The Recourse Rule, Regulatory Arbitrage, and the Financial Crisis

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Abstract

In November 2001, bank regulators finalized the so-called Recourse Rule, which lowered risk weights from 1 to 0.5 for A-rated and to 0.2 for AAA- and AA-rated private-label securitization tranches. After the rule change, on average, securitization-active bank holding companies with at least $50 billion in assets increased their holdings of the highly rated tranches, relative to total assets and Tier 1 capital. Smaller holding companies, on average, show little variation in their holdings of highly rated tranches. Holding companies with positive holdings of private-label securitizations also experienced greater declines in distance-to-default after Q1 2008, but not before then.

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The Recourse Rule, Regulatory Arbitrage, and the Financial Crisis

Stephen Matteo Miller

After the Latin American debt crisis of 1982, Congress passed the International Lending Supervision Act of 1983 (Public Law 98-181; 97 Stat. 1278), which encouraged regulators to find a multilateral way to increase capital requirements that would not put US banks at a competitive disadvantage (see Kapstein 1991, 1994). That process culminated in the 1988 Basel Accords (often referred to as Basel I). US banks were expected to comply with Basel I by 1992, but officials and regulators subsequently began fine-tuning regulatory capital requirements in response to the perceived shortcomings of the initial requirements (see Barth and Miller 2017a). Meanwhile, in the years leading up to the 2007–2009 crisis, some academics observed that regulatory capital standards could create arbitrage opportunities (see Merton 1995, Jones 2000, and Brealey 2006). More recent research shows that while banks satisfied regulatory capital requirements, which rely on book values, market valuations of capital plunged well below book values during the crisis (see Flannery 2014; Flannery and Giacomini 2015; and Barth and Miller 2017a). Other researchers have pointed out that the risk-weights found in regulatory capital requirements have little relationship with firm performance and risk.

For instance, Demirgüç-Kunt, Detragiache, and Merrouche (2013) find a stronger empirical relationship between stock returns and non-risk-based measures of capital than between risk-based measures. Similarly, Acharya, Engle, and Pierret (2014) find no cross-sectional relationship between risk-weighted measures of capital and market risk. Hogan (2015) and Hogan and Meredith (2016) find that the non-risk-based leverage ratio better predicts measures of bank risk than risk-based capital measures.

In what follows, I show how some banks increased their holdings of some of the very financial products that lay at the heart of the recent banking crisis after a key regulatory change reduced capital requirements for those financial products. I also examine whether those holdings were associated with greater insolvency risk.

The regulatory change I focus on is the so-called Recourse Rule. "Recourse" in this context refers to arrangements in which bank holding companies retain any credit risk associated with sales of assets, such as during the process of securitizing those assets.[1] The Recourse Rule was finalized on November 29, 2001, by the Federal Reserve (Fed), the Federal Deposit Insurance Corporation (FDIC), and the Office of the Comptroller of the Currency (OCC). The final rule, under development since 1994, suggested lowering risk weights for AAA- and AA-rated "private-label" mortgage-backed securities (MBS) and collateralized debt obligation (CDO) tranches originated by large banks to 0.2 in line with government-sponsored enterprise (GSE)–originated MBS. For A-rated tranches, the risk weights equaled 0.5, while lower-rated tranches would be assigned higher risk weights. Friedman and Kraus (2011) point out that the rule was designed to encourage securitization without encouraging risk taking, and also that the Recourse Rule risk weights were nearly identical to the 2004 Basel II risk weights. So, although US regulators never officially adopted Basel II in its entirety, by finalizing the Recourse Rule they adopted Basel II risk weights for private-label securitizations.

Lowering risk weights effectively lowers regulatory capital requirements because the risk weights are multiplied by the regulatory capital requirement. For instance, an 8 percent capital requirement falls to 4 percent, 1.6 percent, and 0 percent for assets with risk weights of 0.5, 0.2,

[1] The "Recourse Rule" refers to the final rules covering "Risk-Based Capital Guidelines; Capital Adequacy Guidelines; Capital Maintenance: Capital Treatment of Recourse, Direct Credit Substitutes and Residual Interests in Asset Securitizations."

and 0, respectively. Bankers may wish to increase leverage by relying on more debt and less equity financing, and they might do so by holding assets with lower risk weights. Lower risk weights allow banks to operate with less capital than they would have had if the capital ratios had been measured relative to total assets. This, in turn, reduces the banks' ability to withstand reductions in net worth following declines in asset values.

The Recourse Rule took effect on January 1, 2002, and banks were allowed to delay the application until December 2002. However, the rule also allowed banks already holding such tranches to apply the new rule immediately on November 29, 2001. Roughly six years later, the recent crisis began to unfold. In response to the crisis, Congress passed the Wall Street Reform and Consumer Protection Act (Public Law 111-203; 124 Stat. 1376), or the Dodd-Frank Act. Dodd-Frank established that banks with at least $50 billion in total assets were systemically important financial institutions, or SIFI banks. The SIFI designation indicates that regulators believe that these banks' failure would have the potential to trigger a crisis in the financial system; in other words, the banks could be considered "too big to fail." Yet if distressed assets explain bank insolvency, then perhaps a more appropriate designation would have focused on bank assets rather than on bank size.

I find that on average, SIFI banks began increasing their holdings of highly rated tranches after the Recourse Rule was finalized in the fourth quarter (Q4) of 2001, until the third quarter (Q3) of 2007. However, that finding appears to mask that it was primarily SIFI banks engaged in securitizing assets that increased their holdings. Erel, Nadauld, and Stulz (2014) explain that securitizing banks may have incentives to hold the highest-rated tranches rather than the traditional equity tranche. A key reason to hold the highest-rated tranches is having "skin in the game," but other reasons exist as well. Erel, Nadauld, and Stulz (2014)

describe this increased demand from banks that originated securitized assets as the "securitization by-product" effect.

I also find that for securitizing SIFI banks on average, their holdings of highly rated tranches approached the size of their regulatory capital buffer leading up to the crisis. Thus, if the highly rated tranche holdings of these banks suffered large losses, the banks could have experienced the largest declines in their capital. Highly rated tranches could therefore have been associated with changes in bank insolvency risk because large losses on the market value of these assets would also have resulted in lossed on the market value of bank capital.

I measure changes in bank insolvency risk as the quarterly first differences of bank holding company distance-to-default, computed as the natural log of the z-score (see Roy 1952). The z-score is appropriate because it is computed as the sum of return on assets and the equity-to-asset ratio, divided by the asset return standard deviation, which reflects whether bank losses exceed the equity buffer (see Laeven and Levine 2009). I find that for most of the sample from Q4 2001 to Q4 2007, bank holdings of the highly rated tranches were not associated with changes in the natural log of the z-score. It is only in the period from Q1 2008, when the Fed introduced the Term Securities Lending Facility (TSLF) to purchase the risky assets, through Q1 2009 that holdings of the highly rated tranches become associated with large declines in distance-to-default, not before then.

Although the results here do not establish causality, they are consistent with the view that an unintended consequence of the Recourse Rule was that it encouraged securitizing banks, especially the largest ones, on average to hold more of the assets that turned out to be at higher risk of distress. That's even though the rule was intended to lower risk-taking. Holdings of these assets, therefore, can shed light on how insolvency risk could have spread throughout

the banking system during the financial crisis. I begin by briefly recounting the origins of regulatory capital requirements in the United States, including the Recourse Rule. Next, I show how bank asset allocations evolved before and after the Recourse Rule. Then I provide evidence of how holdings of highly rated tranches were associated with changes in bank solvency, before concluding.

A Brief Chronology of Regulatory Capital Requirements and Why They Might Matter

Table 1 (page 32) summarizes some of the regulatory changes that might relate to bank holdings of the highly rated, private-label securitization tranches, as described at the beginning of this paper.

The Recourse Rule and Capital Rules for Asset-Backed Commercial Paper Programs

After the 1988 Basel Accords, guidelines for US banks established that capital should equal 8 percent of total assets adjusted for risk through the use of risk weights (see table 6 in Barth and Miller 2017a). The guidelines defined capital as either Tier 1, primarily consisting of equity, or Tier 2, which could include subordinated debt.[2] The guidelines further established that Tier 1 capital must equal at least 4 percent of risk-weighted assets, whereas Tier 2 capital must not exceed 100 percent of Tier 1 capital.

Although regulatory capital requirements were set at 8 percent of total assets, assets were assigned to various risk buckets that had specific risk weights, which accordingly varied capital requirements. For instance, some assets, such as mortgages, had a risk weight of 0.5, which

[2] Tier 1 capital includes common equity capital, noncumulative perpetual preferred stock, and minority interests in equity capital accounts of consolidated subsidiaries, minus goodwill, other intangible and deferred tax assets disallowed, and any other amounts deducted as determined by the bank's federal supervisor. Tier 2 capital includes cumulative perpetual preferred stock, convertible and subordinated debt and intermediate-term preferred stock, and the allowance for credit losses, such as loan and lease losses, and up to 45 percent of pretax net unrealized holding gains on available-for-sale equity securities with readily determinable fair values.

halved the capital requirement to only 4 percent. For some MBS originated by the GSEs, such as Federal Home Loan Mortgage Corporation (Freddie Mac) and Federal National Mortgage Association (Fannie Mae), the risk weight fell to only 0.2, which reduced the capital requirement to only 1.6 percent. Finally, some assets, such as short-term sovereign debt, had no risk weight, implying that they were not subject to capital requirements.

Friedman and Kraus (2011) and Erel, Nadauld, and Stulz (2014) point out that the potential for regulatory arbitrage grew further after the Fed, FDIC, and OCC finalized the Recourse Rule (66 Federal Register 59614, November 29, 2001). The risk weight for some private-label securitized tranches was at least 0.5 before the Recourse Rule, meaning that the capital requirement for holding those assets was at least 4 percent. The Recourse Rule lowered capital requirements for highly rated "private-label" AAA- and AA-rated tranches, from at least 4 percent to 1.6 percent. Capital requirements for A-rated tranches equaled 4 percent. For BBB-rated tranches, the risk weight equaled 1, implying an 8 percent capital requirement. For BB- and lower-rated tranches, the risk weight equaled 2, meaning that capital requirements increased to 16 percent.

Acharya, Schnabl, and Suarez (2013) identify a related reason for the growth in asset-backed commercial paper (ABCP) programs, used by some large banks to finance the creation of the highly rated, private-label securitization tranches. They observe that growth in ABCP programs stalled after the Enron disaster in late 2001. Regulators at the time considered raising capital requirements on assets held in the ABCP programs, an action that could have dampened the supply of highly rated tranches. Acharya, Schnabl, and Suarez (2013) suggest that the securitization could have been subsequently spurred on by the interim and final risk-based

capital rules concerning the treatment of assets in ABCP programs for the purpose of establishing capital adequacy.

In late 2003, bank regulators issued the interim rule (68 Federal Register 56530, October 1, 2003), which allowed banks to temporarily exclude the assets in their ABCP programs from the computation of risk-weighted assets used to assess capital adequacy. The interim rule applied to the reporting periods ending September 30, 2003; December 31, 2003; and March 31, 2004. On April 26, 2004, the interim rule was extended through July 1, 2004 (69 Federal Register 22382, April 26, 2004). Regulators subsequently issued a final rule to make the change permanent, and the finalized rule took effect on September 30, 2004 (69 Federal Register 44908, July 28, 2004). By excluding assets in ABCP programs from the measurement of risk-weighted assets, banks could operate with less capital, and the interim and final risk-based capital rules potentially stimulated the supply. The interim and final rules also could have stimulated demand, through the securitization by-product effect, whereby banks might hold the securities they create. Next, I summarize several hypotheses that concern how banks may have changed their balance sheets after the regulatory changes.

Hypotheses

Erel, Nadauld, and Stulz (2014) use data from a cross-section of bank holding companies just before the recent crisis to examine a variety of hypotheses, including regulatory arbitrage, to understand why some banks held so many highly rated securitizations.[3] They find no evidence to

[3] Merrill, Nadauld, and Strahan (2014) examine detailed asset-backed securities holdings in insurance company accounts between 2003 and 2007 and find that companies closer to the minimum regulatory capital for accounts subject to capital requirements held more structured finance securities. A related study by Nadauld and Sherlund (2013) shows how US investment banks adopted Basel II regulatory capital standards to satisfy European regulators of their capital adequacy. Although they have no data on holdings to test the hypothesis, given the similarities mentioned earlier between Basel II and the Recourse Rule, the effects for investment banks in principle might be similar to those examined here.

support common claims that banks holding more highly rated securitizations between 2002 and 2006 did so because they were "too big to fail," or because incentives within the banks encouraged them to take on more risk. Instead, they find evidence of a "securitization by-product" effect, as banks might have held the highly rated tranches for "skin in the game" to signal that they believed in the quality of the underlying collateral for several reasons.

When a bank holds securitization tranches, the equity tranche may not signal quality of the collateral, but the highly rated tranches may signal that the securitization is relatively safe. Holding highly rated tranches together with other investors may also signal quality of the underlying product. Another possible explanation, not associated with "skin in the game" motives, includes the notion that securitizing banks may have been familiar with the products, even if those banks did not originate particular tranches. Also, CDO originators would hold an inventory of asset-backed securities, and should the tranches take time to sell, that might result in banks' reporting increased tranche holdings.

Erel, Nadauld, and Stulz (2014) also hypothesize that some banks may have engaged in regulatory arbitrage to lower their regulatory capital burden. They find no evidence of a direct regulatory arbitrage effect, in the sense that banks that engaged in more leverage after the Recourse Rule did not increase their holdings of highly rated tranches. Still, the authors argue that to the extent that securitizing banks benefited most from regulatory arbitrage, their findings could still be consistent with the regulatory arbitrage hypothesis. By testing several hypotheses, I therefore examine whether the timing of the Recourse Rule would be consistent with any observed changes in bank holdings that would be consistent with regulatory arbitrage, and whether that might relate to the securitization by-product effect.

Hypothesis 1a: Did large banks increase highly rated tranche holdings after the Recourse Rule? After the interim or final risk-based capital rule?

Hypothesis 1b: Did securitizing banks hold more highly rated tranches after the Recourse Rule? After the interim or final risk-based capital rule?

Hypothesis 1c: Did large securitizing banks hold more highly rated tranches after the Recourse Rule? After the interim or final risk-based capital rule?

Given the post-crisis focus by regulators on bank size, hypothesis 1a aims to shed light on whether bank size might relate to bank holdings of the very assets that experienced distress during the crisis. Evidence supporting this hypothesis would merely indicate that a correlation rather than a causal relationship might exist between bank size and risky activity. Yet even if evidence exists to support hypothesis 1a, Erel, Nadauld, and Stulz (2014) have established that securitizing banks referenced in hypothesis 1b would have held more highly rated tranches than would large banks in general. Hypothesis 1b offers an alternative view that rather than bank size, risky activity should be the focus of reform. Finally, hypothesis 1c offers a way to examine whether size-based differences exist among securitizing banks.

The bank holding company data, described in the next section, extend back before the Recourse Rule went into effect. Therefore, tests of hypotheses 1b and 1c also make it possible to verify Erel, Nadauld, and Stulz's (2014) conjecture that while they found no direct evidence of a regulatory arbitrage effect, securitization-active banks would have been the most likely to take advantage of regulatory arbitrage opportunities arising from the Recourse Rule. Increased holdings of highly rated tranches also would have exposed bank capital to greater potential for losses, a risk that concerns the second, related hypothesis (hypothesis 2).

Hypothesis 2: Did holdings of highly rated tranches equal or exceed holding company regulatory capital after the Recourse Rule?

The purpose of testing this second hypothesis is to determine whether banks, especially securitization-active banks, had holdings of highly rated tranches that equaled or exceeded regulatory capital. To see why such a threshold might be important, Erel, Nadauld, and Stulz (2014) estimate that Citigroup had roughly 10 percent of its portfolio allocated to its highly rated tranche measure and CDOs, and 6 percent to equity capital. A loss of 60 percent on that portion of its portfolio would have wiped out Citigroup's net worth as measured by its capital. Although such a loss rate might seem high, Cordell, Huang, and Williams (2012) find that in the case of CDO tranches, writedowns averaged 65 percent during the entire sample, which might have been sufficient to wipe out much of Citigroup's capital. If some banks increased their holdings of highly rated tranches relative to their regulatory capital after the Recourse Rule or interim or final risk-based capital rule, they would have been exposed to the very products that experienced distress during the crisis. This possibility relates to the third and final hypothesis.

Hypothesis 3: Did banks holding more highly rated tranches experience a larger decline in distance-to-default during the crisis?

Highly rated tranches played a role during the recent crisis because, as Coval, Jurek, and Stafford (2009) argue, investors typically invested in the assets that experienced distress during the crisis because of the credit rating of those assets. At the same time, those assets, given their complex nature, were priced according to credit risks, not according to risks associated with the state of the economy. In that case, bank holdings of such securities could have been at higher risk of distress. I therefore test whether, on average, those with higher holdings of highly rated tranches

could have experienced greater declines in distance-to-default. I discuss the data used to test these hypotheses next.

Bank Holding Company Data

To examine how bank asset allocations could have changed after the Recourse Rule, I use bank holding company consolidated financial statements data.[4] The data are sourced from the Wharton Research Data Services quarterly bank holding company call report filings. Changes to form FR Y-9C ("Consolidated Financial Statements for Bank Holding Companies") in March 2001 make this study possible because the changes required bank holding companies to report information about assets, as well as derivatives and off-balance sheet items, by risk weight.[5]

The key variable in this study is Erel, Nadauld, and Stulz's (2014) suggested measure of highly rated tranches. Their suggested measure has value because call report data did not require holding companies to provide detailed information about their highly rated, private-label securitization tranche holdings in the same manner as other tranche investors, such as insurance companies, were required to do (see Merrill, Nadauld, and Strahan, forthcoming).

To estimate highly rated tranche holdings, Erel, Nadauld, and Stulz (2014) suggest first aggregating total securities assigned risk weights of 0.2 and 0.5, then subtracting from that total the amount of other securities, such as GSE securitizations, that are not private-label securitizations. One shortcoming of the measure is that it provides an aggregate measure of assets with risk weights of 0.2 or 0.5; it is therefore not possible to separate the AAA- and AA-rated assets from A-rated assets. Erel, Nadauld, and Stulz (2014) show that the performance of

[4] See Chicago Federal Reserve Bank Call Report Y-9C form data.
[5] See Micro Report Series Description (series name: Combined Bank Holding Company File), http://www.federal reserve.gov/apps/mdrm/pdf/BHCF.PDF, 30–31.

the highly rated tranche measure yields results similar to those that are based on other measures that include CDO tranches. So even though the measure does not include the most potentially damaging tranches, the results can still be informative.

Erel, Nadauld, and Stulz (2014) measure the highly rated residual only after the Recourse Rule, when highly rated tranches were assigned risk weights of 0.2 and 0.5. In what follows, I compute the measure before and after the rule change because, as Erel, Nadauld, and Stulz (2014) point out, before the Recourse Rule some private-label securitizations were assigned risk weights equal to 0.5. Because data on bank securitization activity appears only starting in Q2 2001, the sample includes all banks with at least $1 billion in total assets (as in Erel, Nadauld, and Stulz 2014) from Q2 2001 to Q1 2009 that report data for each of the series used in the subsequent analysis.

In addition to the call report data, to estimate the changes in distance-to-default, I also use daily closing stock price and market value of equity data for holding companies from Q4 2001 through Q1 2009, available from the Center for Research in Security Prices through Wharton Research Data Services. I describe the construction of the variables used in this study in table A1 in the appendix. Table 2 (page 33) reports bank holding company summary statistics by asset size in columns 2, 3, and 4, and across all bank holding companies in column 5. Table A2 in the appendix lists the names of the SIFI banks in the sample by their securitization activity.

Empirical Framework

After the crisis, legislators who drafted the Dodd-Frank Act, as well as regulators, have focused on bank size as a key indicator of whether a bank poses a threat to the financial system as a whole. Yet bank size alone does not provide a causal explanation for why banks experienced distress during the recent crisis. (Bank size does, however, turn out to be a crude proxy for

trouble leading up to the recent crisis, but that seems to result from the fact that larger, securitizing banks tended to buy more of the very financial products that experienced distress.[6])

I demonstrate this assertion by estimating average bank holdings of highly rated tranches over time according to bank size or securitization activities, or both. The following equations summarize the regression specifications used to estimate the average holdings of highly rated tranches by bank size or securitization-active group (or both) over time:

$$y_{it} = \alpha + \delta_t T_t + \delta_s I_{ist} + \delta_{st} I_{ist} T_t + \beta X_{it} + \varepsilon_{it}, \quad (1a)$$

$$y_{it} = \alpha + \delta_t T_t + \delta_a A_{it} + \delta_{at} A_{it} T_t + \beta X_{it} + \varepsilon_{it}, \quad (1b)$$

$$y_{it} = \alpha + \delta_t T_t + \delta_a A_{it} + \delta_{at} A_{it} T_t + \delta_s I_{ist} + \delta_{st} I_{ist} T_t + \delta_{as} A_{it} I_{ist} + \delta_{ast} A_{it} I_{ist} T_t + \beta X_{it} + \varepsilon_{it}. \quad (1c)$$

I estimate each equation using an ordinary least squares (OLS) regression, with standard errors clustered at the bank holding company. Here, the dependent variable y_{it} equals the time *t* ratio for bank *i* of Erel, Nadauld, and Stulz's (2014) highly rated tranche measure divided by either total assets or Tier 1 capital. The variables in X_{it} include quartiles of holdings of other securities and quartiles of short-term wholesale funding, as well as one-quarter lagged, regulatory capital slack, measured as the difference between Tier 1 capital and 4 percent.

In equation (1a), the dummy variable I_{ist} assigns to bank *i* one of three size-based categories: banks with at least $50 billion in total assets or banks with at least $10 billion but less than $50 billion in total assets, with the baseline being banks with less than $10 billion in total assets. In equation (1b), the dummy variable A_{it} indicates whether bank *i* earns income from

[6] This does not imply that bank size will always explain where trouble will lurk in the financial system. As Calomiris and Haber (2014) and Bordo, Redish, and Rockoff (2015) have shown, for much of US history, banking crises arose from interstate banking and branching restrictions that tended to result in banks' being less geographically diversified than they might have been absent the regulations and therefore less able to withstand regional shocks.

securitization activities in quarter *t*, with the baseline being nonsecuritization-active banks. Finally, equation (1c) captures six bank groups, based on the three size categories and whether they are securitization-active, with the baseline case being nonsecuritization-active banks with less than $10 billion in total assets.

Excluding the other right-hand-side variables in X_{it}, equation (1a) or (1b) provides estimates of averages by bank group. For banks in the baseline $\$1\ billion \leq size < \$10\ billion$ or nonsecuritization-active group, the intercept α estimates the sample average value of y_{it} in the baseline period of Q4 2001. Adding δ_t to the intercept estimates the average value for other quarter *t* for banks in the smallest bank baseline group. For banks in the $\$10\ billion \leq size < \$50\ billion$, $\$50\ billion \leq size$ group *s*, or securitization-active group *a*, adding δ_s or δ_a, respectively, to the intercept α estimates the sample average value of y_{it} in the baseline period of Q4 2001. Adding the sum of δ_s and δ_{st} or δ_a and δ_{at} to the sum of the α and δ_t estimates the average value of y_{it} for each of the larger bank or securitization-active groups, respectively, for each other quarter *t*. Excluding the other right-hand-side variables in X_{it}, equation (1c) provides estimates of averages by bank group controlling for both size and securitization activity.

I report summaries of my estimates of equations (1a), (1b), and (1c) for the highly rated tranches to total asset ratio in the next section. I report summaries of my estimates of equations (1a) and (1c) for the highly rated tranche to Tier 1 capital ratio in the section after that.

Average Holdings of Highly Rated Tranches Relative to Total Assets, Q2 2001–Q1 2009

To demonstrate why lawmakers and regulators might believe that SIFI designation could serve as a valid indicator for potential trouble, I begin by depicting in figure 1 (page 29) the average

ratio of highly rated tranche holdings to total assets for banks in each bank size group, generated from equation (1a) previously given; adding controls, X_{it}, does not qualitatively change the observed patterns. The first vertical bar in figure 1 indicates when the Recourse Rule could have taken effect in Q4 2001, and the second vertical bar indicates when the interim risk-based capital rule took effect in Q3 2003. The figure reveals that patterns in holdings across bank groups differ considerably.

For instance, average holdings for SIFI banks show an upward trend starting in Q4 2001. Figure A1 in the appendix depicts the sum of the SIFI bank coefficient estimation and its interaction with the time-fixed effect, and it measures the premium relative to banks with less than $10 billion in total assets, together with the 95 percent confidence interval. Figure A1 suggests that on average, SIFI bank holdings of highly rated tranches increased relative to banks with less than $10 billion in total assets after the Recourse Rule. The differences are statistically significant in Q2 2002 and Q3 2002 and for the duration of the sample after Q1 2003. The observed trends in figure 1 and figure A1 would be consistent with the hypothesis that SIFI banks increased their holdings of highly rated tranches from the time that the Recourse Rule took effect until the time of the crisis.

However, figure 1 also shows that the same pattern does not exist for other banks. Average holdings for banks with at least $10 billion in total assets but less than $50 billion reveal an upward trend only between Q3 2003 and Q1 2006 and also reveal that the average holdings of those banks are eclipsed by average SIFI bank holdings starting in Q2 2003. Confirming the importance of Q3 2003 in a statistical sense, figure A2 in the appendix shows that the premium for banks in this range is statistically significantly different from zero after Q3 2003. This finding could be consistent with banks with at least $10 billion in total assets but less than $50 billion

taking advantage of the interim rule on capital treatment of consolidated asset-backed commercial paper programs, but it does not rule out other factors.

Finally, figure 1 also shows that banks with less than $10 billion in assets show nearly constant holdings. Figure A3 shows that the coefficient estimates are statistically significantly different from zero throughout the sample, but the size is small nonetheless. Taken together, the findings in figure 1, as well as those in figures A1, A2, and A3, lend support to hypothesis 1a (that the largest banks held more highly rated tranches after the Recourse Rule was finalized); smaller banks did not respond in the same way. Since bank size appears to be associated with holdings of highly rated tranches, as a first approximation, bank size may provide a crude way to spot trouble. Yet size may reflect the fact that larger banks tend to engage in other nontraditional banking activities, such as securitization, which lay at the heart of the recent crisis.

Erel, Nadauld, and Stulz (2014) find evidence of the securitization by-product effect, which reflects the fact that securitizing banks were more likely to hold the highly rated tranches, instead of the equity tranche, as conventional wisdom suggests. Figure 2 (page 29) provides further evidence to support Erel, Nadauld, and Stulz's finding of the securitization by-product effect by reporting the average fraction of highly rated tranches for securitizing and nonsecuritizing banks from the time and securitization-active dummies, as well as the interaction in equation (1b), and it lends support to hypothesis 1b. Figure 2 in this paper resembles figure 2 in Erel, Nadauld, and Stulz (2014), except that I include estimates before the Recourse Rule. These findings also lend support to the conjecture by Erel, Nadauld, and Stulz (2014) that the securitization by-product effect and the effects of the Recourse Rule could have been reinforcing each other leading up to the crisis, and that the reinforcing effect of the Recourse Rule could have grown over time.

Because securitizing banks and SIFI banks appear to have similar patterns, I test whether securitizing SIFI banks could have been the ones that took the most advantage of the regulatory changes. Although I omit most of the output, figure 3 (page 30) shows that for securitization-active SIFI banks, relative to nonsecuritizing banks with less than $10 billion in total assets, the coefficients begin their rise in Q4 2001 and are statistically significantly different from zero starting in Q2 2002. These findings lend support to hypothesis 1c (that the largest securitizing banks increased their holdings after the Recourse Rule).

Taken together, these findings are consistent with the conjecture by Erel, Nadauld, and Stulz (2014) that the securitization by-product effect and the Recourse Rule could have been reinforcing, as that seems to be the case for securitizing SIFI banks leading up to the crisis.[7] The decline in holdings for securitizing SIFI banks after Q2 2006 could still be consistent with the securitization by-product effect. Before the crisis, securitizing SIFI banks that had favorable views about the underlying collateral would have held more assets to signal that they stood by the products they were creating. However, as perceptions about the quality of the underlying collateral changed, banks might have reduced their holdings because they perceived greater holdings to be a possible threat to their solvency.

In the second, fourth, and sixth columns of table 3 (page 34), I report results of regressions used to generate figures 1–3. In the the third, fifth, and seventh columns, I report similar results for regressions that control for other factors, such as quartiles of other held-to-maturity and available-for-sale securities, or short-term funding, each as a fraction of total assets. I also include regulatory capital slack, computed as the one-quarter lagged Tier 1 capital to risk-

[7] Although I do not show the figure, nonsecuritizing SIFI banks on average increased their holdings of the highly rated tranches in Q3 2006, just as the securitizing SIFI banks were reducing their holdings, although the estimates are not statistically significant except in Q3 2008, which may reflect considerable variation within this group of banks.

weighted asset ratio minus 4 percent. The time-fixed effects and interactions between time and bank group fixed effects are omitted for the sake of brevity. These results show that the other factors do not relate systematically to holdings of highly rated tranches.

Average Holdings of Highly Rated Tranches Relative to Tier 1 Capital, Q2 2001–Q1 2009

Given Erel, Nadauld, and Stulz's (2014) Citigroup example about relative sizes of the firm's highly rated tranche holdings and capital, discussed earlier, I estimate equation (1a), but after replacing the dependent variable with the ratio of highly rated tranche holdings to Tier 1 capital. Figure 4 (page 30) depicts estimates of a regression of highly rated tranche assets to Tier 1 capital ratio for each bank against the same right-hand-side variables used to generate figure 1. Adding controls, described later, does not qualitatively change the observed patterns.

Although the patterns resemble those in figure 1, the output in figure 4 provides an indication of how banks differed on average by size in terms of the size of their highly rated tranche holdings relative to capital. This variation sheds light on the potential for asset write-downs to affect the solvency of the bank holding company in question. The average for SIFI banks rises from 0.24 in Q4 2001 to a peak of 1.04 in Q3 2007. These findings lend support to hypothesis 2. Smaller banks on average tended to be less exposed to the risk that highly rated tranche holdings would wipe out bank capital. The average ratio for banks in the $10 billion to $50 billion range never exceeds 0.56, while the average ratio for the smallest banks never exceeds 0.14.

In figure 5 (page 31), I show that for securitizing SIFI banks, much as in figure 3, the interaction between the time, the securitization-active, and the SIFI dummies rises starting in Q4 2001 and is statistically significantly different from zero starting in Q2 2002 and going through the end of the sample. This finding lends support to the idea that changes in capital regulations

could have encouraged securitizing SIFI banks to increase their holdings of assets that could have wiped out their capital in the run-up to the crisis.

The findings in the past two sections may therefore help explain why lawmakers and regulators have placed significant emphasis on SIFI banks in the design of regulations after the crisis. However, the findings also suggest that in response to the crisis, the focus should be more on bank asset holdings that could have exposed banks to the risk of having their capital wiped out, rather than on SIFI designation. Although I return to the issue of distance-to-default shortly, the fact that the largest, securitizing banks were among those with the highest exposures to the highly rated tranches casts doubt on the notion that size alone explains why the large banks were at risk. Given that the behavior of the large, securitizing banks may have changed in response to the rule changes, the observed unintended effects suggest that appropriate reform measures should focus on what went wrong with the rules.

Lastly, table 4 (page 35) shows results similar to those in table 3, except that the dependent variable is measured relative to Tier 1 capital rather than to total assets. The second, fourth, and sixth columns omit controls, while the third, fifth, and seventh columns control for other factors, such as quartiles of other held-to-maturity and available-for-sale securities, or short-term funding, each as a fraction of total assets, as well as Tier 1 regulatory capital slack. As before, the time-fixed effects and interactions between time and bank group fixed effects are omitted for the sake of brevity. The results change little when the additional variables are added.

Highly Rated Tranche Holdings and Declines in Distance-to-Default

Because some banks—especially the largest, securitizing banks—appear to have altered their portfolios and had higher exposure to highly rated tranches following the Recourse Rule, I now examine the extent to which the holdings themselves could have related to changes in bank

distress measured using changes in distance-to-default, which in turn is computed by the change in the natural log of bank z-scores.

Drawing from Laeven and Levine (2009) and Erel, Nadauld, and Stulz (2014), I define the z-score as

$$z_t = \frac{ROA_{it} + \frac{mktval_{it}}{Assets_{it}}}{s.d.(R_{it})\sqrt{trading\ days}\,\frac{mktval_{it}}{Assets_{it}}},$$

where ROA_i is the holding company's return on assets and

$$\frac{mktval_i}{Assets_i}$$

is the holding company's end-of-quarter stock market value relative to book value of total assets. For the denominator, however, instead of computing the standard deviation of lagged ROA_i, I draw from Correira, Kang, and Richardson (2014), who compute a "naïve" asset standard deviation from historical market data by multiplying the standard deviation of intraquarterly daily equity returns, $s.d.(R_{i,t})\sqrt{trading\ days}$, by the holding company's end-of-quarter stock market value relative to book value of total assets.[8]

Table 5 (page 36) reports estimates of OLS regressions of changes in the natural log of the z-score between Q1 2002 and Q1 2009:[9]

[8] Although Laeven and Levine (2009) and Erel, Nadauld, and Stulz (2014) measure the denominator using the standard of lagged return on assets, a referee on an earlier draft of this paper pointed out that the overlapping samples used to construct the denominator could bias the estimates. By using intraquarterly daily data, Correira, Kang, and Richardson's (2014) measure can be used to address the overlapping samples problem. The difference is that whereas Correira, Kang, and Richardson (2014) divide market value of equity by the sum of market value of equity, book value of short-term debt, and book value of long-term debt, I use the book value of assets, which must equal the sum of the book values of equity and all liabilities.

[9] I also estimate the same regressions with bank holding company fixed effects, but statistical tests fail to reject the null hypothesis that all bank holding company fixed effects equal zero.

$$\ln(z_{it}) - \ln(z_{i,t-1}) = b_0 + b_1 \frac{HRR_{i,t-1}}{Assets_{i,t-1}} + X'_{igt} b + e_{it}. \quad (2)$$

The key variable is lagged highly rated tranche holdings relative to total assets,

$$\frac{HRR_{i,t-1}}{Assets_{i,t-1}},$$

and e_{it} is the error term. The second column presents results when the only other variable in X' is the lagged share of assets in other held-to-maturity and available-for-sale securities. The third column presents results when I add other controls, including the lagged share of assets in commercial and industrial loans, the lagged share of assets in mortgages, lagged short-term wholesale funding as a fraction of total assets, lagged unused loan commitments as a fraction of total assets, the lagged difference between Tier 1 capital relative to risk-weighted assets and 4 percent, $ROA_{i,t-1}$, a dummy variable for banks with at least $10 billion in assets but less than $50 billion, a dummy variable for SIFI banks with at least $50 billion, and a dummy variable for securitizing banks that reported securitization income. The fourth and fifth columns repeat the exercises reported in the second and third columns, but after interacting each of the variables with a dummy variable for the Q2 2007–Q1 2009 period when the crisis began to unfold and a dummy variable for the Q1 2008–Q1 2009 period, after the TSLF program was created.[10]

Comparing the second and third columns with the fourth and fifth columns provides additional insights concerning the role that the highly rated securitizations could have played during the crisis. For instance, for the highly rated tranche coefficient, the second and third columns suggest there was nothing on average during the entire sample that would indicate

[10] For a timeline of events during the crisis, see the website of the Federal Reserve Bank of St. Louis, https://www.stlouisfed.org/financial-crisis/full-timeline. Ratings downgrades began in Q2 2007 during June. In Q1 2008, during March, the Federal Reserve announced the creation of the TSLF to purchase securitizations, including highly rated, private-label MBS.

that the highly rated tranches could have been associated with declines in the natural log of the z-score. In contrast, greater holdings of commercial and industrial loans or mortgages, as well as more reliance on short-term funding or whether a bank was large, were each associated with banks experiencing relatively small declines in the natural log of the z-score for the whole sample.

The fourth and fifth columns, however, show that it was after 2008 that the highly rated tranches were associated with large declines in the natural log of the z-score. This would be consistent with Erel, Nadauld, and Stulz's (2014) finding that greater holdings of highly rated tranches were associated with negative stock returns between 2007 and 2008. The late and dramatic change in the signs of the coefficient could indeed suggest that the poor performance of the highly rated tranches might have come as a surprise. The size of the coefficient is much larger than for other common explanations of the crisis, such as mortgage holdings, short-term funding, and bank size, which are also statistically insignificant. Similarly, results for other held-to-maturity and available-for-sale securitizations from either the government or lower-rated private-label tranches reveal no particular patterns before or during the crisis.[11] The fourth and fifth columns confirm that the other tranches were not a problem during the crisis, a determination that would be consistent with Erel, Nadauld, and Stulz's (2014) findings.

In terms of other asset classes, however, although there is a negative association between mortgages and commercial industrial loans as a fraction of total assets for the whole sample, that

[11] An alternative view suggests that holdings of trading assets, specifically, might have been associated with bank insolvency risk during the crisis. In table A3 of the appendix, I report estimates of the regressions similar to those reported in table 5, which replace the lagged other held-to-maturity and available-for-sale securitization tranches variable with lagged trading assets (bhck3435) as a fraction of total assets (bhck2170). While greater holdings of trading assets are negatively associated with changes in the natural log of the z-score, the magnitudes are smaller than for the highly rated tranche variable, and they are statistically insignificant. This suggests that trading assets, specifically, were not likely a key associated with bank insolvency risk during the crisis.

negative correlation disappears after adding in the crisis interaction terms. Similarly, the short-term funding and unused loan commitments are not associated with large declines in the natural log of the z-score, except before the crisis.[12]

Finally, the coefficients for bank size dummy variables are generally negative and often statistically significantly different from zero, whereas for securitizing banks the coefficients are positive and statistically significantly different from zero. However, the results during the crisis are statistically insignificant.

Conclusion

Many narratives that are used to justify changes in the law and financial regulations since the crisis emphasize what went wrong on the supply side of the market before the crisis. Bank size often factors into the explanation. To the extent that the demand side of the market played a role, an important issue remains: Why might demand have been so great for the securities that spread insolvency risk throughout the financial system?

One answer suggested by the findings presented here could be that the Recourse Rule created incentives for securitizing banks, especially the largest ones, to hold more of the very assets that wiped out bank capital. Moreover, since Deng, Gabriel, and Sanders (2011) show that the CDO market drove demand for subprime MBS (and also drove the funding available to subprime borrowers), that suggests the Recourse Rule could have played a role in the subprime crisis. Although the findings do not identify causality, they show that the largest, securitizing

[12] Although not shown here, quarter-by-quarter rolling regression estimates of the full specification without crisis dummy variables reported in the fourth and fifth columns of table 5 indicate that the coefficient between changes in the natural log of the z-score between Q2 and Q3 2008 and unused loan commitments in Q2 2008 is large, negative, and statistically significantly different from zero. This could be consistent with Loutskina and Strahan's (2011) and Erel, Nadauld, and Stulz's (2014) findings for the negative relationship between unused loan commitments and stock returns.

banks held more of the highly rated tranches after the Recourse Rule was finalized until the onset of the crisis. Finally, rather than larger banks, banks with greater holdings of the highly rated tranches were more exposed to losses as the crisis unfolded.

Taken together, these findings suggest that capital adequacy could have been a problem in the run-up to the crisis. Even though banks satisfied regulatory capital requirements, lowering capital requirements for some of the very assets that experienced distress during the crisis resulted in banks' having relatively little capital. The findings here would therefore offer support for recent calls for simpler and higher equity capital requirements (e.g., Haldane 2012; Admati and Hellwig 2013; Admati et al. 2013; and Barth and Miller 2017a, 2017b).

References

Acharya, Viral, Robert Engle, and Diane Pierret. 2014. "Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights." *Journal of Monetary Economics* 65, 36–53.

Acharya, Viral, Philipp Schnabl, and Gustavo Suarez. 2013. "Securitization without Risk Transfer." *Journal of Financial Economics* 107 (3): 515–36.

Admati, Anat, Peter DeMarzo, Martin Hellwig, and Paul Pfleiderer. 2013. "Fallacies, Irrelevant Facts, and Myths in the Discussion of Capital Regulation: Why Bank Equity Is Not Socially Expensive." Stanford University Working Paper.

Admati, Anat, and Martin Hellwig. 2013 *The Bankers' New Clothes*. Princeton, NJ: Princeton University Press.

Barth, James R., and Stephen Matteo Miller. 2017a. "A Primer on the Evolution and Complexity of Bank Regulatory Capital Standards." Unpublished manuscript.

———. 2017b. "Benefits and Costs of a Higher Bank Leverage Ratio." Unpublished manuscript.

Bordo, Michael, Angela Redish, and Hugh Rockoff. 2015. "Why Didn't Canada Have a Banking Crisis in 2008 (or in 1930, or 1907, or . . .)?" *Economic History Review* 68 (1): 218–43.

Brealey, Richard A. 2006. "Basel II: The Route Ahead or Col-de-sac?" *Journal of Applied Corporate Finance* 4, 34–43.

Calomiris, Charles, and Stephen Haber. 2014. *Fragile by Design: The Political Origins of Banking Crises and Scarce Credit*. Princeton, NJ: Princeton University Press.

Cordell, Larry, Yilin Huang, and Meredith Williams. 2012. "Collateral Damage: Sizing and Assessing the Subprime CDO Crisis." Federal Reserve Bank of Philadelphia Working Paper No. 11-30.

Correia, Maria, Johnny Kang, and Scott Richardson. 2014. "Asset Volatility." Unpublished working paper.

Coval, Joshua D., Jakub W. Jurek, and Erik Stafford. 2009. "Economic Catastrophe Bonds." *American Economic Review* 99 (3): 628–66.

Demirgüç-Kunt, Asli, Enrica Detragiache, and Ouarda Merrouche. 2013. "Bank Capital: Lessons from the Financial Crisis." *Journal of Money, Credit and Banking* 45 (6): 1147–64.

Deng, Yongsheng, Stuart Gabriel, and Anthony Sanders. 2011. "CDO Market Implosion and the Pricing of Subprime Mortgage-Backed Securities." *Journal of Housing Economics* 20, 68–80.

Erel, Isil, Taylor Nadauld, and René M. Stulz. 2014. "Why Did Holdings of Highly Rated Securitization Tranches Differ So Much across Banks?" *Review of Financial Studies* 27 (2): 404–53.

Flannery, Mark. 2014. "Maintaining Adequate Bank Capital." *Journal of Money Credit and Banking* 46 (1): 157–80.

Flannery, Mark, and Emanuela Giacomini. 2015. "Maintaining Adequate Bank Capital: An Empirical Analysis of the Supervision of European Banks." *Journal of Banking and Finance* 59, 236–49.

Friedman, Jeffrey, and Wladimir Kraus. 2011 *Engineering the Financial Crisis: Systemic Risk and the Failure of Regulation*. Philadelphia: University of Pennsylvania Press.

Haldane, Andrew. 2012. "The Dog and the Frisbee" (speech by Andrew Haldane, executive director, financial stability, Bank of England, and Vasileios Madouros, economist, Bank of England, at the Federal Reserve Bank of Kansas City's Economic Policy Symposium, "The Changing Policy Landscape," Jackson Hole, Wyoming, August 31, 2012).

Hogan, Thomas L. 2015. "Capital and Risk in Commercial Banking: A Comparison of Capital and Risk-Based Capital Ratios." *Quarterly Review of Economics and Finance* 57, 32–45.

Hogan, Thomas L., and Neil R. Meredith. 2016. "Risk and Risk-Based Capital of U.S. Bank Holding Companies." *Journal of Regulatory Economics* 49, 86–112.

Jones, David. 2000. "Emerging Problems with the Basel Capital Accord: Regulatory Capital Arbitrage and Related Issues." *Journal of Banking and Finance* 24, 35–58.

Kapstein, Ethan. 1991. "Supervising International Banks: Origins and Implications of the Basle Accord." Essays in International Finance, No. 185. International Finance Section, Princeton University.

———. 1994. Governing the Global Economy. Cambridge, MA: Harvard University Press.

Laeven, Luc, and Ross Levine. 2009. "Bank Governance, Regulation, and Risk Taking." *Journal of Financial Economics* 93 (2): 259–75.

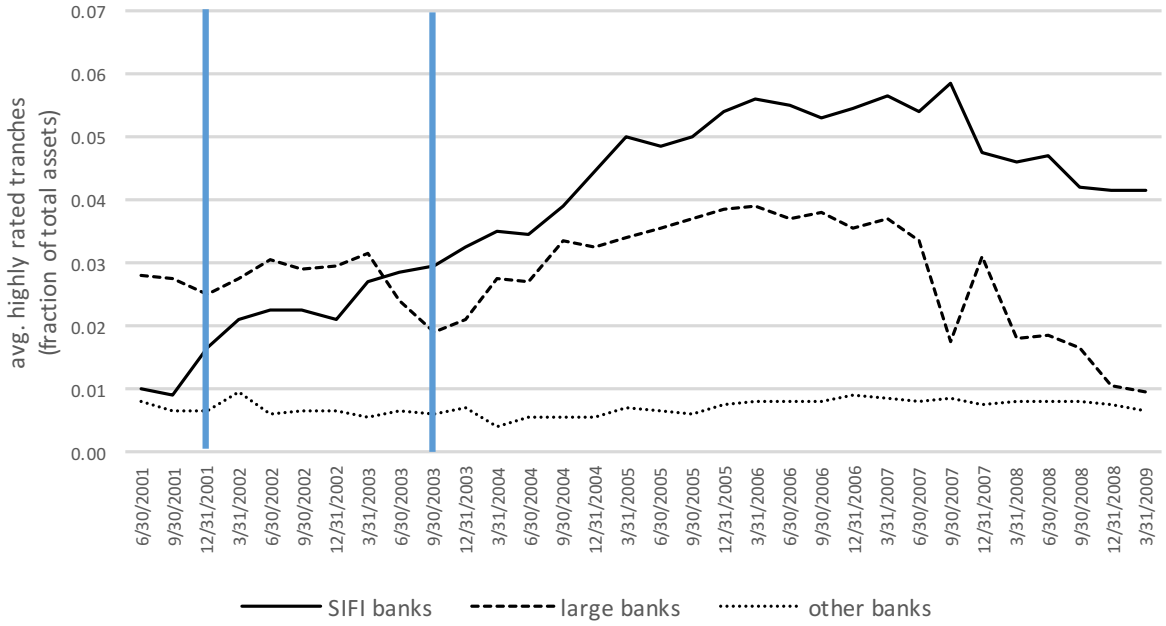
Loutskina, Elena, and Philip E. Strahan. 2011. "Informed and Uninformed Investment in Housing: The Downside of Diversification." *Review of Financial Studies* 24 (5): 1447–80.

Merrill, Craig B., Taylor D. Nadauld, and Philip E. Strahan. Forthcoming. "Final Demand for Structured Finance Securities." *Management Science*.

Merton, Robert. 1995. "Financial Innovation and the Management and Regulation of Financial Institutions." *Journal of Banking and Finance* 19, 461–81.

Roy, Andrew. 1952. "Safety First and the Holding of Assets." *Econometrica* 20 (3): 431–49.

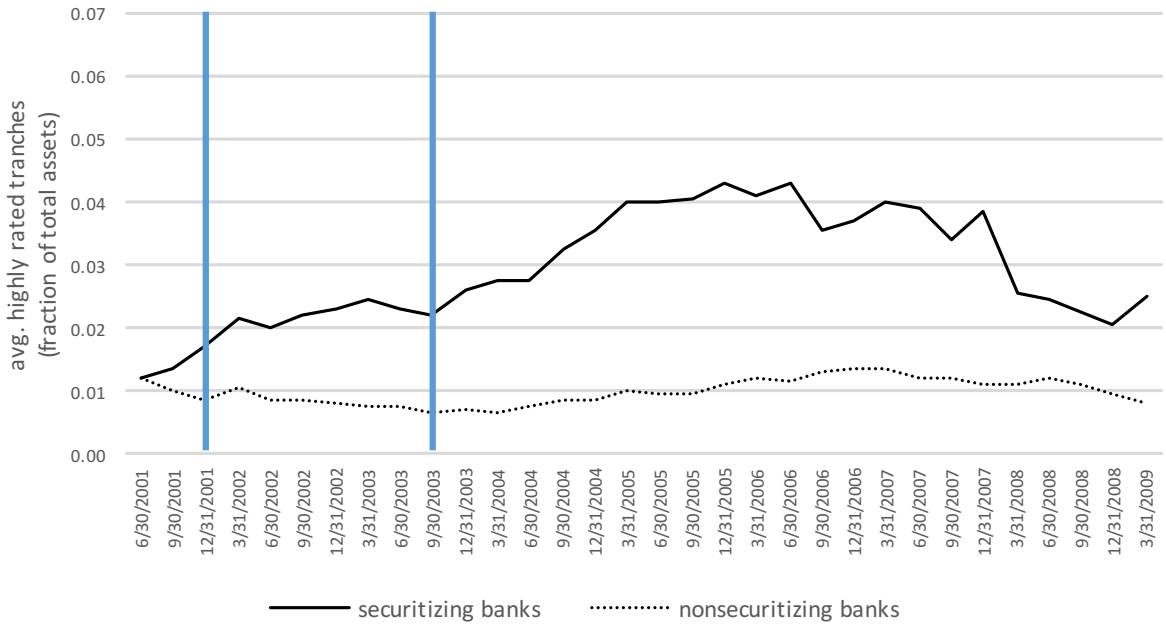
Figure 1. Average Holdings of Highly Rated Tranches as a Fraction of Total Assets by Bank Size, Quarterly Average, Q2 2001–Q1 2009



Note: SIFI = systemically important financial institution.

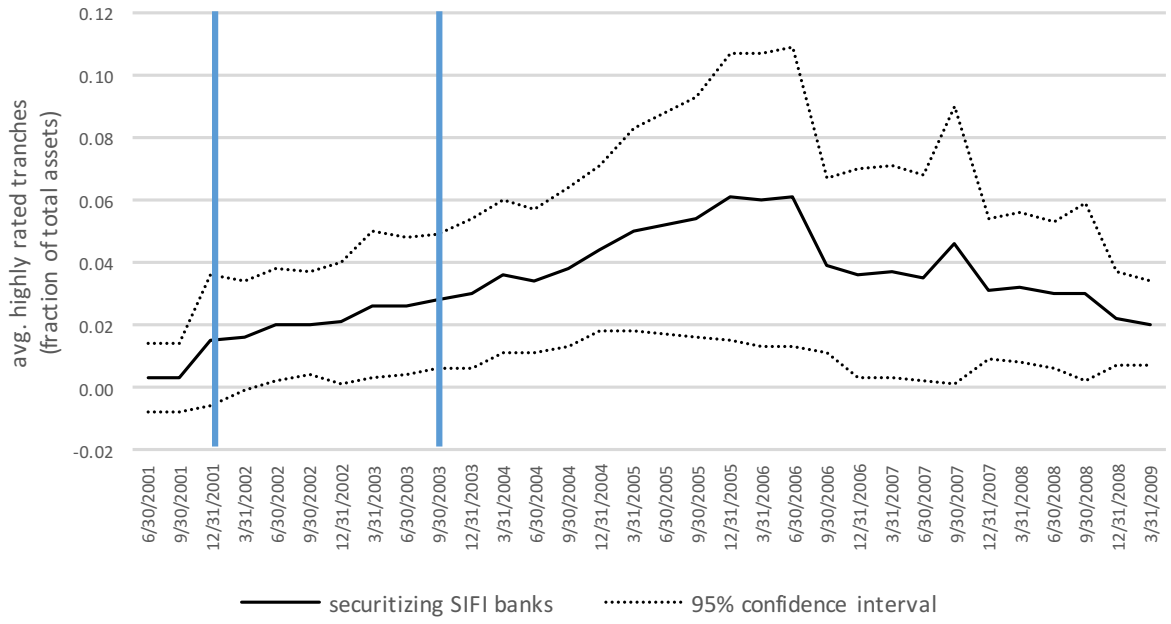
Source: Based on author's estimates.

Figure 2. Average Ratio of Highly Rated Tranches as a Fraction of Total Assets by Securitization Activity, Quarterly Average, Q1 2001–Q1 2009



Source: Based on author's estimates.

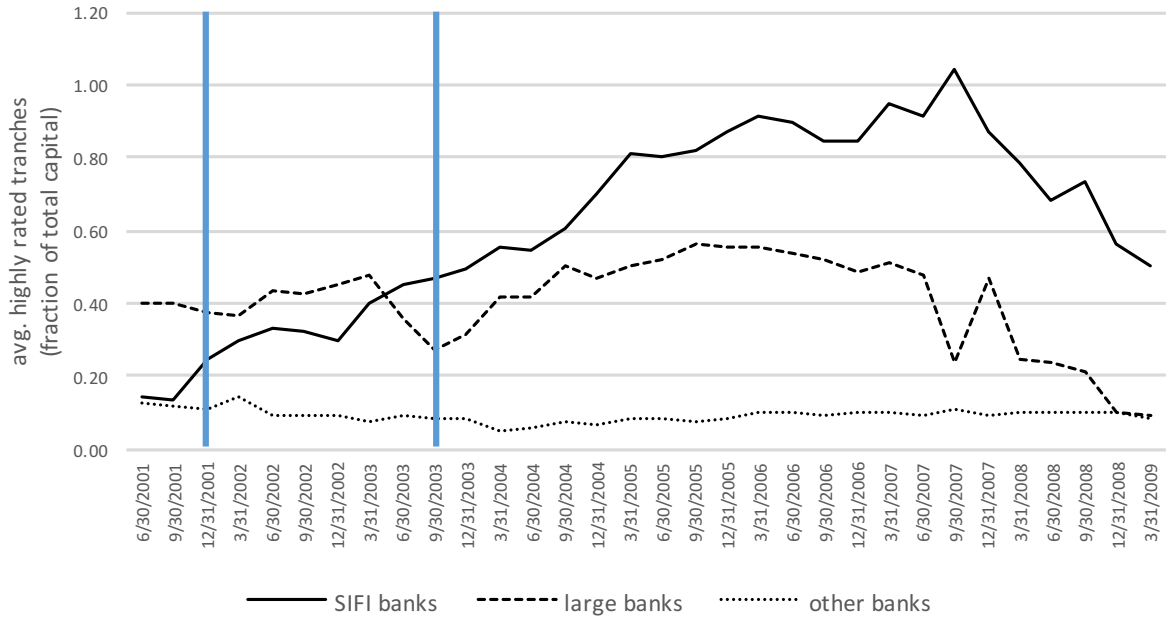
Figure 3. Premium of Highly Rated Tranche Holdings to Total Assets by Securitizing SIFI Banks Relative to Nonsecuritizing Banks with Less Than $10 Billion in Total Assets, Quarterly Average Q1 2001–Q1 2009



Note: SIFI = systemically important financial institution.

Source: Based on author's estimates.

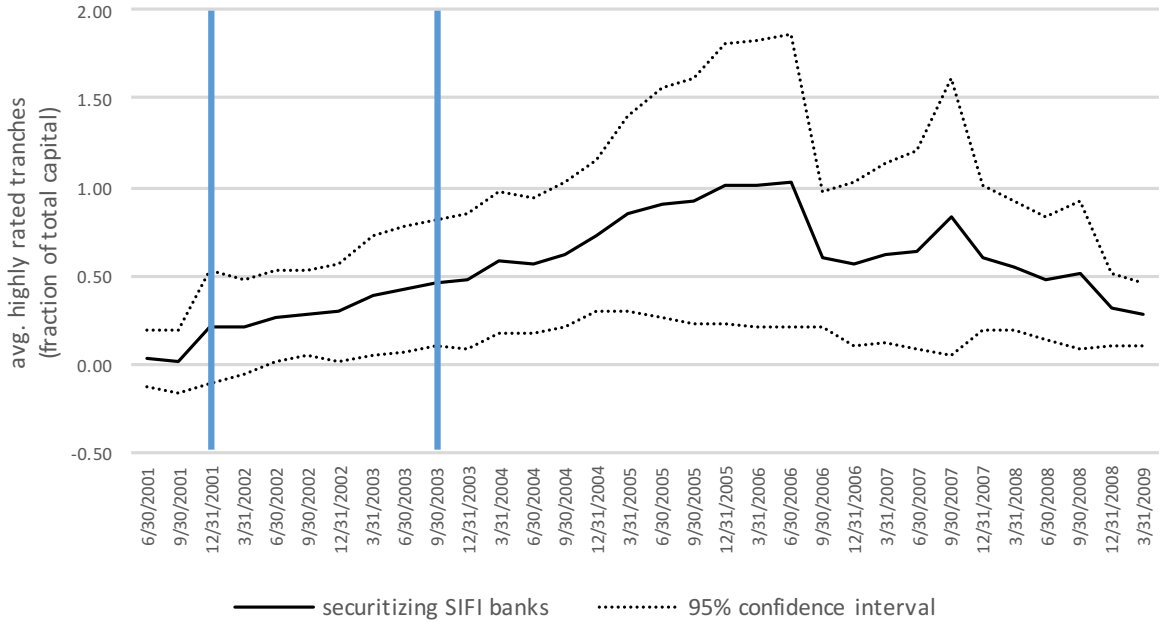
Figure 4. Average Holdings of Highly Rated Tranches as a Fraction of Tier 1 Capital by Bank Size, Quarterly Average Q2 2001–Q1 2009



Note: SIFI = systemically important financial institution.

Source: Based on author's estimates.

Figure 5. Premium of Highly Rated Tranche Holdings to Tier 1 Capital for Securitizing SIFI Banks Relative to Nonsecuritizing Banks with Less Than $10 Billion in Total Assets, Quarterly Average Q1 2001–Q1 2009



Note: SIFI = systemically important financial institution.

Source: Based on author's estimates.

Table 1. Regulatory Changes to Capital Treatment of Securitizations

Event	Date	Summary of change
Basel I	Introduced in United States between 1988 and 1991, applied to all US banks in 1992	Introduced asset class–based risk weights equal to 0, 0.2, 0.5, and 1, which were used to adjust total assets used to compute the 8% minimum capital requirement relative to risk-weighted assets
Risk-Based Capital Guidelines; Capital Adequacy Guidelines; Capital Maintenance: Capital Treatment of Recourse, Direct Credit Substitutes and Residual Interests in Asset Securitizations; Final Rules or "Recourse Rule" (66 FR 59614)	November 29, 2001	Established risk weights for private-label MBS and other similarly structured products such as CDOs, on the basis of ratings. For AAA- and AA-rated securities, the risk weight was 0.2; for A-rated securities, the risk weight was 0.5. For BBB-rated securities, the risk weight was 1; for BB- and lower-rated securities, the risk weight increased to 2. Before the rule, the risk weight was either 0.5 or 1.
Interim rule on capital treatment of consolidated asset-backed commercial paper program assets (68 FR 56530)	October 1, 2003	Banks with ABCP programs allowed to temporarily exclude assets in those programs from the computation of risk-weighted assets used to assess capital adequacy. The interim rule applied to the reporting periods of September 30, 2003; December 31, 2003; and March 31, 2004. It was set to expire on April 1, 2004.
Extension of interim rule on capital treatment of consolidated asset- backed commercial paper program assets (69 FR 22382)	April 26, 2004	Extended the interim rule on capital treatment of consolidated asset-backed commercial paper program assets through July 1, 2004
Final rule on capital treatment of consolidated asset-backed commercial paper program assets (69 FR 44908)	July 28, 2004	Made the interim rule on capital treatment of consolidated asset-backed commercial paper program assets permanent starting on September 30, 2004

Note: ABCP = asset-backed commercial paper; CDO = collateralized debt obligation; MBS = mortgage-backed securities. For Recourse Rule, see https://www.gpo.gov/fdsys/pkg/FR-2001-11-29/pdf/01-29179.pdf. For interim risk-based capital rule, see https://www.gpo.gov/fdsys/pkg/FR-2003-10-01/pdf/03-23756.pdf. For extension of interim risk-based capital rule, see https://www.gpo.gov/fdsys/pkg/FR-2004-04-26/pdf/04-9361.pdf. For final risk-based capital rule, see https://www.gpo.gov/fdsys/pkg/FR-2004-07-28/pdf/04-16818.pdf.

Table 2. Bank Summary Statistics, Q2 2001–Q1 2009

	Banks < $10 billion in total assets	Banks ≥ $10 billion but < $50 billion in total assets	Banks ≥ $50 billion in total assets	Total
Total banks	4,510	1,005	570	6,085
Securitizing banks	350	462	435	1,247
Average HRR to total assets	0.01	0.03	0.04	0.01
Minimum HRR to total assets	−0.19	−0.12	−0.03	−0.19
Maximum HRR to total assets	0.33	0.36	0.35	0.36
Average HRR to Tier 1 capital	0.09	0.41	0.63	0.20
Minimum HRR to Tier 1 capital	−2.72	−1.45	−0.39	−2.72
Maximum HRR to Tier 1 capital	4.36	6.00	6.36	6.36
Average Tier 1 slack(t−1)	0.08	0.07	0.05	0.07
Minimum Tier 1 slack(t−1)	−0.03*	0.02	0.03	−0.03*
Maximum Tier 1 slack(t−1)	0.37	0.19	0.18	0.37
Average holdings of other HTM and AFS securities	0.22	0.20	0.13	0.21
Average holdings of C&I loans	0.11	0.12	0.14	0.12
Average holdings of mortgages	0.48	0.42	0.29	0.45
Average short-term wholesale funding	0.21	0.22	0.22	0.21
Average unused loan commitments	0.08	0.09	0.07	0.08
Average change in natural log of z-score	−0.03	−0.03	−0.05	−0.03
Minimum change in natural log of z-score	−3.89	−2.10	−2.25	−3.89
Maximum change in natural log of z-score	3.39	2.09	2.82	3.39

* In the sample, only Sterling Financial Corporation reported negative Tier 1 regulatory capital slack during quarters between 2007 and 2008.

Note: HRR = highly rated residual; HTM = held-to-maturity; AFS = available-for-sale; C&I = commercial and industrial.

Table 3. Estimates of Holdings of Highly Rated Tranches Relative to Total Assets, Q2 2001–Q1 2009

	Bank size fixed effects		Securitizing bank fixed effects		Bank size and securitizing bank fixed effects	
Other HTM/AFS Q2		0.00 (0.00)		0.00 (0.00)		0.00 (0.00)
Other HTM/AFS Q3		0.00 (0.00)		0.00 (0.00)		0.00 (0.00)
Other HTM/AFS Q4		0.00 (0.01)		0.00 (0.01)		0.00 (0.01)
Short-term funding Q2		0.00 (0.00)		0.00 (0.00)		0.00 (0.00)
Short-term funding Q3		0.00 (0.01)		0.00 (0.01)		0.00 (0.00)
Short-term funding Q4		0.00 (0.01)		0.00 (0.01)		0.00 (0.01)
Tier 1 slack(t−1)		0.11 (0.07)		0.05 (0.07)		0.11 (0.07)
Securitizing SIFI bank					0.02 (0.01)	0.02* (0.01)
Securitizing large bank					0.02* (0.01)	0.02** (0.01)
Securitizing bank			0.01 (0.01)	0.01 (0.01)	0.00 (0.00)	0.00 (0.00)
SIFI	0.02** (0.01)	0.02** (0.01)			−0.01* (0.01)	−0.01 (0.01)
Large bank	0.01 (0.01)	0.01* (0.01)			0.02 (0.01)	0.02 (0.01)
Constant	0.01** (0.00)	0.00 (0.01)	0.01** (0.00)	0.01 (0.01)	0.01** (0.00)	0.00 (0.01)
N	6,085	6,085	6,085	6,085	6,085	6,085
R-squared	0.11	0.12	0.05	0.05	0.13	0.14

* = 90% significance level.
** = 95% significance level.

Note: Standard errors are clustered by bank holding company. In the last two columns, the estimates are generated after creating five different bank groups, beyond the benchmark case of nonsecuritizing banks with less than $10 billion in total assets. “Large bank” indicates a nonsecuritizing large bank. “SIFI” indicates a nonsecuritizing systemically important financial institution. “Securitizing bank” indicates a securitizing bank with less than $10 billion in total assets. HTM = held-to-maturity. AFS = available-for-sale.

Table 4. Estimates of Holdings of Highly Rated Tranches Relative to Tier 1 Capital, Q2 2001–Q1 2009

	Bank size fixed effects		Securitizing bank fixed effects		Bank size and securitizing bank fixed effects	
Other HTM AFS Q2		−0.01		−0.04		−0.01
		(0.05)		(0.05)		(0.04)
Other HTM AFS Q3		0.01		0.02		0.01
		(0.08)		(0.07)		(0.07)
Other HTM AFS Q4		0.08		0.04		0.07
		(0.10)		(0.10)		(0.09)
Short-term funding Q2		−0.04		−0.04		−0.04
		(0.07)		(0.07)		(0.07)
Short-term funding Q3		−0.06		−0.05		−0.07
		(0.08)		(0.08)		(0.07)
Short-term funding Q4		0.03		0.01		0.02
		(0.10)		(0.11)		(0.11)
Tier 1 slack(t−1)		1.26		0.29		1.21
		(1.13)		(1.07)		(1.12)
Securitizing SIFI bank					0.21	0.28*
					(0.16)	(0.16)
Securitizing large bank					0.28	0.33*
					(0.17)	(0.17)
Securitizing bank			0.11	0.12	−0.04	−0.03
			(0.09)	(0.09)	(0.07)	(0.07)
SIFI	0.14	0.21			−0.21*	−0.17
	(0.14)	(0.13)			(0.12)	(0.13)
Large bank	0.27**	0.31**			0.24	0.28
	(0.13)	(0.14)			(0.20)	(0.20)
Constant	0.11**	−0.01	0.14**	0.13	0.11**	0.01
	(0.05)	(0.12)	(0.05)	(0.11)	(0.06)	(0.11)
N	6,085	6,085	6,085	6,085	6,085	6,085
R-squared	0.12	0.13	0.05	0.06	0.14	0.15

* = 90% significance level.
** = 95% significance level.

Note: Standard errors are clustered by bank holding company. In the last two columns, the estimates are generated after creating five different bank groups, beyond the benchmark case of nonsecuritizing banks with less than $10 billion in total assets. “Large bank” indicates a nonsecuritizing large bank. “SIFI” indicates a nonsecuritizing systemically important financial institution. “Securitizing bank” indicates a securitizing bank with less than $10 billion in total assets. HTM = held-to-maturity. AFS = available-for-sale.

Table 5. Panel Estimates of Quarterly Changes in Natural Log of Z-Score, Q4 2001–Q1 2009

	No controls or crisis interaction effects	Controls, no crisis interaction effects	No controls, crisis interaction effects	Controls, crisis interaction effects
HRR(t−1)	0.03 (0.11)	−0.03 (0.11)	0.05 (0.06)	0.06 (0.08)
× Q2 2007			0.52* (0.29)	0.74** (0.31)
× Q1 2008			−1.56*** (0.40)	−1.80*** (0.48)
Other HTM AFS(t−1)	0.23*** (0.04)	0.13** (0.04)	−0.04*** (0.02)	0.01 (0.05)
× Q2 2007			0.29*** (0.10)	0.34* (0.18)
× Q1 2008			0.16 (0.14)	−0.16 (0.25)
C&I loans(t−1)		−0.09* (0.06)		−0.03 (0.05)
× Q2 2007				0.07 (0.19)
× Q1 2008				−0.04 (0.24)
Mortgages(t−1)		−0.09** (0.04)		0.00 (0.05)
× Q2 2007				0.09 (0.15)
× Q1 2008				−0.32 (0.20)
Short-term funding(t−1)		−0.13*** (0.04)		0.01 (0.03)
× Q2 2007				−0.08 (0.13)
× Q1 2008				−0.01 (0.18)
Unused loan commitments(t−1)		−0.08 (0.07)		−0.15** (0.07)
× Q2 2007				0.20 (0.21)
× Q1 2008				−0.13 (0.41)
Tier 1 slack(t−1)		−0.12 (0.17)		−0.50*** (0.15)
× Q2 2007				0.13 (0.77)
× Q1 2008				2.02** (0.92)
Return on assets(t−1)		5.32 (3.72)		13.04*** (1.61)

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	No controls or crisis interaction effects	Controls, no crisis interaction effects	No controls, crisis interaction effects	Controls, crisis interaction effects
× Q2 2007				−25.72***
				(3.64)
× Q1 2008				5.03
				(3.67)
Large bank		−0.03***		−0.03***
		(0.01)		(0.01)
× Q2 2007				0.00
				(0.03)
× Q1 2008				0.03
				(0.04)
SIFI		−0.06***		−0.03**
		(0.02)		(0.02)
× Q2 2007				0.04
				(0.04)
× Q1 2008				−0.08
				(0.06)
Securitize		0.04***		0.01
		(0.01)		(0.01)
× Q2 2007				−0.05
				(0.03)
× Q1 2008				0.05
				(0.05)
Q2 2007 (dummy)			−0.30***	−0.20
			(0.02)	(0.13)
Q1 2008 (dummy)			−0.01	0.05
			(0.03)	(0.15)
Constant	−0.09***	0.00	0.03***	−0.02
	(0.01)	(0.04)	(0.00)	(0.04)
N	5,765	5,765	5,765	5,765
R-squared	0.003	0.011	0.052	0.071

* = 90% significance level.
** = 95% significance level.
*** = 99% significance level.

Note: HRR = highly rated residual. HTM = held-to-maturity. AFS = available-for-sale.

Appendix: Supplementary Tables and Figures

Table A1. Variable Construction

Variable name	Transformation applied to raw series
Highly Rated Residual	Erel, Nadauld, and Stulz's (2014) measure of the highly rated residual equals the sum of "held-to-maturity" securities with risk weights of 0.2, bhc21754, and 0.5, bhc51754, "available-for-sale" securities with risk weights of 0.2, bhc21773, and 0.5, bhc51773, and all other mortgage-backed securities in trading accounts, bhck3536, minus "held-to-maturity" GSE-issued US Government Agency Obligations, bhck1294, "available-for-sale" GSE-issued US Government Agency Obligations, bhck1297, "held-to-maturity" MBS issued by Freddie Mac and Fannie Mae, bhck1703, "available-for-sale" MBS issued by Freddie Mac and Fannie Mae, bhck1706, other "held-to-maturity" MBS issued by Freddie Mac, Fannie Mae, Ginnie Mae, bhck1714, other "available-for-sale" MBS issued by Freddie Mac, Fannie Mae, Ginnie Mae, bhck1716, other "held-to-maturity" collateralized MBS issued by Freddie Mac, Fannie Mae, Ginnie Mae, bhck1718, other "available-for-sale" collateralized MBS issued by Freddie Mac, Fannie Mae, Ginnie Mae, bhck1731, "held-to-maturity" municipal securities, bhck8496, "available-for-sale" municipal securities, bhck8498. Throughout the paper, this variable is either divided by total assets, bhck2170, or by Tier 1 capital, bhck8274.
Large Bank	Dummy variable that equals 1 if the bank's total assets, which are reported in thousands of US dollars, equal $10 billion but less than $50 billion, measured as bhck2170 < 50,000,000 and bhck2170 ≥ 10,000,000, and zero otherwise.
SIFI Bank	Dummy variable that equals 1 if the bank's total assets, which are reported in thousands of US dollars, greater than or equal to $50 billion, measured as bhck2170 ≥ 50,000,000, and zero otherwise.
Securitization Active Bank	Dummy variable that equals 1 if bank reports income from securitization of 1-4 Family Residential Loans, bhckb705, home equity lines of credit, bhckb706, credit card receivables, bhckb707, auto loans, bhckb708, other consumer loans, bhckb709, commercial and industrial loans, bhckb710, or all other loans, leases, or other assets, bhckb711, and equals zero otherwise.
Other Held-to-Maturity and Available-for-Sale Securities as a Fraction of Total Assets	The quantity of the sum of total held-to-maturity securities, bhck1754, and available-for-sale securities, bhck1773, minus the highly rated tranches, described above, and all other mortgage-backed securities in trading accounts, bhck3536, divided by total assets, bhck2170
Commercial & Industrial Loans as a Fraction of Total Assets	The sum of commercial and industrial loans to US addressees, bhck1763, and foreign addressees, bhck1764, divided by total assets, bhck2170
Total Real Estate as a Fraction of Total Assets	Total loans secured by real estate, bhck1410, divided by total assets, bhck2170
Short-Term Wholesale Funding as a Fraction of Total Assets	The quantity of the sum of time deposits of $100,000 or more, bhcb2604, commercial paper, bhck2309, other borrowed money with a remaining maturity of one year or less, bhck2332, federal funds purchased in domestic offices, bhdmb993, securities sold under agreements to repurchase, bhckb995, and trading liabilities, bhck3548, divided by total assets, bhck2170
Unused Loan Commitments as a Fraction of Total Assets	The quantity of the sum of revolving, open-end loans secured by 1–4 family residential properties, such as home equity lines, bhck3814, and credit card lines, bhck3816, divided by total assets, bhck2170

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Variable name	Transformation applied to raw series
Lagged Tier 1 to Risk-Weighted Assets minus 0.04	The slack in the quantity of one-quarter lagged Tier 1 capital, bhck8274, divided by risk-weighted assets, bhcka223, minus 0.04
Quarterly Changes in the Log of the Z-Score	The quarterly first difference in the natural log of the z-score measured as log([bhck4340/bhck2170 + mktval/bhck2170]/[stdev(intraquarterly daily returns) × (trading days) × mktval/bhck2170]. • bhck4340/bhck2170 measures return on assets • mktval/bhck2170 equals the end-of-quarter stock market value of the firm divided by book value of assets, where the numerator measures the end of quarter market value of each bank holding company's shares (market price multiplied by number of shares) taken from the Center for Research in Security Prices (CRSP) database available from https://wrds-web .wharton.upenn.edu/wrds/. I merge the CRSP data with the Call Report data, using the Federal Reserve Bank of New York's 2014-3 "CRSP-FRB Link," available from https://www.newyorkfed.org/research/banking _research/datasets.html. • stdev(intraquarterly daily returns) × (trading days) × mktval/bhck2170, in the denominator is a variant of Correira, Kang, and Richardson's (2014) measure of "naïve" asset volatility, by estimating the intraquarterly standard deviation of each bank's stock returns and multiplying that by the end-of-period market value of the bank's equity as a fraction of total assets, mktval/bhck2170.

Table A2. SIFI Banks

Nonsecuritizing SIFI banks (at least $50 billion in assets)			
AmSouth	BB&T	Comerica	Huntington Bancshares
MetLife	Northern Trust	UnionBanCal Corp.	
Securitizing SIFI banks (at least $50 billion in assets)*			
Bank of America (merged with FleetBoston Financial Corp.)	Bank of New York	Citigroup	Fifth Third Bancorp
JPMorgan Chase & Co. (merged with Bank One)	M&T	MBNA	National City Corp.
North Fork	PNC Financial Services Group	State Street Corp.	SunTrust Bank
U.S. Bancorp	Wachovia (merged with SouthTrust)	Wells Fargo & Co. (merged with First Union Corp.)	Zions Bancorporation

Note: Commerce Bancshares appears as a securitizing SIFI in Q3 2007 only, as it crossed the $50 billion threshold.
SIFI = systemically important financial institution.

Table A3. Panel Estimates of Quarterly Changes in Natural Log of Z-Score, Q4 2001–Q1 2009: Highly Rated Tranches versus Trading Assets

	No Controls or crisis interaction effects	Controls, no crisis interaction effects	No controls, crisis interaction effects	Controls, crisis interaction effects
HRR(t−1)	0.04 (0.10)	−0.11 (0.11)	0.05 (0.07)	0.06 (0.08)
× Q2 2007			0.61* (0.33)	0.61** (0.30)
× Q1 2008			−1.51*** (0.41)	−1.80*** (0.44)
Trading assets(t−1)	−0.15 (0.09)	-0.25 (0.16)	0.03 (0.04)	0.04 (0.13)
× Q2 2007			-0.29 (0.19)	-0.04 (0.26)
× Q1 2008			0.14 (0.22)	−0.50 (0.35)
C&I loans(t−1)		−0.18*** (0.06)		−0.04 (0.04)
× Q2 2007				-0.10 (0.18)
× Q1 2008				0.01 (0.23)
Mortgages(t−1)		−0.179*** (0.03)		0.00 (0.03)
× Q2 2007				-0.10 (0.11)
× Q1 2008				−0.25* (0.15)
Short-term Funding(t−1)		−0.10** (0.04)		0.02 (0.03)
× Q2 2007				−0.04 (0.12)
× Q1 2008				0.01 (0.17)
Unused loan commitments(t−1)		−0.09 (0.07)		−0.15** (0.07)
× Q2 2007				0.24 (0.22)
× Q1 2008				−0.18 (0.43)
Tier 1 slack(t−1)		−0.06 (0.16)		−0.50*** (0.15)
× Q2 2007				0.47 (0.77)
× Q1 2008				1.80** (0.89)
Return on assets(t−1)		5.16 (3.70)		12.83*** (1.61)
× Q2 2007				−25.35*** (3.68)

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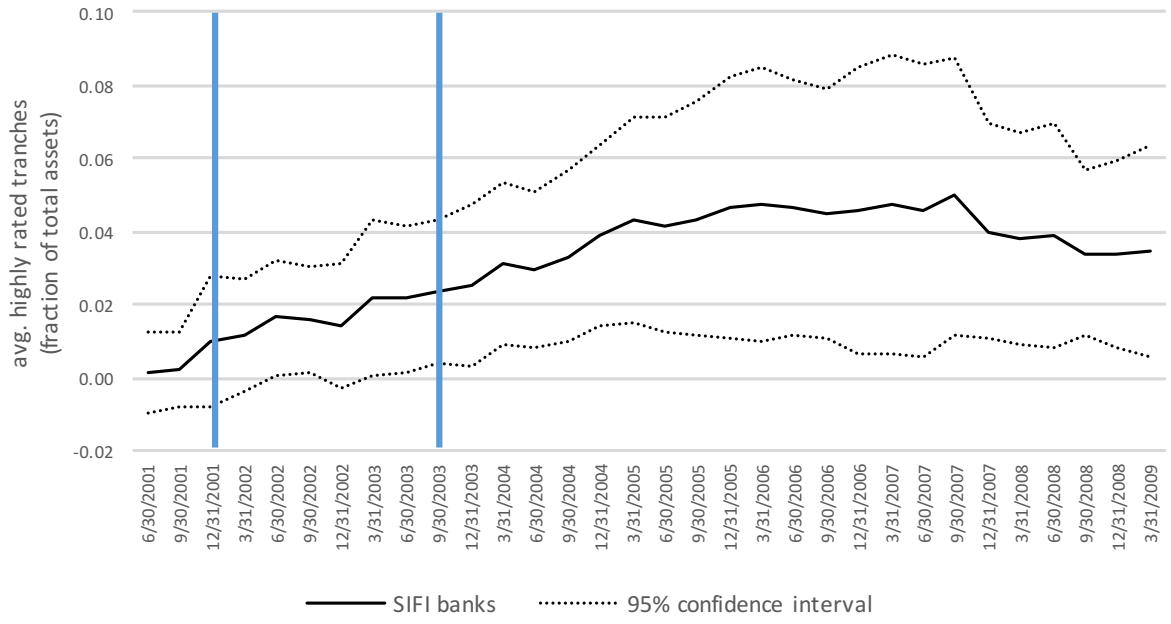
	No Controls or crisis interaction effects	Controls, no crisis interaction effects	No controls, crisis interaction effects	Controls, crisis interaction effects
× Q1 2008				4.84
				(3.70)
Large bank		−0.03***		−0.03***
		(0.01)		(0.01)
× Q2 2007				0.00
				(0.03)
× Q1 2008				0.03
				(0.04)
SIFI		−0.07***		−0.04**
		(0.02)		(0.01)
× Q2 2007				0.01
				(0.04)
× Q1 2008				−0.04
				(0.06)
Securitize		0.04***		0.01
		(0.01)		(0.01)
× Q2 2007				−0.06**
				(0.03)
× Q1 2008				0.07
				(0.04)
Q2 2007 (dummy)			−0.24***	−0.06
			(0.01)	(0.11)
Q1 2008 (dummy)			0.02	0.00
			(0.02)	(0.13)
Constant	−0.04***	0.07*	0.02***	−0.02
	(0.00)	(0.04)	(0.00)	(0.03)
N	5,745	5,745	5,745	5,745
R-squared	0.000	0.010	0.051	0.071

* = 90% significance level.
** = 95% significance level.
*** = 99% significance level.

Note: HRR = highly rated residual.

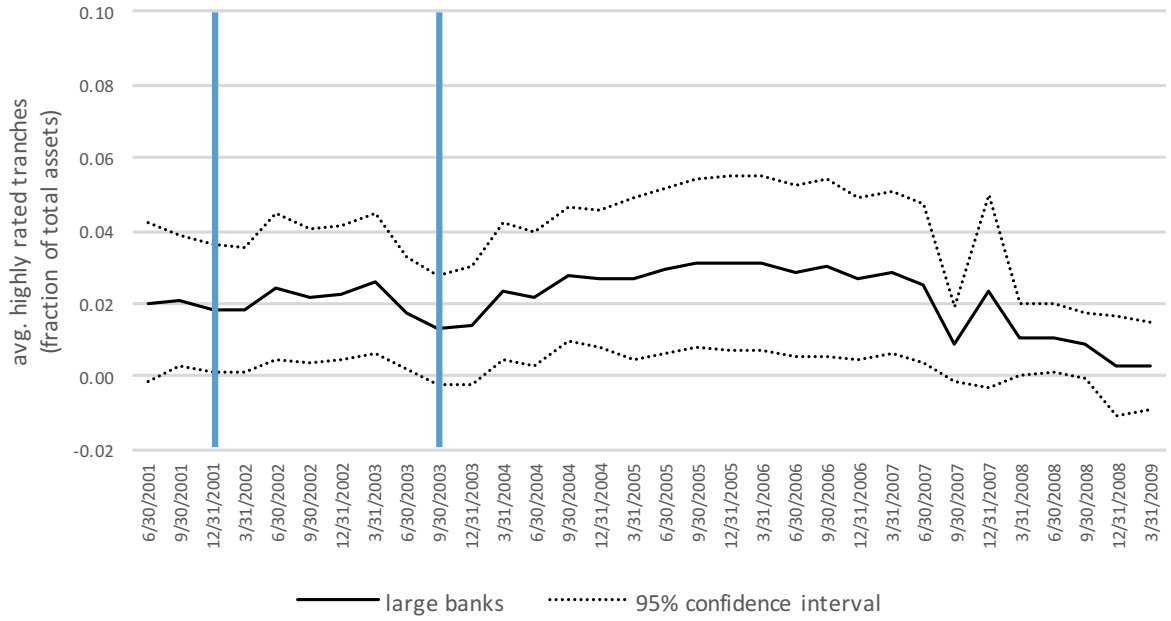
Figure A1. Average Excess Holdings (Relative to Banks with Less Than $10 Billion in Assets) for Banks with at Least $50 Billion in Assets, Q1 2001–Q1 2009



Note: SIFI = systemically important financial institution.

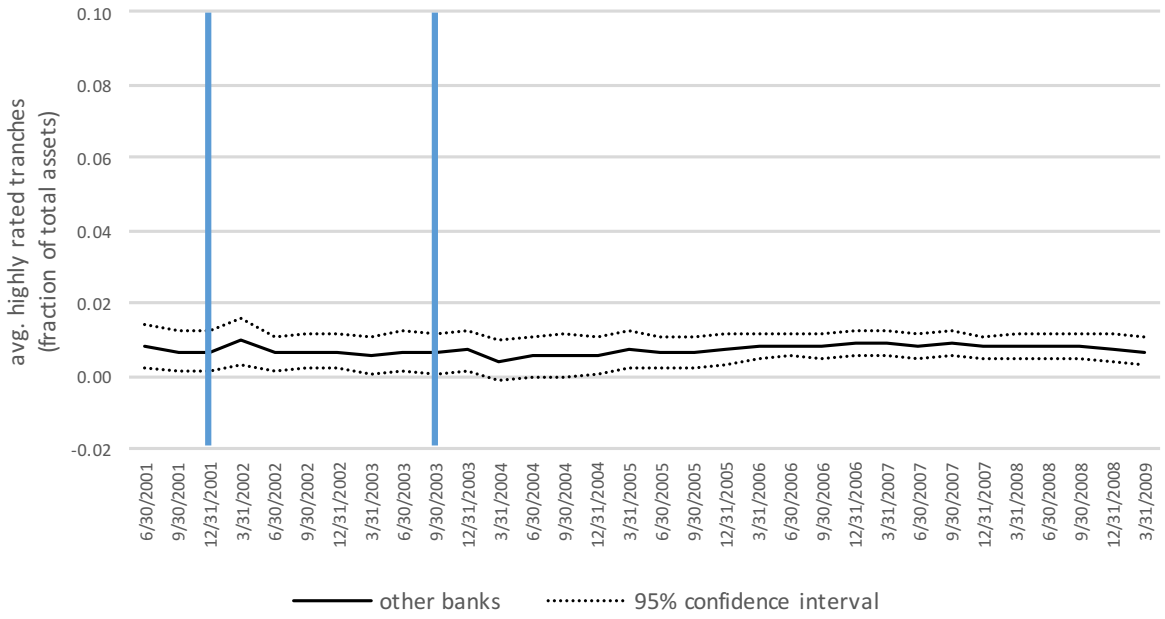
Source: Based on author's estimates.

Figure A2. Average Excess Holdings (Relative to Banks with Less Than $10 Billion in Assets) for Banks with at Least $10 Billion and Less Than $50 Billion in Assets, Q1 2001–Q1 2009



Source: Based on author's estimates.

Figure A3. Average Holdings of Highly Rated Tranches for Banks with Less Than $10 Billion in Assets, Q1 2001–Q1 2009



Source: Based on author's estimates.