented using ΔReserves + ONRRP-to-assets. Column (10) is based on the 2010-2020 period because ONRRP data are only available since 2004. We report *t*-statistics based on standard errors clustered at the bank level in parentheses. We report the Sanderson-Windmeijer multivariate *F*-test of excluded instruments. All variables are defined in the Appendix. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 2. Exogenous variation in loans and deposits and bank holdings of liquid assets – continued

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dependent variable:		*ΔLoans$_t$-to-assets$_{t-1}$*			*ΔDeposits$_t$-to-assets$_{t-1}$*			*ΔLiquid assets$_t$-to-assets$_{t-1}$*		
Stage:		First-stage			First-stage			Second-stage		
Sample period:	1984-2020	1984-2006	2010-2020	1984-2020	1984-2006	2010-2020	1984-2020	1984-2006	2010-2020	2010-2020
ΔLoans$_t$/assets$_{t-1}$ (Instrumented)[A]							-0.346***	-0.422***	-0.266***	-0.265***
							(-4.75)	(-3.25)	(-2.96)	(-2.95)
ΔDeposits$_t$ /assets$_{t-1}$ (Instrumented)[B]							0.562***	0.544***	0.638***	0.639***
							(17.27)	(11.21)	(9.08)	(8.86)
Bartik instrument: ΔLoans	0.100***	0.058**	0.215***	-0.187***	-0.177***	-0.168***				
	(4.66)	(2.29)	(3.94)	(-9.01)	(-7.47)	(-4.62)				
Bartik instrument: ΔDeposits	0.046***	0.061***	-0.065	0.324***	0.316***	0.286***				
	(3.38)	(3.80)	(-1.40)	(19.04)	(15.97)	(8.08)				
Net income$_t$/assets$_{t-1}$	1.973***	1.605***	1.815***	1.108***	0.862***	1.247***	0.077	0.396*	-0.669***	-0.673***
	(13.65)	(6.83)	(8.06)	(6.26)	(3.22)	(5.68)	(0.54)	(1.93)	(-3.18)	(-3.12)
ΔROA volatility$_{t-1,t}$	-0.055	0.031	-0.650	0.437**	0.590**	-0.542	-0.292**	-0.349**	0.316	0.318
	(-0.28)	(0.15)	(-0.94)	(2.09)	(2.53)	(-0.98)	(-2.48)	(-2.49)	(1.10)	(1.10)
ΔTrading assets$_{t-1,t}$	0.001	0.001	-0.001	0.003	0.001	0.004	-0.002	-0.002**	0.005	0.005
	(1.02)	(0.42)	(-0.31)	(1.63)	(0.51)	(1.10)	(-1.62)	(-2.16)	(1.58)	(1.58)
ΔFed funds rate$_{t-1,t}$	0.002***	0.003***	0.007*	-0.002***	-0.002***	0.016***	-0.000	0.000	-0.003	-0.003
	(3.27)	(5.52)	(1.68)	(-3.36)	(-2.81)	(3.05)	(-0.65)	(0.28)	(-1.03)	(-0.89)
ΔDefault spread$_{t-1,t}$	1.445***	1.250***	1.168***	1.565***	2.629***	0.599**	0.141	0.256	-0.187	-0.196
	(12.14)	(4.48)	(5.21)	(10.04)	(8.52)	(2.12)	(1.14)	(1.16)	(-1.03)	(-1.00)
ΔInterest on excess reserves$_{t-1,t}$	-1.608***		-2.606***	-2.431***		-4.209***	0.119		0.660	0.691
	(-8.83)		(-7.20)	(-12.36)		(-10.51)	(0.74)		(1.62)	(1.43)
ΔAggregate reserves$_t$-to-assets$_{t-1}$	-0.257***	3.986***	-0.198***	-0.052	3.922***	0.034	0.077***	1.857***	0.061*	
	(-10.58)	(6.67)	(-4.68)	(-1.39)	(5.82)	(0.62)	(3.06)	(3.33)	(1.87)	
ΔAgg.reserves$_t$-to-assets$_{t-1}$ (Instrumented) [C]										0.055
										(1.33)
Observations	43,634	27,515	12,575	43,634	27,515	12,575	43,634	27,515	12,575	12,575
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	No	No	No	No	No	No	No	No	No	No
SW F-test of excl. instrument [A]							72.27	26.51	28.27	26.81
SW F-test of excl. instrument [B]							349.98	76.64	42.10	38.56
SW F-test of excl. instrument [C]										549.77

Table 3. Low levels of liquid asset holdings and exogenous variation in loans and deposits

This table shows second-stage results from 2SLS regressions using quarterly data to explain changes in bank liquid asset holdings with instrumented changes in loans and deposits, including interaction terms. The sample consists of US-chartered commercial banks with assets that exceed $2 billion (in constant 2018 dollars). We instrument *ΔLoans-to-assets$_{t-1}$* and *ΔDeposits-to-assets$_{t-1}$* using Bartik-like instruments, as discussed in Table 2. This table shows results from interactions between the instrumented *ΔLoans-to-assets$_{t-1}$* and *ΔDeposits-to-assets$_{t-1}$* with two different indicator variables. In columns (1)-(3), we show results using interactions with *Bottom LAR*, an indicator variable that is equal to one for banks with an *LAR* in the bottom decile of the distribution at *t*-2. In columns (4)-(8), we show results using interactions with *High loan growth,* an indicator variable that is equal to one if a bank's loan growth in the previous eight quarters is in the top decile of loan growth across banks. The sample period is 1984-2020 and we show results using three periods: the full sample period, the pre-GFC period, and the post-GFC period, respectively. Independent variables include *Net income$_t$-to-assets$_{t-1}$*; *ΔROA volatility; ΔTrading assets; ΔFed funds rate; ΔDefault spread; ΔInterest on excess reserves*, and *ΔAggregate reserves-to-assets.* We report *t*-statistics based on standard errors clustered at the bank level in parentheses. We report *p*-values from *F*-tests of the sum of the coefficients *ΔLoans (ΔDeposits)* × *Indicator* + *ΔLoans (ΔDeposits*) = 0 and the Sanderson-Windmeijer multivariate F-test of excluded instruments. All variables are defined in the Appendix. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	*ΔLiquid assets$_t$-to-assets$_{t-1}$*					
	1984-2020	1984-2006	2010-2020	1984-2020	1984-2006	2010-2020
Indicator:	Indicator: *Bottom LAR*			Indicator: *High loan growth*		
ΔLoans$_t$/assets$_{t-1}$ (Instrumented) [A]	-0.559***	-0.805***	-0.426***	-0.399***	-0.535*	-0.373***
	(-6.68)	(-3.57)	(-4.68)	(-3.78)	(-1.77)	(-3.44)
ΔDeposits$_t$/assets$_{t-1}$ (Instrumented)[B]	0.646***	0.688***	0.716***	0.650***	0.602***	0.689***
	(18.70)	(9.08)	(10.60)	(17.75)	(11.16)	(9.60)
ΔLoans$_t$/assets$_{t-1}$ × *Indicator [A']*	0.583***	0.790***	0.511***	0.608***	0.791**	0.409***
	(6.29)	(3.41)	(4.21)	(3.26)	(2.11)	(2.74)
ΔDeposits$_t$/assets$_{t-1}$ × *Indicator [B']*	-0.408***	-0.393***	-0.501***	-0.209**	-0.255**	-0.293**
	(-5.60)	(-3.55)	(-4.34)	(-2.13)	(-2.04)	(-2.02)
Indicator	0.001	-0.003	0.006	-0.023**	-0.023	-0.010
	(0.65)	(-0.77)	(1.58)	(-2.09)	(-1.52)	(-1.33)
Net income$_t$/assets$_{t-1}$	0.310**	0.799***	-0.444**	0.123	0.632	-0.560***
	(2.03)	(2.58)	(-2.13)	(0.57)	(1.32)	(-2.64)
ΔROA volatility$_{t-1,t}$	-0.328***	-0.463***	0.310	-0.280	-0.519*	0.167
	(-2.68)	(-2.84)	(1.07)	(-1.36)	(-1.67)	(0.56)
ΔTrading assets$_{t-1,t}$	-0.001	-0.001	0.005	-0.001	-0.002	0.005
	(-0.97)	(-0.79)	(1.57)	(-1.21)	(-1.63)	(1.41)
ΔFed funds rate$_{t-1,t}$	0.000	0.002*	-0.002	-0.001	0.001	-0.002
	(1.04)	(1.93)	(-0.74)	(-0.95)	(0.25)	(-0.61)
ΔDefault spread$_{t-1,t}$	0.248**	0.230	-0.094	-0.113	0.187	-0.094
	(2.04)	(0.92)	(-0.54)	(-0.52)	(0.25)	(-0.54)
ΔInterest on excess reserves$_{t,t-1}$	-0.055		0.457	0.576**		0.621
	(-0.34)		(1.19)	(2.16)		(1.60)
ΔAggregate reserves$_t$/assets$_{t-1}$	0.058**	2.373***	0.063**	0.090***	2.689**	0.063*
	(2.38)	(3.35)	(2.20)	(3.09)	(2.23)	(1.78)
Observations	43,341	27,222	12,575	37,348	22,841	11,367
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	No	No	No	No	No	No
p-value [A+A']=0	0.651	0.855	0.393	0.209	0.373	0.719
p-value [B+B']=0	0.000	0.000	0.069	0.000	0.002	0.007
SW F-test of excl. instrument [A]	82.63	17.26	34.53	49.42	7.33	63.27
SW F-test of excl. instrument [B]	242.08	24.59	50.01	291.75	53.21	80.33

Table 4. Do liquid asset holdings of large banks increase more after the GFC?

This table shows second-stage results from 2SLS regressions using quarterly data to explain changes in bank liquid asset holdings with instrumented changes in loans and deposits with *Large* (an indicator variable equal to one for banks with assets in excess of $50 billion dollars in 2018 dollars) as an additional independent variable. The sample consists of US-chartered commercial banks with assets that exceed $2 billion (in constant 2018 dollars). We instrument *ΔLoans-to-assets$_{t-1}$* and *ΔDeposits-to-assets$_{t-1}$* using Bartik-like instruments, as discussed in Table 2. We show results for two subperiods: the pre-GFC period, and the post-GFC period, respectively. Independent variables include *Net income$_t$-to-assets$_{t-1}$*; *ΔROA volatility; ΔTrading assets; ΔFed funds rate; ΔDefault spread; ΔInterest on excess reserves*, and *ΔAggregate reserves-to-assets.* Columns (2) and (3) show results for the post-GFC period after instrumenting aggregate reserves with reserves + ONRRP (overnight reverse repurchase), following Lopez-de-Salido and Vissing-Jorgensen. (2023). Specifically, *ΔAggregate reserves-to-assets* is instrumented using *ΔReserves + ONRRP-to-assets.* In Column (3), we interact *ΔAggregate reserves-to-assets* with *Large*. We report *t*-statistics based on standard errors clustered at the bank level in parentheses. We report the Sanderson-Windmeijer multivariate F-test of excluded instruments. All variables are defined in the Appendix. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)
Dependent variable:	*ΔLiquid assets$_t$-to-assets$_{t-1}$*		
	1984-2006	2010-2020	2010-2020
ΔLoans$_t$/assets$_{t-1}$ (Instrumented) [A]	-0.517***	-0.330***	-0.331***
	(-3.87)	(-3.76)	(-3.77)
ΔDeposits$_t$ /assets$_{t-1}$ (Instrumented)[B]	0.559***	0.590***	0.588***
	(10.82)	(11.02)	(10.86)
Large	0.001	0.003***	0.003***
	(1.57)	(3.76)	(3.49)
Net income$_t$/assets$_{t-1}$	0.782***	-0.305	-0.304
	(3.07)	(-1.58)	(-1.58)
ΔROA volatility$_{t-1,t}$	-0.418***	0.251	0.254
	(-2.89)	(0.91)	(0.92)
ΔFed funds rate$_{t-1,t}$	0.001	0.002	0.002
	(0.74)	(1.18)	(1.06)
ΔDefault spread$_{t-1,t}$	0.326	-0.015	-0.009
	(1.40)	(-0.10)	(-0.06)
ΔAggregate reserves$_t$-to-assets$_{t-1}$	1.831***		
	(3.43)		
ΔAggregate reservest-to-assets$_{t-1}$(Instrumented) [C]		0.078*	0.070*
		(1.95)	(1.80)
ΔAggregate reserves$_t$-to-assets$_{t-1}$ × Large			0.079
			(0.85)
Observations	27,515	12,575	12,575
Bank fixed effects	Yes	Yes	Yes
Time fixed effects	No	No	No
SW F-test of excl. instrument [A]	30.16	60.72	60.78
SW F-test of excl. instrument [B]	101.55	167.33	166.80
SW F-test of excl. instrument [C]		951.46	991.92

Table 5. Difference-in-differences regressions around the adoption of the LCR

This table shows results from difference-in-differences regressions using quarterly data for the seven-year [*year -3, year +3*] window around the adoption of the LCR, where the treatment year (*year* 0) is 2013. The sample consists of US-chartered commercial banks with assets that exceed $2B billion (in constant 2018 dollars). We exclude trust banks and banks with foreign ownership, and we only include the largest entity within a multibank holding company. Dependent variables are *LAR,* the sum of cash holdings and non-cash liquid assets, scaled by total assets; *Tier 1 ratio,* total Tier 1 capital scaled by risk-weighted assets; *RWA-to-assets*, total risk-weighted assets scaled by total assets; *Loans-to-assets*; and *HQLA-to-assets*, high-quality liquid assets scaled by total assets. We estimate HQLA following Yankov (2020) and construct the liquidity coverage ratio (LCR) following Hong et al. (2014). We have two groups of treated banks, sorted by size as of *year -1* (fourth quarter of 2012): *Largest,* banks with assets in excess of $250B (in constant 2018 dollars) and *Large*, banks with assets between $50B and $250B. The control group includes banks with assets below $50B. *Post* is an indicator variable equal to one starting in the first quarter of 2013. In Columns (6) through (8), we show regressions with LAR as the dependent variable and with triple interactions with the indicator variables equal to one for banks with, respectively, *LAR*, *Tier 1 capital*, and *LCR* in the bottom quartile in its size group as of *year -1*. In column (9), we include interactions with *LCR gap*. *LCR gap* is computed as of *year -1* (2012) as: 100% - LCR ratio for largest banks, and 70% - LCR ratio for large banks. Independent variables include *Log(assets)*, *Demand deposits-to-assets, Other deposits-to-assets, Equity-to-assets*, *Net income-to-assets*, *ROA volatility*, and *Trading assets*. All regressions show results using interactions between independent variables measured as of *year -1* and *Post*. We report *t*-statistics based on standard errors clustered at the bank level in parentheses. All variables are defined in the Appendix. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 5. Difference-in-differences regressions around the adoption of the LCR – continued

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable:	LAR	Tier 1 ratio	RWA-to-assets	Loans-to-assets	HQLA-to-assets	LAR	LAR	LAR	LAR
Post × Largest	0.090***	0.027*	-0.096***	-0.064**	0.072**	0.091***	0.106***	0.101***	0.071***
	(3.41)	(1.92)	(-3.00)	(-2.35)	(2.06)	(3.39)	(3.49)	(3.21)	(2.77)
Post × Large	0.038*	0.016*	-0.082***	-0.026	0.019	0.036*	0.049**	0.064**	0.032
	(1.92)	(1.68)	(-3.20)	(-1.08)	(0.86)	(1.73)	(2.05)	(2.59)	(1.38)
Post × Largest × Low LAR						-0.004			
						(-0.13)			
Post × Large × Low LAR						0.011			
						(0.37)			
Post × Low LAR						0.016*			
						(1.95)			
Post × Largest × Low LCR							-0.037*		
							(-1.83)		
Post × Large × Low LCR							-0.029		
							(-1.48)		
Post × Low LCR							0.004		
							(0.53)		
Post × Largest × LCR gap								-0.027	
								(-0.79)	
Post × Large × LCR gap								-0.091*	
								(-1.87)	
Post × Largest × Low Tier 1									0.074***
									(5.24)
Post × Large × Low Tier 1									0.030
									(1.13)
Post × Low Tier 1									-0.011
									(-1.28)
Post × Log(assets)$_{t-1}$	0.002	-0.000	0.007	0.005	0.006	0.002	0.001	0.002	0.002
	(0.36)	(-0.12)	(1.01)	(0.87)	(0.95)	(0.33)	(0.22)	(0.40)	(0.27)
Post × Loans-to-assets$_{t-1}$	0.055*	0.042***	-0.018		0.060*	0.027	0.056*	0.070**	0.065*
	(1.68)	(2.67)	(-0.50)		(1.81)	(0.71)	(1.71)	(2.12)	(1.89)
Post × Demand deposits-to-assets$_{t-1}$	0.094	0.028	-0.136	-0.166*	-0.120	0.105	0.107	0.113	0.090
	(1.05)	(0.65)	(-1.26)	(-1.76)	(-1.61)	(1.17)	(1.17)	(1.24)	(1.00)
Post × Other deposits-to-assets$_{t-1}$	0.055	0.027	-0.114*	-0.075	0.018	0.067	0.062	0.063	0.053
	(1.23)	(1.34)	(-1.93)	(-1.55)	(0.45)	(1.47)	(1.37)	(1.41)	(1.22)
Post × Equity-to-assets$_{t-1}$	-0.282*	-0.720***	1.096***	0.559***	-0.414**	-0.287*	-0.280*	-0.318**	-0.317
	(-1.73)	(-3.76)	(3.60)	(3.21)	(-2.34)	(-1.74)	(-1.72)	(-2.00)	(-1.65)
Post × Net income-to-assets$_{t-1}$	-0.936	1.027	1.160	1.447	-0.947	-1.038	-0.960	-0.938	-1.117
	(-0.97)	(1.10)	(0.70)	(1.15)	(-0.78)	(-1.08)	(-0.98)	(-0.95)	(-1.19)
Post × ROA volatility$_{t-1}$	2.126	2.377*	-5.011*	-2.668	1.295	2.366	2.167	1.943	1.877
	(0.71)	(1.85)	(-1.73)	(-1.13)	(0.51)	(0.81)	(0.73)	(0.65)	(0.63)
Post × Trading assets$_{t-1}$	0.004	0.003	-0.016	-0.014	0.014	0.004	0.005	0.004	0.006
	(0.40)	(0.55)	(-1.25)	(-1.32)	(1.12)	(0.41)	(0.42)	(0.38)	(0.55)
Observations	5,916	5,912	5,916	5,916	5,916	5,916	5,916	5,916	5,916
Adjusted R^2	0.856	0.600	0.816	0.898	0.752	0.857	0.856	0.857	0.857
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 6. Difference-in-differences regressions around the adoption of the LCR: Robustness tests

This table shows results from difference-in-differences regressions using quarterly data for the seven-year [*year -3, year +3*] window around the adoption of the LCR, where the treatment year (*year* 0) is 2013. The sample consists of US-chartered commercial banks with assets that exceed $2B billion (in constant 2018 dollars). Unless otherwise noted, we exclude trust banks and banks with foreign ownership, and we only include the largest entity within a multibank holding company. The dependent variable is *LAR*, the sum of cash holdings and non-cash liquid assets, scaled by total assets. We have two groups of treated banks, sorted by size as of *year -1* (fourth quarter of 2012): *Largest,* banks with assets in excess of $250B (in constant 2018 dollars) and *Large*, banks with assets between $50B and $250B. The control group includes banks with assets below $50B. *Post* is an indicator variable equal to one starting in the first quarter of 2013. In columns (1)-(3), we use triple interactions with the indicator variables equal to one for banks with, respectively, *LAR*, *Tier 1 capital*, and *LCR* below the median of its size group as of *year -1*. In columns (4)-(9), the *Low* indicators are equal to one for banks in the bottom quartile in its size group as of *year -1*. In columns (4)-(6), we include additional LCR banks (foreign banks and investment banks with assets >$50B as of the end of 2012). In columns (7)-(9), the sample period is from 2011-2017. Independent variables (omitted to conserve space) include *Log(assets)*, *Demand deposits-to-assets, Other deposits-to-assets, Equity-to-assets*, *Net income-to-assets*, *ROA volatility*, and *Trading assets*. All regressions show results using interactions between independent variables measured as of *year -1* and *Post*. We report *t*-statistics based on standard errors clustered at the bank level in parentheses. All variables are defined in the Appendix. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

Table 6. Difference-in-differences regressions around the adoption of the LCR: Robustness tests – continued

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable:	LAR	LAR	LAR	LAR	LAR	LAR	LAR	LAR	LAR
	Low: below median			Full sample of LCR banks			2011-2017		
Post × Largest	0.072***	0.089***	0.068**	0.084***	0.097***	0.066**	0.085***	0.101***	0.065**
	(2.71)	(2.98)	(2.46)	(3.13)	(3.21)	(2.54)	(3.10)	(3.37)	(2.46)
Post × Large	0.033	0.043	0.031	0.040**	0.048**	0.034*	0.026	0.041*	0.022
	(1.28)	(1.52)	(1.13)	(2.14)	(2.51)	(1.74)	(1.39)	(1.88)	(1.11)
Post × Largest × Low LAR	0.049*			-0.006			-0.005		
	(1.69)			(-0.19)			(-0.16)		
Post × Large × Low LAR	0.012			-0.010			0.028		
	(0.44)			(-0.52)			(1.27)		
Post × Low LAR	-0.013			0.016**			0.023***		
	(-1.15)			(2.04)			(2.99)		
Post × Largest × Low LCR		0.003			-0.034			-0.043**	
		(0.10)			(-1.64)			(-2.14)	
Post × Large × Low LCR		-0.011			-0.032			-0.022	
		(-0.41)			(-1.59)			(-1.21)	
Post × Low LCR		0.000			0.004			0.003	
		(0.04)			(0.53)			(0.37)	
Post × Largest × Low Tier 1			0.049**			0.070***			0.074***
			(2.17)			(4.91)			(4.67)
Post × Large × Low Tier 1			0.016			0.021			0.040*
			(0.64)			(1.13)			(1.75)
Post × Low Tier 1			-0.005			-0.009			-0.010
			(-0.53)			(-1.08)			(-1.27)
Observations	5,916	5,916	5,916	6,266	6,266	6,266	5,906	5,906	5,906
Adjusted R^2	0.857	0.856	0.857	0.855	0.855	0.855	0.877	0.876	0.877
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Figure 1. Aggregate liquid asset holdings and loans

This figure shows the aggregate liquid assets-to-assets ratio (*LAR*), the *Loans-to-assets* ratio, and the components of the *LAR*: *Cash-to-assets* and *Non-cash LAR* for US-chartered commercial banks with assets that exceed $2 billion (in constant 2018 dollars). We use quarterly data. The aggregate *LAR* (*Loans-to-assets*) is computed by summing liquid assets (loans) for all banks in the sample and dividing them by the sum of assets for all banks. Liquid assets represent the sum of cash holdings and non-cash liquid assets. Cash holdings include vault cash, cash items in the process of collection, balances due from depository institutions, and balances due from Federal Reserve Banks. Non-cash liquid assets include US Treasuries, US government and government-sponsored agency obligations, and mortgage-backed securities issued or guaranteed by GNMA, FNMA, or FHLMC. We obtain the data from the quarterly Reports of Condition and Income "Call Reports" (Form FFIEC 031) from 1984-2020.

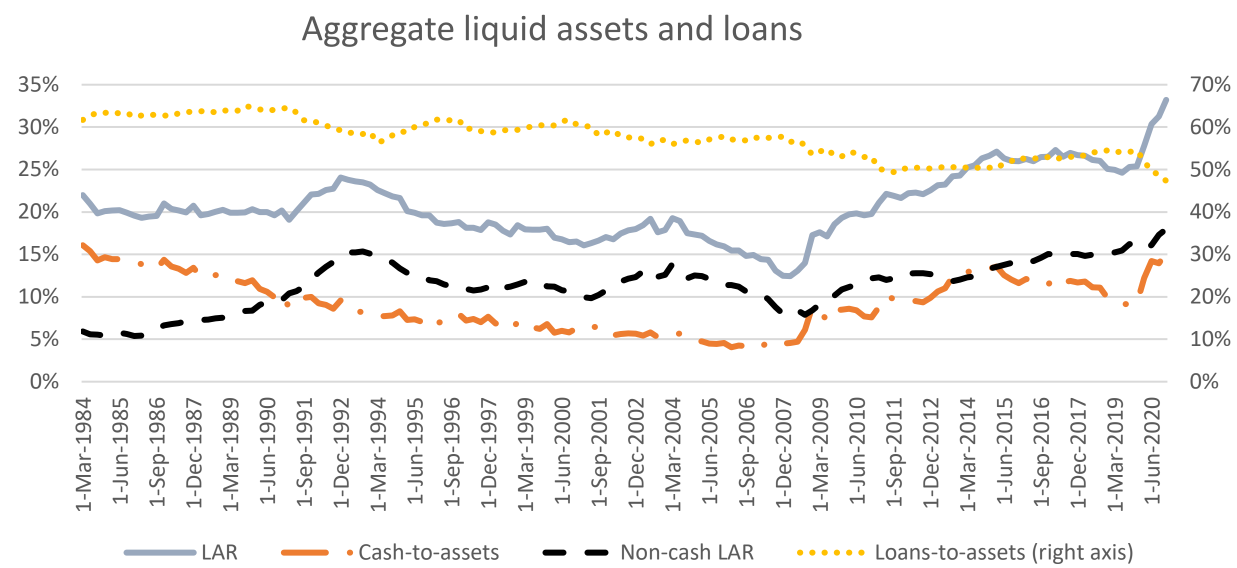


Figure 2. LAR by bank size

This figure shows the equally-weighted average liquid assets-to-assets ratio (*LAR*) by bank size. We use quarterly data. We group banks into four size groups: 1) Largest banks– with assets in excess of $250 billion dollars; 2) Large banks– with assets between $50 billion and $250 billion dollars; 3) Medium banks– with assets between $10 billion and $50 billion, and 4) Small banks– with assets between $2 billion and $10 billion. All amounts are in constant 2018 dollars. Liquid assets represent the sum of cash holdings and non-cash liquid assets. Cash holdings include vault cash, cash items in the process of collection, balances due from depository institutions, and balances due from Federal Reserve Banks. Non-cash liquid assets include US Treasuries, US government and government-sponsored agency obligations, and mortgage-backed securities issued or guaranteed by GNMA, FNMA, or FHLMC. We obtain the data from the quarterly Reports of Condition and Income "Call Reports" (Form FFIEC 031) from 1984-2020.

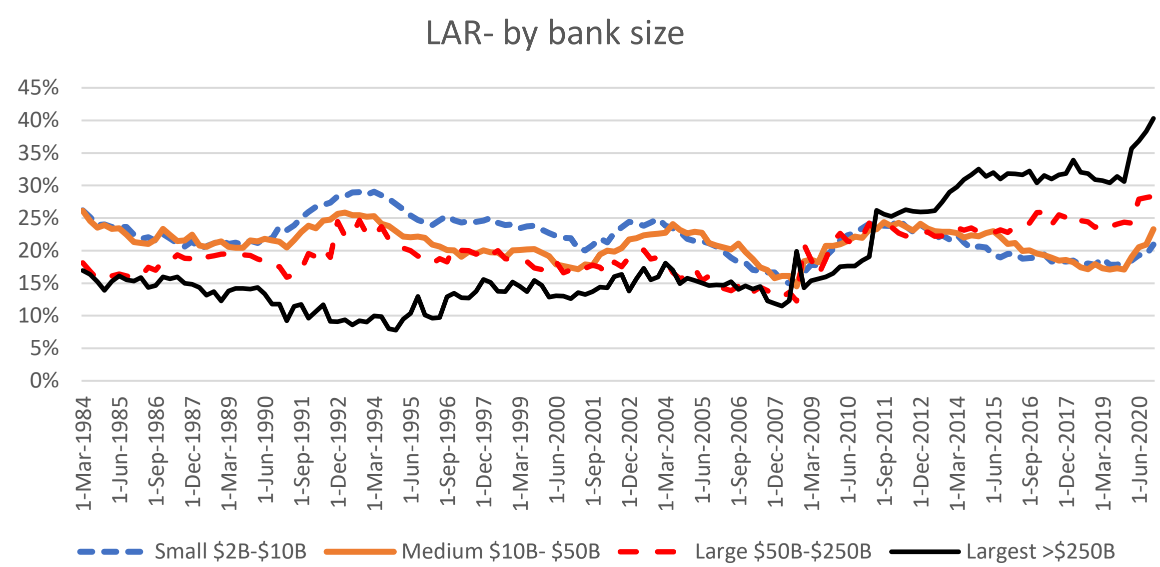
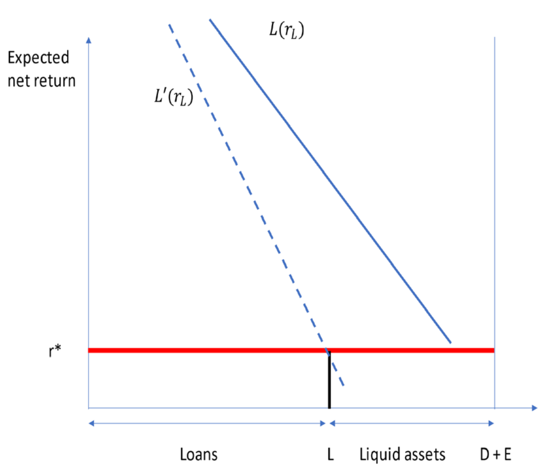


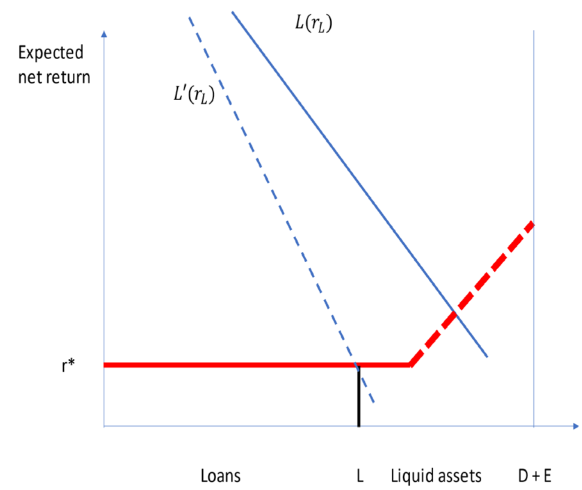
Figure 3. Equilibrium holdings of liquid assets

The size of the bank balance sheet is fixed at the sum of deposits (D) and equity (E). The market for loans is imperfectly competitive so that the demand for loans L(r_L) falls with the expected net return on loans r_L, i.e., L'(r_L) < 0. The bank sets the level of loans where the marginal revenue of loans, L'(r_L), equals the net expected return on liquid assets. The net expected return on liquid assets is equal to r^* when the marginal holdings of liquid assets have no risk management benefit, which is the continuous red line. The amount of loans is L. The amount of liquid assets is (D + E) – L. In Panel A, there is no risk management benefit of liquid assets. In Panel B, there is such a benefit. In Panel C, there is an exogenous increase in deposits. In Panel D, the liquidity requirement immobilizes an amount of liquid assets equal to (D+E) – LCR. Following the introduction of the LCR, the amount of liquid asset holdings increases from (D+E) – L to (D+E) – L*. The amount of loans falls from L to L*.

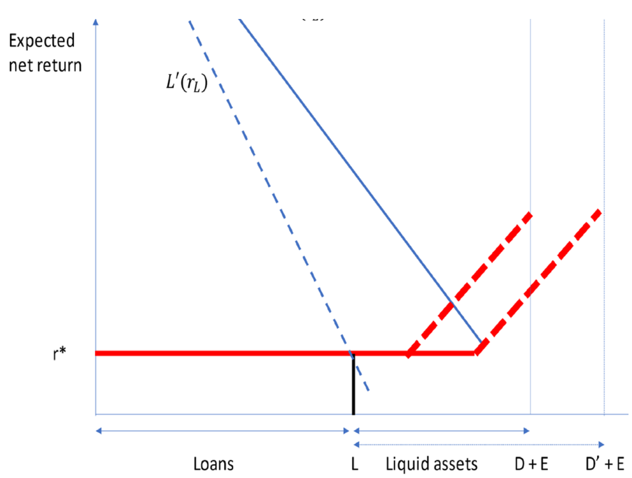
Panel A.



Panel B.



Panel C.



Panel D.

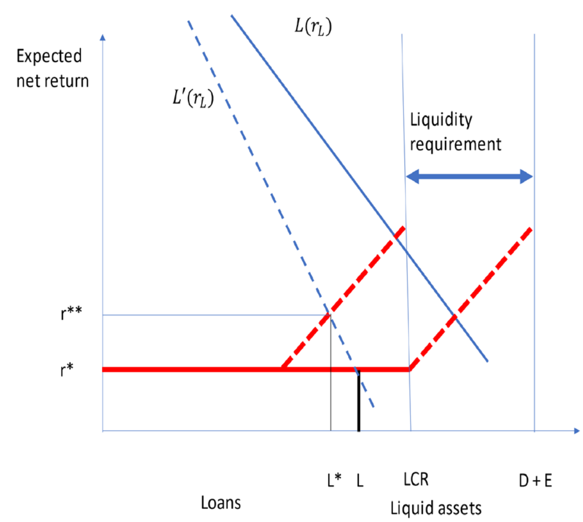


Figure 4. Cumulative growth in bank loans and deposits

This figure shows the cumulative real growth in aggregate bank loans and deposits during our sample period 1984-2020 using quarterly data. We first convert loan and deposit amounts into constant 2018 dollars (using the CPI deflator). We compute aggregate loans (deposits) by summing loans (deposits) for all banks in the sample each quarter. We then compute the cumulative growth rate in loans (deposits) since the start of the sample period (Q1 1984).

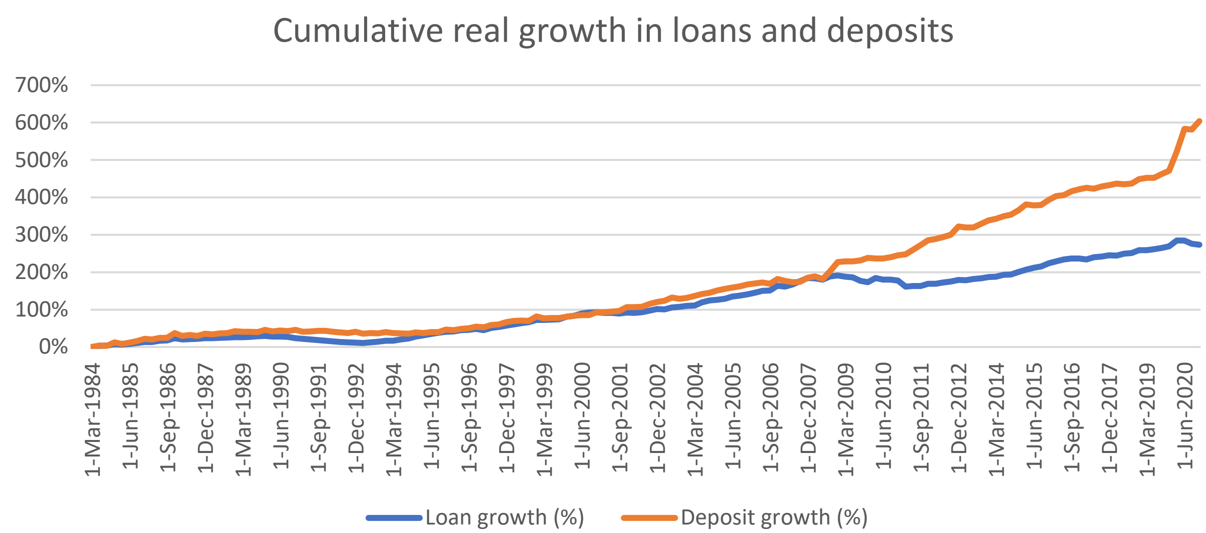
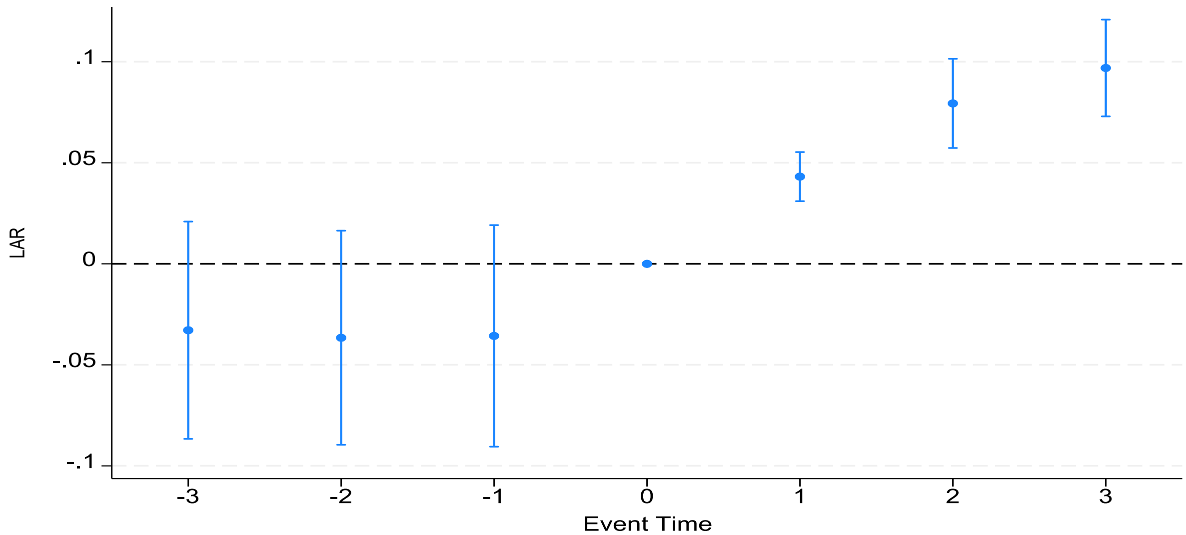


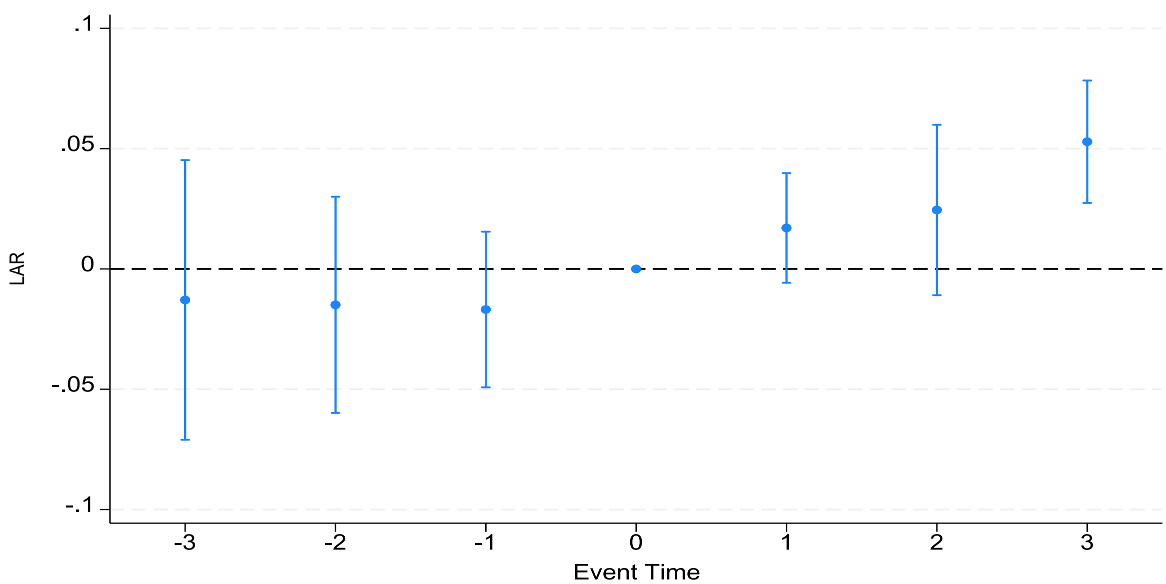
Figure 5. Tests of the parallel trends assumption.

This figure plots the coefficients on the interaction terms between the timing indicators (*year -3*,…, *year +3*) and indicators for our treatment groups: Largest (Panel A) and Large (Panel B) based on the Table 5 difference-in-differences regressions of LAR using quarterly data for the seven-year [*year -3, year +3*] window around the adoption of the LCR, where the treatment year (year 0) is 2013. Banks are ranked by size as of *year -1* (4^{th} quarter of 2012). We estimate regressions for the [*year -3*, *year +3*] window around the treatment year (*year 0*) of 2013. The control group includes banks with assets below <$50B. The sample of banks consists of US-chartered commercial banks with assets that exceed $2B billion (in constant 2018 dollars). We exclude trust banks and banks with foreign ownership, and we only include the largest entity within a multibank holding company. The solid dots represent the point estimates, and the lines represent the 95% confidence interval.

Panel A. Treatment group: Largest banks (>$250B)



Panel B. Treatment group: Large banks ($50B-$250B)



Appendix. Variable definitions

Variable name	Definition
Aggregate reserves	Total reserves of depository institutions (series TOTRESNS), scaled by total assets of commercial banks (TLAACBM027NBOG). Source: FRB St. Louis FRED database.
Cash holdings	Vault cash, cash items in the process of collection, balances due from depository institutions, and balances due from Federal Reserve Banks.
C&I loans-to-assets	Commercial and industrial loans scaled by total assets.
Default spread	Difference between Moody's seasoned Baa bond yield (series BAA) and Aaa (series AAA) corporate bond yield. Source: FRB St. Louis FRED database.
Demand deposits-to-assets	Total demand deposits scaled by total assets.
Deposits-to-assets	Total deposits scaled by total assets.
Deposit volatility	The standard deviation of deposits-to-assets over the prior four quarters.
Derivatives	Total fair value of interest rate, equity, foreign exchange, and commodity derivate contracts held for trading, scaled by total assets.
Dividend payout	Indicator equal to one if a firm (bank) pays a common dividend in the year and zero otherwise. Source: COMPUSTAT.
Equity-to-assets	Total book value of equity scaled by total assets.
Fed funds rate	Effective Federal Funds Rate (series FEDFUNDS). Source: FRB St. Louis FRED database.
HQLA-to-assets.	High quality liquid assets (HQLA), scaled by total assets. We estimate regulatory HQLA following Yankov (2020) using call report data.
Interest on excess reserves	Interest rate on excess reserves as determined by the Board of Governors (series IOER). Source: FRB St. Louis FRED database .
Large	Indicator variable for banks with assets greater than $50B (in constant 2018 US$).
Largest	Indicator variable for banks with assets greater than $250B (in constant 2018 US$) that are subject to the Liquidity Coverage Ratio (LCR) rule.
Large public banks	Publicly traded banks with assets greater than $10 billion in constant 2018 US$. We classify banks as public if stock price data are available for the bank or for its bank holding company. For public multibank holding companies, a public bank is the largest entity in the holding company structure.
LAR	Total liquid assets, scaled by total assets. Liquid assets represent the sum of cash holdings, US Treasuries, US government and government-sponsored agency obligations, and mortgage-backed securities issued or guaranteed by GNMA, FNMA, or FHLMC.
LCR	Liquidity coverage ratio, computed as HQLA, scaled by net cash outflows. We follow Hong et al. (2014) in constructing net cash outflows using the 2013 revised standards, and compute HQLA following Yankov (2020).
Leverage	Long-term debt plus debt in current liabilities scaled by total assets.
Loan growth	Average loan growth over the prior eight quarters.

Appendix. Variable definitions – continued

Variable name	Definition
Loans-to-assets	Loans scaled by total assets.
Log (assets)	Natural logarithm of total assets ($000s).
Net income-to-assets	Net income scaled by total assets.
Net loan growth	Growth rate of loans minus growth rate of deposits.
Non-cash liquid assets-to-assets	Non-cash liquid assets scaled by total assets. Non-cash liquid assets represent the sum of US Treasuries, US government and government-sponsored agency obligations, and mortgage-backed securities issued or guaranteed by GNMA, FNMA, or FHLMC.
Non-deposit liabilities-to-assets	Non-deposit liabilities, scaled by total assets. Non-deposit liabilities equal total liabilities minus total deposits.
ONRRP	Overnight reverse repurchase agreements (series RRPONTSYD). Source: FRB St. Louis FRED database.
Other banks	All banks with assets between $2B and $50B (constant 2018 US$).
Other deposits-to-assets	Total deposits minus demand deposits, scaled by total assets.
Other securities-to-assets	Other securities scaled by total assets. Other securities equal total securities minus liquid securities (non-cash liquid assets).
Personal loans-to-assets	Loans to individuals scaled by total assets.
RE loans-to-assets	Loans secured by real estate scaled by total assets.
ROA volatility	Standard deviation of return on assets (ROA) over the prior four quarters.
Small	Indicator variable for banks with assets between $2B and $10B (constant 2018 US$).
T-bill rate	3-month Treasury bill rate (series TB3MS). Source: FRB St. Louis FRED database.
Trading assets	Indicator variable equal to one for banks with trading assets as of the prior quarter-end.
Tier 1 capital ratio	Tier 1 capital scaled by risk-weighted assets.
Commitments-to-assets	Total unused commitments scaled by total assets, where unused commitments is the sum of unused commitments involving revolving open-end lines secured by 1-4 family residential properties, credit card lines, commitments to fund commercial real estate construction and development, securities underwriting, and other unused commitments.
US Treasuries	Sum of the amortized cost held-to-maturity US Treasury securities and the fair value of available for sale US Treasuries
Wholesale funding-to-assets	Sum of large time deposits, deposits booked in foreign offices, subordinated debt and debentures, gross fed funds purchased, repos, and other borrowed money, scaled by total assets.