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The Difficult Business of Measuring Banks' Liquidity: Understanding the Liquidity Coverage Ratio

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Abstract

In the wake of the financial crisis of 2007-09, the Basel Committee on Banking Supervision recommended bank regulators adopt a new short-term liquidity requirement, the liquidity coverage ratio (LCR), to promote greater liquidity resilience. U.S. bank regulators announced the final rule implementing that recommendation in 2014. We highlight complexities in interpreting LCRs under both Basel III and the U.S. rule when banks undertake transactions that simultaneously affect the LCR numerator and denominator, and therefore, the ratio itself. Furthermore, we show how the numerator and denominator caps in the LCR formulas introduce nonlinearities that add to the complexity of interpreting changes in the metric. LCRs calculated under the U.S. rule are more volatile and difficult to interpret than LCRs calculated under the Basel standard. This is because the U.S. rule adds a time dimension to the LCR's volatility through inclusion of a maturity mismatch add-on term in the denominator to account for the peak-day net cash outflow during the 30-day window. Unlike some other regulatory ratios, bank supervisors, analysts, and investors need to have a clear understanding of the mechanics of LCR calculations to interpret the LCR metric, separate signal from noise, and perform informed peer analysis. In this paper, we demonstrate how the LCR is calculated under both Basel and U.S. rules to help market participants, the public, and researchers better understand this new liquidity metric.

Keywords: Banking, funding
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Introduction

The financial crisis of 2007-09 revealed material liquidity risks at U.S. banks and bank holding companies. Banks experienced loan commitment drawdowns, collateralized loan obligation pipeline back-ups, and asset fire-sales. Credit rating downgrades pressured banks' funding costs, funding availability, and solvency. Illiquid banks pulled funding from other banks.

In response, Federal Reserve discount window lending and special liquidity programs — such as the Term Auction Facility, Primary Dealer Credit Facility, and Term Securities Lending Facility — provided hundreds of billions of dollars in loans to banks and their broker-dealer affiliates. Liquidity stress was not limited to U.S. banks; European banks' U.S. branches and subsidiaries were some of the largest beneficiaries of Federal Reserve lending. Additionally, European banks borrowed in dollars from the Federal Reserve-European Central Bank swap line, and in euros from the European Central Bank.

Post-crisis, the Basel Committee on Banking Supervision sought to address liquidity risk through the development of a more rigorous standard that included the first quantitative liquidity regulation for banks since the introduction of reserve requirements. The Basel Committee introduced the Liquidity Coverage Ratio (LCR) to measure and limit a bank's liquidity risk over 30 days as well as a longer-term liquidity metric, the Net Stable Funding Ratio, to measure and limit banks' structural asset and liability mismatches. This paper is about the first of these measures, the LCR.

The Basel Committee finalized its LCR rule in January 2013. U.S. regulators released their final version in September 2014. The LCR will be fully phased in by January 2017 in the United States. Eurozone banks must comply with the LCR under Capital Requirements Directive IV, the European Union's implementation of Basel III, by January 2018.

A key initial impetus behind the development of the LCR was a desire to adopt a quantitative minimum liquidity requirement comparable across banks because of the fragile liquidity positions exhibited by a number of banks during the 2007-09 crisis. This goal is reflected in the final U.S. rule, which states "the LCR is intended to be a standardized liquidity metric, designed to promote a consistent and comparable view of the liquidity of covered companies."[1] However, the final U.S. rule intentionally departs from the Basel III standard to prevent banks from manipulating their LCRs in ways arguably not fully addressed by the Basel standard. It states "the proposed [and final] unwind methodology was intended to prevent a covered company from manipulating the composition of its HQLA amount by engaging in transactions such as repurchase or reverse repurchase agreements that could ultimately unwind within the 30 calendar-day stress period."[2]

Differences in LCR computation among jurisdictions make it difficult to compare liquidity risk across banks. Moreover, a feature of the U.S. rule complicates assessment of liquidity risk changes at the same bank over time. Although it is tempting to grab a set of banks' LCR data and draw conclusions about their — and the financial system's — short-term liquidity risk, the calculation of the ratio is complex and can pose challenges to such analysis.

Possible misinterpretation of the LCR is an important systemic risk issue because of potential negative signaling effects associated with public disclosures of LCRs, particularly when they drop below the minimum required ratio of 100 percent. Such disclosures could exacerbate, or even start, systemic liquidity stress events. U.S. regulators acknowledged those concerns in the final rule, noting that "other than any public disclosure requirements that may be proposed in a separate notice, reports to the agencies of any decline in a covered company's LCR below 100

[1] See OCC and others (2014), p. 61473.
[2] Ibid.

percent and any related supervisory actions would be considered and treated as confidential supervisory information."[3] However, the Federal Reserve, OCC, and FDIC are not the only organizations, federal or otherwise, imposing disclosure requirements. It remains to be seen whether disclosure requirements under securities laws or stock exchange listing rules compel banks to publicize LCRs below 100 percent or the adoption of associated remediation plans.[4] Such public disclosures could make it more costly for a bank to sell liquid assets or take other measures to improve its LCR during times of stress.

These concerns about public disclosure are borne out by the literature on externalities in financial reporting. Ross (1979), Grossman (1981), and Milgrom (1981) show that firms disclose negative information, whether required or not, since no news will be regarded as bad news. Their findings imply banks will publicly disclose their LCRs, whether required or not.

Bankers have also expressed concerns about negative externalities associated with LCR disclosure. For example, in JPMorgan Chase's 2014 Annual Report, CEO Jamie Dimon suggests that "banks and their boards of directors will be very reluctant to allow a liquidity coverage ratio below 100 (percent) — even if the regulators say it is okay. And, in particular, no bank will want to be the first institution to report a liquidity coverage ratio below 100 (percent) for fear of looking weak." Indeed, Griffin (1977) shows that the first company to disclose a problem affecting others in its industry suffers the most in terms of stock price volatility.

[3] See OCC and others (2014), p. 61517.
[4] Disclosure requirements under securities laws generally fall under Item 303 of Regulation S-K, *Management's Discussion and Analysis of Financial Condition and Report of Operations*; Item 303 of Regulation S-B, *Management's Discussion and Analysis or Plan of Operations*; and Item 5 of Form 20-F, *Operating and Financial Review and Prospects*; and are collectively known as the Securities and Exchange Commission's MD&A rules.

LCR Literature

Liquidity requirements, like capital requirements, are expected to enhance the resilience of the banking industry during times of financial stress but at the cost of reduced credit during times of economic expansion. The OFR's *2014 Annual Report* summarizes the findings of several studies of the LCR's potential effect on economic growth.[5] Although estimates vary, these studies suggest the LCR could reduce lending volumes by 3-5 percent, increase interest rates by 15-30 basis points, and reduce economic growth by anywhere between a few basis points and 3 percentage points. However, these studies date from 2011 and consider an early version of the LCR, which the Basel Committee subsequently made less stringent in 2013. The final U.S. rule is more restrictive than the 2013 Basel standard, so it is difficult to say anything conclusive about the relationship between these studies and the final U.S. standard as adopted.

Concerns have also been raised in the literature about potential LCR interactions with monetary policy, particularly in Europe. Bech and Keister (2013) model the potential effects of a high-quality liquid assets shortfall within the banking system on a central bank's ability to control short-term interest rates. They find central banks must account for changes in the relationship between the quantity of central bank reserves and market interest-rate changes and that a combination of reduced demand for overnight funding and increased demand for term funding tends to steepen the short end of the yield curve. Similarly, Bonner and Eijffinger (2013) investigate borrowing in the interbank lending market by Dutch banks subject to a domestic liquidity coverage ratio similar to the LCR. They find banks near the compliance threshold pay more for interbank loans, particularly those with maturities beyond 30 days. Schmitz (2013) shows how the LCR could interfere with monetary policy in the euro area. He also shows the

[5] See Figure 3-7, page 52.

LCR could create feedback effects that make the unsecured interbank market more susceptible to liquidity shocks.

Another important line of LCR research examines the new liquidity standard's impact on financial stability. Van den End and Kruidhof (2013) argue the LCR could serve as a helpful macroprudential instrument if regulators are allowed to use discretion in how liquidity buffers are deployed during times of stress. Conversely, Hartlage (2012) shows how the LCR's construction undermines financial stability by creating market distortions associated with bank attempts to maintain compliance. His examples demonstrate a snowballing effect that could occur when a bank attempts to roll over short-term wholesale funding subject to a 100 percent runoff rate in the rule. Hartlage also shows that if banks attempt to avoid the problem by substituting retail deposits for wholesale funding, aggressive competition for those deposits among banks subject to the LCR standard could result in increased retail deposit runoff rates and volatility across the banking sector.

There are also studies of the likely effects of the LCR on bank balance sheets. Balasubramanyan and VanHoose (2013) present a theoretical model of bank-balance-sheet dynamics to test how the LCR constraint is likely to affect deposits. They find mostly ambiguous and confounding deposit dynamics given the complexity of the LCR calculation. Banerjee and Mio (2014) empirically investigate British banks' response to the United Kingdom's Individual Liquidity Guidance regulation and find evidence banks increased their nonfinancial deposits and reduced their reliance on short-term wholesale funding.

Lastly, there are a few studies examining the relationship between various accounting measures and the LCR. Song (2014) investigates the application of accounting rules to liquidity regulation and finds that recurring fair value measurements have procyclical effects on the LCR.

Hong et al. (2014) use Call Report data to approximate the LCR and the net stable funding ratio and find only limited effects on bank failures.

This paper contributes to the literature on the efficacy of the LCR's ratio approach to measuring liquidity risk. Examples demonstrate the analytical challenges in interpreting banks' LCRs when transactions simultaneously affect the numerator and denominator. We proceed as follows: First, we describe how the LCR is defined and calculated under the Basel rule, which uses adjustments to remove the effects of secured funding transactions or asset exchanges. Next, we show that even with those adjustments, there is room for manipulation of buffer diversification requirements under the Basel rule. The U.S. rule addresses that manipulation, but introduces the potential for significant divergence from the Basel standard that reduces comparability across banks operating under the two different standards. The U.S. rule also introduces volatility in reporting for the same bank over time. Under both standards, banks can undertake secured funding transactions which affect the numerator and denominator of the LCR, and thus, alter the ratio itself.

Computing the LCR

The LCR requires covered banks to hold sufficient high-quality liquid assets (HQLA) to survive a significant liquidity stress scenario lasting 30 days. The most basic form of the LCR, often used in academic papers to explain the standard to the reader, is:

$$\frac{HQLA}{net\ cash\ outflow\ over\ 30\ days} \geq 100\%$$

But there is much more to the rule than this simple summary ratio. The calculation of both the numerator and denominator are complex and involve over 300 inputs. The Basel version contains two caps in the LCR numerator to ensure asset diversification in banks' HQLA buffers and another cap in the denominator to prevent over-reliance on cash inflows. These caps make use of min/max functions that introduce nonlinearities into banks' LCRs and increase the complexity of forecasting and maintaining compliance, particularly during liquidity shocks. The U.S. rule contains additional min/max functions in both the numerator and denominator.

The Basel standard categorizes the types of assets that qualify as HQLA in decreasing order of quality and liquidity. Level 1 assets are the highest quality and most liquid assets and are included in the HQLA pool at their full market value. Level 2A assets are considered liquid, stable, and readily marketable, but less so than Level 1 assets. As a result, Level 2A assets are subject to a 15 percent haircut before inclusion in the HQLA pool. Level 2B assets receive haircuts of 25 or 50 percent, depending on type, to reflect both their lower liquidity and higher price volatility. Table 1 compares qualifying assets and haircuts under the Basel and U.S. standards.[6]

The diversification caps are applied to Level 2 assets to ensure banks do not rely too much on these less liquid assets during a time of liquidity stress. The amount of Level 2B assets allowed in a bank's total HQLA pool is capped at 15 percent. The amount of Level 2A and Level 2B assets, combined, is capped at 40 percent.

[6] The European Union definitions in Capital Requirements Directive IV also differ from Basel. For example, certain high-quality covered bonds are considered Level 1 assets but are subject to a 7 percent haircut.

Table 1. Asset Qualifications by Level Under Basel and U.S. Standards

Asset	Basel	U.S.
Level 1, 0% haircut	Coins and banknotes.	
	Withdrawable central bank reserves, including required reserves.	Central bank reserves, excluding required reserves not met with coins and banknotes.
		Withdrawable foreign central bank reserves.
		Securities issued (guaranteed) by an agency whose obligations are fully and explicitly backed by the U.S. government.
	Securities guaranteed by a 0% risk-weighted foreign sovereign, central bank, public sector entity (PSE), or certain multilateral organizations.	Securities guaranteed by a 0% risk-weighted foreign sovereign, central bank, or certain multilateral organizations.
	Foreign currency-denominated debt securities issued by non-0% risk-weighted sovereigns or central banks, to the extent of currency-matched net cash outflows.	Foreign currency-denominated debt securities issued by non-0% risk-weighted sovereigns or central banks, to the extent of currency-matched net cash outflows.
Level 2A, 15% haircut	Nonfinancial corporate debt securities, including commercial paper, and covered bonds not issued by the bank or its affiliates. Credit quality must be equivalent to at least an AA- rating.	Securities issued by U.S. government-sponsored enterprises.
	Securities guaranteed by a 20% risk-weighted foreign sovereign, central bank, PSE, or certain multilateral organizations.	Securities guaranteed by a 20% risk-weighted foreign sovereign, central bank, or certain multilateral organizations.
Level 2B, 25% haircut	Residential mortgage-backed securities not issued by, or containing mortgages originated by, the bank or its affiliates. Credit quality must be equivalent to at least an AA rating.	
Level 2B, 50% haircut	Nonfinancial corporate debt securities, including commercial paper, not issued by the bank or its affiliates. Credit quality equivalent to a BBB- to A+ rating.	Nonfinancial corporate debt securities with an investment grade credit quality.
	Exchange-traded, centrally cleared common equity shares issued by nonfinancial corporations and included in a major index. Must be currency matched.	Common equity securities of nonfinancial companies listed in the Russell 1000 index. Must be currency matched.

Sources: Authors' review of BCBS (2013) and OCC and others (2014).

LCR Manipulation: Numerator Effects Under Basel III

To prevent the bank from using secured funding transactions to circumvent the caps on the lower quality Level 2 and Level 2B assets, the Basel rule requires adjusting a bank's HQLA. Adjusted Level 1, Level 2A, and Level 2B HQLA amounts are determined by unwinding all of the bank's secured lending and funding transactions and asset exchanges involving HQLA and maturing within the 30-day window. These adjusted values are then used to determine the amount of Level 2 and Level 2B HQLA excluded from the LCR numerator based on the caps.

Under the Basel rule, the formula for the LCR numerator is:

$$HQLA = L1 + L2A + L2B - L2B\ excess\ under\ 15\%\ cap - L2\ excess\ under\ 40\%\ cap$$

Where,

$$L2B\ excess\ under\ 15\%\ cap = max\left(L2B_{adj} - \frac{15}{85} \times \left(L1_{adj} + L2A_{adj}\right), L2B_{adj} - \frac{15}{60} \times L1_{adj}, 0\right)$$

$$L2\ excess\ under\ 40\%\ cap = max\left(\left(L2A_{adj} + L2B_{adj} - L2B\ excess\ under\ 15\%\ cap\right) - \frac{40}{60} \times L1_{adj}, 0\right)$$

Our first LCR calculation example, shown in Table 2, has no HQLA adjustments. That is, $L1_{adj}$ = L1, $L2A_{adj}$ = L2A, and $L2B_{adj}$ = L2B. Subtracting the excess L2B and L2 assets from the sum of L1, L2A, and L2B yields HQLA of $250. Because of the caps on Level 2B and Level 2 assets, $1,550 of the bank's $1,800 in eligible HQLA is excluded from the LCR numerator. Clearly, the bank has an incentive to exchange Level 2B assets for Level 1 and Level 2A assets to boost the amount of HQLA in its LCR numerator.

Table 2. LCR Numerator with No HQLA Adjustments

HQLA Category	Pre-haircut HQLA	Haircut	Unadjusted HQLA	Adjusted HQLA
Level 1	150.00	0.00	150.00	150.00
Level 2A	294.12	0.15	250.00	250.00
Level 2B	2,800.00	0.50	1,400.00	1,400.00
Total			1,800.00	1,800.00
Subtraction for 15% cap			1,362.50	
Subtraction for 40% cap			187.50	
LCR numerator			250.00	

Sources: Federal Register and authors' data adjustments and calculations

In our second example, the bank initiates a five-day repurchase agreement (repo) and an asset exchange backed by a total of \$2,600 in Level 2B HQLA in an attempt to increase its LCR numerator. The bank obtains \$1,050 in cash, a Level 1 asset, in exchange for posting \$2,100 in Level 2B collateral. The difference between the amount of cash received and the amount of collateral posted reflects the 50 percent haircut on the Level 2B assets. The bank exchanges another \$500 in Level 2B assets, worth \$250 in cash, for \$250/(1 – 0.15) = \$294.12 in Level 2A assets (pre-haircut). The bank's unadjusted HQLA on Day 0 at the start of the 30-day LCR calculation window is shown in the last column of Table 3. Its total unadjusted HQLA is still \$1,800, but its HQLA is now mostly higher quality Level 1 and 2A assets.

Table 3. Manipulation of HQLA Using Repo and Asset Exchange

HQLA Category	Pre-haircut HQLA Before Repo/Exchange	Repo/Exchange Amounts	Pre-haircut HQLA After Repo/Exchange	Haircut	Unadjusted HQLA
Level 1	150.00	1,050.00	1,200.00	0.00	1,200.00
Level 2A	294.12	294.12	588.24	0.15	500.00
Level 2B	2,800.00	-2,600.00	200.00	0.50	100.00
Total					1,800.00

Source: Federal Register and authors' data adjustments and calculations

In Table 4, we use these pre- and post-repo HQLA amounts to show how the Basel rule prevents this type of HQLA manipulation. The unadjusted Level 1, 2A, and 2B amounts in Table

4 match those in the last column of Table 3. When we unwind the repo and asset exchange, we get the adjusted HQLA amounts shown in the last column of Table 4, which match those in the last column of Table 2. The Basel calculation recognizes the cash on the bank's balance sheet today obtained through the repo might not be available at the end of the 30-day horizon and gives the firm no credit for the cash as a Level 1 asset in determining whether its HQLA buffer is diversified.[7] It does so by computing the caps on Level 2A and Level 2B assets using the adjusted HQLA amounts, which are the same amounts the bank started with before it attempted to manipulate its HQLA.

Table 4. LCR Numerator with Repo and Asset Exchange

HQLA Category	Pre-haircut HQLA	Haircut	Unadjusted HQLA	Adjusted HQLA
Level 1	1,200.00	0.00	1,200.00	150.00
Level 2A	588.24	0.15	500.00	250.00
Level 2B	200.00	0.50	100.00	1,400.00
Total			1,800.00	1,800.00
Subtraction for 15% cap			1,362.50	
Subtraction for 40% cap			187.50	
LCR numerator			250.00	

Sources: Federal Register and authors' data adjustments and calculations

Although this calculation solves the important problem of banks using short-term repo transactions to create the appearance of HQLA diversification, it leaves unresolved issues posed by banks' reverse repos. A bank could, in theory, lend out most, or even all, of its cash in a 29-day reverse repo transaction and still receive credit under the Basel rule for its Level 2 assets because the diversification cap applies only to the bank's HQLA at the end of the 30-day window. Although the bank's cash is locked up for most of the month in a reverse repo, it is still credited for the cash's return on Day 29, allowing the Level 2 assets it continues to hold on its

[7] See OCC and others (2014), pp. 61474-61477. We scaled the Levels 1, 2A, and 2B amounts by a factor of 100.

balance sheet to count as HQLA. In other words, the bank's adjusted Level 1 amount of $1,200 under the reverse repo "uncaps" the Level 2 assets it currently holds because the reverse repo unwinds within the 30-day window. The HQLA diversification cap under the Basel rule arguably is not binding even though the firm's $1,800 in HQLA consists almost solely of Level 2 assets for most of the 30-day period.

This problem can be demonstrated by reversing the previous example. We start with Level 1 assets of $150, Level 2A assets of $250, and Level 2B assets of $1,400. After unwinding the reverse repo, we get Level 1 assets of $1,200, Level 2A assets of $500, and Level 2B assets of $100. For the adjustments for the 15 and 40 percent caps, we get zero, as shown in Table 5. The bank has HQLA of only $250 for most of the 30-day window, making it LCR deficient, but the Basel rule calculation yields HQLA of $1,800 and a compliant LCR. All of the bank's Level 2B assets are included in the LCR numerator despite greatly exceeding the 15 percent cap.

Table 5. LCR Numerator with Reverse Repo

HQLA Category	Pre-haircut HQLA	Haircut	Unadjusted HQLA	Adjusted HQLA
Level 1	150.00	0.00	150.00	1,200.00
Level 2A	294.12	0.15	250.00	500.00
Level 2B	2,800.00	0.50	1,400.00	100.00
Total			1,800.00	1,800.00
Subtraction for 15% cap			0.00	
Subtraction for 40% cap			0.00	
LCR numerator			1,800.00	

Sources: Federal Register and authors' data adjustments and calculations

The U.S. Rule Prevents HQLA Manipulation

In response to this problem, the U.S. rule includes a second numerator cap that requires HQLA diversification not only at the end of the 30-day window as in the Basel formula but also at the beginning. This term is bolded in the formula for the LCR numerator under the U.S. rule:

$$HQLA = L1 + L2A + L2B - max(\boldsymbol{HQLA\ excess}, HQLA_{adj}\ excess)$$

Where,

$HQLA\ excess = L2\ excess + L2B\ excess$

$HQLA_{adj}\ excess = L2_{adj}\ excess + L2B_{adj}\ excess$

Where,

$L2\ excess = max(L2A + L2B - 0.6667 \times L1{,}0)$

$L2B\ excess = max(L2B - L2\ excess - 0.1765 \times (L1 + L2A), 0)$

$L2_{adj}\ excess = max(L2A_{adj} + L2B_{adj} - 0.6667 \times L1_{adj}, 0)$

$L2B_{adj}\ excess = max(L2B_{adj} - L2_{adj}\ excess - 0.1765 \times \left(L1_{adj} + L2A_{adj}\right), 0)$

Although the formulas are stated a little differently under the U.S. rule as compared to Basel, in practice, they apply the 40 percent cap on Level 2 and 15 percent cap on Level 2B HQLA on the unadjusted HQLA amounts measured on Day 0 and the adjusted amounts measured on Day 30.[8] The U.S. calculation considers HQLA diversification on both Day 0 and Day 30 and avoids potential circumvention of the HQLA diversification cap using reverse repos and repos. Table 6 shows no matter what the starting and ending HQLA amounts are for the 30-day window, the amount of HQLA included in the LCR numerator equals \$250 under the U.S. rule, avoiding the problem of uncapping excess Level 2 assets.[9]

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[8] Rounding error differences can arise in calculations since the U.S. rule uses the approximation 0.6667 for the 40/60 ratio of Level 2 to Level 1 assets and the approximation 0.1765 for the 15/85 ratio of Level 2B to Level 1 + Level 2A assets.

[9] In this example, the U.S. formula for computing the L2B excess produces the counterintuitive result of zero for the Scenario 1 adjusted HQLA amounts and the Scenario 2 unadjusted HQLA amounts because the L2 excess already fully accounts for the Level 2B excess and is subtracted to avoid double counting: max(1400 – 1550 – 0.1765 × (150 + 250), 0) = 0.

Table 6. U.S. LCR Numerator Calculated Under Repo and Reverse Repo Scenarios

	Scenario 1: Repo		Scenario 2: Reverse Repo	
HQLA Category	**Unadjusted HQLA**	**Adjusted HQLA**	**Unadjusted HQLA**	**Adjusted HQLA**
Level 1	1,200.00	150.00	150.00	1,200.00
Level 2A	500.00	250.00	250.00	500.00
Level 2B	100.00	1,400.00	1,400.00	100.00
Total	1,800.00	1,800.00	1,800.00	1,800.00
U.S. HQLA Adjustment				
L2 Excess	0.00	1,550.00	1,550.00	0.00
L2B Excess	0.00	0.00	0.00	0.00
Excess HQLA	0.00	1,550.00	1,550.00	0.00
LCR Numerator Under U.S. Rule		250.01	250.01	

Note: The L2 excess is rounded from 1,449.995, so the LCR numerator = 1,800.000 – 1,449.995 = 250.005, which is rounded to 250.01.
Sources: Federal Register and authors' data adjustments and calculations

LCR Manipulation: Denominator Effects

The previous examples compared the effectiveness of the Basel and U.S. rules in stripping out the effects of secured funding and lending transactions and asset exchanges from the LCR numerator but left out the effects of these transactions on the denominator. The examples in this section show how, under certain conditions, a bank can inflate its LCR because of the combined numerator and denominator effects. We use the Basel standard as the basis for these examples, but the effect can also be demonstrated using the U.S. standard.

The LCR denominator is defined by the Basel rule as:

$$\textit{Total net cash outflows} = \textit{aggregated outflows} - \min(0.75 \times \textit{aggregated outflows}, \textit{aggregated inflows})$$

Aggregated outflows and inflows are defined as the cumulative sum of the cash outflows and inflows over the 30-day window. The min function forces the bank to keep HQLA sufficient to meet at least 25 percent of its expected cash outflows rather than over-rely on expected cash inflows that might not materialize during an adverse liquidity event.

The cash inflows and outflows associated with HQLA adjustments are not simply added and subtracted from the denominator.[10] In the case of repos — or similar secured funding transactions or asset exchanges — the incoming cash is counted as Level 1 HQLA in the LCR numerator, but it is not included as a cash inflow in the denominator because that would double count it. However, assuming the repo matures within the 30-day LCR window, there is potentially a cash outflow associated with the transaction to include in the LCR denominator. The size of this cash outflow reflects the risk the bank will not be able to roll over its funding. This rollover risk, in turn, depends on the quality of the underlying collateral. If the repo is backed by a Level 1 asset, there is no outflow associated with the transaction. The underlying assumption is the bank can roll over 100 percent of the short-term funding it can secure with that collateral. If the repo is backed by a Level 2A asset, the outflow on the day the repo matures equals 15 percent of the amount of cash borrowed. The underlying assumption is that, under stress, the bank will only be able to roll over 85 percent (100 percent minus the 15-percent haircut) of the short-term funding it can secure with the now-devalued collateral. For Level 2B collateral, the outflow is 25 percent or 50 percent, depending on the underlying collateral.[11]

In the case of reverse repos, or similar transactions, there is no cash outflow since the cash was already deducted from the HQLA amount in the numerator. However, similar to the treatment of cash outflows associated with repos, the cash inflows associated with reverse repos

[10] The rules for determining cash inflows and outflows are complex and differ according to Basel and U.S. rules. Details on the Basel rule can be found in BCBS (2013). Details on the U.S. rule can be found in OCC and others (2014).

[11] Under the Basel standard, residential mortgage-backed securities have an assumed outflow of 25 percent of the amount borrowed while other Level 2B assets have an assumed outflow of 50 percent.

are tied to the haircuts applied to the underlying collateral. The haircuts reflect assumptions about the reduction in secured lending that will occur during a time of liquidity stress. If the collateral underlying a reverse repo is a Level 1 asset, there is no cash inflow included in the LCR denominator calculation because it is assumed the bank will renew the agreement in full. However, if, for example, the underlying collateral is a Level 2A asset, the bank records a cash inflow on the day the transaction matures equal to 15 percent of the amount of cash lent. The underlying assumption is the bank will only provide 85 percent of the cash originally lent when it renews the agreement.

The next example demonstrates both numerator and denominator effects under a Basel rule reverse repo scenario. We start with the pre-reverse repo HQLA values shown in Table 7, Scenario 1. The bank's starting LCR is 133 percent, which is well above the minimum 100 percent required for compliance. The HQLA caps are minimally binding; Level 2B assets are 15 percent of total HQLA and Level 2 assets are 40 percent of total HQLA, so none of the Level 2 assets are deducted from total HQLA. The denominator constraint is nonbinding since 75 percent of $300 in aggregated cash outflows equals $225, which is greater than the aggregated cash inflows of $150. So the LCR denominator is simply equal to aggregated outflows of $300 minus aggregated inflows of $150.

Table 7. Comparison of Basel LCR Without and with Reverse Repo Backed by HQLA

	Scenario 1: No Reverse Repo		Scenario 2: Reverse Repo	
HQLA Category	**Unadjusted HQLA**	**Adjusted HQLA**	**Unadjusted HQLA**	**Adjusted HQLA**
Level 1	120.00	120.00	0.00	120.00
Level 2A	50.00	50.00	101.00	50.00
Level 2B	30.00	30.00	60.00	30.00
Subtraction for 15% cap	0.00		0.00	
Subtraction for 40% cap	0.00		0.00	
LCR numerator	200.00		161.00	
Aggregated outflows	300.00		300.00	
Aggregated inflows	150.00		189.00	
LCR denominator	150.00		111.00	
LCR	133.33%		145.04%	

Source: Authors' data and calculations

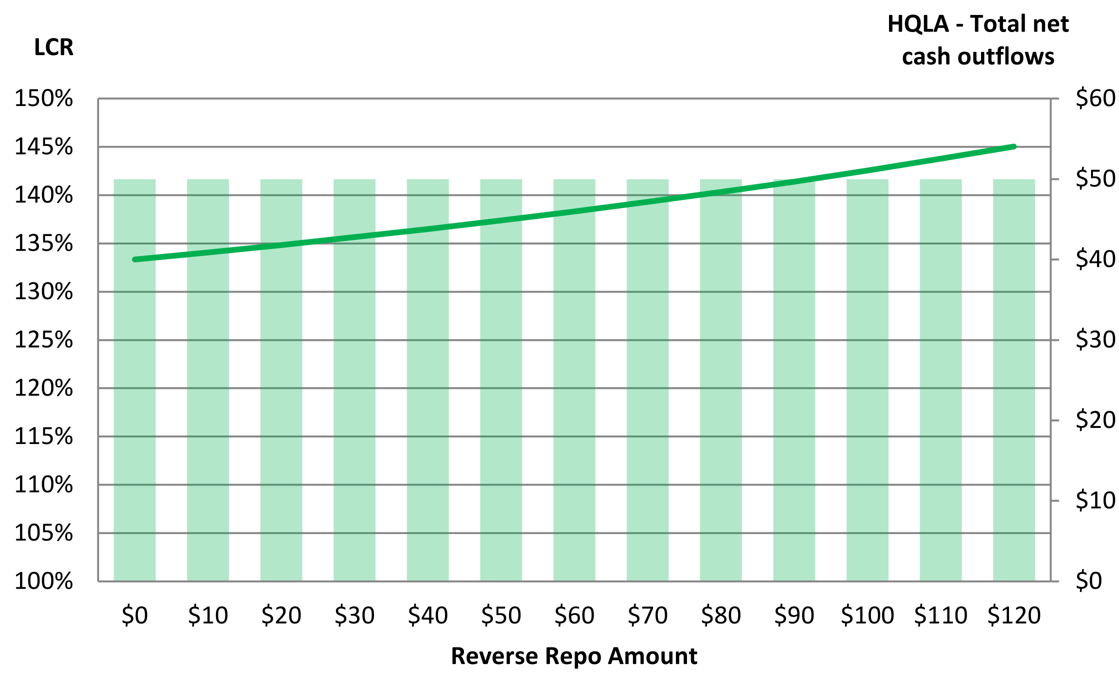
For example, the bank initiates a reverse repo of $120 backed by $60 in Level 2A collateral and $60 in Level 2B collateral before the start of its LCR calculation window. As shown in Table 7, Scenario 2, its Day 0 HQLA is $161 instead of $200 because of the $120 reduction in its Level 1 HQLA, which is partially offset by an $81 increase in its Level 2 HQLA after the haircuts have been applied. The bank's Level 2B assets now account for 37 percent of its total HQLA and its Level 2A and 2B assets together comprise 100 percent of its total HQLA. Yet, the HQLA excess computed under the 15 and 40 percent caps equals zero because the caps are based on the HQLA amounts adjusted by the unwind of the reverse repo.

Despite the $39 decrease in the numerator, the reverse repo results in a substantially higher LCR of 145 percent. This is because the denominator has also fallen by $39 on the rule's assumption that some of the lending backed by the Level 2 HQLA collateral will not be renewed during a time of liquidity stress. Specifically, since we assume the collateral backing the reverse repo is divided equally between Level 2A and Level 2B HQLA, the cash inflow when the reverse repo matures on Day 29 = (0.50 × reverse repo amount × 0.15) + (0.50 × reverse repo amount × 0.50).

The LCR under the Basel framework rises with the amount of reverse repo up until the point the bank has lent out all of its Level 1 cash (see Figure 1). The LCR rises continuously since the denominator constraint never binds. If it had, the LCR would have increased only up to the point the constraint became binding and then would have decreased.

Figure 1 also compares the LCR's ratio approach to assessing liquidity needs with an analogous liquidity gap approach. Specifically, the bar chart measures the adequacy of the bank's HQLA buffer by subtracting the LCR denominator from the numerator. This liquidity gap approach completely strips out the effects of the reverse repo transaction. No matter how much is lent, the bank's liquidity gap remains steady at $50.

Figure 1. Liquidity Coverage Ratio and Gap Approaches by HQLA-backed Reverse Repos



Source: Authors' data and calculations

The next example shows that changes in a bank's LCR from engaging in secured lending transactions depend on the LCR starting level. In Table 8, we assume a bank engages in a $5 reverse repo backed by non-HQLA and maturing on Day 29 for three different LCR starting levels. The first two columns correspond to a starting LCR of 100 percent. The bank lends out $5 of its Level 1 cash, which comes out of the LCR numerator, but it also records a cash inflow of $5 in the denominator to reflect the assumption it will not renew any secured lending transactions backed by non-HQLA collateral under conditions of liquidity stress. In this case, the LCR is unchanged by the reverse repo because the numerator and denominator effects associated with the transaction perfectly offset each other.

In Columns 3 and 4, the bank has a starting ratio of 95 percent. After subtracting $5 from both the numerator and denominator as a result of the $5 reverse repo, the bank's LCR falls slightly below 95 percent since the subtraction from the numerator has a larger impact than the subtraction from the denominator. In Columns 5 and 6, the bank has a starting ratio of 105 percent. After subtracting $5 from both the numerator and denominator because of the reverse repo, its LCR rises to a little over 105 percent since the subtraction has a proportionally larger effect on the denominator than the numerator.

Table 8. Changes to a Bank's LCR from a $5 Reverse Repo Depend on its Starting Level

	Baseline LCR = 100%		Baseline LCR = 95%		Baseline LCR = 105%	
	Baseline	Reverse Repo	Baseline	Reverse Repo	Baseline	Reverse Repo
Level 1 HQLA	60.00	55.00	60.00	55.00	65.00	60.00
Level 2A HQLA	25.00	25.00	25.00	25.00	25.00	25.00
Level 2B HQLA	15.00	15.00	10.00	10.00	15.00	15.00
LCR Numerator	100.00	95.00	95.00	90.00	105.00	100.00
LCR Denominator	100.00	95.00	100.00	95.00	100.00	95.00
LCR	100.00%	100.00%	95.00%	94.74%	105.00%	105.26%

Source: Authors' data and calculations

Repo transactions cause similar, but far more limited, effects. In the example shown in Table 9, the bank has a starting LCR of 95 percent. It can increase the ratio using repo transactions; however, no amount of repo will flip the bank into compliance. Larger and larger repo amounts can, at most, cause the bank's LCR to asymptotically approach 100 percent. Still, a bank with a noncompliant LCR can at least appear to reduce the extent of its noncompliance with the standard using repo, potentially distorting both time-series and peer analysis.

Table 9. Incremental Effects of Repos on LCR When Starting Ratio Is Under 100 Percent

	Baseline LCR = 95 %			
	Baseline	**$ 5 Repo**	**$100 Repo**	**$1,000 Repo**
Level 1 HQLA	60.00	65.00	160.00	1060.00
Level 2A HQLA	25.00	25.00	25.00	25.00
Level 2B HQLA	10.00	10.00	10.00	10.00
LCR Numerator	95.00	100.00	195.00	1095.00
LCR Denominator	100.00	105.00	200.00	1100.00
LCR	95.00%	95.24%	97.50%	99.55%

Source: Authors' data and calculations

The U.S. Rule Increases LCR Volatility

Because the Basel approach doesn't account for potentially higher cumulative net cash outflows during the month as compared to the end of the month — which can be important during an adverse liquidity event — the U.S. definition includes a maturity mismatch add-on term in the denominator.

The LCR denominator is defined by the U.S. rule as:

$$\textit{Total net cash outflows} = \textit{aggregated outflows} - \min(0.75\times \textit{aggregated outflows}, \textit{aggregated inflows}) + \textit{maturity mismatch add-on}$$

Where,

$$Maturity\ mismatch\ add\text{-}on$$
$$= max[0, \max_{i=1\ to\ 30}(net\ cumulative\ maturity\ outflow_{Day\ i})]$$
$$- max(0, net\ cumulative\ maturity\ outflow_{Day\ 30})$$

Aggregated outflows (inflows) are defined as the cumulative sum of the maturity cash outflows (inflows) over the 30-day window plus the non-maturity outflows (inflows). Maturity cash flows are those transactions expected to occur on a contractually determined date within the 30-day window. Maturity cash flows include, for example, the cash inflows or outflows associated with the maturity of the repo and reverse repo transactions used in the earlier examples. Non-maturity cash flows may occur during the 30-day window but cannot be assigned to a particular day. Non-maturity cash flows include, for example, the assumed cash outflows associated with retail deposits under the LCR calculation assumption of a 3 percent runoff rate.

The maturity mismatch add-on is equal to the peak-day net cumulative maturity outflow during the 30-day window (or zero, if negative) minus the net cumulative maturity outflow on day 30 (or zero, if negative). That is, the net cumulative maturity outflow is calculated for each day within the 30-day window, and the calculation differs from that for the total net cash outflow by excluding the non-maturity inflows and outflows. The U.S. rule took this approach out of concern a bank could have substantial mismatches in its cash inflows and outflows during the 30-day period and face liquidity risk even while satisfying the LCR. The Basel Committee has also expressed this concern and recommends bank supervisors implement a monitoring regime to detect mismatches within the 30-day window. Federal Reserve Forms 2052a and 2052b could allow U.S. supervisors to monitor these mismatches.

The maturity mismatch add-on encourages banks to better match inflows and outflows, improving liquidity risk management. However, such time-varying volatility in the LCR complicates the interpretation of the LCR metric both across banks and for the same bank over time. To demonstrate, we use a simple example with no HQLA adjustments. Table 10 compares the LCR calculated under Basel and U.S. rules using the assumed cash inflows and outflows shown in Table 11. The numerator calculated under both rules yields HQLA of $250. The maturity mismatch add-on equals the peak-day net cumulative maturity outflow of $85 on Day 18, shown in red font in Table 11. Note that the full peak-day outflow is included in the LCR denominator since the net cumulative maturity outflow on Day 30 is not positive and so is not subtracted.

Table 10. LCR Under Basel and U.S. Rules Assuming No HQLA Adjustments

	Basel		U.S. Rule	
HQLA Category	**Unadjusted HQLA**	**Adjusted HQLA**	**Unadjusted HQLA**	**Adjusted HQLA**
Level 1	150.00	150.00	150.00	150.00
Level 2A	250.00	250.00	250.00	250.00
Level 2B	1,400.00	1,400.00	1,400.00	1,400.00
Total	1,800.00	1,800.00	1,800.00	1,800.00
Subtraction for 15% cap		1,362.50	1,550.00	1,550.00
Subtraction for 40% cap		187.50	0.00	0.00
Rule	**HQLA**	**Net Cash Outflows**	**Maturity Mismatch Add-on**	**LCR**
Basel	250.00	177.50		140.85%
U.S.	250.01	177.50	85.00	95.24%

Sources: Federal Register and authors' data adjustments and calculations

Table 11. Cash Flows for Calculating the LCR with the Maturity Mismatch Add-on

Day	Non-maturity Outflows	Maturity Outflows	Cumulative Maturity Outflows	Non-maturity Inflows	Maturity Inflows	Cumulative Maturity Inflows	Net Cumulative Maturity Outflows
1		100	100		90	90	10
2		20	120		5	95	25
3		10	130		5	100	30
4		15	145		20	120	25
5		20	165		15	135	30
6		0	165		0	135	30
7		0	165		0	135	30
8		10	175		8	143	32
9		15	190		7	150	40
10		25	215		20	170	45
11		35	250		5	175	75
12		10	260		15	190	70
13		0	260		0	190	70
14		0	260		0	190	70
15		5	265		5	195	70
16		15	280		5	200	80
17		5	285		5	205	80
18		10	295		5	210	**85**
19		15	310		20	230	80
20		0	310		0	230	80
21		0	310		0	230	80
22		20	330		45	275	55
23		20	350		40	315	35
24		5	355		20	335	20
25		40	395		5	340	55
26		8	403		125	465	-62
27		0	403		0	465	-62
28		0	403		0	465	-62
29		5	408		10	475	-67
30		2	410		5	480	-70
Sum	**300**	**410**		**100**	**480**		

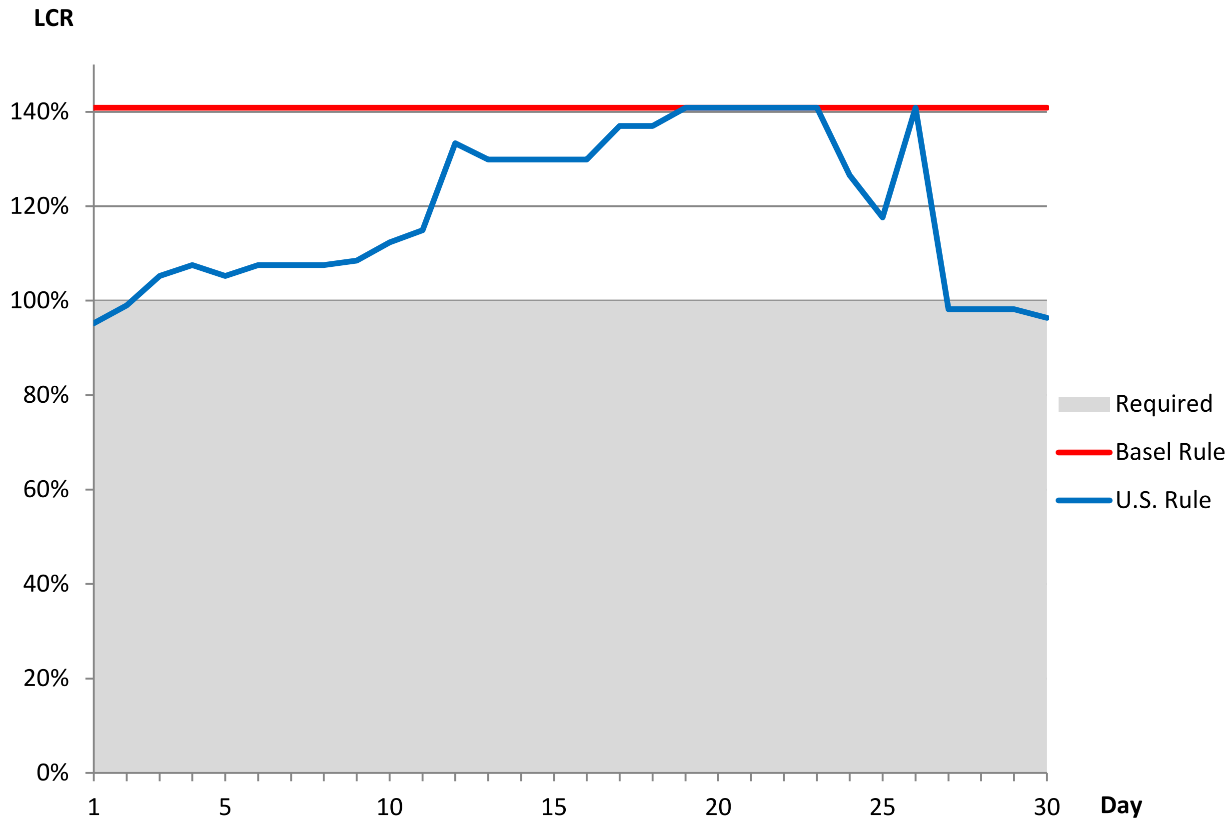
Note: The peak-day net cumulative maturity outflow is shown in red.
Source: Federal Register

The maturity mismatch add-on helps address the problem of high liquidity risk during the month even when the bank's LCR is compliant under the Basel standard, but it also can create time-varying volatility with the potential to increase LCR compliance costs and complicate interpretation of LCR changes. To demonstrate, we shift the Table 11 cash flows sequentially over the 30-day window to illustrate the passage of a month. At no time in the exercise is the size of daily cash inflows or outflows over the next 30 days changing. Rather, what is changing is the position of this pattern of inflows and outflows within the LCR's 30-day window.

As shown in Figure 2, the LCR for this hypothetical bank varies considerably over the 30-day window. Most of the time, the LCR is above the 100 percent minimum required. It even equals the LCR computed under the Basel rule for 6 of the 30 days. Note that the LCR computed under the Basel rule remains steady at just over 140 percent and never requires the bank to report a shortfall. In contrast, under the U.S. rule, the bank must report an LCR deficiency for 6 of the 30 days. Moreover, for the 4-day consecutive deficiency at the end of the 30-day window, the bank is also required to provide its supervisor a plan for remediation of the liquidity shortfall.[12]

[12] The U.S. rule requires banks to submit remediation plans for deficiencies over three consecutive business days.

Figure 2. Volatility of LCR Under the U.S. Rule



Source: Federal Register and authors' data adjustments and calculations

So shifts in the timing of the same set of cash flows within the 30-day window have significant implications for a bank's required amount of HQLA. Moreover, changes in HQLA requirements do not follow a smooth functional form. One way to understand the intuition behind this finding is that when a day with significant cash inflows falls before the peak day, it helps offset the bank's requirement to hold buffer assets. On the other hand, when those cash inflows shift to the back of the 30-day window, the required amount of HQLA increases dramatically because the cash flows are no longer available to help offset the peak day.

As demonstrated by this example, when cash inflows and outflows are similar from month to month, banks are likely to maintain HQLA sufficient to cover their worst day even if they need substantially lower levels of liquidity over the rest of the month. Although some may argue this contributes to bank safety and soundness, the introduction of volatility into banks' LCR denominators makes comparisons across banks and over time far less meaningful in practice. Analysts will need to decompose LCRs calculated under the U.S. rule into Basel-equivalent and add-on components for comparison with LCRs computed under Basel standards.

Conclusion

Under both Basel and U.S. standards, covered banks' LCRs can vary in complex, nonlinear ways not necessarily related to underlying liquidity risk. This is, in part, due to the use of min/max functions in the numerator and denominator. However, it is also because the metric was built using a ratio approach, creating the potential for secured lending and borrowing transactions to simultaneously affect the LCR numerator and denominator. A complementary gap approach could be used to enhance the regulatory goal of a quantifiable measure of liquidity risk with meaningful variance. For example, HQLA – net cash outflows > 0 could be an equivalent regulatory standard.[13] For peer analysis, this gap measure could be normalized by dividing it by total assets or exposures. Such a change could help strengthen the LCR's efficacy as a regulatory metric. Alternatively, although the LCR is a stress metric, liquidity stress testing could be used to address some of the shortcomings we identify in this paper.

Comparability of LCRs across banks is also reduced by substantial differences between the Basel and U.S. rules for calculating the ratio. U.S. regulators made a change in implementing the Basel standard to make it harder for banks to circumvent the HQLA diversification requirements through their use of reverse repos. U.S. regulators also made changes to the Basel standard to quantify liquidity mismatches within the 30-day window. However, there are potential

[13] This would exclude the add-on term in the U.S. rule, and thus, would not capture liquidity mismatches within the 30-day window.

unintended consequences from those changes, including difficulty in interpreting daily fluctuations in U.S. banks' LCRs due to the maximum peak day add-on. Additionally, we document examples in which a bank could appear comfortably above the standard using the Basel approach, but could be significantly noncompliant under the U.S. rule. Finally, banks can alter their LCRs through their use of repos and reverse repos under both the Basel and U.S. standards.

Because of potential negative signaling effects, banks are likely to feel pressured to maintain LCRs above 100 percent even during times of stress. Indeed, the Basel Committee recognizes the threat to financial stability posed by banks attempting to maintain an LCR over 100 percent during times of stress. In the January 2013 publication "Basel III: The Liquidity Coverage Ratio and Liquidity Risk Monitoring Tools," the committee notes, "The potential for contagion to the financial system and additional restricted flow of credit or reduced market liquidity due to actions to maintain an LCR of 100 (percent)." The committee also suggests that a bank "periodically monetize a representative proportion of the assets in the stock [of HQLA] through repo or outright sale, in order to test its access to the market, the effectiveness of its processes for monetization, the availability of the assets, and to *minimize the risk of negative signaling during a period of actual stress*."

The literature also shows the LCR could have unintended negative effects on interbank funding and interest rates through interactions with monetary policy. Banks' secured funding transactions with the central bank could alter their LCRs and potentially complicate the implementation of monetary policy. Schmitz (2013) has already identified one likely regulatory arbitrage strategy pursued by banks, namely obtaining HQLA from repos with the European Central Bank by swapping non-HQLA for central bank reserves, which are Level 1 HQLA. In light of the impacts of secured funding transactions on banks' LCRs we have illustrated in this paper, the LCR's implications for central banks' open market operations remain an important area for further study.

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