

Incorporating Liquidity Shocks and Feedbacks in Bank Stress Tests

By Jill Cetina¹

Stress testing can be an important tool to assess the health of the financial system. U.S. supervisory stress tests measure the impact of hypothetical credit and collateral shocks on banks' capital ratios. Supervisors have also begun liquidity stress tests to evaluate the effect of funding shocks on banks. This brief discusses how four types of shocks that can affect banks could be incorporated into stress tests and shows that shocks can affect regulatory ratios for capital and liquidity simultaneously. Additionally, a bank's responses to a binding regulatory ratio in stress can spread shocks to other banks.

Banks perform several important functions for the economy. They extend credit, provide liquidity, and transform short-term liabilities, such as deposits, into long-term assets, such as mortgages. All of these functions expose banks to potential channels of stress. U.S. stress tests since the 2007-09 financial crisis have largely focused on the effect on capital from stresses on the credit and collateral channels. Stress tests pose a theoretical shock in the form of credit losses or market price declines and then model the impact on banks' regulatory capital ratios, which measure banks' solvency.

The principal U.S. supervisory stress tests are the Comprehensive Capital Analysis and Review and Dodd-Frank Act stress tests, but neither considers potential risks in the funding or liquidity channels.² "Funding channel" refers to risks from changes in the price, term, mix or, in the extreme, ongoing availability of funding to the bank. "Liquidity channel" refers to unanticipated growth in a bank's balance sheet from commitments, a backup in the loan securitizations pipeline, or other issues.

The financial crisis contained examples of funding stress and liquidity stress contributing to capital losses — as

opposed to capital losses arising solely from credit losses — at banks such as Wachovia, Lehman Brothers, RBS, and Dexia. These funding and liquidity stresses included draws on loan commitments; backups in the collateralized loan obligation pipeline; asset fire sales; downgrades in credit ratings that pressured banks' funding costs, funding availability, and solvency; and illiquid banks pulling funding from other banks.

A third supervisory stress test is the Federal Reserve's Comprehensive Liquidity Assessment and Review, which assesses the impact of a market stress on banks' liquidity. However, these capital and liquidity stress tests are not integrated into a common framework. Building an integrated stress test for liquidity and solvency is challenging. Integration between liquidity and solvency risks in many supervisory stress tests is limited because of the difficulty in defining possible channels for interaction to occur.

This brief sets out some ways to think about a more integrated approach to stress tests that would include funding and liquidity shocks as well as the possible second-round effects of a bank's deleveraging. To deleverage means to sell assets quickly. This brief illustrates how different shocks

Figure 1. High-level Summary of Key Bank Regulatory Ratios Under Basel III

Risk-based Capital Ratio	Leverage Ratio	Liquidity Coverage Ratio	Net Stable Funding Ratio
$\frac{\text{Common equity Tier 1}^a}{\text{Risk-weighted assets}}$	$\frac{\text{Tier 1 capital}^b}{\text{Total exposure (all assets and off-balance-sheet items)}}$	$\frac{\text{High-quality liquid assets}^c}{\text{Net cash outflows over 30 days}}$	$\frac{\text{Available stable funding over the next year (including capital and deposits)}}{\text{Required stable funding (weights applied to bank assets and off-balance-sheet exposures)}}$

^a Common equity tier 1 capital consists primarily of shareholders' equity and retained earnings and is available to absorb unexpected losses in stress.

^b Tier 1 capital consists of common equity Tier 1 capital as well as some additional elements, such as cumulative perpetual preferred shares and trust preferred securities, which are restricted to 25 percent of Tier 1.

^c High-quality liquid assets are the types of assets permitted in the liquidity coverage ratio and net stable funding ratio calculations. Level 1 assets refer to the highest quality and most liquid instruments, such as excess central bank reserves and Treasury securities. Level 2 assets are less liquid and subject to discounts on their market values to reflect these differences. Examples of Level 2 assets include agency mortgage backed securities, corporate bonds, and equities issued by nonfinancial firms. In addition to the types of assets, to qualify as HQLA, the securities also need to be unencumbered and under the operational control of the bank's treasurer so they can be used to meet the bank's liquidity needs.

Source: OFR analysis

can result in banks engaging in transactions to maintain compliance with regulatory ratios and what the potential implications of such transactions could be on other banks through deleveraging.

Regulatory Ratios

Large U.S. banks must comply with multiple regulatory constraints (see **Figure 1**). In the next few years, capital standards — most prominently the risk-based capital ratio and the leverage ratio³ — will be joined by new liquidity standards, the liquidity coverage ratio and net stable funding ratio.⁴ Minimum capital standards were reformed and liquidity standards developed by the Basel Committee on Banking Supervision, an international forum of bank supervisors. These new global capital and liquidity standards for banks are collectively referred to as Basel III.

The potential interactions of these regulatory constraints are not fully understood. In the extreme, banks seeking to avoid a breach in one ratio could create undesirable consequences for financial stability, such as deleveraging and asset fire sales. Even less extreme actions by banks could create systemic feedback effects, because banks might try adjustments to affect cashflows to minimize the risk of breaching a regulatory ratio. For example, banks might reduce interbank lending, reduce long-term lending to corporations and households, or hoard collateral. Understanding potential bank responses to the threat of breaching a required regulatory ratio is important, because an individual bank's response to stress could place stress on other banks and spread shocks throughout the financial system.

Impact of Potential Shocks on Bank Regulatory Ratios

This section discusses shocks related to credit, funding, liquidity, and collateral. Figure 2 shows a typology of shocks along with key regulatory ratios under Basel III that can become binding on banks when the shocks are realized. Figure 2 yields two important observations. First, the net stable funding ratio is sensitive to all four types of shocks because it incorporates both capital and funding. Second, the addition of liquidity shocks to the suite of supervisory scenarios would provide more comprehensive coverage of risks to a firm's capital adequacy in stress because a bank's risk-based capital ratio or leverage ratio could be breached from unanticipated balance sheet growth.

Credit Shock. Supervisory stress tests primarily focus on the credit channel and the associated impact from a credit shock on bank's risk-based capital ratios. However, credit shocks also directly affect banks' leverage ratios and net stable funding ratios. Specifically, capital losses or higher loan loss provisions could reduce capital and worsen banks' leverage ratios.⁵ Reductions to capital will also affect banks' available stable funding and lower their net stable funding ratios. The empirical effect on funding costs and market access remains to be seen of a bank breaching its capital conservation buffer, a new element to capital requirements for U.S. banks. Under the final U.S. capital rule, banks must cut their dividends if they breach the capital conservation buffer, an additional 250 basis point cushion on top of the minimums assessed under the Comprehensive Capital Analysis and Review. Cuts to dividends may affect banks' share prices and share price volatility, which could negatively affect market

Figure 2: Shocks and Key Regulatory Ratio Constraints

Shocks	Credit	Funding	Liquidity	Collateral
	Risk-weight migration, credit loss hits capital, increase in provisions	Maturities shorten, mix changes, funding run-off or “run-in”	Commitments drawn, securitization backup, liquidity puts exercised	Securities prices fall
Regulatory Ratio Constraints Affected	Risk-based Capital Ratio		Risk-based Capital Ratio	Risk-based Capital Ratio
	Leverage Ratio	Leverage Ratio	Leverage Ratio	
		Liquidity Coverage Ratio	Liquidity Coverage Ratio	Liquidity Coverage Ratio
	Net Stable Funding Ratio	Net Stable Funding Ratio	Net Stable Funding Ratio	Net Stable Funding Ratio

Sources: Basel III regulatory ratios, OFR analysis

perceptions of a bank’s creditworthiness and affect its access to funding.

Funding Shocks. Funding shocks can take multiple forms. Shocks to banks’ funding costs can affect bank earnings. Changes in the maturity or composition of banks’ funding can cause noncompliance with the liquidity coverage ratio or net stable funding ratio. More repurchase agreements or even a surge in deposits to a relatively healthy bank during a crisis could adversely affect compliance with the leverage ratio. Figure 2 shows that risk-based capital is not directly affected in a funding shock, although deleveraging could negatively affect capital.

Liquidity Shocks. Liquidity shocks, such as a backup in a bank’s pipeline of collateralized loan obligations, mortgage putbacks, or the drawdown of loan commitments, can adversely affect risk-based capital ratio, net stable funding ratio, and leverage ratio as a result of balance sheet growth. As a practical matter, banks generally respond to unanticipated balance sheet growth by making use of short-term wholesale funding that could put firms at risk of breaching the liquidity coverage ratio as well.

Collateral Shocks. Many of the core functions and transactions that banks perform require collateral, and the effect of a shock to the collateral channel can have wide-reaching implications on several regulatory ratios. Specifically, changes under Basel III allow unrealized gains and losses to flow through to the risk-based capital ratio, and high-quality liquid assets (HQLA) are marked-to-market under the liquidity coverage ratio and net stable funding ratio. Although the Comprehensive Capital Analysis and Review applies a shock to the trading portfolio of six large banks, mark-to-market shocks are not applied to banks’ available-for-sale securities holdings. Growth in the size of U.S. banks’ securities holdings in recent years coupled with changes in fixed-income trading, such as reduced

market making and more high-frequency trading, and less liquidity in fixed-income markets may suggest that the collateral channel’s possible effect on banks’ available-for-sale portfolios should be the subject of greater attention in supervisory stress tests (see Chapter 2 of the OFR’s *2014 Annual Report*).

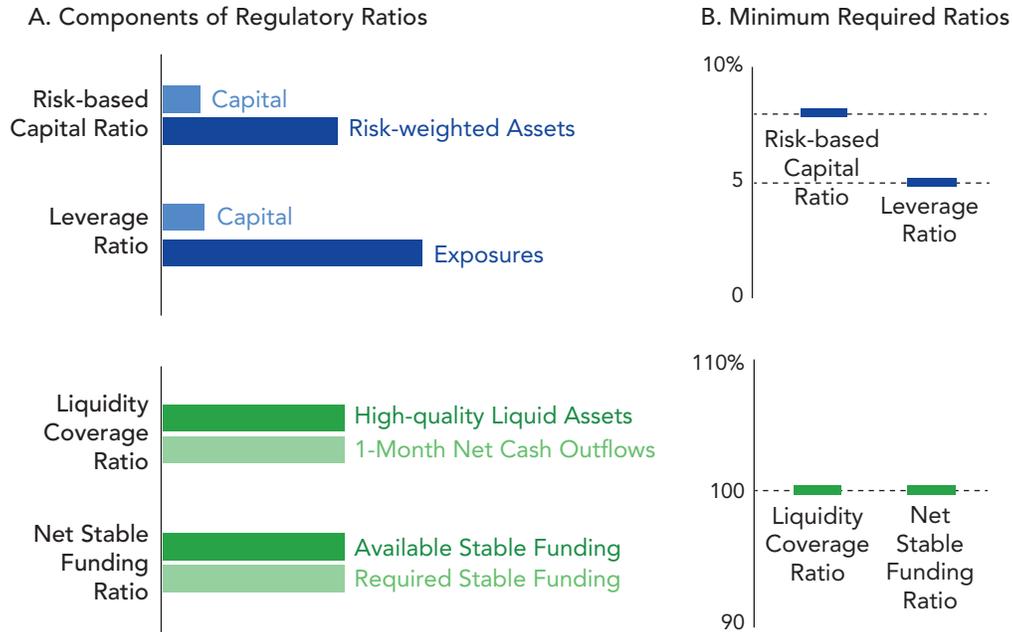
Possible Bank Responses to Binding Regulatory Ratios

Regulatory oversight of banks focuses on several measurements with multiple variables: the risk-based capital ratio (comparing risk-weighted assets to capital), the leverage ratio (comparing total on- and off-balance-sheet exposures to capital), and the liquidity coverage ratio and net stable funding ratio, which compare the stock of HQLA to net cash outflows on a short-term basis and a longer-term measure that evaluates the structural balance sheet liquidity of a bank. Figure 3 illustrates a simplified hypothetical composition of the regulatory ratios under normal conditions and where these ratios become binding.

Figure 4 illustrates the effect of a binding risk-based capital ratio constraint on a bank’s balance sheet. The impact of a credit, liquidity, or collateral shock could lead to an increase in risk-weighted assets or a decrease in capital, causing the risk-based capital ratio to become binding and potentially fall below the 8 percent regulatory minimum. To restore the risk-based capital ratio to prescribed levels, the bank must either raise capital or deleverage (see **Figure A1** in Appendix A, for a detailed depiction of bank response options).

Figure 5 explores the impact of a funding shock on a bank’s liquidity coverage ratio. Under normal circumstances, the ratio of HQLA stock to one-month net cash outflows is, at minimum, 1 to 1. However, if a funding

Figure 3. Bank Regulatory Ratios Under Normal Conditions



Source: OFR analysis

shock caused a maturity shortening or an adverse change in the bank’s funding mix, the bank’s one-month net cash outflow would rise. Alternatively, if a collateral shock were to occur affecting securities markets, the value of the bank’s stock of HQLA could fall. In these scenarios, the bank’s liquidity coverage ratio would fall below the regulatory minimum of 100 percent. The bank could respond by either changing its funding mix, extending the maturity of its funding (if able) or by selling less-liquid assets to obtain cash (see **Figure A3** in Appendix A, for a detailed depiction of bank responses to liquidity coverage ratio constraints).

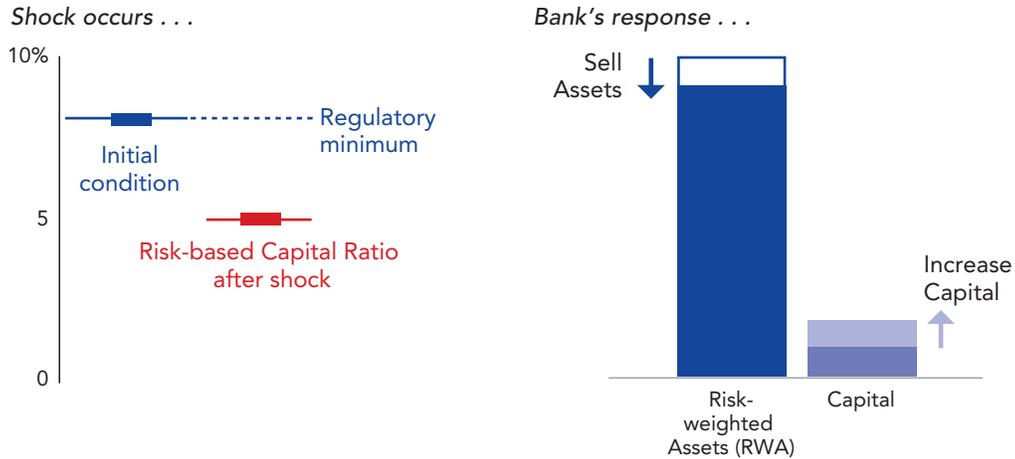
In theory, banks always have options before deleveraging (see **Figure 5**). For supervisors, figures 4 and 5 also illustrate whether assuming alternative options, such as the bank raising capital, extending the maturity of funding, or improving its funding mix, is plausible under the stress test scenario. For breaches of any of the four key regulatory ratios — risk-based capital ratio, leverage ratio, liquidity coverage ratio, and net stable funding ratio — deleveraging is a last-ditch option.

Although the channel of distressed selling has received extensive attention as a means of systemic propagation, less attention has focused on the channels that may spark asset fire sales. Any of the four risk channels can lead to a breach of one or more of the four Basel III ratios and potentially result in a bank’s fire sale of assets.

If a bank has no options other than to deleverage, the deleveraging strategy might vary depending on which regulatory ratio is most at risk of being breached (see **Figure 6**). For example, when facing risk-based capital ratio as a constraint, a bank can sell non-zero risk-weighted securities, such as Level 2 assets, to reduce risk-weighted assets as a first line of defense. By contrast, a bank cannot improve its leverage ratio through asset sales because cash counts as part of total exposures, the leverage ratio’s denominator. Banks can only deleverage on-balance-sheet assets to improve the leverage ratio if they can also retire outstanding liabilities, for example, through exercising a call option and using the cash to retire a bond. A bank could quickly and easily improve its leverage ratio denominator by shedding off-balance-sheet items, such as repurchase agreements, derivatives, and loan commitments.

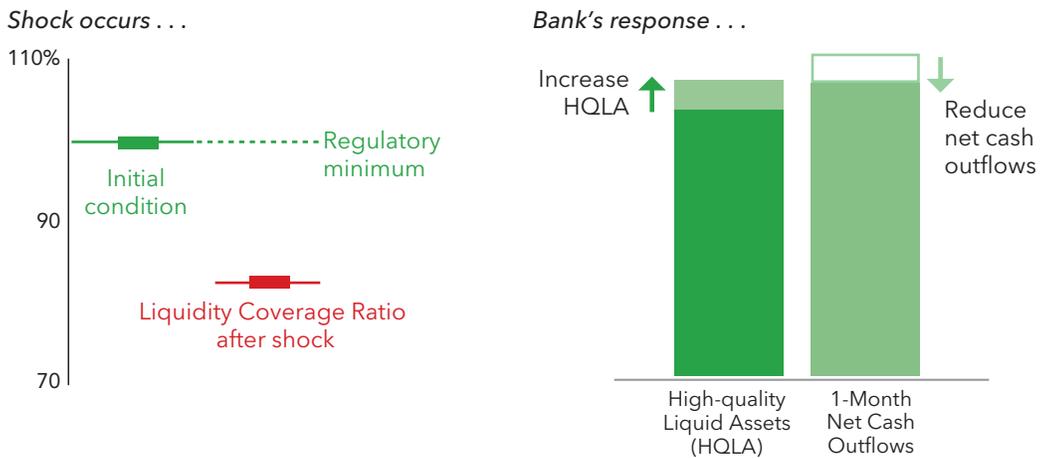
Although the liquidity coverage ratio and net stable funding ratio encourage banks to hold substantial amounts of Level 1 HQLA, a bank’s sale of Level 1 assets would not improve either of these regulatory ratios because Level 1 HQLA is marked-to-market and is fully credited as if it were cash in both regulatory calculations. A liquidity-constrained firm would sell its assets that are not Level 1 first, if forced to deleverage. Similarly, a bank facing a risk-based capital constraint would also tend to sell non-Level-1 assets, which generally have higher risk weights. If facing constraints, a bank would presumably sell its most liquid non-Level-1 assets first.

Figure 4. Bank Balance-sheet Response to Risk-based Capital Ratio Constraints



Source: OFR analysis

Figure 5. Bank Balance-sheet Response to Liquidity Coverage Ratio Constraints



Source: OFR analysis

Figure 6. Hypothetical Bank Deleveraging Strategies by Regulatory Ratio

CAPITAL-BASED RATIOS

Risk-based Capital Ratio	Leverage Ratio
<ul style="list-style-type: none"> - Sell Level 2 assets - Cut interbank loans or reverse repos - Sell noncore assets - Do not roll over maturing loans 	<ul style="list-style-type: none"> - Cut repos - Cut derivative positions - Cut commitments (selling assets doesn't help as cash counts in denominator).

FUNDING-BASED RATIOS

Liquidity Coverage Ratio	Net Stable Funding Ratio
<ul style="list-style-type: none"> - Sell Level 2 assets - Cut interbank loans or reverse repos - Reduce maturity of other loans 	<ul style="list-style-type: none"> - Sell Level 2 assets - Sell non-HQLA or noncore assets

Source: OFR analysis

Conclusions

The Comprehensive Capital Analysis and Review and Dodd-Frank Act stress tests are largely focused on credit and collateral shocks, and the resulting effects on individual banks' capital and leverage ratios. It could be argued that liquidity risk and contagion are present in the shocks captured in banks' 2008 data (and implicitly in existing supervisory stress tests). However, if the positions exposed to liquidity risk and contagion channels were to be different in a future crisis, risks could be understated.

U.S. banking supervisors' implementation of heightened prudential standards are vital to strengthening the ability of the banking system to withstand shocks. However, during stress events, compliance with these ratios could cause a feedback loop that pushes a bank toward deleveraging, which could further stress other banks and the broader financial system. For bank supervisors formulating stress tests, consideration of these second-round effects and the impact of the types of regulatory ratio breaches could help improve understanding of how shocks are spread. The

channel a shock originates from influences which regulatory ratio would be breached. The ratio, in turn, can affect how the bank's response is transmitted to other banks in the system.

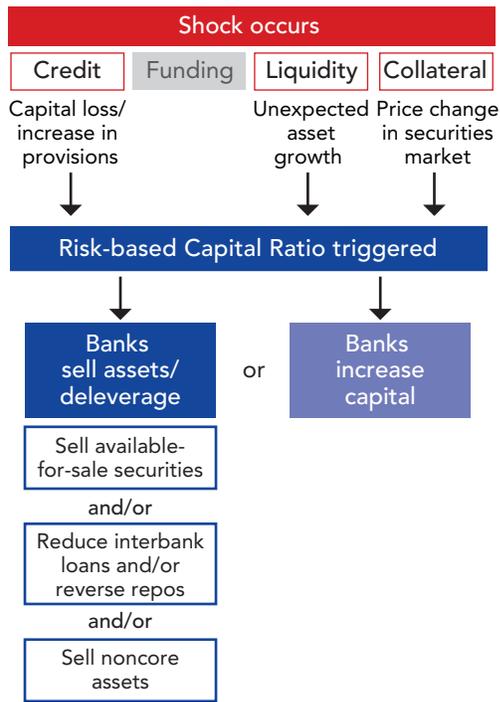
Taking into account funding and liquidity shocks, the new Basel liquidity ratios, and potential spillover effects onto other banks from a stressed bank's behavior could strengthen the stress testing regime for large U.S. banks. Including in supervisory stress tests a liquidity shock scenario and the net stable funding ratio, once a U.S. rule is adopted, could be helpful. By contrast, spillovers caused by bank behavior in stress could be more usefully considered in a complementary but separate macroprudential stress testing exercise. Although these suggestions are arguably ambitious, they are consistent with Basel principles that recommend banks take into account systemwide interactions and feedback effects, and consider interactions between liquidity and funding.⁶

Endnotes

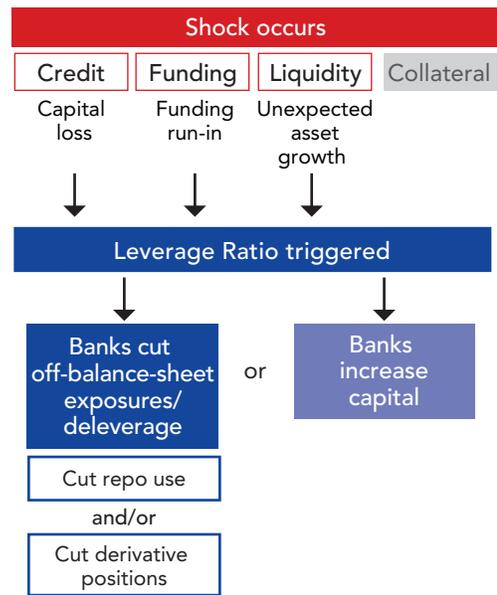
- ¹ Jill Cetina, Associate Director for Policy Studies (Jill.Cetina@treasury.gov). Thanks to John McDonough for valuable assistance in the preparation of this piece and to Greg Feldberg, Paul Glasserman, David Rappoport, and members of the Liquidity Stress Testing workgroup of the Basel Committee on Banking Supervision's Research Task Force for valuable comments on prior drafts.
- ² The Comprehensive Capital Analysis and Review and the Dodd-Frank Act stress tests assess the capital position and capital planning of large banks under several scenarios: see Board of Governors of the Federal Reserve System, *Capital Plan and Stress Test Rules*, Final Rule, Federal Register 79, No. 207, October 27, 2014 (available at www.gpo.gov/fdsys/pkg/FR-2014-10-27/pdf/2014-25170.pdf, accessed July 21, 2015); and the Dodd-Frank Act, Public Law 111-203, Section 165, July 21, 2010, Government Printing Office, Washington: Dodd-Frank Act, 2010.
- ³ Large U.S. banks with \$700 billion in assets or more than \$10 trillion in assets under custody are also subject to an enhanced supplemental leverage ratio of 5 percent for the consolidated bank holding company and 6 percent for their affiliated bank charters. See Office of the Comptroller of the Currency, Board of Governors of the Federal Reserve System, and the Federal Deposit Insurance Corporation, *Regulatory Capital Rules: Regulatory Capital, Revisions to the Supplementary Leverage Ratio*, Final Rule, Federal Register 79, No. 187, September 26, 2014, p. 57727 (available at www.gpo.gov/fdsys/pkg/FR-2014-09-26/pdf/2014-22083.pdf, accessed July 21, 2015). For the risk-based capital ratio, see Office of the Comptroller of the Currency and Board of Governors of the Federal Reserve System, *Regulatory Capital Rules: Regulatory Capital, Implementation of Basel III, Capital Adequacy, Transition Provisions, Prompt Corrective Action, Standardized Approach for Risk-weighted Assets, Market Discipline and Disclosure Requirements, Advanced Approaches Risk-Based Capital Rule, and Market Risk Capital Rule*, Final Rule, Federal Register 78, No. 198, October 11, 2013 (available at www.gpo.gov/fdsys/pkg/FR-2013-10-11/pdf/2013-21653.pdf, accessed July 21, 2015).
- ⁴ In October 2014, U.S. regulators adopted a final rule implementing the liquidity coverage ratio standard established by the Basel Committee on Banking Supervision (BCBS). See Office of the Comptroller of the Currency, Board of Governors of the Federal Reserve System, and the Federal Deposit Insurance Corporation, *Liquidity Coverage Ratio: Liquidity Risk Measurement Standards*, Final Rule, Federal Register 79, No. 197, October 10, 2014 (available at www.gpo.gov/fdsys/pkg/FR-2014-10-10/pdf/2014-22520.pdf, accessed July 21, 2015). U.S. regulators have yet to implement the net stable funding ratio standard, which was finalized by the BCBS in October 2014. See Basel Committee on Banking Supervision, *Basel III: The Net Stable Funding Ratio*, Bank for International Settlements, Basel, October 2014 (available at <http://www.bis.org/bcbs/publ/d295.pdf>, accessed July 21, 2015).
- ⁵ Loan loss reserves can be counted in Tier 2 capital. Tier 2 capital includes less loss absorbing instruments such as subordinated debt and loan loss reserves. The inclusion of Tier 2 capital in a bank's capital ratio is limited.
- ⁶ See Basel Committee on Banking Supervision, *Principles for sound stress testing practices and supervision*, Bank for International Settlements, May 2009 (available at <http://www.bis.org/publ/bcbs155.pdf>, accessed July 21, 2015).

Appendix A. Bank Responses to Key Regulatory Ratio Constraints After a Shock

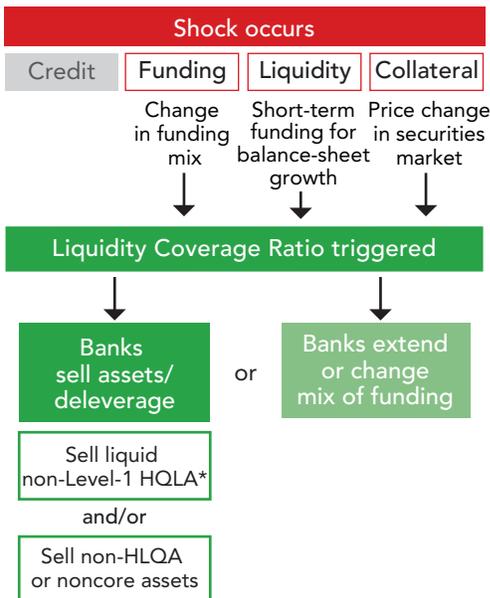
A1. Risk-based Capital Ratio Constraint



A2. Leverage Ratio Constraint



A3. Liquidity Coverage Ratio Constraint



A4. Net Stable Funding Ratio Constraint

