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Investor Demands for Safety, Bank Capital, and Liquidity Measurement

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Abstract

We construct a model of a bank's optimal funding choice, where the bank negotiates with both safety-driven short-term bondholders and (mostly) risk-taking long-term bondholders. We establish that investor demands for safety create a negative relationship between the bank's capital choices and short-term funding, as well as negative relationships between capital and common measures of bank liquidity. Consistent with our model, our bank-level empirical analysis of these capital-liquidity tradeoffs show (1) that bank liquidity measures have a strong and negative relationship to its capital ratio for both large and small banks, and (2) that this relationship has weakened with the advent of stronger liquidity regulation. Our results suggest that the safety concerns of bank debt investors may underlie capital-liquidity tradeoffs and that a bank's share of collateralized short-term debt may be a more robust measure of bank liquidity.

JEL CODES: G11; G18; G21; G23; G28

KEY WORDS: Safe assets, Bank Liquidity, Liquidity regulation, capitalization, bank balance sheet management

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Section 1: Introduction and Summary

In its pure form, the Miller-Modigliani theorem suggests that a bank's choice of capital and liquidity holdings is irrelevant (Modigliani and Miller, 1958; Miller, 1995). In response to the bank's asset and capital choices, market participants adjust risk premiums on the bank's debt so that the funding costs to the bank are unaltered. Thus, some economists have argued strongly that bank capital ratios could be set by regulators at historically high levels with little cost, and thereby minimize the social costs of a bank's failure (e.g. Admati and Hellwig, 2013).

In contrast, others have argued that banks' capital and liquidity decisions are closely intertwined and that high leverage at banks is the result of intermediation that is focused on optimal production of liquid financial claims that are privately-held and socially beneficial (DeAngelo and Stulz, 2015). High leverage, however, introduces the possibility of bank runs because uninsured depositors and/or short-term liabilities holders may perceive the bank as too risky. One response to the possibility of bank runs is to increase capital requirements for banks. However, in a world where liquid financial claims are an important output of the bank, raising capital requirements may crimp the ability of banks to produce needed liquid assets (the bank's short-term liabilities) for the economy.

Since welfare gains from less frequent bank failures may come at the cost of losing some of the special use of bank debt for transactions purposes (Gorton and Winton, 2017), some observers have focused on liquidity regulation as a supplement or substitute for capital requirements. Diamond and Kashyap (2016) provide a succinct and useful discussion of this tradeoff. In addition, a very broad overview of liquidity and capital instruments and their areas of interactions generally is found in Basel Committee on Banking Supervision (BCBS, 2016).[2]

We carry out our examination of the tradeoff between capital and liquidity in several steps. First, to our knowledge for the first time, we present a model of the tradeoffs that banks face in their choices of balance sheet management when interacting with safety-driven short-term bond holders and with risk-sensitive longer-term bond holders. We establish that investor

[2] The Basel Committee is often referred to as BCBS.

demands for safety determine the bank's supply of safe assets, that is, its short-term funding. The bank's choice of short-term funding is negatively related to the bank's capital choices, and creates a negative relationships between capital and common measures of bank liquidity. To our knowledge, we are first to illustrate this tradeoff using theoretical foundations. In our second step, we construct various empirical measures of balance sheet liquidity for each US-chartered bank holding company in our sample. Specifically, we construct measures of short-term liabilities, the Liquidity Coverage Ratio (LCR), the Net Stable Funding Ratio (NSFR) and the asset-scaled Liquidity Mismatch Index (LMIA). Relating these four measures to each bank's equity ratio, we find strong evidence that a bank's higher balance sheet liquidity is significantly and negatively related to its equity ratio. In our third step, we consider liquidity regulation. Using the LMIA as out measure of liquidity, we find that the liquidity-equity tradeoff holds strongly among banks subject to the LCR rule, as well as among non-LCR banks. Consistent with our model, we also find that the tradeoff banks face between capital and liquidity has become less pronounced over time as higher minimum capital and liquidity regulations have become fully implemented. Importantly, these findings suggest that the equity-liquidity tradeoff is particularly pronounced during periods of regulatory adjustment.

In our model, we examine the tradeoffs that banks face in their choices of balance sheet management when interacting with safety-driven short-term bond holders and with risk-sensitive longer-term bond holders.[3] Since short-term debtholders demand complete safety, banks must carry enough capital, collateral, or liquidity, or have the debt guaranteed by the government, so that short-term debtholders can expect to avoid losses under all circumstances. In contrast, the bank's long-term funding costs are subject to bondholders' risk preferences. In other words, the bank's capital and liquidity choices reflect the market discipline imposed on the bank shareholders by long-term bondholders.[4]

[3] We assume that bank shareholders book risky assets and then maximize their profits. Like DeAngelo and Stulz (2015) and Gorton (2019), we also assume short-term debtholders are uninformed. In particular, short-term debtholders are seeking low-cost, ultra-safe bank liabilities to use for transactions and thereby forgo due diligence. Instead they

[4] However, long-term debt holders are unwilling to become de facto shareholders and therefore cap the risk they are willing to shoulder. Bank shareholders are wiped out when there is a catastrophic outcome.

Several features of our model serve as contributions. First, it illustrates that shareholders, when interacting with both traditional bondholders (who risk-adjust their prices) and uninformed bondholders (who purchase only short-term bank debt they perceive as totally safe), use a *profit-maximizing rule* for trading-off liquidity and capital.[5] Second, we show that *the proportion of collateralized short-term bonds* not only has a direct link to popular measures of liquidity, but also *embeds broader concerns related to bank profitability*. Therefore, as a focus of bank choice when maximizing profits, the share of collateralized short-term debt may be a preferred measure of liquidity because of its strong relation to economic fundamentals, as well as to popular measures of liquidity: A high share of this measure suggests a bank is well-prepared for negative liquidity shocks.[6] Third, our model illustrates a clear trade-off between capital and liquidity at banks because of the presence of uninformed investors who want a risk-free asset. The bank's costs when providing this safe asset to these investors determines the proportion of bank debt that is short-term. Bank capital and liquidity choices reflect this underlying cost and are thus *endogenous*. As discussed below, our model also implies how we can measure the importance of this endogenous trade-off.[7]

Our model suggests caution about reduced-form liquidity measures in banking. Common liquidity indexes, such as the measure of liquidity mismatch proposed by Bai, Krishnamurthy, and Weymuller (2018), reflect the endogenous nature of capital and liquidity.[8] But the response by a bank to market stress, as well as the haircuts used to scale assets and liabilities, reflect a bank's risk management actions that move both capital and liquidity. This makes it complicated to

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[5] In particular, we show that the bank's share of collateralized short-term bonds is higher when (1) the costs from converting illiquid assets to liquid assets are lower, (2) the bank's return from a maturity mismatch in funding is higher, and (3) the expectation of loan losses is higher.

[6] In particular, we show that the determinants of a bank's choice of short-term funding include recession losses and term premia.

[7] Importantly, banks' tradeoff of capital and liquidity is endogenous because banks operate with ample capital and liquidity buffers. As such, our result is not due to a mechanical tradeoff that binding capital and liquidity constraints would exogenously imply.

[8] As described in Bai et al (2018), using the liquidity mismatch index (LMI) has several advantages over other common liquidity proxies: (1) the LMI captures and reflects market/funding stress on both the asset and liability side of a bank's balance sheet (for instance, the LMI is designed to decrease in times of high asset-side haircuts during periods of market stress), and (2) it is an index expressed in dollars, which is thus scalable and sum-able across entities

interpret movements in a liquidity index without a model that relates liquidity to fundamentals like risk preferences, transaction costs, loss probabilities, and the outlook for growth.

In our second, empirical, step, we construct various liquidity proxies such as a measure of short-term liabilities, the LCR, the NSFR and the LMIA, and relate these four measures to each bank's equity ratio using IV estimation methods in a system of simultaneous equations. We find strong evidence that a bank's higher balance sheet liquidity is significantly and negatively related to its equity ratio. In general, a one standard deviation increase in balance sheet liquidity corresponds to about a one percentage point decline in a bank's tier 1 equity ratio.

Finally, in our third step, we consider liquidity regulation. Liquidity regulation often is discussed as two different forms: minimum liquid asset requirements based on the need to deter bank runs, and limits on maturity mismatches between banks' assets and liabilities.[9] We find that the liquidity-equity tradeoff holds strongly among banks subject to the LCR rule, as well as among non-LCR banks. Our model and estimations suggest that higher liquidity requirements should lead banks to hold less capital. In order to limit the negative impact of liquidity regulation on capital holdings, capital requirements may be needed. From a policy perspective, our findings on the trade-off of capital and liquidity on bank balance sheets are consistent with capital and liquidity regulations being complements rather than substitutes. In the context of the discussion on the safe assets shortage conundrum (Caballero, Farhi and Gourinchas, 2017), our findings imply that investors' excess demand for safe assets may lead banks to hold too much liquidity and not enough capital.

[9] This distinction is reflected in Basel III liquidity regulations, which are the minimum regulatory and supervisory standards promulgated by the BCBS after the financial crisis. The BCBS has both the LCR and the NSFR. The LCR is the primary tool for regulating liquidity at the largest banks (referred to as globally-systemically important banks or G-SIBs). The LCR measures the unencumbered high-quality liquid assets (HQLA) that might be available to convert easily and immediately into cash using private markets relative to a bank's cash needs determined by using a highly-specified run scenario (BCBS, 2013). Standard LCR banks are those with $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. Modified LCR banks are those that do not qualify as LCR banks under these conditions but have $50 billion or more ($100 billion or more, post-2018) in consolidated assets. For these banks, the denominator of the LCR is multiplied by 70 percent. The second tool, the NSFR, is designed to ensure resilience over a longer time period by incentivizing banks to arrange to fund their activities from more stable and sustainable sources (FSI, 2018).

Consistent with our model, we find that the tradeoff banks face between capital and liquidity has become less pronounced over time as higher minimum capital and liquidity regulations have become fully implemented. Notably, the tradeoff was stronger in 2010 shortly after the crisis and the subsequent introduction of liquidity regulation plans. The tradeoff then diminished in the post-2014 period as banks built up substantial capital buffers (in response to post-crisis capital regulations) and liquidity buffers (partly in anticipation of the LCR requirement). In fact, the liquidity-capital tradeoff diminished in size by as much as 65 percent, depending on the liquidity measure, from before to after 2014.

Related literature. As discussed above, this paper was inspired by the insight that a major role of banks is to produce safe assets for safety-driven investors. We show this process creates liquidity for investors (liquidity creation), but lowers capitalization and liquidity at banks. A safe asset is a simple debt instrument that is expected to preserve its value during adverse systemic events (Caballero, Farhi, and Gourinchas, 2017). Often the government produces these safe financial assets, but privately-produced assets can acquire substantial safety premiums during safe asset shortages (Kacperczyk, Perigon, and Vuillemey, 2017). Investors in safe assets do not want to engage in due diligence and, by design, there is no benefit to producing private information about a safe asset (Gorton, 2017). We explicitly incorporate these observations.

There is also an extensive and growing literature on the relationship between liquidity and capital on banks' balance sheets. From a theoretical perspective, Walther (2016) argues that in the presence of financial frictions, banks choose excessive leverage (low capital) and maturity mismatch (low liquidity) in equilibrium, highlighting the need for regulations to establish capital and liquidity minimum. In addition, Gertler and Kyotaki (2015) develop a macroeconomic model of banking that allows for liquidity mismatch and high leverage. In line with our model, they show that the behavior of bank investors depends on bank balance sheets and on the liquidation price for bank assets.

The more extensive empirical literature related to our work primarily studies the relationship between banks' liquidity creation and bank capital. Liquidity creation is analogous to maturity transformation (turning illiquid bank assets into short-term liquid bank liabilities that can be traded by investors) and is thus negatively related to bank liquidity measures.[10] Berger and Bouwman (2009) document a positive relationship between liquidity creation and capital at large banks. As such, our findings of tradeoffs between common liquidity measures and bank capital are consistent with this result. Contrary results in the literature which document a *positive* relationship between LMI and capital generally do so for *smaller* banks: Horvath et al (2014) examine the relationship between capital and liquidity creation, and find that higher liquidity creation (a lower LMI) causes a reduction in capital among small Czech banks over 2000-2010. Similarly, Distinguin et al (2013) find that small European and US commercial banks decrease their regulatory capital ratios when they create more liquidity (that is, lower their LMI). DeYoung et al (2018) find that small US commercial banks treated (unregulated) liquidity and (regulated) capital as substitutes in the pre-Basel III era, but find little similar behavior at larger banks. Acosta-Smith et al (2019) analyze a confidential Bank of England dataset on bank-specific capital requirement changes since 1989, and find that banks engage in less liquidity transformation (a higher LMI) when they have higher capital. Regarding the role of regulations, Berger et al (2016) find that regulatory interventions reduce liquidity creation among German banks, while capital support (bailouts) does not affect liquidity creation.

The paper proceeds as follows. In Section 2, we present the theoretical background and derive the model's predictions (hypothesis development). In Section 3, we present the econometric methodology and we describe the data in Section 4. We then examine and discuss our empirical findings in Section 5, and summarize and conclude in Section 6.

[10] The strength of this inverse relationship may vary over time and across banks as well: in the time series, Roberts et al (2019) argue that the implementation of the LCR rule has made the negative link between liquidity creation and LMI at large banks even stronger in the post-2014 period. In particular, the implementation of the LCR rule has caused LCR banks to extend the maturity of their borrowings on the liabilities side by relying less on overnight repo funding and more on core deposits. At the same time, on the asset side LCR banks also increase the share of liquid assets and reduce the share of illiquid loans. Regarding cross-sectional differences, Khan et al (2017) find that the inverse connection between balance sheet liquidity and liquidity creation at US bank holding companies weakens with higher capital.

Section 2: Theoretical background: The Tradeoffs between Capital and Liquidity

We use a simple game theoretic model to illustrate the tradeoffs between liquidity and capital that result from investor demands for safety. The economy faces four possible future outcomes, with known probabilities. A *boom* occurs with probability p. Conditional on a recession taking place, the outcome ban be a *mild* recession and bounce back with probability q_{mild}; a recession with *moderate* losses with probability q_{mod}; or a *severe* recession with catastrophic losses that occurs with probability q_{sev}. We present the probability structure in Figure 1. The odds of these outcomes are structured as:

1. $p + (1-p)(q_{mild} + q_{mod} + q_{sev}) = 1; \quad p > q_{mild} > \frac{1}{2} > q_{mod} > q_{sev} \sim 0;$

$$(q_{mild} + q_{mod} + q_{sev}) = 1$$

We assume that banking clients take up fully any amount of loans offered by banks. Bank loans are illiquid assets that mature after two periods, and are financed using four sources of funds: deposits, short-term bonds, long-term bonds, and capital. All deposits are insured and thus yield the risk-free yield R over two periods. Banks want to fund themselves with insured deposits, but the households' narrow needs for noninterest-yielding safe assets and convenience services limits the quantity of deposits. Note that there is no discounting of returns in our game.

In our model, there are three types of bank investors: bondholders are distinct from shareholders, and short-term bondholders are distinct from long-term bondholders. Shareholders maximize the expected value of the bank and bear the credit risk of bank assets. Long-term bondholders also maximize returns and bear the credit risk of bank assets. Short-term bondholders strive to avoid all losses, and earn a yield that is slightly above zero (e.g. a non-deposit, no-government-guarantee yield r).

The bank's shareholders maximize profits at time 0 by choosing capital and its proportion of short-term debt versus long-term debt. After the bank extends loans and chooses the maturity of its debt financing, all parties learn if the economy is entering a boom or bust. With this information, short-term bondholders must decide whether to roll over their bank debt based on their view of whether or not the bust will end, continue, or become more severe.

The bank's balance sheet is:

$$2.\quad \bar{A} = E + \bar{D} + \lambda B + (1-\lambda)B$$

where $\bar{A}$ is a fixed amount of illiquid assets, E is the bank's choice of equity, $\bar{D}$ is a fixed-quantity of core deposits, and $\lambda B + (1-\lambda)B$ is the weighted-average of short-term debt and long-term debt. The bank chooses λ, the proportion of short-term debt. Note that knowing E means also knowing B or, in other terms, $B = \bar{A} - E - \bar{D}$. At this point, we drop the superscripts on fixed-quantities of A and D for ease of exposition.

We present the extensive form of the game in Figure 1. As described above, the game has four outcomes: a boom, a mild recession, a moderate recession, and a severe recession. We assume there are four levels of losses, as a proportion of bank assets, associated with each outcome: $\{0 = l_{boom} \leq l_{mild} < l_{mod} \leq \bar{k} < l_{sev}\}$, where l is the loss ratio (losses as a share of illiquid assets) and $\bar{k}$ is the capital-to-asset ratio. For shareholders, there are no losses during a boom, but all is lost during a severe recession. There are two intermediate outcomes for shareholders: a mild recession and a moderate recession. As we will show, mild recessions diminish profits for shareholders because of the need to carry liquidity. Short-term bondholders impose this need on the shareholders. As for a moderate recession, losses wipe out most, but not all, of shareholder's equity. Since equity is endogenous, we will verify these relationships after we have explained how equity is determined.

We calculate the payoffs associated with each possible outcome for each type of liability holder: shareholders and bondholders. Starting with shareholders, during the boom, profits are:

$$3.\quad \pi_{boom} = (R+2\Delta_P + z)A - \left(R + 2\Delta_p\right)(1-\lambda)B - R\lambda B$$

Banks hold risky assets for two periods. These assets yield an expected return of $R+2\Delta_P + z$ each period, where $2\Delta_P$ is a two-period credit-risk premium, R is the two-period risk-free return, and z is the idiosyncratic return to bank lending. Using Equation (1), we can write boom profits as:

$$4.\quad \pi_{boom} = (R + 2\Delta_P)(D + E) + zA + \left(2\Delta_p\right)\lambda B.$$

If boom times were all times and the bank had sufficient access to deposits, then the bank's shareholders would fund the bank with only deposits and short-term bonds. That is, the bank would choose $\lambda = 1$, since short-term bonds are cheaper than long-term bonds and since in boom times short-term bondholders always roll over their debt. Note that $\left(2\Delta_p\right)\lambda B$ is the profit from maturity mismatch between assets and liabilities.

However, in a recession, short-term bondholders do not roll over their debt automatically. After the signs of recession appear, short-term bondholders foresee three possible outcomes: (1) a mild recession, (2) the recession is moderate, or (3) the recession is severe. When a boom follows the bust, the recession is mild and short-lived, and short-term bondholders get $(1 + 2r)$. During a moderate recession, bank equity is sufficient to cover asset losses, and short-term bondholders get $(1 + 2r)$. However, in a severe recession, short-term bondholders potentially bear some losses.

By assumption, short-term bondholders avoid all losses. As a result, they demand collateral to cover any possible loss once a recession begins. Once a recession has occurred, the bank must carry sufficient liquid assets (that is, safe assets that shareholders have pledged to the short-term bondholders in the case of default) to cover the possible loss in a severe recession. The bank protects short-term bondholders from bankruptcy by legally committing a liquid asset collateral holding that bondholders can quickly seize if needed. This process is costly for the bank to implement and the costs of conversion increase when more short-term liabilities have to be converted.[11]

Liquid assets yield the risk-free return *R* and cost ε to create, where ε denotes a fraction of short-term debt. Thus, we write the bank's profit in a mild recession as:

$$5.\quad \pi_{mild} = \left(R + 2\Delta_p + z\right)(A - \lambda B) + R\lambda B - \left(R + 2\Delta_p\right)(1 - \lambda)B - R\lambda B - \varepsilon\lambda^2 B$$

[11] Historically, when the FDIC actually closes a bank, it steps in and directly guarantees the short-term bondholders (e.g. Federal Home Loan Banks that have extended advances or repos extended by market participants). Otherwise, the short-term bondholders would not roll over their debt. However, by this point, usually the collateral demands by short-term bondholders have already be put in place.

or:

$$\pi_{mild} = \pi_{boom} - (2\Delta_p + z + \varepsilon\lambda)\lambda B.$$

Note that $(2\Delta_p + z + \varepsilon\lambda) > 0$ is the lost revenue from converting a dollar's worth of loans into a liquid asset. Thus, relative to "boom" profits, profits decline with the prospect of a mild recession because of this lost revenue. Banks must now compare the costs of carrying adequate liquidity to reassure short-term bondholders and the risk premium charged by long-term bondholders. It may no longer be profit maximizing to fund the bank with only deposits and short-term bonds.

In a moderate recession, the resulting loan losses eliminate some, but not all, shareholders' equity. Shareholders cannot offset these losses by using the liquid assets because the liquid assets are pledged to short-term bondholders. Neither short-term bondholders nor long-term bondholders take a loss. The resulting profits are:

$$6. \quad \pi_{mod} = \pi_{mild} - l_{mod}(A - \lambda B) = \pi_{boom} - (2\Delta_p + z + \varepsilon\lambda)\lambda B - l_{mod}(A - \lambda B)$$

The loss is a haircut l_{mod} on the value of illiquid assets, which is applied to the stock of illiquid assets $(A - \lambda B)$.

In contrast, a severe recession wipes out equity and second-stage asset returns. The liquidity holdings of the bank protect short-term bondholders. We assume the government does not bail out the bank. Instead, the government makes depositors whole by seizing the remaining deposit franchise and selling it to other investors.[12] With deposits covered, the government imposes losses on long-term bondholders. Consequently, long-term bondholders protect themselves by charging a term premium that covers potential losses when shareholders issue the debt.[13]

[12] If the government absorbs the losses, then the term premium will be lower or disappear.

[13] This is because they cannot renegotiate their contract at the end of the first stage of the game.

Profits in a severe recession are:

$$7.\quad \pi_{sev} = 0$$

Given the cases outlined above, the bank's expected profits at time 0 are boom-time revenues minus the possible losses imposed by creating liquid assets for short-term bondholders and absorbing losses in a moderate recession:

$$8.\quad E(\pi) = [p + (1-p)(q_{mild} + q_{mod})]\pi_{boom} + (1-p)\big[q_{mod}l_{mod} - (q + q_L)(2\Delta_p + z + \varepsilon\lambda)\big]\lambda B - (1-p)q_{mod}l_{mod}A$$

The credit premium is set in the market for long–term bonds. In the boom and the mild and moderate recession scenarios, the long-term debt holders get their contractual amount. In the severe scenario, they bear the uncovered losses. The payoff to long-term bondholders in the severe scenario is:

$$9.\quad S = -l_{sev}(A - \lambda B) + E < 0.$$

Long-term bondholders set the credit premium so that the expected return on their investment $(1-\lambda)B$ in the bank should at least equal what their risk-free return on the investment would be. Then the minimum credit premium that long-term bondholders are willing to accept is characterized by[14]:

$$10.\quad 2\Delta_p = \frac{(1-p)q_{sev}}{p+(1-p)(q_{mild}+q_{mod})]}\left\{R + \frac{[l_{sev}(A-\lambda B)-E]}{(1-\lambda)B}\right\}$$

Equation (10) reveals some interesting comparative statics. The lower the relative odds of a catastrophic outcome, the lower the credit premium. In addition, as $(1-p)$ (probability of a recession) or q_{sev} (probability of a severe outcome) go to zero, the credit premium goes to

[14] The credit premium is characterized by $[p + (1-p)(q_{mild} + q_{mod})] * \big(R + 2\Delta_p\big)(1-\lambda)B + (1-p)q_{sev}S = R(1-\lambda)B$. Substituting Equations (9) and (1) into this expression: $[p + (1-p)(q_{mild} + q_{mod})] * 2\Delta_p(1-\lambda)B = (1-p)q_{sev}[R(1-\lambda)B - [-l_{sev}(A-\lambda B) + E]]$. Solving for the credit premium, we get Equation (10).

zero. The credit premium also falls when the bank holds more liquid assets (if $(A - \lambda B)$ goes down) or when the bank holds more equity.

We assume that when long-term bondholders buy bonds, there is a maximum share of their investment that they are willing to lose: $\frac{[l_{sev}(A-\lambda B)-E]}{(1-\lambda)B} \leq \alpha.$[15] The shareholders want the credit premium to be as large as possible because it increases the gain from a maturity mismatch when funding assets.[16] Thus, the maximum loss that bondholders are willing to take becomes binding:

$$11.\ \alpha = \frac{[l_{sev}(A-\lambda B)-E]}{(1-\lambda)B}$$

The credit/term premium reflects the relative odds of a catastrophic outcome and the common risk preference of long-term bondholders:

$$12.\ 2\Delta_p = P_{sev}(R+\alpha) \quad \text{where} \quad P_{sev} = \frac{(1-p)q_{sev}}{p+(1-p)(q_{mild}+q_{mod})]}$$

As a result, based on Equation (11) equity and short-term bond holdings are related by:[17]

$$13.\ E = l_{sev}(A-\lambda B) - \alpha(1-\lambda)B \quad \text{which implies:} \quad E < l_{sev}(A-\lambda B)$$

If the loss ratio on illiquid assets in the severe recession scenario exceeds the maximum share of investment that long-term bondholders are willing to lose (if $l_{sev} > \alpha = \frac{[l_{sev}(A-\lambda B)-E]}{(1-\lambda)B}$):

$$14.\ l_{sev}(1-\lambda)B > l_{sev}(A-\lambda B) - E \quad \Longrightarrow \quad E > l_{sev}(A-B) \Longrightarrow \frac{E}{D} > \frac{l_{sev}}{(1-l_{sev})}$$

For example, if losses are between 10 percent and 30 percent of illiquid assets (consistent with losses experienced during the Great Recession), then equity would have to

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[15] Thus, the maximum loss rate for long-term debt holders (in a world with no equity) is $\frac{l_{sev}(A-\lambda B)}{(1-\lambda)B}$.

[16] From Equations (3) and (8) we have: $\frac{dE(\pi)}{d2\Delta_p} = \frac{d\,\pi_{boom}}{d2\Delta_p} + p\lambda B = A - (1-\lambda)B + p\lambda B \geq 0$.

[17] Equivalently, $E = (l_{sev}A - \alpha B) + (\alpha - l_{sev})\lambda B$.

range from 11 percent to 42 percent of deposits. A bank with 10 percent equity to assets and 60 percent deposits to assets would correspond to a severe recession loss ratio of 14 percent.

By definition, losses exceed equity in the severe recession scenario.[18] So, if $l_{sev} > \alpha$ then Equations (13) and (14) imply: $0 < E < l_{sev}(1-\lambda)B$. That is, equity is insufficient to cover lost long-term bonds in the severe recession scenario.

Next, we turn to bank shareholders' optimal choice of the share of short-term debt. Using the expression in Equation (8) to derive the first-order condition for shareholders to maximize the bank's expected profits subject to the constraint imposed by long and short-term bondholders, substituting in Equations (4) and (12) and solving for the optimal lambda:[19]

$$15.\ \lambda^* = \frac{\frac{p}{(1-p)}(2\Delta_p) + [q_{mod}l_{mod} - (q_{mild} + q_{mod})z]}{2\varepsilon(q_{mild} + q_{mod})}$$

Therefore, the optimal amount of short-term debt is determined by the odds of good times $\frac{p}{(1-p)}$, multiplied by the return to maturity mismatch or the term/credit premium $(2\Delta_p)$. If the odds of good times are higher, or the return to maturity mismatch is higher, the bank desires to take on more short-term debt.

Of course, more short-term debt implies the possibility of more liquid assets might be needed to collateralize short-term debt. A higher cost of holding liquid assets is the loss spread on the higher-yielding illiquid asset *z*, which implies a lower level of short-term debt. However, holding liquid assets means no credit losses during a recession for the shareholders, so the bank saves $q_{mod}l_{mod}$. If credit losses are expected to be higher, the bank is willing to carry more safe

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[18] Otherwise, the shareholders bear all the loss and we are back to the moderate recession case.

[19] The first-order condition is: $\frac{dE(\pi)}{d\lambda} = [p + (1-p)(q_{mild} + q_{mod})]\frac{d\pi_{boom}}{d\lambda} + (1-p)\big[q_{mod}l_{mod} - (q_{mild} + q_{mod})(2\Delta_p + z + 2\varepsilon\lambda)\big]B = 0$. From Equations (4) and (12), we have: $\frac{d\pi_{boom}}{d\lambda} = 2\Delta_p B = P_{sev}(R+\alpha)B$. Therefore, we get:

$$\frac{dE(\pi)}{d\lambda} = [p + (1-p)(q_{mild} + q_{mod})]2\Delta_p B + (1-p)\big[q_{mod}l_{mod} - (q_{mild} + q_{mod})\big(2\Delta_p + z + 2\varepsilon\lambda\big)\big]B = 0$$

assets. Finally, if the cost of converting illiquid assets to liquid assets is higher, the bank uses less short-term funding. To summarize, the share of bonds that are short-term increases when:

- the cost ε of converting illiquid assets to liquid assets is lower
- the maximum loss α that long-term bondholders are willing to take is higher
- the probability of a catastrophic outcome $[q_{sev} = 1 - q_{mild} - q_{mod}]$ is higher
- the loss in expected revenues $q_{mod}l_{mod} - (q_{mild} + q_{mod})z$ from converting illiquid assets to liquid assets is smaller in magnitude
- the losses on a moderate recession l_{mod} are higher
- the risk-free rate R is higher.

Hypothesis #1: The share of short-term bonds and equity ratios are negatively related.

The expression in Equation (15) for the share of short-term funding suggests an empirical approach that links the credit premium, recession probabilities and loan spreads to the bank's desired holding of short-term bonds λ^*. Using Equation (13), the equity to assets ratio is:

$$16.\ \frac{E}{A} = (l_{sev} - \alpha\frac{B}{A}) + [(\alpha - l_{sev})\frac{B}{A}] * \lambda$$

Plugging λ^* into the equity equation, we can estimate the relationship between the share of short-term debt and the equity to assets ratio. Note that if $(\alpha - l_{sev}) < 0$ as in Equation (16), then a higher share of short-term bonds implies lower equity ratios.

Hypothesis #2: There is a negative relationship between the equity ratio and the LCR.

Next, we relate the share of short-term debt λ^* to broadly used measures of bank balance sheet liquidity, such as the Liquidity Coverage Ratio (LCR), the Liquidity Mismatch Index (LMI) and the Net Stable Funding Ratio (NSFR). The LCR, which is the ratio of high-quality liquid assets to expected liability outflows over the course of a month in a stress scenario, can be expressed as:

$$17.\ LCR = \frac{\lambda B}{\phi_1\lambda B + \phi_2 D} = \frac{\lambda}{\phi_1\lambda + \phi_2 D/B} \quad \Rightarrow \quad \lambda = \frac{\phi_2}{(1-\phi_1 LCR)}\frac{D}{B}$$

Where ϕ denotes outflow rates, that is, the shares of debt that is expected to be called over the course of a month on the liability side of the balance sheet. Plugging Equation (17) into (16):

$$18.\quad \frac{d(E/A)}{dLCR} = (\alpha - l_{sev})\phi_1\phi_2\frac{D}{A}$$

That is, if $(\alpha - l_{sev}) < 0$, there is a negative relationship between the equity ratio and the LCR.

Hypothesis #3: The equity ratio and the LMI to assets ratio are negatively related.

Next, we examine the relationship between the *LMI* and the equity ratio, through the short-term debt ratio λ. Based on Bai et al (2018), the *LMI* takes the general form:

$$19.\ LMI_{j,t} = \sum_{k=1}^{K} \beta_{k,t}\, Assets_{j,t} - \sum_{n=1}^{N} \varphi_{n,t}\, Liabilities_{j,t}$$

where the asset-side weights $\beta_{k,t}$ decrease as asset class-specific haircuts increase or as asset liquidity declines. Similarly, the liability-side weights $\varphi_{n,t}$ decrease as maturity increases and as the OIS – T-bill spread narrows.[20] In the context of our model, the *LMI* takes the form:

$$20.\ LMI = \beta_1\lambda B + \beta_2(A - \lambda B) - \varphi_1\lambda B - \varphi_2(1-\lambda)B - \varphi_3 D - \varphi_4 E$$
$$\Rightarrow \quad \lambda = \frac{\beta_2 - LMI/A - \varphi_3 D/A - \varphi_2 B/A - \varphi_4 E/A}{[(\varphi_1 - \varphi_2) - (\beta_1 - \beta_2)]B/A}$$

Where, as in Bai et al (2018), the weight on short-term liabilities is greater than the weight on long-term debt: $(\varphi_1 - \varphi_2) > 0$, and the weight on liquid assets is greater than the weight on illiquid assets: $(\beta_1 - \beta_2) > 0$. From Equation (16), E/A is a function of the LMI to assets ratio:[21]

$$21.\quad \frac{d(E/A)}{dLMI/A} = \frac{(\alpha - l_{sev})}{[T - (\alpha - l_{sev})\varphi_4]} \quad \text{where} \quad T = (\beta_1 - \beta_2) - (\varphi_1 - \varphi_2)$$

In Bai et al (2018), the weight on equity φ_4 is close to zero (as equity is the most stable funding source). Therefore, the sign of the relationship between the equity ratio and the *LMI* in Equation (27) depends on (1) the sign of $(\alpha - l_{sev})$, and (2) the difference between the asset weights gap $\beta_1 - \beta_2$ and the liability weights gap $\varphi_1 - \varphi_2$. For (1), as described above, for reasonable parameter values we have $(\alpha - l_{sev}) < 0$. Therefore, from (2), if liquid liabilities are penalized less relative to illiquid liabilities than liquid assets are rewarded relative to illiquid

[20] To illustrate the LMI through a simple examine, suppose Bank A has all cash assets and all deposit liabilities and Bank B has all intangible assets and all overnight debt as liabilities. Then we have $LMI_{A,t} > LMI_{B,t}$.

[21] We scale the *LMI* by total assets, so as to express this measure of liquidity as a ratio as well. The intermediate step in this derivation is: $\frac{E}{A} = \frac{(l_{sev} - \alpha\frac{B}{A})T - (\alpha - l_{sev})[\beta_2 - LMI/A - \varphi_3 D/A - \varphi_2 B/A]}{T - (\alpha - l_{sev})\varphi_4}$.

assets (that is, if $(\beta_1 - \beta_2) > (\varphi_1 - \varphi_2)$), then there is a negative relationship between the equity ratio and the LMI to assets ratio.

Hypothesis #4: There is a negative relationship between the equity ratio and the NSFR.

Lastly, we examine the relationship between the *NSFR* and the equity ratio, through the short-term debt ratio λ. Based on BCBS (2014), in our model the *NSFR* takes the general form:

$$22. \quad NSFR = \frac{\tau_1 \lambda B + \tau_2 (1-\lambda)B) + \tau_3 E + \tau_4 D}{\tau_5 \lambda B + \tau_6 (A - \lambda B)} \quad \Longrightarrow \quad \lambda = \frac{\tau_6 NSFR - \tau_2 \frac{B}{A} - \frac{\tau_3 E}{A} - \tau_4 D/A}{[\tau_1 - \tau_2 - NSFR(\tau_5 - \tau_6)]B/A}$$

Then from Equation (22), if $\tau_5 = \tau_6$ then the equity ratio as a function of the NSFR is:[22]

$$23. \quad \frac{d(E/A)}{dNSFR} = \frac{(\alpha - l_{sev})\tau_6}{(\tau_1 - \tau_2 + (\alpha - l_{sev})\tau_3)}$$

According to BCBS (2014), the weight on equity $\tau_3 = 1$. As described above, for reasonable parameter values we have $(\alpha - l_{sev}) < 0$. Therefore, the sign of the relationship between the equity ratio and the *NSFR* in Equation (23) depends on the relative size of $\tau_1 - \tau_2$ (the extra weight short-term available funding receives (around 0.5) relative to the weight on longer-term funding in the *NSFR;* around zero) vs. $(\alpha - l_{sev})$. Therefore, as long as $0 > (\alpha - l_{sev}) > -0.5$, there is a negative relationship between the equity ratio and the NSFR.

Section 3: Estimation methodology

Guided by our hypothesis development described in Section 2, we set up our estimable regressions as follows.

3.1 The relationship between the equity ratio and short-term bond holdings

Based on Equation (15), the share of short-term bonds $\lambda_{j,t}$ can be expressed as:

$$24. \quad \lambda_{j,t} = \chi_1 + \chi_2 \, \Delta_p + \chi_2 \, (l_{mod})_{j,t} + \chi_3 \, z_{j,t} + \mu_{j,t}$$

[22] The intermediate step in this derivation is: $\frac{E}{A} = \frac{(\tau_1 - \tau_2)(l_{sev} - \alpha \frac{B}{A}) + (\alpha - l_{sev})(\tau_6 NSFR - \tau_2 \frac{B}{A} - \tau_4 D/A)}{(\tau_1 - \tau_2 + (\alpha - l_{sev})\tau_3)}$.

where, based on Equation (16), we estimate the relationship between the equity ratio and short-term bond holdings as:

$$25. \quad (\frac{E}{A})_{j,t} = \pi_1 + \pi_2 \widehat{\lambda_{j,t}} + \eta_{j,t}$$

The "hat" over λ indicates predicted values estimated from Equation (24). We estimate Equations (24) and (25) in a three-stage least squares (3SLS) instrumental variables (IV) setup. *Hypothesis #1* implies that $\pi_2 < 0$.

Next, we estimate the empirical relationship between the *LCR* and λ and the equity ratio and *LCR* based on Equations (17) and (18).

$$26. \quad LCR_{j,t} = \text{¥}_1 + \text{¥}_2 \widehat{\lambda_{j,t}} + \acute{\varepsilon}_{j,t} \text{ and } (\frac{E}{A})_{j,t} = \omega_1 + \omega_2 LCR_{j,t} + \upsilon_{j,t}$$

We estimate the equations in (25) and (26) in a system of simultaneous equations (SSE), using three-stage least squares (3SLS). *Hypothesis #2* implies that $\omega_2 < 0$.

Next, we estimate the empirical relationship between the *LMI* and λ and the equity ratio and the *LMI to assets ratio* (from hereon, *LMIA)* based on Equations (20) and (21).

$$27. \quad LMIA_{j,t} = \pounds_1 + \pounds_2 \widehat{\lambda_{j,t}} + \kappa_{j,t} \text{ and } (\frac{E}{A})_{j,t} = \vartheta_1 + \vartheta_2 LMIA_{j,t} + \epsilon_{j,t}$$

We estimate Equations (25) and (27) in an SSE with 3SLS. *Hypothesis #3* implies that $\vartheta_2 < 0$.

Lastly, we estimate the empirical relationship between the *NSFR* and λ and the equity ratio and the *NSFR* based on Equations (22) and (23).

$$28. \quad NSFR_{j,t} = \mathit{\Omega}_1 + \mathit{\Omega}_2 \widehat{\lambda_{j,t}} + \varkappa_{j,t} \text{ and } (\frac{E}{A})_{j,t} = \text{Ϙ}_1 + \text{Ϙ}_2 NSFR_{j,t} + \check{\varepsilon}_{j,t}$$

We estimate Equations (25) and (28) in an SSE with 3SLS. *Hypothesis #4* implies that $\text{Ϙ}_2 < 0$.

Section 4: Data description

4.1. Measures of liquidity

As described above, we use four measures of balance sheet liquidity: the share of short term liabilities, the LCR, the NSFR and the asset-scaled LMI. To calculate these liquidity measures, we use the Y9C data on US bank holding companies to construct an unbalanced panel of nearly 1,400 US-chartered holding companies over the 2010 Q1 – 2019 Q4 period. Our choice of the start date of our sample is guided by the availability of publicly posted asset-side haircut data used in the calculation of the LMI, and we choose the end-date to reflect the most recent quarter for which all our variables are available.

4.1.1. Share of short-term liabilities (Lambda)

We define lambda as the ratio of short-term liabilities to all non-deposit liabilities. Short-term liabilities are overnight fed funds purchased plus repo securities plus trading liabilities plus commercial paper with maturity less than one year. Non-deposit liabilities are defined as total assets minus equity minus the sum of insured and uninsured deposits.

4.1.2. Liquidity Coverage Ratio (LCR) and Stable Net Funding Ratio (NSFR)

LCR and NSFR values are calculated using commercial bank Call Reports data. We then aggregate each commercial bank up to its top-holder bank holding company, and average LCR and NSFR across the commercial banks belonging to the same holding company in the given year:quarter.[23]

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[23] Standard LCR banks are those with $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. Modified LCR banks are those that do not qualify as LCR banks under these conditions but have $50 billion or more in consolidated assets. The Economic Growth, Regulatory Relief, and Consumer Protection Act in 2018 raised the "modified LCR" threshold to $100 billion. For these banks, the denominator of the LCR is multiplied by 70 percent. To maintain a consistent sample of banks, the group of LCR banks is fixed as categorized prior to the 2018 threshold change, then those banks which are no longer subject to the modified LCR rule as of 2018 (as a result of the regulatory easing) are removed. This choice implies that these formerly modified LCR banks are not part of the pre-2018 sample either (since we work with a fixed sample of banks over time). In addition, small formerly non-LCR banks which subsequently became subject to the LCR rule due to asset growth are not in the LCR sample either. This conservative categorization is preferable in that including the no-longer-modified-LCR banks would wrongly categorize them as LCR banks in the later years of the sample, and including the (formerly small) banks would wrongly categorize them as LCR banks in the early years of the sample.

4.1.3. Asset-scaled Liquidity Mismatch Index (LMIA)

As described above, we follow the methodology laid out in detail in Bai et al (2018) to construct the LMI for each bank-year:quarter combination, and scale it by total assets. We use balance sheet data from the Y9C, and data on asset-class-specific haircuts from the Federal Reserve Bank of New York's website. Data on syndicated loan haircuts come from Refinitiv (Thomson Reuters).

As seen in Figure 2, our sample constitutes a period of continuous buildup of liquidity in the US banking system. However, there are notable differences across banks in the pattern of liquidity buildup. Figure 3 shows that much of this rapid increase is due to the buildup of liquidity on the balance sheets of the top US banks – that is, those which are subject to the "standard LCR" treatment. The rise in liquidity during our sample is much less pronounced for "modified LCR" banks, and those banks that are not subject to the LCR requirement (Non-LCR banks).

4.2. Credit risk premia, idiosyncratic return to bank lending and moderate recession losses

We measure credit risk premium by taking the first principal component of term premia on the 1, 2, 5 and 10-year US Treasury securities from the Federal Reserve Bank of New York's website (Adrian, Crump and Moench, 2013). To measure the idiosyncratic return to bank lending, we first calculate total return on lending as each bank's interest income, divided by total assets. We then subtract from this ratio the risk-free rate (the average US Treasury rate across the 1, 2, 5 and 10-year maturities) and the credit risk premium, as described above. Lastly, we measure moderate recession losses as the 95th percentile of each bank's non-performing assets ratio (NPA) over rolling 8 quarter windows, where NPA is the share of non-accruing assets in total assets.

4.3. Equity ratio

We measure the equity ratio as the ratio of each bank's tier 1 equity to total assets, calculated from the Y9C. Table 1 provides summary statistics for the full sample of banks and for the subsample excluding those banks that are subject to the LCR treatment as of end-2017. Table A1 in the Appendix provides summary statistics for the earlier 2000-2014 and the later 2015-2019 periods separately.

Section 5: Empirical results

Based on the description of bank-level liquidity and capitalization, there are two important features which we need to address in our empirical methodology. First, Section 2 highlights the endogeneity/feedback effects between liquidity and equity. Second, the description in Sections 1 and 4 suggests that the tradeoff between banks' LMI and equity ratio may have weakened over time. We address the first issue by employing Instrument Variable and system of simultaneous equations estimations methods. We tackle the second issue (weakening tradeoff over time) by including interactions with period dummies in our regressions. In addition, we add bank fixed effects to our estimations to account for any time-invariant unobserved bank characteristic that may affect bank equity and liquidity. Furthermore, we add year:quarter fixed effects in our estimations, so as to "take out" any time-varying macroeconomic effects that would affect all banks equally.

Our empirical investigation shows evidence of the tradeoff banks face between balance sheet liquidity and capitalization. Tables 2 through 5 present our findings on the negative relationship between banks' equity ratio and the short-term liability ratio (lambda), the LCR, the NSFR and the LMIA, respectively.

5.1. Tradeoff between equity and short-term liquidity

The Table 2 Panel A results show strong and consistent evidence that higher lambdas (bank balance sheets with more short-term liquidity) correspond to lower equity ratios. Panel A shows the results of estimating the relationship between equity and liquidity, and Panel B describes the drivers of lambda.[24] We include bank fixed effects throughout. In addition, Column 1 includes quarter dummies to take out seasonal balance sheet effects; Column 2 adds time (year:quarter) fixed effects. Column 3 shows results excluding those banks that are subject to the LCR rule as of

[24] Columns 1 in Panel A and B are estimated together in a simultaneous 3SLS setup, as are Columns 2, and so on.

end-2017, and Column 4 allows the tradeoff between liquidity to equity to vary in strength in the earlier (2010-2014) vs. later (2015-2019) part of our sample.

The magnitude and significance of the coefficients on lambda are consistent across the specifications in Panel A. Column 1 shows that a ten percent increase in banks' short-term liability ratio (about a two percentage point increase in the short-term liquidity ratio) corresponds to an approximately 70 basis point decline in the equity ratio. This effect is robust to the inclusion of time fixed effects in Column 2, and increases to over 80 basis points when we exclude LCR banks (Column 3). Column 4 shows that the tradeoff is stronger at almost 100 basis points in the first part of our sample, and declines in magnitude by about half by the 2015-2019 period. Panel B shows that all of the credit risk premium, moderate recession loss and the idiosyncratic return on lending affect short-term liquidity lambda negatively and significantly.

5.2. Tradeoff between equity and the LCR

Table 3 shows the relationship between the equity ratio and the LCR (Panel A), the LCR and short-term liquidity lambda (Panel B) and lambda's determinants (Panel C). Columns 1 of each panel are estimated simultaneously in a 3SLS setup, as are Columns 2, 3 and 4, respectively. The structure of Table 3 in constructed similarly as Table 2.

Similar to Table 2, Panel A shows evidence of a strong tradeoff between bank equity and balance sheet liquidity. A one percent increase in the LCR (corresponding to an approximately 2 percentage point increase in high-quality liquid assets relative to expected liability outflows) translates into a 1.4 percentage point decline in the equity ratio. This is a notable magnitude, given that the average equity ratio is 10.4 percent during our sample. The magnitude and significance of this effect are robust to the inclusion of time fixed effects in Column 2 and the exclusion of LCR banks in Column 3. Consistent with Table 2, Column 4 suggests that the tradeoff between equity and the LCR has weakened in the second part of our sample (that is, farther from the implementation of liquidity regulations which mostly took place over the 2010-2014 period).

Panel B describes the relationship between the LCR and short-term liquidity lambda, and shows a significant negative relationship. That is, higher short-term liability (corresponding to higher short-term outflows, thus increasing the denominator in the LCR calculations) translates into a lower LCR. A ten percent increase in lambda lowers the LCR by about half a percent, and this negative relationship has grown stronger in the post-2014 period (Column 4). The results in Panel C on the drivers of lambda are consistent with the comparable findings in Table 2.

5.3. Tradeoff between equity and the NSFR

Next, we examine the relationship between bank equity and the net stable funding ratio (NSFR). Table 4 is constructed similarly to Table 3 – estimating simultaneous equations across bank equity (Panel A), the NSFR (Panel B) and short-term liquidity (Panel C) in a 3SLS setup. The results in Panel A confirm a strong and consistent tradeoff between the equity ratio and liquidity, and the magnitude of this tradeoff is a bit larger than that seen in the case of the LCR. A one percent increase in the NSFR (corresponding to a one percentage point increase) translates into a 1.6 percentage point decline in the equity ratio. This effect, however, is notably smaller (at one percentage point) when we exclude LCR banks in Column 3. Consistent with the earlier results, Column 4 shows that the tradeoff between equity and liquidity has weakened in the second half of our sample.

Panel B shows the relationship between the NSFR and lambda, and, consistent with NSFR's definition, shows significant negative (though modest) effects. A ten percent increase in short-term liabilities lowers the NSFR by less than 0.1 percent, and this effect is somewhat more pronounced in the post-2014 period. Lastly, Panel C shows results on the drivers of lambda that are consistent with those seen in Tables 2 and 3.

5.4. Tradeoff between equity and the LMIA

In Table 5, we study the empirical relationship between bank equity and the LMI, scaled by total assets (LMIA). Table 5 is constructed similarly to Tables 3 and 4 – estimating simultaneous equations across bank equity (Panel A), the LMIA (Panel B) and short-term liquidity (Panel C) in a 3SLS setup. The results in Panel A show a strong and consistent tradeoff between the equity ratio and the liquidity mismatch index: A one percent increase in the LMI (corresponding to about one percentage point increase in the LMI relative to assets) translates into a 12 percentage point decline in the equity ratio. This effect is even larger (at 16 percentage points) when we exclude

LCR banks in Column 3. As before, Column 4 shows that the tradeoff between equity and liquidity has weakened in the second half of our sample.

Panel B shows the relationship between the LMIA and lambda, and, consistent with the LMI's definition, shows significant negative (though small) effects. A ten percent increase in short-term liabilities lambda lowers the LMI relative to assets by less than 0.05 percent, and this effect is somewhat more pronounced in the post-2014 period. Lastly, Panel C shows significant relationships between lambda and the credit risk premium, moderate recession losses and the idiosyncratic return on lending, consistent with those seen in Tables 2, 3 and 4.

Section 6: Summary and conclusion

In this paper, we examine the tradeoff that banks make between capitalization and balance sheet liquidity when they have heterogeneous debtholders. In particular, banks face short-term debtholders who demand complete safety and long-term debtholders who accept risk but cap their risk exposure. We construct a model of banks' optimal funding choice, showing that safety demands by investors influence a bank's liquidity decisions, that liquidity choices drive a bank's capital decisions, and that capital and liquidity are negatively related.

We then conduct detailed bank-level empirical analysis of the capital-liquidity tradeoff banks face. First, we construct four empirical measures of balance sheet liquidity: short-term liabilities, the Liquidity Coverage Ratio, the Net Stable Funding Ratio, and the asset-scaled Liquidity Mismatch Index with quarterly frequency between 2010 and 2019 for all US-chartered bank holding companies. We relate these liquidity measures to each bank's ratio using IV simultaneous equations estimation methods. Consistent with our model, we show that a bank's higher liquidity is significantly and negatively related to its equity ratio, and this tradeoff has weakened overtime. Furthermore, we find that the liquidity-equity tradeoff exists not only for the largest banks subject to the standard liquidity coverage ratio (LCR) regulations, but also for smaller bank holding companies.

Our results suggest that the safety concerns of bank debt investors underlie a strong endogenous tie between bank capital and liquidity, and suggest that changes in liquidity at banks may be difficult to interpret without information on more fundamental economic determinants. In addition, our findings imply that the capital-liquidity tradeoff is particularly strong for banks who face balance sheet constraints in the face of adjusting to regulations. Furthermore, the capital-liquidity tradeoff we identify is consistent with a complementary relationship between capital and liquidity regulations.

References

Acosta-Smith, Jonathan, Guillaume Arnouldz, Kristoffer Milonas and Quynh-Anh Vo (2019). "Bank capital and liquidity transformation," working paper.

Adrian, Tobias, Richard K. Crump and Emanuel Moench (2013). "Pricing the term structure with linear regressions," *Journal of Financial Economics* 110(1), pp. 110-138.

Bai, J., Krishnamurthy, A. and Weymuller, C.-H. (2018). "Measuring Liquidity Mismatch in the Banking Sector," *The Journal of Finance* 78(1).

Basel Committee on Banking Supervision (2013) "Basel III: The Liquidity Coverage Ratio and liquidity monitoring tools," *Bank for International Settlements*.

Basel Committee on Banking Supervision (2016). "Literature review on integration of regulatory capital and liquidity instruments," *Bank for International Settlements*.

Berger, Allen N. and Christa H.S. Bouwman (2009). "Bank liquidity creation," *The Review of Financial Studies* 22(9), pp. 3779–3837.

Berger, Allen N., Christa H.S. Bouwman, Thomas Kick and Klaus Schaeck (2016). "Bank liquidity creation following regulatory interventions and capital support," *Journal of Financial Intermediation* 26, pp. 115-141.

Caballero, Ricardo J., Emmanuel Farhi, and Pierre-Olivier Gourinchas (2017), "The Safe Assets Shortage Conundrum, "*Journal of Economic Perspectives*, Vol. 31, No. 3, pp. 29-46, Summer

DeAngelo, Harry and Rene M. Stulz (2011). "Liquid claim production, risk management, and bank capital structure: Why high leverage is optimal for banks," *Journal of Financial Economics* 116, pp. 219-236.

DeYoung, Robert, Isabelle Distinguin and Amine Tarazic (2018). "The joint regulation of bank liquidity and bank capital," *Journal of Financial Intermediation* 34, pp. 32-46.

Diamond, Douglas W. and Anil K. Kashyap (2016). "Liquidity Requirements, Liquidity Choice, and Financial Stability," *NBER Working Paper* 22053.

Distinguin, Isabelle, CarolineRoulet and AmineTarazia (2013). "Bank regulatory capital and liquidity: Evidence from US and European publicly traded banks," *Journal of banking and finance* 37(9), pp. 3295-3317.

Egan, Mark, Ali Hortacsu, and Gregor Matvos (2017). "Deposit Competition and Financial Fragility: Evidence from the US Banking Sector," *American Economic Review* 107(1), pp. 169-216.

Financial Stability Institute (2018). “Net Stable Funding Ratio (NSFR): Executive Summary,” *Bank for International Settlements.*

Gertler, Mark and Nobuhiro Kiyotaki (2015). “Banking, Liquidity, and Bank Runs in an Infinite Horizon Economy,” *American Economic Review* 105(7), pp. 2011-2043.

Gorton, Gary B. (2019). “The Regulation of Private Money,” *Journal of Money, Credit and Banking*, Forthcoming.

Gorton, Gary B. and Andrew Winton (2017). “Liquidity Provision, Bank Capital, and the Macroeconomy,” *Journal of Money, Credit and Banking* 49(1), pp. 5-37.

Gorton, Gary B . (2017), “The History and Economics of Safe Assets,” *Annual Review of Economics,* 9:547-86.

Horváth, R., J. Seidler and L.J Weill (2014). “Bank Capital and Liquidity Creation: Granger-Causality Evidence,” *Journal of Financial Services Research* 45(3), pp. 341–361.

Khan, Muhammad Saifuddin, Harald Scheule and Eliza Wu (2017). “Funding liquidity and bank risk taking,” *Journal of Banking and Finance* 82, pp. 203-216.

Kacperczyk, Marcin, Christophe Perignon, and Guillaume Vuillemey (2017), “The Private Production of safe Assets,” September 24.

Martin, Christopher, Munju Puri and Alexander Ufier (2017). “Deposit Inflows and Outflows in Failing Banks: The Role of Deposit Insurance,” *Manuscript*.

Miller, M. 1995. Do the M&M Propositions Apply to Banks? Journal of Banking and Finance 19, 483-489.

Modigliani, F., and M. Miller, (1958). The Cost of Capital, Corporate Finance, the Theory of Investment, *American Economic Review*, 48, 261-297.

Roberts, Daniel, Asani Sarkar and Or Shachar (2019). “Bank Liquidity Creation, Systemic Risk and Basel Liquidity Regulations,” working paper.

Schleifer, Andrei and Robert Vishney (2011). “Fires Sales in Finance and Economics,” *Journal of Economic Perspectives* 25(1), pp. 29-48.

Walther, Ansgar (2016). “Jointly Optimal Regulation of Bank Capital and Liquidity,” *Journal of Money, Credit and Banking* 48(2-3), pp. 415-448.

Figure 1: Banks' tradeoff between debt and equity

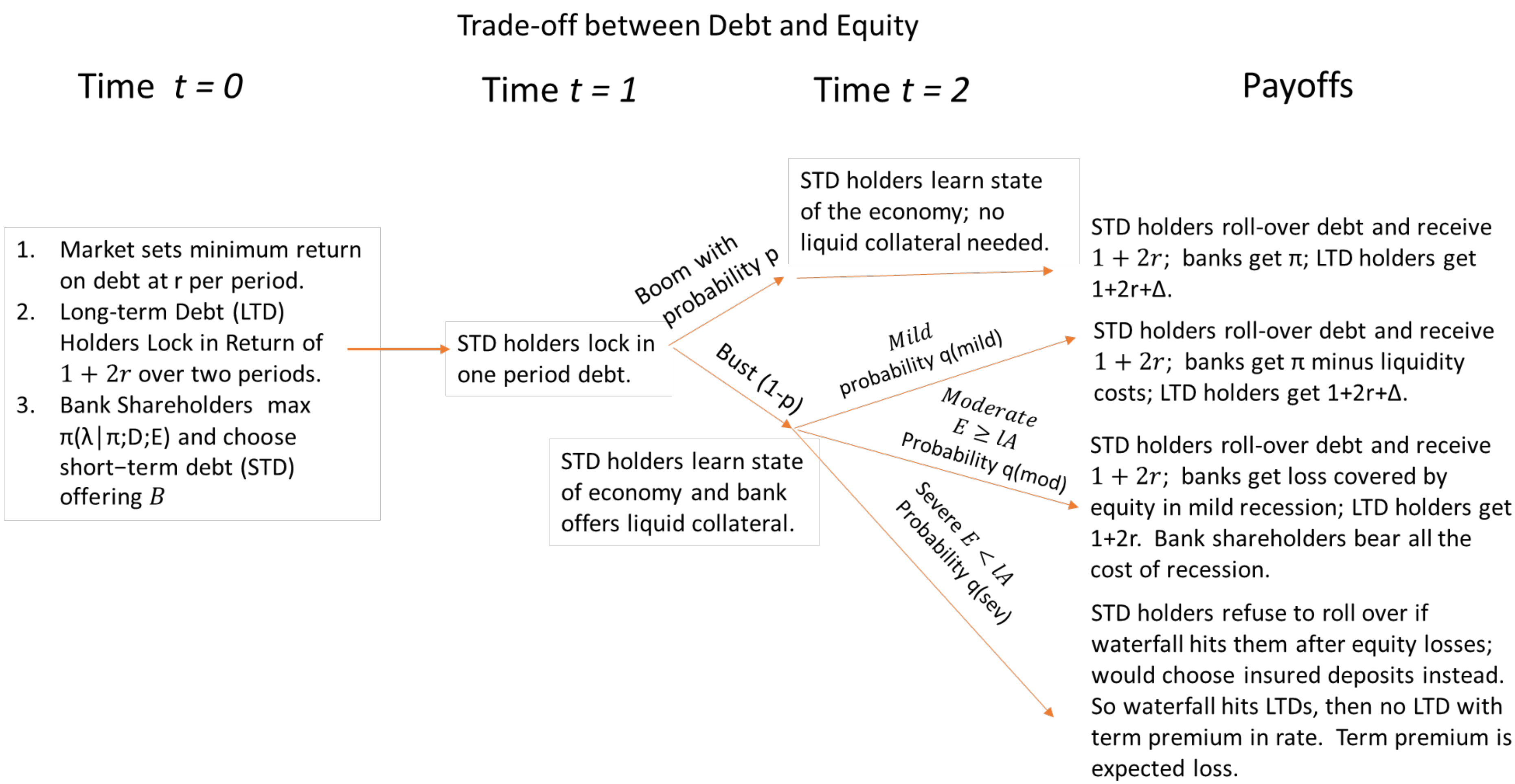
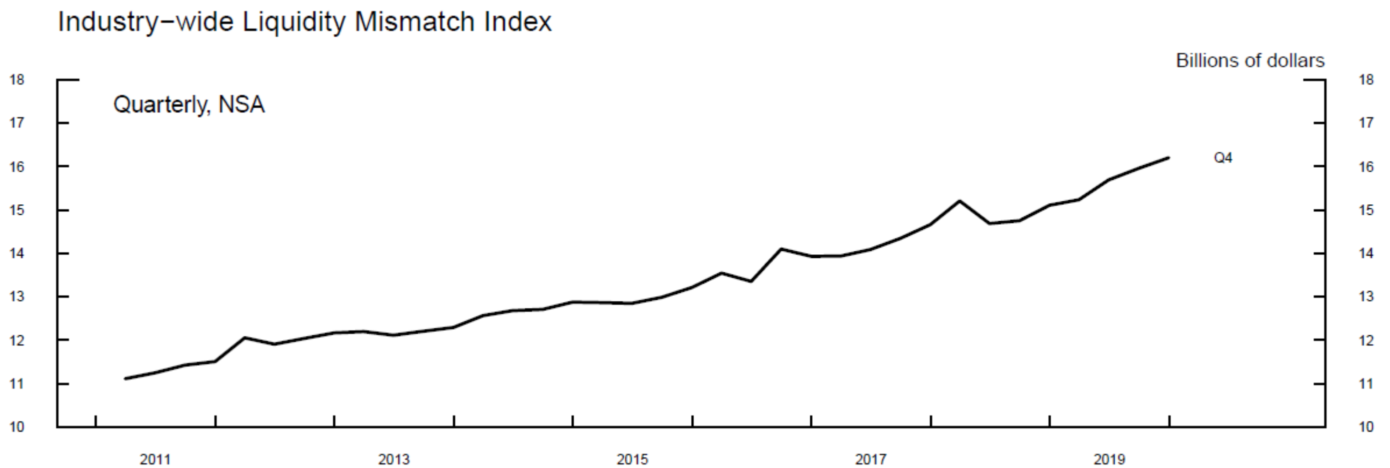
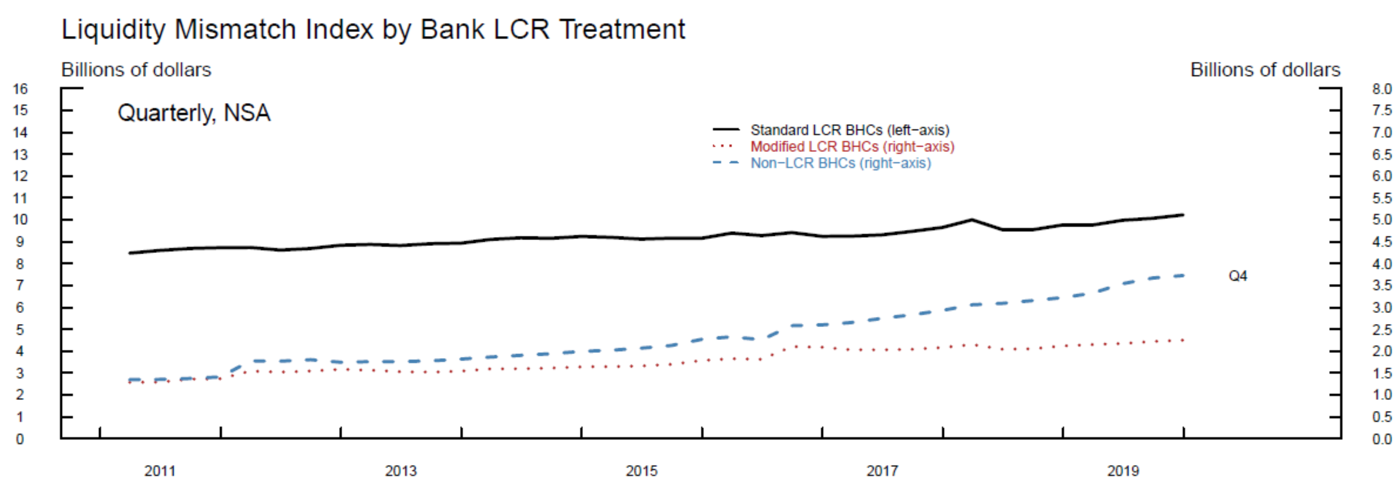


Figure 2: Aggregate Liquidity Mismatch Index for the US banking system: 2010 Q1 - 2019 Q4



Source: FR Y−9C; NY Fed; Refinitiv (Thomson Reuters).
Note: : The Liquidity Mismatch Index (LMI) gauges the mismatch between the market liquidity of assets and the funding of liquidity of liabilities and is computed as in Bai et al (2018). Aggregated across U.S. Bank Holding Companies.

Figure 3: Aggregate Liquidity Mismatch Index by LCR treatment of banks: 2010 Q1 - 2019 Q4



Source: FR Y−9C; NY Fed; Refinitiv (Thomson Reuters).
Note: : The Liquidity Mismatch Index (LMI) gauges the mismatch between the market liquidity of assets and the funding of liquidity of liabilities and is computed as in Bai et al (2018). Aggregated across U.S. Bank Holding Companies by LCR treatment category. Grouping by LCR categories is determined as described in the text.

Table 1 Panel A: Variable Definitions

Variables	*Definition*
Equity Ratio	Ratio of Total tier 1 equity to total assets, times 100
Short-term Liabilities	Ratio of short-term liabilities to total assets, times 100. Short-term liabilities are overnight fed funds purchased plus repo securities plus trading liabilities plus commercial paper with maturity less than one year. Non-deposit liabilities are defined as total assets minus equity minus the sum of insured and uninsured deposits.
Liquidity Coverage Ratio	Ratio of high-quality liquid assets to expected liability outflows during a stress scenario, times 100.
Net Stable Funding Ratio	Ratio of available stable funding relative to required stable funding, times 100. Available stable funding is the portion of capital and liabilities expected to be reliable over one year. Required stable funding is a function of the liquidity characteristics and residual maturities of the various assets held.
Liquidity Mismatch Index over Total Assets [LMIA]	Liquidity Mismatch Index (LMI) of the bank, divided by total assets, times 100. LMI is weighted assets minus weighted liabilities, where the asset-side weights decrease as asset class-specific haircuts increase or as asset liquidity declines. Liability-side weights decrease as maturity increases and as the OIS – T-bill spread narrows.
Treasury Term Premium [1st Principal Component]	First principal component of term premia on the 1, 2, 5 and 10-year US Treasury securities from the Federal Reserve Bank of New York's website (Adrian, Crump and Moench, 2013)
Idiosyncratic Return on Lending	Interest income divided by total assets, times 100, minus risk-free rate (average US Treasury rate across the 1, 2, 5 and 10-year maturities) minus Treasury risk premium
Moderate Recession Losses	95th percentile of bank's non-performing assets ratio (NPA) over rolling 8 quarter windows, where NPA is the share of non-accruing assets in total assets times 100.

Table 1 Panel B: Summary statistics: All US bank holding companies, 2010 Q1 - 2019 Q4

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Variables	Mean	SD	p10	p25	p50	p75	p90	N
Equity Ratio	10.43	3.85	6.86	8.46	10.04	11.94	14.25	33,401
Short-term Liabilities	19.72	17.51	0.00	4.52	16.16	30.58	45.04	33,369
[Log of] Short-term Liabilities	0.82	5.22	-13.82	1.51	2.78	3.42	3.81	33,369
Liquidity Coverage Ratio	197.80	131.70	57.57	87.67	159.10	275.80	418.70	27,173
[Log of] Liquidity Coverage Ratio	5.06	0.68	4.05	4.47	5.07	5.62	6.04	27,173
Net Stable Funding Ratio	105.40	15.25	89.54	94.05	101.70	112.00	125.50	27,173
[Log of] Net Stable Funding Ratio	4.65	0.13	4.50	4.54	4.62	4.72	4.83	27,173
Liquidity Mismatch Index over Total Assets [LMIA]	93.04	6.09	86.63	91.07	94.32	96.99	98.74	33,401
[Log of] Liquidity Mismatch Index over Total Assets [LMIA]	4.53	0.07	4.46	4.51	4.55	4.58	4.59	33,401
Treasury Term Premium [1st Principal Component]	0.75	1.11	-0.61	-0.06	0.62	1.67	2.50	33,401
Idiosyncratic Return on Lending	2.03	2.40	-0.59	0.32	2.03	3.52	4.91	33,374
Moderate Recession Losses	2.13	2.84	0.28	0.56	1.18	2.59	5.08	33,401
Total Assets (millions USD)	22,073	154,604	560.2	759	1,340	3,520	13,780	33,401

Table 1 Panel C: Summary statistics: Excluding LCR bank holding companies, 2010 Q1 - 2019 Q4

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Variables	Mean	SD	p10	p25	p50	p75	p90	N
Equity Ratio	10.37	3.89	6.78	8.41	9.97	11.87	14.23	32,024
Short-term Liabilities	19.66	17.62	0.00	4.28	16.02	30.61	45.30	31,992
[Log of] Short-term Liabilities	0.75	5.31	-13.82	1.45	2.77	3.42	3.81	31,992
Liquidity Coverage Ratio	199.50	132.80	57.57	87.30	161.20	279.70	424.20	26,066
[Log of] Liquidity Coverage Ratio	5.07	0.69	4.05	4.47	5.08	5.63	6.05	26,066
Net Stable Funding Ratio	105.40	15.06	89.54	94.32	101.90	111.90	125.20	26,066
[Log of] Net Stable Funding Ratio	4.65	0.13	4.50	4.55	4.62	4.72	4.83	26,066
Liquidity Mismatch Index over Total Assets [LMIA]	93.33	5.61	87.12	91.30	94.45	97.06	98.78	32,024
[Log of] Liquidity Mismatch Index over Total Assets [LMIA]	4.53	0.07	4.47	4.51	4.55	4.58	4.59	32,024
Treasury Term Premium [1st Principal Component]	0.76	1.11	-0.61	-0.06	0.62	1.67	2.50	32,024
Idiosyncratic Return on Lending	1.99	2.36	-0.59	0.31	2.02	3.50	4.84	31,997
Moderate Recession Losses	2.18	2.88	0.30	0.58	1.22	2.66	5.15	32,024
Total Assets (millions USD)	4,665	22,070	556	740.8	1,270	2,984	8,703	32,024

Table 2 Panel A: Relationship between Equity and Short-term Liabilities at US Bank Holding Companies; 2010 Q1 - 2019 Q4

	[1]	[2]	[3]	[4]
Dependent Variable:	*Equity Ratio*	*Equity Ratio*	*Equity Ratio*	*Equity Ratio*
Sample of Banks:	*All Banks*	*All Banks*	*Excluding LCR Banks*	*All Banks*
Variables				
Short-term Liability Ratio [Lambda, Log of]	-0.0732***	-0.0747***	-0.0832***	-0.0978***
	[0.00507]	[0.00506]	[0.00513]	[0.00631]
Post-2014 Dummy * Short-term Liability Ratio [Lambda, Log of]				0.0593***
				[0.00940]
Constant	10.46***	10.46***	10.41***	10.46***
	[0.0211]	[0.0211]	[0.0217]	[0.0210]
Observations	33,344	33,344	31,967	33,344
Bank fixed effects	Yes	Yes	Yes	Yes
Year:Quarter dummies	No	Yes	Yes	Yes
Quarter dummies	Yes	--	--	--

Coefficient estimates from three-stage least squares (3SLS) simultaneous estimation of the relationship between Equity and Short-term Liabilities at US bank holding companies from 2010 Q1 to 2019 Q4. Each column in Panel A is estimated simultaneously with each corresponding column from Panel B. "--" indicates that the set of controls is subsumed by more restrictive controls in the regression. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 2 Panel B: Determinants of Short-term Liabilities at US Bank Holding Companies; 2010 Q1 - 2019 Q4

	[1]	[2]	[3]	[4]
Dependent Variable:	*Short-term Liability Ratio [Lambda, Log of]*	*Short-term Liability Ratio [Lambda, Log of]*	*Short-term Liability Ratio [Lambda, Log of]*	*Short-term Liability Ratio [Lambda, Log of]*
Sample of Banks:	*All Banks*	*All Banks*	*Excluding LCR Banks*	*All Banks*
Variables				
Treasury Term Premium [1st Principal Component]	-0.0764***	-0.0761***	-0.0890***	-0.0756**
	[0.0294]	[0.0294]	[0.0306]	[0.0294]
Idiosyncratic Return on Lending	-0.121***	-0.121***	-0.144***	-0.122***
	[0.0129]	[0.0129]	[0.0136]	[0.0129]
Moderate Recession Losses	-0.104***	-0.103***	-0.0899***	-0.102***
	[0.0107]	[0.0107]	[0.0109]	[0.0107]
Constant	1.353***	1.352***	1.308***	1.350***
	[0.0507]	[0.0507]	[0.0528]	[0.0507]
Observations	33,344	33,344	31,967	33,344
Bank fixed effects	Yes	Yes	Yes	Yes
Year:Quarter dummies	No	Yes	Yes	Yes
Quarter dummies	Yes	--	--	--

Coefficient estimates from three-stage least squares (3SLS) simultaneous estimation of the determinants of Short-term Liabilities at US bank holding companies from 2010 Q1 to 2019 Q4. Each column in Panel A is estimated simultaneously with each corresponding column from Panel B. "--" indicates that the set of controls is subsumed by more restrictive controls in the regression. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 3 Panel A: Relationship between Equity and Liquidity Coverage Ratio at US Bank Holding Companies; 2010 Q1 - 2018 Q4

	[1]	[2]	[3]	[4]
Dependent Variable:	*Equity Ratio*	*Equity Ratio*	*Equity Ratio*	*Equity Ratio*
Sample of Banks:	*All Banks*	*All Banks*	*Excluding LCR Banks*	*All Banks*
Variables				
Liquidity Coverage Ratio [LCR, Log of]	-1.450***	-1.409***	-1.395***	-1.168***
	[0.0356]	[0.0353]	[0.0359]	[0.0360]
Post-2014 Dummy * Liquidity Coverage Ratio [LCR, Log of]				0.146***
				[0.0101]
Constant	17.45***	17.24***	17.10***	15.81***
	[0.182]	[0.180]	[0.183]	[0.188]
Observations	27,162	27,162	26,055	27,162
Bank fixed effects	Yes	Yes	Yes	Yes
Year:Quarter dummies	No	Yes	Yes	Yes
Quarter dummies	Yes	--	--	--

Coefficient estimates from three-stage least squares (3SLS) simultaneous estimation of the relationship between Equity and Liquidity Coverage Ratio at US bank holding companies from 2010 Q1 to 2018 Q4. Each column in Panel A is estimated simultaneously with each corresponding column from Panel B and Panel C. "--" indicates that the set of controls is subsumed by more restrictive controls in the regression. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 3 Panel B: Relationship between Liquidity Coverage Ratio and Short-term Liabilities at US Bank Holding Companies; 2010 Q1 - 2018 Q4

	[1]	[2]	[3]	[4]
Dependent Variable:	*Liquidity Coverage Ratio [LCR, Log of]*	*Liquidity Coverage Ratio [LCR, Log of]*	*Liquidity Coverage Ratio [LCR, Log of]*	*Liquidity Coverage Ratio [LCR, Log of]*
Sample of Banks:	*All Banks*	*All Banks*	*Excluding LCR Banks*	*All Banks*
Variables				
Short-term Liability Ratio [Lambda, Log of]	-0.0495***	-0.0492***	-0.0487***	-0.0486***
	[0.000965]	[0.000963]	[0.000974]	[0.00117]
Post-2014 Dummy * Short-term Liability Ratio [Lambda, Log of]				-0.00937***
				[0.00184]
Constant	5.105***	5.105***	5.107***	5.107***
	[0.00414]	[0.00414]	[0.00424]	[0.00412]
Observations	27,162	27,162	26,055	27,162
Bank fixed effects	Yes	Yes	Yes	Yes
Year:Quarter dummies	No	Yes	Yes	Yes
Quarter dummies	Yes	--	--	--

Coefficient estimates from three-stage least squares (3SLS) simultaneous estimation of the relationship between Liquidity Coverage Ratio and Short-term Liabilities at US bank holding companies from 2010 Q1 to 2018 Q4. Each column in Panel A is estimated simultaneously with each corresponding column from Panel B and Panel C. "--" indicates that the set of controls is subsumed by more restrictive controls in the regression. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 3 Panel C: Determinants of Short-term Liabilities at US Bank Holding Companies; 2010 Q1 - 2018 Q4

	[1]	[2]	[3]	[4]
Dependent Variable:	*Short-term Liability Ratio [Lambda, Log of]*	*Short-term Liability Ratio [Lambda, Log of]*	*Short-term Liability Ratio [Lambda, Log of]*	*Short-term Liability Ratio [Lambda, Log of]*
Sample of Banks:	*All Banks*	*All Banks*	*Excluding LCR Banks*	*All Banks*
Variables				
Treasury Term Premium [1st Principal Component]	-0.0645*	-0.0638*	-0.0785**	-0.0319
	[0.0340]	[0.0341]	[0.0355]	[0.0342]
Idiosyncratic Return on Lending	-0.0994***	-0.0996***	-0.113***	-0.0979***
	[0.0146]	[0.0146]	[0.0154]	[0.0146]
Moderate Recession Losses	-0.204***	-0.203***	-0.194***	-0.204***
	[0.0113]	[0.0113]	[0.0115]	[0.0113]
Constant	1.572***	1.570***	1.520***	1.540***
	[0.0592]	[0.0592]	[0.0619]	[0.0593]
Observations	27,162	27,162	26,055	27,162
Bank fixed effects	Yes	Yes	Yes	Yes
Year:Quarter dummies	No	Yes	Yes	Yes
Quarter dummies	Yes	--	--	--

Coefficient estimates from three-stage least squares (3SLS) simultaneous estimation of the determinants of Short-term Liabilities at US bank holding companies from 2010 Q1 to 2018 Q4. Each column in Panel A is estimated simultaneously with each corresponding column from Panel B and Panel C. "--" indicates that the set of controls is subsumed by more restrictive controls in the regression. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 4 Panel A: Relationship between Equity and Net Stable Funding Ratio at US Bank Holding Companies; 2010 Q1 - 2018 Q4

	[1]	[2]	[3]	[4]
Dependent Variable:	*Equity Ratio*	*Equity Ratio*	*Equity Ratio*	*Equity Ratio*
Sample of Banks:	*All Banks*	*All Banks*	*Excluding LCR Banks*	*All Banks*
Variables				
Net Stable Funding Ratio [NSFR, Log of]	-1.635***	-1.556***	-1.086***	-0.367**
	[0.177]	[0.176]	[0.182]	[0.179]
Post-2014 Dummy * Net Stable Funding Ratio [NSFR, Log of]				0.233***
				[0.0106]
Constant	17.70***	17.33***	15.08***	11.50***
	[0.823]	[0.818]	[0.845]	[0.835]
Observations	27,162	27,162	26,055	27,162
Bank fixed effects	Yes	Yes	Yes	Yes
Year:Quarter dummies	No	Yes	Yes	Yes
Quarter dummies	Yes	--	--	--

Coefficient estimates from three-stage least squares (3SLS) simultaneous estimation of the relationship between Equity and Net Stable Funding Ratio at US bank holding companies from 2010 Q1 to 2018 Q4. Each column in Panel A is estimated simultaneously with each corresponding column from Panel B and Panel C. "--" indicates that the set of controls is subsumed by more restrictive controls in the regression. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 4 Panel B: Relationship between Net Stable Funding Ratio and Short-term Liabilities at US Bank Holding Companies; 2010 Q1 - 2018 Q4

	[1]	[2]	[3]	[4]
Dependent Variable:	*Net Stable Funding Ratio [NSFR, Log of]*	*Net Stable Funding Ratio [NSFR, Log of]*	*Net Stable Funding Ratio [NSFR, Log of]*	*Net Stable Funding Ratio [NSFR, Log of]*
Sample of Banks:	*All Banks*	*All Banks*	*Excluding LCR Banks*	*All Banks*
Variables				
Short-term Liability Ratio [Lambda, Log of]	-0.00864***	-0.00875***	-0.00887***	-0.00910***
	[0.000190]	[0.000190]	[0.000188]	[0.000230]
Post-2014 Dummy * Short-term Liability Ratio [Lambda, Log of]				-0.000769**
				[0.000362]
Constant	4.656***	4.656***	4.656***	4.656***
	[0.000814]	[0.000814]	[0.000817]	[0.000813]
Observations	27,162	27,162	26,055	27,162
Bank fixed effects	Yes	Yes	Yes	Yes
Year:Quarter dummies	No	Yes	Yes	Yes
Quarter dummies	Yes	--	--	--

Coefficient estimates from three-stage least squares [3SLS] simultaneous estimation of the relationship between Net Stable Funding Ratio and Short-term Liabilities at US bank holding companies from 2010 Q1 to 2018 Q4. Each column in Panel A is estimated simultaneously with each corresponding column from Panel B and Panel C. "--" indicates that the set of controls is subsumed by more restrictive controls in the regression. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 4 Panel C: Determinants of Short-term Liabilities at US Bank Holding Companies; 2010 Q1 - 2018 Q4

	[1]	[2]	[3]	[4]
Dependent Variable:	*Short-term Liability Ratio [Lambda, Log of]*	*Short-term Liability Ratio [Lambda, Log of]*	*Short-term Liability Ratio [Lambda, Log of]*	*Short-term Liability Ratio [Lambda, Log of]*
Sample of Banks:	*All Banks*	*All Banks*	*Excluding LCR Banks*	*All Banks*
Variables				
Treasury Term Premium [1st Principal Component]	-0.0951***	-0.0982***	-0.125***	-0.0725**
	[0.0343]	[0.0343]	[0.0357]	[0.0343]
Idiosyncratic Return on Lending	-0.134***	-0.135***	-0.155***	-0.137***
	[0.0147]	[0.0147]	[0.0155]	[0.0147]
Moderate Recession Losses	-0.150***	-0.149***	-0.139***	-0.144***
	[0.0113]	[0.0113]	[0.0116]	[0.0113]
Constant	1.541***	1.545***	1.513***	1.515***
	[0.0594]	[0.0594]	[0.0621]	[0.0595]
Observations	27,162	27,162	26,055	27,162
Bank fixed effects	Yes	Yes	Yes	Yes
Year:Quarter dummies	No	Yes	Yes	Yes
Quarter dummies	Yes	--	--	--

Coefficient estimates from three-stage least squares (3SLS) simultaneous estimation of the determinants of Short-term Liabilities at US bank holding companies from 2010 Q1 to 2018 Q4. Each column in Panel A is estimated simultaneously with each corresponding column from Panel B and Panel C. "--" indicates that the set of controls is subsumed by more restrictive controls in the regression. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 5 Panel A: Relationship between Equity and asset-scaled Liquidity Mismatch Index at US Bank Holding Companies; 2010 Q1 - 2019 Q4

	[1]	[2]	[3]	[4]
Dependent Variable:	*Equity Ratio*	*Equity Ratio*	*Equity Ratio*	*Equity Ratio*
Sample of Banks:	*All Banks*	*All Banks*	*Excluding LCR Banks*	*All Banks*
Variables				
Liquidity Mismatch Index [Asset-scaled, LMIA, Log of]	-12.13***	-11.79***	-16.00***	-8.967***
	[0.312]	[0.307]	[0.352]	[0.320]
Post-2014 Dummy * Liquidity Mismatch Index [Asset-scaled, LMIA, Log of]				0.207***
				[0.0100]
Constant	65.37***	63.82***	82.91***	50.71***
	[1.412]	[1.393]	[1.596]	[1.454]
Observations	33,344	33,344	31,967	33,344
Bank fixed effects	Yes	Yes	Yes	Yes
Year:Quarter dummies	No	Yes	Yes	Yes
Quarter dummies	Yes	--	--	--

Coefficient estimates from three-stage least squares (3SLS) simultaneous estimation of the relationship between Equity and asset-scaled Liquidity Mismatch Index at US bank holding companies from 2010 Q1 to 2019 Q4. Each column in Panel A is estimated simultaneously with each corresponding column from Panel B and Panel C. "--" indicates that the set of controls is subsumed by more restrictive controls in the regression. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 5 Panel B: Relationship between Net Stable Funding Ratio and Short-term Liabilities at US Bank Holding Companies; 2010 Q1 - 2019 Q4

	[1]	[2]	[3]	[4]
Dependent Variable:	*Liquidity Mismatch Index [Asset-scaled, LMIA, Log of]*	*Liquidity Mismatch Index [Asset-scaled, LMIA, Log of]*	*Liquidity Mismatch Index [Asset-scaled, LMIA, Log of]*	*Liquidity Mismatch Index [Asset-scaled, LMIA, Log of]*
Sample of Banks:	*All Banks*	*All Banks*	*Excluding LCR Banks*	*All Banks*
Variables				
Short-term Liability Ratio [Lambda, Log of]	-0.00464***	-0.00448***	-0.00379***	-0.00423***
	[9.40e-05]	[9.37e-05]	[8.55e-05]	[0.000116]
Post-2014 Dummy * Short-term Liability Ratio [Lambda, Log of]				-0.000930***
				[0.000173]
Constant	4.535***	4.535***	4.537***	4.535***
	[0.000392]	[0.000392]	[0.000362]	[0.000390]
Observations	33,344	33,344	31,967	33,344
Bank fixed effects	Yes	Yes	Yes	Yes
Year:Quarter dummies	No	Yes	Yes	Yes
Quarter dummies	Yes	--	--	--

Coefficient estimates from three-stage least squares [3SLS] simultaneous estimation of the relationship between asset-scaled Liquidity Mismatch Index and Short-term Liabilities at US bank holding companies from 2010 Q1 to 2019 Q4. Each column in Panel A is estimated simultaneously with each corresponding column from Panel B and Panel C. "--" indicates that the set of controls is subsumed by more restrictive controls in the regression. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Table 5 Panel C: Determinants of Short-term Liabilities at US Bank Holding Companies; 2010 Q1 - 2019 Q4

	[1]	[2]	[3]	[4]
Dependent Variable:	*Short-term Liability Ratio [Lambda, Log of]*	*Short-term Liability Ratio [Lambda, Log of]*	*Short-term Liability Ratio [Lambda, Log of]*	*Short-term Liability Ratio [Lambda, Log of]*
Sample of Banks:	*All Banks*	*All Banks*	*Excluding LCR Banks*	*All Banks*
Variables				
Treasury Term Premium [1st Principal Component]	-0.161***	-0.156***	-0.166***	-0.113***
	[0.0291]	[0.0291]	[0.0303]	[0.0292]
Idiosyncratic Return on Lending	-0.0757***	-0.0773***	-0.0972***	-0.0700***
	[0.0128]	[0.0128]	[0.0135]	[0.0128]
Moderate Recession Losses	-0.185***	-0.182***	-0.172***	-0.181***
	[0.0106]	[0.0106]	[0.0108]	[0.0106]
Constant	1.497***	1.492***	1.453***	1.442***
	[0.0503]	[0.0504]	[0.0525]	[0.0504]
Observations	33,344	33,344	31,967	33,344
Bank fixed effects	Yes	Yes	Yes	Yes
Year:Quarter dummies	No	Yes	Yes	Yes
Quarter dummies	Yes	--	--	--

Coefficient estimates from three-stage least squares (3SLS) simultaneous estimation of the determinants of Short-term Liabilities at US bank holding companies from 2010 Q1 to 2019 Q4. Each column in Panel A is estimated simultaneously with each corresponding column from Panel B and Panel C. "--" indicates that the set of controls is subsumed by more restrictive controls in the regression. Robust standard errors in brackets. *** p<0.01, ** p<0.05, * p<0.1

Appendix tables

Table A1 Panel A: Summary statistics by time period: 2010 Q1 - 2014 Q4

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Variables	Mean	SD	p10	p25	p50	p75	p90	N
Equity Ratio	9.98	3.95	6.16	8.03	9.66	11.55	13.92	22,033
Short-term Liabilities	18.50	17.02	0.00	3.92	14.53	28.63	43.11	22,021
[Log of] Short-term Liabilities	0.63	5.37	-13.82	1.37	2.68	3.36	3.76	22,021
Liquidity Coverage Ratio	223.00	136.90	63.85	106.60	189.80	319.00	463.80	19,304
[Log of] Liquidity Coverage Ratio	5.20	0.67	4.16	4.67	5.25	5.77	6.14	19,304
Net Stable Funding Ratio	107.60	15.41	91.04	96.71	104.00	114.50	127.90	19,304
[Log of] Net Stable Funding Ratio	4.67	0.13	4.51	4.57	4.64	4.74	4.85	19,304
Liquidity Mismatch Index over Total Assets [LMIA]	94.55	5.67	88.89	93.25	96.13	97.87	99.33	22,033
[Log of] Liquidity Mismatch Index over Total Assets [LMIA]	4.55	0.07	4.49	4.54	4.57	4.58	4.60	22,033
Treasury Term Premium [1st Principal Component]	1.31	0.90	0.14	0.62	1.17	2.09	2.59	22,033
Idiosyncratic Return on Lending	1.91	2.55	-0.93	0.07	1.95	3.61	5.07	22,009
Moderate Recession Losses	2.78	3.21	0.44	0.89	1.79	3.46	6.36	22,033
Total Assets (millions USD)	15,772	129,898	526.3	640.1	967.2	2,093	7,403	22,033

Table A1 Panel B: Summary statistics by time period: 2015 Q1 - 2019 Q4

Variables	[1] Mean	[2] SD	[3] p10	[4] p25	[5] p50	[6] p75	[7] p90	[8] N
Equity Ratio	11.31	3.48	8.12	9.24	10.68	12.53	14.82	11,368
Short-term Liabilities	22.09	18.19	0.07	6.31	19.48	33.72	48.04	11,348
[Log of] Short-term Liabilities	1.20	4.91	-2.60	1.84	2.97	3.52	3.87	11,348
Liquidity Coverage Ratio	136.00	92.18	57.57	63.77	104.60	174.20	263.50	7,869
[Log of] Liquidity Coverage Ratio	4.73	0.59	4.05	4.16	4.65	5.16	5.57	7,869
Net Stable Funding Ratio	99.96	13.39	89.54	89.58	95.43	104.40	117.50	7,869
[Log of] Net Stable Funding Ratio	4.60	0.12	4.50	4.50	4.56	4.65	4.77	7,869
Liquidity Mismatch Index over Total Assets [LMIA]	90.12	5.80	84.24	88.61	91.76	93.66	94.82	11,368
[Log of] Liquidity Mismatch Index over Total Assets [LMIA]	4.50	0.07	4.43	4.48	4.52	4.54	4.55	11,368
Treasury Term Premium [1st Principal Component]	-0.34	0.49	-1.00	-0.69	-0.31	-0.06	0.27	11,368
Idiosyncratic Return on Lending	2.25	2.05	-0.03	0.62	2.14	3.38	4.49	11,365
Moderate Recession Losses	0.87	1.15	0.17	0.36	0.62	1.02	1.71	11,368
Total Assets (millions USD)	34,287	193,137	1,066	1,382	2,747	7,763	29,769	11,368