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How have banks been managing the composition of high-quality liquid assets?

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Abstract

We study banks' post-crisis liquidity management. We construct time series of U.S. banks' holdings of high-quality liquid assets (HQLA) and examine how these assets have been managed in recent years to comply with the Liquidity Coverage Ratio (LCR) requirement. We find that, in becoming LCR compliant, banks initially ramped up their stock of reserve balances. However, once the requirement was met, some banks subsequently shifted the compositions of their liquid portfolios significantly. This raises the question: What drives the compositions of banks' HQLA? We show that a risk-return framework can account for a range of potential portfolio compositions depending on banks' tolerance for interest rate risk. And, our data indicate that banks have indeed adopted a range of portfolio compositions, with some components exhibiting a high degree of daily variance. These findings lead us to conclude that about half of large banks are largely focused on risk-return considerations in managing the compositions of their HQLA pools while the other half appear bound by other factors. We highlight the importance of our findings for both the transmission and implementation of monetary policy.

Keywords: bank balance sheets, liquidity management, liquid assets, LCR, HQLA, reserve balances
JEL: E51, E58, G21, G28

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Analysis and conclusions set forth in this paper are those of the authors and do not indicate concurrence by other members of the staff of the Federal Reserve Board.

1. Introduction

Liquidity management—having access to sufficient quantities of cash and cash-like assets that can be converted easily and quickly into cash with little or no loss of value—has always been a key factor in banks' operations. However, it has become an even more important consideration in banks' balance sheet management in the wake of the Global Financial Crisis of 2007–09 with the introduction of new financial regulations aimed at ensuring the ability of banks to meet cash and collateral obligations. In particular, beginning in 2015, large banks in the United States have needed to comply with the Liquidity Coverage Ratio (LCR) by holding sufficient "high-quality liquid assets," or HQLA, a requirement that has induced significant changes in banks' balance sheets. In this paper we examine how U.S. banks have managed the *composition* of their HQLA over the past few years.[1] In particular, we address the following questions: Which liquid assets have banks chosen to hold? Have those liquid shares changed over time? To what extent do banks' preferences for these liquid shares vary? What factors may be driving banks' preferences in this regard?

Understanding banks' liquidity management is central to both the transmission and the implementation of monetary policy. Banks' preferences regarding their liquid pools—and in particular their demand for excess reserve balances—will interact with various short-term market interest rates and thus the Federal Reserve's setting of its administered rates. These interest rates affect the trade-off between lending and holding liquid assets and hence the transmission of monetary policy (Bianchi and Bigio 2017). In addition, these preferences could influence the longer-run size of the Federal Reserve's balance sheet and thus its options and preferences regarding how to effectively implement monetary policy in the future.

To begin our analysis, because a time series of HQLA is not available, we construct bank-level estimates of HQLA from 1997 to present. We focus on the three largest components of HQLA—banks' excess reserve balances held at the Federal Reserve as well as banks' holdings of both Treasury securities and certain mortgage-backed securities (MBS). We use our bank-level estimates to document how U.S. banks have managed the compositions of their HQLA pools over time. We find that during the run-up to becoming LCR compliant, banks in aggregate took on a significant quantity of excess reserves. However, after becoming compliant, many such banks adjusted their liquid asset holdings, reducing their stocks of reserve balances and raising their holdings of other HQLA components, presumably to achieve a more optimal configuration.

To explain our compositional findings, we use a risk-return framework that captures the relative return of the different HQLA assets, the covariance of these returns, and the sensitivity of banks'

[1] Our analysis focuses on the numerator of the LCR—banks' adjustments to the compositions of their holdings of HQLA. We recognize that to implement and manage the LCR requirement, banks also make adjustments to their balance sheet liabilities, which feed back into the calculation of necessary HQLA. Abstracting from the denominator does not affect our results.

preferences for these assets to changes in interest rates (returns). We find that the post-compliant adjustments that banks made to their HQLA shares and the current, wide variation of HQLA shares across the eight U.S. global systemically important banks (GSIBs) can be accounted for by our model. That is, our model suggests that a wide range of possible "optimal" portfolios of HQLA is plausible, a range that, in the context of portfolio theory, largely depends on a bank's tolerance for interest rate risk. Of course, other factors are relevant to banks' liquidity management and these factors may influence banks' demand for cash-like assets as well.

We also examine daily, bank-reported confidential HQLA data for the eight GSIBs and find that the volatility of banks' HQLA shares differ. About half of these banks have high daily volatility in their reserve share, suggesting that decisions regarding reserve holdings for these banks may primarily be tied to daily business operations and not a risk-return decision framework. Meanwhile, the other half have relatively stable HQLA shares, which is consistent with a risk-return framework and a preference for keeping these asset holdings relatively constant at the desired targets.

We proceed as follows. Section 2 positions our work in the related literature. Section 3 provides background information about the LCR and HQLA and describes the data series we construct. Based on those data, section 4 describes how banks initially adjusted, and then subsequently managed, the compositions of their HQLA. Section 5 introduces our model, highlighting key factors that drive the range of optimal HQLA shares. Sections 6 and 7 examine bank-level data for the GSIBs, the range of both the size and volatility of these banks' HQLA shares. Section 8 concludes.

2. Related Literature

Given that regulatory liquidity requirements are relatively new for the U.S. banking industry, research regarding how banks are adjusting to these post-crisis regulations is nascent and growing. For example, Allen (2014) and Diamond and Kashyap (2016) survey the existing literature and generally conclude that more research is needed to understand the effects of liquidity regulation on banks' behavior.

That said, our work is complementary to a few studies. Banerjee and Mio (2015) describe their work as being the first study to estimate the causal effect of liquidity regulation on bank balance sheets. They examine the impact on banks' balance sheets of the implementation of a new LCR-like requirement in the United Kingdom (U.K.) and find that U.K. banks adjusted the composition of both their assets and liabilities at the onset of the new requirement, increasing the share of HQLA held. Our findings are similar in that we document an increase in U.S. banks' share of HQLA in response to new U.S. liquidity regulation. Our study differs in that we also consider how banks subsequently managed the compositions of their liquid assets once initially becoming regulatory compliant.

Cetina and Gleason (2015) use examples to show how compositional asset and liability caps in the U.S. LCR rule introduce nonlinearities in the calculation of the ratio, and conclude that banks' LCRs can vary in complex ways not necessarily related to underlying liquidity risk. In our analysis, we also account for the nonlinearity of caps in our model estimates. However, our work differs from this study in that we focus on the compositional shares of HQLA and abstract from the issues associated with the computation of the LCR itself.

Balasubramanyan and VanHoose (2013) use a theoretical model to examine how the LCR is likely to affect bank balance sheet dynamics and conclude that the LCR may generate bank responses that are not necessarily fully consistent with a policy objective of greater stability of bank deposits and loans. Our study differs in that we focus on a different slice of banks' balance sheets—their HQLA portfolios—and shed light on how such holdings have evolved in light of the LCR and why that may be the case.

Other LCR-related research includes theoretical work that explores the interaction between liquidity regulation and monetary policy (Bech and Keister (2017) and Duffie and Krishnamurthy (2016)) and dynamic general equilibrium models that explore the interactions between banks' responses to liquidity and capital regulations (Adrian and Boyarchenko (2013) and Covas and Driscoll (2014)). Our paper adds to the literature on theoretical approaches to studying the effects of liquidity regulation on bank behavior by using a risk-return framework—optimal portfolio theory—to motivate banks' preferences for the compositions of their HQLA portfolios.

We now review key aspects of the U.S. LCR requirement, including why it was implemented, and then describe how we compute our time series estimates of bank-level HQLA.

3. Background and data construction

During the Global Financial Crisis of 2007–09, substantial stress in U.S. funding markets—illiquidity—caused solvency issues for several large financial institutions. With financial markets quite fragile, funding shocks easily spread across the financial system. As a result, international financial regulators sought to improve the resiliency of the financial system by incorporating liquidity requirements into the Basel III framework for enhanced regulation of banking institutions. Basel III is a comprehensive set of reform measures, developed by the Basel Committee on Banking Supervision (BCBS), to strengthen the regulation, supervision, and risk management of the banking sector.[2] One key liquidity measure, and the focus of this paper, is the LCR.

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[2] The BCBS is a committee of international banking supervisory authorities that was established by the central bank governors of the G10 countries in 1975. The Office of the Comptroller of the Currency (OCC), Federal Reserve Board, and Federal Deposit Insurance Corporation (FDIC) actively participate in the BCBS and its international efforts. Documents issued by the BCBS are available through the Bank of International Settlements web site at this

The LCR aims to strengthen the liquidity positions of financial institutions by creating a standardized minimum daily liquidity requirement for large and internationally active banking organizations.[3] In particular, relative to the pre-crisis period, the LCR requires that bank holding companies (BHCs) maintain ready access to a pre-determined minimum level of highly liquid assets to meet demand for cash over the short term, a rolling 30-day period. (In this paper we will use the terms "BHCs" and "banks" interchangeably.) The LCR formula is shown by equation (1).

$$LCR = \frac{HQLA}{Estimated\ net\ cash\ outflows} \geq 100\% \qquad (1)$$

The numerator of the ratio, HQLA, is made up of a range of liquid assets that are grouped into categories according to their approximate "level" of liquidity. We describe these categories to the extent that is relevant for our analysis and also establish naming conventions for these asset groupings.

As shown in table 1, "Level 1" assets, the most liquid form of HQLA and free of haircuts and limiting compositional caps, include excess reserves and securities issued or guaranteed by the U.S. government. Excess reserves are balances held at Federal Reserve Banks in addition to any that banks' must hold to meet reserve requirements against their deposit liabilities. The allowable securities in the Level 1 asset category include U.S. Treasury securities, Government National Mortgage Association (GNMA) MBS, and obligations issued by U.S. government agencies (or "non-GSE agency debt"). U.S. government agencies (non-GSEs) include GNMA, the Federal Deposit Insurance Corporation, and the Small Business Administration.

"Level 2" assets, which cannot be more than 40 percent of total HQLA, are comprised of two subcategories:

- Level 2A assets are subject to a 15 percent haircut and include securities issued or guaranteed by a U.S. government-sponsored enterprise (GSE), such as GSE debt

link: http://www.bis.org/. The BCBS' description of the LCR may be found here: http://www.bis.org/publ/bcbs238.pdf. Information about the Basel III framework may be found here: http://www.bis.org/bcbs/basel3.htm.

[3] The text of the final U.S. LCR rule, issued in September 2014, may be found here: https://www.federalreserve.gov/newsevents/pressreleases/bcreg20140903a.htm. For a descriptive overview of the LCR rule, see House, Sablik, and Walter (2016). Of course, the LCR is not the first incidence of liquidity regulation of U.S. financial institutions. Reserve requirements of depository institutions, administered by the Federal Reserve, were originally implemented as a prudential requirement to promote banks' liquidity positions. However, the prevalence of banks' retail deposit sweep programs, begun in the mid-1990s, meant that reserve requirements were not commonly a binding consideration for most large banks prior to the financial crisis. See Bouwman (2015) for a synthesis of the theoretical and empirical literature on the economics of how banks create liquidity and of related issues regarding liquidity requirements. A historical overview of liquidity regulation is also provided, ending with Basel III and the Dodd-Frank Act.

securities as well as these institutions' residential MBS and commercial MBS (CMBS). (U.S. GSEs are defined in the notes to table 1.)

- Level 2B assets (not shown), which include corporate debt securities and tend to comprise a much smaller portion of banks' balance sheets, are subject to a substantial haircut (50 percent) and can be no more than 15 percent of total HQLA. Without loss of generality, we abstract from these assets in our analysis.[4]

Of the various HQLA assets, banks in aggregate hold the largest amounts of excess reserves, Treasury securities, and GSE MBS, the highlighted cells of table 1 and the predominant focus of our analysis.

Table 1
Selected Components of HQLA
(largest 3 components highlighted)

Level 1 assets (no haircut)	**Level 2A assets** (15% haircut)
Excess reserves	GSE debt**
Treasury securities	GSE MBS**
GNMA MBS	GSE CMBS**
Non-GSE agency debt*	

* Non-GSE agency debt includes U.S. government agency securities such as the debt of GNMA, the Federal Deposit Insurance Corporation, and the Small Business Administration.
** GSEs include the Federal National Mortgage Association (FNMA, or Fannie Mae), the Federal Home Loan Mortgage Corporation (FHLMC, or Freddie Mac), the Federal Home Loan Bank (FHLB) System, and the Farm Credit System.

A bank's size and the degree of its international exposure determine which of two required stringency levels it must meet. The largest and most exposed banking organizations are subject to the "standard" LCR rule (hereafter, "standard LCR banks" or BHCs). At year-end 2016, 17 U.S. banks exceeded the standard LCR thresholds. Smaller banking organizations are subject to a less stringent, "modified" LCR requirement (hereafter, "modified LCR banks" or BHCs).[5] At

[4] When the largest banks began publicly disclosing their LCR-related data for the quarter ending June 30, 2017, Bank of America, Citigroup, JP Morgan, and Wells Fargo each reported that Level 2B assets made up less than 1 percent of their total HQLA. LCR-related disclosure requirements for U.S. banks are described here: https://www.federalreserve.gov/newsevents/pressreleases/bcreg20161219a.htm.
[5] The requirements for meeting the standard versus the modified rule are as follows: Banks subject to the standard LCR requirement have $250 billion or more in total consolidated assets or $10 billion or more in on-balance sheet foreign exposure, or are these banking organizations' subsidiary depository institutions with assets of $10 billion or more. Banks that do not meet these thresholds but have $50 billion or more in consolidated assets are subject to the "modified" LCR requirement; the denominator of the modified LCR is multiplied by 70 percent.

the end of 2016, 19 banks met such requirements, but we excluded 2 such institutions from our sample because of insufficient time spent in this category. Thus our sample of study includes a total of 17 standard LCR banks and 17 modified LCR banks. For comparison purposes, we also consider banks that are not subject to the LCR requirement over our period of study ("non-LCR banks").

Although the largest U.S. banks began publicly disclosing metrics related to the LCR requirement in the second quarter of 2017, historical data are not required to be reported. And while some large banks began publically disclosing their LCRs as early as early 2014 (during events such as quarterly earnings conference calls and other investor presentations at the time), they did so without releasing the detailed data that underlie the ratio. Here, using a range of data sources, we construct two different time series of banks' HQLA holdings. The first is a quarterly series based on publicly-available data sources. The second is a daily series based on confidential supervisory data. Our proxy HQLA series allow us to analyze which assets these institutions chose to hold to satisfy their LCRs over time. The data appendix provides a full description of our data sources, both public and confidential, as well as our calculation methods and the assumptions we made either for simplicity or due to data limitations; we describe how we take asset haircuts and caps into account in subsequent sections.

As we show in the next section, although the deadline for banks' full LCR compliance was phased in between January 2015 and January 2017, banks' balance sheet management was affected well before this period.[6]

4. How did banks initially increase, and then subsequently manage, HQLA?

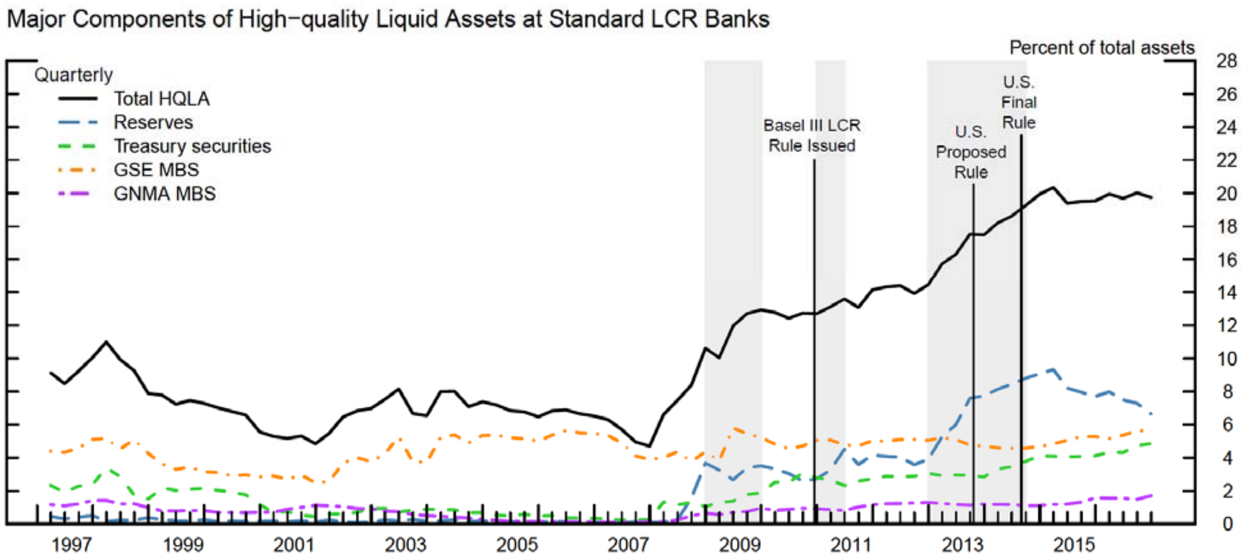
Figure 1 shows our constructed time series measure of standard LCR banks' aggregate HQLA and each of the three key components of HQLA highlighted in table 1—total reserves, Treasury securities, GSE MBS. For comparison purposes, we also show GNMA MBS, a much less widely-held Level 1 component of HQLA. Each of the five data series is plotted as a share of these banks' *total assets*. Looking at the key LCR-related announcement dates denoted by the vertical bars, one sees that in the years leading up to the initial deadline for LCR compliance (January 2015), these institutions substantially increased the share of liquid assets on their balance sheets, particularly in 2013 and 2014, and did so primarily by taking on substantial reserve balances, shown by the blue-dashed line.

It is important to remember that accumulating reserve balances over this period was easy for banks to do; in fact, it was not a choice for the banking sector as a whole. Prior to the financial crisis, the amount of reserve balances in the banking system was consistently quite small—that is, prior to 2008, the blue-dashed line is very close to the zero line (the x-axis). However, as a

[6] Compliance with the U.S. LCR was phased in as follows: Standard LCR banks were required to maintain an LCR of 80 percent beginning in January 2015, all LCR banks were required to maintain a 90 percent ratio beginning in January 2016, and full compliance was required (a ratio of 100 percent or more) beginning in January 2017.

result of the Federal Reserve's large-scale asset purchase programs (LSAPs), which were conducted between 2009 and 2014 and are denoted in the figure by the gray-shaded regions, reserve balances grew at varying rates over many quarters.[7] In total, the amount of reserves in the banking system increased by over $2 trillion as a result of the LSAPs.

Figure 1



Note: Standard LCR institutions are defined as BHCs with $250 billion or more in total assets or $10 billion or more in on-balance sheet foreign exposures. Shaded bars indicate periods of the Federal Reserve's large-scale asset purchase programs. See appendix for explicit line items used to construct the categories.
Source: FR Y−9C, FR 2900 (for reserve balances).

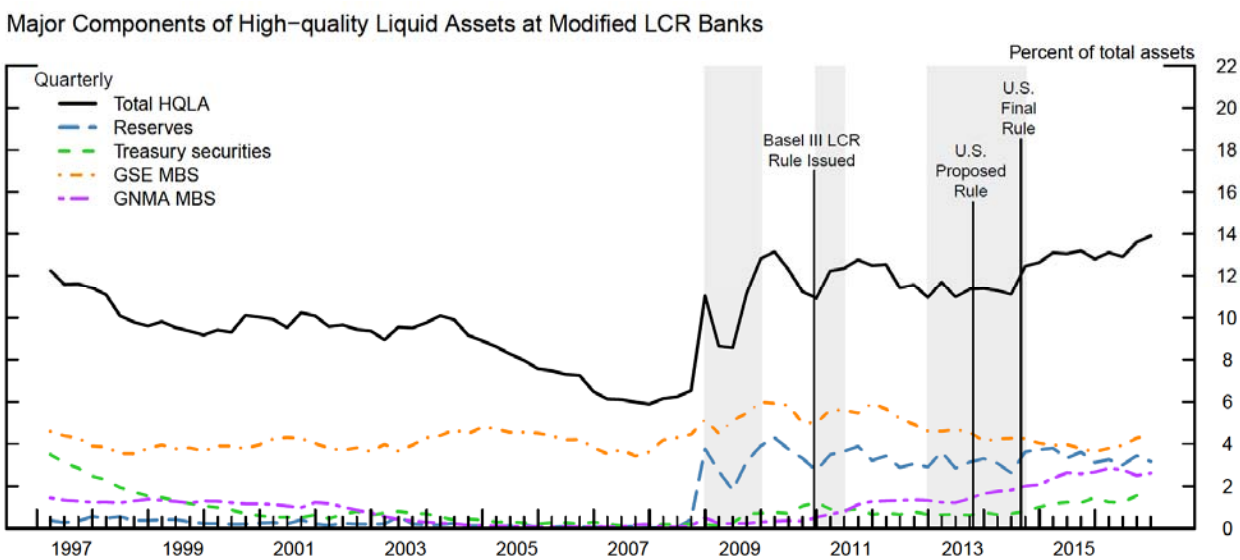
The figure also illustrates that standard LCR banks actively acquired other HQLA-eligible securities in the lead-up to the full-compliance deadline (January 2017). In particular, the share of these institutions' holdings of Treasury securities, shown by the green-dashed line, rose over 2014 and continued to grow thereafter. Indeed, at the end of 2013, the standard LCR BHCs held 3 percent of all outstanding Treasury securities; by the end of 2016, this share had risen to 4.5 percent. In addition, as shown by the orange-dashed line, the share of these banks' holdings of GSE MBS increased some in 2015 and 2016. Meanwhile, these banks' holdings of GNMA MBS, the purple-dashed line, stayed relatively low and flat as a share of total assets.

Figure 2 reports the same data for the set of smaller, modified LCR banks. Here we see a very different pattern. These banks' reserve holdings as a share of total assets have been roughly steady from the issuance of the Basel III rule through the end of 2016. In contrast to the standard LCR institutions, over the past several years, these firms mostly increased their holdings of

[7] For an explanation of the mechanism by which increases in the Federal Reserve's security holdings, such as via LSAPs, result in a commensurate increase in the amount of reserve balances in the banking system, see the appendix to Ihrig, Meade, and Weinbach (2015a or 2015b).

GNMA MBS, a Level 1 asset, and also decreased their holdings of GSE MBS, a Level 2 asset. Of course, another important difference between the two sets of banks is that the modified LCR banks needed to undertake a much smaller overall buildup of HQLA, with HQLA at the end of 2016 representing about 14 percent of total assets (the black line) compared to about 20 percent for the standard BHCs. This differential in the share of total assets comprised of HQLA at standard versus modified LCR banks is approximately accounted for by the differential treatment of the denominator of the modified LCR rule (see footnote 5).

Figure 2

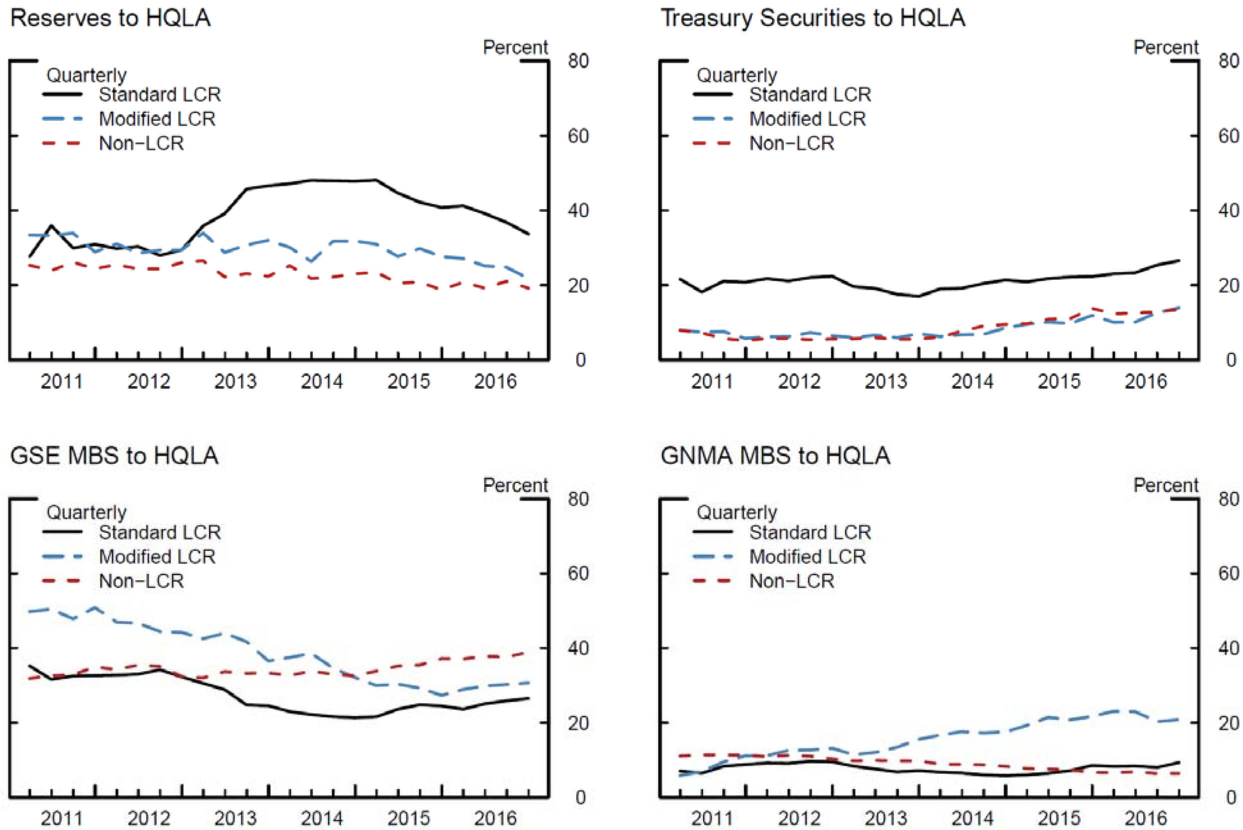


Note: Modified LCR institutions are defined as BHCs with $50 billion or more in total assets. Shaded bars indicate periods of the Federal Reserve's large−scale asset purchase programs. See appendix for explicit line items used to construct the categories.
Source: FR Y−9C, FR 2900 (for reserve balances).

Next we compare the behavior of the two LCR bank groups just discussed side-by-side with similar data for the set of non-LCR banks. In particular, figure 3 shows each of the same four HQLA components—reserves, Treasury securities, GSE MBS, and GNMA MBS—but now as a share of banks' holdings of *total HQLA* (instead of total assets), and presents these component shares for standard LCR BHCs (the black lines), modified LCR BHCs (dashed-blue lines), and non-LCR banks (red-dashed lines). The same component contours described above are apparent. Meanwhile, the asset holdings of non-LCR banks remained relatively flat during the period of transition to meet the liquidity requirement, suggesting that the LCR was in fact a driver of banks' balance sheet management over that period.

Importantly, banks likely faced somewhat different incentives in the run-up to becoming LCR compliant than they subsequently faced. In the run-up, Wall Street analysts were regularly asking about banks' progress and some institutions began publicly reporting updates; as a result, banks may have felt some pressure to build a sufficient *stock* of HQLA to become compliant. If so, managing the *composition* of HQLA over that period may not have been banks' top priority.

Figure 3
Comparing Shares of Selected HQLA-Eligible Assets by Bank Group
(units as a percent of HQLA)



Note: Reserves defined as balances held at Federal Reserve Banks as reported in (FFIEC) Call Reports. Only reserve balances held in excess of required amounts are HQLA-eligible. All other data are from the FR Y-9C. Security balances are based on fair values for available-for-sale (AFS) and held-to-maturity (HTM) securities, as well as securities held in trading accounts. See appendix for explicit line items used to construct the categories.
Source: FR Y−9C and Call Reports (FFIEC 031/041).

But after the end of 2014, the time at which standard LCR banks had to meet initial LCR compliance, *total* HQLA generally leveled off—HQLA comprised about 20 percent of the total assets of standard LCR banks at the end of 2014 and remained roughly constant thereafter (figure 1). And in contrast to the earlier years, over this subsequent period, banks' primarily made compositional adjustments to their HQLA. In particular, reserves comprised about 45 percent of these institutions' HQLA at the end of 2014 and then this share declined by about 10 percentage points (figure 3). Meanwhile, the GSE MBS and Treasury shares at these same institutions each increased. Similarly, as noted above, modified LCR banks also adjusted the composition of HQLA after becoming LCR compliant, substituting GNMA MBS for GSE MBS as well as more recently increasing the share of Treasury securities.

This reshuffling of banks' HQLA raises the question: What are the optimal shares of HQLA? The next section addresses this question using a risk-return framework.

5. What does portfolio theory suggest are optimal HQLA shares?

As we showed in the section above, the introduction of the LCR had a large effect on banks' asset holdings. Here we examine the drivers of banks' choice of liquid assets and subsequent management of those shares. A bank chooses its asset allocation to not only maximize the risk-adjusted return on its holdings but also with an eye to meeting liquidity and capital constraints. The latter come both in the form of regulatory constraints and also in the form of self-imposed, internal controls regarding liquidity, capital, or other aspects of balance sheet management. In addition, banks face other regulations and considerations that may constrain their balance sheet decisions. To account for these multiple factors, we model a bank's choice of the composition of its HQLA as a portfolio optimization problem that explicitly accounts for the LCR and implicitly considers other constraints.

Our motivation is similar to Cuoco and Liu (2006), Halaj (2013), and Halaj (2016) who model a bank's asset holding decisions with respect to minimizing volatility or value at risk (VaR) in order to reduce the probability that a particular regulation is violated.[8] Here we apply standard portfolio theory to solve for the bank's optimal portfolio of HQLA, which maximizes the risk-return ratio.[9] In so doing, the bank considers the return on various HQLA assets to maximize profits while internalizing interest rate risk from the volatility of the market price of these assets that impacts its regulatory and internal balance sheet constraints.

We assume a bank allocates HQLA across three assets—reserve balances, Treasury securities, and GSE MBS. Reserves are guaranteed to have the same principal value returned the next day and they receive a fixed overnight return. Therefore, there is no interest rate, credit, or liquidity risk associated with holding this asset, and we consider it the risk-free asset. We also assume that each individual bank can choose the level of reserve balances it wishes to hold. Of course, the aggregate quantity of reserve balances is determined by the Federal Reserve; unlike other assets, while an individual bank may adjust its holdings of reserves, the banking system as a whole cannot do so, and this factor likely constrains our results.

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[8] Alternatively, use of a risk aversion model in our setting can be motivated by a principal-agent problem where the agent is the portfolio risk manager such as in Danielsson, Jorgenson, and de Vries (2002).

[9] VaR is a statistical technique used to estimate potential losses on investments in extreme circumstances (tail risk) and tends to be applied to highly volatile exposures or components of the balance sheet such as swaps and currency exposures and other derivatives positions. Thus we deem VaR less useful in our setting for assessing the composition of HQLA.

Unlike reserve balances, the day-to-day returns on Treasuries and MBS vary as their market prices adjust with current and expected future financial market conditions. A bank may wish to reduce the interest rate risk associated with its liquid portfolio because it faces unwanted volatility in its regulatory capital stock through marked-to-market changes in its securities holdings.[10] To reduce interest rate risk from Treasury holdings, shorter tenors can be purchased. But such a step will not completely eliminate the market price volatility of these holdings. For MBS, while shorter tenors can also be used to manage interest rate risk, the duration of MBS generally lengthens when interest rates rise because mortgage prepayments tend to decline in that situation. As a result, interest rate risk can be higher for MBS than Treasury securities, even if the securities pay the same coupon rate. Overall, banks have to determine the share of HQLA they want to hold in reserves—the risk free asset with an average lower return—versus these longer-term assets that yield higher average returns.[11]

To determine a bank's optimal portfolio, we first solve for the optimal "risky" HQLA portfolio (denoted with subscript "R")—that is, the shares of Treasury securities and MBS—that maximize the risk-return tradeoff captured by the Sharpe ratio shown in equation (2):

$$Sharpe\ ratio = \frac{E(r_R) - r_{RB}}{\sigma_R}, \tag{2}$$

where $E(r_R)$ is the expected return of the risky portfolio, r_{RB} is the risk-free rate on reserve balances, and σ_R is the standard deviation of the risky portfolio. Daily returns are used to make these calculations.

After determining the optimal risky portfolio, a specific bank's complete HQLA portfolio ("P") will depend on its interest rate risk tolerance, which is captured in parameter A in equation (3):

$$U(r_P) = E(r_P) - \frac{1}{2} A\,\sigma_P^2, \tag{3}$$

where

$$E(r_P) = (1 - w) * r_{RB} + w * E(r_R - r_{RB}), \tag{4}$$

$$\sigma_P^2 = w^2 * \sigma_R^2, \tag{5}$$

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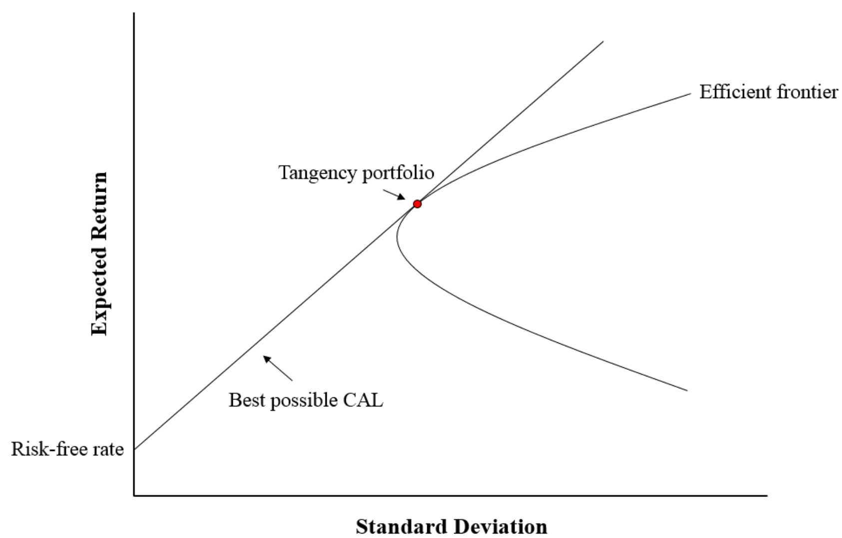
[10] Treasuries and MBS also carry some credit risk. For example, in August 2011, Standard & Poor's downgraded the credit rating of U.S. Treasury debt from AAA to AA+ shortly after Congress voted to raise the debt ceiling of the federal government by means of the Budget Control Act of 2011.

[11] Under Basel III, some BHCs must include net unrealized gains and losses from available-for-sale (AFS) securities in their calculation of the common equity tier 1 capital to risk-weighted assets (CET1) ratio. For such institutions, changes in the valuation of AFS securities add volatility to their capital ratios. While both AFS and held-to-maturity (HTM) securities qualify for HQLA, only AFS securities can be immediately sold without accounting rule penalties. There has been a notable increase in the share of HTM securities at large banks since 2011, thus reducing the impact of interest rate risk on the regulatory capital ratios of such banks.

and *w* is the share of risky assets. The higher a bank's value of *A,* the less risk tolerant it is. We return to this topic below.

The curve in figure 4 provides a stylized illustration of the efficient frontier that represents optimal shares of Treasury securities and MBS holdings—the risky portfolio—for given risk-return tradeoffs. When a risk-free asset is introduced, the straight line shown in the figure, known as the capital allocation line (CAL), is the new efficient frontier for the complete portfolio. The line's vertical intercept represents a portfolio that contains only the risk-free asset. The red dot designates the optimal risky portfolio. All points on the line between these two corner solutions represent portfolios that allocate some funds to both the risk-free asset and the optimal risky portfolio. Where a bank ends up on that line depends on its tolerance for risk—its value of *A*.

Figure 4
The Standard Investment "Efficient Frontier"



This figure illustrates the construction of an optimal portfolio of assets given the efficient frontier of risky assets and the inclusion of a risk-free asset. The capital allocation line is constructed by connecting the risk-free rate (y axis) to the tangency of the efficient frontier which is the optimal risky portfolio.

In solving for a bank's optimal portfolio shares, we use one representative Treasury security and one representative GSE MBS security in the analysis.[12] Information on the maturity of banks'

[12] For simplicity, our analysis ignores the tradeoffs banks face in choosing among various types of Treasury securities and MBS, as well as among other types of securities that may be held to meet HQLA (albeit under a range of haircuts). Given that rates of return are not perfectly correlated, the choice of assets considered does affect the estimated shares. For example, if in the last row of table 2 a 2-year Treasury security is considered instead of a 5-year security (column 2), the optimal reserves share (column 4) rises to 16 percent (with the share of Treasury

securities holdings is not available through publicly available sources, so we use the confidential FR 2052a data as described in the appendix to compute the average maturity of securities held by large banks. The maturity buckets collected are not sufficiently granular to distinguish among specific maturity holdings of Treasury securities or MBS, but we do see that the largest banks tend to hold securities of these types that mature in 5 or more years. Therefore, we assume that the market yield on Treasury securities of 5-year constant maturity and 5- and 10-year constant maturity MBS (Fannie Mae) are the best available proxies for the returns on the two risky assets in our model portfolio.

We let the level of the risk tolerance parameter, A, vary from 1 (relatively risk tolerant) to 10 (relatively risk intolerant).[13] In our setting, a relatively risk intolerant bank prefers less volatility in the interest rates—or, in terms of fixed-income securities, less volatility of market pricing—associated with its HQLA portfolio. A bank's risk tolerance in this context will depend in part on the extent to which it faces a need to manage effects from mark-to-market volatility in its securities holdings on its regulatory capital constraints. For example, relative to a bank with a large regulatory cushion, if a bank is operating close to its regulatory minimum leverage ratio, it may not want much market price volatility associated with its assets and, therefore, have a relatively higher value of A.

Regarding our sample period, to start, we consider a fairly recent period beginning in 2012 in which the Federal Reserve's balance sheet was large and it operated the current monetary policy implementation framework, a floor system. In this case, our model suggests that a bank should not want to hold any amount of the risk-free asset—reserve balances—to satisfy HQLA. This holds for all of the considered values of the risk tolerance parameter, A. In fact, given the relatively high return on GSE MBS, each institution in this case prefers to hold all of its liquid assets in MBS. But, as noted above, there is a limit to the amount of Level 2 assets that may be used to satisfy HQLA; because no more than 40 percent of a bank's HQLA holdings may consist of such assets, the optimal composition of HQLA in this case is 60 percent Treasury securities and 40 percent GSE MBS.[14]

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securities and MBS falling to 50 and 34 percent, respectively). In addition, as already noted, for simplicity our analysis ignores other HQLA-eligible assets which are held in much smaller shares.

[13] It is difficult to benchmark our coefficient of relative risk aversion, A, to values, or a range of values, that might be representative for banks. The coefficient is mostly used in the risk aversion literature for households; see Grandelman and Hernández-Murillo (2014) for a review. While the most commonly accepted estimates in that context lie between 1 and 3, a wide range of estimates have been presented—from as low as 0.2 to 10 and higher. Thus we examine a wide range of parameter values.

[14] We do not account here for the 15 percent haircut that is applied to banks' holdings of GSE MBS; doing so in this scenario would result in banks holding even more MBS to achieve the 60-40 portfolio. We exclude the haircut in our portfolio model because it is not straightforward to adjust the relative yields we consider to reflect such a constraint.

However, one may think that during the period beginning in 2012, the volatility in market interest rates was significantly constrained by the zero lower bound, and, given that our model relies on the relationship between asset returns and covariances, this circumstance could bias the results away from holding the risk-free asset toward holding a riskier portfolio. Therefore, we also consider a period from 2001 onward, one that embodies much more variability in the returns on liquid assets. Because the Federal Reserve began paying interest on reserve balances during this longer period—in late 2008—we assume the risk-free asset is remunerated at the effective federal funds rate prior to the onset of interest on reserves. This assumption can be interpreted as one in which the pre-crisis monetary policy implementation framework was a corridor system that paid interest on excess reserves.[15]

For this longer time period, we do find demand for the risk-free asset. As shown in table 2, the share of reserves in an optimal HQLA portfolio (column 4) ranges widely depending on the assumed degree of a bank's tolerance for risk (column 1). For example, when a bank's risk

Table 2
Optimal Portfolio Composition using Data from 2001 to 2016

Bank's risk aversion (A)	Maturity of the two "risky" assets		Portfolio Compositions (optimal portfolio shares, in percent)			
	Treasury securities	GSE MBS	Reserves	Treasury securities	GSE MBS	Total *(by definition)*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Very high *A* (*A* = 10; **low risk tolerance**)	5 year	5 year	79	0	21	100
		10 year	40	20	40	100
Middle of range (*A* = 5)		5 year	59	1	40	100
		10 year	15	45	40	100
Very low *A* (*A* = 1; **high risk tolerance**)		5 year	0	60	40	100
		10 year	0	60	40	100

tolerance is low (that is, *A* is set to 10; the first pair of rows in the table), the optimal share of reserve balances ranges from 40 percent to about 80 percent of total HQLA, depending on the

[15] Setting the return on reserves equal to the effective federal funds rate over the entire sample period—including the early portion of this sample period—may constitute a return that was higher at times than in practice, which would upwardly bias the resultant reserve balance shares derived from our model. More generally, standard models of the federal funds market show that an increase in the rate at which federal funds are remunerated decreases the opportunity cost of holding reserves, suggesting that banks would demand more reserve balances as the remuneration rate rises (see figure 5 of Ihrig et al. (2015a)).

securities considered. In contrast, when a bank's risk tolerance is assumed to be high (A = 1; the bottom pair of rows in the table), the optimal share of reserves is zero regardless of the other securities considered. We conclude that our model supports a fairly wide range of plausible liquid portfolio compositions.

These results have implications for the Federal Reserve's longer-run supply of reserves in the banking system. The LCR requirement has effectively caused a structural change that may boost banks' demand for reserves and other liquid assets relative to the pre-crisis period. This means that for any given level of the federal funds rate, more excess reserves may be needed in the banking system to meet banks' demand. However, the extent of that additional demand is very hard to gauge, in part because it is dependent on banks' risk tolerance, as we have shown. Moreover, relative interest rates also matter—if the yield on Treasury securities or MBS is sufficiently higher than the administered rate of interest that the Federal Reserve sets on excess reserves, then any LCR-driven demand for reserves could be relatively dampened. For example, according to our model, for a bank whose A is equal to 3, if the return on Treasury securities was boosted by 25 basis points relative to its historical average, all else equal the optimal Treasury share of this bank's liquid portfolio would rise by about 10 percentage points, the MBS share would remain at 40 percent, and the reserves share would decline by 10 percentage points. So far we have very little direct information regarding banks' current underlying demand for excess reserves. As the aggregate level of reserves in the banking system declined through 2016, from $2.5 trillion in March to about $1.9 trillion in December, no pressure was evident on the various interest rates that one might expect if banks in fact preferred to hold all of those reserve balances.

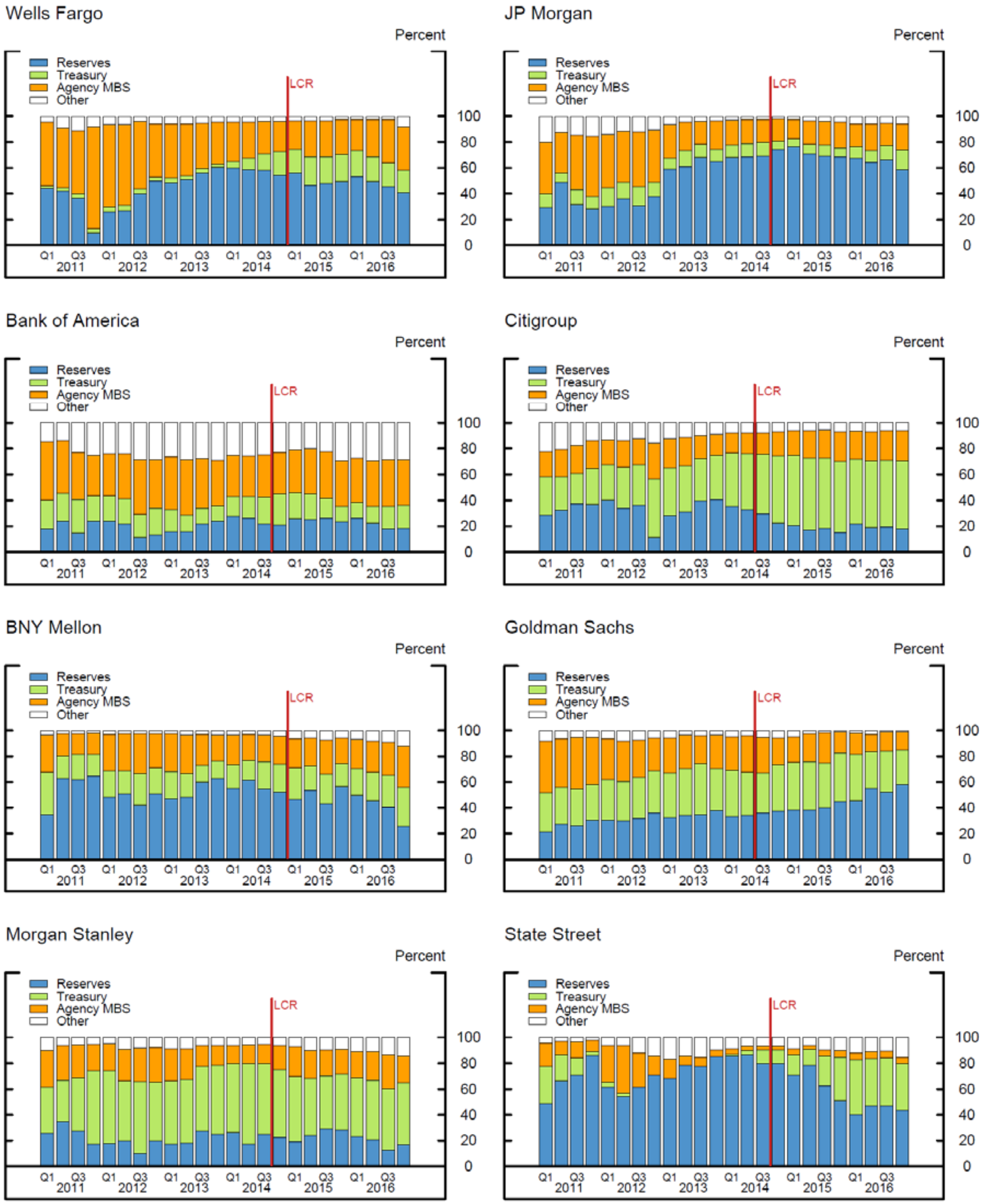
We next consider the extent to which banks' individual preferences regarding the compositions of their liquid pools have actually varied in recent years.

6. What do individual, bank-level data show?

To get an understanding of how individual banks responded to the LCR, we look at bank-level data for the eight U.S. GSIBs. At the end of 2016, these eight institutions together held more than $1.5 trillion of HQLA and represented 70 percent of the total assets of standard LCR banks (those shown in figure 1).

Figure 5 displays the composition of each of these eight institution's HQLA, where the institutions are ordered by size of HQLA holdings, largest to smallest from left to right. The red vertical bars indicate when each institution publically announced that it had fully met its LCR requirement (that is, the point at which it announced it had a ratio of at least 100 percent). As shown, in the run-up to meeting the LCR, about half of these banks displayed a heavy reliance on reserve balances, the blue portions of the bars, while others relied on a wider range of assets.

Figure 5
Individual Bank's HQLA Shares



Note: Security balances based on fair value of available-for-sale (AFS), held-to-maturity (HTM), and trading account securities. Other HQLA includes GNMA MBS, agency CMBS, and agency debt. Red lines indicate quarter in which entity publicly stated it met the fully phased-in final U.S. LCR rule based on its own calculations.
Source: Call Reports (for reserves, or balances held at Federal Reserve Banks; FFIEC 031/041), FR Y-9C (all other data), and transcripts from quarterly earnings calls and financial updates (the red lines).

However, after this time, those that had relied heavily on reserves exhibit a decline in such reliance, albeit to varying degrees. Such adjustments are consistent with banks subsequently aiming to improve the return on their HQLA portfolios and determining that less reserves was needed to meet their internal liquidity needs.

Consistent with our portfolio calculations, these banks currently display a wide range of shares of HQLA comprised of the risk-free asset—the portion of HQLA that is reserve balances ranges from as little as around 20 percent or less for about half of these institutions to above 50 percent.

Even the four largest holders of HQLA are noticeably dissimilar in their compositional choices: Wells Fargo relies mainly on a mix of reserve balances and GSE MBS; JP Morgan mainly reserves;[16] Bank of America mainly GSE MBS; and Citigroup mainly Treasury securities. In addition, these data provide other indications that banks differ significantly in their individual approaches to managing HQLA. For example, Citigroup and Bank of America maintained roughly the same composition of HQLA in 2015 and 2016. Meanwhile, many of the other six banks replaced some reserves with Treasury securities or GSE MBS.

Of course, other factors besides an interest rate risk-return tradeoff may influence banks' decision-making regarding their liquid portfolios. For example, a bank's business model or internal needs may predominate. A bank that engages in significant payment, settlement, and clearing activities may desire a relatively high share of reserve balances to meet its intraday and next-day liquidity needs, one that may be larger than that chosen solely based on risk-return analysis.[17] Investment banks that face intraday liquidity needs from dealer-intermediated activities or prime brokerage services and banks that engage in commercial lending activities, manage significant amounts of volatile deposits from institutional clients, or provide retail clients with credit lines, such as credit cards and home equity lines of credit that can be unpredictably tapped, may also have a preference for certain quantities and types of liquid assets. In addition, the scale of a bank's operations matters. A bank that deems it hard or unwise to raise funds quickly by engaging in sufficiently sizable repurchase agreement transactions (repos), or by conducting sufficiently sizable outright asset sales, may want to hold a relatively abundant level of reserves for precautionary reasons, more than suggested by risk-return considerations alone. Such targets may be established by internal liquidity stress tests.[18] Importantly, banks' capital

[16] In a recent earnings call with market analysts, JP Morgan responded to a question about why it held so many excess reserves rather than higher-yielding assets such as MBS by pointing out that it already has high mortgage exposure taking both its mortgage loans and MBS holdings into account, and that further increasing its MBS holdings to augment returns would cause it to exceed its internal duration target (Thomson Reuters StreetEvents (2017)). Limiting the duration of a securities portfolio is an example of how banks actively manage interest rate risk, consistent with our portfolio model.

[17] Payments processing banks such as State Street, Bank of NY Mellon, and JP Morgan likely fall into this category.

[18] For example, Bank of America noted in its 2016 10-K filing that it uses "liquidity stress analysis" to help determine the appropriate amounts of liquidity to maintain and to establish limits and guidelines on certain funding sources and businesses. JP Morgan explained during a 2014 earnings call with market analysts that "We're

constraints can also influence their choice of HQLA holdings. A bank with an effectively binding risk-based capital ratio would likely lean, on the margin, toward onboarding additional excess reserves and Treasury securities to meet its HQLA requirement because those assets carry a zero risk weight.

Overall, the importance of factors such as these in determining banks' demand for reserves is hard to know. In the next section, using daily HQLA data, we find evidence that some institutions are likely focused on these factors in making HQLA decisions while others are likely using a risk-return framework.

7. Recent behavior of HQLA shares—daily variability

Thus far we have considered the behavior of banks' shares of HQLA based on publically-available, quarter-end data. Here we examine the *daily* movement in banks' individual HQLA shares based on confidential supervisory data collected from the *Complex Institution Liquidity Monitoring Report* (FR 2052a) described in the appendix. Overall, we find that the pattern of dispersion in the variance of these shares supports the view that about half of the U.S. GSIBs appear to be managing HQLA using mainly a risk-return framework while the other half have individual business models or other factors that appear to be binding in their management of HQLA.

In particular, focusing on the period after 2014 in which banks had become compliant with the LCR and adjustments to HQLA component shares were more common, we compute the average daily standard deviation of the reserves, Treasury securities, and GSE MBS shares of HQLA for each of the eight banking firms—the U.S. GSIBs—shown in figure 5. As shown in figure 6, we divide the sample into two equal-sized bank groups—those with a relatively high reliance on reserve balances, the left-hand set of bars, and those with a relatively low reliance on reserve balances, the right-hand set of bars.

As shown by the left-most blue bar, the median share of reserves that comprises reserve-reliant institutions' HQLA varies day-to-day by about 10 percentage points, and the interquartile dispersion runs from 5 to 15 percentage points on any given day. Meanwhile, the shares of these banks' Treasury securities (in green) and MBS (in orange) are significantly more stable. The volatility of the share of reserve holdings for these institutions suggests that they are using reserves for purposes other than to solely to meet their LCR.

In contrast, as shown by the right-hand set of bars, banks with relatively low reliance on reserve balances tend to exhibit much less variation in their HQLA shares, with the highest average daily variation being in the Treasury share. Here risk-return decisions are more likely an important

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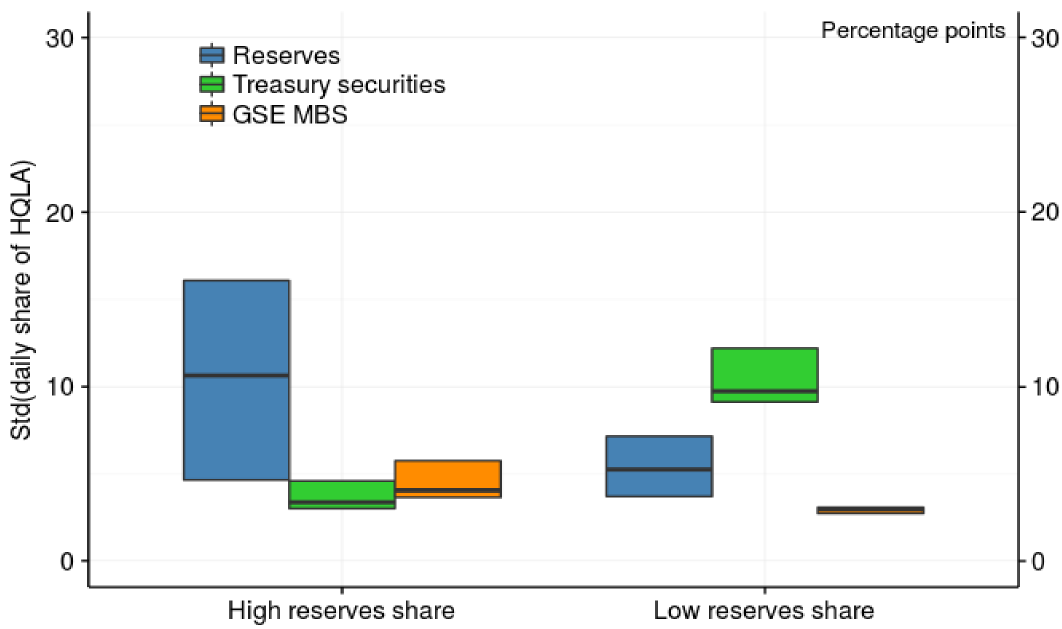
measuring [the LCR], we're reporting [the LCR], but we run the firm based upon our own internal liquidity stress framework" (FactSet CallStreet (2014)).

factor in determining HQLA holdings, with banks targeting a somewhat steady share of each type of HQLA.

Finally, we note that we do not find it surprising that the MBS shares exhibit relatively little daily volatility across the two bank groups. Because MBS are less liquid than Level 1 assets, are subject to duration risk, and holdings must be capped under the LCR, banks may largely position their MBS holdings at a desirable level and not seek to adjust that component on the margin. As evidence of this, GSIBs currently have about 30 percent of their MBS holdings booked as held to maturity (not available for sale) while they have classified only about 20 percent of their holdings of Treasury securities as such. (See footnote 11 for more on the significance of classifying securities as "held to maturity" in this context.)

Figure 6
Daily Variance of Bank's HQLA Shares Post-LCR (Jan. 2015–Mar. 2017)



Note: "High reserves share" banks are comprised of the four banks with highest average shares of reserves to HQLA, and "Low reserves share" banks are comprised of the remaining four banks. The horizontal line through each bar is the median bank's standard deviation; the high and low ends of each bar signify the 75th and 25th percentiles, respectively. (With four observations in each bank group, medians and percentiles are the midpoint (average) of the appropriate neighboring observations.)
Source: FR 2052a.

8. Conclusion

The LCR is a post-crisis liquidity requirement that has importantly affected the management of banks' balance sheets, research about which is only recently emerging. Our paper contributes to the discussion by constructing time series data to document how U.S. banks have managed the compositions of their HQLA over recent years and providing a theoretical framework to model banks' preferences for the composition of HQLA. Empirically, we documented how banks' choice of HQLA holdings have evolved over time. We explained banks' decisions in the context of our model, which highlights that a bank's demand for reserves is sensitive to its interest rate risk preferences as well as to the opportunity cost of holding such balances. If a bank is relatively risk tolerant in this regard, its demand for reserves to meet its LCR may not be very large.

We also discussed how business model practices or other factors may lead a bank to hold more reserves than otherwise would be preferred based on risk-return considerations alone. Looking at both the current compositions of individual banks' HQLA shares and the pattern of daily volatility of those shares, we conclude that about half of large banks' decision-making—those with a relatively large and volatile reserves share of HQLA—is primarily driven by business model needs or other factors. Meanwhile, the other half of these banks appear to determine their HQLA holdings consistent with their preferences regarding the risk-return trade-off associated with the underlying assets, resulting in relatively constant HQLA shares.

Understanding banks' post-crisis liquidity management practices is important for both the transmission and the implementation of monetary policy. Banks' demand for reserves interacts with various short-term market interest rates and thus the Federal Reserve's setting of its administered rates. These interest rates affect the trade-off between lending and holding liquid assets and hence the transmission of monetary policy. In addition, banks' demand for reserves will likely influence the longer-run size of the Federal Reserve's balance sheet and thus its options and preferences regarding how best to implement monetary policy in the future.

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Data Appendix

Here we describe the data sources and the method we used to construct both versions of bank-level HQLA used in our paper

Data sources and method for constructing the quarterly bank-level HQLA time series

Our quarterly HQLA time series is based on publicly-available data. Our data sources include quarterly regulatory filings, some of which are reported at the commercial bank (depository institution) level; when this was the case, we subsequently mapped individual commercial banks to their affiliated (parent) BHC. These sources included:

- *Consolidated Financial Statements for Holding Companies* (FR Y-9C) from which we obtained individual BHCs' securities holdings, including investment securities and securities in banks' trading accounts. The FR Y-9C reporting form and instructions are available on the Board's website: https://www.federalreserve.gov/apps/reportforms/reportdetail.aspx?sOoYJ+5BzDal8cbqnRxZRg==

- *Consolidated Reports of Condition and Income for a Bank with Domestic Offices* (FFIEC 041) and *Domestic and Foreign Offices* (FFIEC 031) for data on reserve balances. The FFIEC 031 and 041 forms and instructions are available on the FFIEC's website: https://www.ffiec.gov/ffiec_report_forms.htm.

For simplicity and as a result of some data limitations, we made the following methodological choices in constructing our quarterly bank-level HQLA estimate:

- We ignored LCR-eligible HQLA assets outside of the seven asset categories listed in table 1, including banks' holdings of Level 2B assets such as corporate debt. Banks generally hold relatively small shares of such assets, making our conclusions robust to their exclusion. For example, for the eight GSIBs we examined in detail, less than 2 percent of their HQLA consisted of Level 2b assets in the second quarter of 2017 as reported in their first required public disclosures.

- We used data on banks' total reserve balances instead of excess reserves, but these measures differ little in aggregate over the period we primarily study. According to the Federal Reserve's H.3 statistical release, *Aggregate Reserves of Depository Institutions and the Monetary Base*, required reserves in the banking system totaled about $160 billion on average in February 2017 while total reserves averaged about $2,300 billion.

- For figures 1 and 2, we ignored Level 2 asset caps (described in the main text); however, most BHCs are not near those caps. The share allocations in our risk-return model analysis did account for the caps.

- Due to limitations of the granularity of the publicly-available data, some non-GSE agency securities (Level 1 assets) are included in our estimates of the GSE asset (Level 2A) categories. However, for very large banks, we think our HQLA asset category estimates are reasonable. For example, for the eight GSIBs examined, we estimate that use of the publicly-available data results in roughly about 80 percent of banks' Level 1 assets to be sorted accurately, with the remaining 20 percent inaccurately included in our GSE (Level 2A) asset categories.

- Finally, also due to data limitations, we ignored whether the securities included in our HQLA estimates were deemed by each bank to be "unencumbered" or not (the LCR requires securities be unencumbered, that is, free of legal, regulatory, contractual or other restrictions on the ability of the bank to liquidate, sell, transfer, or assign the asset). We do not believe that making such a generality has biased our findings or conclusions.

In table A.1 we list each of the specific line items we used to construct quarterly HQLA using these publicly-available data sources. Given that the LCR requirement is based on assets valued at market values, the fair value measures of banks' securities holdings are used (as reported on schedule HC-B for both available-for-sale securities and held-to-maturity securities).

Data sources and method for constructing the <u>daily</u> bank-level HQLA time series

To construct our daily bank-level measure, we utilized two sources of confidential micro data collected by the Federal Reserve.

- For historical data on individual bank's reserve balances, we relied on the confidential flows associated with the *Report of Transaction Accounts, Other Deposits and Vault Cash* (FR 2900). FR 2900 reporting forms and instructions are available on the Board's website: https://www.federalreserve.gov/apps/reportforms/reportdetail.aspx?sOoYJ+5BzDblI7g2+r203S0gg6NcUIj6.

- For daily data on HQLA reported directly by BHCs, we relied on the confidential supervisory data collected from the *Complex Institution Liquidity Monitoring Report* (FR 2052a). This form is collected from U.S. GSIBs—those with $700 billion or more in consolidated assets or with $10 trillion or more in assets under custody. These BHCs submit a report each business day and have been doing so since December 14, 2015; prior to that time, the same BHCs submitted more limited daily data since 2012. The FR 2052a data are comprised of the detailed balance sheet inputs necessary to calculate the LCR, but do not include the actual LCR ratios, or the numerators and denominators of the ratios, themselves. FR 2052a reporting forms and instructions are available on the Board's website: https://www.federalreserve.gov/apps/reportforms/reportdetail.aspx?sOoYJ+5BzDbpqbklRe3/1zdGfyNn/SeV.

These source data for the daily measure of HQLA are quite limited prior to December 2015—they consist of reserves, Level 1 HQLA (which includes reserves), and (total) Level 2 HQLA. Because we are interested in tracking banks' behavior over the past several years, we created separate proxy measures for banks' Treasury securities and GSE MBS holdings, as follows. For the period in which insufficiently detailed data are available, we assumed that each of the following two relationships held:

$$\textit{Treasury securities} = \textit{Level 1 assets} - \textit{total reserves} \tag{A.1}$$

$$\textit{GSE MBS} = \textit{Level 2 assets} \tag{A.2}$$

Our assumptions are reasonably robust to a couple of checks. First, we compared each proxy measure to the actual measure using data for 2016, when both measures are available. A ratio of our proxy measure to its corresponding actual measure indicates higher accuracy the closer it is to 1, or 100 percent, in terms of indicating its completeness of coverage. The performance of our Treasury proxy is somewhat mixed, averaging about 43 percent across banks, while our MBS proxy averages 93 percent. Two banks largely account for the miss in the Treasury proxy, one with large GSE debt holdings and one with a large portion of its Treasury holdings ineligible for the LCR because the assets are not unencumbered.

In addition, we considered whether the proxy and actual measures behaved similarly over time. We computed the daily standard deviation of our proxies as a share of HQLA, as we estimated it, and compared those results to analogous figures using the actual shares. Our proxy shares exhibit reasonably similar volatility to that of the actual ratios.

We concluded that while not perfect, our proxy measures are reasonable for the analysis undertaken in this paper.

Table A.1
Construction of Quarterly Bank-level HQLA Estimates from Public Sources

HQLA Component	**Calculation**
Reserves	FFIEC 031/041 RC-A item 4
Treasury securities	FR Y-9C HC-B item 1 (column B) + item 1 (D) + HC-D item 1 (A)
GNMA MBS	FR Y-9C HC-B item 4.a.(1) (B) + item 4.a.(1) (D)
Non-GSE agency debt	FR Y-9C HC-B item 2.a (B) + item 2.a (D)
GSE debt	FR Y-9C HC-B item 2.b (B) + item 2.b (D) + HC-D item 2 (A)†
GSE MBS	FR Y-9C HC-B item 4.a.(2) (B) + item 4.a.(2) (D) + item 4.b.(1) (B)† + item 4.b.(1) (D)† + HC-D item 4.a (A)† + item 4.b (A)†
Agency CMBS	FR Y-9C HC-B item 4.c.(1)(a) (B)† + item 4.c.(1)(a) (D)† + item 4.c.(2)(a) (B)† + item 4.c.(2)(a) (D)† + HC-D item 4.d (A)†

† Includes obligations of both U.S. government agencies and U.S. government-sponsored enterprises.

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