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# Do banks actively manage their liquidity? ☆

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ABSTRACT

We test whether and how U.S. commercial banks actively managed their liquidity positions between 1992 and 2012, prior to the implementation of the Basel III liquidity rules. On average, the data are consistent with a liquidity management regime in which banks targeted the traditional loans-to-core deposits (LTCD) ratio. Perhaps surprisingly, the data are also consistent on average with the net stable funding ratio (NSFR), a regulatory liquidity ratio that was not formally introduced by the Bank for International Settlements until 2010. We find evidence of LTCD and (implicit) NSFR targeting at banks of all sizes, but concordance is strongest for small banks and weakest for so-called SIFI banks. As banks increase in size, they set lower liquidity targets—often in violation of the coming Basel III standards—but manage those targets more efficiently.



## 1. Introduction

One of the lessons of the global financial crisis is that liquidity risk can and does lead to the failure of financial institutions. In response to this lesson, the Basel III Accord (2010) requires minimum liquidity standards for internationally active and important banks. This is a departure from the first two Basel Accords (1988 and 2004) which focused mainly on minimum capital standards. Basel III outlines two separate minimum liquidity ratios: a liquidity coverage ratio (LCR) and a net stable funding ratio (NSFR). The LCR standard requires banks to hold enough liquid assets to cover 30 days of cash outflows during a crisis, while the NSFR standard requires banks to finance their medium- and long-term loans with stable funds that are unlikely to run during a crisis. With these two liquidity rules added to the Basel Accord's traditional focus on equity capital rules, Basel III becomes consistent with Tirole's (2011) analysis of bank liquidity which focuses on three key areas: holding liquid assets to service short-term funding runs; issuing stable or 'sticky' deposits that are unlikely to run; and maintaining strong levels of equity funding to signal long-term solvency and hence reduce the likelihood of runs.

While these specific policy prescriptions are new, the short-term liquidity and matched funding concepts underlying the LCR and NSFR are not at all new. U.S. bank supervisors have for decades included about a dozen different "liquidity and funding" ratios in the Uniform Bank Performance Reports (UBPRs), statistical reports released each quarter that allow banks to compare their own financial condition and performance to their peer institutions.[1] For example, the UBPR currently contains three ratios that are similar in spirit to the LCR (short-term investments to short-term non-core funds; short-term assets to short-term liabilities; net short-term liabilities to assets) and two funding ratios that are similar in spirit to the NSFR (net loans and leases to deposits; net loans and leases to core deposits). It is important to note that these liquidity and funding ratios were neither invented by bank supervisors nor imposed by bank regulators. Calculating, monitoring and benchmarking these various liquidity ratios have long been standard practice for many U.S. banks; the inclusion of these ratios in the UBPRs merely reflects supervisory recognition of these standards.

An important difference between the Basel III-mandated liquidity standards and the benchmark liquidity ratios in the UBPRs is that the former will impose binding liquidity and funding levels on banks, while the latter have always been considered non-binding

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[1] The Uniform Bank Performance Report for every U.S. commercial bank can be viewed at http://www.ffiec.gov/UBPR.htm.

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diagnostics of banks' liquidity risks. Once the LCR and NSFR constraints are implemented, banks below or close to the minimum thresholds will be required to take actions so that their balance sheets comply with the new standards; because such hard liquidity constraints have never before been placed on banks, we cannot know exactly what actions banks will take. As always in the aftermath of regulatory intervention, some of these actions will be unexpected, and some may actually prove counterproductive for bank safety and soundness.

There are close structural and theoretical similarities between the NSFR and the traditional loans-to-core deposits ratio (LTCD). Both ratios compare a bank's illiquid assets to its stable funding: The NSFR compares the overall illiquidity of a bank's assets to the overall stability of its funding sources, while the LTCD ratio compares loans (which are typically illiquid assets) to core deposits (which are typically stable funds).[2] For both ratios, the value 1.0 has an important meaning: The drafters of the Basel III regulations chose a weighting scheme such that NSFR = 1.0 provides a prudential balance between liquid and illiquid exposures; we show below that LTCD = 1.0 is theoretically consistent with balancing a bank's liquid assets with its liquid liabilities. Thus, by observing how banks have in the past reacted to liquidity shocks that moved them away from their traditional LTCD liquidity benchmarks, we are likely to learn how banks will behave in the future should their balance sheet liquidity positions fall below the newly mandated NSFR = 1.0 level.

We begin this line of inquiry by estimating a partial adjustment model for LTCD ratios at U.S. commercial banks from 1992 through 2012. We do not limit our analysis to the large internationally active banks of primary concern to the writers of Basel III, but instead we include U.S. commercial banks of all sizes in our investigation. We do this for two reasons. First, U.S. regulatory authorities have announced that the new LCR regulations will be applied only to larger banks, but they have not yet announced which banks will be expected to comply with the new NSFR regulations.[3] Because the NSFR is easier to construct and maintain than the LCR—the former is simply a fixed-weight average of existing balance sheet ratios, while the latter requires banks to estimate monthly future cash inflows and outflows—it would impose a relatively small compliance burden on community banks. Indeed, some banking industry experts have suggested that NSFR coverage is likely to include mid-sized and perhaps even smaller banks.[4]

Second, before deciding which banks must adhere to minimum NSFR thresholds, it is important to understand how balance sheet liquidity management practices currently vary across those banks. For example, if banks of all sizes already tend to operate according to the spirit of NSFR—that is, if their balance sheets usually comply with the NSFR > 1 standard and they tend to repair their balance sheets quickly following liquidity shocks—then blanket imposition of the NSFR standards would have only idiosyncratic effects across banks. But if current balance sheet liquidity management practices vary systematically with bank size—say, with small banks managing their liquidity in the spirit of the NSFR standards, but large banks pursuing different standards—then blanket imposition of binding NSFR standards could have large and systematic effects on credit supply that bank supervisors and economic policymakers will need to be ready for.

Our econometric model allows us to investigate a number of questions about how U.S. banks have managed their liquidity in the past: Do banks target their loans-to-core deposits ratio? If so, do they also maintain separate targets for the loans component and/or the core deposits component of this ratio? When good or bad shocks force banks away from their targets, how quickly do banks adjust in order to re-establish their desired liquidity levels? Do banks' liquidity targets and adjustment speeds vary systematically across bank characteristics and/or across the business cycle? To what degree is observed bank liquidity management optimal, in the sense that it is associated with profit maximization?

We continue our analysis by estimating an NSFR partial adjustment model, using the Basel Committee's formula (October 2014) to retro-actively calculate the NSFRs for U.S. commercial banks during our 1992–2012 sample period. Even though this liquidity ratio was not fully spelled out until after our sample period—and hence, the banks in our data could not have been explicitly targeting this ratio—estimating this model allows us to test an important question: To what extent were banks' liquidity management practices between 1992 and 2012 *consistent with* an NSFR standard?

Our models generate strong evidence consistent with active balance sheet liquidity management for the majority of U.S. banks during our sample period. The data suggest that community banks (banks with assets less than $2 billion, which includes well over 90 percent of all U.S. commercial banks) maintained LTCD targets, operated close to those targets, and when shocked away from those targets made methodically rapid and non-trivial adjustments. We find similar evidence of LTCD targeting and rapid balance sheet liquidity adjustment for mid-sized banks (with assets up to $50 billion), albeit with some differences in the signs, magnitudes and precision of the estimated model parameters. On average, LTCD management centered on the targeting and manipulation of core deposits balances, with only relatively passive management of loan balances. The data also suggest that liquidity management tended to be financially optimal: We find that bank accounting returns (ROA, ROE) followed an inverted U-shape with respect to liquidity adjustment speeds, with the average bank operating very close to the industry-wide profit maximizing adjustment speed.

Importantly, we find relatively similar results when we superimpose an NSFR liquidity standard on community banks' and mid-sized banks' historical balance sheet behaviors. The implication is that balance sheet liquidity management practices have (implicitly) contained NSFR targets all along. Hence, any future implementation of the Basel III standards could be expected to have little impact on liquidity risk management *processes* at these banks. But we also show that about one-in-seven U.S. banks were operating below the NSFR $\geqslant 1$ standard at the onset of the financial crisis, with the rate of violation increasing with bank size. Hence, any future implementation of the Basel III standards will require a large percentage of U.S. banks to change (strengthen) their liquidity *targets* during economic expansions.

[2] Core deposits include transactions deposits and fully insured (but non-brokered) time deposits. A key feature of these deposits is their insensitivity to market interest rates. Once these customers have been attracted to the bank, these deposits represent very stable sources of funds.

[3] The Federal Reserve will require the following subset of U.S. financial institutions to comply with the LCR standard (or some modified version of that standard) by January 1, 2017: Internationally active bank holding companies with assets greater than $250 billion; depository institution subsidiaries with assets greater than $10 billion; non-bank financial companies identified by the Financial Stability Oversight Council (FSOC) as systemically important financial institutions (SIFIs); and non-internationally active bank holding companies with assets greater than $50 billion. As this manuscript was being prepared, the Federal Reserve had not yet announced NSFR standards for U.S. banking companies, but was expected to propose NSFR-compliance rules that would take effect in 2018 ("About That Other Basel Liquidity Formula," *American Banker*, 10-8-2014, pages 1 and 3).

[4] Former FDIC chairman Sheila Bair argues that bank regulators have incentives to extend to small banks rules initially meant only for larger banks: "There is this fear that…you are going to look weak if you aren't dealing with the small banks the same way as big banks (American Banker, 2015a)." Hester Pierce, researcher at George Mason University, argues that bank supervisors have incentives to implicitly extend large bank standards to small banks: "Well, it's a best practice, and so you really don't legally have to do it, but we expect you to do it. (American Banker, 2015b)." A survey conducted by Sageworks (2015) confirms these arguments: One-third of U.S. depository institutions reported pressure from their supervisors to start or expand stress testing, and 99 percent of these firms were smaller than the $10 billion Dodd-Frank asset threshold requiring annual stress tests.

A different picture emerges for the larger, systemically important financial institutions (SIFIs) at which the Basel III liquidity regulations are primarily aimed. We find little evidence that balance sheet liquidity management practices at these banks have been consistent with traditional LTCD targets or with the coming Basel III NSFR standards. Moreover, at the onset of the financial crisis, more than half of these large banks failed to meet the NSFR $\geqslant 1$ standard. Thus, future implementation of the Basel III liquidity standards will require large U.S. commercial banks to substantially increase their absolute levels of balance sheet liquidity as well as re-engineer their balance sheet liquidity risk management practices. Because the changes required to be in compliance with the NSFR standards would include reducing high-yielding assets and increasing expensive deposits (King, 2013), these banks will have incentives to circumvent regulations through liquidity arbitrage schemes.

This study adds to the emerging literature on the potential impact of the net stable funding ratio on banks in Europe and the U.S. (e.g., King, 2013; Hong et al., 2014). We also contribute to the larger empirical literature on bank liquidity management (e.g., Kashyap et al., 2002; Repullo, 2003; Agenor et al., 2004; Aspachs et al., 2005; Gatev and Strahan, 2006; Gatev et al., 2009; Tirole, 2011; Calomiris et al., 2012; Delechat et al., 2012; Distinguin et al., 2013; Ratnovski, 2013; Bonner et al., 2013; Acharya and Mora, 2015; Bonner, 2015). We discuss this literature later in this article.

The remainder of the paper proceeds as follows. In Section 2 we provide a simple conceptual framework for thinking about liquidity risk management and review the existing theoretical and empirical literature that informs this framework. In Section 3 we derive our partial adjustment model. In Section 4 we describe our data and provide definitions for all of the variables used in our partial adjustment models. In Section 5 we present the results of our model for the LTCD ratio and test whether banks' estimated liquidity adjustment speeds are financially optimal. In Section 6 we re-estimate our model for the two component parts of LTCD, the loans-to-assets ratio and the core deposits-to-assets ratio. In Section 7 we re-estimate our model for banks' NSFR ratios. In Section 8 we test whether and how banks' targeting and adjustment of LTCD and NSFR vary with bank size. Section 9 concludes.

## 2. Loans, deposits and bank liquidity

Liquidity risk at banks can be defined simply as the likelihood that the demand for cash by bank customers exceeds the bank's ready supply of cash. The demand for cash is to some degree stochastic: Institutional depositors might unexpectedly not roll over their time deposits at maturity, or clients with pre-existing lines of credit might draw down unexpectedly large portions of their credit lines. All else equal, most banks would prefer to fund their loans with core deposits, which by definition are less likely to be withdrawn unexpectedly and hence provide a stable funding base for loans. Consistent with this, we can define the bank's funding gap as follows:

$$\text{Funding Gap} = \text{Loans} - \text{Core Deposits} > 0 \tag{1}$$

A positive funding gap requires the bank to raise additional funding for its loans. Expressed in this way, the funding gap is consistent in spirit with Basel III's net stable funding ratio (NSFR) requirement that banks hold enough stable funding (e.g., core deposits) to fully fund their illiquid assets (e.g., loans).

While banks may prefer to fund their loans with core deposits, it is generally not possible to raise new core deposits quickly. So in the short-run, banks must fill the funding gap with non-core deposits and other short-term borrowings and/or by selling liquid assets. These temporary fixes create an imbalance in short-term assets and short-term liabilities, and this imbalance is simply an alternative way of defining the funding gap:

$$\begin{aligned}\text{Funding Gap} &= \text{Loans} - \text{Core Deposits}\\ &= \text{Short-term Borrowing} - \text{Liquid Assets} > 0\end{aligned} \tag{2}$$

Clearly, a bank that over-relies on these temporary fixes to fill its funding gap is assuming a negative carry position, as its cost of short-term wholesale funding will eventually exceed its return on liquid securities investments. Expressed in this way, we can see that the funding gap is also consistent in spirit with Basel III's liquidity coverage ratio (LCR) requirement that banks hold enough liquid assets (e.g., cash, Treasuries) to cover their short-term borrowings (e.g., non-core deposits, Treasury repos, commercial paper).

By rearranging the terms in Eq. (2) we can derive an instructive expression for the loans-to-core deposits ratio (LTCD):

$$\frac{\text{Loans}}{\text{Core Deposits}} = 1 + \frac{\text{Short-term Borrowing} - \text{Liquid Assests}}{\text{Core Deposits}} \tag{3}$$

This straightforward analysis demonstrates three important properties of the LTCD ratio: (a) LTCD is logically related to both of the new liquidity ratios (NSFR, LCR) mandated by Basel III; (b) LTCD is positively related to liquidity risk (short-term borrowing − liquid assets); and (c) there is an important threshold value, LTCD = 1, above which a bank is engaging in pure liquidity risk (i.e., short-term borrowing > liquid assets) in the short term. Fig. 1 shows how the median loans-to-core deposits ratio has fluctuated around this theoretical benchmark value over time for U.S. commercial banks. The data indicate that balance sheet liquidity declined substantially from 1992 through 2008 (passing the theoretical threshold of 1.0 in 1999) but reversed course dramatically following the financial crisis. The data also show that larger banks tend to operate with less balance sheet liquidity than smaller banks.

To be sure, banks have incentives to operate with high LTCD ratios. Illiquid loans tend to earn higher returns than the liquid securities investments that commercial banks are permitted to hold, and funding an additional loan with Treasury repos, overnight fed funds purchased or (for banks with access to public credit markets) commercial paper is typically less expensive than issuing core deposits for which the bank must provide costly payments services or maturity premiums. A well-managed bank will be hesitant to drive its LTCD ratio too high, however, as this can expose the bank not just to liquidity risk but also to interest rate risk and/or credit risk: Interest rate risk may increase due to the mismatch between long loan maturities and the very short maturities of money market instruments, while credit risk may increase if the bank attained its high LTCD ratio by accepting increasingly marginal loan applications. Clearly, a value-maximizing bank that chooses a high LTCD ratio is hoping to benefit from a positive expected risk-return tradeoff; in contrast, its bank supervisor places a larger weight on liquidity risk and a smaller weight on a marginal dollar of expected bank profits.

A large theoretical literature credits the very existence of banks to the joint issuance of, and interrelationships among, loans and deposits.[5] Some of the more prominent recent work in this area focuses on the joint effects of loan-related shocks (unexpected borrower takedowns of credit lines) and deposit-related shocks (unexpected demands for cash by depositors and/or money market creditors) to bank liquidity. Kashyap et al. (2002) argue that there

[5] This literature dates (at least) to Diamond and Dybvig (1983) and is too extensive to review here. See Allen and Carletti (2010) for a brief overview. See Freixas and Rochet (2008) for a rigorous treatment.

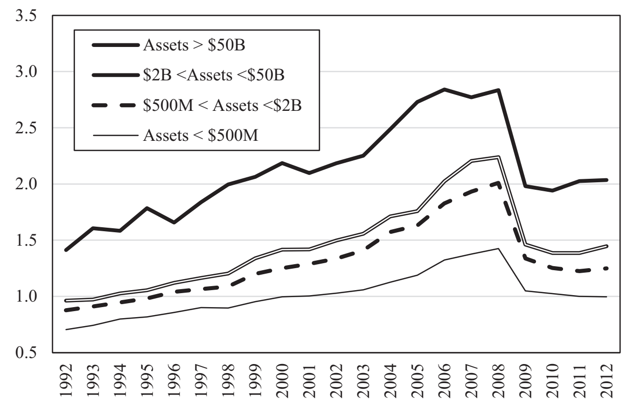


**Fig. 1.** Loans-to-Core Deposits ratio. Annual medians for various asset size groups of U.S. commercial banking companies, 1992–2012. Assets measured in 2010 dollars.

are positive synergies between these two phenomena, so long as deposit withdrawals and loan commitment takedowns are not highly positively correlated. Indeed, Gatev and Strahan (2006) and Gatev et al. (2009) provide evidence that these deposit withdrawals and loan facility takedowns are not positively correlated across the business cycle: During periods of tight liquidity in public credit markets, nervous investors flee to the quality of bank deposits while borrowers simultaneously draw down their lines of credit at banks. This 'natural liquidity hedge' is an example of passive bank liquidity management, and it serves to moderate business cycle-related fluctuations in banks' loans-to-deposits ratios. Acharya and Mora (2015) argue that this hedge is institutional rather than natural, as it relies on the presence of deposit insurance.

There is much less research on whether and how banks manage liquidity. One line of research studies the determinants of bank liquidity buffers (Kashyap et al., 2002; Repullo, 2003; Agenor et al., 2004; Aspachs et al., 2005; Delechat et al., 2012). These studies provide empirical benchmarks for considering the impact of government liquidity regulations on bank liquidity management; in general, they find that liquidity buffers are positively related to bank deposit funding and bank profitability, but negatively related to bank size, market concentration, the generosity of the government safety net, and the business cycle. Using data from 30 different countries, Bonner et al. (2013) find that the empirical correlations of bank liquidity buffers (e.g., liquid assets-to-assets, liquid assets-to-deposits) with bank size, market concentration, and deposit liabilities are substantially weaker in countries with bank liquidity regulations; the authors conclude that liquidity regulations act as substitutes for (i.e., reduce) active liquidity management by banks. Evaluating the effects of regulatory liquidity coverage ratios on 17 banks in the Netherlands, Bonner (2015) concludes that liquidity regulation has real effects, causing banks to increase their investments in government bonds and decrease their investments in loans.

There is very little theoretical research on bank liquidity management. Tirole (2011) models banks' demand for liquid assets, and identifies a number of demand determinants including (but not limited to) corporate governance, external sources of liquidity, marketability of bank assets, bank hedging policies, and bank financial leverage. Calomiris et al. (2012) focus on the substitutability of minimum regulatory capital requirements and minimum liquid asset (cash) requirements.[6] The authors demonstrate three efficiencies associated with cash holdings: reduced incentives for bank runs, increased inter-bank liquidity risk sharing, and reduced moral hazard incentives.

Ratnovski (2013) constructs a model in which banks can manage liquidity risk via two methods: higher liquidity buffers which protect against small liquidity shocks, and greater transparency regarding their solvency which lessens the likelihood of large liquidity shocks. Both methods are costly, and they are strategic substitutes (i.e., adopting one of these hedging methods reduces the value of the adopting the other). Realistically, government can impose effective and verifiable liquidity buffers, but cannot impose transparency. Thus, government liquidity regulation results in reduced amounts of active liquidity management: Banks hold high liquidity buffers by law but reduce their costly transparency efforts.

## 3. Partial adjustment model

We use a partial-adjustment model similar to that developed in Berger et al. (2008) to model the dynamics of banks' balance sheet liquidity management. The model allows us to estimate the following four attributes of bank liquidity management: a target LTCD (or NSFR) ratio for each bank in each time period; the cross-sectional determinants of these target LTCD ratios; how quickly each bank adjusts toward its target LTCD ratio; and the cross-sectional determinants of these adjustment speeds.

We begin by assuming that each bank has a target (or desired) LTCD ratio $LTCD_{i,t}^*$ which can be expressed as a function of the bank's observable characteristics:

$$LTCD_{i,t}^* = \beta_{i,t-1} \tag{4}$$

where $LTCD_{i,t}^*$ is the bank-specific and potentially time-varying target value for the LTCD ratio. $X_{i,t-1}$ is a vector of bank characteristics that determine its target ratio, including a set of bank fixed effects. $\beta$ is a vector of coefficients to be estimated. It is important to note that an estimated value $\hat{\beta} = 0$ might indicate either of two things: (a) banks do not have systematic targets for $LTCD$ or (b) $X$ is misspecified.

Shocks can occur that push banks away from their liquidity targets. Exogenous events could cause deposits to leave the bank in search of higher yields or flow into the bank in search of a safe harbor. Demand for loans may increase or decrease with changes in local economic conditions or competitive rivalry. Making a sizeable acquisition could force a bank away from its desired balance sheet composition. In any of these cases, returning to their desired liquidity targets requires banks to make potentially costly adjustments. To capture this process, we assume (for now) that banks close a constant proportion $\lambda$ of the gap between $LTCD_{i,t-1}$ and $LTCD_{i,t}^*$ each period:

$$LTCD_{i,t} - LTCD_{i,t-1} = \lambda(LTCD_{i,t}^* - LTCD_{i,t-1}) + \tilde{\delta}_{i,t} \tag{5}$$

where $\lambda$ is the scalar adjustment speed to be estimated and $\tilde{\delta}_{i,t}$ is a random error term. A value of $0 < \lambda < 1$ indicates a 'partial adjustment' toward the target $LTCD^*$ between $t-1$ and $t$. A high (low) estimated value for $\lambda$ indicates that banks are active (passive) managers of balance sheet liquidity and/or that banks face minimal (substantial) adjustment costs. Substituting Eqs. (4) into (5) yields:

$$LTCD_{i,t} - LTCD_{i,t-1} = \lambda(\beta X_{i,t-1} - LTCD_{i,t-1}) + \tilde{\delta}_{i,t} \tag{6}$$

It is difficult to estimate the parameters $\beta$ and $\lambda$ directly from this nonlinear equation. Estimation is simplified by rearranging Eq. (6):

$$LTCD_{i,t} = \lambda\beta X_{i,t-1} + (1-\lambda)LTCD_{i,t-1} + \tilde{\delta}_{i,t} \tag{7}$$

[6] The empirical findings of Distinguin et al. (2013) also imply that banks substitute capital for liquidity at the margin.

We can recover $\hat{\lambda}$ directly from the estimated parameter $(\widehat{1-\lambda})$, after which we can then recover $\hat{\beta}$ by dividing the estimated parameter $\widehat{\lambda\beta}$ by $\hat{\lambda}$. With $\hat{\beta}$ in-hand, we can use Eq. (4) to calculate the bank-specific and potentially time-varying target ratios $LTCD_{i,t}{}^{*}$.

In Eq. (7), the adjustment speed $\lambda$ is constrained to be identical for each bank in each time period. More realistically, we would expect banks to adjust toward their targets at different speeds according to their unique individual situations and abilities, and we would also expect adjustment speeds to be different across time according to prevailing economic, competitive and technological conditions. We relax this constraint by specifying $\lambda$ as follows:

$$\lambda_{i,t} = \Lambda Z_{i,t-1} \tag{8}$$

where $\lambda_{i,t}$ is the bank-specific, time-varying speed of adjustment toward the target ratio $LTCD_{i,t}{}^{*}$. $Z_{i,t-1}$ is a vector of bank and time period characteristics that affect the adjustment speeds. $\Lambda$ is a vector of coefficients to be estimated. Substituting Eqs. (8) into (6) yields the complete model:

$$LTCD_{i,t} - LTCD_{i,t-1} = \Lambda Z_{i,t-1}(\beta X_{i,t-1} - LTCD_{i,t}) + \tilde{\delta}_{i,t} \tag{9}$$

To estimate this nonlinear equation, we substitute $\hat{\beta}$ (estimated above) for $\beta$ in Eq. (9) and rearrange:

$$\Delta LTCD_{i,t} = \Lambda(Z_{i,t-1}GAP_{i,t-1}) + \tilde{\delta}_{i,t} \tag{10}$$

where three of the terms have been redefined for simplicity. First, the term $(LTCD_{i,t} - LTCD_{i,t-1})$ is now written as $\Delta LTCD_{i,t}$, which is directly observable from the data. Second, the term $(\hat{\beta}X_{i,t-1} - LTCD_{i,t-1})$ is now written as $GAP_{i,t-1}$, which is the estimated distance $(LTCD_{i,t}{}^{*} - LTCD_{i,t-1})$ between a bank's target and actual LTCD ratios. Third, the vector of exogenous regressors is now written as the product $Z_{i,t-1}GAP_{i,t-1}$. The parameter $\Lambda$ can now be directly estimated; once $\hat{\Lambda}$ is in-hand, we can use Eq. (8) to calculate the bank-time-specific adjustment speeds $\lambda_{i,t}$.

## 4. Data and variables

We estimate our models using twenty-one years of annual data for U.S. commercial banking companies from 1992 through 2012. Our two main data sources are the Consolidated Reports of Condition and Income (Federal Financial Institutions Examination Council call reports) and the Consolidated Financial Statements for Holding Companies (Federal Reserve Y-9C reports). The call reports contain detailed financial statement data for individual (separately chartered) commercial banks; the Y-9C reports contain a parallel set of financial information for commercial bank holding companies. We operate under the assumption that balance sheet liquidity is a company-wide policy decision and is made by senior management. The unit of observation in our study is the highest level of the organization: We use data from the call reports for all free-standing banks and single-bank holding companies, and we use data from the Y-9C reports for multiple-bank holding companies. We shall refer to this set of firms collectively as "banks" or "banking companies."

We begin with 150,206 bank-year observations from 1992 to 2012, and then judiciously filter out a limited number of observations. We remove 22,378 bank-year observations with one or more of the following characteristics: the bank held less than $1 million in assets; the bank reported either no loans or no insured deposits; the bank was controlled by non-U.S. concerns (i.e., more than 10% foreign ownership); the bank was less than five years old; the bank had an equity-to-assets ratio less than 0.04; the bank grew by more than 25% via acquisition in the year; or the bank was a so-called systemically important financial institution (SIFI) with more than $50 billion in assets (in 2010 dollars).[7] The final sample is an unbalanced panel of 127,828 bank-year observations containing data from 10,190 different banking companies. Summary statistics and variable definitions are displayed in Table 1.

Because liquidity management can be a relatively short-run phenomenon, we also estimate our baseline model using an alternative data set containing 512,986 bank-*quarter* observations. We construct this alternative data set using the same data filters described above, applied to quarterly call report data and quarterly Y-9C report data. Summary statistics for this quarterly data sample are available from the authors upon request.

### 4.1. Target ratios

Conceptually, core deposits can be defined as "deposits that act as a financial institution's long-term source of funds" (Saunders and Cornett, 2011). In practice, bank supervisors typically define core deposits to include (a) balances held in transactions accounts, which provide a store of liquidity and a means of payment for household and business customers, and (b) time deposits (including certificates of deposit, but excluding brokered deposits) in denominations small enough to be protected by deposit insurance, which provide small investors with modest but risk-free investment income.[8] Accordingly, we define core deposits as the sum of (a) and (b), and define the loans-to-core deposits ratio *LTCD* as a bank's total loans divided by its core deposits.

We use core deposits, rather than total deposits, in our tests for two reasons. First, banks are better able to manage their core deposit levels than their non-core deposits levels. The liquidity-based, savings-based and safety-based motives of core depositors make core deposits rate-insensitive—so core deposits will not flow out of the bank in response to small increases in market interest rates. In contrast, non-core deposits (such as large time deposits and brokered deposits) are rate-sensitive funds that flow into and out of the bank with changes in market rates. Because non-core deposits cannot be relied upon as stable long-run sources of funds, banks cannot easily select and manage target levels for these deposits. Second, for the majority of commercial banks, total assets minus total deposits approximately equals equity capital. Hence, modeling the loans-to-total deposits ratio would be equivalent to modeling the loans-to-capital ratio. Our focus here is liquidity management, not capital management.

A bank might not target and manage its LTCD ratio directly. Instead, it might set explicit targets for one or both of the components of LTCD—the loans-to-assets (LTA) ratio and core deposits-to-assets (CDTA) ratio—and in doing so only indirectly targets its LTCD ratio.[9] There are three mutually exclusive scenarios: (a) Banks might set independent (unrelated) targets for loans-to-assets and core deposits-to-assets. In this case, the loans-to-core deposit ratio is simply a passive byproduct of those two processes (i.e.,

7 We remove SIFI banks largely because, as banks that were potentially "too-big-to-fail," their managers may have been less sensitive to all forms of risk taking, including liquidity risk. In addition, these very large banks have access to market liquidity sources (e.g., commercial paper) that may make targeting and active management of balance sheet liquidity ratios less necessary. Moreover, many of these banks practiced business models (e.g., loan securitization) that make targeting and active management of balance sheet ratios less relevant. While we remove SIFI banks from all of our main tests, we do run size-based subsample tests that include these SIFIs.

8 Deposit insurance coverage at U.S. banks was increased from $100,000 per account to $250,000 per account on July 21, 2010. The data in the 2010, 2011 and 2012 call reports reflect this change, and hence both our core deposits and *LTCD* variables also reflect this change. The time fixed effects in our regression tests should absorb any variation associated with this change in deposit insurance coverage. For a formal definition of core deposits used by the FDIC, see http://www2.fdic.gov/idasp/main.asp.

9 Given that LTCD = LTA/CDTA, targeting any two of the three ratios will passively determine the third ratio.

**Table 1**
Summary statistics. Unbalanced panel of 127,828 annual observations of 10,190 different U.S. commercial banks, 1992–2012. All variable means and standard deviations are calculated after winsorizing the data at the 1st and 99th percentiles of their sample distributions.

| Variable | Mean | Std. dev. | 1st | 25th | 50th | 75th | 99th | Definition |
|---|---|---|---|---|---|---|---|---|
| *LTCD* | 1.092 | 0.531 | 0.300 | 0.776 | 0.982 | 1.263 | 3.673 | Loans/core deposits |
| *LTA* | 0.597 | 0.151 | 0.183 | 0.503 | 0.613 | 0.706 | 0.886 | Loans/assets |
| *CDTA* | 0.598 | 0.140 | 0.188 | 0.513 | 0.615 | 0.701 | 0.853 | Core deposits/assets |
| *NSFR* | 1.408 | 0.342 | 0.938 | 1.179 | 1.331 | 1.539 | 2.830 | Available stable funding/required stable funding |
| *RSF* | 0.626 | 0.108 | 0.311 | 0.561 | 0.640 | 0.706 | 0.818 | Required stable funding/assets |
| *ASF* | 0.847 | 0.046 | 0.703 | 0.821 | 0.855 | 0.882 | 0.922 | Available stable funding/assets |
| *LTCD** | 1.118 | 0.437 | −0.154 | 0.856 | 1.072 | 1.386 | 2.219 | Estimated target *LTCD* |
| *LTA** | 0.670 | 0.298 | 0.006 | 0.427 | 0.721 | 0.920 | 1.164 | Estimated target *LTA* |
| *CDTA** | 0.588 | 0.110 | 0.317 | 0.515 | 0.595 | 0.666 | 0.825 | Estimated target *CDTA* |
| *NSFR** | 1.327 | 0.262 | 0.793 | 1.139 | 1.295 | 1.508 | 1.979 | Estimated target *NSFR* |
| *RSF** | 0.667 | 0.129 | 0.387 | 0.566 | 0.686 | 0.758 | 0.961 | Estimated target *RSF* |
| *ASF** | 0.845 | 0.027 | 0.777 | 0.827 | 0.846 | 0.863 | 0.907 | Estimated target *ASF* |
| $\lambda$*(LTCD)* | 0.290 | 0.184 | 0.070 | 0.146 | 0.208 | 0.455 | 0.779 | *LTCD* adjustment speed |
| $\lambda$*(LTA)* | 0.144 | 0.036 | 0.087 | 0.114 | 0.137 | 0.168 | 0.220 | *LTA* adjustment speed |
| $\lambda$*(CDTA)* | 0.362 | 0.037 | 0.311 | 0.334 | 0.351 | 0.392 | 0.448 | *CDTA* adjustment speed |
| $\lambda$*(NSFR)* | 0.251 | 0.090 | 0.114 | 0.147 | 0.303 | 0.330 | 0.358 | *NSFR* adjustment speed |
| $\lambda$*(RSF)* | 0.222 | 0.021 | 0.178 | 0.214 | 0.225 | 0.237 | 0.266 | *RSF* adjustment speed |
| $\lambda$*(ASF)* | 0.320 | 0.036 | 0.278 | 0.290 | 0.296 | 0.361 | 0.372 | *ASF* adjustment speed |
| *ASSETS($ millions)* | 219.8 | 460.8 | 8.186 | 39.46 | 84.00 | 193.1 | 3.430 | Assets |
| *lnASSETS* | 11.44 | 1.205 | 9.010 | 10.58 | 11.34 | 12.17 | 15.05 | Natural log of assets |
| *EQUITY* | 0.103 | 0.031 | 0.055 | 0.082 | 0.096 | 0.116 | 0.224 | Book equity (common equity, preferred equity and subordinated notes) as percentage of assets |
| *GROWTH PLAN* | 0.043 | 0.092 | −0.139 | −0.009 | 0.027 | 0.073 | 0.485 | Inflation-adjusted internal asset growth rate (net of acquisitions) over the next two years |
| *PUBLIC* | 0.054 | 0.227 | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 | =1 if bank or its holding company is publicly traded |
| *MORTGAGES* | 0.306 | 0.196 | 0.008 | 0.162 | 0.273 | 0.408 | 0.911 | 1–4 family mortgage loans as percentage of loans |
| *COMMITMENTS* | 0.076 | 0.063 | 0.000 | 0.030 | 0.062 | 0.107 | 0.307 | Unused loan commitments as percentage of assets |
| *BRANCHES* | 0.040 | 0.028 | 0.005 | 0.021 | 0.032 | 0.050 | 0.160 | Number of branches as percentage of assets (in million dollars) |
| *ECON* | 128.7 | 19.03 | 96.27 | 113.1 | 131.6 | 141.2 | 174.7 | Deposit-weighted Philadelphia Fed Coincident Index |
| *ABOVE(LTCD)* | 0.334 | 0.472 | 0.000 | 0.000 | 0.000 | 1.000 | 1.000 | =1 if *LTCD* > *LTCD** |
| *ABOVE(LTA)* | 0.398 | 0.490 | 0.000 | 0.000 | 0.000 | 1.000 | 1.000 | =1 if *LTA* > *LTA** |
| *ABOVE(CDTA)* | 0.656 | 0.475 | 0.000 | 0.000 | 1.000 | 1.000 | 1.000 | =1 if *CDTA* > *CDTA** |
| *BELOW(NSFR)* | 0.403 | 0.490 | 0.000 | 0.000 | 0.000 | 1.000 | 1.000 | =1 if *NSFR* > *NSFR** |
| *ABOVE(RSF)* | 0.365 | 0.481 | 0.000 | 0.000 | 0.000 | 1.000 | 1.000 | =1 if RSF > RSF* |
| *ABOVE(ASF)* | 0.587 | 0.492 | 0.000 | 0.000 | 1.000 | 1.000 | 1.000 | =1 if ASF > ASF* |
| *GAP(LTCD)* | 0.046 | 0.551 | −2.097 | −0.088 | 0.134 | 0.337 | 0.961 | *LTCD** minus *LTCD* |
| *GAP(LTA)* | 0.077 | 0.336 | −0.665 | −0.172 | 0.106 | 0.333 | 0.753 | *LTA** minus *LTA* |
| *GAP(CDTA)* | −0.019 | 0.126 | −0.241 | −0.099 | −0.041 | 0.033 | 0.415 | *CDTA** minus *CDTA* |
| *GAP(NSFR)* | −0.096 | 0.387 | −1.351 | −0.274 | −0.068 | 0.140 | 0.629 | *NSFR** minus *NSFR* |
| *GAP(RSF)* | 0.045 | 0.161 | −0.298 | −0.056 | 0.049 | 0.139 | 0.473 | *RSF** minus *RSF* |
| *GAP(ASF)* | −0.004 | 0.041 | −0.083 | −0.032 | −0.009 | 0.019 | 0.116 | *ASF** minus *ASF* |
| *ROA* | 0.010 | 0.007 | −0.023 | 0.007 | 0.010 | 0.013 | 0.027 | Return on assets |
| *ROA/RISK* | 6.048 | 5.346 | −2.023 | 2.364 | 4.850 | 8.359 | 26.45 | ROA/(std. dev. of past 12-quarter ROA) |
| *ROE* | 0.095 | 0.078 | −0.301 | 0.066 | 0.100 | 0.135 | 0.278 | Return on equity |
| *ROE/RISK* | 6.155 | 5.510 | −2.164 | 2.367 | 4.910 | 8.493 | 27.50 | ROE/(std. dev. of past 12-quarter ROE) |

LTCD = LTA*/CDTA*). (b) Banks might set targets for core deposits-to-assets and passively let the market determine loans-to-assets. In this case, banks are simultaneously targeting their loans-to-core deposits and their core deposits-to-assets ratios (i.e., LTCD* = LTA/CDTA*). (c) Banks might set targets for loans-to-assets and passively let the market to determine core deposits-to-assets. In this case, banks are simultaneously targeting their loans-to-core deposits and their loans-to-assets ratios (i.e., LTCD* = LTA*/CDTA). To determine which if any of these three scenarios dominates in the data, we estimate our partial adjustment models three separate ways: for LTCD target ratios, for CDTA target ratios, and for LTA target ratios.[10]

### 4.2. Determinants of target ratios

Only a small handful of studies explore the theoretical determinants of bank loans-to-deposits ratios, and to the best of our knowledge there are no previous empirical studies on the optimal loans-to-core deposits ratio.[11] Accordingly, we specify the vector $X_{i,t-1}$ of *LTCD* determinants parsimoniously, based in part on the theoretical determinants of bank liquidity from Tirole (2011).

How much liquidity a bank targets is likely to be influenced by a bank's size, its rate of growth, and its ability to inexpensively finance its growth. We expect that larger banks (*lnASSETS*) will target higher *LTCD* ratios (lower balance sheet liquidity), as they have access to large-denomination purchased liquidity solutions (e.g., large brokered deposits, negotiable CDs) and can invest in large-denomination loans that can be liquidated when necessary (e.g., syndicated loans). We expect fast-growing banks (*GROWTH PLAN*) to target higher *LTCD* ratios, as it is difficult to fund rapid asset or loan growth by raising new core deposits. We expect publicly traded banks (*PUBLIC*) to target higher *LTCD*, as these

[10] We note that a fourth scenario—in which the bank sets targets for neither its LTA nor its CDTA ratios—is equivalent to not targeting its LTCD ratio at all. In this case, we would expect $\hat{\beta} = 0$.

[11] In contrast, there is a large literature on optimal capital ratios, dating to Modigliani and Miller (1958). Recent studies use partial adjustment models to estimate target equity-to-asset ratios for non-financial firms (Flannery and Rangan, 2006) and for commercial banks (Berger et al., 2008).

banks have faster and less expensive access to sources of liquidity.[12] Better capitalized banks (*EQUITY*) might target either higher or lower *LTCD* ratios: With greater debt capacity, banks might willingly operate with higher liquidity risk knowing that they can easily borrow needed liquidity in the future; but with higher franchise value (e.g., Marcus, 1984; Keeley, 1990), banks might reject marginal lending opportunities in order to control both credit risk and liquidity risk.

Banks' liquidity targets should also be consistent with their business activities. Banks that invest heavily in branch locations (*BRANCHES*) are likely to target lower *LTCD* ratios, as the main function of a bank branch is to generate and service core deposit accounts. Banks that invest heavily in portfolios of long-duration loans such as residential mortgages (*MORTGAGES*) will mitigate interest rate risk by funding their portfolios with long-duration liabilities; given that core deposits have longer effective durations, these banks are likely to target lower *LTCD* ratios. Banks for which loan commitments and lines of credit (*COMMITMENTS*) are a relatively important line of business are likely to target higher *LTCD* ratios because, all else equal, they will expect their customers to draw down these lines of credit. Related to this, because the demand for loans varies positively with local economic conditions (*ECON*), a bank operating in strong economic environment is likely to target a higher *LTCD* ratio.

### 4.3. Determinants of adjustment speeds

We specify the determinants of banks' adjustment speeds $Z_{i,t-1}$ parsimoniously as well, largely following the literature on partial adjustment of bank capital ratios (e.g., Berger et al., 2008). As shown in Eq. (10), banks' distance from their targets (*GAP*) is the primary factor determining how fast banks adjust toward their targets. Assuming that banks set their *LTCD* targets optimally, larger deviations from these targets (larger *GAP*s) will be increasingly costly. Hence, banks should have incentives to adjust more quickly if they are further away from their targets.

The sensitivity of banks' adjustment speeds to *GAP* may depend on existing conditions external or internal to the bank. We expect banks operating under favorable local economic conditions (*ECON*) to be able to adjust faster toward their targets. We expect banks that are operating above their *LTCD* targets (*ABOVE* = 1 when *LTCD* > *LTCD**) will adjust quickly relative to banks operating below their *LTCD* targets, because the latter set of banks will be reticent to rid themselves of the extra (difficult-to-raise) core deposits. We have ambiguous expectations regarding the impact of bank size (*lnASSETS*) on adjustment speed. On-the-one-hand, larger banks have more resources at their disposal and hence may have the ability to adjust loans and/or core deposits more quickly. On-the-other-hand, these resources may allow larger banks to operate away from their loan and/or core deposit targets in the short-run without adverse consequences for financial performance, reducing their incentives to adjust more quickly.

## 5. Main results: estimated *LTCD* targets and adjustment speeds

We estimate our model, which consists of Eqs. (7) and (10), in a two-stage sequence. In the first stage we estimate Eq. (7), which is a dynamic panel model, using the Blundell and Bond (1998) GMM approach. In the second stage we estimate Eq. (10), which is a linear panel regression, using Ordinary Least Squares (OLS) techniques. We include bank fixed effects and time fixed effects in both stages—the former absorbs idiosyncratic variation in liquidity levels across banks, the latter absorbs variation in macroeconomic, financial market and regulatory conditions across time—and we add a constant term to both the $X_{i,t-1}$ and $Z_{i,t-1}$ vectors. Variables are winsorized at the 1st and 99th percentiles of their annual sample distributions in both stages.

### 5.1. LTCD targets

The first stage estimations are displayed in Table 2, Panel A. For the annual data (column 1), the average estimated target *LTCD** is 1.1185, very close to the average value of 1.0920 in the raw data. The estimated value of $\lambda$ indicates that, on average, banks closed about 26% of the gap between *LTCD* and *LTCD** in the course of a year; at this rate of annual adjustment, it would take approximately 7.6 years to close 90% of the estimated *LTCD* gap, all other conditions unchanged.[13] By themselves, these two results constitute some initial, albeit crude, evidence that the typical U.S. bank targets and actively manages its loans-to-core deposits ratio.

The estimated *LTCD* targets vary sensibly with bank characteristics. As expected, larger banks, publicly traded banks, and fast growing banks set (non-trivially) higher *LTCD* targets. Based on the annual data, a doubling of bank asset size is associated with an estimated 5.51% increase in *LTCD**;[14] access to public capital markets is associated with an estimated 7.92% increase in *LTCD**; and a doubling of a bank's internal asset growth rate is associated with an estimated 4.75% increase in *LTCD**.[15] Banks set lower *LTCD* targets as equity capital ratios increase—a 100 basis point increase in equity-to-assets is associated with a 69 basis point (or 0.63%) reduction in *LTCD**—which suggests that franchise value effects (reducing risk to protect an increasingly valuable bank) overwhelm debt capacity effects (increasing leverage and lending out the proceeds).[16]

Banks' liquidity targets also vary sensibly with their business activities. As expected, higher unused credit commitments are associated with higher *LTCD* targets, while higher branching intensity is associated with lower *LTCD* targets. We find no statistical evidence linking balance sheet liquidity targets to residential mortgage holdings; this may simply indicate that a bank that holds residential mortgages in portfolio (as opposed to securitizing them) tends to fund these loans with core deposits, a dollar-for-dollar financing scheme that leaves *LTCD* unchanged. Finally, we find only a weak statistical and economic relationship between local economic conditions and banks' balance sheet liquidity targets: A one-standard deviation increase in *ECON* is associated with just a 3.58% standard deviation increase in *LTCD**.[17]

The quarterly data (column 2) generate very similar results, the one notable exception being the substantially slower average adjustment speed. The estimated quarterly adjustment speed of 0.1789 is 32% slower than the estimated annual adjustment speed of 0.2619. The direction of this discrepancy is to be expected: Given a shorter period of time, a bank should be able to close only a smaller portion of its *GAP*. The size of this discrepancy suggests that adjustment speeds are not linear across time: Closing *GAP* in a linear fashion would require the quarterly adjustment speed to be on the order of 75% slower than the annual adjustment speed.

### 5.2. LTCD adjustment speeds

In the second stage we no longer constrain all banks to have the same adjustment speed $\lambda$. The results are displayed in Table 2,

[12] While both public equity markets and public debt markets can serve as sources of external liquidity for banking companies, equity market access dominates. For example, in the final year of our data period, 274 of the banks in our main sample were publicly traded (*PUBLIC* = 1), while just 27 of the banks in our main sample had S&P Domestic Long-term Issuer Credit Ratings.

[13] Solving $(1 - .2619)^X = .10$ yields this result.

[14] 0.0602/1.0920 yields this result.

[15] (1.2051 * 0.043)/1.0920 yields the result.

[16] −0.6910/1.0920 yields the result.

[17] (0.0010 * 19.03)/0.531 yields the result.

**Table 2**
Partial adjustment model for loans-to-core deposits (*LTCD*) ratio, using annual and quarterly 1992–2012 data for U.S. commercial banking companies. Panel A displays results for Eq. (7) using GMM estimation techniques. Panel B displays results for Eq. (10) using OLS estimation techniques. All models include fixed bank and time effects. All variables are winsorized at the 1st and 99th percentiles. Robust standard errors appear in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively. *lnASSETS* is the natural log of bank assets ($ thousands). *PUBLIC* = 1 for banks that are publicly traded. *GROWTH PLAN* is bank asset growth rate over the next two years. *EQUITY* is the ratio of book equity to assets. *MORTGAGES* is the ratio of residential mortgages to total loans. *COMMITMENTS* is the ratio of unused loan commitments to assets. *BRANCHES* is the ratio of branches to assets (in $ millions). *ECON* is the deposit-weighted Philadelphia Fed Coincident Index of state-level economic conditions. *ABOVE* = 1 if actual *LTCD* is greater than the target *LTCD**.

| | [1] Annual *LTCD* | [2] Quarterly *LTCD* |
|---|---|---|
| *Panel A: Target estimation* | | |
| $lnASSETS_{t-1}$ | 0.0602*** (0.0068) | 0.0465*** (0.0056) |
| $PUBLIC_{t-1}$ | 0.0865*** (0.0272) | 0.0755*** (0.0210) |
| $GROWTH\ PLAN_{t-1}$ | 1.2051*** (0.0542) | 0.7761*** (0.0309) |
| $EQUITY_{t-1}$ | −0.6910*** (0.1746) | −0.7305*** (0.1348) |
| $MORTGAGES_{t-1}$ | −0.0034 (0.0244) | −0.0225 (0.0219) |
| $COMMITMENTS_{t-1}$ | 2.1788*** (0.1477) | 2.7843*** (0.1076) |
| $BRANCHES_{t-1}$ | −0.6838*** (0.1789) | −0.7950*** (0.1645) |
| $ECON_{t-1}$ | 0.0010* (0.0005) | 0.0009* (0.0005) |
| *CONSTANT* | −0.0644 (0.0904) | 0.0514 (0.0781) |
| Mean estimated target | 1.1185 | 1.0841 |
| Mean actual ratio | 1.0920 | 1.0884 |
| $\lambda$ (adjustment speed) | 0.2619*** (0.0138) | 0.1789*** (0.0058) |
| Pseudo *R*-squared | 0.7000 | 0.8894 |
| *Panel B: Adjustment speed estimation* | | |
| $GAP_{t-1}$ | −0.3686*** (0.0379) | −0.0547*** (0.0163) |
| $lnASSETS_{t-1} * GAP_{t-1}$ | 0.0324*** (0.0025) | 0.0068*** (0.0012) |
| $ECON_{t-1} * GAP_{t-1}$ | 0.0008*** (0.0002) | 0.0001 (0.0001) |
| $ABOVE_{t-1} * GAP_{t-1}$ | 0.3297*** (0.0131) | 0.1240*** (0.0048) |
| *CONSTANT* | 0.0410*** (0.0022) | 0.0116*** (0.0011) |
| Mean estimated $\lambda$ | 0.2901 | 0.1070 |
| Median estimated $\lambda$ | 0.2085 | 0.0761 |
| *R*-squared | 0.4199 | 0.2336 |
| Observations | 127,828 | 512,986 |
| Number of banks | 10,190 | 10,236 |

Panel B. For the annual data, the bank-specific adjustment speeds (mean $\lambda_{i,t} = 0.2901$, median $\lambda_{i,t} = 0.2085$) indicate an upward skew in the distribution of adjustment speeds, but are generally consistent with the constrained adjustment speed from the first stage estimation ($\lambda = 0.2619$). However, the mean and median adjustment speeds are substantially lower for the quarterly data, at 0.1070 and 0.0761, respectively. The relative sizes of the annual and quarterly adjustment speeds are economically intuitive. First, the slower quarterly adjustment speeds reflect the reality that a shorter time period allows for less adjustment. Second, given the annual mean adjustment speed of 0.2901, the quarterly mean adjustment speed of 0.1070 remains faster than the 0.0658 speed necessary for linear adjustment over time.[18] Given that it is costly to operate away from *LTCD**, a bank should allocate a larger amount of resources to closing *GAP*s when they first occur (and hence are relatively large) and a smaller amount of resources to closing the reduced *GAP*s during the succeeding quarters.

Larger banks have slightly faster annual adjustment speeds: A doubling of asset size increases the speed of adjustment toward *LTCD** by an estimated 0.0324 (or 11.16%) in the annual data.[19] There is weak evidence that stronger local economic conditions help facilitate the liquidity adjustment process—a one-standard deviation increase in the speed of adjustment is associated with an estimated 0.0152 (or 5.25%) increase in *ECON* in the annual data.[20] As expected, banks that find themselves above their balance sheet liquidity targets (these banks are “too illiquid” because *LTCD* > *LTCD**) adjust more quickly than banks that find themselves below their targets. All else equal, the annual marginal adjustment in *LTCD* for these “too illiquid” banks is 0.3297, which is faster than the 0.2901 sample mean and substantially faster than the 0.2070 sample median. The results for the quarterly data are similar, albeit with smaller coefficient magnitudes that reflect the shorter three-month adjustment periods.

### 5.3. Adjustment speeds and bank profitability

Thus far, our analysis implies that banks are, on average, active and sensible managers of balance sheet liquidity as measured by traditional loans-to-core deposits ratios. However, this analysis tells us nothing about the financial efficiency of those liquidity management practices. We shed some initial light on this issue by regressing banks' annual financial performance on their estimated *LTCD* adjustment speeds $\lambda_{i,t}$ as follows:

$$PERFORMANCE_{i,t} = \mathrm{a} + \mathrm{b} \cdot \lambda_{i,t} + \mathrm{c} \cdot \lambda_{i,t}^2 + \mathrm{d} \cdot lnASSETS_{i,t} + \varepsilon_{i,t} \qquad (11)$$

This simple quadratic functional form allows us to reveal (a) whether a performance maximum exists within the range of industry $\lambda$, and if so, (b) whether banks tend to operate near that optimal adjustment speed. We use four different *PERFORMANCE* measures in our tests: return-on-assets (*ROA*), return-on-equity (*ROE*), risk-adjusted return-on-assets (*ROA/RISK*) and risk-adjusted return-on-equity (*ROE/RISK*), where *RISK* is the standard deviation of the numerator (*ROA* or *ROE*) over the past 12 quarters. We use a parsimonious specification that includes the natural log of bank assets (which is a standard control variable in empirical tests of bank performance) plus bank and time fixed effects.

We acknowledge the possibility that the estimated regressors $\lambda$ and $\lambda^2$ contain measurement error which may result in biased parameter estimates. We have two reasons for optimism. First, the estimated values of $\lambda$ come from a model that generated coefficients, liquidity targets and adjustment speeds with sensible signs and reasonable magnitudes. Second, the most typical bias caused by measurement error is attenuation of parameter estimates toward zero; hence, finding statistically significant parameter estimates in Eq. (11) will provide additional confidence that any bias is minimal. Nevertheless, we characterize the results of this analysis as interesting but merely suggestive.

The results are displayed in Table 3. The regressions using annual adjustment speeds (columns 1–4) generate inverted-U shapes with performance maxima on the interior of the estimated $\lambda$, consistent with the existence of an optimal average adjustment speed. The regressions based on quarterly adjustment speeds (columns 5–8) do not always have internal maxima. To visualize these results, we plot the annual and quarterly *ROE* regression lines (evaluated for the mean value of *lnASSETS*) in Fig. 2. The ROE-maximizing annual adjustment speed is 0.2463; given the median annual adjustment speed of 0.2070, the majority of banks were adjusting their balance sheet liquidity positions too slowly. But the loss of earnings is very small. By increasing its annual adjustment speed from 0.2070 to 0.2463, a bank would increase its ROE only from 0.1160 to 0.1162. On average, banks appear to have been adjusting their balance sheet liquidity positions at financially optimal speeds during our sample period. (Similar quantitative results emerge when this analysis is performed for the other three financial performance measures.)

## 6. Decomposing the *LTCD* ratio

The results in Tables 2 and 3 are consistent with our conjecture that banks actively manage their balance sheet liquidity as

[18] The solution to $(1 + \lambda_{\mathrm{quarterly}})^4 = 1.2901$ yields this result.
[19] 0.0324/0.2901 yields the result.
[20] (0.0008 * 19.03)/0.2901 yields the result.

**Table 3**
Financial performance of banks with respect to loans-to-core deposits (*LTCD*) adjustment speeds, using annual or quarterly 1992–2012 data. Results are displayed for Eq. (11) using OLS estimation techniques with fixed bank and time effects. Data are winsorized at the 1st and 99th percentiles. Robust standard errors appear in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively. *ROA* is return of assets. *ROE* is return on equity. *RISK* is the twelve-quarter trailing standard deviation of *ROA* or *ROE*, accordingly. Adjustment speeds $\lambda$ are the estimated values from the models displayed in Table 2, Panel B. *lnASSETS* is the natural log of bank assets ($ thousands).

| | [1] ROA | [2] ROA/RISK | [3] ROE | [4] ROE/RISK |
|---|---|---|---|---|
| *Panel A: Annual data (mean adjustment speed = 0.29; median adjustment speed = 0.21)* | | | | |
| $\lambda$ | 0.0063*** (0.0010) | 8.4529*** (0.6516) | 0.0708*** (0.0110) | 8.8416*** (0.6785) |
| $\lambda^2$ | −0.0117*** (0.0015) | −13.634*** (1.0168) | −0.1437*** (0.0164) | −14.679*** (1.0554) |
| $lnASSETS_{t-1}$ | 0.0001 (0.0001) | 0.6234*** (0.0757) | 0.0012 (0.0016) | 0.4560*** (0.0783) |
| *Constant* | 0.0081*** (0.0015) | −2.3981*** (0.8302) | 0.0938*** (0.0172) | −0.2154 (0.8595) |
| Inferred optimal $\lambda$ | 0.2696 | 0.3100 | 0.2463 | 0.3012 |
| Observations | 127,828 | 127,828 | 127,828 | 127,828 |
| Number of Banks | 10,190 | 10,190 | 10,190 | 10,190 |
| *R*-squared | 0.1292 | 0.0955 | 0.1316 | 0.0929 |
| | [5] ROA | [6] ROA/RISK | [7] ROE | [8] ROE/RISK |
| *Panel B: Quarterly data (mean adjustment speed = 0.14; median adjustment speed = 0.10)* | | | | |
| $\lambda$ | −0.0050** (0.0021) | 1.0391** (0.4866) | −0.0985*** (0.0215) | 3.0794* (1.5909) |
| $\lambda^2$ | 0.0218** (0.0087) | −4.4485** (2.1522) | 0.3400*** (0.0916) | −15.872** (7.0183) |
| $lnASSETS_{t-1}$ | 0.0005*** (0.0001) | 0.1522*** (0.0216) | 0.0091*** (0.0014) | 0.4847*** (0.0729) |
| *Constant* | 0.0057*** (0.0014) | −0.7550*** (0.2362) | 0.0288* (0.0154) | 1.0768 (0.7997) |
| Inferred optimal $\lambda$ | NA | 0.1168 | NA | 0.0971 |
| Observations | 512,986 | 512,986 | 512,986 | 512,986 |
| Number of Banks | 10,236 | 10,236 | 10,236 | 10,236 |
| *R*-squared | 0.1112 | 0.3266 | 0.1188 | 0.0926 |

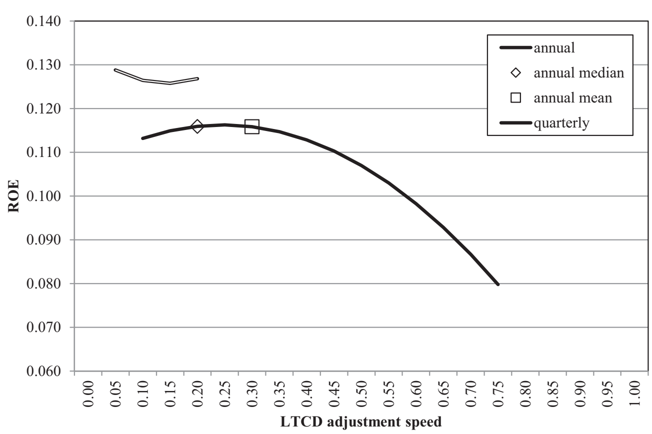


**Fig. 2.** Estimated associations between bank return on equity (ROE) and LTCD adjustment speeds. The line plotted for the annual data is based on Table 3, column 3. The line plotted for the quarterly data is based on Table 3, column 7. The horizontal ranges of the two lines are determined by the 1st and 99th percentiles of the estimated LTCD adjustment speeds.

measured by the loans-to-core deposits ratio. But are banks really setting explicit LTCD targets? But an equally compelling conjecture is also consistent with the results in Tables 2 and 3: Banks actively target their loans-to-assets (LTA) and core deposits-to-assets (CDTA) ratios, and the LTCD ratio is simply the passive outcome of those processes. We attempt to disentangle these two conjectures by re-estimating our partial adjustment model for the loans-to-assets (*LTA*) and core deposits-to-assets (*CDTA*) ratios.

The results in Table 4 provide compelling evidence that banks target and actively manage their core deposits-to-assets ratios, but do not target or actively manage their loans-to-assets ratios. Banks' actual core deposits-to-assets ratios are centered on the estimated target ratio (mean $CDTA = 0.5982$, $CDTA^* = 0.5877$), but banks' actual loans-to-assets ratios are not centered on the estimated target (mean $LTA = 0.5966$, $LTA^* = 0.6696$). The average *CDTA* adjustment speed of 0.4414 indicates that nearly half of any core deposit gap gets closed within one year, while the average *LTA* adjustment speed of 0.0461 indicates the absence of any active management of the loans-to-assets ratio; at this rate of adjustment, it would take 49 years to close 90% of the *LTA* gap.

The estimated right-hand side coefficients are intuitive and instructive.[21] Larger banks rely less on core deposit funding but invest a larger portion of their assets in loans (i.e., because larger banks can better diversify their loan portfolios, they can absorb greater amounts of idiosyncratic credit risk). Similarly, publicly traded banks rely less on core deposit funding. When banks are growing their assets quickly (*GROWTH PLAN*), it is generally not possible to match asset expansion dollar-for-dollar with new core deposit funding or new loan investments. The negative *EQUITY* coefficient in the *CDTA* model is consistent with our debt capacity conjecture; the negative *EQUITY* coefficient in the *LTA* model is consistent with our franchise value conjecture; and the relatively larger magnitude of the latter explains the negative *EQUITY* coefficient in the *LTCD* model in Table 2. The positive coefficient on *MORTGAGES* in the *CDTA* model is consistent with our earlier conjecture that retail banks use core deposits to fund their long-term mortgage portfolios. Loan commitments are associated with lower core deposit targets but are unrelated to loan targets. Because loan commitments are contingent assets—banks cannot control when these credit lines get drawn down or paid back—including them in loan targets is difficult, and funding them with long-term liabilities (e.g., core deposits) is inefficient. As expected, bank branches are associated with higher core deposit targets, but are unrelated to loan targets. Also as expected, stronger local economic conditions (stronger loan demand) are associated with higher lending targets, which in turn are financed (at least in the short run) with non-core deposits.

The second stage estimates for the *CDTA* and *LTA* models are displayed in Table 4, Panel B. Consistent with the first stage estimates, these more flexible estimated adjustment speeds also indicate fast adjustment toward core deposit targets but slow adjustment toward loan targets. All else equal, the mean estimated adjustment speeds of 0.3623 and 0.1442 indicate that banks need

[21] The *MORTGAGES* variable is excluded from the *LTA* model because of its close mechanical relationship with the dependent variable.

**Table 4**
Partial adjustment model for core deposits-to-assets (*CDTA*) and loans-to-assets (*LTA*), using annual 1992–2012 data for U.S. commercial banking companies. Panel A displays results for Eq. (7) using GMM estimation techniques. Panel B displays results for Eq. (10) using OLS estimation techniques. All models include fixed bank and time effects. All variables are winsorized at the 1st and 99th percentiles. Robust standard errors appear in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively. *lnASSETS* is the natural log of bank assets ($ thousands). *PUBLIC* = 1 for banks that are publicly traded. *GROWTH PLAN* is bank asset growth rate over the next two years. *EQUITY* is the ratio of book equity to assets. *MORTGAGES* is the ratio of residential mortgages to total loans. *COMMITMENTS* is the ratio of unused loan commitments to assets. *BRANCHES* is the ratio of branches to assets (in $ millions). *ECON* is the deposit-weighted Philadelphia Fed Coincident Index of state-level economic conditions. *ABOVE* = 1 if *CDTA* or *LTA* are greater than the targets *CDTA** or *LTA**, respectively.

| | [1] *CDTA* | [2] *LTA* |
|---|---|---|
| *Panel A: Target estimation* | | |
| $lnASSETS_{t-1}$ | −0.0287*** (0.0013) | 0.0130** (0.0052) |
| $PUBLIC_{t-1}$ | −0.0259*** (0.0044) | −0.0154 (0.0179) |
| $GROWTH\ PLAN_{t-1}$ | −0.2679*** (0.0068) | −0.4946*** (0.0740) |
| $EQUITY_{t-1}$ | −0.5799*** (0.0320) | −2.6487*** (0.2678) |
| $MORTGAGES_{t-1}$ | 0.1011*** (0.0058) | |
| $COMMITMENTS_{t-1}$ | −0.2641*** (0.0172) | 0.0371 (0.1365) |
| $BRANCHES_{t-1}$ | 0.5317*** (0.0417) | −0.0764 (0.2071) |
| $ECON_{t-1}$ | −0.0003*** (0.0001) | 0.0017*** (0.0004) |
| *CONSTANT* | 1.0588*** (0.0302) | 0.3404*** (0.1200) |
| Mean estimated target | 0.5877 | 0.6696 |
| Mean actual ratio | 0.5982 | 0.5966 |
| $\lambda$ (adjustment speed) | 0.4414*** (0.0106) | 0.0461*** (0.0087) |
| Pseudo *R*-squared | 0.7000 | 0.8894 |
| *Panel B: Adjustment speed estimation* | | |
| $GAP_{t-1}$ | 0.2988*** (0.0300) | 0.0807*** (0.0090) |
| $lnASSETS_{t-1} * GAP_{t-1}$ | −0.0010 (0.0021) | 0.0023*** (0.0005) |
| $ECON_{t-1} * GAP_{t-1}$ | 0.0009*** (0.0001) | 0.0003*** (0.0001) |
| $ABOVE_{t-1} * GAP_{t-1}$ | −0.0620*** (0.0093) | 0.0038 (0.0027) |
| *CONSTANT* | −0.0047*** (0.0006) | 0.0068*** (0.0008) |
| Mean estimated $\lambda$ | 0.3623 | 0.1442 |
| Median estimated $\lambda$ | 0.3510 | 0.1367 |
| *R*-squared | 0.4775 | 0.1461 |
| Observations | 127,828 | 127,828 |
| Number of banks | 10,190 | 10,190 |

5.1 years to close 90% of their *CDTA* gaps, but need 14.8 years to close 90% of their *LTA* gaps, respectively. Larger asset size is associated with faster loan adjustment speed but is unrelated to core deposit adjustment speed. Stronger local economic conditions allow banks to adjust more quickly toward both their core deposit targets and their loan targets. The coefficient on *ABOVE * GAP* is statistically negative in the *CDTA* model but is statistically non-significant in the *LTA* model, an indication that "too liquid" banks adjust their balance sheet liquidity more slowly because they are reticent to part with excess—and difficult-to-generate—core deposit balances.

Combining the results from Tables 2 and 5 allows us to draw the following informed characterization of balance sheet liquidity management at U.S. banks: (a) banks target and actively manage their loans-to-core deposits ratios, (b) core deposits-to-assets levels are the main focus of this active balance sheet liquidity management, and (c) banks passively allow their loans-to-assets levels to increase and decrease depending on the availability of profitable lending opportunities. The data plotted in Fig. 3 offer visual confirmation. The *CDTA* targets (Panel A) migrate downward over time in a slow and systematic way, within tight confidence intervals. The single upward shock in 2009 is consistent with banks re-targeting higher core deposit levels in response to the financial crisis, either because banks themselves had become temporarily more risk averse, or because banks were experiencing large core deposit inflows from investors seeking a safe harbor for their funds. In any case, this shock was followed by a steady return toward core deposits levels last targeted in the early 2000s. In contrast, the *LTA* targets (Panel B) follow no systematic trend, meandering up and down in large annual increments within relatively wider confidence intervals. The large decline in loans-to-assets target in 2009 does not especially stand out among the six other annual shocks of 40 percentage points or more. The *LTCD* targets (Panel C) reflect the characteristics of both the *CDTA* and *LTA* targets. Balance sheet illiquidity increased systematically from 1992 to 2008 within wide confidence bands; targeted liquidity levels were shocked tremendously in 2009, reflecting the combined positive shock to *CDTA** and negative shock to *LTA**; and these shocks were followed by a gradual return to balance sheet liquidity levels last targeted in the late 1990s.

## 7. Basel III liquidity regulations

Our analysis thus far indicates that U.S. banking companies actively managed their balance sheet liquidity positions (as defined by the loans-to-core deposits ratio) during our 1992–2012 sample period, in the absence of any binding regulatory or supervisory liquidity standards. Going forward, Basel III-compliant regulations will require at least some U.S. banks to maintain minimum liquidity ratios. In an effort to learn whether and how these new regulations might impinge upon existing liquidity management practices, in this section we investigate whether U.S. banking companies *acted as if* they were targeting a net stable funding ratio (NSFR) standard during our pre-Basel III sample period. If banks' balance sheet liquidity management practices have historically conformed with the new standards—that is, if (a) the data show that banks have operated above the NSFR = 1 threshold and (b) our partial adjustment model shows that banks have managed their balance sheets in a manner consistent with

**Table 5**
Net stable funding ratio (*NSFR*). Panel A displays annual calculations for all domestically owned and FDIC insured banks and bank holding companies in the U.S. between 1992 and 2012. To reduce the impact of outliers, values of *NSFR* below the 1st percentile or above the 99th percentile in each year were excluded from the calculations. Panel B compares the 2012 distribution of NSFR for the population of U.S. banking companies with assets greater than $2 billion to the 2012 distribution of NSFR for a voluntarily submitted subset of 223 banks from 27 different countries analyzed by the BIS (Bank for International Settlements, 2013). Internationally active banks with at least €3 billion in equity capital are in Group 1; Group 2 banks are either not internationally active or have less than €3 billion in equity capital.

| Year | All banks | | | NSFR < 1 | |
|---|---|---|---|---|---|
| | Number | Mean | Std.Dev | Number | Percentage |
| *Panel A: Annual statistics for NSFR* | | | | | |
| 1992 | 7254 | 1.720 | 0.518 | 26 | 0.36 |
| 1993 | 7470 | 1.700 | 0.503 | 25 | 0.33 |
| 1994 | 7352 | 1.564 | 0.426 | 39 | 0.53 |
| 1995 | 7217 | 1.517 | 0.369 | 42 | 0.58 |
| 1996 | 6967 | 1.483 | 0.350 | 57 | 0.82 |
| 1997 | 6608 | 1.442 | 0.341 | 66 | 0.76 |
| 1998 | 6356 | 1.429 | 0.322 | 76 | 1.00 |
| 1999 | 6133 | 1.398 | 0.325 | 117 | 1.91 |
| 2000 | 5978 | 1.358 | 0.302 | 133 | 2.22 |
| 2001 | 5868 | 1.341 | 0.310 | 183 | 3.12 |
| 2002 | 5830 | 1.344 | 0.307 | 196 | 3.36 |
| 2003 | 5766 | 1.358 | 0.329 | 223 | 3.87 |
| 2004 | 5752 | 1.329 | 0.338 | 313 | 5.44 |
| 2005 | 5695 | 1.302 | 0.336 | 390 | 6.85 |
| 2006 | 5598 | 1.272 | 0.344 | 479 | 8.56 |
| 2007 | 5525 | 1.243 | 0.287 | 634 | 11.48 |
| 2008 | 5471 | 1.238 | 0.332 | 754 | 13.78 |
| 2009 | 5417 | 1.273 | 0.333 | 395 | 7.29 |
| 2010 | 5381 | 1.312 | 0.341 | 278 | 5.17 |
| 2011 | 5306 | 1.361 | 0.360 | 190 | 3.58 |
| 2012 | 5367 | 1.398 | 0.408 | 163 | 3.04 |

| | U.S. banks More than $50 billion | U.S. banks $2 billion to $50 billion | BIS Group 1 banks | BIS Group 2 banks |
|---|---|---|---|---|
| *Panel B: Comparing distribution of NSFR to BIS calculations* | | | | |
| Number of banks | 483 | 3048 | 101 | 122 |
| 75th percentile | 1.04 | 1.25 | 1.09 | 1.17 |
| 50th percentile | 0.95 | 1.12 | 0.98 | 1.05 |
| 25th percentile | 0.86 | 1.03 | 0.89 | 0.91 |

$NSFR^* > 1$—then the new standards are unlikely to have much impact on liquidity management in the banking system.

### 7.1. Calculating the NSFR

The Basel Committee on Banking Supervision (2014) defines the net stable funding ratio (NSFR) as the ratio of a bank's Available Stable Funding (ASF) to its Required Stable Funding (RSF). ASF is a weighted average of the bank's liabilities and capital (including but not limited to core deposits), with heavier weights assigned to the more stable funding sources, such as equity capital, subordinated debt, and core deposits. RSF is a weighted average of the bank's assets (including but not limited to loans), with heavier weights assigned to longer term, illiquid, and/or volatile assets, such as trading securities, assets pledged as collateral, investments in subsidiary companies, and loans to businesses, consumers, and other financial institutions.

The NSFR might be described as the regulatory analog to the LTCD ratio.[22] Both ratios compare banks' illiquid assets (total loans in the case of the LTCD, required stable funding in the case of the NSFR) to the stability of the funds banks use to fund those assets (core deposits in the case of LTCD, available stable funds in the case of NSFR). There are three main differences in their constructions. First, the NSFR weights bank assets and liabilities depending on their stability and/or liquidity; the LTCD ratio assigns a weight of 1 to all loans and all core deposits, and a weight of zero to all other items on the balance sheet. Second, the NSFR includes equity capital as a funding source; the LTCD ratio does not. Third, by construction the NSFR increases with balance sheet liquidity while the LTCD decreases with balance sheet liquidity.

Regulatory databases do not currently contain the necessary asset and liability account details to calculate the NSFR exactly as defined by the Bank Committee on Banking Supervision (2014), but a reasonably close approximation is possible for U.S. banks using the call report data and Y-9C report data. The bank financial statements reported in these two databases have become more detailed over time, which allows us to calculate the NSFR more accurately at the end of our data period (2012) than at the beginning of our data period (1992). However, in order to construct an inter-temporally consistent version of the *NSFR* variable in every year of our data sample, we calculate *NSFR* using the less detailed definitions from the earlier regulatory reports. Appendix A shows this mapping of the Basel III NSFR definition into the less detailed 1991 call report categories (our estimations require one year of lagged exogenous variables). Appendix B we shows how NSFR can be mapped into the more detailed 2012 call report categories.[23] In practice, this difference in detail has very little impact on our *NSFR* variable: using 2012 data, the cross sectional correlation between the less detailed *NSFR* defined in Appendix A and the more detailed *NSFR* defined in Appendix B is 0.99.

[22] The NSFR is far more similar to the LTCD ratio than is the LCR. The LCR requires banks to hold enough liquid assets to withstand (a) a base case scenario similar to the liquidity supply shocks experienced in 2008 plus (b) additional short-run liquidity exposures idiosyncratic to banks' individual business models, to be determined by bank-specific liquidity stress tests designed by the banks but approved by the regulators (Basel Committee on Banking Supervision, 2010, pp. 3–25). Given the uncertainties involved, the optimal minimum coverage ratio is open to some disagreement among banks and their regulators. Clearly, measuring the LCR is beyond the scope of this study, if not beyond the resources of its authors.

[23] Although we conduct our discussion in terms of the call report data, the account definitions in the Y9-C reports are virtually identical to the account definitions in the call reports in all years.

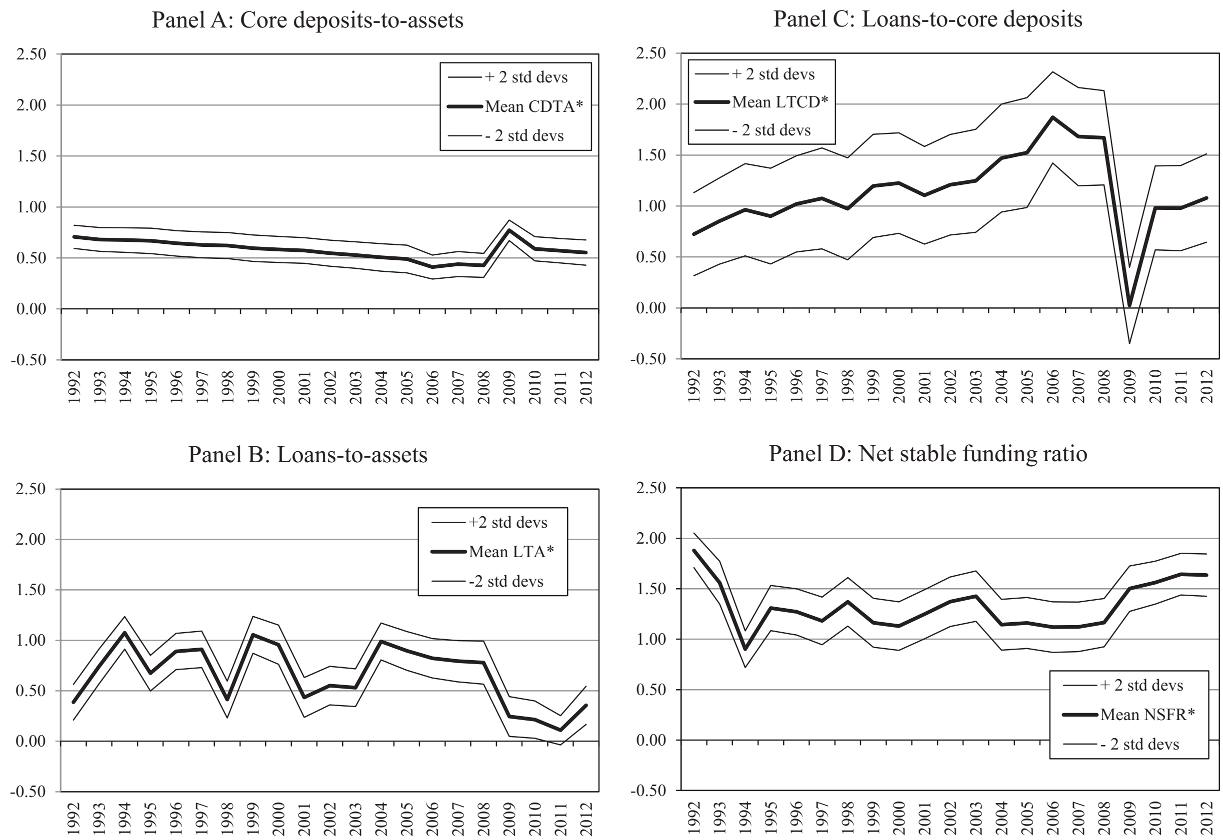


**Fig. 3.** Estimated targets for LTCD, LTA, CDTA and NSFR ratios 1992–2012. Annual means and annual 5–95% confidence intervals. Estimates based on results in Tables 2, 4 and 6.

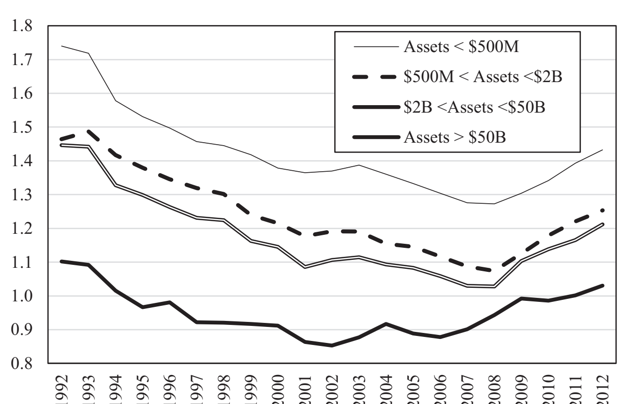


**Fig. 4.** Net stable funding ratio (NSFR). Annual medians for various asset size groups of U.S. commercial banking companies, 1992–2012. Assets measured in 2010 dollars.

Table 5, Panel A displays annual data for *NSFR* between 1992 and 2012 for all domestically owned and FDIC-insured commercial bank holding companies and commercial banks. The intertemporal movement of this ratio is similar (though inverse) to the intertemporal movements in *LTCD* in Fig. 1; the linear correlation between the two time series is −0.87. While the average bank exceeded the NSFR ⩾ 1 threshold in every year of the data, some fell below this threshold each year, ranging from a trivial 0.36% of all banks in 1992 to a substantial 13.78% of all banks in 2008. Fig. 4 disaggregates the data by bank size, and reveals that larger banks were much more likely to fall below the NSFR ⩾ 1 threshold than smaller banks. Had the Basel III standards been in force during our sample period, a nontrivial number of (mostly larger) banks would have been forced to increase their balance sheet liquidity in every year of our data.

Because our calculations of *NSFR* are estimates based on incomplete publicly available data, it is important to check whether our calculations are consistent with full-information calculations made by bank regulators. As part of its ongoing monitoring efforts, the Bank for International Settlements (2013) calculated the year-end 2012 NSFR ratios for 223 voluntarily reporting banks from 27 different countries. The distribution of these full-information NSFR calculations is displayed in Table 5, Panel B for internationally active banks with at least €3 billion in equity capital (Group 1) and banks that were either not internationally active or had less than €3 billion in equity capital (Group 2). The distributions of our estimated *NSFR* variable are quantitatively similar to the BIS distributions for similarly sized U.S. banks.[24]

### 7.2. NSFR targets and adjustment speeds

We estimate our partial adjustment model once again, this time for *NSFR*. The first stage results are displayed in Table 6, Panel A,

[24] The cleanest comparison can be made by comparing the BIS Group 1 banks with our subsample of SIFI banks with assets greater than $50 billion. The banks in the BIS Group 1 had leverage ratios of 0.047 on average, which means that Group 1 banks with exactly €3 euros of equity capital had about €64 billion of assets, or about $84 billion in assets given the December 2012 exchange rate of $1.31 per euro. Hence, the smallest banks in the BIS Group 1 were approximately the same size as the smallest banks in our subsample of SIFI banks.

**Table 6**
Partial adjustment model for core deposits-to-assets (*LTCD*) and net stable funding ratio (*NSFR*), using annual 1992–2012 data for U.S. commercial banking companies. Panel A displays results for Eq. (7) using GMM estimation techniques. Panel B displays results for Eq. (10) using OLS estimation techniques. All models include fixed bank and time effects. All variables are winsorized at the 1st and 99th percentiles. Robust standard errors appear in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively. *lnASSETS* is the natural log of bank assets ($ thousands). *PUBLIC* = 1 for banks that are publicly traded. *GROWTH PLAN* is bank asset growth rate over the next two years. *EQUITY* is the ratio of book equity to assets. *MORTGAGES* is the ratio of residential mortgages to total loans. *COMMITMENTS* is the ratio of unused loan commitments to assets. *BRANCHES* is the ratio of branches to assets (in $ millions). *ECON* is the deposit-weighted Philadelphia Fed Coincident Index of state-level economic conditions. *ABOVE* = 1 if actual *LTCD* is greater than the target *LTCD**. *BELOW* = 1 if actual *NSFR* is less than the target *NSFR**.

| | [1]<br>*LTCD* | [2]<br>*NSFR* |
|---|---|---|
| *Panel A: Target estimation* | | |
| $lnASSETS_{t-1}$ | 0.0602*** (0.0068) | −0.0520*** (0.0054) |
| $PUBLIC_{t-1}$ | 0.0865*** (0.0272) | 0.0004 (0.0113) |
| $GROWTH\ PLAN_{t-1}$ | 1.2051*** (0.0542) | −0.3099*** (0.0540) |
| $EQUITY_{t-1}$ | −0.6910*** (0.1746) | 2.0748*** (0.2904) |
| $MORTGAGES_{t-1}$ | −0.0034 (0.0244) | −0.0715*** (0.0266) |
| $COMMITMENTS_{t-1}$ | 2.1788*** (0.1477) | −0.4672*** (0.1232) |
| $BRANCHES_{t-1}$ | −0.6838*** (0.1789) | −0.1116 (0.1618) |
| $ECON_{t-1}$ | 0.0010* (0.0005) | −0.0007* (0.0004) |
| *CONSTANT* | −0.0644 (0.0904) | 2.3737*** (0.1972) |
| Mean estimated target | 1.1185 | 1.3270 |
| Mean actual ratio | 1.0920 | 1.4084 |
| $\lambda$ (adjustment speed) | 0.2619*** (0.0138) | 0.1331*** (0.0130) |
| Pseudo *R*-squared | 0.7000 | 0.6408 |
| *Panel B: Adjustment speed estimation* | | |
| $GAP_{t-1}$ | −0.3686*** (0.0379) | 0.2207*** (0.0218) |
| $lnASSETS_{t-1} * GAP_{t-1}$ | 0.0324*** (0.0025) | −0.0055*** (0.0017) |
| $ECON_{t-1} * GAP_{t-1}$ | 0.0008*** (0.0002) | 0.0010*** (0.0001) |
| $ABOVE_{t-1} * GAP_{t-1}$ | 0.3297*** (0.0131) | |
| $BELOW_{t-1} * GAP_{t-1}$ | | −0.1688*** (0.0063) |
| *CONSTANT* | 0.0410*** (0.0022) | 0.0273*** (0.0026) |
| Mean estimated $\lambda$ | 0.2901 | 0.2514 |
| Median estimated $\lambda$ | 0.2085 | 0.3029 |
| *R*-squared | 0.4199 | 0.2487 |
| Observations | 127,828 | 127,828 |
| Number of banks | 10,190 | 10,190 |

**Table 7**
Mean averages for various measures of funding liquidity. All U.S. commercial banks, by asset size (2010 dollars) in 2000, 2006 and 2012. *CDTA* is core deposits-to-assets. *ASFA* is available stable funding-to-assets. *LTA* is loans-to-assets. *RSFA* is required stable funding-to-assets. *NSFR* is the net stable funding ratio.

| | Funding ratios (means) | | Asset ratios (means) | | % Banks with NSFR < 1 (%) |
|---|---|---|---|---|---|
| | CDTA | ASFA | LTA | RSFA | |
| *2000* | | | | | |
| Less than $500 million | 0.6147 | 0.8470 | 0.6123 | 0.6329 | 1.24 |
| $500 million to $2 billion | 0.5260 | 0.8064 | 0.6581 | 0.6751 | 6.68 |
| $2 billion to $50 billion | 0.4650 | 0.7650 | 0.6497 | 0.6782 | 12.98 |
| More than $50 billion | 0.2903 | 0.6749 | 0.6384 | 0.7443 | 73.91 |
| *2006* | | | | | |
| Less than $500 million | 0.4790 | 0.8322 | 0.6387 | 0.6620 | 5.74 |
| $500 million to $2 billion | 0.3835 | 0.7940 | 0.7018 | 0.7220 | 19.67 |
| $2 billion to $50 billion | 0.3285 | 0.7709 | 0.6815 | 0.7362 | 31.98 |
| More than $50 billion | 0.2276 | 0.7061 | 0.6613 | 0.8045 | 95.65 |
| *2012* | | | | | |
| Less than $500 million | 0.5834 | 0.8427 | 0.5838 | 0.6181 | 2.58 |
| $500 million to $2 billion | 0.4932 | 0.8256 | 0.6316 | 0.6727 | 4.42 |
| $2 billion to $50 billion | 0.4218 | 0.8219 | 0.6280 | 0.6941 | 5.64 |
| More than $50 billion | 0.2863 | 0.7776 | 0.6025 | 0.7617 | 23.08 |

where for comparison we also include the *LTCD* results from Table 2. The comparisons imply that the balance sheet liquidity practices at the average U.S. commercial bank between 1992 and 2012 were at least partially consistent with the not-yet-announced Basel III NSFR standards. The mean target *NSFR** of 1.327 is substantially higher than the minimum NSFR threshold of 1.0; had the Basel III regulatory standards had been in place during our sample period, this result would have been evidence that the average bank was maintaining a large liquidity buffer. The variables *lnASSETS*, *GROWTH PLAN*, *COMMITMENTS* and *ECON* are associated with lower balance sheet liquidity targets (i.e., higher values of *LTCD**, lower values of *NSFR**), while the variable *EQUITY* is associated with higher balance sheet liquidity targets in both models. Indeed, comparing Panels C and D in Fig. 3, the

**Table 8**
Partial adjustment model for core deposits-to-assets (*LTCD*) and net stable funding ratio (*NSFR*), using size-based subsamples of annual 1992–2012 data for U.S. commercial banking companies. Panel A displays results for Eq. (7) using GMM estimation techniques. Panel B displays results for Eq. (10) using OLS estimation techniques. All models include fixed bank and time effects. All variables are winsorized at the 1st and 99th percentiles. Robust standard errors appear in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively. *lnASSETS* is the natural log of bank assets ($ thousands). *PUBLIC* = 1 for banks that are publicly traded. *GROWTH PLAN* is bank asset growth rate over the next two years. *EQUITY* is the ratio of book equity to assets. *MORTGAGES* is the ratio of residential mortgages to total loans. *COMMITMENTS* is the ratio of unused loan commitments to assets. *BRANCHES* is the ratio of branches to assets (in $ millions). *ECON* is the deposit-weighted Philadelphia Fed Coincident Index of state-level economic conditions. *ABOVE* = 1 if actual *LTCD* is greater than the target *LTCD**. *BELOW* = 1 if actual *NSFR* is less than the target *NSFR**.

| | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] |
|---|---|---|---|---|---|---|---|---|
| | *LTCD* | *LTCD* | *LTCD* | *LTCD* | *NSFR* | *NSFR* | *NSFR* | *NSFR* |
| | TA < 500M | 500M ⩽ TA < 2B | 2B ⩽ TA < 50B | TA ⩾ 50B | TA < 500M | 500M ⩽ TA < 2B | 2B ⩽ TA < 50B | TA ⩾ 50B |
| *Panel A: Target estimation* | | | | | | | | |
| $lnASSETS_{t-1}$ | 0.0712*** | −0.0600* | −0.0597 | −0.0523 | −0.0631*** | −0.0863*** | −0.0293 | −0.0650 |
| | (0.0078) | (0.0363) | (0.0455) | (0.4479) | (0.0079) | (0.0224) | (0.0225) | (0.0484) |
| $PUBLIC_{t-1}$ | 0.0879** | 0.1656*** | 0.2077*** | 0.0188 | −0.0117 | −0.0564** | −0.0623** | 0.0335 |
| | (0.0366) | (0.0380) | (0.0674) | (0.3714) | (0.0243) | (0.0225) | (0.0301) | (0.0558) |
| $GROWTH\ PLAN_{t-1}$ | 1.3869*** | 0.8453*** | 0.7388*** | 0.4557 | −0.3172*** | −0.1020 | −0.0633 | −0.0632 |
| | (0.0666) | (0.1050) | (0.1371) | (0.3428) | (0.0746) | (0.1038) | (0.1012) | (0.0628) |
| $EQUITY_{t-1}$ | −0.7025*** | 0.4518 (0.7696) | −2.7500*** | −9.0373 | 2.0058*** | 1.2518* | 0.3768 | 1.4710 |
| | (0.1853) | | (0.9879) | (13.898) | (0.3446) | (0.7347) | (0.8176) | (1.4112) |
| $MORTGAGES_{t-1}$ | 0.0371 (0.0247) | −0.4985*** | −0.6255*** | −3.1260* | −0.0585* | −0.0016 | −0.1082 | 0.3433 |
| | | (0.1003) | (0.1747) | (1.7100) | (0.0326) | (0.0559) | (0.1178) | (0.2259) |
| $COMMITMENTS_{t-1}$ | 1.9482*** | 2.9629*** | 1.4747*** | −0.1160 | −0.4675*** | 0.0946 (0.2257) | 0.1152 | −0.0284 |
| | (0.1525) | (0.3878) | (0.3433) | (0.1518) | (0.1588) | | (0.3162) | (0.0213) |
| $BRANCHES_{t-1}$ | −0.4172** | −12.729*** | −23.092*** | −102.62 | −0.1996 | 0.6225 (0.9224) | 4.2415** | 10.584 |
| | (0.1878) | (2.0776) | (3.5406) | (66.431) | (0.1983) | | (1.8146) | (9.9099) |
| $ECON_{t-1}$ | 0.0012** | 0.0012 (0.0016) | 0.0050 (0.0034) | 0.0205 | −0.0011** | 0.0000 (0.0009) | −0.0007 | −0.0016 |
| | (0.0006) | | | (0.0327) | (0.0005) | | (0.0014) | (0.0036) |
| $CONSTANT_{t-1}$ | −0.2041** | 1.7561*** | 1.9194*** | 3.8423 | 2.5694*** | 2.9397*** | 2.2506** | 2.1180 |
| | (0.0957) | (0.5157) | (0.7313) | (11.015) | (0.2384) | (0.6216) | (0.9029) | (1.1305) |
| Mean estimated target | 1.0865 | 1.4672 | 1.6519 | 2.4336 | 1.3248 | 1.1554 | 1.1269 | 0.8459 |
| Mean actual ratio | 1.0328 | 1.5256 | 1.6785 | 2.4958 | 1.4349 | 1.2157 | 1.1635 | 0.9508 |
| $\lambda$ (adjustment speed) | 0.2050*** | 0.4425*** | 0.7112*** | 0.4217*** | 0.1159*** | 0.0877*** | 0.1113*** | 0.3433*** |
| | (0.0122) | (0.0481) | (0.0471) | (0.1591) | (0.0128) | (0.0305) | (0.0550) | (0.1305) |
| Pseudo $R$-squared | 0.7239 | 0.5077 | 0.5024 | 0.4709 | 0.7389 | 0.6909 | 0.7768 | 0.7102 |
| $F$-statistic | 4692.78*** | 203.22*** | 34.82*** | 24.78*** | 6976.65*** | 911.36*** | 393.00*** | 314.84*** |
| *Panel A: Target estimation* | | | | | | | | |
| $GAP_{t-1}$ | −0.2927*** | 0.2178 (0.5168) | 1.2078** | −0.3821 | 0.2002*** | 0.1822* | −0.0660 | 1.3892*** |
| | (0.0347) | | (0.5842) | (0.5876) | (0.0255) | (0.0990) | (0.1413) | (0.4631) |
| $lnASSETS_{t-1} * GAP_{t-1}$ | 0.0249*** | −0.0205 | −0.0807** | 0.0324 | −0.0035 | 0.0029 (0.0066) | 0.0032 | −0.0463 |
| | (0.0025) | (0.0443) | (0.0400) | (0.0463) | (0.0022) | | (0.0094) | (0.0281) |
| $ECON_{t-1} * GAP_{t-1}$ | 0.0010*** | 0.0027** | 0.0006 (0.0013) | −0.0004 | 0.0010*** | 0.0009*** | 0.0023*** | −0.0007 |
| | (0.0002) | (0.0013) | | (0.0040) | (0.0001) | (0.0003) | (0.0007) | (0.0032) |
| $ABOVE_{t-1} * GAP_{t-1}$ | 0.3109*** | 0.3571*** | 0.8445*** | 0.5369*** | | | | |
| | (0.0113) | (0.0630) | (0.0765) | (0.1706) | | | | |
| $BELOW_{t-1} * GAP_{t-1}$ | | | | | −0.1710*** | −0.1036*** | −0.0913 | −0.0079 |
| | | | | | (0.0066) | (0.0174) | (0.0560) | (0.1402) |
| *CONSTANT* | 0.0362*** | 0.1188*** | 0.2210*** | 0.0650 | 0.0247*** | −0.0733*** | 0.0012 | 0.0257 |
| | (0.0019) | (0.0260) | (0.0425) | (0.1164) | (0.0029) | (0.0145) | (0.0248) | (0.0221) |
| Mean estimated $\lambda$ | 0.2743 | 0.5861 | 0.6498 | 0.6301 | 0.2668 | 0.3335 | 0.2554 | 0.4819 |
| Median estimated $\lambda$ | 0.1857 | 0.5105 | 0.4282 | 0.4579 | 0.3174 | 0.3848 | 0.2616 | 0.4921 |
| $R$-squared | 0.4210 | 0.4783 | 0.6444 | 0.4775 | 0.2491 | 0.3011 | 0.3202 | 0.4277 |
| $F$-statistic | 976.21*** | 109.17*** | 76.03*** | 26.320*** | 573.33*** | 105.11*** | 32.35*** | 30.720*** |
| Observations | 113,182 | 11,598 | 3048 | 483 | 113,182 | 11,598 | 3048 | 483 |
| Number of banks | 9358 | 1710 | 455 | 63 | 9358 | 1710 | 455 | 63 |

estimated *NSFR* targets were less volatile than the estimated *LTCD* targets both across time and across banks.[25]

In the first-stage model (Panel A), the estimated average adjustment speed toward *NSFR** is just 0.1331, only about half as fast as the 0.2619 average adjustment speed toward *LTCD**. But the flexible methodology employed in the second-stage model (Panel B) generates much more similar adjustment speeds for *NSFR* and *LTCD*. The coefficient on *ECON * GAP* is positive in both models, consistent with our priors that a strong economic climate should allow banks to adjust their balance sheet liquidity positions more quickly. The coefficient on *lnASSETS * GAP* is negative in the *NSFR* model but positive in the *LTCD* model, consistent with our ambiguous priors concerning the impact of bank size on adjustment speed. We specify the *NSFR* model with the interaction term *BELOW * GAP* (illiquidity is high for low levels of *NSFR*) as opposed to *ABOVE * GAP* in the *LTCD* model (illiquidity is high for high levels of *LTCD*). Thus, the significantly negative coefficient on *BELOW * GAP* is a surprise, as it indicates that banks that were

[25] It is natural for *LTCD* targets and levels to be more volatile over time than *NSFR* targets and levels. For example, if a bank reduces its loans (or its loans target), it will move assets from loans into, say, securities investments. This will reduce the *LTCD* ratio (or target) dollar-for-dollar because this ratio does not account for securities investments, but will increase the *NSFR* by a smaller amount because it does account for securities investments. For similar reasons, a change in core deposits (or the core deposits target) will have larger impact on the *LTCD* ratio than on the *NSFR*.

"too illiquid" as measured by the future NFSR standard adjusted more slowly toward their targets than did banks that were "too liquid" banks as measured by this standard.[26]

We also estimated the targets and adjustment speeds for the two components of *NSFR*: available stable funding-to-assets (*ASFA*) and required stable funding-to-assets (*RSFA*). The results appear in Appendix C. The results for *ASFA* and *RSFA* are for the most part consistent with the deposits-to-assets (*CDTA*) the loans-to-assets (*LTA*) results displayed in Table 4. Perhaps the most interesting finding occurs in the second-stage, where *ASFA* and *RSFA* have similar adjustment speeds, in contrast to the substantially different adjustment speeds for *CDTA* and *LTA* in Table 4.

## 8. Bank size and balance sheet liquidity management

In September 2014, U.S. bank regulators (the Federal Reserve, the Comptroller of the Currency, and the Federal Deposit Insurance Corporation) announced that most small and mid-sized U.S. commercial banking companies will not have to comply with the Basel III liquidity coverage ratio (LCR) rules. The final rule contains a number of bank asset size categories (e.g., $10 billion, $50 billion, $250 billion) above and below which the LCR rule will be differentially applied.[27] As this manuscript was being prepared, U.S. regulators had not yet decided whether and how they would apply the Basel III net stable funding ratio (NSFR) rule to banks of different sizes.

Historically, large U.S. banks have been more likely than smaller banks to operate below the NSFR = 1 threshold (see Fig. 4) and have in general tended to operate with less liquid balance sheets (see Table 7). This does not mean that large banks have been inactive managers of their balance sheet liquidity; these banks may have been managing liquidity very actively, but doing so around lower liquidity targets. Furthermore, this does not mean that large noncompliant banks will alter their liquidity management processes once Basel III is implemented; after making a one-time upward adjustment of their liquidity targets, these banks might continue to use their existing liquidity management processes. Understanding these issues is important for the efficient implementation of minimum liquidity requirements. To investigate, we re-estimate our LTCD and NSFR models separately for subsamples based on bank size: small community banks with assets less than $500 million; larger community banks with assets between $500 million and $2 billion; mid-sized banks with assets between $2 and $50 billion; and systemically important banks with assets greater than $50 billion (which have been excluded from our earlier tests).[28]

The results of these subsample estimations are displayed in Table 8. There are three key results. First, the determinants of banks' liquidity targets (Panel A) and banks' liquidity adjustment speeds (Panel B) tend to be robust across the three subsamples of smaller banks with assets less than $50 billion. This is especially the case in the *LTCD* models, though somewhat less so in the determinants *NSFR* models; in either case, however, the estimated coefficients are very seldom statistically significant with unexpected signs. In contrast, the specified determinants of liquidity targets are nearly always statistically non-significant for the subsample of banks with assets greater than $50 billion; nevertheless, the *F*-tests remain statistically significant for the largest banks, so the model specification is jointly explaining the variation in bank liquidity management, even if individual variables in that specification do not. Second, banks target lower balance sheet liquidity (Panel A) as they grow larger; mean $LTCD^*$ increases monotonically, while mean $NSFR^*$ decreases monotonically, with subsample asset size. Third, adjustment speeds (Panel B) tend to increase with bank size; on average, the slowest adjustment speeds occur for small community banks, while the fastest adjustment speeds occur for banks with more than $50 billion in assets.

We can draw three general conclusions from these results. First, banks of all sizes actively managed their balance sheet liquidity during our sample period (a) in a manner consistent with traditional loans-to-core deposits ratios and (b) in a manner not wholly inconsistent with the newly conceptualized net stable funding ratio. Second, while larger banks make plans to operate (and in fact do operate) with less liquid balance sheets, they also exhibit a greater capacity for adjusting once they are shocked away from their liquidity targets. Coupled with the vanishing statistical significance of the right-hand side coefficient estimates (i.e., the drivers of liquidity targets and liquidity adjustments) for these banks, these results imply that the very largest banks employ different liquidity management processes than do smaller banks. Third, as shown in Table 7, the balance sheets of larger banks are less liquid both because their assets are more illiquid and because these banks tend to use more liquid funding sources. *RSFA* increases substantially and monotonically with bank size, and both *CDTA* and *ASFA* decrease substantially and monotonically with bank size.[29] Hence, size-based differences in balance sheet liquidity reflect both greater liquidity storage at small banks (e.g., holding liquid securities) and greater access to and/or reliance upon low cost market funding sources at larger banks (e.g., purchased fed funds, Treasury repurchase agreements, commercial paper, or long-term debt instruments).

## 9. Conclusions

The Basel Committee on Bank Supervision in 2010 outlined a plan requiring banks to alter their balance sheets to comply with two new liquidity regulations: a minimum liquidity coverage ratio, or LCR, and a minimum net stable funding ratio, or NSFR. These two liquidity standards are aimed at preventing a repeat of the liquidity crisis that destabilized financial markets and institutions in 2008, and are meant to complement existing Basel equity capital requirements by ensuring that banks have stable funding in the short run as well as in the long run. These new requirements were created and parameterized quickly in response to the financial crisis, and were not informed by a large body of independent

[26] While a separate investigation of this inconsistency lies beyond the scope of this study, one likely explanation is that NFSR includes in its numerator (ASF) bank equity capital, which is expensive to raise in the short-run. In contrast, LTCD does not include bank equity capital.

[27] Under this policy (Joint Press Release, 2014), the Basel III LCR rule will be applied to banking organizations with more than $250 billion in assets or more than $10 billion in on-balance sheet foreign exposures, as well as to any deposit-issuing subsidiaries of these organizations with more than $10 billion in assets. In addition, a somewhat less stringent version of the LCR rule will be applied to non-internationally active deposit-issuing banking organizations with more than $50 billion in assets. Full compliance is required by January 1, 2017.

[28] For decades, banking industry analysts have defined a community bank as having assets less than $1 billion; our upper size threshold of $2 billion simply allows for inflation. The $50 billion dollar threshold for systemically important banks is consistent with the asset size threshold in the Dodd-Frank Act.

[29] These findings are roughly consistent with Hein et al. (2005). These authors characterize banks with high *CDTA* ratios and low *LTA* ratios as having "deposit-driven" business strategies and, conversely, banks with high *LTA* ratios and low *CDTA* ratios as having "loan-driven" business strategies. Using a 1998–2002 dataset, they show that U.S. commercial banks move from being "deposit-driven" to being "loan-driven" as they grow larger. Over the longer 1992–2012 time period, we find strong evidence that larger U.S. commercial banks tend to be less "deposit-driven" than smaller banks (see *CDTA* and *ASFR* in Table 7) and somewhat weaker evidence that larger banks tend to be more "loan-driven" than smaller banks (see *LTA* and *RSFR* in Table 7). Moreover, the data in Table 7 suggest that U.S. banks of all sizes became relatively more "loan-driven" during the economic expansion that preceded the global financial crisis. Whether this represented a shift in bank business strategies, or merely opportunistic lending and loan financing in the short-run, is a question deserving further research.

**Appendix A**

This table shows how we calculated the variable *NSFR* for all of our tests, tables and figures. The calculations are based on the definition of the net stable funding ratio (NSFR) that appears in Basel Committee on Banking Supervision (2014). The NSFR is the ratio of Available Stable Funding (ASF) to Required Stable Funding (RSF). ASF and RSF are weighted averages, respectively, of bank balance sheet asset and liability accounts. The table summarizes the components of ASF and RSF, the weights associated with each of these components, and the appropriate item numbers in the 1991 Statements of Condition and Income (call reports). Item numbers in the Consolidated Financial Statements of Holding Companies (Y9-C reports) are virtually identical. Our calculated *NSFR* will not match exactly the NSFR calculations performed by bank supervisors, as the historical regulatory data do not map perfectly into the Basel III NSFR definitions. However, we expect a very high degree of concordance.

| ASF weight (%) | Components of ASF category | CALL report items (1991) |
|---|---|---|
| 100 | Total equity capital | RCFD3210 |
| | Subordinated notes and debentures | RCFD3200 |
| 95 | Total transaction deposits | RCON2215 |
| 90 | Non-transaction savings deposits | RCON0352 |
| | MMDAs | RCON6810 |
| | Time deposits of less than $100,000 | RCON6648 |
| 50 | Time deposits of more than or equal to $100,000 | RCON2604 |
| | Other borrowed money | RCFD2850 |
| 0 | Other liabilities | RCFD2930 |
| | Trading liabilities | RCON2840 |
| | Fed funds purchased in domestic offices | RCFD0278 |
| | Securities sold under agreements to repurchase | RCFD0279 |
| 100 | Loans to depository institutions | RCFD1506 + RCFD1507 + RCFD1517 + RCFD1513 + RCFD1516 |
| | Trading assets | RCFD2146 |
| | Premises and fixed assets | RCFD2145 |
| | Other real estate owned | RCFD2150 |
| | Investments in unconsolidated subsidiaries and associated companies | RCFD2130 |
| | | RCFD2155 |
| | Customers' liability to the bank on acceptances outstanding | RCFD2143 |
| | Intangible assets | RCFD1756 + RCFD1757 |
| | Acceptances of other banks | sum of "past due 90 days or more" and "nonaccrual" items from Schedule RC-N |
| | Nonperforming loans | |
| | Other assets | RCFD2160 |
| 85 | 1–4 family mortgages | RCON1797 + RCON5367 + RCON5368 |
| | Loans secured by real estate excluding 1–4 family mortgages | RCON1415 + RCON1420 + RCON1460 + RCON1480 |
| | Agricultural loans | RCFD1590 |
| | Commercial and industrial loans | RCON1766 |
| | Loans to individuals | RCON1975 |
| | Lease financing receivables | RCFD2165 |
| 65 | Loans to foreign governments and official institutions | RCFD2081 |
| | Obligations of states and political subdivisions in the U.S. | RCFD2107 |
| 50 | Fed funds sold and securities purchased under agreements to resell | RCFD1350 |
| | All securities excluding pledged securities | RCFD0390 − RCFD0416 |
| 15 | U.S. Government agency obligations | RCFD1289 + RCFD1293 + RCFD1294 + RCFD1298 |
| | Securities issued by states and political subdivisions in the U.S. | RCFD1676 + RCFD1679 + RCFD1681 + RCFD1691 + RCFD1694 + RCFD1697 |
| 5 | U.S. Treasury securities | RCFD0211 + RCFD1287 |
| | Unused loan commitments | RCFD3814 + RCFD3815 + RCFD3816 + RCFD6550 + RCFD3817 + RCFD3818 |
| | Financial standby letters of credit | RCFD3819 |
| | Performance standby letters of credit | RCFD3821 |
| | Commercial and similar letters of credit | RCFD3411 |
| 0 | Cash and balances due from depository institutions | RCFD0071 + RCFD0081 |

*Notes:* All loans are net of nonperforming loans. The call reports only list aggregate pledged securities (not disaggregated by security type), so we make the assumption that all securities are unencumbered. The Basel Committee (2014) leaves the treatment of derivatives up to each national regulator, so we assume zero weight for net derivatives positions. The call reports do not include loan-to-value ratios, so we include all 1–4 family mortgage loans in the 85% category.

research; in general, there is very little theoretical or empirical research on the impact of minimum liquidity standards on bank liquidity risk or other bank risk-taking behaviors.

In this paper, we investigate how banks might respond to an NSFR-like liquidity standard by observing how U.S. commercial banks managed their loans-to-core deposits (LTCD) ratios between 1992 and 2012. The LTCD ratio is a traditional diagnostic measure for gauging the liquidity of bank balance sheets, and is similar in spirit and construction to the NSFR proposed in Basel III. The results of our partial adjustment model (Berger et al., 2008) strongly imply that the typical U.S. commercial bank was an active manager of its balance sheet liquidity during our sample period. On average, the data suggest that community banks and mid-sized commercial banks set internal targets for their LTCD ratios, operate close to these targets, and when shocked away make non-trivial and methodical annual adjustments. The data indicate a sensible asymmetry in these practices: Banks manage their core deposits balances (over which they have substantial control) more actively than they manage their loan balances (which are subject to the exogenous supply of profitable lending opportunities). Moreover, the speeds with these banks make these adjustments appear to be financially optimal; on average, we find LTCD adjustment speeds that are only slightly slower than the implied profit-maximizing adjustment speed.

We also test whether the historical liquidity management behavior of U.S. banks has been consistent with the soon-to-be-implemented Basel III NSFR standards. While in most years only a handful of banks were in violation of the NSFR $\geqslant 1$ standard, about one-in-seven banks had fallen below this threshold at the onset of the financial crisis. When we re-estimate our partial adjustment model for the NSFR, the results suggest that the liquidity management practices of both community banks and mid-sized banks have also been consistent with NSFR targets, even though the NSFR $\geqslant 1$ rules were not in place for these banks during our sample period.

We find qualitatively similar, but quantitatively different, evidence concerning liquidity management at the larger, so-called SIFI banks with assets greater than $50 billion. These banks set lower balance sheet liquidity targets (higher LTCD ratios, lower NSFRs) than smaller banks, but when knocked away from

**Appendix B**

This table shows how the variable *NSFR* can be calculated in 2012, using the more detailed 2012 Reports of Condition and Income (call reports). Item numbers in the Consolidated Financial Statements of Holding Companies (Y9-C reports) are virtually identical. Our calculated *NSFR* will not match exactly the NSFR calculations performed by bank supervisors, as the historical regulatory data do not map perfectly into the Basel III NSFR definitions. However, we expect a very high degree of concordance.

| ASF factor (%) | Components of ASF category | CALL report items (2012) |
|---|---|---|
| 100 | Total equity capital<br>Subordinated notes and debentures<br>Time deposits of less than $100,000 with remaining maturity one year or more<br>Time deposits of $100,000 through $250,000 with remaining maturity one year or more<br>Time deposits of more than $250,000 with remaining maturity one year or more<br>Federal Home Loan Bank advances with remaining maturity more than a year<br>Other borrowings with remaining maturity more than a year | RCFDG105<br>RCFD3200<br>RCON6648 − RCONA241<br>RCONJ473 − RCONK221<br>RCONJ474 − RCONK222<br>RCFDF055 + RCFDF056 + RCFDF057 + RCFDF058 − RCFD2651<br>RCFDF060 + RCFDF061 + RCFDF062 + RCFDF063 − RCFDB571 |
| 95 | Transaction deposits of individuals, partnerships, and corporations<br>Non-MMDA savings deposits<br>Non-brokered time deposits of less than $100,000 with remaining maturity less than a year<br>Non-brokered time deposits of $100,000 to $250,000 with remaining maturity less than a year | RCONB549<br>RCON0352<br>RCONA241 − RCONA243<br>RCONK221-RCONK219 |
| 90 | MMDAs<br>Non-brokered time deposits of more than $250,000 with remaining maturity less than a year | RCON6810<br>RCONK222-RCONK220 |
| 50 | Non-retail transaction deposits<br>Brokered time deposits with remaining maturity less than a year<br>Federal Home Loan Bank advances with a remaining maturity of one year or less<br>Other borrowings with remaining maturity one year or less | RCON2202 + RCON2203 + RCONB551 + RCON2213 + RCON2216<br>RCONA243 + RCONK219 + RCONK220<br>RCFD2651<br>RCFDB571 |
| 0 | Other liabilities<br>Trading liabilities<br>Fed funds purchased in domestic offices<br>Securities sold under agreements to repurchase | RCFD2930<br>RCFD3548<br>RCONB993<br>RCFDB995 |
| 100 | Loans to depository institutions and acceptances of other banks<br>Loans to nondepository financial institutions and other loans<br>Trading assets<br>Premises and fixed assets<br>Other real estate owned<br>Investments in unconsolidated subsidiaries and associated companies<br>Direct and indirect investments in real estate ventures<br>Intangible assets<br>Nonperforming loans<br>Other assets | RCFDB532 + RCFDB533 + RCFDB534 + RCFDB536 + RCFDB537<br>RCFD1563<br>RCFD3545<br>RCFD2145<br>RCFD2150<br>RCFD2130<br>RCFD3656<br>RCFD0426 + RCFD3163<br>sum of "past due 90 days or more" and "nonaccrual" items from Schedule RC-N<br>RCFD2160 |
| 85 | 1–4 family mortgages<br>Loans secured by real estate excluding 1–4 family mortgages<br>Agricultural loans<br>Commercial and industrial loans<br>Loans to individuals<br>Lease financing receivables | RCON1797 + RCON5367 + RCON5368<br>RCON1415 + RCON1420 + RCON1460 + RCON1480<br>RCFD1590<br>RCON1766<br>RCON1975<br>RCFD2165 |
| 65 | Loans to foreign governments and official institutions<br>Obligations of states and political subdivisions in the U.S. | RCFD2081<br>RCFD2107 |
| 50 | Mortgage-backed securities<br>Asset-backed securities and structured financial products<br>Other debt securities<br>Mutual funds and equity shares with readily determinable fair values<br>Fed funds sold in domestic offices<br>Securities purchased under agreements to resell | RCFDG300 + RCFDG303 + RCFDG304 + RCFDG307 + RCFDG308 + RCFDG311 + RCFDG312 +RCFDG315 + RCFDG316 + RCFDG319 + RCFDG320 + RCFDG323 + RCFDK142 + RCFDK145 +RCFDK146 + RCFDK149 + RCFDK150 + RCFDK153 + RCFDK154 + RCFDK157<br>RCFDC026 + RCFDC027 + RCFDG336 + RCFDG339 + RCFDG340 + RCFDG343 +RCFDG344 + RCFDG347<br>RCFD1737 + RCFD1741 + RCFD1742 + RCFD1746<br>RCFDA511<br>RCONB987<br>RCFDB989 |
| 15 | U.S. Government agency obligations<br>Securities issued by states and political subdivisions in the U.S. | RCFD1289 + RCFD1293 + RCFD1294 + RCFD1298<br>RCFD8496 + RCFD8499 |

(*continued on next page*)

**Appendix B** (*continued*)

| ASF factor (%) | Components of ASF category | CALL report items (2012) |
|---|---|---|
| 5 | U.S. Treasury securities | RCFD0211 + RCFD1287 |
| | Unused commitments | RCFD3814 + RCFD3815 + RCFDF164 + RCFDF165 + RCFD6550 + RCFD3817+RCFD3818 |
| | Financial standby L/C | RCFD3819 |
| | Performance standby L/C | RCFD3821 |
| | Commercial and similar L/C | RCFD3411 |
| 0 | Cash and balances due from depository institutions | RCFD0071 + RCFD0081 |

*Notes:* All loans are net of nonperforming loans. The call reports only list aggregate pledged securities (not disaggregated by security type), so we make the assumption that all securities are unencumbered. The Basel Committee (2014) leaves the treatment of derivatives up to each national regulator, so we assume zero weight for net derivatives positions. The call reports do not include loan-to-value ratios, so we include all 1–4 family mortgage loans in the 85% category.

**Appendix C**

Partial adjustment model for available stable funding (*ASF*) and required stable funding (*RSF*), using annual 1992–2012 data for U.S. commercial banking companies. Panel A displays results for Eq. (7) using GMM estimation techniques. Panel B displays results for Eq. (10) using OLS estimation techniques. All models include fixed bank and time effects. All variables are winsorized at the 1st and 99th percentiles. Robust standard errors appear in parentheses. ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively. *lnASSETS* is the natural log of bank assets ($ thousands). *PUBLIC* = 1 for banks that are publicly traded. *GROWTH PLAN* is bank asset growth rate over the next two years. *EQUITY* is the ratio of book equity to assets. *MORTGAGES* is the ratio of residential mortgages to total loans. *COMMITMENTS* is the ratio of unused loan commitments to assets. *BRANCHES* is the ratio of branches to assets (in $ millions). *ECON* is the deposit-weighted Philadelphia Fed Coincident Index of state-level economic conditions. *ABOVE* = 1 if *ASF* or *RSF* are greater than the targets *ASF** or *RSF**, respectively.

| | [1] *ASF* Annual data | [2] *RSF* Annual data |
|---|---|---|
| *Panel A: Target estimation* | | |
| $lnASSETS_{t-1}$ | −0.0093*** (0.0006) | 0.0185*** (0.0024) |
| $PUBLIC_{t-1}$ | −0.0106*** (0.0019) | 0.0047 (0.0066) |
| $GROWTH\ PLAN_{t-1}$ | −0.1103*** (0.0032) | −0.0045 (0.0256) |
| $EQUITY_{t-1}$ | | −1.2760*** (0.1041) |
| $MORTGAGES_{t-1}$ | 0.0035* (0.0021) | |
| $COMMITMENTS_{t-1}$ | −0.0333*** (0.0066) | 0.0282 (0.0501) |
| $BRANCHES_{t-1}$ | 0.1291*** (0.0149) | 0.0652 (0.0783) |
| $ECON_{t-1}$ | 0.0000 (0.0000) | 0.0004** (0.0002) |
| *CONSTANT* | 0.9835*** (0.0283) | 0.3297*** (0.0548) |
| Mean estimated target | 0.8451 | 0.6669 |
| Mean actual ratio | 0.8473 | 0.6264 |
| $\lambda$ (adjustment speed) | 0.3378*** (0.0095) | 0.0889*** (0.0091) |
| Pseudo *R*-squared | 0.6275 | 0.7133 |
| *Panel B: Adjustment speed estimation* | | |
| $GAP_{t-1}$ | 0.4164*** (0.0338) | 0.1795*** (0.0135) |
| $lnASSETS_{t-1} * GAP_{t-1}$ | −0.0041 (0.0027) | −0.0010 (0.0009) |
| $ECON_{t-1} * GAP_{t-1}$ | 0.0000 (0.0002) | 0.0006*** (0.0001) |
| $ABOVE_{t-1} * GAP_{t-1}$ | −0.0723*** (0.0078) | −0.0429*** (0.0040) |
| *CONSTANT* | −0.0009*** (0.0002) | 0.0095*** (0.0006) |
| Mean estimated $\lambda$ | 0.3203 | 0.2224 |
| Median estimated $\lambda$ | 0.2957 | 0.2248 |
| *R*-squared | 0.2304 | 0.2055 |
| Observations | 127,828 | 127,828 |
| Number of banks | 10,190 | 10,190 |

these targets they adjusted more quickly than smaller banks. Importantly, large majorities of these larger banks operated with NSFRs below 1.0 in the years prior to the global financial crisis. Moreover, the right-hand side drivers of liquidity ratios tend to be statistically significant for small and mid-sized banks, but tend to be statistically non-significant for the largest banks; this implies that large and small banks use fundamentally different methods for managing their balance sheet liquidity.

From these results, we conclude that the implementation of the Basel III NSFR standards will have real effects on bank liquidity management. For small and mid-sized U.S. banks, implementation will not fundamentally alter the manner in which balance sheet liquidity management is performed, but will likely limit the buildup of balance sheet illiquidity that tends to occur naturally during late stages of economic expansions. For the larger SIFI banks—which hold well over 75 percent of industry assets—becoming compliant with the NSFR standards will likely require these banks to substantially increase balance sheet liquidity and perhaps also re-engineer their liquidity risk management practices.

We close with some caveats. When regulatory environments change, banks may react by altering their behaviors in ways that are inconsistent with the historical track record (Lucas, 1976). We suggest three possibilities. First, the minimum NSFR threshold could become a risk-management focal point (Schelling, 1960). For example, a bank that currently operates far above the NSFR = 1 standard might set a new (post-regulation) target at NSFR* = 1 + ε, in effect adopting the new regulatory threshold as its target and potentially reducing its balance sheet liquidity.[30] Second, adjusting their balance sheets to meet the NSFR standard will be expensive for many large banks. Based on 2009 balance sheet data for banks in 15 different countries, King (2013) finds that meeting the NSFR = 1 standard will reduce net interest margins by 70 to 88 basis points on average, and by even more than this for universal banks. Hence, banks may attempt to circumvent the new regulation via some type of liquidity arbitrage similar to banks' efforts to circumvent risk-based capital minimums by moving credit risk exposures off their balance sheets (Tarullo, 2014). By successfully masking some of their exposure to illiquid assets, banks could reduce their required stable funding (RSF) and operate with fewer expensive stable funds. And third, Basel III increased balance sheet capital requirements along with imposing balance sheet liquidity minimums. Bank capital ratios are naturally volatile over the business cycle (Brei and Gambacorta, 2014) and we have no experience, and hence little understanding, of how minimum capital and liquidity constraints jointly influence bank lending or risk-taking behaviors. For example, capital and liquidity serve as balance sheet substitutes in Calomiris et al. (2012), but act like balance sheet complements in Covas and Driscoll (2015). Thus, any analysis of bank liquidity management based on the pre-Basel III capital rules may be a poor predictor of banks' liquidity behaviors under tighter post-Basel III capital rules.

## Appendix A

See Appendices A–C.

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[30] Berger et al. (2008) suggest that banks set targets for their equity capital positions consistent with such a 'regulatory focal point plus a buffer' approach.

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