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THE IMPACTS OF FINANCIAL REGULATIONS: SOLVENCY AND LIQUIDITY IN THE POST-CRISIS PERIOD

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Abstract

This paper discusses the new financial regulations in the post–financial crisis period, focusing on capital and liquidity regulations. Basel III and the capital stress tests introduced new requirements and new definitions while retaining the structure of the pre-2010 requirements. The total number of requirements increased, making it difficult to determine which constraints are binding. We find that the new common equity tier 1 (CET1) and Level 1 high-quality liquid assets (HQLAs) are the binding constraints at large U.S. banks, especially for banks that are active in capital markets activities. Banks have been holding more CET1 and a larger share of Level 1 HQLAs since the financial crisis of 2007 to 2009. We also find that the market pricing of bank debt appears to have responded to changes in liquidity measures, especially at large capital markets banks. The Basel III regulatory capital ratios appear to have little direct influence on spreads.

JEL Classifications: G12, G21, G28, G18
Keywords: bank capital regulations, bank liquidity, CET1, high-quality liquid assets (HQLAs), Basel III, Dodd–Frank Act, financial stability

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I. Introduction

For many large financial institutions, the financial crisis of 2007–09 led to a severe depletion of common equity and an inability to fund in short-term, wholesale funding markets. Out of necessity, governments and central banks around the world intervened to support distressed financial institutions and dysfunctional markets. Consequently, the G20 nations' regulatory reform agenda prioritized revision of international capital and liquidity regulation.

The Basel III capital and liquidity framework reflects this agenda and key lessons learned from the financial crisis. These lessons include a much stronger emphasis on the common equity component in bank capital, additional capital requirements (i.e., buffers) for systemically important banks, and new liquidity requirements for larger institutions.

This paper examines the Basel III requirements for large U.S. financial institutions and discusses three key effects of their implementation at such institutions. First, we explore the creation of capital and liquidity binding constraints. We posit that the new capital requirements form new binding constraints, such as the common equity tier 1 (CET1) requirement, and that the liquidity constraints are more binding for banks with large capital markets activities. Second, we explore how these requirements may be affecting banks' balance sheet choices (e.g., reductions in trading assets and increases in less "runnable" liabilities) and how the impacts differ with the banks' business models. Third, we relate our empirical results to existing theoretical and empirical work and fill a gap in the financial stability literature.

Our findings are consistent with the argument that the enhanced capital and liquidity rules would likely improve many measures of financial stability. Related to this, we also find that debt spreads

incorporate bank liquidity and have had greater volatility and dispersion since the crisis, which is consistent with some theories of the life cycle of financial crises and perhaps reflects an erosion of the belief that large institutions are too-big-to-fail (TBTF).

II. The Literature Review

The financial crisis of 2007 to 2009, the most serious such crisis since the Great Depression, began with bank-like runs outside of the traditional banking system in the *shadow banking system* (Gorton and Metrick, 2013). Repurchase agreements, off-balance-sheet entities, derivatives, and securitized products compose this parallel banking system (Gorton, 2008), estimated to have approximated the size of the traditional banking system as the crisis began (Gorton and Metrick, 2013). During the lead up to the financial crisis, markets initially understood little about the complex production chain creating securitized, subprime mortgage assets (Gorton, 2008).

During the recent crisis, the liquidity shortages created enormous demands for cash that the shadow banking system could not meet and endangered the solvency of global systemically important financial institutions (G-SIFIs).[1] Consequently, policymakers around the world took massive actions such as "interest rate cuts, liquidity support, recapitalization, asset purchases, and liability guarantees" to rescue their financial systems.[2] Post-crisis reforms focus on increased capital and liquidity requirements, especially for G-SIFIs — entities regarded as TBTF.

[1] Indeed, during the crisis, 12 of the 13 largest financial firms risked insolvency. Gorton and Metrick (2013) reference the testimony given by Ben Bernanke, who was at the time chairman of the Board of Governors of the Federal Reserve System, before the Financial Crisis Inquiry Commission on September 2, 2010, available at www.federalreserve.gov/newsevents/testimony/bernanke20100902a.htm.

[2] These classifications of policy actions are from the International Monetary Fund's 2009 Global Financial Stability Report, available at www.imf.org/external/pubs/ft/gfsr/2009/01.

Surprisingly, although there is general agreement about the identity of TBTF institutions,[3] there is no accepted definition of the term (Brewer and Jagtiani, 2013; Kaufman, 2014). Perceptions of this status can diverge among market participants and regulators. The Dodd–Frank Wall Street Reform and Consumer Protection Act of 2010 (DFA) sought to end TBTF. However, Acharya, Anginer, and Warburton (2016) find that investors continue to view large financial firms as implicitly supported by the government.

An antidote to TBTF and its accompanying breakdown in market discipline is to ensure that large financial institutions have significant levels of liquidity and capital such that they are unlikely to fail. Acharya, Engle, and Richardson (2012) argue that a key consideration in calculating the appropriate capital level for an individual financial firm is the additional capital it is expected to need (its capital shortfall) in a crisis. They argue that it is the aggregate drop in bank capital levels during a crisis that causes systemic risk. The principal measure the authors use to capture the capital shortfall of an individual financial firm in a market-wide crisis is SRISK, which they define as "the capital that a firm is expected to need if we have another financial crisis."

The post-crisis financial stability literature seeks to explain how leverage and liquidity mismatch in the financial sector shape a financial crisis. The effects on net worth of a large negative economic or financial shock are persistent, since net worth takes time to rebuild. The initial shocks are amplified by leverage and liquidity mismatch in the financial sector, and to a lesser extent, the nonfinancial sector.[4] Adrian, Boyarchenko, and Shin (2015) and Adrian, Moench, and Shin (2010) present empirical evidence of how balance sheet management of capital and liquidity amplifies financial disturbances for the

[3] The Financial Stability Board, in conjunction with the Basel Committee on Banking Supervision and national regulatory authorities, has developed a list of G-SIFIs. As of November 2016, this list comprised 30 banks. See www.fsb.org/2016/11/fsb-publishes-2016-g-sib-list.

[4] Brunnermeier, Eisenbach, and Sannikov (2013) provide a thorough exposition of these features of financial crisis.

banking and the nonbank financial sector, respectively. In this literature, measures of capital and liquidity in the financial sector have predictive power for future economic distress.

Adrian and Boyarchenko (2013) investigate the role of capital and liquidity constraints and find that the probability of distress is lowest when both capital and liquidity constraints are high but consumption growth is slowed.[5] In their model, the combination of a tight liquidity constraint and a moderately loose capital constraint allows for a relatively low probability of financial distress but much higher consumption growth. In addition, Pierret (2015) argues that leverage and liquidity mismatch are related; that is, solvency and liquidity have a nexus. As a measure of liquidity, she shows that access to and the terms of short-term debt are influenced negatively by SRISK, which is the risk of a bank's capital shortfall in a general financial distress.

Aikman, Kiley, Lee, Palumbo, and Warusawitharana (2015) develop a visual representation of risks to financial stability. SRISK, ΔCoVaR, developed by Adrian and Brunnermeier (2016), and financial stability indicators such as that developed by Aikman et al. (2015) incorporate measures of leverage, liquidity (especially vulnerable short-term wholesale funding), risk, asset prices, size, and interconnectedness. Higher (tighter) capital and liquidity requirements thus should have direct effects on the measure of financial stability. In this paper, we examine the changes in capital and liquidity at large banks since the recent financial crisis.

III. Pre-crisis Problems in the Regulatory Landscape

Issues in Solvency and Liquidity Regulation: Latent issues in the pre-crisis regulation of capital and liquidity for G-SIFIs revealed themselves during the crisis. The Basel Committee identified the key shortcomings to be excessive leverage through on- and off-balance-sheet activities, an erosion of the

[5] Brunnermeier and Sannikov (2014) similarly develop a macroeconomic model with a financial sector that can have two equilibria, a near-steady-state equilibrium and one in which financial constraints contribute to economic instability and volatility.

level and quality of regulatory capital, and insufficient liquidity buffers (Basel Committee, 2011). Banks' published capital ratios lagged their true condition. Consequently, capital indicators failed to timely signal the need for corrective supervisory and regulatory action. Moreover, necessary corrective measures were arguably further delayed by regulators partly because of the lack of appropriate supervisory tools.

Additionally, liquidity regulation had been neglected. No formal liquidity regulation requirements had existed for banking institutions, just guidance on liquidity stress testing. During the crisis, many banks became liquidity insolvent and nonviable well before they were technically capital insolvent (Occhino, 2016). Such liquidity shortfalls triggered widespread asset "fire sales," as banks attempted to quickly sell assets to increase their liquidity position. However, these sales drove down the market value of assets, which in turn exacerbated capital shortages in the banking system and further intensified the crisis (Dudley, 2011).

These flaws in the basic framework of capital and liquidity regulations applied to all banks. For large U.S. banks with substantial nonbank activities, especially capital markets activities, maintaining sufficient liquidity proved to be challenging. The recent crisis of market confidence in banking institutions significantly decreased liquidity in financial markets and business confidence in the real economy. Governments around the world came to the rescue of their banking systems by providing massive amounts of capital and liquidity assistance in addition to guarantees (Basel Committee, 2011). Authorities viewed G-SIFIs as TBTF.

Special Costs and Risks of G-SIFIs: A primary concern about TBTF institutions is the negative impact their collapse could have on the stability of the financial system. Negative externalities could arise from a SIFI's failure for a variety of reasons. A global bank's corporate or legal structure could be so complex that it is insufficiently understood by its own executives, market participants, or government

authorities. Arguably, this was the case for many global banks prior to the implementation of post-crisis reforms. Global banks have hundreds — and potentially thousands — of majority-owned subsidiaries.[6]

A global bank could also be viewed as TBTF because it is too interconnected or too central within financial markets. For example, the opacity around counterpart relationships in the over-the-counter (OTC) derivative markets and the poorly understood interconnections among large institutions could and did fuel a contagion of nonconfidence throughout the banking and financial markets. Similarly, Bank of New York Mellon and JPMorgan Chase had long been the core institutions in the operation of the triparty repo market.[7] The collapse of either institution would have threatened the stability of this critical market for funding liquidity.

Nonbank Financial Institutions: Commercial banking firms were not the only problematic financial institutions during the crisis. Systemically important investment banks and other nonbank financial institutions also had capital and liquidity problems. In fact, such institutions constituted many of the most notable collapses during the crisis. JPMorgan Chase (aided by a Federal Reserve nonrecourse loan) bought the investment bank Bear Stearns, which could no longer access funding in wholesale funding markets. Similarly, Lehman Brothers lost access to wholesale funding markets and filed for bankruptcy. Both investment banks had uncertain capital adequacy and assets of questionable value. Finally, the multinational insurer American International Group (AIG) nearly collapsed in September 2008 because of collateral calls on its OTC derivative markets contracts and securities lending activities. AIG avoided collapse only with the assistance of eventually more than $180 billion from the Federal Reserve and the U.S. Department of the Treasury.

[6] See Table 1 of Carmassi and Herring (2016).
[7] JPMorgan Chase has recently decreased its role in the triparty repo market, making Bank of New York Mellon a key institution in this market.

IV. Post-crisis Solutions in the Regulatory Landscape

A. Addressing Shortcomings in Solvency and Liquidity Regulations

The most important revision after the crisis was to address the quality of capital and to set higher tier 1 capital requirements for banks. The Basel III capital framework stresses the importance of CET1 capital. The measure CET1 is intended to be pure equity; it is composed principally of common stock plus retained earnings. CET1 is fully available to absorb losses. Its loss-absorbing strength results from its permitted component instruments, which constitute the most subordinated claims in liquidation and have no maturity or expectation of redemption. Any related distributions are discretionary and paid out of retained earnings. A combination of market pressures and policymakers' decisions motivated financial firms to substitute CET1 for hybrid instruments or subordinated debt.

Basel III sets a new CET1 requirement of 4.5 percent of risk-weighted assets (RWAs) and raises the minimum tier 1 capital to RWAs ratio from 4 percent to 6 percent. These new requirements substantially increase the true equity component in capital. Basel III introduces an additional requirement for all banks, a capital conservation buffer of 2.5 percent of RWAs to be composed of CET1. Another important revision in the Basel III standards is the introduction of a leverage ratio, which has long been included in U.S. domestic bank capital requirements since the early 1980s. The leverage ratio requirement measures the amount of tier 1 capital to total assets. The inclusion of a leverage ratio alongside the risk-weighted capital standards recognizes the negative role high balance sheet leverage played in the 2007 to 2009 crisis and also the subsequent widespread concern that RWAs are an imprecise measure of bank risk exposures. Using a measure of total assets that encompasses estimates of off-balance-sheet exposures as required in the Basel III leverage ratio reflects a fail-safe

measurement. All assets carry some risk, and leverage plays an exacerbating factor in crises. Ultimately, the new Basel III leverage ratio is more conservative than the pre-crisis U.S. leverage ratio.[8]

Additionally, while not formally a part of Basel III's capital standards, capital stress tests are now a critical element of authorities' evaluation and regulation of capital adequacy. Such stress tests simulate severely adverse (stress) scenarios and show how loan and trading losses, changes in reserves, asset growth, revenues, and income evolve over the scenario and demonstrate their impact on the bank's balance sheet. Adverse scenario stress test results carry important consequences and may restrict proposed capital actions such as dividends, buybacks, or any share issuance contemplated by the bank. In the U.S., under the DFA, the Federal Reserve annually approves the capital plans of banks based on the results of the stress tests.

Basel III introduces two liquidity requirements: the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR). Both measures draw upon the liquidity stress test literature, which focuses on the acceleration of cash outflows and the reduction of cash inflows during a period of financial distress. The LCR considers the ratio of high-quality assets to a measure of expected net cash flows in a period of serious financial distress. High-quality liquid assets (HQLAs) are the stock of unencumbered assets that are expected to be readily available and capable of conversion to cash within a 30-day period of financial distress. HQLAs are tiered by their value retention and market liquidity (the ease with which they can be converted to cash at close to face value).

Level 1 HQLAs are assets that are readily convertible to cash, including central bank deposits; vault coin and cash; and sovereign securities that qualify for the 0 percent risk weight, trade in deep and liquid markets, and have a track record of high liquidity and value retention. Level 1 HQLAs must comprise at least 60 percent of required HQLAs. The opportunity cost of such assets is high. Therefore,

[8] While loan loss reserves can be netted against loans, netting of deposits, collateral, and other risk mitigants are not allowed against credit exposures, and the full current and potential future value of derivatives exposure is included.

they are expensive to hold and constitute the most binding part of the HQLA requirement. Level 2 assets (split into level 2A and level 2B) are marketable securities generally subject to haircuts of between 15 percent and 50 percent.

Cash outflows are based on the liability side of the balance sheet. Deposits are categorized by the likely "stickiness" of customers. Stable retail deposits are assumed to have runoffs of a minimum of 3 percent over the 30-day period, whereas those deposits categorized as somewhat less stable are assumed to have minimum runoffs of 10 percent. Operational and business deposits are assumed to have minimum runoffs of 20 percent to 40 percent, and all other liabilities are assumed to have a runoff rate of at least 25 percent. Potential outflows from off-balance-sheet items, such as committed lines of credit, are also assigned runoff factors. Cash inflows have stringent requirements and, if they are to be netted with cash outflows, must have a high probability of occurring. Banks are not allowed to assume that cash inflows would cover more than 75 percent of cash outflows, resulting in the 25 percent of cash outflows being a lower bound of net cash outflow in the LCR calculation.

The NSFR, the ratio of the amount of available stable funding relative to the amount of required stable funding, is computed using a one-year horizon. The bank's available stable funding reflects one-year runoff factors for bank liabilities, while the amount of required stable funding takes account of both prudent rollovers of assets to sustain business viability and asset reductions resulting from maturing assets and asset sales. For both the LCR and the NSFR, *ceteris paribus*, more capital and long-term debt improve the liquidity ratios.

B. Addressing Special Costs and Risks Posed by SIFIs

In addition to the tighter standards for capital and liquidity requirements of Basel III, domestic and international policymakers also introduced extra measures targeting TBTF institutions. Basel III introduces a discretionary countercyclical capital buffer (CET1 to RWA ratio) of between 0 percent and

2.5 percent.[9] The amount set depends upon and varies with authorities' assessment of credit conditions for such institutions. Basel III also implements a surcharge for G-SIFIs to be met with CET1. The surcharge amount varies between 1 percent and 2.5 percent,[10] depending upon authorities' judgment of an institution's systemic importance. It can be increased by an additional 1 percent (to a maximum of 3.5 percent) for the most systemically important banks.

Lastly, the Federal Reserve has implemented a rule to strengthen the total loss absorbing capacity (TLAC) of U.S. G-SIFI bank holding companies (applicable to the top-level holding company) and the top intermediate holding company for U.S. subsidiaries of G-SIFI foreign institutions.[11] This rule aims to ensure that such holding companies maintain a sufficient amount of long-term debt capable of being converted to equity to facilitate a holding company resolution — rather than relying upon government assistance — in the event of distress. The requirement includes two components.[12] The first is a minimum external long-term debt requirement (unsecured and plain vanilla, issued by the top holding company and governed by U.S. law) in an amount that equals the greater of: 1) 6 percent of RWAs added to the G-SIFI surcharge, and 2) 4.5 percent of the total leverage exposure. The second component is a minimum external TLAC in an amount that is the greater of: 1) 18 percent of its RWAs (plus a buffer of 2.5 percent plus the G-SIB surcharge (for global systemically important banks) plus any applicable countercyclical capital buffer), and 2) 7.5 percent of its total leverage exposure (plus a buffer of 2 percent).

[9] See the Basel III: International Regulatory Framework for Banks at www.bis.org/bcbs/basel3.htm.
[10] In the U.S., initial estimates suggest this surcharge is likely to be between 1 percent and 4.5 percent. See www.federalreserve.gov/newsevents/press/bcreg/20150720a.htm.
[11] See https://www.federalreserve.gov/newsevents/press/bcreg/20161215a.htm. This rule follows a global standard published by the Financial Stability Board (2015).
[12] Note that this discussion describes requirements for U.S.-based global systemically important bank holding companies. The requirements for the U.S.-based top-level intermediary holding company of foreign global systemically important bank holding companies resemble those for such U.S. institutions.

C. Systemically Important Nonbank Financial Institutions.

In the U.S., the DFA also provides for authorities to impose prudential requirements on certain U.S. global systemically important nonbank financial institutions. The Financial Stability Oversight Council (FSOC) is tasked with identifying and designating such institutions.[13] Thus far, the FSOC has designated four such institutions.[14] Despite the considerable distress and failure of many other nonbank financial institutions during the crisis, prudential requirements for such institutions have thus far received scant attention from policymakers.

D. Binding Constraints

The post–financial crisis capital and liquidity reforms impose new binding constraints on banks and bank holding companies. Basel III and capital stress tests introduced new requirements and new definitions while retaining the structure of the pre-2010 requirements. The total number of requirements increased, making it difficult to determine which and how many constraints are binding. In this paper, we argue that the relevant binding "macro-level" constraints are few in number when looking across the banking system as a whole. These macro-level requirements include three measures of capital and two liquidity-related ratios.

The first relevant (binding) capital measure is CET1 to RWA ratio. CET1, consisting largely of common stock and retained earnings, is the most expensive form of capital. It now makes up the bulk of capital at all U.S. G-SIFIs as well as large domestic banks. The second capital measure, applicable to larger banks, is the results of the Federal Reserve stress tests, which are intended to be more forward-looking than the Basel III standards.[15] Since the outcomes of the stress tests determine the ability to pay

[13] See Section 113 of the Dodd–Frank Act.
[14] The four designated institutions were American International Group, Inc., GE Capital Corporation, Inc., Prudential Financial, Inc., and MetLife Inc.; however, GE Capital and MetLife have since been released from the nonbank SIFI status. See www.treasury.gov/initiatives/fsoc/designations/Pages/default.aspx.
[15] Acharya, Pedersen, Philippon, and Richardson (2016a and2016 b) demonstrate that initially SRISK was a good predictor of the stress test results.

dividends and make share buybacks, banks have a strong incentive to have sufficient capital to satisfy the stress test. The third is the Basel III CET1 leverage ratio. This measure may or may not be binding for banks depending on their balance sheet structure. Banks meeting Basel III's CET1 capital requirements and with balance sheets largely composed of commercial loans will generally not find this requirement restrictive. However, banks that predominantly hold trading assets and manage repo books, derivatives, and other often low-weight risk assets may find the Basel III (U.S. supplementary) leverage ratio binding. In addition, banks that predominantly hold high-quality assets with low capital risk-weights (e.g., some clearing institutions) might also find the leverage ratio binding.

The first liquidity-related ratio is the Level 1 asset share in required HQLAs. Level 1 assets almost certainly have a high opportunity cost relative to their maturity because they generally earn only the risk-free rate (or less). Our review of bank balance sheets in the U.S. in recent years suggests that virtually all banks have level 2 assets well in excess of their ability to use these assets (after haircuts) in HQLAs, so HQLAs are constrained by Level 1 assets.

The second liquidity-related ratio is the Level 1 HQLA/retail deposit tradeoff. To meet the LCR, the amount of HQLAs necessary will depend in part on the structure of a bank's liabilities and, therefore, potential cash outflows. Since the estimated cash inflows cannot exceed 75 percent of estimated cash outflows in the LCR calculation, we could identify the minimum asset share of HQLAs for any given value of the retail deposit to assets ratio to map the lower bound of the HQLA/cash flow tradeoff. This relationship could be used to understand how banks with different business models might choose to hold different levels of HQLAs. We focus on retail deposits because they have unusual "stickiness" and low historical runoff rates relative to other liabilities. We could construct a general HQLA/liability tradeoff curve by considering all the elements of the liability structure and their runoff rates. Note that if a large portion of a bank holding company's activities (especially capital markets activities) occurs outside of its depository subsidiaries, the bank would be unable to use deposits to fund those nonbank

activities. Therefore, the Level 1 asset constraint is likely to be more binding and require higher levels of HQLAs to assets for such capital markets institutions than for traditional commercial banking structures, which can choose a point all along the tradeoff curve.

V. The Data

We divide our sample of large banks into two groups and perform a separate analysis for each of these groups because they are expected to be different in their business models and their risk management strategies. The first group is more active in capital markets activities (capital markets banks) and includes Bank of America Corp. (BAC), Citigroup (C), Goldman Sachs (GS), JPMorgan Chase (JPM), and Morgan Stanley (MS). The second group focuses on traditional commercial and retail banking activities (traditional banks) and includes KeyCorp (KEY), PNC Financial Services (PNC), U.S. Bancorp (USB), and Wells Fargo & Co. (WFC).

A. *Financial and Accounting Data*

We use financial accounting data from the FR Y-9C quarterly reports filed by bank holding companies with federal regulators. These data are used to calculate the key risk factors related to capitalization, liquidity, trading assets, asset size, and retail deposits. For liquidity measures, we estimate the variable HQLAs based on reported Level 1 assets and level 2 assets, where level 2 assets cannot exceed 40 percent of the overall HQLAs. All Level 1 assets are counted toward the HQLAs. Since the Level 1 and level 2 assets started to be reported only in 2009, our sample period in the regression analysis starts in 2009.

For capitalization, we use the actual CET1 as reported in the Y-9C reports starting in 2014. For the period prior to 2014, we estimate the CET1 variable based on the variables available in the Y-9C

reports.[16] Thus, CET1 is calculated as common equity net of treasury stock — *plus* retained earnings and surplus related to common stock and *minus* the "deductibles":

> *The deductibles = Estimated net gains (losses) on liabilities attributable to changes in instrument-specific credit risk – ((Net deferred tax assets + Goodwill + (Other intangible assets-mortgage servicing assets)) – Net deferred tax liabilities)*

B. *Market Data*

We collect data on existing publicly traded bonds that were issued by large bank holding companies and their pricing information (transaction level data) from the OTC corporate bond transaction data (Trade Reporting and Compliance Engine (TRACE)) through the Wharton Research Data Services (WRDS). We collect bond yields for every subordinated bond issued by the sample banks and calculate the yield spreads by subtracting the matching Treasury yields (with the same time to maturity as the bond as of the observation date) collected from Bloomberg. We then calculate the par-value weighted average of bond yields for each banking firm and each observation date to facilitate equal weighting for all the sample banks. Note that we include only straight bonds that are not convertible, not callable, and so on to ensure that they are all comparable.

We try to include only subordinated debt when possible. However, Goldman Sachs and Morgan Stanley had only senior bonds outstanding during our study period. In addition, a few other banking institutions have had very few subordinated bonds outstanding and with very thin trading in some quarters. In these cases, we also include straight senior bonds, but we flag them in the regression analysis using a dummy indicator for senior debt (and found significantly smaller spreads for senior than subordinated bonds, as expected).[17]

[16] We compare the estimated CET1 with the reported CET1 for the period 2015 to 2016; the numbers are very close, although they are not identical due to some data items not reported prior to 2014.

[17] Wells Fargo had senior debt only from 2004 through 2009. PNC had senior debt only from 2007 through 2009, and USB had senior debt only from 2010 through 2016. Due to the already limited observations, we also included these senior bond spreads in our analysis.

VI. The Empirical Results

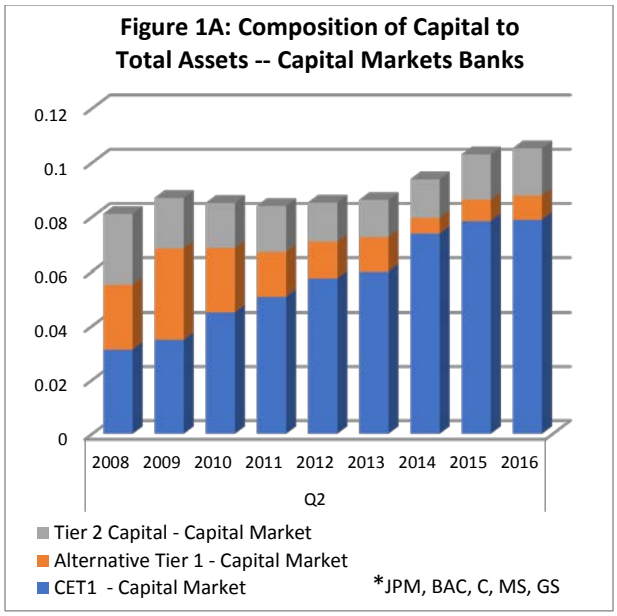
A. The Presence of Binding Constraints

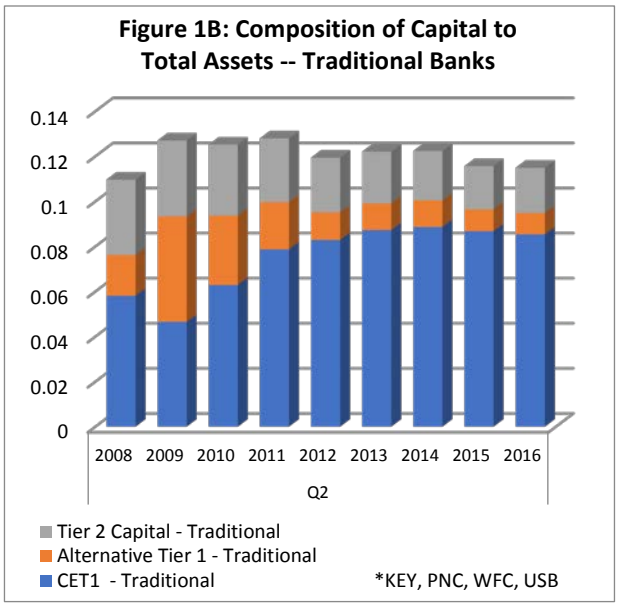
How much has the introduction of CET1 and the LCR changed the structure of banks' balance sheets? In our small sample of capital markets banks, we see that CET1 relative to total assets grew sharply from 2009 to 2012 and more slowly thereafter in both absolute amount and relative to total assets. Larger banking institutions now hold higher total capital and substantially higher quality capital, with most large banks having CET1 to RWAs ratios well above 9 percent.[18]

Figures 1A and 1B present the ratio of CET1 to total assets for the capital markets banks and for the traditional banks, respectively. For several banks, not only increases in capital but also some decline in assets contributed to the initial rise in the CET1 ratios. At the traditional banks, the ratio of CET1 to total assets has stabilized since 2012, while the ratio of total capital to assets has declined somewhat. The CET1 constraint seems to be of greater importance at the capital markets banks than at traditional banks, requiring capital markets banks to build CET1 capital continuously in the post-crisis period.

The HQLA comprises Level 1, level 2a, and level 2b assets, with the tier based on the liquidity of the market for those assets and the likelihood of value retention. In general, level 2 assets exceed by multiples the amount of Level 1 assets, making the Level 1 assets the determinant of the total available HQLAs.

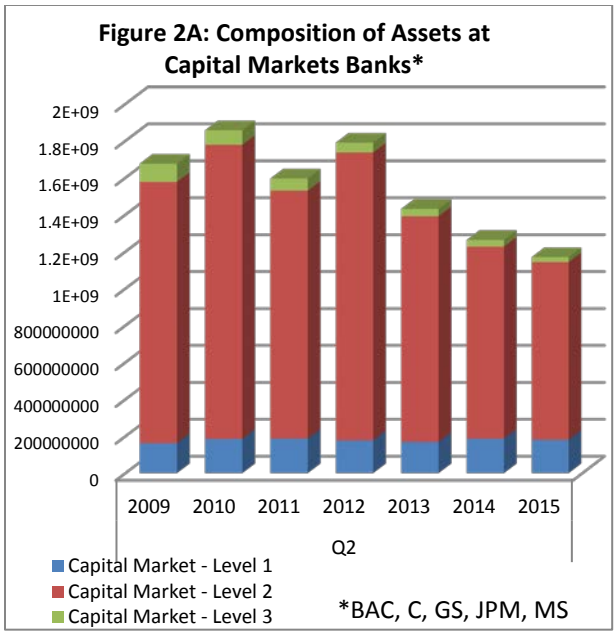
[18] The Board of Governors of the Federal Reserve System publishes a chart with each publication of the annual Comprehensive Capital Analysis and Review (CCAR) results; this chart shows staff estimates of CET1 at 5.5 percent in 2009 and at more than 12 percent in 2016.

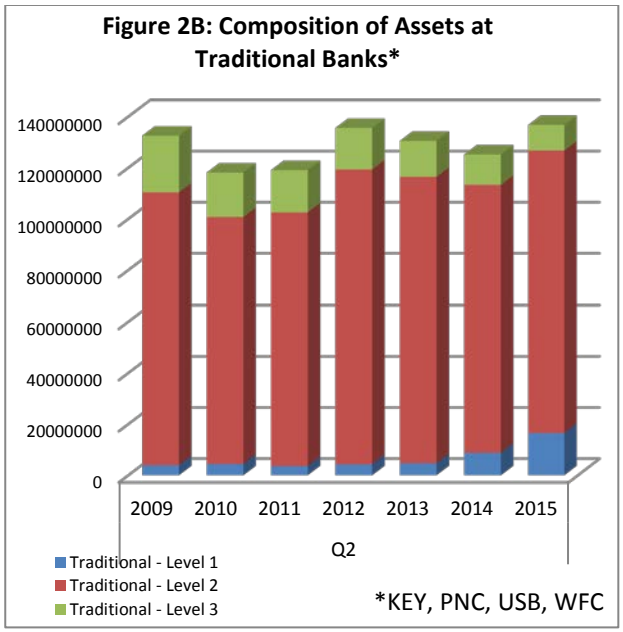




Data source: Y-9C reports. *Note*: Capital markets banks are BAC, C, GS, JPM, and MS. Traditional banks are KEY, PNC, USB, and WFC.

Figures 2A and 2B present the composition of fair-value assets (Level 1, level 2, and level 3) for the capital markets banks and the traditional banks, respectively. While it is unclear from the figures how binding the Level 1 assets are as a constraint, some constraint may be reflected in the significant reduction of level 2 assets at the capital markets banks from 2012 to 2015. That reduction (and the runoff of level 3 assets) may also reflect the flattening of the yield curve and adjustments in business strategy since the financial crisis.

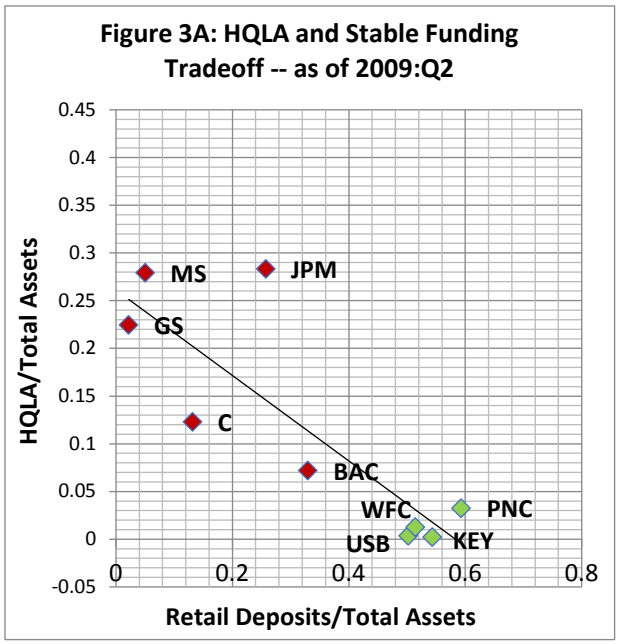


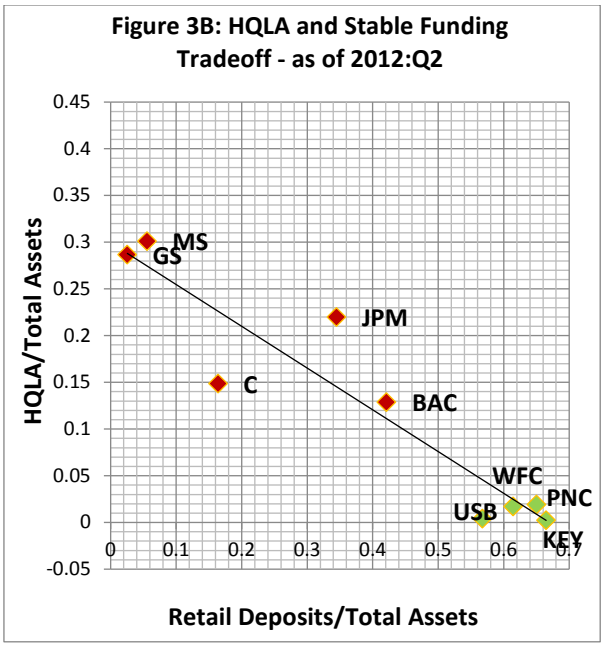


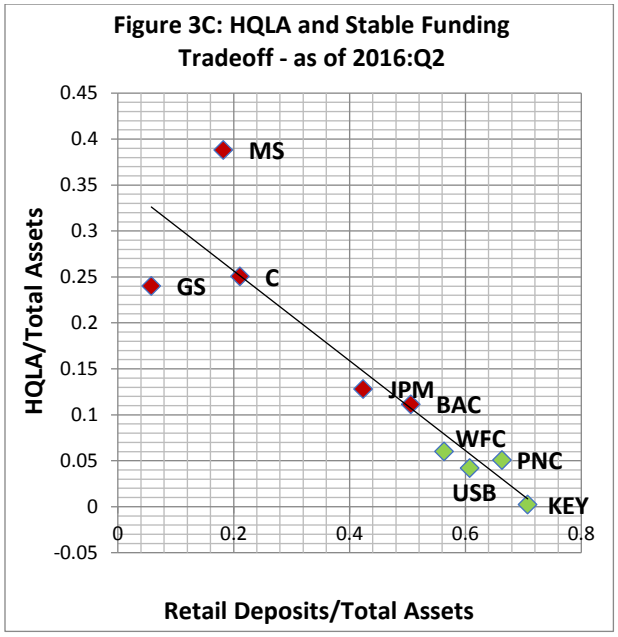
Data source: Y-9C reports.

More evidence of the significance of a constraint introduced by the LCR can be seen in the tradeoffs between the HQLAs and stable funding (retail deposits) in Figures 3A, 3B, and 3C. Since 2009, the tradeoff between retail deposits/assets and HQLAs/assets has shifted to the right, and the slope of the estimated tradeoff has become modestly steeper, reflecting more overall liquidity at the banks. Indeed, each institution had both higher HQLAs and retail deposits relative to assets in 2015 than in 2009. It is interesting to observe that the capital markets banks tend to appear in the northwest quadrant of the scatter plot, where reliance on HQLAs is high, and the traditional banks in the southeast quadrant, where retail deposits substantially reduce the need for HQLAs.

Morgan Stanley and Goldman Sachs, predominantly investment banks, occupy the highest end of the tradeoff curve throughout but do not alone determine the shape of the tradeoff curve; in 2009 and 2012, Citibank and JPMorgan, as the largest outliers, contributed substantially to the ordinary least squares regression estimate of the curve. By 2015, the banks were more aligned along a curve, while still forming two distinct groups.







Data source: Y-9C reports.

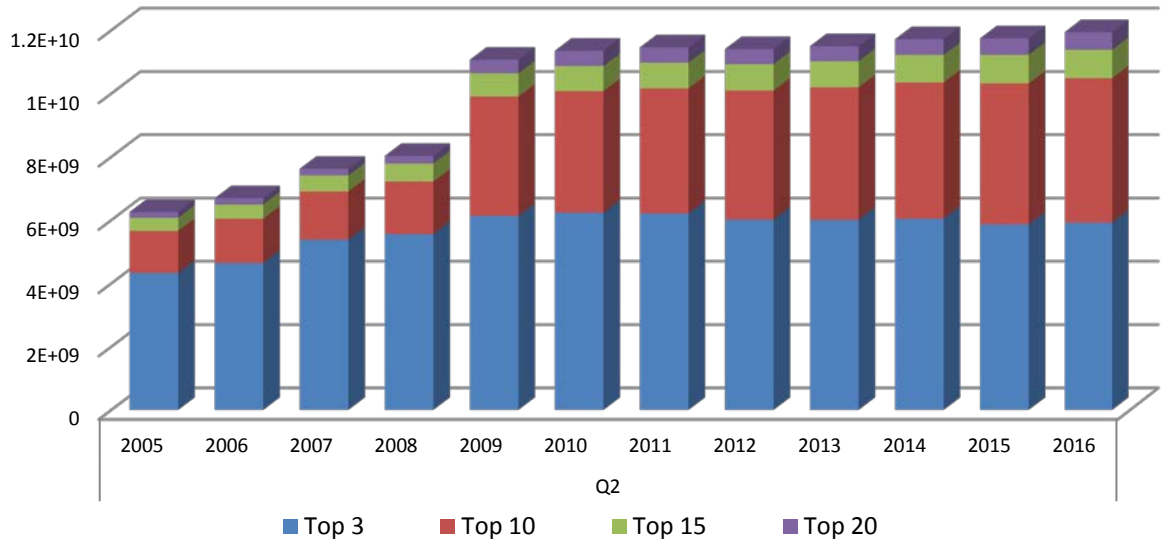
B. Differential Impacts for Banks with Different Business Models

The tumult of the financial crisis immediately reorganized the banking industry. Failing depository institutions such as Wachovia, Washington Mutual, and Countrywide were absorbed into large banking companies. Most of the so-called bulge bracket of investment banking firms was

integrated into the banking industry either through adoption of a financial holding company structure (e.g., Goldman Sachs and Morgan Stanley) or through mergers (e.g., Bear Stearns and Merrill Lynch).

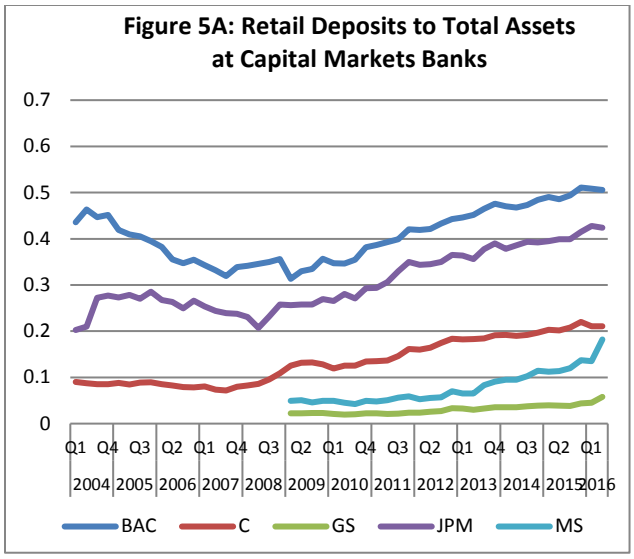
Asset Size: The assets of the top 20 firms in the banking industry rose sharply in 2009, and most of that increase was included in the assets of the top 10 financial companies (Figure 4).

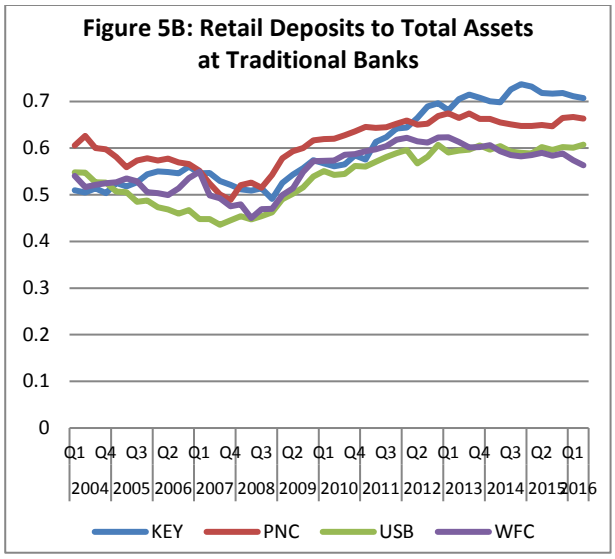
Figure 4: Total Assets of Bank Holding Companies by Asset Size Ranking

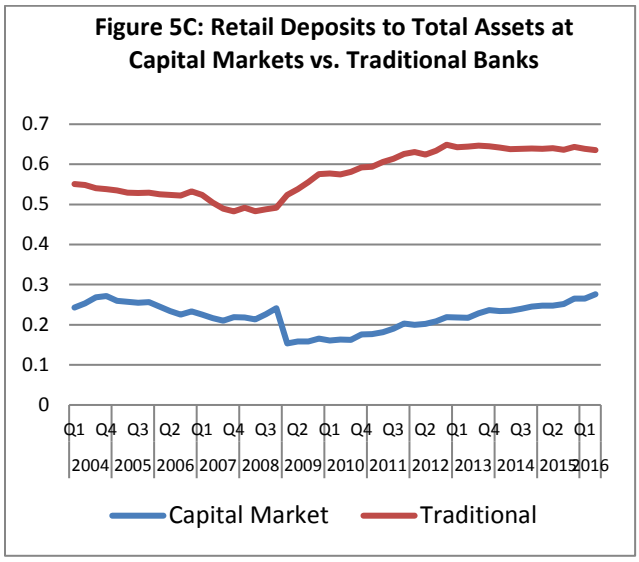


Source: Y-9C reports. Annual asset size is inflation adjusted.

Retail Deposits: Both capital markets and traditional banks have increased their retail deposits relative to assets since 2009, but the trajectories are quite different. The deposit to asset ratio at traditional banks grew rapidly until the end of 2012 and then leveled off, while the deposit to asset ratio at capital markets banks initially fell in early 2009 with the addition of Goldman Sachs and Morgan Stanley and has grown slowly but steadily since, while still a little less than at traditional banks (Figures 5A, 5B, and 5C).

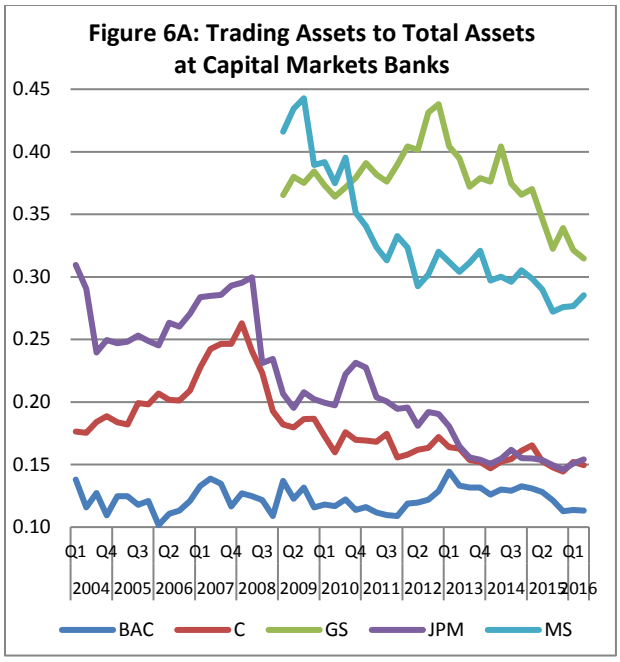


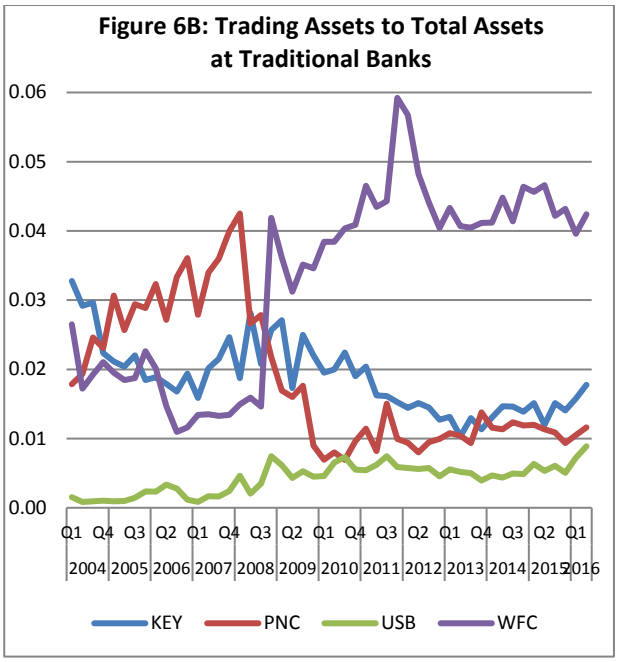




Data source: Y-9C reports.

Trading Assets: The share of trading assets to total assets has declined considerably since late 2008 at all but one of the capital markets banks and is flat at the exception (Figures 6A and 6B). Trading assets at traditional banks, already very low, have been fairly stable, with the exception of WFC, which acquired Wachovia, a bank with significant trading operations, in 2008.





Data source: Y-9C reports.

The new constraints are not the only reason for changes in balance sheets. The policies adopted after the crisis had the character of "defense in depth" and involved more direct restraints on bank risk-taking (e.g., the Volcker Rule), a shift away from derivatives exposures on bank balance sheets to netting and risk management by central counterparties, which also led to a reduction in leverage.

C. Implications for Financial Stability

The new capital and liquidity requirements may have contributed to a reduction in systemic risk and enhanced financial stability.[19] Consistent with the literature, we find that the trend of increasing concentration (based on the size of the largest institutions) seems contained at current levels. In the heat map of Aikman et al. (2015), the reductions in leverage, the dependence on runnable liabilities, and risk-taking in the financial sector generally have turned the financial sector's heat map from deep red in the midst of the financial crisis to deep blue in 2013 to 2014, the end of the observation period.[20] The

[19] See, for example, "Biggest U.S. banks have more than $120bn of 'excess' capital," *Financial Times,* February 9, 2017.

[20] While all factors in the heat map cooled from 2009 to 2014, some factors associated with risk appetite had started to turn amber or red (notably commercial real estate) by 2014.

SRISK factor has signaled a reduction in the risk profile of the banking industry. The highest SRISK on the 2017 list is below the SRISK of the institution ranked #11 in August 2008, Lehman Brothers.[21]

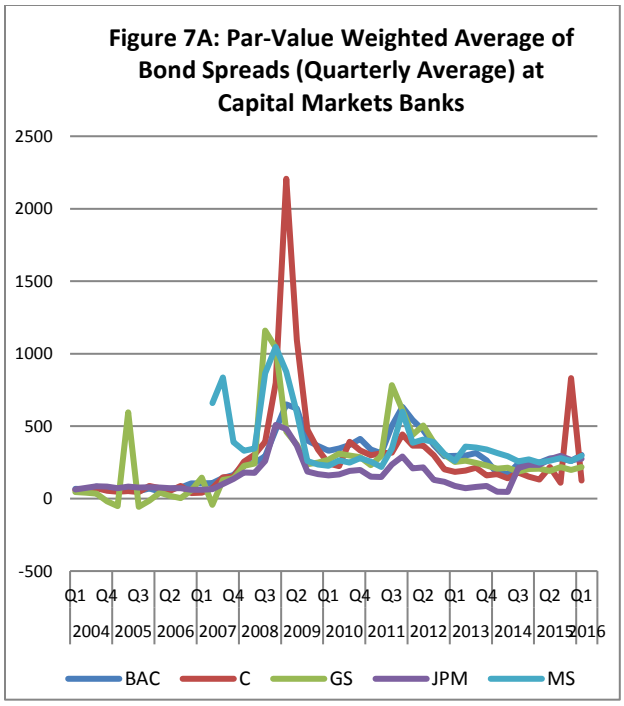
Despite these signs of progress, caution is still merited. Innovation in both the form and the substance of risk-taking can, and will, occur, with the possibility that vulnerabilities will be missed. The role of the nonbank financial sector post-crisis could use further research inquiry.

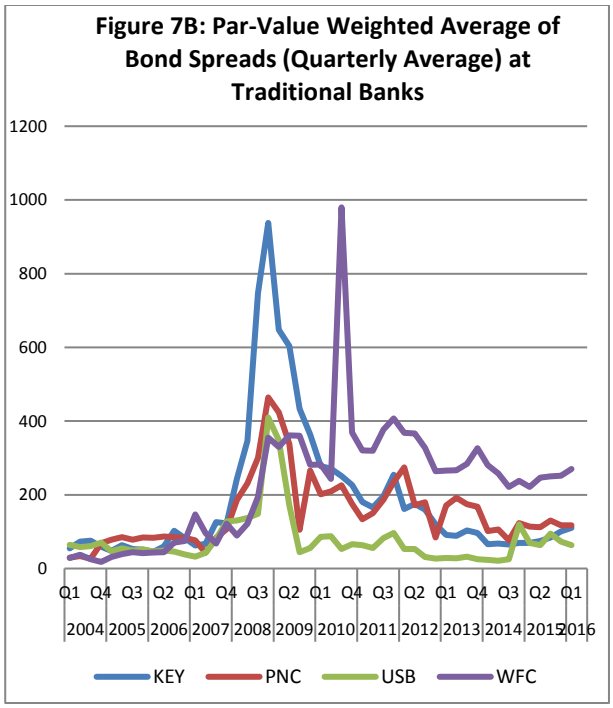
D. Implications for Market Discipline

For changes to capital and liquidity policies to be fully effective, private-sector market participants need to take account of and place substantial weight on capital and liquidity. While the evolution of market discipline post-crisis requires in-depth analysis beyond the scope of this paper, we provide some very preliminary insights.

Bond spreads over Treasury yields are often seen as a good measure of financial friction, especially related to credit, in the financial and macroeconomic literatures; see Evanoff, Jagtiani, and Nakata (2011); Jagtiani, Kaufman, and Lemieux (2002); and Flannery and Sorescu (1996). The striking features of the bond debt spreads for the banks in our sample are small and stable subordinated debt spreads prior to the financial crisis (Figures 7A and 7B). During the period from 2009 to 2016, bond spreads became much larger and more dispersed across the sample of banks. Bond spreads rose sharply and fluctuated widely during the financial crisis in 2008 to 2009. Over time, bond spreads have declined somewhat and fluctuated in narrower ranges, but in regard to both size of spread and volatility, they are well above their pre-crisis levels.

[21] The NYU Stern Volatility Institute website (available at http://vlab.stern.nyu.edu/welcome/risk/) features a list of the 10 financial firms with the highest SRISK.





Data sources: Bond yields from TRACE through the WRDS and daily Treasury yields from Bloomberg.

Bond markets are clearly discriminating more among banks in the post-crisis period. How much do bond spreads reflect attention to capital and liquidity developments? We performed simple regression analysis to explore the relationship between subordinated debt spreads and various risk factors, including measures of capital adequacy and liquidity for the period from 2009 to 2016. The spread is calculated for each individual subordinated bond issued by bank holding companies as described in the data section. We include in the regression the relevant factors that may be important in determining bond spreads, such as time to maturity, senior vs. subordinated debt, asset size, and firm fixed effects. We also include dummy indicators for the years 2010–2011, 2012–2013, and 2014–2016 to pick up systematic changes to bond spreads relative to 2009.

We run separate regressions for capital markets banks and traditional banks. When both capital markets banks and traditional banks are included in the analysis, we used a dummy variable for the traditional banks in the sample. The results are reported in Table 1 for traditional banks (columns 1 and 2), capital markets banks (columns 3 and 4), and both types (columns 5 and 6).

For the measures of capital, we use our estimated CET1 to RWAs.[22] In these regressions, the capital coefficient was mostly either significant with the unexpected sign or insignificant. For the two liquidity variables, we find that banks with a superior liquidity position appear to be rewarded with lower funding costs. The market perceives liquidity to be important even after controlling for all the other relevant risk factors and the firm fixed effects.

Unlike the liquidity measures, our capital measures based on CET1 or tier 1 capital ratios are not perceived by the market as good measures for their capital strength. This is in fact consistent with Pierret (2015), who suggests that the capital variable that matters from a market perspective is less likely to be any of the regulatory capital ratios, such as the CET1 or tier 1 capital ratio, but more likely to be related to the SRISK or the stress test results. The degree of variability in coefficient estimates and statistical insignificance of capital measures also suggest that capital and liquidity may indeed be linked, as Pierret (2015) and Adrian and Boyarchenko (2013) have documented.

The coefficients of asset size are significantly negative at large capital markets banks, implying that among these large capital markets banks, those with larger assets are subject to smaller funding costs. This could be because of the extent of risk reduction due to more sophisticated risk management strategies, but the possibility of TBTF perception at these large institutions cannot be ruled out. Overall, traditional banks pay smaller risk spreads than do capital markets banks, as reflected in the significantly negative coefficients of the dummy indicator for traditional banks in columns 5 and 6.

VII. Concluding Remarks

Our analysis in this paper suggests that the post-crisis Basel III CET1 and Level 1 HQLAs requirements have reshaped the balance sheets of large financial institutions with some differential

[22] Since our estimates of CET1 involved measurement error, we also explore the use of the lagged reported tier 1 capital ratio to RWAs.

impacts on traditional versus capital markets banks. These changes appear to respond to the binding constraints identified in this paper (CET1 being a preponderance of required regulatory capital, Level 1 HQLAs a majority of required HQLAs, and the expense of both). These new requirements also appear to have constrained asset growth at the very largest institutions.

Our results suggest that the new requirements are less constraining for large traditional banks than for capital markets banks and that liquidity requirements are important new constraints. Traditional banks show a rapid increase in CET1 capital to steady-state levels by 2012 and strong retail deposit rebuilding resulting in a relatively low required HQLA. Capital markets banks show continuous building of CET1 capital over the post-crisis observation period, declines in the share of trading assets, and increases in the share of HQLAs combined with efforts to increase retail deposits.

Credit risk spreads rose dramatically during the financial crisis of 2008–09. Although the spreads have since decreased, they remain higher and have greater dispersion (for both groups of banks) than they did pre-crisis. Preliminary regression analysis suggests that the market responds to changes in measured liquidity rather than to regulatory capital ratios when pricing bank risk (as reflected on bond spreads). Finally, the post-crisis literature on financial stability substantiates both direct (reducing systemic risk) and indirect (reducing the financial system's amplification of financial and economic shocks) effects of strengthened capital and liquidity requirements.

Table 1: Regression Results

Dependent variable is par-value weighted average bond spread. Standard errors are reported in parentheses under the coefficients. ***, **, and * represent significance at the 1 percent, 5 percent, and 10 percent levels, respectively.

Independent Variables	Traditional Banks (1)	Traditional Banks (2)	Capital Markets (3)	Capital Markets (4)	Both (5)	Both (6)
(HQLA+Retail Dep)/TA	-0.0097	--	-0.0316*	-0.03645***	-0.0347***	--
	(0.0199)		(0.0190)	(0.00783)	(0.0055)	
CET1/RWA	--	0.07696	--	-0.00983	--	0.04877*
		(0.05218)		(0.03854)		(0.02863)
Log(Tot Assets)	2.7907***	2.85228***	0.3341	-0.48189**	-0.2029***	-0.03692
	(0.8075)	(0.66787)	(1.4263)	(0.23516)	(0.0635)	(0.08013)
Time to Maturity	0.00576***	0.00655***	0.0117***	0.01243***	0.0113***	0.00882***
	(0.0017)	(0.00172)	(0.0018)	(0.00128)	(0.0007)	(0.00089)
Dum_Year 2010–2011	0.0192	-0.27356	0.3581*	0.41096*	0.1551	-0.536***
	(0.1546)	(0.22604)	(0.2011)	(0.21784)	(0.1353)	(0.16309)
Dum_Year 2012–2013	-0.5681**	-0.99936***	-0.1455	-0.12527	-0.2131	-1.06266***
	(0.2222)	(0.28074)	(0.2257)	(0.26809)	(0.1403)	(0.19863)
Dum_Year2014–2016	-1.0912***	-1.56665***	-0.6372**	-0.70445**	-0.5840***	-1.55348***
	(0.2929)	(0.30051)	(0.2718)	(0.33104)	(0.1433)	(0.21938)
Dum_Senior Debt	-0.0631	0.06182	-0.1966	-0.80118***	-0.6011***	-0.07218
	(0.2106)	(0.22517)	(0.3320)	(0.23023)	(0.1150)	(0.11292)
Dum_Traditional Bank	--	--	--	--	-0.4153***	-0.63717***
					(0.1589)	(0.16481)
Dum_BAC	--	--	0.6463***	--	--	--
			(0.2211)			
Dum_Citi	--	--	0.6506	--	--	--
			(0.6001)			
Dum_MS	--	--	1.0203	--	--	--
			(1.5701)			
Dum_GS	--	--	0.3608	--	--	--
			(1.5039)			
WFC	-3.8458***	-3.97548***	--	--	--	--
	(1.2147)	(1.04309)				
KEY	3.2899***	3.3523***	--	--	--	--
	(0.9823)	(0.79747)				
USB	-1.2593***	-1.18561***	--	--	--	--
	(0.2749)	(0.1968)				
Intercept	-51.8732***	-54.15702***	-4.4022	13.76121**	7.7501***	3.00805*
	(16.3948)	(12.89507	(31.1298)	(5.16084)	(1.3575)	(1.7414)
Adj R-square	0.8371	84.06%	56.89%	49.71%	66.08%	48.54%
Observation (N)	99	99	128	128	225	250

REFERENCES

Acharya, Viral, Robert Engle, and Matthew Richardson (2012). "Capital Shortfall: A New Approach to Ranking and Regulating Systemic Risks," *American Economic Review* 102(3): 59–64.

Acharya, Viral, Deniz Anginer, and A. Joseph Warburton (2016). "The End of Market Discipline? Investor Expectations of Implicit Government Guarantees," New York University Working Paper.

Acharya, Viral, Lasse H. Pedersen, Thomas Philippon, and Matthew Richardson (2016a). "How to Calculate Systemic Risk Surcharges," in eds. Joseph G. Haubrich and Andrew W. Lo, *Quantifying Systemic Risk*. Chicago: University of Chicago Press, pp. 175–212.

Acharya, Viral, Lasse H. Pedersen, Thomas Philippon, and Matt Richardson (2016b). "Measuring Systemic Risk," *Review of Financial Studies* 30(1): 2–47.

Adrian, Tobias, Nina Boyarchenko, and Hyun Song Shin (2015). "The Cyclicality of Leverage," Federal Reserve Bank of New York Staff Report No. 743.

Adrian, Tobias, Emanuel Moench, and Hyun Song Shin (2010) "Macro Risk Premium and Intermediary Balance Sheet Quantities," Federal Reserve Bank of New York Staff Reports, no. 428, January.

Adrian, Tobias, and Nina Boyarchenko (2013). "Liquidity Policies and Systemic Risk," Federal Reserve Bank of New York Staff Report 661.

Adrian, Tobias, and Markus K. Brunnermeier (2016). "CoVaR," *American Economic Review* 106(7): 1705–1741.

Aikman, David, Michael T. Kiley, Seung Jung Lee, Michael G. Palumbo, and Missaka N. Warusawitharana (2015). "Mapping Heat in the U.S. Financial System," Federal Reserve Board Finance and Economics Discussion Series 2015-059.

Basel Committee on Banking Supervision (2011). "Basel III: A Global Regulatory Framework for More Resilient Banks and Banking Systems," www.bis.org/publ/bcbs189.pdf.

Brewer III, Elijah, and Julapa Jagtiani (2013). "How Much Did Banks Pay to Become Too-Big-to-Fail and to Become Systemically Important?" *Journal of Financial Services Research* 43(1): 1–35.

Brunnermeier, Markus K, Thomas Eisenbach, and Yuliy Sannikov (2013). "Macroeconomics with Financial Frictions: A Survey". Advances in Economics and Econometrics, Tenth World Congress of the Econometric Society. New York: Cambridge University Press.

Carmassi, Jacopo, and Richard Herring (2016) "The Corporate Complexity of Global Systemically Important Banks," *Journal of Financial Services Research* 49(2): 175–201.

Dudley, William C. (2011). "Regulatory Reform of the Global Financial System," speech, Institute of Regulation and Risk North Asia, Hong Kong, April 12, 2011.

Evanoff, Douglas D., Julapa Jagtiani, and Taisuke Nakata (2011). "Enhancing Market Discipline in Banking: The Role of Subordinated Debt in Financial Regulatory Reform," *Journal of Economics and Business* 63(1): 1–22.

Financial Stability Board (2015). "Principles on Loss-Absorbing and Recapitalisation Capacity of G-SIBs in Resolution and Total Loss-Absorbing Capacity (TLAC) Term Sheet."

Flannery, Mark, and S. Sorescu (1996). "Evidence of Bank Market Discipline in Subordinated Debenture Yields: 1983–1991," *Journal of Finance* 51(4): 1347–1377.

Gorton, Gary B. (2008). "The Subprime Panic," Yale ICF Working Paper 08-25.

Gorton, Gary, and Andrew Metrick (2013). "The Financial Crisis of 2007–2009," in Randall E. Parker and Robert Whaples (eds.), *Routledge Handbook of Major Events in Economic History*. New York: Routledge, pp. 378–386.

Jagtiani, Julapa, George Kaufman, and Catharine Lemieux (2002). "The Effect of Credit Risk on Bank and Bank Holding Company Bond Yields: Evidence from the Post-FDICIA Period," *Journal of Financial Research* 25(4): 559–575.

Kaufman, George (2014). "Too Big to Fail in Banking: What Does It Mean?" *Journal of Financial Stability* 13(C):214–223.

Occhino, Filippo (2016). "Central Bank Lending in a Liquidity Crisis," Federal Reserve Bank of Cleveland *Economic Commentary* No. 2016-02.

Pierret, Diane (2015). "Systemic Risk and the Solvency-Liquidity Nexus of Banks," *International Journal of Central Banking* 11(3): 193–227.