LIQUIDITY RISK AT LARGE U.S. BANKS

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Abstract

This paper studies liquidity risk at the six largest U.S. banks. The starting point is the stress tests performed under the Liquidity Coverage Ratio (LCR) regulation, which compare a bank's liquid assets to its loss of cash in a stress scenario that regulators say is based on the 2008 financial crisis. These tests find that all of the large banks could endure a liquidity crisis for 30 days without running out of cash. This paper argues, however, that some of the assumptions in the LCR stress scenario are not pessimistic enough to capture what could happen in a crisis like 2008. The paper then proposes changes in the dubious assumptions and performs revised stress tests. For 2019 Q4, the revised tests suggest that all of the banks are at risk of running out of cash in less than 30 days. This negative finding is most clear-cut for Goldman Sachs and Morgan Stanley.

I. INTRODUCTION

The central events of the 2008 financial crisis were liquidity crises at large financial institutions. These firms lost the confidence of customers and counterparties, leading to losses of cash through withdrawals of deposits, cutoffs of short-term lending, and other channels. Lehman Brothers was forced into bankruptcy and Washington Mutual was closed by the FDIC. Other firms such as Bear Stearns were sold at distressed prices, and many survived only with extraordinary assistance from the Federal Reserve.

How great is the risk of similar crises in the future? Since 2008, financial institutions—which I will simply call "banks"—have increased their levels of capital and curbed some risky activities, in part because of new regulations. But such measures will never eliminate risk completely, and sooner or later some unexpected mishap will shake confidence in large banks. When that happens, will a flight of customers and counterparties again drain the banks of cash and threaten their survival? Or can banks weather such a crisis because of improvements in liquidity management or liquidity regulation?

Opinions on this question vary. Bankers say that liquidity risk has fallen greatly since 2008 because banks have increased their reserves of liquid assets (e.g., Bank Policy Institute, 2019). Skeptics point out that banks still have high levels of runnable liabilities, making them susceptible to sudden losses of cash (e.g., Johnson and Scott, 2019). The Treasury Department's Office of Financial Research (2019) rates banks' liquidity risk as "moderate."

This paper contributes to the debate by analyzing liquidity risk at specific banks. I examine the six largest U.S. banks: JPMorgan Chase, Bank of America, Citigroup, Wells Fargo, Goldman Sachs, and Morgan Stanley. I ask whether these firms could survive the kinds of liquidity crises that occurred in 2008.

My starting point is the fact that, since 2017, the six big banks have been subject to the Liquidity Coverage Ratio (LCR) regulation. This rule requires a bank to repeatedly perform a liquidity stress test. The bank must calculate its loss of cash in a 30-day stress scenario specified in the rule, a scenario that regulators say is based on the 2008 crisis. The bank must also calculate its holdings of "high quality liquid assets" (HQLA) that could be monetized quickly to accommodate cash outflows. A bank's LCR—the ratio of its HQLA to its loss of cash in the stress scenario—must be at least 100%.

The six big banks comply with the LCR rule. This fact implies that, if the rule's stress scenario captures what would happen in an actual liquidity crisis, the banks have enough liquid assets to continue their operations for 30 days. That period is a long time compared to the runs at Bear Stearns and Lehman Brothers, which wiped out those firms' cash in less than a week. With 30 days, a bank and its regulators would have a good chance of resolving a crisis in an orderly way.

This paper argues, however, that some of the LCR rule's assumptions are not pessimistic enough to capture what would happen in a crisis like 2008. A bank's losses of cash in a crisis would probably exceed its losses in the rule's stress scenario. Specifically, I argue that the LCR scenario understates three types of cash outflows: withdrawals of retail deposits; losses of secured funding such as repurchase agreements; and collateral calls under derivatives contracts. The scenario also *overstates* the level of cash inflows available to offset outflows.

These flaws in the stress scenario raise the possibility that, despite compliance with the LCR rule, the big banks might not have enough liquidity to cover their losses of cash in a crisis. To help assess this risk, I propose revisions of the rule's questionable assumptions that seem reasonable based on the 2008 experience and use them in alternative stress tests for the six banks. Lacking some relevant information, I cannot determine revised LCRs exactly, but I derive a range of possible

LCRs for each bank. I use data from the fourth quarter of 2019, before banking was disrupted by the pandemic.

My alternative stress scenario leads to LCRs that are substantially lower than those under the current rule. Based on official assumptions, the LCRs for the six banks vary from 115% to 134%. In contrast, for each of the six, the range for the revised LCR lies mostly or entirely below 100%, suggesting that liquidity crises could threaten the banks' survival. This finding is most clear for Goldman Sachs, whose range for the revised LCR is 65% to 88%, and Morgan Stanley, whose range is 68% to 83%.

The calculation of an LCR is a stress test, an inherently speculative exercise in imagining what might happen in unusual circumstances. The stress tests in this paper are even more speculative than most because I lack proprietary information that banks and regulators use in their tests. At some points I must rely on educated guesses about factors in my calculations, so the results are far from definitive about what would happen in a liquidity crisis. Nonetheless, I believe it is useful for a disinterested researcher to analyze liquidity risk as well as possible with public information. History teaches us that we should not uncritically accept the risk assessments of banks and regulators.

To be clear, this paper is not a normative analysis and I do not take a position on the policy issue of whether the LCR rule should be more stringent. The answer to that question depends on the costs of tighter regulation to banks and the economy, which I do not study, as well as the benefits. However, my analysis of liquidity risk can provide one input into a broader analysis of optimal policy.

The rest of this paper begins with overviews of liquidity risk at large banks and of the LCR rule. I then discuss the problematic parts of the rule, my proposed revisions, and the derivation of revised LCRs for the six banks.

II. MAJOR TYPES OF LIQUIDITY RISK

Each of the large banks is a financial holding company that makes investments and owns subsidiaries that operate various businesses. These subsidiaries include commercial banks that take deposits and make loans. They also include broker-dealers that serve as financial intermediaries, buying or borrowing securities from clients and selling or lending them to other clients. Some of the broker-dealer businesses include prime brokers serving large investors such as hedge funds, and some include retail brokers.

These businesses expose the banks to various types of liquidity risk. The following types were among the most important in 2008 and remain important today:

Deposit Runs

The four largest banks—JPMorgan Chase, Bank of America, Wells Fargo, and Citi—hold hundreds of billions of dollars of deposits from individuals, firms, and governments. Goldman Sachs and Morgan Stanley have deposit franchises that are smaller and more specialized but have grown since 2008.

Deposits expose banks to the most famous kind of liquidity risk: the risk of a run in which depositors start to question the safety of their money and make sudden large withdrawals.

The most famous liquidity crises of 2008—those at Lehman, Bear Stearns, and AIG—did not involve deposit runs. However, runs occurred at a number of banks when losses on mortgages shook confidence in their viability (Rose, 2015). The largest of these banks was Wachovia, which avoided failure when it was acquired by Wells Fargo. Runs led the FDIC to close at least a dozen banks, including Washington Mutual and Indy Mac.

Many of the deposits withdrawn in the 2008 runs were large ones that were not fully insured by the FDIC. However, there were also substantial withdrawals of insured deposits. Apparently, not all insured depositors were confident that they were protected if their banks failed. (See Section 4 for more on this point.)

<u>Losses of Repurchase Agreements</u>

Repurchase agreements, or repos, are an important source of funds for all the large banks. In a repo, a bank sells a security and agrees to buy it back a short time later at a slightly higher price. In economic terms, a repo is equivalent to a short-term loan of cash to the bank with the security as collateral. Banks' counterparties in repos are other financial institutions, predominantly money market mutual funds.

The securities that banks use for repos include both securities they own and securities they have received in transactions called reverse repos. In the latter case, a bank is an intermediary: it temporarily gives cash to one counterparty in exchange for a security (a reverse repo) and gives the security to another counterparty to recoup the cash (a repo).

The terms of repos are short—often overnight—but normally they are rolled over repeatedly and provide banks with a steady source of funds. Before 2008, banks and their regulators assumed that repos would roll over even for a bank in distress, because the bank's counterparties seemed to face little risk. Repos impose haircuts on collateral: the cash received by a bank is less than the value of the security it pledges. If the bank defaults on its obligation to return cash, the counterparty can make itself whole by seizing the security.

A major surprise in 2008 was that distressed banks abruptly lost repo funding—first Bear Stearns in March and then Lehman Brothers in September. When counterparties became worried that these firms might fail, they refused to roll over repos, returned collateral, and demanded the cash they had lent. It is not completely clear why this happened, but students of the episode suggest that the counterparties feared bad publicity from dealing with Bear and Lehman and that liquidating collateral would somehow be risky or subject them to litigation (see Duffie, 2011, and Ball, 2018). Whatever the reasons, losses of repos were the largest factors in Bear's and Lehman's liquidity crises.

Prime Broker Runs

Some of the large banks operate prime brokers that serve large investors such as hedge funds. These customers deposit cash and securities with the prime brokers and may receive margin loans to help them buy the securities. Customers also borrow securities from their prime brokers to make short sales, and post cash collateral. Some of the securities that prime brokers lend to customers belong to other customers.

A prime broker's customers are exposed to the bank that operates the prime broker. If the bank fails, customers may lose cash that they have deposited. They may also lose collateral they have posted—either securities posted for margin loans or cash posted to borrow securities. If that happens, the customers are disadvantaged because they are usually on the wrong side of haircuts: the collateral they stand to lose is greater in value than the cash or securities they have received from the prime broker.

Because of these risks, customers have strong incentives to flee a prime broker if they fear it will fail. They are likely to withdraw the cash and securities they have deposited and return borrowed securities to recover their cash collateral.

In such a run, customers' withdrawals of cash and the need to return cash collateral are liquidity drains for the bank. When customers withdraw securities, the direct effect on liquidity is positive, because the customers must return margin loans collateralized by the securities. However, as emphasized by Duffie (2013) and Infante and Vardoulakis (2019), these "collateral runs" end up reducing liquidity because the prime broker can no longer raise cash by lending the securities to other customers. This loss of cash exceeds the gain from returning the securities to their owners because of differences in haircuts.

In 2008, prime broker runs were significant factors in the crises at Bear Stearns, Lehman Brothers, and Morgan Stanley. Duffie (2013) reports that Morgan Stanley's prime broker lost $57 billion of cash from September 10 to September 22. The firm survived the loss only with massive support from the Fed's Primary Dealer Credit Facility (Ball, 2018, chapter 10).

Collateral Calls

Large banks are parties to derivatives contracts with notional values of many trillions of dollars. These contracts create liquidity risk because they require the posting of cash collateral under various circumstances that may arise in a financial crisis.

One trigger for collateral calls is a change in a bank's financial condition, such as a downgrades by rating agencies. Another is a change in the market value of a derivatives contract, which occurs when prices change for the securities referenced in the contract. If the value of a bank's derivatives position falls, which means the value of its counterparty's position rises, the bank must post collateral called "variation margin" to protect the counterparty from the risk that the bank will default on the contract.

A famous example from 2008 is the credit default swaps sold by AIG for mortgage-backed securities. As the prices of the MBSs fell, AIG received repeated collateral calls from the holders of the credit default swaps. This cash drain was a major factor in AIG's liquidity crisis and near-failure.

III. DEVELOPING A LIQUIDITY STRESS TEST

This section reviews the Liquidity Coverage Ratio rule and the stress test it requires banks to perform, and then introduces my approach to modifying the test.

An Overview of the LCR Rule

The LCR rule was adopted in 2014 by the Federal Reserve, the OCC, and the FDIC, and it became fully effective in 2017. The full rule is presented in the Federal Register (2014, pp. 61440-61541). Like many U.S. bank regulations, the rule is based on an international standard developed by the Basel Committee for Banking Supervision at the BIS.

The rule requires that a covered bank repeatedly perform a liquidity stress test. The bank must compute its cash outflows in a 30-day stress scenario, which include the liquidity drains discussed in Section 2 and others such as take-ups of loan commitments made by the bank. The scenario also includes offsetting inflows of cash, primarily from decreases in lending by the bank (including lending through reverse repos). A bank must compute outflows and inflows using assumptions specified in the rule, which regulators say are based on the 2008 crisis.

A bank must also calculate its holdings of "high quality liquid assets" (HQLA). The LCR rule specifies the assets that qualify as HQLA, the most common of which are deposits at the Federal Reserve, Treasury securities, and securities issued by government-sponsored enterprises. These assets must be unencumbered so the bank could monetize them in a crisis.

A bank's Liquidity Coverage Ratio is its HQLA divided by its net cash outflow (outflow minus inflow). The LCR must normally be 100% or higher, which means the bank could meet its cash obligations during a liquidity crisis for the 30 days covered by the stress scenario. The Basel Committee (2013a) says that, over these 30 days, "it is assumed that appropriate corrective actions can be taken by management and supervisors, or that the bank can be resolved in an orderly way."

In one significant way, the LCR calculation is conservative in assessing a bank's liquidity position: it ignores some feasible but extreme actions that the bank could take to raise cash, such as major sales from its inventory of securities or a major shrinkage of its derivatives book (which would return cash collateral for its contracts). Regulators have not said explicitly why such actions are assumed away, but a likely reason is that they would represent a significant unwinding of the bank's business. In the short run, such actions might backfire by signaling distress and thereby worsening the loss of confidence underlying a liquidity crisis. Even if the firm survived the crisis, its franchise would be badly damaged, and regulators want to avoid that outcome.[1]

Currently, the full LCR rule applies to only eight banks, the ones that regulators have designated as "globally systemically important banks" (G-SIBs). These banks are the six examined in this paper plus the two custody banks, BNY Mellon and State Street.

A G-SIB must compute its LCR every day. It is allowed to let the LCR drop below 100% temporarily if unusual liquidity stresses arise, but it must develop a plan to eliminate this shortfall with guidance from supervisors.

In practice, the LCR has never fallen below 100% for any covered bank. In the fourth quarter of 2019, the average LCRs at the six banks ranged from 115% at Citigroup to 134% at Morgan Stanley.

<u>The LCR Calculation and Disclosure</u>

The LCR rule includes many complex details, some of which we need to discuss before

[1] This interpretation was suggested by a referee, and it seems to be a common view that extreme actions to raise cash would be very costly. For example, in discussing asset sales in a crisis, Duffie (2011) says that banks eschew them because "even if they can sell enough assets to raise cash, market participants may make fatal inferences." Cohan (2009) reports that some Bear Stearns executives suggested asset sales during that firm's crisis but CEO Alan Schwartz rejected the idea because of "signaling risk."

considering revisions to the rule. To understand these points, it is helpful to examine the quarterly LCR disclosure that banks are required to publish. Figure 1 shows the disclosure for JPMorgan Chase for the fourth quarter of 2019.

Measuring HQLA: In defining HQLA, the LCR rule recognizes that assets are liquid to varying degrees. The rule defines HQLA as a weighted sum of different kinds of assets, with only the most liquid having the highest weight of one. Other assets have lower weights to capture the risk that not all of them could be monetized quickly.

Specifically, there are three classes of HQLA. Level 1 HQLA, which have a weight of one, include deposits at the Federal Reserve, Treasury securities, and the sovereign debt of some foreign countries. Level 2A HQLA, with a weight of 0.85, include some other sovereign debt and securities issued by government-sponsored enterprises such as Fannie Mae and Freddie Mac (aka agency securities). Level 2B HQLA, with a weight of 0.5, include equities in the Russell 1000 index and many investment-grade corporate and municipal bonds.[2]

Lines 1-4 of the LCR disclosure report a bank's calculation of its HQLA. In this part of the disclosure, the column labeled "Average Unweighted Amount" reports the bank's holdings of Levels 1, 2A, and 2B assets, and the simple sum of the three. All figures are averages of daily levels over a quarter. The column labeled "Average Weighted Amount" reports the three types of assets multiplied by their weights, and the weighted sum. The weighted sum is total HQLA in the numerator of the LCR.

[2] Municipal bonds were not included in HQLA when the LCR rule was adopted, but they were added through amendments in 2016 and 2019. The equities and bonds that count as Level 2B HQLA are limited in a number of ways. Securities are excluded, for example, if they are issued by financial institutions or if their prices are unusually volatile.

It is debatable whether the assets in the Level 2B category should be included in HQLA, even with a 0.5 weight. Experts on liquidity management suggest that equities and corporate and municipal bonds are not reliable sources of liquidity in a systemic crisis (e.g. Matz, 2011, pp. 256-262). This issue is not important in practice, however, because Level 2B assets are a very small part of the HQLA reported by the big banks. Level 2B assets are less than 0.1 percent of total HQLA at JPMorgan Chase.

An important nuance is that not all of the unencumbered HQLA owned by a bank is "eligible" for satisfying the LCR rule. The rule excludes some HQLA held by subsidiaries of the bank if these assets are not freely transferable to other parts of the enterprise for regulatory or other reasons. As we will see, this detail complicates my calculations of LCRs with revised outflow assumptions, because these assumptions affect the amounts of HQLA that are eligible.

Cash Outflows and Inflows: Lines 5-19 of the LCR disclosure summarize the cash outflows in the LCR stress scenario. Here, the numbers in the "Unweighted" column are exposures to losses of cash, such as levels of deposits that customers could withdraw or commitments by the bank to provide credit. The "Weighted" column reports the amounts of these possible losses that occur in the stress scenario. In most cases, the weighted amounts are determined by multiplying the unweighted exposures by assumed outflow rates, such as withdrawal rates for deposits and take-up rates for loan commitments.

The disclosure summarizes calculations based on a plethora of outflow rates. For example, the stress scenario includes outflow rates for deposits based on factors such as insurance coverage, the types of customers who hold deposits, the customers' other relationships with the bank, what deposits are used for, and whether deposits were placed with the bank by a broker. The outflow rates for deposits range from 3% to 100%. Most of the outflows reported in the disclosure are aggregates of items with different outflow rates.

One part of the disclosure that will be important below is Line 13, “Secured wholesale funding and asset exchange outflow.” Among the outflows included here are losses of repos and losses of cash collateral for securities loaned by the bank. Repos and securities loans have outflow rates ranging from zero to 100% depending primarily on the types of securities involved.

Cash inflows in the stress scenario are summarized in Lines 20-28. The calculation of inflows parallels the calculation of outflows: possible inflows in the Unweighted column are multiplied by inflow rates. For all the big banks, the largest category of inflows is “Secured lending and asset exchange inflow,” Line 20. This item is the mirror image of the secured-funding outflow on Line 13: it includes decreases in reverse repos and in loans of cash collateralized by securities.

<u>The LCR</u>: Lines 29-33 of the disclosure compute the LCR, which is the ratio of HQLA to net cash outflow. The level of HQLA is simply taken from Line 1, but the calculation of net cash outflow includes two wrinkles.

First, an initial level of net cash outflow, shown on Line 30, is computed as total outflows minus total inflows—but with the level of inflows capped at 75% of outflows. According to regulators, this cap is meant to ensure that banks are not “overly reliant on inflows that may not materialize in a stress scenario” (Federal Register, p. 61478). In practice, the cap does not affect LCR calculations for the big banks, because their inflows are less than 75% of outflows. However, the reasoning behind the cap will be relevant for my revision of the LCR rule.

Second, the initial level of net outflow is augmented by a “maturity mismatch” term to get the final level, shown on Line 32. The mismatch term accounts for the fact that the cash outflows reported on the disclosure may occur earlier within the 30-day stress period than the inflows. The term is calculated so that the final net cash outflow equals the highest net outflow on any day within the 30-day period.

A Critical Look at the LCR Calculation

A stress test is a sound approach to assessing liquidity risk, one that banks have long used in their internal risk management. However, the results of a test are credible only if its specific assumptions are reasonable. Is that true of the test prescribed by the LCR rule?

I will not question the measurement of HQLA in the numerator of the LCR. As noted above, almost all of the HQLA reported by the big banks are Level 1 and 2A assets such as deposits at the Fed and Treasury and agency securities. Clearly these assets are easy to monetize, even in a crisis like 2008.

In contrast, it is not at all clear whether the LCR rule's assumptions about cash outflows and inflows are reasonable. I therefore examine these assumptions as carefully as I can.

The assumptions of the U.S. LCR rule were taken with only minor changes from the rule proposed by the Basel Committee on Bank Supervision. Both the Basel Committee and U.S. regulators say the assumptions are based on the 2008 crisis. The Basel Committee (2013a) says: "The stress scenario specified incorporates many of the shocks experienced during the crisis that started in 2007 into one significant stress scenario." The Federal Reserve says that outflow rates "were calibrated based on historical data observed during the recent financial crisis" (Board of Governors, 2014).

Both the Basel Committee and U.S. regulators say their stress scenarios combine idiosyncratic shocks at a bank and market-wide shocks. U.S. regulators also say their calibration is based on "a substantial amount of supervisory data collected from U.S. financial institutions" (Board of Governors, 2014).

However, beyond these broad principles, regulators have said remarkably little to justify the specific assumptions of the LCR rule. For example, the many outflow rates for different types of deposits and secured funding are presented with almost no comment. Regulators do not cite relevant evidence, such as outflow rates in 2008.

There has also been little discussion of specific LCR assumptions by academic researchers. All I can find is a slide from a 2012 talk by Darrell Duffie, who cryptically questions several assumptions, including low outflow rates for some deposits and repos. Duffie also remarks that "other runoff ratios seem arbitrary or 'negotiated.'"

This paper tries to fill the gap in research and judge whether the LCR's outflow and inflow assumptions are reasonable. This task is challenging because I lack the supervisory information available to regulators, but I do my best using public information. Like regulators, I use the 2008 crisis as the primary basis for calibration.

Some of the assumptions in the LCR stress scenario appear reasonable. For some others, there is insufficient evidence to judge one way or the other. An example is outflows from take-ups of loan commitments, which are included on Line 16 of the LCR disclosure. Take-ups of commitments rose considerably in 2008 as banks' customers lost access to other financing (Ivashina and Scharfstein, 2010), but it is unclear how to calibrate an outflow rate for commitments. In such cases, I give the benefit of the doubt to the LCR regulation and leave its assumptions unchanged in my revised stress test.

In the end, there are clear reasons to doubt four parts of the LCR stress scenario. The scenario appears to understate the cash outflows in a crisis from losses of retail deposits (Lines 6 and 7 of the disclosure); from losses of secured funding (Line 13); and from collateral calls under derivatives contracts (Line 15). The scenario also overstates the offsetting cash inflows (Lines 20-28). All of these flaws contribute to an understatement of net cash outflow in the denominator of the LCR.

IV. LOSSES OF RETAIL DEPOSITS

This section examines the LCR rule's assumptions about outflows of retail deposits, and proposes revised assumptions. The analysis is based primarily on the 2008 run on Washington Mutual Bank.

The LCR Rule Assumptions

In specifying outflow rates for deposits, the LCR rule first distinguishes between deposits of retail and wholesale customers, where the former include all individuals plus businesses with deposits below $1.5 million. The deposits of retail customers are then split into three categories: "stable deposits," "other retail funding," and deposits placed at banks by brokers.

This paper questions the outflow rates for the "stable" and "other funding" parts of retail deposits, which are covered in Lines 6 and 7 of the LCR disclosure. I do not question the treatment of wholesale deposits or brokered retail deposits, for which assumed outflow rates are relatively high.

To be counted in the stable category, a retail deposit must be fully covered by FDIC insurance. It must also meet at least one of two other criteria: it is a "transactional" account such as a demand deposit or NOW account; or the depositor has "another established relationship with the bank," such as a second deposit account or a loan, which "would make deposit withdrawal highly unlikely during a liquidity stress event."

If a retail deposit does not qualify as stable and it was not placed by a broker, it is included in "other retail funding."

The LCR rule assumes a 3% outflow rate for stable retail deposits. The rate for other retail funding is generally 10%, with small exceptions that are not important for this analysis.[3]

The Run on Washington Mutual

As discussed in Section 2, a number of banks experienced deposit runs in 2008. Washington Mutual, or WaMu, is an interesting case because it was the sixth-largest U.S. bank by deposits and the largest ever closed by the FDIC. However, the principal reason for focusing on WaMu is data availability. Rose (2015) reports daily data on WaMu's retail deposits, which we can use to evaluate the LCR assumptions about retail deposits. Such data are not available for the other banks where runs occurred.[4]

The WaMu run is described by Rose and by Grind (2015). The run began on Monday September 8, when the bank's regulator, the Office of Thrift Supervision, announced an enforcement action involving mortgage underwriting. The run accelerated on September 15 when the Lehman Brothers failure caused panic throughout the financial system, and it ended when the FDIC seized WaMu on September 25. Throughout the episode there was heavy media coverage of WaMu's

[3] The outflow rate is 20% or 40% for "deposits placed at the bank by a third party on behalf of a retail customer that are not brokered deposits." Those deposits are a negligible part of the other retail funding category for the banks with major deposit franchises, a fact that is clear because the average outflow rate for the category is close to 10%. For example, for JPMorgan Chase in 2019 Q4, the average outflow rate for other retail funding (calculated from weighted and unweighted amounts on the LCR disclosure) is 10.4%.

[4] Focusing on WaMu would be questionable if its run stood out as more severe than others in 2008, but that does not appear to be the case. We can compare runs at different banks using information from Rose on total deposit outflows, including both retail and wholesale deposits. WaMu lost 10.1% of its total deposits over 16 days, which implies a 30-day outflow rate of 18.6%. Indy Mac's total deposit outflows were similar: 8.4% over 14 days, for a 30-day rate of 17.6%. Wachovia's run was ended by the Wells Fargo acquisition after a loss of only 2.4% of deposits over eight days. However, an FDIC analysis during the run suggested that deposit outflows could accelerate to 1.5% per day, a 30-day rate of 36%, if Wachovia were not acquired (FDIC, 2008).

predicament, rumors that the bank might fail, and lines of panicked customers at WaMu's branches.

As one would expect, there were heavy withdrawals of deposits that exceeded the FDIC insurance limit (then $100,000), but there were also substantial withdrawals of fully-insured deposits. Grind reports that many depositors did not know about insurance or did not trust that it kept their money safe. WaMu employees tried to explain deposit insurance to worried customers, but many replied with sentiments like "We just don't want to deal with it."[5]

Rose's data on WaMu's retail deposits come from a declaration in a court case concerning the bank's failure. This document reports daily deposits by "individuals and small businesses," and it excludes brokered deposits. These data appear comparable to the sum of "stable retail deposits" and "other retail funding" as defined in the LCR rule.[6]

The reported level of deposits was $141.1 billion on September 8, the start of WaMu's run. Deposits fell to $139.5 billion on September 12, the last business day before the Lehman bankruptcy, and then $124.6 billion on September 25 when the FDIC seized the bank. The loss of deposits over the 17 days from September 8 to September 25 was $16.5 billion, or 11.7% of the September 8 level.

These deposit losses were more severe than those assumed in the LCR stress scenario. The

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[5] From August 29 to September 19, WaMu lost $5.7 billion of less-than-fully-insured retail deposits and $7.2 billion of fully-insured retail deposits (based on total deposits from Blake [2008] and less-than-fully-insured deposits from an internal WaMu memo [Discussion Materials, 2008]). We do not have this breakdown for the period from September 8 to 25.

[6] The court case is the bankruptcy proceeding for Washington Mutual Inc., the holding company that owned Washington Mutual Bank. The data on retail deposits appear in a declaration by an expert witness (Blake, 2009). The declaration does not say whether the series includes brokered deposits, but we can tell that it does not by comparing the declaration to other sources on WaMu's deposits. Specifically, it is clear from comparing numbers that retail deposits are defined the same way in the declaration, in the "Discussion Materials" memo from WaMu, and in WaMu's 10-Qs for 2008 Q1 and Q2. The 10-Qs explicitly put brokered deposits in a separate category from retail deposits.

scenario assumes outflows of 3% of stable retail deposits and 10% of other retail funding over 30 days. If the two types of deposits are aggregated, as they are in the WaMu data, the outflow rate should be somewhere between 3% and 10% over 30 days. In WaMu's actual experience, it lost a larger percentage of deposits (11.7%) over a shorter period (17 days).

A 30-Day Outflow Rate

To revise the LCR rule, we need to calibrate deposit outflows over the rule's 30-day stress period. WaMu's run was terminated after 17 days because the FDIC closed the bank. To use the WaMu experience, we need an assumption about what would have happened if the FDIC had not acted and the run had followed its course for another 13 days.

There are, of course, different possibilities. At the time of its closure, WaMu was seeking new sources of funds and trying to reassure the public about its health. If these efforts succeeded, deposit withdrawals might have slowed after September 25. On the other hand, with continuing media coverage of the run and bad news about the broader financial crisis, confidence in WaMu might have continued to fall, causing withdrawals to accelerate.

Given the range of possibilities, I make a natural intermediate assumption: if WaMu had not been closed, its run would have continued at the same pace as before. More precisely, the daily rate of deposit outflow after September 25 would have equaled the average daily rate from September 8 to September 25.

WaMu lost 11.7% of its retail deposits from September 8 to 25, which implies a daily outflow rate of $1 - (1 - 0.117)^{1/17} = 0.729\%$. If the bank had experienced that daily outflow over 30 days, its total loss would have been $1 - (1 - 0.00729)^{30} = 19.7\%$. I will use 19.7% as the 30-day outflow rate for WaMu's retail deposits.

Outflow Rates for Stable and Other Retail Deposits

The 19.7% figure is an outflow rate for a mixture of stable and other retail deposits as defined in the LCR rule. To revise the rule, we need separate outflow rates for the two types of deposits. The daily data on WaMu's deposits are not broken down that way, but I estimate the two rates as follows:

I first estimate the fraction of WaMu's retail deposits that fell in each category at the start of its run. These estimates are based on a breakdown of WaMu's deposits in its 10-Q for the second quarter of 2008, and they are imprecise because of the timing of the data and because the categories of deposits in the 10-Q differ from those in the LCR rule. The Appendix describes the details of my calculation. The end result is an estimate that 32% of WaMu's retail deposits fell in the stable category and 68% in the other category.

This estimate and the 19.7% estimate for WaMu's average outflow rate allow us to pin down a linear combination of the two individual outflow rates. The average of the two rates, weighted by the fractions of initial deposits in each category, must equal 19.7%:

$$(0.32)r^s + (0.68)r^o = 19.7\% ,$$

where r^s and r^o are the outflow rates for stable and other retail deposits.

We need one more assumption to determine the two rates. An assumption that seems plausible is that the ratio of r^o to r^s is 10/3, the ratio of the 10% and 3% rates assumed in the LCR rule:

$$r^o/r^s = 10/3 .$$

This assumption means the rule is correct about the relative severity of liquidity risk from stable and other deposits. Compared to the WaMu episode, the rule understates the two outflow rates by the same proportion.

We now have two equations in r^s and r^o, which together yield $r^s = 7.6\%$ and $r^o = 25.4\%$. I round off these numbers to $r^s = 7.5\%$ and $r^o = 25.0\%$. Each of these outflow rates is 2.5 times the corresponding rate in the LCR rule. I use these rates when I calculate revised LCRs for the six big banks.

V. LOSSES OF SECURED FUNDING

This section considers the LCR rule's assumptions about secured funding. This term refers to any transaction in which a bank has temporarily received cash in exchange for securities, and it includes repurchase agreements and loans of securities against cash collateral. Once again, I compare the LCR stress scenario to experiences in 2008, the most relevant of which are those of Bear Stearns, Lehman Brothers, and Morgan Stanley.

The LCR Rule Assumptions

A bank's repos and security loans have different types of counterparties with different motives for giving cash to the bank, and one might think they create different liquidity risks. In most cases, however, the LCR rule treats different types of secured funding as equivalent transactions. One important exception is discussed below.

Secured funding is covered in Line 13 of the LCR disclosure. The unweighted column reports a bank's total amount of secured funding that matures within 30 days, which means the bank will have to return cash during the stress period unless the funding is rolled over. The weighted column is calculated by applying a range of outflow rates to different components of total funding. An outflow rate is the fraction of funding that does not roll over in the stress scenario.[7]

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[7] In addition to repos and securities loans, Line 13 includes less common types of secured funding such as collateralized deposits. It also includes asset exchanges, transactions in which a bank pledges securities to obtain more liquid securities rather than cash. The LCR rule includes cash outflow rates for various types of asset exchanges, which I do not question (see Appendix for details).

The primary factor that determines the assumed outflow rate for a secured funding transaction is the liquidity of the security involved—the security that a bank has posted to a repo counterparty or lent to a customer. The LCR rule refers to this security as the "collateral" in the transaction, and I will use that terminology in what follows. (This can be confusing in the case of security loans, because elsewhere the term "collateral" is used for the cash posted by customers who borrow securities.)

The LCR rule assumes that secured funding with liquid collateral is more likely to berolled over, and therefore produces lower cash outflows, than funding with less liquid collateral. As discussed below, this basic idea is consistent with banks' experiences in 2008. Counterparties were more willing to roll repos with liquid collateral because they were less fearful of losses if a bank defaulted and they needed to seize and sell the collateral.

The rule distinguishes among collateral with varying degrees of liquidity using the categories that are also used to determine High Quality Liquid Assets in the numerator of the LCR. The rule assumes a 0% outflow rate for secured funding with collateral that is Level 1 HQLA, which means all of this funding is rolled over. Outflow rates become higher as collateral becomes less liquid: they are 15% for collateral that is Level 2A HQLA, 50% for Level 2B, and 100% for collateral that is not HQLA of any type.

I do not question the low outflow rates for secured funding with Level 1 collateral (such as Treasury securities) and Level 2A collateral (such as agency securities). I also do not question the 100% outflow rate for non-HQLA collateral, which is obviously the most pessimistic possible assumption. I will, however, question the 50% rate for the in-between category of Level 2B HQLA, and argue that 100% is more realistic for this category as well as for non-HQLA collateral. This detail is important because the big banks have large amounts of secured funding with Level 2B collateral.

There is one other important nuance in the LCR assumptions about secured funding. Although the outflow rate is usually 100% for non-HQLA collateral, the rule makes an exception for some loans of non-HQLA securities. The outflow rate is only 50% if the loans are made to effect customers' short positions and the securities belong to other customers of the bank. The special treatment of these transactions is a second assumption about secured funding that I question.[8]

The Outflow Rate for Level 2B Funding

Level 2B HQLA include Russell 1000 equities and many investment-grade bonds issued by corporations and municipalities. The LCR stress scenario assumes that a bank loses 50% of funding with this type of collateral but retains the other 50%. Here I argue that this assumption is clearly overoptimistic for repos and questionable for securities loans, although there is less evidence about the latter. All in all, a 100% outflow rate for Level 2B funding is more reasonable than a 50% rate.

Level 2B Repos: We have lots of information on losses of repos in the Lehman Brothers and Bear Stearns crises. These firms completely lost the ability to roll over repos with any collateral besides Treasury and agency securities. This happened suddenly: at both Lehman and Bear, previously stable repo funding collapsed in less than a week, a far shorter period than the 30 days covered by the LCR stress test.

Ball (2018, chapter 5) describes the collapse of Lehman's repo funding in September 2008. Lehman's repo collateral included about $100 billion of non-Treasury/agency securities, of which a large part was investment-grade bonds and major-index equities that would probably be categorized as Level 2B HQLA under the LCR rule. Repo funding was stable until Tuesday

[8] The LCR treatment of secured funding also includes details that I ignore, such as special outflow rates for some collateralized deposits and for transactions with a government or government-sponsored enterprise.

September 9, when bad news including a disappointing earnings announcement triggered a collapse of confidence in Lehman and repo counterparties began to flee. Over the weekend of September 13-14, consultants advising Lehman suggested that no non-Treasury/agency repos would roll over during the week of September 15, and that expectation was a major reason for Lehman's bankruptcy filing.

Journalist Kate Kelly (2009) gives a detailed account of Bear Stearns's crisis in March 2008, and policymakers such as Cox (2009) and Dudley (2009) give overviews. Dudley's summary is that "Bear Stearns saw a complete loss of its short-term secured funding virtually overnight." As a result, the firm's liquidity pool, which had been stable, dropped from $18 billion on March 10 to $2 billion on March 13, when Bear notified regulators that it would be "unable to operate normally" on the next day and received an emergency loan from the Fed.

By the ends of the Lehman and Bear crises, these firms even had trouble rolling over repos collateralized by Treasury and agency securities—the securities that the LCR rule classifies as Level 1 and 2A HQLA. This development was surprising because it appears essentially riskless to lend cash against Treasuries and agencies. SEC Chair Cox's discussion of Bear's crisis emphasizes its loss of Treasury and agency repos, and Kelly gives examples, such as a refusal by Fidelity Investments to accept Treasury collateral on March 14.

When Bear and Lehman lost repos with Treasury and agency collateral, they were able to replace them (but not other repos) with General Collateral Finance (GCF) repos. GCF repos are arranged anonymously through a clearinghouse, so they remain available to a bank even if it experiences a run. Because of this back-up market, Treasury and agency repos create much less liquidity risk than repos with other collateral. But Bear's and Lehman's difficulties in rolling these repos are nonetheless relevant: they reinforce the point that a distressed bank is unlikely to roll any repos with less liquid collateral, including Level 2B HQLA.[9]

Loans of Level 2B Securities: In addition to repos, a bank's secured funding includes the cash collateral posted by prime broker customers when they borrow securities from the bank. This kind of cash also flows out of a bank when its customers lose confidence. This occurs as customers (like repo counterparties) return securities and demand their cash. In addition, as discussed in section 2, the banks experience collateral runs: they are forced to terminate loans of rehypothecated securities and return cash because the owners of the securities withdraw them.

Bear, Lehman, and Morgan Stanley all experienced sharp contractions in securities lending during their crises. Over Lehman's last three business days, the value of securities lent for customer short positions fell from $34.4 billion to $24.3 billion, a drop of 29% (Lowitt and Tonucci, 2008). Extrapolating that experience yields a 30-day outflow rate of 97%.

Unfortunately, we do not have data on securities loans broken down by collateral type, so we cannot be sure what fraction of Level 2B loans were lost during the 2008 crises. It seems natural, however, to assume that the outflow rate for Level 2B securities loans is the same as the outflow rate for Level 2B repos, because the LCR rule usually assumes that the two kinds of funding have the same liquidity risk for given collateral. Since there is a strong case for raising the outflow rate from 50% to 100% for Level 2B repos, it seems natural to raise it to 100% for Level 2B securities loans as well.

A referee points out a reason that a bank might lose securities loans less quickly than repos:

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[9] A referee points out that the ability to pledge securities to a clearinghouse may not eliminate liquidity risk completely because the clearinghouse may raise haircuts or limit the quantity of securities it will accept. For agency securities, the LCR rule appears to amply account for such risk with a 15% haircut. For Treasuries it does not, because there is no haircut. I doubt that Treasury repos create significant liquidity risk, but to the extent they do, my revisions of the LCR rule are conservative and could understate true liquidity risk.

customers who borrow specific securities from the bank may find it difficult to borrow the securities elsewhere, whereas repo lenders can easily lend their cash to another bank. However, there is also a reason to think that securities loans might disappear *faster* than repos, involving haircuts in the two types of transactions. In a repo, the value of the security pledged by a bank exceeds the cash it receives, and this overcollateralization reduces counterparties' incentives to terminate repos during a crisis. In a security loan, by contrast, the cash posted to the bank by the borrower usually exceeds the value of the security, so the borrower suffers a loss if the bank fails to unwind the transaction. This risk gives customers of a distressed bank a strong incentive to return borrowed securities and demand cash.

All in all, it seems dubious to assume that a bank can maintain a substantial fraction of its securities loans for any type of security except Treasuries and agencies. (In the case of Treasuries and agencies, even if customers terminate securities loans the bank can recoup the cash it loses by pledging the securities in GCF repos.)[10]

The Special Treatment of Loans of Customers' Securities

Here I question an arcane detail of the LCR rule's assumptions about secured funding with non-HQLA collateral. A 100% outflow rate applies to most funding with this type of collateral, including a bank's loans of non-HQLA securities to effect customer short positions when the bank owns the securities. However, the outflow rate is only 50% for the same type of securities loans when the securities are owned by other customers of the bank– that is, when the bank rehypothecates non-HQLA securities that customers have deposited in prime broker accounts or posted as collateral

[10] In a prime broker run, customers withdraw unencumbered cash deposits from their brokerage accounts as well as demanding the return of cash they posted for securities loans. The LCR rule assumes a 100% outflow rate for most brokerage deposits, so the treatment of this item is not overly optimistic and I do not change it in my revised stress scenario.

for margin loans.

These assumptions do not make sense. A bank's securities loans create liquidity risk because borrowers may return the securities and demand cash that they posted in the transaction. That is likely to happen if customers lose confidence in the bank's viability. There is no apparent reason that this risk should differ depending on who owns the securities. Indeed, customers who borrow securities are unlikely even to know whether the securities are part of a bank's inventory or come from other customers.

There is actually a reason to think that loans of customers' securities expose a bank to *more* liquidity risk than loans of its own securities, not less as the LCR rule assumes. The reason is the risk of collateral runs: the owners of securities lent by the bank may demand the securities back, which would force the bank to stop lending them and return cash to borrowers. There is no such risk when the bank lends its own securities. The risk of collateral runs is separate from the risk that borrowers of securities choose to return them and demand cash, the risk for which the ownership of the securities seems irrelevant.[11]

In the discussion of the LCR rule in the Federal Register (p. 61507), regulators report that commentators on the rule criticized the inconsistent treatment of securities loans with non-HQLA collateral. The commentators argued, as I do, that "the source of the collateral covering the customer short position is irrelevant" to the risk that borrowers will return the collateral. They say that the outflow rate should be the same for all loans of non-HQLA securities.

[11] Regulators discuss the 50% outflow rate examined here in the Federal Register (2014, p. 61507). The justification for the assumption is difficult to understand, but it appears to rest on symmetry with the 50% cash inflow rate assumed for margin loans secured with non-HQLA collateral. Section 7 of this paper criticizes assumptions of symmetry between cash outflows and inflows.

The commentators—which are presumably banks seeking a less stringent regulation—say that the 50% outflow rate for some loans of non-HQLA securities should be extended to other loans of these securities, which have a 100% rate under the current rule. But that change, while making the rule more internally consistent, would not be prudent. The 2008 experience suggests a 100% outflow rate for securities loans even for collateral in the relatively liquid category of Level 2B HQLA. It follows that the outflow rate should also be 100% for all non-HQLA collateral, regardless of the source of the collateral.

VI. DERIVATIVES VALUATION CHANGES[12]

Derivatives contracts include a variety of provisions concerning cash collateral. When a bank enters a contract, it must post "initial margin" to guarantee its performance, and after that the bank's counterparties can demand additional collateral in certain circumstances. The bank must post "variation margin" if the value of a contract decreases, which can happen when prices change for the underlying assets referenced in the contract. Other triggers for collateral calls include rating downgrades of the bank and changes in the value of non-cash collateral that the bank has previously posted.

The LCR stress scenario includes cash outflows from several types of collateral calls. Many of the assumptions about these outflows are difficult to evaluate, but one is clearly problematic: the assumption about variation margin.

The Dubious Assumption About Variation Margin

A bank must post variation margin when the fair value of a derivatives contract becomes

[12] The problem with the LCR rule that this section discusses was pointed out to me by an economist at a regulatory agency.

negative for the bank and positive for its counterparty. The new collateral protects the counterparty from loss if the bank defaults on the contract. A famous example is the collateral calls on AIG's credit default swaps in 2008. These calls were triggered by declines in the values of AIG's CDS positions due to falling prices for the mortgage-backed securities that AIG guaranteed.

In the LCR stress scenario, cash outflows from variation margin are determined in a different way from most outflows. The calibration is *not* based on the liquidity crises of 2008. Instead, each bank's calibration is based on its own experience in the recent past.

Specifically, the rule requires a bank to look back over the previous 24 months. For every 30-day period within that time span, the bank must compute its net cash outflow due to derivatives valuation changes: collateral it must post due to decreases in derivatives values minus collateral it receives from counterparties due to increases in values. The outflow from valuation changes in the LCR stress scenario is the highest absolute value of the bank's net outflow in any of the 30-day periods.

When regulators published the final LCR rule, they gave a cryptic explanation for the treatment of variation margin: "The historical experience of the covered company with its derivatives portfolio should be a reasonable proxy for potential derivative valuation changes" (Federal Register, 2014, p. 61490).

Historical experience is a reasonable basis for calibrating the LCR stress scenario, but the 24-month look-back period seems inappropriate. It means that the assumed outflows of variation margin are based entirely on *recent* history, which often will be a tranquil period in financial markets. Outflows in a financial crisis could be much larger than any 30-day outflow in the previous 24 months. A crisis typically causes volatility in asset prices, interest rates, and credit spreads, which in turn implies volatility in the values of derivatives that reference these variables and greater demands for variation margin than banks normally face.

We do not have data on variation margin in the 2008 crisis, but we can examine the volatility of the variables that determine derivatives values. One prominent spread is the difference between the yields on BAA corporate bonds and ten-year Treasuries. Over 2018-2019—the 24 month look-back period for the 2019Q4 LCRs that I examine—the largest 30-day change in this spread was 0.35 percentage points. During 2008, the largest 30-day change was more than five times as big at 1.83 percentage points (from September 21 to October 21).

The 24-month look-back period in the LCR rule is especially puzzling in light of other regulation of derivatives. In 2015, U.S. regulators adopted a Basel Committee proposal concerning the initial margin that banks must post when they enter derivatives contracts. The Basel Committee (2013b) says that initial margin must protect counterparties against exposures in an "extreme but plausible" scenario with a one percent chance of occurring. It also says that calibration of the scenario should be "based on historical data that incorporates a period of significant financial stress… to ensure that sufficient margin will be available when it is most needed." This approach seems more prudent than calibration based on the last 24 months.

Revising the Assumption

While it is clear that the LCR treatment of variation margin is unsatisfactory, it is not clear how the treatment should be changed or how much difference it makes for cash outflows at the big banks. For each bank, we would like to know (i) the outflows due to variation margin that it currently reports and (ii) the outflows in a more reasonable stress scenario. The difference between these numbers would tell us how much the LCR rule understates outflows. Unfortunately, there are two problems.

First, we do not know the outflows from variation margin that banks currently report. These outflows are included in Line 15 of the LCR disclosure, "Outflow related to derivative exposures and other collateral requirements." But this line also includes other kinds of collateral calls, such as those triggered by rating downgrades, plus non-contingent payments due under derivatives contracts.

Second, not much evidence is available on banks' postings of variation margin during financial crises. I have found nothing, for example, for investment banks in 2008. The one well documented case is the AIG crisis, for which the Financial Crisis Inquiry Commission (2011) reports data, but its relevance is unclear because AIG had a one-sided position in mortgage CDS that is uncharacteristic of banks' derivatives positions.

In this situation, the best one can do is to calibrate derivatives-related outflows with an assumption that seems plausible given available information–admittedly, a subjective exercise. In my revision of the LCR stress scenario, I simply double the outflows reported on Line 15 of the disclosure. That is, I assume that derivatives-related outflows in a crisis are 100% higher than the levels calculated under the official LCR rule.

To interpret this assumption, suppose that half of the outflows that are currently reported on Line 15 are due to variation margin. In this case, raising the total amount on Line 15 by 100% is equivalent to raising outflows from variation margin by 200%. These outflows are three times as large in the revised stress scenario as they are under the LCR calculation based on 24 months. Tripling these outflows is arguably a cautious adjustment in light of the much greater volatility in credit spreads in 2008 than in the lookback period of 2018-19.

As detailed below, my doubling of Line 15 adds amounts ranging from $9 billion to $40 billion to the cash outflows in stress tests for the big banks. The average is $29 billion. For what it is worth, in the summer and fall of 2008, AIG had to post $35 billion in variation margin on its CDS contracts, and more was expected until the Fed created Maiden Lane III in November (FCIC, 2011). That entity paid an additional $27 billion on one day to purchase the securities referenced in the CDSs and terminate the CDSs. These numbers are the same order of magnitude as the additional variation margin implied by my revised stress assumption, suggesting that the assumption captures something that could happen to a large financial institution.

VII. INFLOWS IN THE LCR CALCULATION

So far this paper has argued that the LCR stress scenario understates the cash outflows that are likely in a liquidity crisis. This section argues that the scenario also *overstates* the cash inflows available to offset outflows.

For all the big banks, the largest category of inflows is "secured lending and asset exchanges," Line 20 of the LCR disclosure. I argue that the treatment of this item is inconsistent with both the 2008 experience and basic principles of liquidity management. I also suggest reasons that other types of inflows may be overstated, and propose an adjustment to total inflows to account for all of these problems.

The LCR Rule's Treatment of Secured Lending

We have previously discussed secured funding, transactions in which a bank temporarily receives cash in exchange for securities. Secured lending is the opposite: the bank temporarily provides cash to a counterparty and receives securities as collateral. The main types of secured lending are reverse repurchase agreements and margin loans that help finance customers' purchases of securities.

The LCR stress scenario assumes that part of a bank's secured lending with maturities of 30 days or less does not roll over. That creates a cash inflow, just as an outflow occurs when secured funding does not roll over.

The specific LCR assumptions about secured lending are symmetric to the assumptions about secured funding. In particular, the inflow rate for a secured lending transaction is usually the same as the outflow rate for secured funding with the same collateral. The inflow rate is zero when the collateral held by the bank is Level 1 HQLA, 15% for Level 2A, 50% for Level 2B, and 100% for collateral that is not HQLA.

Like many parts of the LCR rule, the assumptions about secured lending are rarely discussed. Regulators apparently believe that a bank facing a crisis will treat counterparties to which it lends cash in the same way as it is treated by counterparties that provide it with cash. In particular, the bank will terminate large fractions of its lending against Level 2B and non-HQLA collateral. However, no rationale for this idea appears in official discussions of the LCR rule such as the Federal Register (2014) and Basel Committee (2013a).

Regulators' thinking may reflect the fact that much of banks' secured funding involves rehypothecation of collateral they receive through secured lending. Fed Governor Stein discussed this case in a 2013 speech:

> If a dealer borrows on a collateralized basis with repo and then turns around and lends the proceeds to a hedge fund in a similar fashion, the LCR deems the dealer to have no net liquidity exposure—and hence imposes no incremental liquidity requirement.

Stein is pointing out that, in the LCR stress scenario, the cash inflow associated with the loan to the hedge fund equals the outflow associated with the repo, because the collateral in the two transactions is the same. There is no effect on net cash outflow or the required level of HQLA. Stein continues:

> The implicit logic is that as long as the dealer can generate the necessary cash by not rolling over its loan to the hedge fund, it will always be able to handle any outflows of funding that come from being unable to roll over its own borrowing.[13]

[13] Stein goes on to criticize this part of the LCR rule based on externalities: if a bank generates cash by reducing its lending, it causes liquidity stress for its customers. This effect is outside the scope of my analysis.

Critiques of the Symmetry Assumption

The LCR's symmetric treatment of secured funding and lending conflicts with widely-accepted principles of liquidity management. Experts on the subject say that a bank facing a crisis could offset losses of funding by reducing its lending, but that the bank has strong incentives not to do so because of reputational costs. A decrease in lending would be a signal of distress that worsens the run on the bank. In addition, even if the bank survives, its action would damage customer relationships and reduce the value of its franchise.

These ideas appear, for example, in a book on liquidity management by consultants from PricewaterhouseCoopers (Venkat and Baird, 2016, pp. 131-132). These authors warn:

> [A] suspension of activities, such as reverse repo or other customer funding operations, could be perceived as signs of distress. These contingent actions may be necessary during the later stages of a crisis; however, at earlier stages, perceived signals of weakness may actually precipitate a liquidity crunch for the institution.

The authors also warn that a cutoff of lending will drive away customers "who believe that the institution has spurned their business."

Matz (2011, pp. 35-36) says that one failure of liquidity management in 2008 was that banks did not understand the asymmetry between secured funding and lending. They "underestimated or ignored the need to extend credit in order to avoid reputational threats." In the same vein, the international Senior Supervisors Group (2009) reports that "asymmetrical unwinding of client positions was a material drain on liquidity." Banks lost cash when customers closed short positions, and they still needed to lend cash to finance other customers' long positions.

The LCR's treatment of secured lending has even been criticized by Federal Reserve officials, including Tarullo (2014) and Van Der Weide (2016). The latter questions the idea, discussed above, that a bank faces no net liquidity risk when it receives collateral in secured lending transactions and passes it on in secured funding transactions. Such an arrangement is called a “matched book.” Van Der Weide says[14]:

> The LCR generally assumes a very large book of matched book repo can be unwound pretty seamlessly in a very short period of time. We don’t think that’s a reasonable assumption…. The funding risk is primarily one where firms often have very strong reputational incentives to maintain their lending to many of their clients, even if they’re losing funding on the repo side.

To be clear, it would be legal and feasible for a bank to create cash inflows by cutting off customer lending. It appears to be widely believed, however, that the reputational effects could be sufficiently dire that the overall effect would be to worsen rather than ameliorate the bank’s liquidity crisis. As discussed in Section 3, the LCR rule generally assumes that banks will eschew actions that raise cash but have dire reputational effects, such as liquidation of their inventories of assets or drastic shrinkage in their derivatives book. The rule’s treatment of secured lending is a deviation from this prudent aspect of the rule.

The Experience of Lehman Brothers

We have extensive information on cash outflows and inflows in the Lehman Brothers crisis, thanks to documents made public by Lehman’s court-appointed bankruptcy examiner (Valukas, 2010). This evidence is starkly at odds with the idea that a bank will offset losses of secured funding by terminating secured lending in a symmetric fashion.

The evidence includes memos from Lehman’s Treasury department that give a daily accounting of cash flows and the firm’s dwindling liquidity pool. As discussed before, cash flowed

[14] Van Der Weide makes this point in discussing the proposed Net Stable Funding Ratio (NSFR) rule. That regulation focuses on banks’ liquidity over a one-year horizon and sets minimum levels for equity and non-runnable liabilities such as long-term debt. Unlike the LCR rule, the NSFR rule treats secured funding and lending asymmetrically. An increase in matched book repo implies an increase in required stable funding.

out of Lehman during its final week because repos did not roll over and customers closed short positions. In contrast, the Treasury memos do not report *any* offsetting inflows from termination of secured lending. Indeed, there is no evidence that Lehman executives even discussed the possibility of raising cash that way. (They did discuss other possibilities for raising cash, such as drawing on credit lines.)[15]

Earlier in 2008, both Lehman and the New York Fed had performed liquidity stress tests for the firm. Summaries of these tests occasionally mention the possibility of cutting off secured lending, and reject the idea. A Fed test from June assumes "no cash inflows from reverse repos of less liquid securities." Lehman tests in April and July assume the firm would "avoid termination of prime broker agreements" and maintain liquidity "without reducing client funding." For all the tests, the results include large cash outflows from secured funding and no inflows from secured lending.[16]

Recall Venkat and Baird's view that, despite reputational costs, a bank might reduce secured lending "during the later stages of a crisis." Based on Lehman's experience, even this view seems too optimistic about cash inflows. Lehman maintained its secured lending even as its liquidity was completely exhausted and it declared bankruptcy.

<u>Other Inflows</u>

So far my analysis of inflows in the LCR stress scenario has focused on secured lending. The other components of inflows are smaller and we have less information to evaluate them, but some

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[15] Ball (2018, chapter 5) reviews this experience. The relevant memos, which are available through links in the footnotes of the Valukas report, include Lehman memos on September 13 and October 7 and a memo from Lehman's advisors at Lazard on September 13 or 14 (fns 5604, 6341, and 2716). Although Lehman did not choose to terminate any secured lending, some customers who had received margin loans terminated them to avoid losing securities they had posted as collateral.

[16] These stress tests are summarized in memos available through the Valukas footnotes (fn 6331 for the New York Fed test and fn 6329 for the Lehman tests).

seem questionable:

Retail and Wholesale Cash Inflows: These items, reported on Lines 21 and 22 of the LCR disclosure, reflect payments due over the next 30 days on loans to retail customers and unsecured loans to wholesale customers. In computing cash inflows, the rule applies weights of 100% for customers that are financial institutions (a subset of wholesale customers) and 50% for all other customers. This calibration means that none of the payments due from financial institutions, and only half of those from other customers, are refinanced or replaced by new lending.

Liquidity experts say that banks must always roll over a substantial part of their lending to preserve customer relationships. Banks must also continue to make new loans to protect their reputations (e.g., Matz, p. 241-243). In light of these issues, the LCR assumptions about inflows from loan payments seem aggressive.

Net Derivative Cash Inflow: This item is reported on Line 24 of the LCR disclosure. It covers payments due to a bank over the next 30 days under derivatives contracts, including the return of collateral. A risk ignored by the LCR rule is that the bank's counterparties may not deliver the payments.

This problem arose for Lehman Brothers, according to the Trustee who oversaw the liquidation of the firm's U.S. broker-dealer (Giddens, 2010, pp. 29-39). The Trustee reports that, as counterparties "became concerned about Lehman's continuing operations," they failed to return collateral for currency derivatives after Lehman fulfilled its obligations to them. The Trustee says: "These significant increases in failed transactions reduced [the broker-dealer's] available cash and increased the need for financing positions at the very time when borrowing capacity was contracting."

Duffie (2012) also briefly mentions this type of problem. In a liquidity crisis, Duffie warns, "contractual claims to cash can fail (e.g., margin)."

Adjusting Inflows in the Stress Scenario

While it seems clear that the LCR stress scenario is overly optimistic about inflows, it is hard to know how drastically the assumptions should be changed. In looking for a reasonable calibration, I take inspiration from a provision of the LCR rule mentioned in section 3: the cap on total inflows.

This provision limits the inflows that a bank can count when it calculates its net cash outflows: inflows cannot exceed 75% of gross outflows. If a bank's outflows are $100 and its inflows would otherwise be $90 under the LCR assumptions, then inflows are capped at $75 and net cash outflows are $25 rather than $10.

Regulators gave a cryptic explanation for the inflow cap when they published the LCR rule. At several points in the Federal Register, they say that the cap ensures banks are not "overly reliant on inflows," which "may not materialize in a period of stress." They do not say why inflows calculated under the other LCR assumptions "may not materialize," but I conjecture that they are thinking of the issues about inflows discussed above.

In practice, the inflow cap is far from binding for any of the big banks: for the six, total inflows range from 11% to 58% of total outflows. Therefore, the cap is irrelevant for the banks' liquidity management.

This fact suggests a flaw in the LCR rule. The factors that may prevent inflows from occurring—such as reputational effects of cutting off secured lending—are present regardless of the ratio of inflows to outflows. It is generally prudent to scale down the inflows in the LCR stress scenario, and the cap in the current rule does not do so for the big banks.

To scale down inflows in my revised stress scenario, I borrow the 75% figure from the inflow cap in the current rule. I presume that this figure is motivated by reasonable intuition on the part of regulators about the severity of the problems that might prevent inflows from materializing. To account for these problems, I simply multiply total inflows on Line 28 of the LCR disclosure by 0.75. Here, I view my adjustment to the LCR rule as cautious. One could argue for a larger haircut on inflows based on evidence such as Lehman's extreme reluctance to raise cash by cutting secured lending.

VIII. BOUNDS FOR ELIGIBLE HQLA

My goal is to calculate LCRs for the six big banks based on the revised assumptions about cash outflows and inflows discussed above. Unfortunately, an arcane detail of the LCR rule complicates these calculations and makes them less precise. This part of the rule concerns the calculation of HQLA in the numerator of the LCR.

To understand this issue, recall that the big "banks" are financial holding companies with subsidiaries including commercial banks and broker-dealers. The total HQLA of a bank includes assets owned directly by the holding company and assets owned by the subsidiaries. According to the LCR rule, not all of total HQLA counts as "eligible" HQLA in the LCR numerator. Eligible HQLA includes all HQLA owned by the holding company but only part of the HQLA owned by subsidiaries. This provision is motivated by regulatory restrictions on transfers of HQLA between different parts of a bank, which can prevent the bank from accessing its subsidiaries' HQLA to absorb liquidity losses.

The Appendix describes this part of the LCR rule in more detail. The reason it matters is that the amount of a subsidiary's HQLA that counts in a bank's eligible HQLA depends on how much of the net cash outflow in the bank's stress scenario occurs at the subsidiary. This amount changes when the assumptions of the scenario change. As a result, my revisions to the scenario change the eligible HQLA in the numerator of the LCR as well as the NCO in the denominator.

With only publically available information, it is not possible to calculate a bank's eligible HQLA after my changes in LCR assumptions. All we can do is determine bounds on eligible HQLA. The lower bound is eligible HQLA under the official LCR rule, which a bank reports on its LCR disclosure. The upper bound is the bank's total HQLA, including HQLA that is ineligible under the official rule.

Banks are not required to report total HQLA in their LCR disclosures, only eligible HQLA. Goldman Sachs voluntarily reports total HQLA, but the other big banks do not. In three cases—Bank of America, Wells Fargo, and Morgan Stanley—we can estimate total HQLA from information in the banks' 10-Ks. See the Appendix for details. Unfortunately, we lack information on total HQLA at JPMorgan Chase and Citi, so for those banks we do not have upper bounds on the revised level of eligible HQLA.

IX. REVISED LCRS FOR THE SIX LARGE BANKS

Earlier sections of this paper propose changes to four parts of the LCR stress scenario. This section examines the implications for the six big banks in 2019 Q4. I calculate the total change in net cash outflow implied by my revised assumptions, and then compute ranges for revised LCRs using the upper and lower bounds on eligible HQLA.

Revised Calculations of Net Cash Outflow

Table 1 summarizes my four proposed changes in the LCR stress scenario: those concerning retail deposits, secured funding, derivatives, and cash inflows. The Table also describes how to calculate the effects of the revised assumptions on a bank's net cash outflow.

For most of the revised assumptions, the effects on NCO are easy to calculate from information in LCR disclosures. The one exception is outflows from secured funding. The disclosures lump together all types of secured funding, and we need to know how much falls in the categories for which I increase the assumed outflow rates. To estimate these amounts, I use banks' disclosures on form FR Y-15, the Banking Organization Systemic Risk Report, which breaks down secured funding by type of collateral. See the Appendix for details.

Table 2 reports calculations of net cash outflows for 2019 Q4, with a row for each of the big banks. The banks are ordered by their assets at end of the quarter, which are reported for reference in the first column of the Table. The second column shows net cash outflow as computed under the official LCR rule, from Line 32 of the LCR disclosure ("official NCO"). Columns (3) through (6) show the increases in NCO resulting from each of my changes in outflow and inflow assumptions. We can see that each of the four changes is material for most of the banks.

Column (7) shows one more adjustment to net cash outflow: an addition to the maturity mismatch term, Line 31 in the LCR disclosure. To derive this adjustment, I assume that the official stress scenario understates a bank's peak level of net cash outflow within the 30-day stress period by the same fraction as it understates net outflow at 30 days. The addition to the maturity mismatch term proves to be substantial for one bank, JPMorgan Chase, but small for the other five.[17]

Column (8) of Table 2 shows net cash outflow after all my adjustments ("revised NCO"). This quantity equals official NCO in column (2) plus the additions in columns (3)-(7). Finally, column (9) gives revised NCO in (8) as a percentage of official NCO. Revised NCO ranges from 125% of

[17] In the LCR disclosure, Line 30 gives net cash outflow after 30 days and Line 32 gives the peak net outflow within 30 days. Line 32 is the denominator of the LCR. The maturity mismatch term, Line 31, is the difference between Lines 32 and 30. I revise the number in Line 30 by adding the increases in net outflow in columns (3)-(6) of Table 2. I then assume that Lines 31 and 32 increase by the same percentage as Line 30, which yields the figures in columns (7) and (8).

official NCO for Wells Fargo to 198% for Morgan Stanley.

Ranges for Revised LCRs

Table 3 examines the impact of the revised stress scenario assumptions on the LCR. Columns (1) and (2) repeat the official and revised versions of net cash outflow from Table 2. Column (3) reports eligible HQLA under the official LCR rule ("official eligible HQLA"), and column (4) reports total HQLA (with missing values for JPMorgan and Citi). As discussed above, these two values of HQLA are bounds on eligible HQLA under the revised stress assumptions.

The rest of Table 3 shows alternative versions of the LCR for the six banks. Column (5) reports the official LCR: official eligible HQLA divided by official NCO. Column (6) reports official eligible HQLA divided by revised NCO, and column (7) reports total HQLA divided by revised NCO. The numerators of the LCRs in columns (6) and (7) are bounds on eligible HQLA in the revised stress scenario, so the numbers in these columns are bounds on the revised LCR.

Finally, column (8) gives official NCO divided by revised NCO. To interpret this ratio, note that official NCO is the minimum level of eligible HQLA that a bank must hold to comply with the current LCR rule—the level of HQLA that would yield an official LCR of 100%. Column (8) shows what the revised LCR would be if a bank reduced its HQLA to the legal minimum.

The results in Table 3 are shown visually in Figure 2. For each bank, the Figure shows the range of revised LCRs determined by the bounds on eligible HQLA. The Figure also shows the official LCR and the revised LCR if HQLA were the legal minimum.

Recall that we do not know total HQLA for JPMorgan Chase or Citi. In Figure 2, I use proxies for these missing numbers to derive upper bounds on JP Morgan's and Citi's revised LCRs. For each of these firms, I assume that the ratio of total HQLA to official eligible HQLA equals the average of that ratio at the other four banks. This average ratio is 1.19.

Discussion

The six big banks fall naturally into two groups. The members of the first group are Goldman Sachs and Morgan Stanley, the two firms that are primarily broker-dealers and investment banks. They have the highest official LCRs of the six banks, but the lowest revised LCRs. Their ranges of revised LCRs are well below 100%: 65% to 88% for Goldman Sachs and 68% to 83% for Morgan Stanley.

The second group contains the four banks with large commercial banking franchises. For each of these banks, most or all of the range for the revised LCR is below 100%. The upper bounds on the range are around 100% and the lower bounds are around 80-85% except for Wells Fargo, which has a narrow range of 96% to 97%. Based on these results, it is likely that the revised LCRs for the four banks are less than 100%, but this finding is less clear-cut than it is for Goldman Sachs and Morgan Stanley. All in all, the results suggest a serious risk that the six big banks do not have enough cash to cover their net outflow during a crisis.

The result that Goldman Sachs and Morgan Stanley have the lowest revised LCRs reflects the fact that the broker-dealer operations at these firms involve large amounts of secured funding and lending and derivatives transactions. My revisions to the LCR stress scenario imply higher net cash outflows from these activities. These factors outweigh the fact that my assumptions about retail deposits have less effect on Goldman Sachs and Morgan Stanley than on the other banks.

The revised stress tests suggest that the big banks could be endangered by liquidity crises even though their official LCRs range from 115% to 134%. This risk would be even greater if the banks held the minimum levels of HQLA required for an official LCR of 100%, which would imply the revised LCRs in the last column of Table 3. These ratios range from 50% to 80%, suggesting a large gap between the liquidity needed in a crisis and the minimum requirements of the current LCR rule.

Robustness to Variation in Assumptions

If my revised stress scenario captures what would happen in a future financial crisis, then the six big banks have tenuous liquidity positions. However, as emphasized throughout this paper, there is great uncertainty about the parameters of stress tests. Readers who question any of my assumptions can redo the LCR calculations in Tables 1-3 with alternative assumptions. Here, I explore the robustness of my results by presenting some simple variations on my baseline case.

My four revisions of the LCR rule can be adjusted separately, but here I vary them together to see the effects of generally more optimistic or pessimistic assumptions. Each of the revisions changes certain inflows or outflows in the LCR stress scenario by some amount. For example, I raise some repo outflow rates from 50% to 100%, and I reduce all inflows by 25% compared to official assumptions. Here I scale all the adjustments to the official rule by a fraction x. For example, for x=0.5, all adjustments are half as large as in my baseline case, so repo outflow rates are raised only to 75% and inflows are reduced by only 12.5%. I calculate revised LCRs for the six banks for values of x from 0.25 up to 1.5.

Table 4 shows the resulting ranges of revised LCRs, with the endpoints of each range determined again by official eligible HQLA and total HQLA. Setting x<1 (that is, making smaller adjustments to the official rule) makes the revised LCRs larger. However, even for x = 0.5, the revised LCRs may not exceed 100%: for all banks but Wells Fargo, the upper end of the range is above 100% but the lower end is below 100%. If we move closer to my baseline assumptions with x = 0.75, then the entire range of LCRs is again below 100% for Goldman Sachs and Morgan Stanley. If x > 1, then the revised LCRs are even lower than in my baseline case; x = 1.25 pushes the entire range below 100% for all four banks for which I can compute both endpoints.

X. CONCLUSION

During the 2008 financial crisis, markets lost confidence in large banks because of their losses on real estate investments. We do not know what will trigger the next financial crisis. Confidence in banks might be shaken by losses on another asset class or some other adverse event in financial markets. A crisis could have roots in a deep recession, or political instability, or a pandemic, or accelerating climate change. A crisis could occur at an individual bank because of a blunder in strategy or the revelation of illegal behavior.

Whatever the trigger, history teaches us that a loss of confidence in a bank will cause its customers and counterparties to reduce their exposure to the bank. These actions can quickly become a run in which the bank is drained of cash and its survival is threatened.

The LCR rule seeks to ensure that a bank can survive a run for at least 30 days, providing time for the bank and regulators to find an orderly resolution of the crisis. The rule requires that a bank hold enough liquid assets to absorb net cash outflows in a 30-day stress scenario. This paper argues, however, that some of the assumptions in the stress scenario understate the cash outflows that are likely in a crisis and overstate the offsetting inflows. Consequently, compliance with the rule does not really ensure that a bank would survive for 30 days.

This paper also proposes alternatives to the problematic assumptions in the LCR stress scenario and uses them to estimate revised LCRs for the six largest U.S. banks. The results suggest that all the banks have LCRs below 100%, which means a crisis could exhaust their liquid assets in less than 30 days. This finding is most clear for Goldman Sachs and Morgan Stanley.

There is much uncertainty about the appropriate parameters for a liquidity stress test, but I do not think my pessimistic revisions of the LCR assumptions are especially aggressive. The net cash outflows in a liquidity crisis might be smaller than my results suggest, but they also might be larger.

One place where my change in assumptions is cautious is the treatment of cash inflows. I assume that inflows are only 75% of the level in the official LCR scenario, but one could argue for even smaller inflows based on evidence such as Lehman's unwillingness to cut secured lending. In any case, when I consider variations on my baseline assumptions, the resulting LCRs are below 100% in a range of plausible cases.

This paper's assessment of liquidity risk could be improved if regulators release more information. To start with, they should provide more explanation for the many choices of inflow and outflow assumptions in the LCR stress scenario. It would also help if regulators release more data from the 2008 financial crisis. The FDIC, for example, could presumably provide data on deposit runs at the banks it seized.

It would be easier to calculate LCRs under alternative assumptions if banks provided more information than they currently do in their LCR disclosures. For example, disaggregation of secured funding by collateral type, and of derivatives collateral calls by type of trigger, could eliminate some guesswork from my LCR calculations. Information on net cash outflow and HQLA at banks' subsidiaries would enable calculations of eligible HQLA under my revised stress assumptions, so one could derive a single value for a bank's revised LCR rather than a range.

APPENDIX

A. Stable and Other Retail Deposits at Washington Mutual

Section 4 calculates outflow rates for stable and other retail deposits at Washington Mutual using an estimate that, at the start of the run, 32% of the retail deposits in the two categories were stable and 68% were other. Here I discuss the basis for this estimate.

We do not have any breakdown of retail deposits at the start of the run on September 8, 2008, but we have some information for June 30 from WaMu's 10-Q for 2008 Q2 (p. 54). Total retail deposits (excluding brokered deposits) were $148.3 billion on June 30, slightly higher than the $141.1 billion on September 8. I estimate the percentages of stable and other deposits on June 30 and assume these percentages were the same on September 8.

Recall that stable retail deposits are fully insured and also meet at least one of two other criteria: they are transactional accounts or relational accounts, the latter meaning that the deposit holder has another relationship with the bank such as another account or a loan.

The 10-Q decomposes total retail deposits on June 30 into three categories: checking deposits of $47.2 billion, savings and money market deposits of $58.0 billion, and time deposits of $43.1 billion. Checking deposits are transactional deposits and the other two categories are not.

Unfortunately, I do not have information on insurance coverage for transactional and non-transactional deposits or on how many of the latter are relational. Given these limitations of the data, I simply assume that the level of stable deposits equals the level of transactional deposits. This level is (47.2) / (148.3) = 32% of stable plus other retail deposits.

With this assumption, the level of stable deposits could be either overstated or understated. The former is possible because transactional deposits may include some that are not insured, so not stable. The latter is possible because insured relational deposits are excluded.

I conjecture that insured relational deposits are more common than uninsured transactional deposits, which means I am conservative in estimating the fraction of deposits that are stable. If I assumed a fraction larger than 32%, the calculations in Section 4 would produce higher outflow rates for both stable and other retail deposits: the increases relative to the LCR assumptions would be larger.

Some information on deposit insurance supports the idea that my assumption about stable deposits is conservative. A WaMu memo reports that on August 29, $16.6 billion of WaMu's retail deposits were deposits exceeding $100,000, which means they were not fully insured.[18] Those deposits were 11.7% of total retail deposits of $141.5 billion on August 29. If we suppose that the percentage of uninsured deposits was also 11.7% on June 30, and that this percentage applies to both transactional and non-transactional deposits as well as total retail deposits, then (0.117)($47.2 billion) = $5.5 billion of transactional deposits were uninsured and should not count in stable deposits. These assumptions also imply that insured non-transactional deposits were (0.883)($101.1 billion) = $89.3 billion. If at least $5.5 billion out of this $89.3 billion were relational deposits, then stable retail deposits were at least as large as transactional deposits.

B. Calculating Revised Outflows from Secured Funding

My revisions to the LCR stress scenario include increases in outflow rates for two categories of secured funding: funding with collateral that is Level 2B HQLA, and customer short positions with non-HQLA collateral where the collateral belongs to other customers. For both of these categories, the outflow rate is 50% in the LCR stress scenario but 100% in my revised scenario.

We need to know the levels of these two types of funding to compute revised LCRs. The LCR

[18] The memo, titled "Discussion Materials" and dated September 23, was released by the bankruptcy examiner for Washington Mutual Inc.

disclosure reports only an aggregate of secured funding, but a breakdown by collateral type appears in another regulatory filing: FR Y-15, the Banking Organization Systemic Risk Report.

The LCR calculations that banks disclose, and my revisions of these calculations, are done at the quarterly frequency. Form Y-15 is published at the end of each quarter, but the reported levels of secured funding are averages over the last twelve months. I use these twelve-month levels as proxies for quarterly levels, presuming that secured funding is stable enough over time that this approximation is reasonable.

Secured funding is reported on Schedule G of Form Y-15. On that Schedule, the first column of Line 3a reports secured funding with Level 2B collateral that matures within 30 days. That is the first category of funding for which I revise the LCR outflow rate.

On Schedule G, the first column of Line 4 reports secured funding with non-HQLA collateral that matures within 30 days. The Schedule does not report how much of this funding is customer short positions with collateral owned by other customers, the second type of funding for which I revise the outflow rate. However, I can estimate this quantity by combining information in Form Y-15 and the LCR disclosure. My approach uses the fact that the outflow from secured funding in Line 13 of the disclosure equals the sum of different types of funding weighted by their outflow rates.

A complication is that Line 13 includes outflows related to asset exchanges as well as secured funding. These transactions are ones in which securities are exchanged temporarily for more liquid securities rather than cash. In the LCR scenario, the assumed outflow rate for an asset exchange is the difference between the outflow rates for secured funding with the type of collateral pledged in the exchange and with the type of collateral received in the exchange. For example, for an exchange of a Level 2B security for a Level 2A security, the outflow rate is 0.5 – 0.15 = 0.35.

Schedule G of Form Y-15 reports exchanges of Level 2A securities for Level 1 securities, which have an outflow rate of 0.15. The Schedule also reports an aggregate of all other asset exchanges: Level 2B securities for Level 1, non-HQLA securities for Level 1, Level 2B for Level 2A, non-HQLA for Level 2A, and non-HQLA for Level 2B. The outflow rates for these categories are 0.5, 1.0, 0.35, 0.85, and 0.5, respectively. I take the average of these five rates, which is 0.64, and assume it is the outflow rate for all the asset exchanges that are grouped together.[19]

With this background, we can proceed to estimate the level of secured funding that is customer short positions with non-HQLA collateral owned by other customers. I will use the terms "special non-HQLA funding" (S) for this category, "regular non-HQLA funding" (R) for other funding with non-HQLA collateral, and "total non-HQLA funding" (T) for the sum of the two: T=S+R.

We start with the fact that the total outflows reported on Line 13 of the LCR disclosure are a weighted sum of various types of secured funding and asset exchanges:

$$F = (0.15)(2A) + (0.15)(E1) + (0.5)(2B) + (0.5)S + (1.0)R + (0.64)(EO) ,$$

where F is total outflows, 2A and 2B are secured funding with Level 2A and 2B collateral, E1 is exchanges of Level 1 for Level 2A assets, and EO is all other asset exchanges. The weights on these variables are LCR outflow rates. Substituting T-S for R and solving for S yields:

$$S = -2F + (0.3)(2A) + (0.3)(E1) + (1.0)(2B) + (2.0)T + (1.28)(EO) .$$

We can use the last equation to estimate a bank's special non-HQLA funding. The levels of the various types of funding and asset exchanges on the right side of the equation are reported on Form Y-15. Outflows in the LCR stress scenario (F) are reported in the Weighted column of Line

[19] The levels of the asset exchanges that are grouped together are small, so my results are not very sensitive to the assumed average outflow rate. My calculation ignores special outflow rates that the LCR rule prescribes for certain kinds of transactions, such as secured funding from foreign central banks and asset exchanges in which the bank rehypothecates the asset it receives for a term exceeding 30 days.

13 of the LCR disclosure. I use the average of these outflows over the last four quarters to match the time period covered by Form Y-15. My calculations for 2019 Q4 use outflows in the four quarterly LCR disclosures for 2019.

We now have estimated levels for the two types of secured funding for which I revise outflow rates, Level 2B funding and special non-HQLA funding. I increase both outflow rates from 50% to 100%. These changes increase a bank's net cash outflow by 50% of Level 2B funding plus 50% of special non-HQLA funding.

Table A1 reports the increases in secured-funding outflows for the six banks in 2019 Q4, which also appear in column 4 of Table 2. Table A1 also breaks these increases into the parts due to Level 2B funding and special non-HQLA funding. The increases due to Level 2B funding are larger, but both increases are material for most of the banks.[20]

C. How Adjustments to NCO Affect Eligible HQLA

As discussed in Section 8, eligible HQLA in the numerator of the LCR excludes some HQLA held at a bank's subsidiaries. This fact complicates my analysis because the amounts of HQLA that count as eligible change when I revise assumptions about outflows and inflows. Here I describe this aspect of the LCR rule and its implications for calculating revised LCRs.

This part of the LCR rule is Section 22 Parts (b)(3) and (b)(4). In determining how much of the HQLA held at a subsidiary is eligible HQLA, the rule first distinguishes between assets that are freely transferable to other parts of the bank and assets that are "trapped" at the subsidiary for regulatory or other reasons. All of the freely transferable HQLA is included in the bank's eligible HQLA. Trapped HQLA is included only up to a limit, which is the amount of the bank's net cash

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[20] For JPMorgan Chase, my calculation yields S = -$3.8 billion. I set S to zero in this case.

outflow that occurs at the subsidiary.

This provision is meant to ensure that enough HQLA is available to absorb cash outflows anywhere at a bank even if some HQLA is trapped at subsidiaries. One can demonstrate that this goal is met if eligible HQLA as defined in the rule exceeds NCO.

When I revise the LCR stress scenario, the resulting increase in a bank's NCO occurs partly at the holding company and partly at subsidiaries. If some of the HQLA trapped at a subsidiary is ineligible because it exceeds NCO at the subsidiary, part of this HQLA becomes eligible when NCO rises. That implies an increase in eligible HQLA in the numerator of the LCR.

The LCR disclosure reports a bank's total levels of eligible HQLA and NCO but does not provide a breakdown for the holding company and subsidiaries. Without such information, we do not know the bank's eligible HQLA after my changes in outflow and inflow assumptions, but we have bounds on that quantity. The lower bound is eligible HQLA under the official LCR rule, because my changes in assumptions cannot reduce eligible HQLA. The upper bound is the bank's total HQLA, which is eligible HQLA if none is ineligible with my assumptions.

D. Determining Total HQLA

A bank's total HQLA is the upper bound on its eligible HQLA in the revised stress scenario. One of the big banks, Goldman Sachs, reports its total HQLA ($229.0 billion) on its LCR disclosure. For three of the others–Bank of America, Wells Fargo, and Morgan Stanley–I estimate total HQLA from information reported on the banks' 10-Ks for 2019 Q4, as described here. Unfortunately, I do not see a way to estimate total HQLA for JPMorgan Chase or Citigroup.

On their 10-Ks, Morgan Stanley, Bank of America, and Wells Fargo all report a pool of assets called "Global Liquidity Sources" or something similar. They all say that the types of assets included in these liquidity pools are "substantially the same" as those included in the LCR rule's definition of HQLA. The pools differ from eligible HQLA on the LCR disclosure in two ways: (i) they do not exclude any HQLA held at subsidiaries; and (ii) all types of HQLA are given weights of one.[21]

The upper bound on HQLA in the revised stress scenario is total HQLA with no assets at subsidiaries excluded, like the pools reported in the 10-Ks, but with the weights in the LCR rule applied to different types of HQLA. I estimate this quantity in several steps summarized in Table A2:

• Column (1) of the Table gives each bank's liquidity pool from its 10-K, which I take as an estimate of unweighted total HQLA. Subtracting unweighted eligible HQLA from the LCR disclosure (column (2)) gives unweighted ineligible HQLA (column (3)).

• Column (4) gives an estimate of weighted ineligible HQLA. The three banks' 10-Ks indicate that almost all of the assets included in ineligble HQLA are Level 1 or Level 2A, but we do not know the breakdown between the two. I assume that the weight on all ineligible HQLA is 0.925, the average of the weights for Levels 1 and 2A.[22]

• Adding weighted ineligible HQLA to weighted eligible HQLA from the LCR disclosure (column (5)) yields weighted total HQLA (column (6)). This item is the upper bound on revised HQLA that is also reported in column (4) of Table 3.

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[21] The liquidity pools are Bank of America's "Global Liquidity Sources" (p. 50 of its 10-K), the unencumbered part of Wells Fargo's "Primary Sources of Liquidity (p. 84), and Morgan Stanley's "Global Liquidity Reserve" (p. 46). My calculations use the average levels of these pools over 2019 Q4, except for Wells where I use the level at the end of the quarter because the average is not available.

[22] The 10-Ks break the liquidity pools into different types of assets, but two of the categories are mixtures of Level 1 and 2A HQLA: agency securities and foreign sovereign debt. (Agencies include securities that are fully guaranteed by the government, which are Level 1, and GSE securities that are not fully guaranteed, which are Level 2A.)

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Table 1

REVISIONS TO LCR STRESS SCENARIO

RETAIL DEPOSITS (Lines 6-7)

Raise outflow rate from 3% to 7.5% for stable retail deposits and from 10% to 25% for other retail deposits.*

SECURED FUNDING (Line 13)

Raise outflow rate from 50% to 100% for funding secured by Level 2B HQLA and for loans of non-HQLA securities owned by customers.**

DERIVATIVES (Line 15)

Double derivatives-related outflow on Line 15.

INFLOWS (Lines 20-28)

Reduce total inflow on Line 28 by 25%.

Line Numbers refer to LCR disclosure.

*Increase in outflow is Revised outflow – Official outflow. Revised outflow is (0.075)(Unweighted Line 6) + (0.25)(Unweighted Line 7). Official outflow is Weighted Line 6 + Weighted Line 7. Weighted Line 7 accounts for official outflow rates above 10% for small parts of other retail deposits.

**See Appendix Part B for details of calculation.

TABLE 2
REVISIONS TO NET CASH OUTFLOW, 2019 Q4
(in billions of dollars)

	(1) Assets	(2) Official NCO	Additions to NCO					(8) Revised NCO	(9) Revised NCO / Official NCO
			(3) Deposits	(4) Secured Funding	(5) Derivatives	(6) Inflows	(7) Maturity Mismatch		
JPMorgan Chase	2687.4	469.4	57.1	31.6	40.0	63.7	23.3	685.1	146%
Bank of America	2434.1	400.7	48.6	39.6	23.7	31.0	1.7	545.3	136%
Citigroup	1951.2	382.0	39.2	11.1	35.9	32.0	1.3	501.5	131%
Wells Fargo	1927.6	312.0	49.4	8.8	8.7	9.7	0.9	389.5	125%
Goldman Sachs	993.0	134.4	8.3	39.1	31.9	44.8	2.6	261.1	194%
Morgan Stanley	895.4	132.5	0.0	54.7	31.9	41.4	1.9	262.4	198%

Summary of Calculations (Lines refer to LCR disclosure):

(1) Assets at end of quarter, from 10-K.
(2) Line 32.
(3) [(0.075)(Unweighted Line 6) + (0.25)(Unweighted Line 7)] – [Weighted Line 6 + Weighted Line 7].*
(4) See Appendix Part B and Table A1.
(5) 100% of Line 15.
(6) 25% of Line 28.
(7) See fn 16.
(8) Sum of Columns 2-7.

*For Morgan Stanley, this formula yields -$0.9 billion. This number is set to zero in calculating revised NCO.

TABLE 3
ALTERNATIVE LIQUIDITY COVERAGE RATIOS, 2019 Q4

	(1) Official NCO	(2) Revised NCO	(3) Official Eligible HQLA	(4) Total HQLA	Official LCR	Bounds on Revised LCR		LCR if Minimal Compliance
					(5) Official Eligible HQLA / Official NCO	(6) Official Eligible HQLA / Revised NCO	(7) Total HQLA / Revised NCO	(8) Official NCO / Revised NCO
JPMorgan Chase	469.4	685.1	545.3	-	116%	80%	-	69%
Bank of America	400.7	545.3	464.4	549.2	116%	85%	101%	73%
Citigroup	382.0	501.5	437.6	-	115%	87%	-	76%
Wells Fargo	312.0	389.5	373.4	378.3	120%	96%	97%	80%
Goldman Sachs	134.4	261.1	170.4	229.0	127%	65%	88%	51%
Morgan Stanley	132.5	262.4	177.8	217.4	134%	68%	83%	50%

Columns 1-4 are billions of dollars.

Summary of Calculations:

(1) From Table 2 Column 2.
(2) From Table 2 Column 8.
(3) LCR disclosure Line 1.
(4) See Appendix Part D and Table A2. Not available for JPMorgan Chase or Citigroup.
(5) Column 3 / Column 1.
(6) Column 3 / Column 2.
(7) Column 4 / Column 2.
(8) Column 1 / Column 2.

TABLE 4
ROBUSTNESS OF REVISED LCRS

Bounds on Revised LCR (%)

Value of x	0.25	0.5	0.75	1.0	1.25	1.5
JP Morgan Chase	[104, - - -]	[94, - - -]	[86, - - -]	[80, - -]	[74, - -]	[69, - -]
Bank of America	[106, 126]	[98, 116]	[91, 108]	[85, 101]	[80, 94]	[75, 89]
Citigroup	[106, - - -]	[99, - - -]	[93, - - -]	[87, - -]	[82, - -]	[78, - -]
Wells Fargo	[113, 114]	[106, 108]	[101, 102]	[96, 97]	[91, 93]	[87, 88]
Goldman Sachs	[103, 138]	[86, 116]	[74, 100]	[65, 88]	[58, 78]	[53, 71]
Morgan Stanley	[108, 132]	[90, 110]	[77, 95]	[68, 83]	[60, 74]	[54, 66]

All additions to NCO are a fraction x of additions in baseline scenario (Table 1, columns 3-7).

Lower bound on LCR = (Official Eligible HQLA) / (Revised NCO).
Upper bound on LCR = (Total HQLA) / (Revised NCO).

TABLE A1
ADDITIONS TO SECURED-FUNDING OUTLOW, 2019 Q4
(in billions of dollars)

	(1) Level 2B Funding	(2) Special Non-HQLA Funding	(3) Total
JPMorgan Chase	31.6	0.0	31.6
Bank of America	27.8	11.8	39.6
Citigroup	10.2	0.9	11.1
Wells Fargo	5.2	3.6	8.8
Goldman Sachs	24.7	14.4	39.1
Morgan Stanley	36.6	18.1	54.7

Summary of Calculations:
See Appendix Part B.

TABLE A2
CALCULATION OF TOTAL HQLA, 2019 Q4
(in billions of dollars)

	(1) Unweighted Total HQLA	(2) Unweighted Eligible HQLA	(3) Unweighted Ineligible HQLA	(4) Weighted Ineligible HQLA	(5) Weighted Eligible HQLA	(6) Total Weighted HQLA
Bank of America	576.0	484.3	91.7	84.8	464.4	549.2
Wells Fargo	394.9	389.6	5.3	4.9	373.4	378.3
Morgan Stanley	223.6	180.8	42.8	39.6	177.8	217.4

Summary of Calculations:
(1) From 10-K. See Appendix Part D.
(2) From LCR disclosure Line 1, Unweighted Column.
(3) Column 1 - Column 2.
(4) (0.925)(Column 3).
(5) From LCR disclosure Line 1, Weighted Column.
(6) Column 4 + Column 5.

Figure 1. LCR disclosure, JPMorgan Chase, 2019 Q4

The following table presents further detail on the Firm's average LCR, and average unweighted and weighted amount of HQLA, cash outflows and cash inflows, for the three months ended December 31, 2019.

	Three months ended December 31, 2019 (in millions)	Average Unweighted Amount[(a)]	Average Weighted Amount[(b)]
	HIGH-QUALITY LIQUID ASSETS		
1	Total eligible high-quality liquid assets (HQLA), of which:[(c)]	**$ 553,152**	**$ 545,286**
2	Eligible level 1 liquid assets	501,408	501,408
3	Eligible level 2A liquid assets	51,447	43,730
4	Eligible level 2B liquid assets	297	148
	CASH OUTFLOW AMOUNTS		
5	Deposit outflow from retail customers and counterparties, of which:	**$ 759,498**	**$ 45,539**
6	Stable retail deposit outflow	477,018	14,311
7	Other retail funding outflow	243,480	25,257
8	Brokered deposit outflow	39,000	5,971
9	Unsecured wholesale funding outflow, of which:	**785,360**	**285,234**
10	Operational deposit outflow	548,374	136,807
11	Non-operational funding outflow	229,770	141,211
12	Unsecured debt outflow	7,216	7,216
13	Secured wholesale funding and asset exchange outflow[(d)]	**732,315**	**178,947**
14	Additional outflow requirements, of which:	**482,015**	**148,067**
15	Outflow related to derivative exposures and other collateral requirements	53,606	39,977
16	Outflow related to credit and liquidity facilities including unconsolidated structured transactions and mortgage commitments	428,409	108,090
17	**Other contractual funding obligation outflow**	**4,956**	**4,956**
18	**Other contingent funding obligations outflow[(e)]**	**293,047**	**10,519**
19	TOTAL CASH OUTFLOW	**$ 3,057,191**	**$ 673,262**
	CASH INFLOW AMOUNTS		
20	**Secured lending and asset exchange cash inflow[(d)]**	**$ 758,707**	**$ 198,014**
21	**Retail cash inflow**	**25,676**	**12,838**
22	**Unsecured wholesale cash inflow[(f)]**	**30,845**	**24,050**
23	**Other cash inflows, of which:**	**19,971**	**19,724**
24	Net derivative cash inflow	2,968	2,968
25	Securities cash inflow	5,218	5,218
26	Broker-dealer segregated account inflow	11,538	11,538
27	Other cash inflow	247	–
28	TOTAL CASH INFLOW	**$ 835,199**	**$ 254,626**
			Average Weighted Amount[(b)]
29	HQLA AMOUNT[(c)]		**$ 545,286**
30	TOTAL NET CASH OUTFLOW AMOUNT EXCLUDING THE MATURITY MISMATCH ADD-ON		**$ 418,636**
31	MATURITY MISMATCH ADD-ON		**50,766**
32	TOTAL NET CASH OUTFLOW AMOUNT		**$ 469,402**
33	LIQUIDITY COVERAGE RATIO (%)		**116%**

(a) Represents the average notional amount of (1) eligible HQLA before applying regulatory-prescribed haircuts; and (2) balances subject to outflows and inflows over a prospective 30-day period before applying regulatory-prescribed outflow and inflow rates.
(b) Represents the average weighted amount after applying regulatory prescribed (1) HQLA haircuts; and (2) cash outflow and inflow rates, respectively.
(c) Excludes average excess HQLA at JPMorgan Chase Bank, N.A. that are not transferable to non-bank affiliates.
(d) Outflows on line 13 predominantly relate to securities loaned or sold under repurchase agreements and collateralized deposits; these amounts are largely offset by inflows reported on line 20 from securities borrowed or purchased under resale agreements and margin loans. These amounts include outflows and inflows associated with certain prime brokerage activities.
(e) Predominantly reflects repurchases of debt securities issued by the Firm that mature more than 30 calendar days after the calculation date.
(f) Predominantly reflects repayments of wholesale loans.

Figure 2
Alternative Liquidity Coverage Ratios, 2019 Q4