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Liquidity, Leverage, and Regulation 10 Years After the Global Financial Crisis

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Keywords

financial crises, banking, leverage, financial regulation

Abstract

The financial system has undergone far-reaching changes since the global financial crisis of 2008. We cast those changes in terms of shifts in the manner in which financial intermediaries manage their balance sheets. We also discuss the regulatory reform agenda, and we review the impact of regulations on market liquidity and credit availability. Current evidence suggests that the financial system has become safer, at limited unintended cost.

1. INTRODUCTION

Following the great deleveraging of 2008–2009, the mood in financial markets changed. The VIX index hovered at low levels for much of the period following the global financial crisis, and overall stock markets rose substantially. Nevertheless, stock indices of the banking sector underperformed, especially for European-headquartered banks. Market-to-book ratios continue to be low, close to the troughs of the aftermath of the global financial crisis. This is all the more striking because, between 2007 and 2016, less than half of banks' cumulative net income was ploughed back into capital, with the remainder paid out in the form of dividends and spent on share buybacks (see Shin 2016). So what explains the difference between the equity performance of banks and overall indices? What are the pressures on banks' funding and balance-sheet capacity?

Figure 1 plots the decline in the overall leverage of the banking sector around the world with leverage measured as total assets divided by book equity. Leverage was well above 25 in the years before the crisis and rising, but—after an initial in-crisis adjustment—it saw a substantial further decrease in the postcrisis years, recently reaching a leverage of around 15. Nevertheless, leverage continues to exhibit considerable variation across major jurisdictions. Leverage of US banks has been lower than the global average, while banks in Japan and the euro area have maintained leverage higher than the global average. Accounting standard differences explain some of the difference between US and European reported leverage ratios: At the end of June 2017, according to the Federal Deposit Insurance Corporation (2017), the average reported leverage ratio of US globally systemically important banks (G-SIBs) of 12.1 would have been 15.1 under European bank accounting standards, whereas EU G-SIBs reported an average leverage ratio of 21.6.

The downward trend in observed bank leverage revealed in **Figure 1** plays out during a period of tightening postcrisis regulation. However, it would be simplistic to attribute deleveraging of banks to regulation alone. For one, the high leverage of internationally active banks in the years

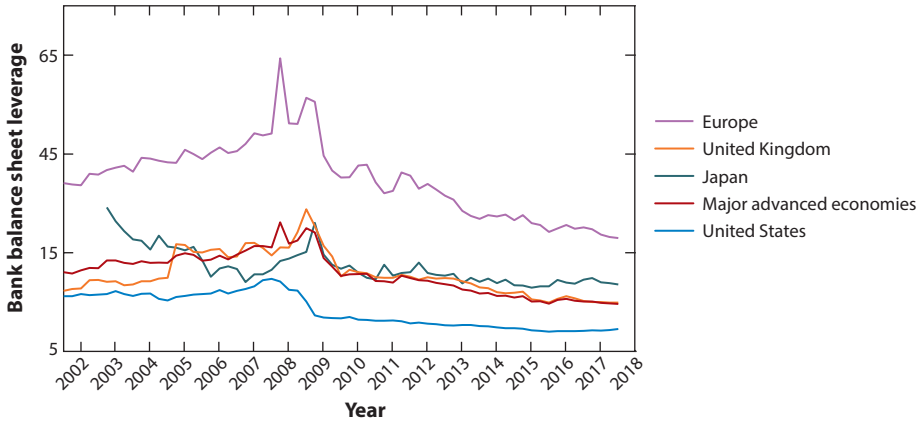

Figure 1

Bank balance-sheet leverage. Total assets divided by total equity, weighted by asset size and showing (*red line*) the global average for all banks in major advanced economies. These include: in the United States (*blue line*), Bank of America, Citigroup, Goldman Sachs, JPMorgan Chase, Lehman Brothers (up to 2008 Q2), Merrill Lynch & Co, Morgan Stanley, Wachovia Corporation (up to 2008 Q2), and Wells Fargo & Company; in Europe (*purple line*), Banco Santander, BNP Paribas, Commerzbank AG, Credit Suisse, Deutsche Bank, UBS, and UniCredit SpA; in the United Kingdom (*orange line*), Barclays, HSBC, Lloyds TSB Group, and Royal Bank of Scotland; and in Japan (*green line*), Mitsubishi UFJ Financial Group, Mizuho Financial Group, and Sumitomo Mitsui Financial Group. Data from Capital IQ, Bank for International Settlements calculations.

immediately prior to 2008 reflected special circumstances at the time, associated with booming leverage, that were not sustainable as a long-run outcome. Broader challenges to changing bank business models are apparent after the crisis, such as the low-interest-rate environment, high level of nonperforming loans, and new competitors from the fintech (financial technology) universe. Those challenges have been reflected in depressed bank stock prices in spite of the supportive macroeconomic backdrop, the relatively more buoyant performance of stock indices more broadly, and banks' higher capital ratios. The ratio of the market capitalization of banks to their book equity—their market-to-book ratio—dipped below 1 for part of the postcrisis period in Europe and Japan (see Bogdanova, Fender & Takats 2018).

An important distinction is between book leverage and market value leverage. Central banks and regulators have focused on book values, and regulations are written in terms of book values. For credit availability, book values are key. For some key purposes, however, market values are important to bear in mind, especially their relationship with book leverage over the cycle. Market capitalization of a bank is a reflection of the market value of the equity holders' stake, and hence an assessment by market participants of the creditworthiness of the bank as a borrower and the present value of the stream of cash flows that derive from the bank's business activities. If market participants have reservations about a bank's business model or creditworthiness, then market capitalization will be correspondingly very thin and the market-to-book ratio of bank equity will be small. In effect, a greater proportion of the bank's value will be held by creditors, rather than equity holders; therefore, the bank has a high market value leverage.

Given recently observed, low market-to-book ratios, the assessment of market participants is that banks are more leveraged than their books suggest. Breuer (2000) and Singh & Alam (2018) also argue that traditional leverage based on accounting standards understates investment bank leverage by not fully reflecting the impact of off-balance-sheet assets and liabilities (for documentation of US bank securitization-related leverage overstatement, particularly prior to the amendment of FAS 140 by SFAS 166 in January 2010, also see Beccalli, Boitani & Di Giuliantonio 2015). High market value leverage, in turn, affects a bank's funding environment. High market value leverage may have knock-on effects and exert downward pressures on a bank's book leverage through tighter funding conditions (Adrian & Shin 2014).

If only a bank could raise more capital when price-to-book ratios are low, it could remedy the perceptions of reduced creditworthiness. However, raising new equity when the market price of bank stocks is so low entails a high degree of dilution of the incumbent shareholders' interests. There are severe challenges to raising new equity precisely when new equity would be most beneficial to the lending operations of a bank. The argument about dilution is even stronger when a bank's price to book ratio is below 1. In such cases, the book value of equity is higher than the market value of equity. Paying $1 of dividends gives the shareholder $1 in the hand, but it incurs a cost of less than $1 in terms of the share price of the bank. In this sense, Tobin's argument on the q theory of investment applies to the bank, in that reducing investment in the bank's operation is less costly for the owners. Perhaps for this reason, banks have continued to pay out dividends even for those cases where banks would arguably have benefited from a bolstering of capital positions by reducing dividends (Shin 2016).

2. BANK LEVERAGE DETERMINANTS AND DRIVERS

Banks are intermediaries: They borrow from other lenders, combine the borrowed funds with their own funds, and then lend the combined total to ultimate borrowers. Bank capital refers to a bank's own funds. The more capital banks have, the more of their own funds they have to lend out. However, bank capital plays an even more important role for overall lending. In addition to lending out their own funds, banks with plentiful own funds are able to borrow more from

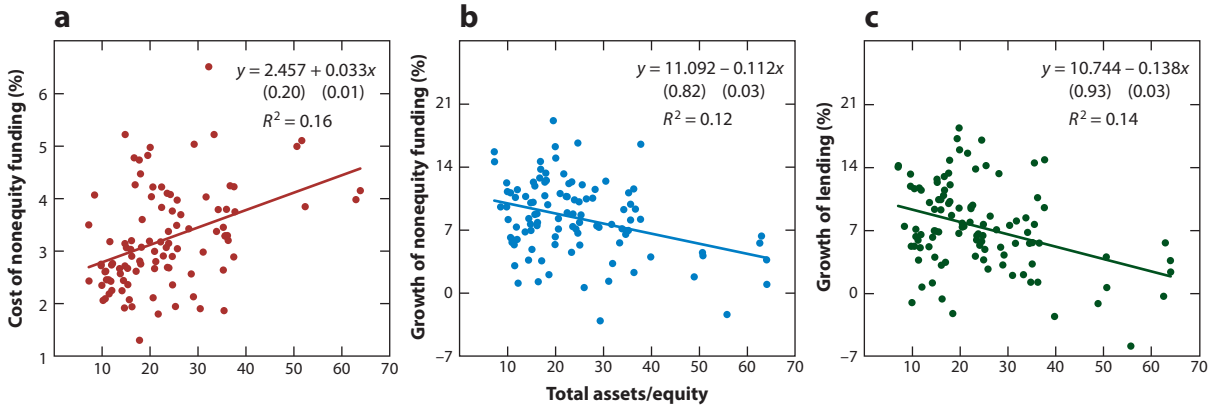

Figure 2

Bank capital and loan growth. Scatter plots show the leverage of 105 advanced-economy banks and (*a*) cost of funding, (*b*) annual growth rate of debt financing, and (*c*) annual growth rate of lending. Standard errors are in brackets. Figure adapted from Gambacorta & Shin (2018) with permission.

their creditors and on much better terms than can banks that are poorly capitalized. Banks' own funds come from several sources, but the most important source is banks' retained earnings. This portion of a bank's own funds refers to the accumulated stock of all the bank's profits since its inception that have not been paid out as dividends to shareholders.

At the same time, bank capital is a loss-absorbing buffer in the sense that a bank's own funds can absorb losses from lending activity without imposing losses on the creditors to the bank. Yet, solvent banks can sometimes be reluctant to lend, and weakly capitalized banks may seek to improve solvency metrics such as their ratio of capital to risk-weighted assets by cutting back on lending. If a bank's solvency metrics are expressed as ratios, there may even be some apparent tension between the objective of unlocking bank lending (which entails expanding credit) and the supervisory imperative of ensuring the soundness of individual banks (which can be achieved by cutting back credit). This is why we sometimes hear calls for the relaxation of bank capital rules.

Figure 2*a* shows a summary scatter chart from Gambacorta & Shin (2018) that plots the relationship between the cost of banks' borrowed funds and their overall leverage. Leverage is again defined as the ratio of a bank's total assets to its equity. The scatter chart is quite dispersed, but it overstates the noise in the relationship, as it is just the simple scatter for the mean values for each bank, without controlling for bank characteristics or macro variables. In their detailed empirical analysis, Gambacorta & Shin (2018) find that a 1 percentage point increase in the equity to total assets ratio is associated with a 4 basis point reduction in the cost of borrowed funds for a bank. This finding sets an important benchmark when considering the benefits of higher bank capital for bank funding costs [see also Carlson, Shan & Warusawitharana (2013), who find that banks with higher capital ratios had stronger growth from 2008 to 2010, and Kapan & Minoiu (2018), who find that banks with stronger balance sheets and higher levels of common equity were better able to cope with liquidity shocks during the crisis]. For typical levels of bank leverage, it would appear that banks could go a long way toward mitigating their supposedly higher cost of equity funding by retaining more of their profits to build capital.[1]

[1]Consider a balance sheet of size 100, with equity of 10. If equity is raised to 11, a 4 basis point reduction in the cost of borrowed funds results in cost saving of $0.0004 \times 89 = 0.0356$. If the cost of equity is assumed to be 10%, the cost of equity

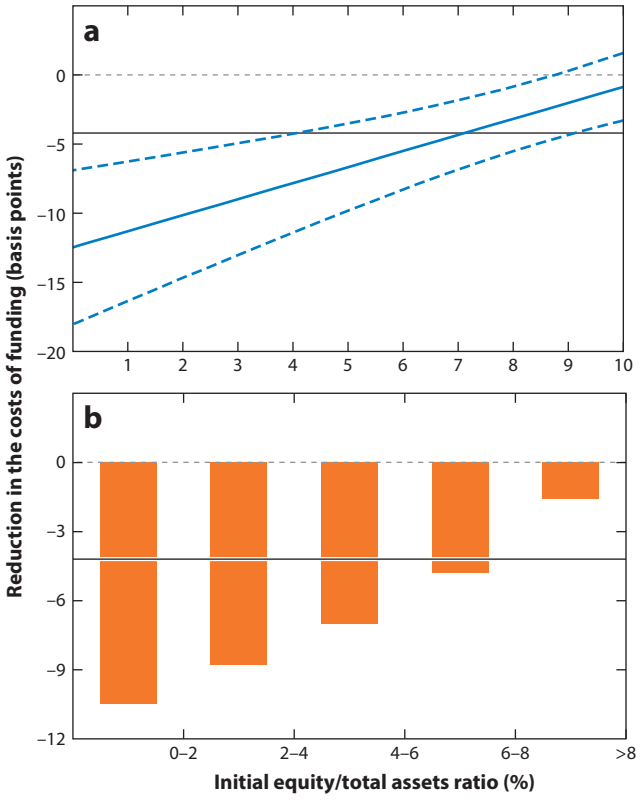

Figure 3

Nonlinear effect of higher bank capital on the cost of funding (basis points). The two panels show the incremental decline in the nonequity funding cost (in basis points) of a 1 percentage point increase in the capital to total assets ratio. (*a*) The coefficient of an interaction term in the panel regression. (*b*) The average of banks arranged in buckets according to their capital to total assets ratio. Figure adapted from Gambacorta & Shin (2018) with permission.

The lower funding cost translates into greater intermediation activity by the bank. **Figure 2*b*** shows that banks with more own funds, and hence lower funding costs, tend to raise borrowed funds at a faster pace. The upshot is that banks with lower leverage also expand their lending at a faster rate, further supporting the claim that sound banks lend more (see above) (also see **Figure 2*c*** for the summary data). Detailed analysis shows that a 1 percentage point increase in the equity to total assets ratio is associated with a 0.6 percentage point uptick in the subsequent growth in lending.

The funding advantage is clearer still when banks are sorted according to their initial capitalization levels. The cost advantage that comes from higher capital is larger for banks that are more thinly capitalized. **Figure 3** illustrates this effect. Gambacorta & Shin (2018) report how nonequity funding cost reported by banks is lower for better-capitalized banks, both in the cross section and in the time series.[2] As shown in **Figure 3*a***, the funding cost advantage from

funding is 1 when equity is 10 and 1.1 when equity is 11. The additional cost of equity is 0.1. The reduction in the cost of borrowed funds is 36% of the supposed incremental cost of equity.

[2]The data set from Gambacorta & Shin (2018) relies mainly on the income statements reported by the banks. Underlying data are retrieved from banks' financial statements. Funding cost is the cost of their borrowed funds, hence, the term nonequity funding.

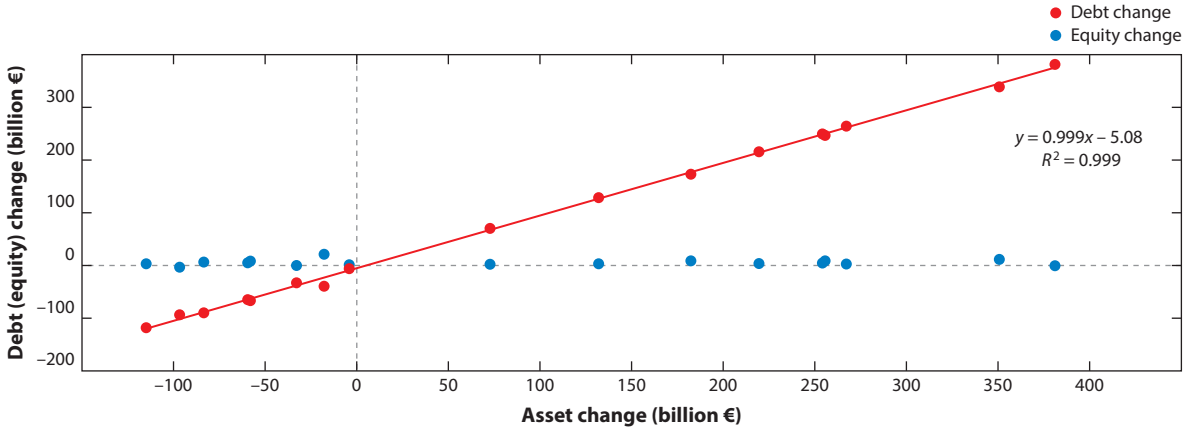

Figure 4

Annual changes in assets, equity, and debt for a large European bank (1999–2015). The scatter plot shows how much of the change in assets is accounted for by changes in debt and equity: (*horizontal axis*) annual change in total assets, (*vertical axis*) assets financed between the bank's own funds (*blue*) and borrowed funds (*red*). Slopes of the two lines add up to 1 owing to the balance-sheet identity (Adrian & Shin 2014). The fitted line through the scatter plot between the change in assets and change in borrowed funds has a slope that is essentially equal to 1, meaning that the change in assets in the short term, over horizons of approximately 1 year, is almost all accounted for by the change in debt. The scatter for equity (*blue*) is flat, meaning that the bank's own funds do not vary much over the cycle. Data from S&P Capital IQ and authors' calculations.

1 percentage point of additional capital to total assets results in a reduction in the cost of funding of 10 basis points for banks that are below 2% in their ratio of capital to total assets. The cost advantage falls as banks becomes better capitalized, but even for banks with a leverage ratio above 8%, there is still a noticeable reduction of the cost of funding, amounting to 2 basis points.

There is a useful analogy: A bank's lending is to its capital what a building is to its foundations. Concretely, if a bank's capital forms the foundation, its leverage corresponds to the height of the building that stands on the foundation. The size of the building is the total lending done by the bank. The bank can expand lending by using more borrowed funds and increasing its leverage. However, this kind of lending is not very resilient. Coining a phrase, we can say this is "fair weather lending." As soon as economic conditions turn less favorable for leverage, the bank may have to shrink its lending, with negative consequences for the real economy.

Figure 4 illustrates how the cyclical variation of lending plays out for a typical bank, plotting the relationship between the annual change in total assets and how the assets are financed between its own funds and borrowed funds. This scatter chart reinforces the analogy between equity and the foundation of a building, suggesting that the latter is pretty much fixed and what changes is the size of the building that stands on that foundation. The taller the building is, the higher is the leverage and the greater is the amount of lending done by the bank. During boom times, the height of the building increases as the bank adds new floors to the existing structure. In other words, the bank increases its total assets by increasing its leverage atop the same equity base. The boom is associated with greater availability of credit and lower risk weights for the bank's assets. Problems arise when financial conditions turn for the worse, and the bank is no longer able to secure borrowed funds. Then, lending also grinds to a halt.

What are the reasons for such large fluctuations in leverage? The great deleveraging of 2008 is an extreme example during a time of heightened financial stress. Nevertheless, the episode holds

lessons for today, by shining a light on the determinants of the risk-taking capacity of the banking sector.

In general, intermediary leverage is influenced by the combination of perceived creditworthiness of the intermediary as a borrower and how tight overall credit conditions are in the financial system. If the financial system as a whole goes through a period of ample funding liquidity, then even thinly capitalized banks can borrow on easy terms. Because banks borrow to lend, easier borrowing conditions translate into easier lending conditions, reinforcing the already-easy financial conditions. By the nature of the interactions between liquidity conditions and leverage, the boom phase rides an apparent virtuous circle of greater leverage and easier liquidity. The problem is that this virtuous circle is only apparent, not real. The true nature of the situation is revealed when the easy conditions go into reverse, and the amplification mechanism kicks in as a downward spiral.

One way to approach this issue is to track the implicit maximum leverage achievable by a broker dealer in a repurchase agreement (repo). Repo is a collateralized borrowing arrangement. In a repo transaction, the borrower, here the broker dealer, sells a security today on the understanding that it will buy back the security in the future at a preagreed price. The difference between the current market price of the pledged security and the amount borrowed by the bank is called the haircut of the repo, and it determines the leverage of the broker dealer. If the haircut is 2%, the borrower can borrow $98 by pledging $100 worth of securities. Then, to hold $100 worth of securities, the borrower must come up with only $2 of equity. Thus, if the repo haircut is 2%, the maximum permissible leverage (ratio of assets to equity) is 50.

However, when borrowers are stretched to such high levels of leverage on top of such thin haircuts, any slight shock to the financial system that raises the haircut will leave the bank vulnerable to a sudden tightening of financing conditions from an increase in the haircut. Suppose that the haircut rises to (a still modest) 4%. Then, in this simple example, the broker dealer's leverage halves from 50 to 25. Assuming the equity stays constant, this means cutting down total assets by half. If the broker dealer had started with a very large balance sheet, the shedding of exposures will be immense, causing repercussions to those entities that were borrowing from the broker dealer, setting in motion second- and third-round effects in the financial system (see Geanakoplos 2009; Adrian & Shin 2010, 2014; Gorton & Metrick 2012).

3. LESSONS FROM THE GREAT DELEVERAGING OF 2008

We can learn a great deal about the postcrisis environment by recalling the boom and bust in bank leverage associated with the global financial crisis. **Figure 5** plots the time path of total assets and leverage of the US security broker-dealer sector from 1990. **Figure 5*a*** shows the total asset series of the broker-dealer sector, scaled to 100 at the start of the period, as well as the total assets of the US nonfinancial corporate sector and the US household sector, both scaled to 100 at the start of the period. **Figure 5*b*** shows the leverage of the US broker-dealer sector, where leverage is again defined as the ratio of total assets to equity. By any standard, these charts for the US broker-dealer sector are dramatic. From **Figure 5*a***, we see that the sector's total assets grew much faster than the rest of the economy. At the peak of the credit boom in June 2007, these assets had grown nearly tenfold from 1990; the assets of nonfinancial corporates and households had grown by a more modest factor of 3. With the onset of the crisis, however, the balance sheet shrank rapidly.

The large fluctuations in the total assets of the US broker-dealer sector are mirrored by the fluctuations in its leverage, as shown in **Figure 5*b***. Leverage started out at 22 in 1990, rose to the dizzy height of 48 at the peak, only to collapse with the onset of the crisis in 2008. Leverage rebounded somewhat in the aftermath of the crisis as financial conditions eased. However, we see that the most recent period has seen a further decline in the leverage of the broker-dealer

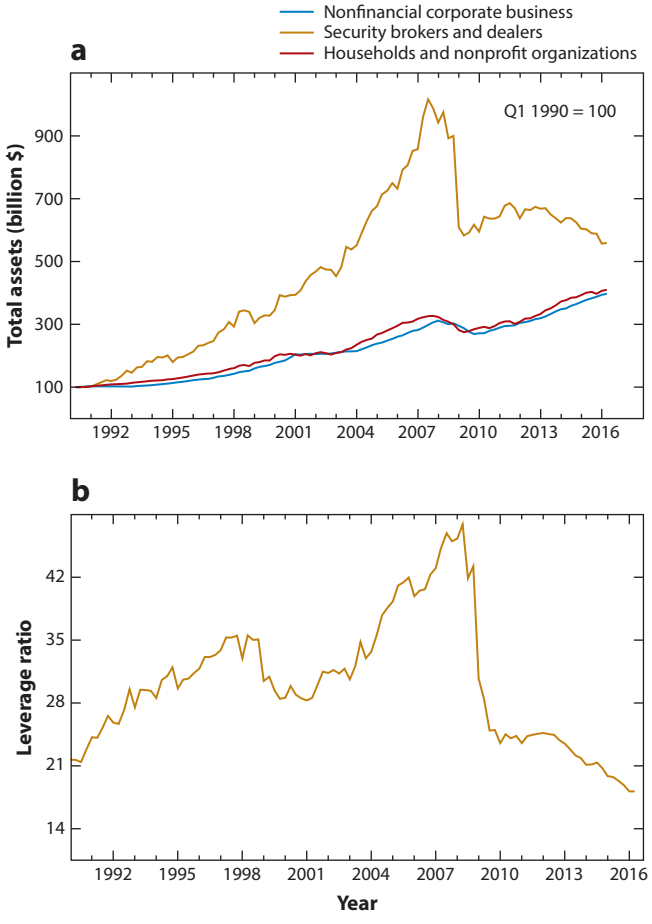

Figure 5

Total assets and leverage of the US security broker-dealer sector calculated as total assets divided by equity. (*a*) Total asset series of the broker-dealer sector from 1990, scaled to 100 at the start of the period; (*b*) total assets of the US nonfinancial corporate sector and the US household sector, both scaled to 100 at the start of the period and defined as the ratio of total assets to equity. Data from Federal Reserve Flow of Funds and authors' calculations.

sector. Leverage at the end of December 2017 stood at 18 and is lower than at the beginning of 1990. Postcrisis regulatory reform may explain some of the reversion, but most of it preceded the announcement of potentially constraining regulation. More likely, the leverage collapse reflects a combination of reduced expected returns, conservative risk management, the diminished role of securitization, and the growth of nonbank lending and market-making.

We can look beyond total balance-sheet size and toward dealer positioning to gain a more granular understanding of the postcrisis environment. Dealer positioning reflects the proprietary trading and risk-management motives of dealers as well as the positioning of dealer clients. To illustrate dealers' positioning, we examine the composition of dealer assets using data from US Financial Accounts. **Figure 6*a*** shows dealers' net positions in Treasury securities and corporate bonds from 1990 to 2016, revealing three key features. First, dealers' net corporate positions grew quickly in the years preceding the crisis, plunged during the crisis, and stagnated after the crisis. Second, dealers' net Treasury positions fluctuated between positive and negative between 1990

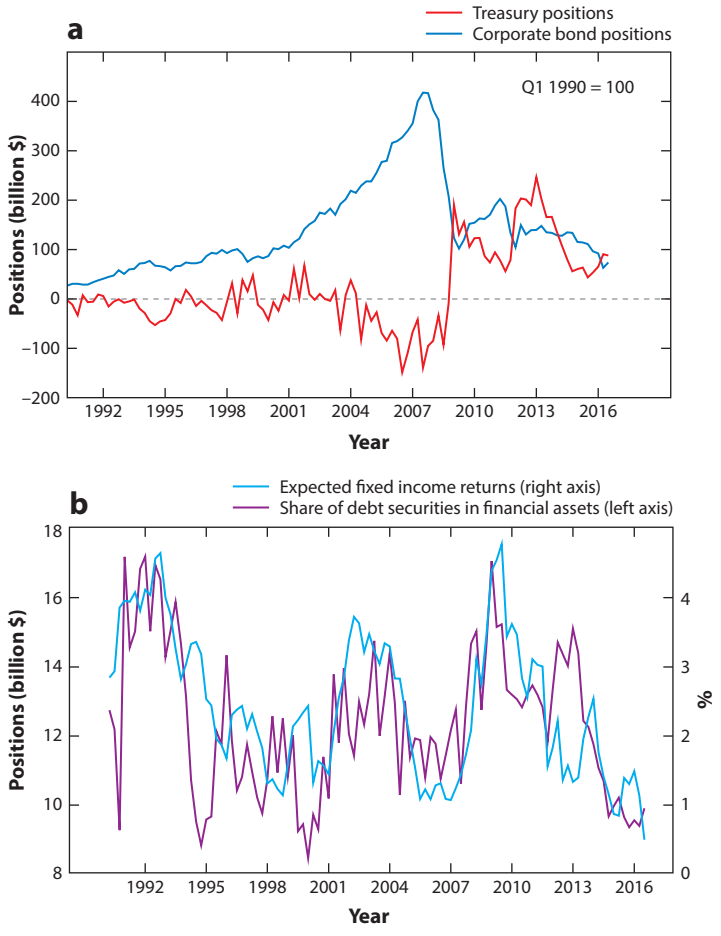

Figure 6

(*a*,*b*) US dealer positioning and (*b*) expected returns. Figure adapted from Adrian et al. (2017) with permission.

and 2016 and were negative for an extended period from 2004 to 2008. Third, in the roughly 15 years between 2001 and 2016, changes in net Treasury and corporate bond positions were negatively correlated and tended to offset, suggesting that dealers trade the credit spread.

The sharp decline in net corporate positions, in particular, raises the potential concern that dealers have reduced their balance-sheet commitment to market-making with potentially adverse effects on market liquidity. Traditionally, dealers acted as principal, buying bonds from their customers when they wanted to sell and holding them on their balance sheet until offsetting trades were found later, thus bearing the risk that prices fell in the interim. More recently, however, they may have shifted toward an agency model, as suggested by Bessembinder et al. (2018), Meli & Gupta (2016), and Choi & Huh (2017), in which dealers match offsetting orders so as to avoid holding bonds on their balance sheets. Although such a shift could explain the decline in net positions, it leaves open the question of whether liquidity is adversely affected and, if so, whether it has moved below its socially desirable level (CGFS 2016). There are tens of thousands of outstanding corporate bond issues with varying maturity, seniority, and optionality characteristics, making it difficult to match demand and supply. By their nature, regulations (if they are effective at

all) are designed to be binding constraints on banks' behavior. Goel, Lewrick & Tarashev (2017, p. 24) show that even "a constraint that does not bind contemporaneously could still influence decisions if financial conditions evolve and imply that this constraint is more or less likely to bind in the future." So, the fact that banks' activities are affected by regulations does not mean that the regulations are undesirable. The benefits of regulation in fostering a sounder financial system should be factored into the calculation of any cost-benefit analysis of regulation.

Across all debt securities, dealer positioning is likely managed to maximize expected returns and, hence, varies over time. In **Figure 6*b***, we show debt securities as a share of dealer financial assets together with a measure of expected fixed-income returns: the sum of the 10-year Treasury term premium and the credit risk premium. The 10-year Treasury term premium (computed in Adrian, Crump & Moench 2013) measures the interest rate risk premium embedded in a Treasury bond portfolio with a 10-year duration. The credit risk premium is measured by Moody's Baa-Aaa spread. **Figure 6** shows a tight correlation (55%) between expected fixed-income returns and dealer fixed-income positioning, with periods of sharp changes in asset valuations typically accompanied by sharp adjustments in positions. Thus, the low level of debt securities as a share of total assets prior to the financial crisis was associated with a simultaneous compression of expected returns. Similarly, the sharp rise in debt securities during the crisis corresponded with a period when expected returns were unusually high.

Another striking feature of dealers' balance-sheet behavior is the covariation of the tightness of risk-management constraints with market volatility. **Figure 7*a*** shows the sum of firm-wide value at risk (VaR) across eight large US dealers and market volatility as proxied by the Merrill Lynch Option Volatility Estimate Index. It shows that total balance-sheet capacity of dealers as measured by total VaRs has declined dramatically since the crisis, in hand with the decline in market volatility. The decline in balance-sheet capacity is often linked to a deterioration of funding cost indicators, two of which are shown in **Figure 7*b***.

Figure 7*b* shows the spread between the 10-year interest rate swap and the 10-year Treasury yield. Swap rates represent the value of a stream of payments indexed to LIBOR, so their pricing depends on the credit risk of LIBOR-panel banks. Treasuries, in contrast, price in the credit risk of the US government and should therefore command lower yields. Indeed, the swap spread has typically been positive. However, such spreads were sometimes negative in 2010 and again turned negative in late 2015 (where they remained through mid-2016). Such negative swap spreads are often cited as evidence of less plentiful funding liquidity (Dudley 2016) and are sometimes attributed to regulatory balance-sheet constraints on banks, hedging demands, and foreign central bank activities.

Figure 7*b* also shows another measure of market dislocation based on the credit-default swap (CDS)-bond basis. The CDS-bond basis is calculated for investment-grade bonds as the average difference between each bond's market CDS spread and the theoretical CDS spread implied by the bond yield. If the CDS spread and bond yields both reflected only the probability of default, then the two series should be identical. However, the difference between the CDS contract and the risky bond is that the former is a zero-money-down bet, whereas the latter entails an intermediary's balance-sheet commitment up to the notional amount. Hence, the CDS-bond basis can be read as signaling the price of bank balance-sheet capacity. When banks are subject to deleveraging pressures, the CDS-bond basis will be negative.

Figure 7*b* shows that the basis was close to zero, but generally positive, before the crisis, plunged to extreme negative values during the crisis before rebounding, and has generally been at moderately negative levels since the crisis. Boyarchenko et al. (2016) find that increased funding costs tied to balance-sheet constraints are an important determinant of this apparent arbitrage

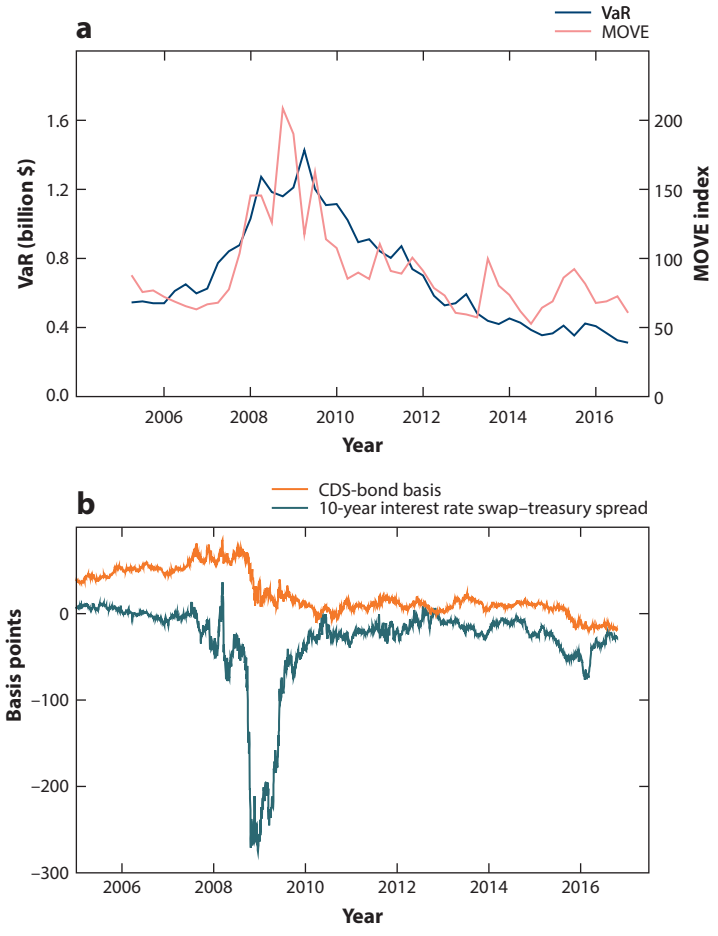

Figure 7

US dealer VaR and funding costs. (*a*) Dealer VaR and market volatility. (*b*) The CDS-bond basis and the 10-year swap spread. Abbreviations: CDS, credit-default swap; MOVE, Merrill Lynch Option Volatility Estimate; VaR, value at risk. Figure adapted from Adrian et al. (2017).

opportunity, with regulatory changes entailing those dealers to commit more capital resources to back such trades.

Another notable trend has been a reduction in the types of shadow banking activities that amplified the effects of the global financial crisis. This has been reflected in a generalized trend toward simplicity and transparency in the intermediation of nonbank credit, toward market-based finance, spurred by the deleveraging of financial intermediaries, regulatory changes, and a reorientation in intermediary business models (FSB 2017). Because data inconsistencies and definitional issues at the cross-country level make attempts at precisely quantifying the size of this shift problematic, two sets of data help to make the general point (without the implication that either is perfect). By one measure—based on the Financial Stability Board (FSB)'s shadow banking monitor (FSB 2018) data—a roughly US$10 trillion swing toward market-based finance (proxied here by standard collective investment vehicles), as well as a US$6 trillion to US$7 trillion swing against all other types of nonbank credit intermediation, including some forms of shadow

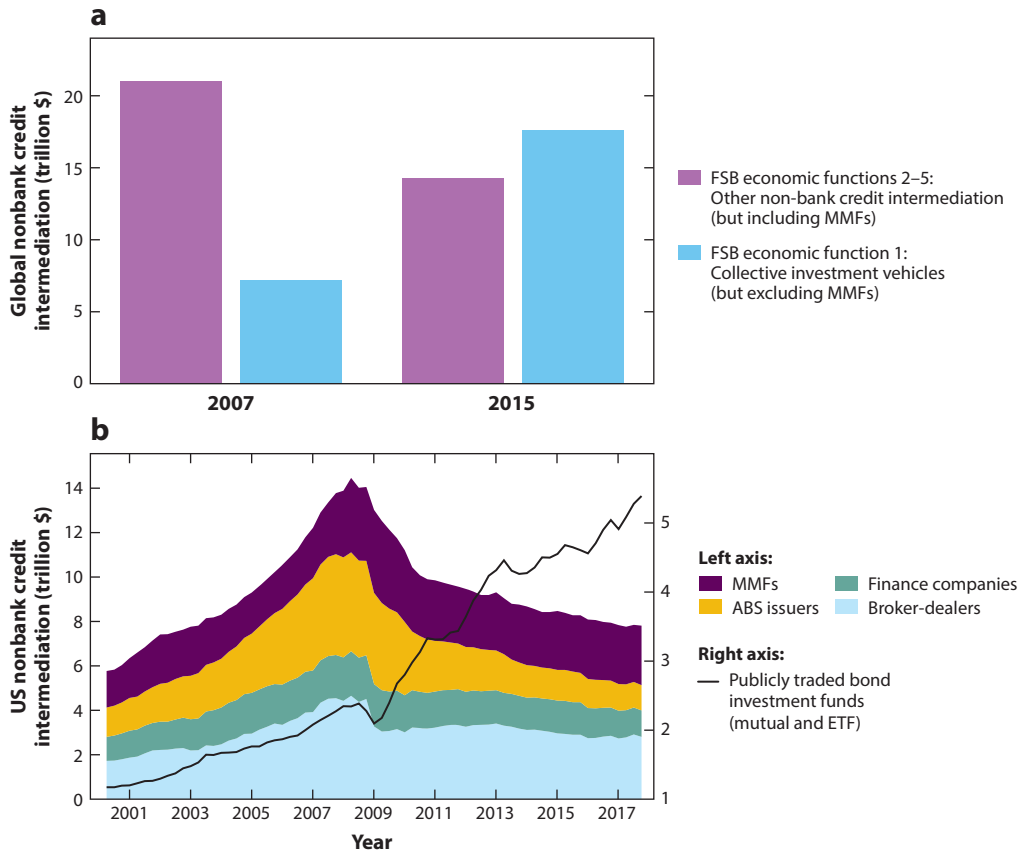

Figure 8

Shadow credit intermediation: (*a*) global nonbank credit intermediation and (*b*) US nonbank credit intermediation. Abbreviations: ABS, asset-backed security; ETF, exchange-traded fund; FSB, Financial Stability Board; MMF, money market fund. Panel *a* data from the FSB and panel *b* data from the Federal Reserve.

banking that created significant problems a decade ago, can be inferred between 2007 and 2015 (**Figure 8*a***) (based on Adrian & Jones 2018).

By another measure—also focusing exclusively on the Federal Reserve's Flow of Funds—a broadly similar trend emerges. This is evident in the fact that assets intermediated through simple, insolvency-remote collective investment vehicles like bond mutual funds and exchange-traded funds have more than doubled since 2007, while the assets of broker dealers, finance companies, asset-backed securities issuers, and money market mutual funds have almost halved (**Figure 9*b***) (for a discussion of these divergent trends in the context of broker-dealer intermediation of corporate bond trading, see Adrian, Boyarchenko & Shachar 2016). Importantly, interconnectedness has also been reduced. In part, this reflects the emergence of shorter collateral chains. After all, collateral does not flow in a vacuum: It needs a balance sheet to move, and balance-sheet space for key entities has become scarcer (Singh 2017).

The core of the shadow banking system constituted securitization activity in the sense that securitization was the primary means of generating nondeposit funding for banks and other financial intermediaries, thereby facilitating the increase in leverage (Shin 2009). By removing assets from balance sheets, securitization increased banks' risk-taking capacity, thereby increasing

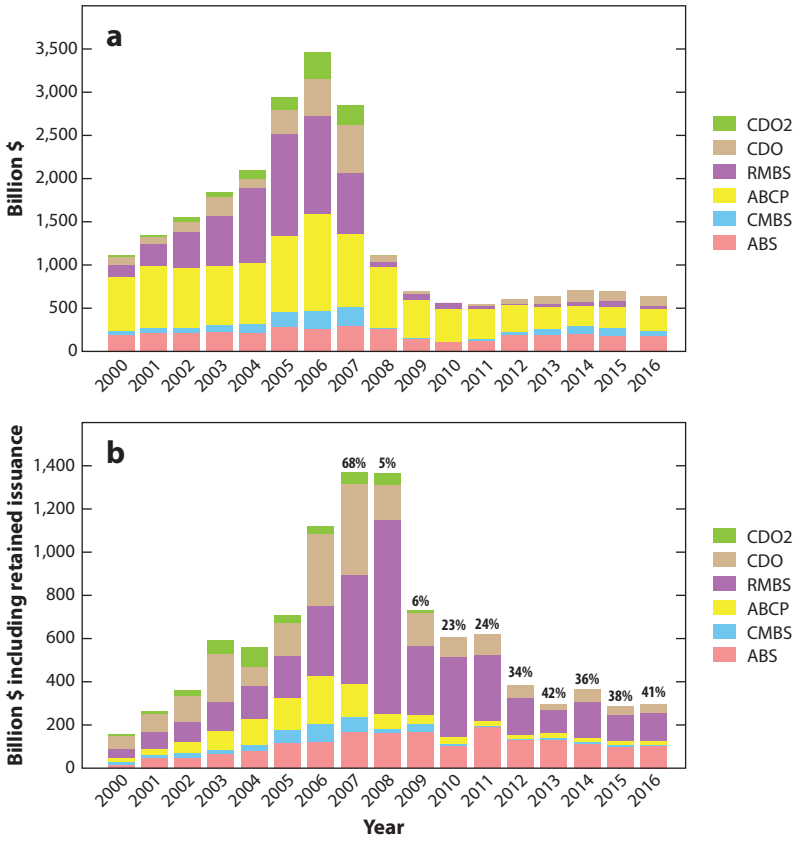

Figure 9

Securitization activity. (*a*) US and (*b*) European private-label securitization issuance by type. Estimates in panel *a* are based on data from JPMorgan Chase & Co., the Board of Governors of the Federal Reserve Systems, the CRE Finance Council, Inside Mortgage Finance, and the Securities Industry and Financial Markets Association. The percentages in panel *b* equal percent placed with investors. Estimates in panel *b* are based on data from Fitch Ratings, JPMorgan Chase & Co., Merrill Lynch, the CRE Finance Council, and the Association for Financial Markets in Europe. Abbreviations: ABS, asset-backed security; ABCP, asset-backed commercial paper; CDO, collateralized debt obligation; CDO2, CDO-squared + CDOs backed by ABS + mortgage-backed security; CMBS, commercial mortgage-backed security; RMBS, residential mortgage-backed security. Figure adapted from Adrian & Jones (2018) with permission.

their effective leverage (Wenying & Pritsker 2008; Beccalli, Boitani & Di Giuliantonio 2015). Under pre-2010 accounting rules, banks could remove most securitized assets off their balance sheets (IMF 2009, box 2.5). Low yields on competing fixed-income products and the misperception given by the major credit ratings that they were "safe" assets both fueled precrisis investor demand for securitization products (Coval, Jurek & Stafford 2009). The postcrisis collapse of securitization volumes represents another manifestation of the dramatic postcrisis changes. As shown in **Figure 9**, volumes dropped off sharply from their peaks of 2006, particularly those of mortgage-backed securities and collateralized debt obligations. Where structures and performance dynamics are well understood, and issuer incentives are perceived to be well aligned with investor interests, issuance continues. However, some securitization activity almost entirely disappeared, such as in private label mortgages.

In the past few decades, peer-to-peer electronic trading platforms have emerged as an intermediation activity outside the formal regulated banking system. To some extent, this activity has also made inroads into the role of broker dealers in many markets. In 2017, 84% of US investment-grade bond investors and 73% of high-yield investors traded electronically, versus 51% and 18%, respectively, in 2008 (McPartland 2017).[3] The electronification of fixed-income markets makes it easier to match buyers and sellers by accessing a central limit order book on electronic trading venues. Hendershott & Madhavan (2015) find that electronic auction markets improve the liquidity of thinly traded corporate bonds (although the effects are larger for the most liquid ones). However, the vast majority of bond trading is still done by phone or chat services, as the relative lack of supply of most corporate bonds makes them too sensitive to price information for electronic trading (Leising & Smith 2018). In addition, opinions are mixed about whether customer-to-customer platforms can fully supplant the dealer model. Choi & Huh (2017, p. 1) find that "among trades where customers are demanding liquidity. . .these customers pay 35 to 50% higher spreads than before the crisis."

4. POSTCRISIS REGULATORY REFORMS

The crisis revealed many weaknesses and fault lines in financial regulation and supervision as well as major deficiencies in firms' risk-management systems. Over the past 10 years, the global financial regulatory community has worked to develop and implement a major reform program to correct the identified fault lines. The overarching aim has been to build a more robust and resilient global financial system that can continue to support the real economy in times of stress.

For internationally active banks, the Basel Committee on Banking Supervision (BCBS) has led these efforts. However, to the extent that the reform effort involves activities that go beyond the formal banking system, the FSB has been an important additional body coordinating the work of national regulators and international standard-setting bodies such as the BCBS, the International Association of Insurance Supervisors, the International Organization of Insurance Commissions, and the Committee on Payments and Market Infrastructures. We review these regulatory changes and the literature on evaluating the impact of reforms. The spirit of these regulatory reforms can be grouped into four main elements:

1. policies to improve the resilience of the financial system in the event of stress,
2. initiatives designed to contain the buildup of risks in the financial system,
3. measures to strengthen the system-wide focus of financial policy making and supervision, and
4. reforms to contain moral hazard and lower the costs of handling failure.

We discuss each of these four areas of reforms in turn. Adrian et al. (2017) provide a more detailed summary of postcrisis regulatory reforms.

4.1. Policies to Improve the Resilience to Stress

Reforms to strengthen the resilience of the banking system to stress are the centerpiece of the reform program. At the heart of the reforms is the Basel III initiative to improve the existing regulatory framework for internationally active banks by raising the quality and quantity of bank

[3] A survey conducted by Liquidnet found a significant difference in attitude toward electronic fixed-income trading between Europe and the United States, largely due to MiFID II. It found 86% of European traders believed regulation is driving more corporate bond trading onto electronic venues, while just 39% of American traders thought the same (Liquidnet 2017).

capital (BCBS 2010, 2011, 2017). Basel III requires the predominant form of so-called common equity tier 1 capital to be in the form of common shares and retained earnings. This capital must be at least 4.5% of risk-weighted assets at all times. The total risk-weighted tier 1 plus tier 2 capital requirement is 8%. Furthermore, Basel III introduced a capital conservation buffer of 2.5% that can be drawn down in periods of stress to reduce procyclicality. In December 2017, BCBS members finalized the Basel III package of regulatory reform, after agreeing on rules that limit the potential for unwarranted variability of internal model-based risk weights across jurisdictions so the capital ratios may be applied more evenly across jurisdictions (BCBS 2017).

The Basel III capital requirements are underpinned by a leverage ratio serving as a backstop to the risk-based capital measures that is intended to constrain excess leverage in the banking system and providing an extra layer of protection against model risk and measurement error (Fender & Lewrick 2016). The leverage ratio requirement is 3% and may incentivize banks to reduce low-margin, balance-sheet-intensive businesses such as market-making in highly rated sovereign bonds and repo, likely providing an incentive to move such businesses to central clearing counterparties (CGFS 2014; Fender & Lewrick 2016; Goel, Lewrick & Tarashev 2017). The macroprudential surcharge aims to reduce the probability of failure of G-SIBs by increasing their going-concern loss absorbency. The extent and impact of failure of G-SIBs are further reduced by improving global recovery and resolution frameworks (see BCBS 2013b).

In addition to the capital regulation improvements described above, Basel III also introduced two pillars of liquidity regulation: the liquidity coverage ratio and the net stable funding ratio (see BCBS 2013a, 2014). The goal of the liquidity coverage ratio is to promote the short-term resilience of the liquidity risk profile of banks by ensuring that banks have an adequate stock of liquid assets that can be used to meet liquidity needs for a 30-day stress scenario. By contrast, the net stable funding ratio aims to reduce funding risk over a longer time horizon by requiring banks to fund their activities with sufficiently stable sources of funding to mitigate the risk of future funding stress.

The December 2017 enhancements address shortcomings of the precrisis regulatory framework by aiming to restore credibility in the calculation of risk-weighted assets and by improving the comparability of banks' capital ratios. The robustness and risk sensitivity of the standardized approaches for credit risk, credit valuation adjustment risk, and operational risk are enhanced. The use of the internal model approaches is restricted by placing limits on certain inputs used to calculate capital requirements under the internal ratings-based approach for credit risk and by removing the use of the internal model approaches for credit valuation adjustment risk and operational risk. A leverage ratio buffer is introduced to further limit the leverage of G-SIBs. The existing Basel II output floor is replaced with a more robust risk-sensitive floor based on the revised Basel III standardized approaches (BCBS 2017).

The regulatory approach to managing market risks has also been significantly overhauled. Basel 2.5 supplemented the BCBS (2006) Basel II VaR-based trading book framework with an incremental risk capital charge that includes default risk as well as migration risk for credit products (BCBS 2010). It also introduced a stressed VaR requirement. In 2019, the Fundamental Review of the Trading Book replaced the VaR methodology with one based on the expected shortfall approach so as to better capture the kind of tail risk events seen during the crisis (BCBS 2016). This comes with much more rigorous preconditions for implementation that include separate approvals at the trading desk level and combines regulatory stringency with intrusive supervision.

In parallel to the strengthening of regulation, many supervisory authorities now place additional reliance on enhanced stress tests to underpin their assessment of capital and liquidity plans. In the European Union and United States, mandatory stress tests for banks and designated systemically important financial institutions were introduced between 2009 and 2011. Launched in 2009,

EU-wide annual bank stress tests are based on scenarios generated by the European Banking Authority. The US Comprehensive Capital Analysis and Review (CCAR) was launched in 2011, providing annual stress tests based on a hypothetical, severely adverse scenario designed by the Federal Reserve. Stress testing is a tool that helps bank and bank holding company (BHC) supervisors measure whether a financial institution has enough capital to support its operations throughout periods of stress. The CCAR also promotes greater resiliency by requiring each BHC to support its capital management decisions with forward-looking comprehensive analysis that takes into account the BHC's risk profile and activities.

Stress tests are an integral part of the risk-management and supervisory tool kit, enabling banks and supervisors to identify areas of potential vulnerability and weakness in a forward-looking context and to support the formulation of plans to address them. Stress-testing techniques have been enhanced significantly in recent years through improvements in analytical models and better data. Stress-testing techniques are also being extended to support systemic risk analysis though models focusing on sectoral contributions to systemic risk, the resilience of nonbank institutions, as well as the robustness of the financial network.

Policy measures have also strengthened the resilience and robustness of financial market infrastructures, which play a pivotal role at the heart of the financial system. Many such infrastructures comprise systemically important institutions and are thus a major supervisory focus. Policy makers have also introduced procedures to support the central clearing of standardized derivative contracts through central clearing counterparties, with the aim of lowering bilateral counterparty credit risk. One of the remaining ongoing elements of the reform agenda is to introduce plans for central clearing counterparty recovery and resolution under stress that ensure continued market functioning.

Another main theme of the regulatory reform agenda has been to transform shadow banking into resilient market-based finance. As highlighted in Section 3, the growth of nonbank vehicles offering bank-like products and susceptible to bank-like risks played a significant role in the buildup to the global crisis. In concert with the sectoral standard-setting bodies and national authorities, the FSB has made considerable progress in addressing major risks, for example, by strengthening money market funds, improving securitization markets, reducing interconnectedness between banking and nonbank sectors, and improving securities financing markets. Work is continuing to address liquidity and leverage risks in the asset management industry. Despite recent progress, it is vital that authorities continue to monitor the nonbank sector closely, paying special attention to the adaptation of the system and the possibility of new systemic risks emerging beyond the regulatory frontier.

4.2. Initiatives Designed to Contain the Buildup of Risks in the Financial System

A framework to contain the buildup of systemic risks must take into account both longitudinal and cross-sectional dimensions. The longitudinal element should focus on dampening the inherent procyclicality in the financial system. It requires tools that help contain the rise of system-wide risks during an upswing, which stem from incentives to overextend leverage and credit and to build risk concentrations and push asset prices beyond fundamentals, and tools that help protect the system during a downswing when these forces move into reverse. Cross-sectional elements aim to improve the resilience of the system to help guard against the failure of an institution at any point in time, in particular, by considering what measures can and should be taken to contain spillover and contagion during such an event.

To strengthen the longitudinal element, the BCBS has introduced a countercyclical buffer in the banking system, wherein supervisory authorities require banks to hold additional capital at

times of excessive credit growth, so that it can be released in a subsequent downswing to cushion deleveraging. Of course, the effectiveness of the countercyclical capital buffer requires regulators with foresight: History will tell how effectively this tool is applied. Strengthened monitoring has also led to more active application of a range of other policies and tools to contain sources of potential systemic risk: for example, loan-to-value and debt-to-income constraints in real estate markets or risk weighting in corporate lending markets. In addition, a capital conservation buffer that can be run down during times of stress counteracts procyclicality.

Perhaps more important, forward-looking stress tests introduced in the supervisory processes of many jurisdictions directly counteract procyclicality, as they condition on severe stress scenarios many months into the future by requiring institutions to hold more capital when risks are building. Hence, these stress tests hardwire an assumption of an extreme form of portfolio illiquidity into behavioral assumptions, overcoming one of the main shortcomings of the VaR methodology. Of course, the severity of stress assumptions needs to be adequate to generate correct levels of capital. Starting with the first Financial Sector Assessment Program in 2000, these stress tests were pioneered by the International Monetary Fund (IMF) and were widely adopted by supervisors following the 2008 crisis (Ong 2014).

Strengthening the cross-sectional dimension of financial regulation entails close attention to the question of how the design of regulation should take account of an institution's contribution to systemic risk. New analytical tools (such as conditional VaR) have been developed to support such an assessment (Adrian & Brunnermeier 2011). Along with the aforementioned as well as more intrusive and intense supervision, additional steps have been taken to contain the buildup of network or interconnectedness risks. For example, large exposure rules have been toughened (with stronger constraints on exposures between SIBs), and measures to mitigate potential spillovers between the banking system and the shadow banking system have been introduced.

4.3. Strengthening the System-Wide Dimension

One of the major lessons of the crisis is the need to focus much more attention on the financial sector as a system, recognizing the importance of collective behavior and of the close interconnections and interactions across the financial network. For example, investors in complex, structured products mistook benign market conditions as an indicator that they would be able to exit positions quickly in the event of an adverse shock. They failed to recognize that there was a concentration of risk and that all other investors were likely to wish to exit their positions at the same time, leading to an evaporation of market liquidity—in the worst case, completely—and thus to a major write-down of value. Furthermore, many banks had liquidity contingency plans that relied on defenses such as liquefying illiquid assets, bidding for additional deposits, or restricting balance-sheet size. If a particular bank were the only one facing stress and overall market conditions were normal, then such plans might work well. However, if other banks faced similar strains, for example, as a result of increased concern about the quality of their loan books and potential exposures to subprime mortgages, then such defenses would no longer work—indeed, they would tend to exacerbate system-wide stress. Yet another example of the interconnectedness of the financial network is the reliance many European banks have had on a steady rollover of short-term wholesale dollar funding from US money market funds. This motivated the creation of the Term Auction Facility, a temporary monetary policy program wherein foreign banks were the major borrowers of term money at the US Federal Reserve's discount window.

These examples (and many more) highlight the importance of taking a strong system-wide perspective in risk assessment as well as in the design and implementation of financial regulation. Doing so is a necessary complement to strong supervision of individual banks. Currently,

authorities are paying more attention to the assessment of potential systemic risks that could impair the financial system and disrupt the provision of financial services. System-wide risk assessments require that much more attention be focused on the buildup of leverage and of common exposures and concentrated risks through interconnections and interlinkages. It is also important that the framework help contain the rise of system-wide risk and that, if risk crystallizes, defenses can be used without creating major externalities and spillovers elsewhere in the system.

Many countries have introduced new institutional macroprudential frameworks to strengthen the oversight and containment of systemic risks—a process welcomed and strongly supported by the IMF (2011, 2013, 2014). Considerable analytical and policy work has been undertaken to help support the design and implementation of effective macroprudential policies (IMF 2014; IMF, FSB & BIS 2016) and to ensure that financial regulation will take into account the precept of protecting the functioning of the system as a whole.

4.4. Containing Moral Hazard and Managing Failure

Taking additional steps to identify and mitigate emerging risk and bolstering the resilience of the financial system should substantially reduce the probability and impact of failures. However, the regulatory framework is not aimed at delivering a no-failure regime—nor should it be. The possibility of failure provides incentives and discipline that strengthen the effective management of financial risks and support the efficiency of financial intermediation.

Because the failure of financial institutions remains inevitable, the final leg of the reform agenda has thus focused on strengthening crisis management arrangements to support the recovery and, if necessary, to enable the orderly resolution of failing firms without major spillovers that would threaten broader financial stability. A clear objective is to eliminate the need for taxpayer support to keep firms afloat because they are seen as too big, too complex, or too interconnected to fail. Such support was a prominent feature of the 2008 crisis, generating moral hazard and the unacceptable privatization of profits and socialization of losses.

Considerable progress has been made internationally to strengthen crisis management arrangements. Special resolution regimes have been introduced in jurisdictions where they were previously absent, and they have been enhanced elsewhere in line with new international standards (FSB 2014). To address the specific risks of institutions being perceived as too big to fail, authorities have toughened regulations through a combination of measures. Capital surcharges have been applied where firms are viewed as systemically important and thus impose additional externalities, buttressed by more intensive and intrusive supervision. Major financial institutions are required to introduce explicit recovery and resolution plans, or living wills, that are subject to supervisory scrutiny and validation. In G-SIBs, such arrangements are underpinned by requirements to hold total loss-absorbing capacity (TLAC) instruments, which can be written down or converted into equity under stress to ensure that critical bank functions can be sustained without taxpayer support. The aim of TLAC, which was finalized in December 2016, is to reduce both the probability and impact of failure of G-SIBs. TLAC provides recapitalization capacity to help ensure an orderly resolution to stress (for an overview, see FSB 2015).

5. THE IMPACT OF REGULATORY REFORMS

Much of the theoretical literature on the impact of regulations on intermediation activity focuses on banks. Furlong & Keeley (1989) show that mean-variance optimizing banks with deposit insurance will reduce risk-taking when capital regulation is tightened. Similarly, in Keeley (1990), capital regulation limits excessive risk-taking owing to deposit insurance. However, increased competition

can raise risk-taking incentives, even in the presence of capital regulation, as competition lowers charter value. Thakor (2014) provides a review of the literature on bank capital regulation. Recent literature also focuses on the impact of regulation in dynamic, general equilibrium settings.

To the extent that regulations are effective, some impact of regulation on intermediary activity should be expected, and the impacts are indeed intended. In addition, the impact of regulation should be assessed from the point of view of its overall benefit to the financial system and the wider economy, rather than on the narrow interests of financial market participants, especially if their horizon is short. Hence, the overall assessment of the impact of regulation concerns the desirability of regulation within the context of the trade-off between trend growth and long-run stability of financial institutions (see Adrian & Boyarchenko 2012, He & Krishnamurthy 2013, Brunnermeier & Sannikov 2014). Updating the analysis of the earlier BIS (2010) Macroeconomic Assessment Group, Fender & Lewrick (2016) suggest that Basel III can be expected to generate sizeable net economic benefits, even after the implied changes to bank business models have been taken into account, in a range of 0.5% to 2.0% of GDP per year.

The Committee on the Global Financial System (CGFS 2014) takes stock of the impact of postcrisis regulations for dealers in particular and market-making more generally. Regulatory changes since 2010 are likely to affect dealers' balance sheets and profitability. Market participants also expect the cost of market-making to rise. New risk weights and credit risk charges make trading corporates and credit derivatives more expensive. In particular, the incremental risk capital charge and the stressed VaR add to inventory costs of corporate bonds. Furthermore, less liquid corporate bonds are ineligible for the liquidity coverage ratio, which is expected to reduce the willingness of banks to warehouse these assets. The leverage ratio increases the balance-sheet cost of repos, including repos backed by corporates and structured credit, thereby constraining dealers' ability to manage inventory risk.

CGFS (2016) provides the results of an informal survey of market participants, who were asked to estimate the relative importance of different cost drivers including regulatory capital requirements as well as trading and operational costs using two highly stylized portfolios: one comprised of sovereign bonds and the other of corporate bonds. The survey results suggest that the profit and loss impacts of recent regulatory changes have been differentiated. For sovereign bonds, both the Basel III leverage ratio and higher risk-weighted capital requirements have had the largest impact on regulatory capital charges and, hence, dealers' profits. For corporate bonds, by comparison, revisions to the Basel II market risk framework (Basel 2.5) have had the largest impact on regulatory charges. The survey responses imply that the gross revenue required to yield a return on capital of 8% under a fully phased-in Basel III framework would have resulted in returns above 20% given the requirements under Basel II. According to CGFS (2016), survey respondents, on average, indicated that Basel 2.5 had the largest impact on regulatory charges for corporate bonds and that capital charges when moving from Basel II to current requirements would have increased significantly. The remaining phase-in of the Basel III requirements, in turn, was expected to have only a minor impact. Assuming constant revenues and a return on capital of 8% annually under the fully phased-in Basel III framework, survey responses suggest that the return on capital would have amounted to approximately 26% annually under Basel II requirements.

Adrian, Boyarchenko & Shin (2015) and Adrian et al. (2017) focus on metrics including bid-ask spreads, price impact, and depth to document the dramatic stagnation of postcrisis US dealer balance sheets in the postcrisis period that occurred contemporaneously with dealer deleveraging (as presented in Section 1). However, traditional market liquidity metrics in US Treasury and corporate bond markets, where dealers are the most important market-makers, indicate robust market liquidity. Compared with precrisis liquidity, market liquidity as measured by price impact is at all-time highs for retail investors of US corporate bonds but worsened for institutional investors

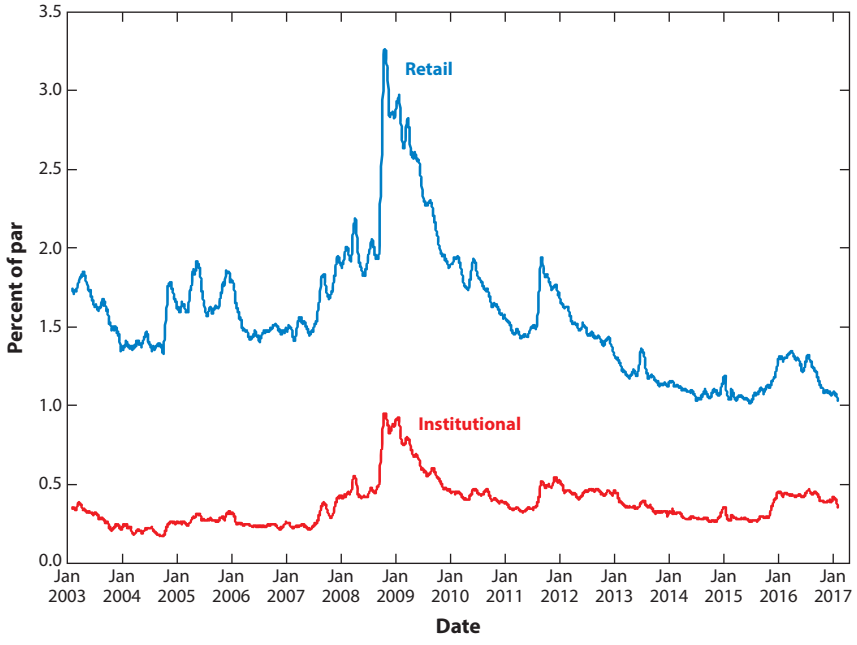

Figure 10

Corporate bond market liquidity measured by price impact. Figure adapted from Adrian et al. (2017) with permission.

(Adrian et al. 2017) (see **Figure 10**). Hence, there appears to be a trade-off for institutional-sized trades: Phase-in of tighter regulatory requirements was accompanied by deleveraging of the dealer sector, making the sector more resilient to adverse shocks. Yet, this might have come at the cost of somewhat higher trading costs for institutional-sized corporate bonds in normal times. Mizrach (2015), Bessembinder et al. (2018), and Anderson & Stulz (2017) also find that US corporate bond liquidity is better in the postcrisis period overall than it was in the precrisis period, although Anderson & Stulz (2017) confirms higher transaction costs and price impact for large (more than US$100,000) trades.

Adrian et al. (2017) point out that some funding liquidity metrics show an increase of balance-sheet costs since the crisis (including the interest rate swap spreads and the CDS-bond basis presented in Section 3). By contrast, others indicate ample liquidity (e.g., yield curve-fitting errors). We also find that three market stress events in the postcrisis era (the 2013 Taper tantrum, the 2014 Treasury flash rally, and the 2015 liquidation of Third Avenue) did not trigger widespread liquidity dislocations, and the degree of deterioration in market liquidity was within historical norms.

Boyarchenko et al. (2016) examine in more detail the evolution of funding liquidity metrics in US corporate bond markets. They look at three explanations of credit market arbitrage trade dislocations: increased idiosyncratic risks, strategic positioning by some market participants, and regulatory changes. They document increased idiosyncratic risk during the relevant period but limited evidence of asset managers' changing their positioning in derivative products. The relative changes in idiosyncratic risk levels and in asset managers' derivatives positions appear small relative to the postcrisis increase in cost of capital. The authors link the CDS-bond arbitrage trade to return-on-equity calculations of a stylized dealer balance sheet and argue that, given current

levels of regulatory leverage, the CDS-bond basis would need to be significantly more negative relative to precrisis levels to achieve the same return-on-equity target.

Separately examining results for BHC-affiliated versus nonbank-affiliated dealers, Bessembinder et al. (2018) study bond liquidity as a function of dealers' willingness to commit capital to bond trading and focus on whether postcrisis banking reforms have affected liquidity provisions in the corporate bond market. They find that capital allocation has shifted from bank-affiliated dealers to independent dealers since the passage of the Dodd-Frank Act and Basel III. Bao, O'Hara & Zhou (2018) document that the liquidity of US corporate bonds that were recently downgraded from investment grade to a high-yield rating has decreased since the Volcker rule took effect. For this subset of bond events, dealers regulated by the Volcker rule have decreased their market-making activities, while non-Volcker-affected dealers have stepped in to provide some additional liquidity. However, Volcker-affected dealers who are not constrained by Basel III and CCAR also change their behavior, which the authors interpret as inconsistent with effects being driven by these latter regulations. In contrast, Trebbi & Xiao (2018) find that postcrisis US regulatory intervention does not appear to have produced structural deteriorations in market liquidity.

Adrian, Boyarchenko & Shachar (2016) study the relationship between bond-level liquidity and financial institutions' balance-sheet constraints in US corporate bond markets. They first document a relationship between institutional constraints and bond liquidity that changes significantly over time. Prior to the crisis, bonds traded by institutions that are akin to investment banks were more liquid. During the rule-implementation period (starting in January 2014), these relationships reversed: Bonds traded by institutions with lower leverage, higher risk-weighted assets, more reliance on repo funding, and lower return on assets were more liquid. That is, the same relationship between bond liquidity and dealer constraints seen in the full sample is the primary driver in the postcrisis period. These results hold true across bonds with different credit ratings, issuance sizes, and levels of liquidity and that are issued by companies in different industries. These findings are consistent with more stringent leverage regulation and greater regulation of dealer banks reducing institutions' ability to provide liquidity to the market overall.

Showing patterns similar to those discussed above, Fender & Lewrick (2015) and IMF (2015) also find little hard evidence of a broad-based rise in trading costs in bond markets. Drawing on the analysis conducted in CGFS (2014), Fender & Lewrick (2015) find that executing large bond trades has become more difficult and that trading has become concentrated in just a few liquid issues. They report that market-makers have become more selective, favoring core clients that generate income in other business lines and narrowing their scope to smaller ranges of markets. Furthermore, market-making in many jurisdictions has shifted away from the principal trading model. IMF (2015) finds that the liquidity of high-yield and emerging market bonds has decreased since the crisis. They also find that growing concentrations of holdings among mutual funds, pension funds, and insurance companies are associated with less-resilient liquidity. In addition, there has been a proliferation of small bond issues that tend not to be very liquid. However, neither Fender & Lewrick (2015) nor IMF (2015) find conclusive evidence that postcrisis regulatory reform is having a detrimental impact on fixed-income market liquidity. As Fender & Lewrick (2015, p. 105) note,

> Regulatory reforms are seeking to improve bank capacity to absorb losses by limiting leverage and promoting more stable funding. Having more resilient banks with sufficient capital and liquidity reduces the probability of widespread liquidity crises. That would help make market-making more robust, although possibly at lower levels of activity in normal times. In addition, better capitalization and more limited leverage can help keep banks from building overly extended positions in financial markets, reducing the risks of sudden market reversals with large imbalances in buy and sell orders.

6. CONCLUSION

Since the global financial crisis of 2008, bank balance sheets and leverage have been shrinking. Total balance-sheet capacity of US banks as measured by total balance-sheet size or total VaRs has declined dramatically. Dealers' net corporate positions plunged during the crisis and have since stagnated. Postcrisis regulatory reform may explain some of these findings, but most have preceded any constraining effect of regulation. Thus, in addition to the impact of regulatory changes, they likely reflect a combination of reduced expected returns, expensive and less-plentiful funding, conservative risk management, reduced shadow banking activity, and the growth of nonbank lending and market-making.

More stringent leverage regulation and greater regulation of dealers may have reduced institutions' ability to provide liquidity, but there is only limited evidence that this has led to a widespread deterioration of bond market liquidity since the global financial crisis. More recently, dealers may have shifted toward an agency model, in which they match offsetting orders to avoid holding bonds on their balance sheets. However, traditional market liquidity metrics in markets where dealers are the most important market-makers tend to indicate robust market liquidity. An exception are institutional-sized corporate bond trades for which market liquidity is markedly below precrisis levels. Certain funding liquidity cost indicators also signal a higher shadow cost of regulatory constraints in recent years.

The bottom line is that regulatory reform has made the financial system markedly safer, yet evidence of adverse unintended consequences is limited to date and needs to be weighed against the broader benefits of regulatory reform. Reforms have increased the quantity and quality of regulatory capital held by banks. They addressed key regulatory loopholes in the Basel II framework by better reflecting the risks. New liquidity requirements enhance the liquidity profile of banks and improve their ability to withstand liquidity shocks arising from financial and economic stress. Owing to their forward-looking nature, stress tests have counteracted procyclical balance-sheet management. Of course, international standard setters are now increasingly focused on evaluating the costs and benefits of the new regulatory regime, and we expect more granular quantification in coming years.

DISCLOSURE STATEMENT

The authors are not aware of any affiliations, memberships, funding, or financial holdings that might be perceived as affecting the objectivity of this review. The views in this paper are those of the authors and do not necessarily represent the views of the International Monetary Fund or the Bank for International Settlements.

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LITERATURE CITED

Adrian T, Boyarchenko N. 2012. *Intermediary leverage cycles and financial stability*. Staff Rep. 567, Fed. Reserve Bank N.Y., NY

Adrian T, Boyarchenko N, Shachar O. 2016. *Dealer balance sheets and bond liquidity provision*. Staff Rep. 803, Fed. Reserve Bank N.Y., NY

Adrian T, Boyarchenko N, Shin HS. 2015. *On the scale of financial intermediaries*. Staff Rep. 743, Fed. Reserve Bank N.Y., NY

Adrian T, Brunnermeier M. 2011. *CoVaR*. NBER Work. Pap. 17454
Adrian T, Crump RK, Moench E. 2013. Pricing the term structure with linear regressions. *J. Financ. Econ.* 110:110–38
Adrian T, Fleming M, Shachar O, Vogt E. 2017. Market liquidity after the financial crisis. *Annu. Rev. Financ. Econ.* 9:43–83
Adrian T, Jones B. 2018. *Shadow banking and market-based finance*. Dep. Pap. 18/14, Int. Monet. Fund, Washington, DC
Adrian T, Shin HS. 2010. Liquidity and leverage. *J. Financ. Intermed.* 19(3):418–37
Adrian T, Shin HS. 2014. Procyclical leverage and value-at-risk. *Rev. Financ. Stud.* 27(2):373–403
Anderson M, Stulz RM. 2017. *Is post-crisis bond liquidity lower*? Work. Pap. 2017-09, Charles A. Dice Cent. Res. Financ. Econ., Ohio State Univ., Columbus, OH
Bao J, O'Hara M, Zhou X. 2018. The Volcker rule and market-making in times of stress. *J. Financ. Econ.* 130:95–113
BCBS (Basel Comm. Bank. Superv.). 2006. *International convergence of capital measurement and capital standards*. Rep. 128, BCBS, Basel, Switz.
BCBS (Basel Comm. Bank. Superv.). 2010. *Revisions to the Basel II Market Risk Framework*. Rep. 193, BCBS, Basel, Switz.
BCBS (Basel Comm. Bank. Superv.). 2011. *Basel III: a global regulatory framework for more resilient banks and banking systems*. Rep. 189, BCBS, Basel, Switz.
BCBS (Basel Comm. Bank. Superv.). 2013a. *Basel III: the liquidity coverage ratio and liquidity risk monitoring tools*. Rep. 238, BCBS, Basel, Switz.
BCBS (Basel Comm. Bank. Superv.). 2013b. *Global systemically important banks: updated assessment methodology and the higher loss absorbency requirement*. Rep. 255, BCBS, Basel, Switz.
BCBS (Basel Comm. Bank. Superv.). 2014. *Basel III: The net stable funding ratio*. Rep. 295, BCBS, Basel, Switz.
BCBS (Basel Comm. Bank. Superv.). 2016. *Minimum capital requirements for market risk*. Rep. 352, BCBS, Basel, Switz.
BCBS (Basel Comm. Bank. Superv.). 2017. *Basel III: finalizing post-crisis reforms*. Rep. 424, BCBS, Basel, Switz.
Beccalli E, Boitani A, Di Giuliantonio S. 2015. Leverage pro-cyclicality and securitization in US banking. *J. Financ. Intermed.* 24:200–30
Bessembinder H, Jacobsen S, Maxwell W, Venkataraman K. 2018. Capital commitment and illiquidity in corporate bonds. *J. Finance* 73:1615–61
BIS (Bank Int. Settl.). 2010. *Assessing the macroeconomic impact of the transition to stronger capital and liquidity environments: final report*. Dec. Rep., Macroecon. Assess. Group, Basel, Switz.
Bogdanova B, Fender I, Takats E. 2018. The ABC of bank PBRs. *BIS Q. Rev.* 2018(Mar.):81–95
Boyarchenko N, Gupta P, Steele N, Yen J. 2016. *Trends in credit market arbitrage*. Staff Rep. 784, Fed. Reserve Bank N.Y., NY
Breuer P. 2000. *Measuring off-balance sheet leverage*. Work. Pap. WP/00/22, Int. Monet. Fund, Washington, DC
Brunnermeier MK, Sannikov Y. 2014. A macroeconomic model with a financial sector. *Am. Econ. Rev.* 104(2):379–421
Carlson M, Shan H, Warusawitharana M. 2013. Capital ratios and bank lending: a matched bank approach. *J. Financ. Intermed.* 22(4):663–87
CGFS (Comm. Glob. Financ. Syst.). 2014. *Market-making and proprietary trading: industry trends, drivers and policy implications*. Rep. 52, Bank Int. Settl., Basel, Switz.
CGFS (Comm. Glob. Financ. Syst.). 2016. *Fixed income market liquidity*. Rep. 55, Bank Int. Settl., Basel, Switz.
Choi J, Huh Y. 2017. *Customer liquidity provision: implications for corporate bond transaction costs*. Finance Econ. Discuss. Ser. Work. Pap. 2017–116, Fed. Reserve Board, Washington, DC
Coval J, Jurek J, Stafford E. 2009. The economics of structured finance. *J. Econ. Perspect.* 23(1):3–25
Dudley W. 2016. *Market and funding liquidity: an overview*. Presented at the 21st Annual Federal Reserve Bank and Financial Markets Conference, Atlanta, May 1–3
Federal Deposit Insurance Corporation. 2017. *Global capital index: capitalization ratios for global systemically important banks*. Rep., Fed. Depos. Insur. Corp., Washington, DC

Fender I, Lewrick U. 2015. Shifting tides–market liquidity and market-making in fixed income instruments. *BIS Q. Rev.* 2015(Mar.):97–109

Fender I, Lewrick U. 2016. *Adding it all up: the macroeconomic impact of Basel III and outstanding reform issues*. Work. Pap. 591, Bank Int. Settl., Basel, Switz.

FSB (Financ. Stab. Board). 2014. *Key attributes of effective resolution regimes for financial institutions*. Rep., FSB, Washington, DC

FSB (Financ. Stab. Board). 2015. *Principles on loss-absorbing and recapitalization capacity of G-SIBs in resolution*. Rep., FSB, Washington, DC

FSB (Financ. Stab. Board). 2017. *Global shadow banking monitoring report 2016*. Rep., FSB, Washington, DC

FSB (Financ. Stab. Board). 2018. *Global shadow banking monitoring report 2017*. Rep., FSB, Washington, DC

Furlong FT, Keeley MC. 1989. Capital regulation and bank risk-taking: a note. *J. Bank. Finance* 13(6):883–91

Gambacorta L, Shin HS. 2018. Why bank capital matters for monetary policy. *J. Financ. Intermed.* 35:17–29

Geanakoplos J. 2009. The leverage cycle. In *NBER Macroeconomic Annual*, Vol. 24, ed. D Acemoglu, K Rogoff, M Woodford, pp. 1–65. Chicago: Univ. Chic. Press

Goel T, Lewrick U, Tarashev N. 2017. *Bank capital allocation under multiple constraints*. Work. Pap. 666, Bank Int. Settl., Basel, Switz.

Gorton G, Metrick A. 2012. Securitized banking and the run on repo. *J. Financ. Econ.* 104(3):425–51

He Z, Krishnamurthy A. 2013. Intermediary asset pricing. *Am. Econ. Rev.* 103(2):732–70

Hendershott T, Madhavan A. 2015. Click or call? Auction versus search in the over-the-counter market. *J. Finance* 70:419–47

Liquidnet. 2017. *Access to liquidity dominates decision-making process for fixed income firms*. Press Release, July 20

IMF (Int. Monet. Fund). 2009. Restarting securitization markets: policy proposals and pitfalls. In *Global Financial Stability Report*, pp. 77–116. Washington, DC: Int. Monet. Fund

IMF (Int. Monet. Fund). 2011. Toward operationalizing macroprudential policies: When to act? In *Global Financial Stability Report*, pp. 103–147. Washington, DC: Int. Monet. Fund

IMF (Int. Monet. Fund). 2013. *Key aspects of macroprudential policy*. Policy Pap., IMF, Washington, DC

IMF (Int. Monet. Fund). 2014. *Staff guidance note on macroprudential policy*. Policy Pap., IMF, Washington, DC

IMF (Int. Monet. Fund). 2015. Market liquidity–resilient or fleeting. In *Global Financial Stability Report*, pp. 49–82. Washington, DC: Int. Monet. Fund

IMF (Int. Monet. Fund), FSB (Financ. Stab. Board), BIS (Bank Int. Settl.). 2016. *Elements of effective macroprudential polices: lessons from international experience*. IMF-FSB-BIS Rep., Washington, DC

Kapan T, Minoiu C. 2018. Balance sheet strength and bank lending: evidence from the global financial crisis. *J. Bank. Finance* 92:35–50

Keeley MC. 1990. Deposit insurance, risk, and market power in banking. *Am. Econ. Rev.* 80(5):1183–200

Leising M, Smith M. 2018. Electronic bond trading gains ground. *Bloomberg*, Feb. 15. **https://www.bloomberg.com/news/articles/2018-02-15/electronic-bond-trading-gains-ground-as-market-finally-matures**

McPartland K. 2017. *Technology transforming a vast corporate bond market*. Greenwich Assoc. Exec. Summ., Oct. 31, Stamford, CT

Meli J, Gupta S. 2016. *Behavior modification*. Barclays Credit Res. Rep., Wilmington, DE

Mizrach B. 2015. *Analysis of corporate bond liquidity*. Res. Note, Off. Chief Econ., FINRA, Washington, DC

Ong LL, ed. 2014. *A Guide to IMF Stress Testing: Methods and Models*. Washington, DC: Int. Monet. Fund

Shin HS. 2009. Securitization and financial stability. *Econ. J.* 119(536):309–32

Shin HS. 2016. *Market liquidity and bank capital*. Presented at the Perspectives on Liquidity and Policy Practices, AQR Asset Management Institute, London Bus. Sch., UK, Apr.

Singh M. 2017. *Collateral reuse and balance sheet space*. Work. Pap. 17/113, Int. Monet. Fund, Washington, DC

Singh M, Alam Z. 2018. *Leverage–a broader view*. Work. Pap. 18/62, Int. Monet. Fund, Washington, DC

Thakor AV. 2014. Bank capital and financial stability: an economic trade-off or a Faustian bargain? *Annu. Rev. Financ. Econ.* 6:185–223

Trebbi F, Xiao K. 2018. Regulation and market liquidity. *Manag. Sci.* In press. **https://doi.org/10.1287/mnsc.2017.2876**

Wenying J, Pritsker M. 2008. *The impacts of securitization on US bank holding companies*. Presented at the 44th Annual Conference on Bank Structure and Competition, Federal Reserve Bank, Chicago, May 14

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