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Abstract

Banks are regulated more than most firms, making them good subjects to study regulatory arbitrage (avoidance). Their latest arbitrage opportunity may be the new leverage rule covering the largest U.S. banks; leverage rules require equal capital against assets with unequal risks, so banks can effectively relax the leverage constraint by increasing asset risk. Consistent with that conjecture, we find that banks covered by the new rule shifted to riskier, higher yielding securities relative to control banks. The shift began almost precisely when the rule was finalized in 2014, well before it took effect in 2018. Security-level analysis suggests banks actively added riskier securities, rather than merely shedding safer ones. Despite the risk-shifting, overall bank risk did not increase, evidently because the banks most constrained by the new leverage rule significantly increased leverage capital ratios.

Key words: Basel III regulation, bank risk, leverage limit, regulatory arbitrage, reaching for yield

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> Because our existing capital standards treat all bank assets alike, they have had the effect of encouraging some institutions to scale back their holdings of relatively liquid, low-risk assets (Paul Volcker, 1987)

> …a leverage requirement that is too high favors high-risk activities and disincentivizes low-risk activities (Randal K. Quarles, 2018)

I. Introduction

The *déjà vu* aspect of our question is reflected in the quotes above. The first is former Federal Reserve Chairman Volcker explaining why bank regulators were moving from the leverage rule imposed in 1981 to risk-based capital rules. The second is the current Vice Chairman for Supervision explaining why the new leverage rule that took effect in 2018 was being recalibrated to curb risk-shifting incentives. Bankers, for their part, have been candid about the incentives created by the new leverage rule:

> … the proposal would have discouraged banks from holding low-yielding, high-quality assets…in preference for riskier assets which would produce a higher relative return of capital. (J.P. Morgan (2014))

Despite these long-standing concerns, evidence that banks arbitraged the old leverage rule by shifting toward riskier assets is limited. The earlier rule is not well suited for testing that conjecture, however, as it covers all banks and rarely binds.[2] The new rule, the Supplementary Leverage Rule (SLR), provides better testing ground as it applies to only the largest U.S. banks and for some is the more binding capital requirement.

[2] Koehn and Santomero (1980) and Kim and Santomero (1988) predicted asset substitution and potentially higher default risk after the leverage rule was imposed in the early 1980s but Furlong (1988), the only test, found no evidence for either prediction.

Using this latest leverage rule experiment, we re-visit the arbitrage conjecture using difference-in-difference (DD) analysis. We test if asset and overall bank risk measures increased after the rule was finalized in 2014 for the 15 banks subject to the SLR ("SLR banks") relative to a control group. Treatment under the SLR is determined entirely by bank size with covered banks all having assets over $250 billion or over $10 billion in foreign exposures. To minimize non-treatment differences, we use the next largest 18 banks with assets between $50 and $250 billion as the control. Though smaller, these "non-SLR banks" are officially "systemically important" under the Dodd Frank Act of 2010 (by virtue of having assets over $50 billion) and so face similar post-crisis reforms, including stress testing and liquidity regulation, apart from the new leverage rule.[3] We estimate fixed effect regression models using a balanced panel of those 33 banks (subject to data availability) that control for size, business models characteristics, and other observable differences between the two sets of banks.

The first risk measure we study is the ratio of risk-weighted assets to total assets, a standard asset risk measure that determines banks' risk-based capital requirement. While we find no evidence of a shift toward riskier loans by the SLR banks, we find qualified evidence of shift toward riskier securities. Following that trail, we then move to security yields. For that analysis we collected the amount of every security held by all banks in the panel each quarter from their confidential stress-test filings (Y-14Q), then matched with yields from multiple sources. These data, spanning over 75,000 unique securities and a million bank-security-

[3] The SLR banks face a stricter version of the new liquidity coverage rule than the control banks. Since the rule requires banks to hold more "high quality liquid assets," (which tend to be safer) it tends to limit the leverage rule arbitrage we are investigating, and more so for the SLR banks, i.e., it tends to attenuate our findings. We discuss this in more detail later in the paper.

quarters, offers an unusually detailed glimpse into banks' security books, their second biggest asset.[4]

The figure below illustrates the "reach for yield" we find in response to the new leverage rule. Mean (volume) weighted security yields at the two sets of banks declined in tandem until the rule was finalized in 2014 when banks learned how constraining the rule might be. Afterwards, yields at the non-SLR banks leveled off while yields at the SLR banks reversed trend and began rising, nearly reaching the level at non-SLR banks. According to our formal DD estimates, mean yields increased about 40 basis points relative to the control banks after the rule was finalized.

Figure 1 here

We use the granular bank-security level data to assess how banks arbitraged the leverage rule; did they *passively* shed safer assets, as in Volcker (1987) above, or did they *actively* add riskier ones as in Quarles (2018). Though both forms imply higher risk, knowing how far banks go to arbitrage regulation is useful for designing incentive compatible regulation. Some banks do not arbitrage regulations (Boyston et al 2018), so whether they actively arbitraged the SLR is not obvious. Our security level analysis, where we study holdings of the same security by different banks, suggests the SRL banks actively arbitraged the leverage rule by adding high yield securities.

[4] Studying yields also avoids potential doubts about the accuracy of those risk weights for the SLR banks. The SLR banks use internal risk estimates for setting risk-weighted capital requirements. Doubt about those risk-weights prompted regulators to impose an "unweighted" leverage requirement as a back stop (BCBS 2009, Greenwood et al. 2017).

We finally look at how overall risk changed at the SLR banks. Despite the evident risk-shifting induced by the leverage rule, the effect on default risk also depends on whether those banks reduced leverage.[5] The bank risk measures we examine, including Z scores, equity volatility, and CDS spread, should capture both asset risk and leverage effects. The findings do not point conclusively toward higher bank default risk, not even for the most constrained SLR banks. Those banks did increase leverage capital, however, which may have offset the effects of risk shifting on default risk. Of course, the opposite could be said; the risk shifting induced by the new leverage rule offsets any benefit of lower leverage in terms of decreasing default risk. Overall, the new leverage rule appears to have been only partially effective; it succeeded in constraining leverage, but seemed not to make banks safer overall.

Our findings extend recent studies of leverage rule arbitrage in the securities repo (repurchase) market (Allahrakha et al. (2018), Bicu et al. (2017), Kotidis and Van Horen (2018), and Bucalossi and Scalia (2016)). The first three studies find evidence of banks reducing repo activity in response to leverage limits in the U.S. or the U.K. Our findings of more active arbitrage beyond repo complements and extends those studies.[6] Acosta Smith et al. (2017) also look beyond repo. They find a similar shift to riskier assets at European banks but no increase in overall bank risk, consistent with our findings. Our findings contribute to the broader literature on regulatory arbitrage, notably Calomiris and Mason (2004), Acharya, Schnabl, and Suarez (2013), Boyson, Fahlenbrach, and Stulz (2016), Becker and Ivashina (2015), and Santos and Plosser (2014).

[5] That was largely the insight from the theoretical literature spurred by the 1980s leverage ratio cited above and more recently by Acosta Smith et al. (2017).

[6] Repo is fertile ground for identifying leverage rule effects because it is precisely the type of low risk/low yield/high volume activity leverage constrained banks might passively exit first. The securities holdings we study do not include securities held for repurchase.

Section II reviews the history of leverage limits in the U.S., from the first in 1981 to the latest. Section III describes our empirical strategy. Section IV presents results. Section V concludes.

II. From Leverage Limits and Back Again

We trace the circle of capital regulation over the last 40 years from leverage limits to risk-based capital rules, then back, partly, to leverage limits.

Concerned about rising failures and falling capital levels across the banking system, U.S. bank regulators announced explicit, uniform capital requirements for the first time in 1981 (Volcker 1987).[7] The rules required at least 5.5 percent primary capital and 6 percent total capital relative to total, on balance sheet assets. While the requirements were conditional on capital quality, they were invariant to asset quality (risk), hence were leverage limits in our terms.

The new rules triggered an active debate whether, theoretically, risk-invariant capital requirements, i.e., leverage rules, might actually increase bank risk via asset substitution (Koehn and Santomero (1980), Kim and Santomero (1988), Furlong and Keeley (1989)). The only empirical test of that question at the time appears to be Furlong (1988). He compares changes in three risk measures between 1981 and 1986 for 24 "capital deficient" banks in 1981 per the new standards and 75 "capital sufficient" banks. He finds no significant differential changes in the market-based asset risk measure he constructs or in bank default risk (Z) scores, contrary to the risk-shifting conjecture.

[7] Capital adequacy before then was assessed bank-by-bank by supervisors so the shift to formal standards marked an important shift in regulatory policy. Regulators could still require higher capital at banks with substantial off-balance-sheet exposures or assets considered particularly risky (Gilbert et al. 1985, p. 16)

Lingering concerns about risk-shifting and other unintended effects led the Federal Reserve in 1986 to propose replacing the leverage rule with risk-based capital requirements based on total assets, including off-balance sheet assets (Volcker 1987, Wall 1989).[8] That proposal, in cooperation with international bank regulators, evolved into the Basel I capital accord in 1990. Basel I defined standard risk weights for broad asset classes and set required capital minimums relative to risk-weighted assets. Basel II in 2004 elaborated more risk-sensitive capital requirements and allowed very large "advanced approach" firms the option of using internal models, subject to supervisory review, to estimate asset risk.

Concerns about excessive leverage preceding the crisis, and evidence that advanced approach firms were exaggerating their risk-based capital positions, led to the return of leverage limits. In 2010, the Basel Committee recommended a new leverage rule (the Basel III leverage ratio) and U.S. regulators proposed their version—the Supplementary Leverage Rule in 2012 (see timeline below). The SLR rule requires advanced approach firms to maintain a minimum ratio of Tier 1 capital per total leverage exposures (including off-balance sheet assets) of 3 percent. The "enhanced" SLR (eSLR) rule finalized in 2014 required advanced approach firms designated as global systemically important banks (G-SIBs) to hold a minimum of 5 percent. The denominator of the SLR was finalized, after much discussion and public comment in September 2014. We use that date as the treatment date since that is when banks learned definitively how binding the rule would be. Covered banks were required to disclose their SLR ratios on their Investor Relations webpages beginning January 2015. The SLR took effect in January, 2018.

[8] Regulators were also concerned that banks were shifting assets off balance sheets to inflate their leverage ratio.

SLR Timeline

1/2012:	U.S regulators propose SLR
7/2013:	U.S. regulators finalize SLR rule; propose eSLR
4/2014:	Finalize eSLR; propose revisions to SLR denominator
9/2014:	SLR denominator finalized
1/2015:	Mandatory disclosures of SLR ratio by covered banks
1/ 2018:	SLR and eSLR compliance date

Under the new rule, the SLR is defined by

$$SLR = \frac{Tier\ 1\ Capital}{Total\ leverage\ exposure},$$

where the denominator includes both on-balance sheet assets and many off-balance sheet exposures.[9] The risk-invariant aspect of the SLR is obvious; two banks with the same total assets (on- and off-balance sheet) face the same limit, even if one has much riskier assets than the other. By contrast, under the risk-based capital (RBC) requirement, the capital ratio is defined by

$$RBC\ ratio = \frac{Tier\ 1\ Capital}{Risk{-}weighted\ assets},$$

where assets are classified into risk classes with different associated risk weights for each. If two banks have the same total assets, but one has more assets in the riskier classes, its minimum required capital will be higher.

[9]More specifically, total leverage exposure is the sum of on-balance sheet assets, derivative exposures, securities financing (i.e., repo-style) transaction exposures, and other off-balance sheet exposures. Derivate exposures include, e.g., potential future exposure for each derivative contract, cash collateral received from or posted to a counterparty, and effective notional principal amount of a credit derivative. Off-balance sheet exposures are the credit equivalent amount of all of its off-balance sheet exposures determined using the applicable credit conversation factor.

It was widely reported that the new leverage limits were *the* binding capital constraint for many banks, meaning their leverage requirement was more binding that their risk-based capital requirement (J.P. Morgan 2014). Figure 2 is consistent with those reports: among the SLR banks, all had at least two percentage points of slack relative to the risk-based requirement (Tier 1 capital relative to risk-weighted assets) in 2013:Q4. By contrast, eight had less than two percentage points of slack relative to their leverage requirement and six had negative slack.[10]

Figure 2 here

Banks bound by the leverage rule have two options: increase tier 1 capital or decrease total leverage exposures. If a bank chooses to raise more capital, they can offset any increased costs by shedding safer, lower-yielding assets and/or adding riskier, higher-yielding ones. If it instead chooses to reduce its assets, the least costly way to do so would be by shedding assets with low yields, such as reserves. In both cases, the bank's share of risky assets relative to safe assets, and its average yield on assets, should rise.

III. Empirical Strategy

We test for risk shifting by SLR banks using difference-in-difference (DD) regressions:

$$\sigma_{it} = \alpha_i + \alpha_t + \beta * SLR_i * Post_t + \gamma * Controls_{it-1} + \varepsilon_{it}. \qquad (1)$$

[10] We calculate the SLR before 2015 (when public disclosure) using "total exposures" from FR Y-15. We use 2013:Q4 (versus 2014:Q2) because only year-end data are available.

The dependent variable is one of the risk measures described below for bank *i* at year-quarter *t*. The firm fixed effect (α_i) controls for constant differences and business models across banks. The year-quarter fixed effect (α_t) controls for time-varying aggregate factors that might affect bank risk.

SLR_i equals 1 for banks subject to the new leverage rule and 0 for control banks. The treated group comprises the 15 banks that have assets of at least $250 billion or foreign exposures of at least $10 billion. Coverage is determined entirely by bank size and so is plausibly exogenous with respect to the risk outcomes we study. For the control group we use the 18 next-to-largest banks with assets between $250 billion and $50 billion.[11] The $50 billion cutoff is from the Dodd Frank Act of 2010 which used that threshold for designating "systemically important financial institutions" (SIFIs) to be subject to heightened regulatory scrutiny, including CCAR stress tests and liquidity regulation.[12]

We use the date the denominator of the SLR was finalized (2014:Q3) as the treatment date for the main analysis. While bankers knew a leverage rule was pending before then, they would not know how binding it might be until the denominator was finalized after much back and forth between bankers and regulators.[13] It is possible that bankers might have postponed any adjustments until 2018 (when the rule actually took effect), so we test for effects around the compliance date as well as an earlier date after presenting the main results. The coefficient β

[11] We excluded the non-bank firms, i.e., Charles Schwab and General Electric.

[12] CCAR (comprehensive capital and analysis review) stress tests covered only banks with assets above $50 billion.

[13] Anecdotally, bankers were already responding to the rule before January, 2015 disclosure date: "…banking organizations are already making changes to comply with the SLR given that the final rules require public disclosures beginning January 1, 2015." Bank of New York Mellon (2014), https://www.bnymellon.com/global-assets/pdf/our-thinking/arriving-at-new-capital-ratios.pdf.

equals the difference-in-difference (DD) in the risk measure. The risk-shifting hypothesis implies $\beta > 0$.[14]

The model includes a number of bank-level variables (lagged one quarter) to control for balance sheet and business model differences between the comparison groups.[15] First are the natural logarithm of total assets and its square to account for the larger size of the SLR banks. Second is the risk-based capital ratio (Tier 1 capital/RWA, denoted *Capital*) since banks with higher risk-based capital may have more leeway to arbitrage the leverage rule (by increasing RWA) while still satisfying their risk-based requirement. Third is a proxy for banks' liquidity coverage ratio (*Liquidity*) to mitigate potential downward bias arising from the stricter liquidity rule faced by the SLR banks. The proxy, the (inverse) of a liquidity stress ratio calculated by Federal Reserve Bank of New York, is conceptually similar to the new liquidity rule but is based only on public information.[16] Last are two proxies to account for the different business models of the comparison groups (see appendix A2 for the list of banks). The treated banks tend to be more "money center" banks with larger capital market operations (trading, investment banking, etc.) while the control banks are "regional" banks oriented more toward traditional, commercial banking activities. To control for any changes in orientation over the sample, we include the ratio of non-interest income to interest income (*non-interest income*) and the ratio of the number

[14] Given the bank and date fixed effects in the model, the "main" effects of Post_t and SLR_i are not identified.
[15] The balance sheet variables are all derived from banks' regulatory reports (form FR Y-9C).
[16] Recall that the liquidity coverage rule (enacted at nearly the same time as the SLR) tends to mitigate the risk shifting incentives created by the leverage rule. Moreover, the SLR banks face a stricter liquidity rule, so absent any control for the exposure to the leverage rule, we would underestimate the risk-shifting effects of the leverage rule on the SLR banks. A proxy is necessary because banks were not required to disclose their official liquidity coverage ratios until 2017. The FRBNY liquidity stress ratio is defined analogously to the liquidity coverage ratio:

$$LSR = \frac{\text{potential liquidity inflow}}{\text{potential liquidity outflow}} = \frac{\text{liquidity adjusted assets}}{\text{liquidity adjusted liabilities and off balance sheet exposures}}.$$

The liquidity adjustments reflect estimates of the "run" (withdrawal) risk of each liability type or off-balance sheet exposure (Choi and Zhou 2016). The proxy may overestimate liquidity coverage at the SLR banks because the outflow adjustments used by FRBNY do not fully capture the stricter assumptions used for the SLR banks.

of non-bank subsidiaries to bank subsidiaries (*non-bank subs.*). Both variables help capture capital market versus commercial banking orientation of the comparison groups (Stiroh 2004; Cetorelli and Goldberg 2014).[17]

IV. Data and Findings

We begin by analyzing the share of risky assets to total assets at the portfolio level. We then examine the security-level data to examine changes in the securities yields, and more importantly, whether SLR banks actively increased their holdings of riskier securities. We finally analyze the overall risk measures that reflect shifts in both asset riskiness and liability structure.

IV.1 Risk-Weighted Assets

The first risk measure we examine is the ratio of risk-weighted assets to total assets: *RWA/A.*[18] The denominator is the sum of all assets held by a bank. The numerator is the weighted sum across regulatory asset classes weighted by the approved risk factor for that class. For the securities asset class, for example, U.S. regulators define four risk categories with a zero weight on Treasuries and higher weights for foreign sovereigns, corporates, etc.

Despite doubts that led to the supplementary leverage rule, these risk-weights still underpin risk-based capital regulation across the most G-20 countries and *RWA/A* is commonly used in research. In our case a particular concern is that *RWA/A* may be less accurate for the SLR banks than for the control banks. Recall that the leverage rule was imposed on those banks because of the concerns that their RWA (and hence required capital) might be understated. The control banks use standardized risk weights which, if not necessarily more accurate, are less

[17] The correlations between bank ln(assets) and the non-interest income share and non-bank subs. share are 0.19 and 0.24, respectively.
[18] Bank holding companies report risk weighted assets in FR Y-9C, Schedule HC-R Part II.

subject to manipulation. If the SLR banks are better able to mute the impact of an asset shift on their *RWA/A*, our estimates will be biased downward.

We compare the means of *RWA/A* (in percent) by treatment in Table 1.[19] We look at *RWA/A* for total assets and for three, broad asset classes: securities, loans, and trading assets. For total assets, *RWA/A* was about three percentage points higher at the SLR banks after the treatment but was unchanged at the control group. A more pronounced differential change is evident for securities; mean *RWA/A* was lower for both sets of banks post-treatment, but by about five percentage points higher at the SLR banks. *RWA/A* for loans, by contrast, barely varied by treatment. *RWA/A* for trading assets rose less at the treated banks after the treatment date, although note the high standard deviation for that outcome.

The lower panel of Table 1 compares the control variables. The SLR banks are substantially larger; the average SLR bank had $790 billion in assets pre-treatment versus $102 billion for control banks. Neither group expanded or contracted assets after the treatment, suggesting that any changes in *RWA/A* reflects changes in the risk profile of assets. Both groups had similar capital and liquidity profiles, but the SLR banks earned significantly more from non-interest activities and had many more non-bank subsidiaries.

Table 1 here

[19] We winsorized at the 1/99 percentile to avoid influential outliers. In the (few) mergers involving the banks in our sample the merging banks treated as a single entity at the beginning. "Trading assets" and "Securities" are counted in distinct regulatory classes; the former includes bonds bought and held "principally for the purpose of selling in the near term" while the latter include bonds that have the "positive intent" to hold to maturity or "long periods." See Financial Accounting Standards Board, Summary of Statement No. 115 (https://www.fasb.org/summary/stsum115.shtml).

Figure 3 plots the trends in *RWA/A*. Pre-treatment the trends were largely parallel, suggesting no earlier effects for the leverage rule or other possible confounds. The trends after differed by asset class. *RWA/A* for loans was flat suggesting no treatment effect. *RWA/A* for trading assets is quite volatile, as comes with trading, but rose less at the SLR banks. *RWA/A* for securities and to a smaller extent total assets rose at SLR banks relative to the control banks at the quarter the rule was finalized, consistent with the risk-shifting conjecture.

Figure 3 here

The regression estimates are reported in Table 2. Although most of the control variables are individually insignificant, they are jointly significant (by an F-test) at below one percent in the model for total assets. *Capital* enters negatively in all models and is significant in the model for total assets, possibly reflecting lower risk tolerance at more highly capitalized banks.[20] *Liquidity* enters negatively across all models, consistent with the notion that holding high-quality, liquid assets could mitigate any shift toward riskier assets. The opposite signs on *ln(Assets)* and its square suggests a hump-shaped relationship between bank size and *RWA/A*.

Table 2 here

The top row of the table reports DD estimates in *RWA/A*. The point estimates for loans and trading assets are small and statistically insignificant, suggesting no risk shifting along those

[20] While the negative relationship between *Capital* (i.e., Tier 1/RWA) and *RWA/A* could be mechanical, bear in mind that the former variable lags the latter by one quarter. The DD estimates are largely unchanged if we omit *Capital* from the model.

asset dimensions. The estimate for securities, by contrast, is positive, significant, and sizable-about $2/5^{th}$ of a standard deviation in that variable over the pre-treatment period for SLR banks. The estimate for total assets is also positive and significant, but smaller-about $1/5^{th}$ of a standard deviation.

If the leverage rule is driving the risk shifting evident in Table 2, we would expect more pronounced effects for the more constrained banks. Table 3 reports separate DD estimates for SLR banks with more or less leverage slack (actual leverage capital – minimum required) as of 2013:Q4, three quarters *before* the rule was finalized. The slack for each bank is shown in Figure 2; *SLR Tighter* banks had below median slack while *SLR Looser* banks had above median slack.[21] The coefficients on each term measures the DD for each group relative to the control banks. For trading assets and loans, the estimates on both terms are insignificantly different from zero, consistent with the null main effect on those outcomes. For securities, only the estimate for *SLR Looser* is significantly different from zero, contrary to expectations, but that estimate and estimate for *SLR Tighter* are very similar (4.62 and 4.70) and are statistically indistinguishable by the Wald-test (bottom row).

Table 3 here

[21] While some SLR banks have positive slack (i.e., their supplementary leverage ratios as of 2013:Q4 are already higher than the required minimum), this does not necessarily imply that these banks are unconstrained by the SLR limit; banks also need to meet the minimum requirement under the CCAR stress scenarios. Besides, our findings are robust when we treat all banks with positive slack as unconstrained, and use the difference between the required minimum and the actual leverage ratio as a continuous treatment for banks with SLR below the limit. We thank an anonymous referee for this suggestion.

No Risk-Shifting in Loans?

Given the evident risk-shifting in securities, the absence of evidence for loans seems surprising; loans, after all, are banks' defining asset. To ensure that the non-evidence did not merely reflect less accurate risk weights for loans, we also examined non-performing loans and loan loss provisions, both measured *per* total loans, but found little evidence of a differential increase in either after the treatment date.[22] An alternative explanation for the asymmetry is that securities are more liquid and thus, "shiftier" than loans (Myers and Rajan 1998). Security risk might also be more predictable, making it easier to add a discrete "quantum" of risk via the securities book than by cultivating new loan relationships.

Alternative Treatments and Robustness

Here we investigate whether banks added risk at other key dates in the leverage rule timeline. To maximally smooth adjustments, banks might have started when the rule was first proposed in 2012:Q2 even before they knew how binding it would be. Alternatively, they may have followed the "bang bang" path and postponed all adjustments until the actual compliance date in 2018:Q1. While Figure 3 does not suggest any obvious divergence for total assets and securities at either date, we re-estimated the model allowing for both as alternative treatment dates. For both we look for *marginal* treatment effects given the effect we have already identified in 2014.

The DD estimates for those alternative treatments are reported in columns 1 to 4 in Table 4. The models include the same controls and we only report the DD estimates for total assets and securities for brevity.[23] The estimates for the early (proposal) and later (compliance)

[22] Specifically, we estimated the same regression models over the same period and with the same controls but with non-performing loan and provisions (both measured relative to total loans) as dependent variables. The DD estimates in both were small and insignificantly different from zero.

[23] There was no significant DD in *RWA/A* for loans and trading assets around these alternative treatment dates.

treatment are generally small and are all statistically insignificant. Allowing for those possible effects does not appreciably alter the size or significance of the effects after the new rule was finalized in 2014:Q3.

Table 4 here

That banks began adjusting to the new leverage rule almost four years before it actually took effect is notable. If their new steady state is second-best relative to no leverage constraint, they might be expected to minimize the cost by waiting until the rule took effect. However, the optimal portfolio should depend more on their actual leverage, and as we show later, the more constrained banks began increasing their leverage capital in early 2015 when they were required to disclose their supplementary leverage ratios.

The remaining columns of Table 4 report results from several robustness tests. To further ensure that differences in business model were not driving the results, we dropped the two "pure" investment banks and the three custody banks.[24] Excluding those banks hardly changes the DD estimates, although shrinking the sample by about 15 percent does reduce statistical significance for total assets. The estimate for securities is significant even with the smaller sample (columns 5 and 6).

Another potential concern is that we are misattributing to the new leverage rule effects stemming from higher (risk-based) capital requirements since the crisis or the new liquidity rule. To address that concern, we included interactions between *Post* and the capital and liquidity coverage variables to allow for possible changes in the relationship between those variables and

[24] The excluded investment banks are Goldman Sachs and Morgan Stanley. The excluded custodian banks are State Street, Bank of NY Mellon, and Northern Trust Corp. We thank a referee for suggesting this robustness test.

RWA/A after the treatment date. As reported in columns 7 – 10, neither *Post x Capital* or *Post x Liquidity* are significant and their inclusion does not quantitatively alter DD estimates. [25] However, the results do change if we include *Post x ln(assets) and Post x ln(assets)*^{2} in the model (columns 11 and 12). Those additional terms are significant in the model for total assets (column 11), and when included, the DD estimates in *RWA/A* are insignificant.[26] While it is not obvious to us why bank size and *RWA/A* would relate differently after 2014, we cannot reject that possibility. Our conclusion for this section is thus qualified; while we find evidence of a shift toward riskier securities after the new leverage rule, we cannot reject that the shift does not owe to some other size-related effect. Our next set of findings on security yields are considerably less ambiguous.

IV.2 Reach for Yield?

The security yields we study next have two advantages over risk-weighted assets. First, they are immune from doubts about risk weights. Second, we can study yields at the bank-security level to see if banks added higher yield securities to their portfolios or merely shed lower yielding ones. Both imply riskier portfolios, of course, but as an act of *commission*, active arbitrage reveals something about how far bankers may go to sidestep a regulation. Some banks arbitrage regulations more than others and some not at all (Boyson et al. 2016), so whether banks actively arbitrage leverage rules is not obvious.[27]

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[25] We obtained similar results after adjusting *RWA/A* to account for a notable change in risk-weights after 2014 under the transition to Basel III capital requirements. Those results and details on the adjustments are available upon request.

[26] Collinearity between bank assets and coverage under the leverage rule (which depends entirely on bank assets) might explain the reduced significance but not the much smaller point estimates.

[27] Boyson et al. (2016) find that banks arbitrage risk-based capital requirements (by issuing lower quality capital instruments) to different degrees. Recent findings of leverage rule arbitrage in the repo market can be explained by passive arbitrage, i.e. banks reducing low-yield, low-risk repo activity.

To study yields we began by gathering the amounts of every security held by banks from a confidential report (FR Y-14Q Schedule B) filed quarterly by banks subject to the Comprehensive Capital Analysis and Review (CCAR) by the Federal Reserve. All banks in our sample were subject to the CCAR by virtue of having over $50 billion in assets. We then matched holdings with corresponding yields from various sources according to asset class (see Appendix A1 for details).

Of 185,497 unique (by CUSIP) securities banks held over 2011:Q3 -2016:Q2, yields were found for 43 percent (by volume) for the SLR banks and 40 percent for the control banks. Match rates pre- and post-treatment were also comparable.[28] The sample ends at 2016:Q2 because we were unable to match banks MBS holdings with yields after that date due to a missing date field in source for security holdings (the Y-14). We obtain very similar results using yields excluding MBS through 2018:Q2, however, so we report only results for the fuller set of securities over the shorter sample.[29]

Before exploiting the security level data, we first confirm the impression from Figure 1 that security yields at the portfolio level rose at the SLR banks after the treatment. We aggregate yields to the portfolio level in two steps to mitigate possible sampling bias arising from the incomplete match between holdings and yields. For each security class at each bank-quarter, we first calculate value-weighted average yields of that security class. [30] We then average these bank-quarter-security class level yields across all security classes, weighted by the value share of

[28] The match rates pre and post-treatment were 38 percent and 49 percent for SLR banks and 42 percent and 37 percent for non-SLR banks

[29] Those results are available upon request. The sample starts at 2011:Q3, when the Y-14 data became available.

[30] The asset classes are: Agency MBS; Auction Rate Securities; Auto ABS; CDO; CLO; CMBS; Common Stock (Equity); Corporate Bond; Covered Bond; Credit Card ABS; Domestic Non-Agency RMBS (incl HEL ABS); Foreign RMBS; Municipal Bond; Other ABS (excl HEL ABS); Preferred Stock (Equity); Sovereign Bond; Student Loan ABS; US Treasuries & Agencies; and Other.

each security class to total securities holdings, to calculate overall average yield at the bank-quarter level**.**

More formally, for each security *s* in class *c* held by bank *b* at time *t*, we first calculate the value weighted average yield by asset class

$$\Sigma_s \, r_{scbt} \times v_{scbt} = w_{cbt}$$

where *r* is the yield on security *s*, and *v* is the value of *s* relative to the total value of asset class *c* held by *b* at *t*. The weighted average portfolio yield for each bank-quarter is then:

$$\Sigma_c \, w_{cbt} \times k_{cbt.}$$

where *k* is the share of the bank *b*'s holdings in asset class *c* to total securities holdings as reported in the Y-14. To minimize any outlier influence, we winsorized portfolio yields at the 1/99 percentile.

Figure 1 plots the mean of portfolio yields by treatment. As noted earlier, the trend in yields for the SLR and control banks appeared parallel until the treatment date, after which yields at SLR banks rose relative to the control banks.

Table 5 reports the DD estimates. The models include the same controls as before but we omit the coefficients for brevity. The DD in yields is 43 basis points (about ½ a standard deviation in yields for the SLR banks) and is significant at the one percent level. While that result is consistent with the risk-shifting conjecture, the DD for *SLR Tighter* and *SLR Looser* are approximately equal and not statistically different.

Table 5 here

Our portfolio results thus far cannot distinguish active from passive arbitrage, so we now bore down to the security level to compare how holdings of the *same* security by different banks changed after the SLR rule was finalized. Including a bank-security fixed effect confers the same identification power as the bank-borrower fixed effect in Khwaja and Mian (2008) except here it controls for change in demand for credit by bond issuers rather than borrowers at banks. A finding that SLR banks demanded more of a specific high-yield security than non-SLR banks suggests more active arbitrage. Security level analysis also reduces concerns that the portfolio level results merely reflect differential changes in security prices that banks are passively marking to market.[31]

The regression for this analysis is:

$$H_{sit} = \alpha_i \times \alpha_s + \alpha_i \times \alpha_t + \beta * SLR_i * Post_t * High\ Yield_{st} + \gamma * C_{it-1} + \varepsilon_{sit}. \quad (2)$$

The dependent variable is the log of holdings of security *s* by bank *i* at time *t*. The bank-security fixed effect ($\alpha_i \times \alpha_s$) allows for correlated holdings over time by each bank while the bank-time fixed effects ($\alpha_i \times \alpha_t$) accounts for correlated holdings over time across banks (due to common changes in security values for example). We clustered standard errors by security.

The indicators SLR_i and $Post_t$ are defined as before. $High\ Yield_{st}$ equals one if the yield on security *s* at *t* was in the top quartile of all yields in that quarter, as in Abbassi et al. (2017). Since holdings and *High Yield* are both measured at the end of the quarter, we alternatively define *High Yield* relative to the distribution of yields in the previous quarter. Allowing for slightly delayed reach for yield may be more plausible.

[31] The change in security prices would have to differ systematically across SLR banks and the control banks to explain the portfolio results. That said, even security level analysis is not entirely free of this concern because only "available-for-sales" securities are marked to market in regulatory reports, but not "held-to-maturity" securities.

The coefficient β measures the extent to which SLR banks added more high-yield securities (relative to non-SLR banks) after the leverage rule was finalized. Including a bank × security fixed effect means that β is identified only by differential changes in holdings of a given high-yield security. Passive arbitrage—merely shedding safer, low-yield assets—does not affect β. Since passive arbitrage can explain our results thus far, we take "passive arbitrage only" (β = 0) as the null hypothesis.

The model estimates are reported in Table 6. The DD estimates are positive and significant at the one percent level using either *High Yield* indicator (columns 1 and 3). Moreover, the estimate is only significant for the *SLR Tighter* banks (columns 2 and 4). Both results contradict the "passive only" hypothesis in favor of "active" arbitrage by the more constrained SLR banks. The estimate in column 2 imply the more constrained banks increased their holding of high yield securities by 8 percent relative non-SLR banks after the treatment. High yield securities as a share of all securities averaged 36 percent at SLR banks before the treatment, with a standard deviation of 25 percent, so that effect is economically meaningful.[32]

Table 6 here

Table 7 shows that the significance and size of the main effect, *SLR x Post x High Yield*, is robust across the same robustness tests as before. As found with the other outcomes studied, we observe no treatment around the proposal of the new rule in 2012 (column 1). When investment and custody banks are excluded, the main effect is somewhat larger (column

[32] The mean and standard deviation of high yield securities holdings for non-SLR banks were 39 and 21 percent.

2).[33] Most notably, the result is robust even allowing for a shift in the relationship between security holdings and all of the balance sheet controls – including bank size – at the treatment date (columns 3 – 6).

Table 7 here

IV.3 Overall Risk and Leverage

While the leverage rule may have tilted banks toward riskier assets, the effect on overall risk – that is, default risk – is theoretically ambiguous as banks may be less levered than they otherwise would have been.[34] To investigate, we next examine various bank default risk measures that should reflect both asset risk and leverage.

We study *Z* scores, a distance-to-default measure based on book values, and four market measures: equity volatility, implied volatility, spreads on a five year CDS, and the delta on a 50% out-of-the-money (OTM) put option expiring in 1 year. That delta captures the likelihood of a major (50 percent) drop in a bank's stock price in the next calendar year such that the option pays off (Sarin and Summers 2016). We report the delta in absolute value, so a higher delta implies a higher probability of a stock price drop of that magnitude.

Means for these risk measures by treatment are shown Table 8. Sources and details on the calculation of each measure are provided in Appendix A1. Pre-treatment the means were similar across the comparison groups except for CDS spreads, which appeared lower for SLR

[33] Excluding the only two banks in the control group that were near the $250 billion threshold did not alter the results. Those banks, BBT and Suntrust, both had $188 billion in assets in 2014:Q2, just before the treatment, and $225 billion and $215 billion respectively by 2018:Q4. We thank the referee for suggesting this robustness test.
[34] In the model in Acosta Smith et al. (2017), the latter effect dominates the risk shifting so a leverage rule reduces bank default risk on net.

banks. Post-treatment both sets of banks appeared safer than before by all five risk measures with no obvious differential change for the SLR and non-SLR banks.

Table 8 here

The DD estimates are reported in Table 9. The results are mixed; the estimates for *Z* and both volatility measures are insignificant but the estimates for CDS spreads and put option deltas are significant and positive, implying higher relative default risk for SLR banks as a whole (Panel A). The lower panel shows results for *SLR Tighter* and *SLR Looser* banks. The increase in CDS spreads and put option delta are similar for both sets of banks and their equivalence cannot be rejected. While that continues to point toward higher default risk for SLR banks, the split sample reveals another finding pointing at the opposite direction; lower equity volatility at (and only at) the *SLR Tighter* banks. As a whole the results seem ambiguous; default risk by some measures increased at SLR bank but was unchanged or perhaps lower, by others.

Table 9 here

Given the risk shifting revealed earlier, why did overall risk *not* rise unambiguously? Perhaps because banks strictly constrained by the new rule were also forced to de-lever their assets. Figure 4 shows the trend in mean leverage capital (tier 1 capital/total assets) for the three sets of banks we have studied: the non-SLR control banks, and the more or less constrained SLR-banks. The trends for all three rose roughly until shortly after the SLR was finalized in

later 2014, when the more constrained SLR banks sharply increased their ratio both absolutely and relative to other sets of banks.[35]

Figure 4

Our final DD estimates in Table 10 confirm that apparent deleveraging. SLR banks as a group significantly increased their leverage ratios (column 1), but the increase was driven entirely by the *SLR Tighter* banks (column 2). The 1.26 percent estimate is substantial relative to the mean for that set of banks in Figure 4. This de-leveraging compelled by the new leverage rule may have offset the risk-shifting it induced (or vice-versa) with no obvious net effect on bank default risk.

Table 10 here

V. Conclusion

We provide new evidence on an old question: do banks arbitrage simple leverage capital requirements by shifting to riskier, high yielding assets? Our study of the new (supplementary) leverage rule recently imposed on very largest U.S. banks suggests they do. Our findings, which look at asset risk for the whole bank, reinforce and extend recent evidence of leverage rule arbitrage in the repo market.

Given regulators' long-running suspicions about leverage rule arbitrage, our findings on *how* banks arbitraged may be as notable as the evidence they did so. Banks effected the

[35] Perhaps not coincidentally, that deleveraging commenced in 2015:Q1, when SLR banks were required to publically disclose their supplementary leverage ratios.

arbitrage entirely by reaching for yield in securities, rather than loans, their signature assets. And rather than simply shedding safer securities, as in Volcker (1987), they actively added riskier securities, as in Quarles (2018). Portfolio risk increases either way, to be sure, but designing incentive compatible regulation requires knowing how far banks go to sidestep it.

The timing we find illustrates that bank regulations can change behavior long before they actually take effect. Although banks could expect a leverage rule as far back as 2012 when regulators first proposed it, they postponed adjustments until 2014 when they learned how constraining the rule would be. We find effects then, but no further effects in 2018 when the rule took effect; implementation was an anti-climax.

On the policy front, the arbitrage seemed to limit purpose of the new leverage rule. It succeeded in limiting leverage at the more constrained banks, the proximate goal, but seemed not to reduce default risk, the ultimate goal.

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Table 1: Means (St. Dev.) of Regression Variables, By Treatment

	SLR		*Control*	
	(1) Post	(2) Pre	(3) Post	(4) Pre
Risk-weighted assets/assets (%)				
Total Assets	62.13	59.13	80.61	80.34
	(13.73)	(15.98)	(9.14)	(9.45)
Securities	19.61	23.80	14.46	23.84
	(7.80)	(10.80)	(4.52)	(11.79)
Trading Assets	13.01	9.38	25.30	11.34
	(19.59)	(24.90)	(38.77)	(14.03)
Loans	83.02	80.86	90.31	88.54
	(10.10)	(11.72)	(5.20)	(5.37)
Bank Controls:				
Ln(Assets)	20.13	20.00	18.56	18.36
	(0.94)	(0.99)	(0.36)	(0.37)
Ln(Assets)^2	406.03	401.16	344.65	337.19
	(38.18)	(39.98)	(13.20)	(13.55)
Capital	12.45	11.70	11.94	10.91
	(1.73)	(2.36)	(4.09)	(2.23)
Liquidity	2.26	1.96	2.39	2.20
	(0.37)	(0.37)	(0.50)	(0.42)
Non-interest Income	1.54	1.71	0.55	0.60
	(1.22)	(1.40)	(0.54)	(0.57)
Non-bank Subsidiaries	173.16	169.04	144.80	128.55
	(209.68)	(174.43)	(265.55)	(190.47)
Observations	270	210	286	252

Note: *SLR banks* (treated) comprises the 15 U.S. banks covered by the supplementary leverage rule. The control group comprises the non-SLR 18 banks with assets between $50 and $250 billion. The sample period is 2011:Q1 to 2018:Q3, with treatment at 2014:Q3, when the denominator of SLR was finalized. The RWA/A measures are winsorized at the 1/99 percentiles and are merger adjusted. *Capital* is Tier 1/RWA. *Liquidity* is the inverse of the liquidity stress ratio calculated by FRBNY (see text for details). *Non-interest Income* equals non-interest income/interest income. *Non-bank Subsidiaries* equals # non-bank subsidiaries/# bank subsidiaries. Controls are all lagged by one quarter.

Table 2: Did SLR Banks Increase Risk-Weighted Assets (RWA/A)?

	(1) *Total Assets*	(2) *Securities*	(3) *Trading Assets*	(4) *Loans*
SLR × Post 2014:Q3	2.85*	4.67*	-1.97	1.19
	(1.67)	(2.49)	(7.47)	(2.12)
Controls:				
Ln(Assets)	99.06	-80.67	112.84	51.45
	(66.09)	(92.79)	(148.48)	(61.58)
$Ln(Assets)^2$	-3.01*	2.05	-3.35	-1.45
	(1.75)	(2.54)	(4.08)	(1.72)
Capital	-1.17***	-0.12	-0.52	-0.24
	(0.28)	(0.26)	(0.59)	(0.28)
Liquidity	-0.53	-0.19	-2.67	-0.69
	(1.70)	(1.74)	(5.40)	(1.36)
Non-interest Income	-0.62	0.15	-1.99	1.60
	(0.67)	(0.76)	(2.05)	(2.15)
Non-bank Subs.	0.00	-0.00	0.02	0.01*
	(0.01)	(0.02)	(0.03)	(0.01)
Obs.	956	956	901	956
R^2	0.96	0.62	0.62	0.88

Note: Reported are fixed effects (bank and year-quarter) OLS estimates using a balanced panel of 33 U.S. banks with assets of $50 billion or more over 2011:Q1 to 2018:Q4. Robust, bank-clustered standard errors are in parenthesis. The top row reports the DD in RWA/A for the 15 banks subject to supplementary leverage rule after its denominator was finalized in 2014:Q3 relative to a control group comprising the next largest 18 banks with assets under $250 billion. RWA/A is winsorized at the 1/99 percentiles. The control variables are lagged one quarter. *Capital* is Tier 1 capital/RWA. *Liquidity* is the inverse of the liquidity stress ratio calculated by FRBNY (see text for details). *Non-interest Income* equals non-interest income/interest income. *Non-bank Subs.* equals the # of non-bank subsidiaries/# of bank subsidiaries.

*, **, and *** indicate significance at the 10%, 5%, and 1% level.

Table 3: Did More Constrained SLR Banks Increase RWA/A by More than Others?

	(1) *Total Assets*	(2) *Securities*	(3) *Trading Assets*	(4) *Loans*
SLR Tighter × Post	5.13***	4.62	-5.45	1.84
	(1.68)	(2.94)	(7.49)	(4.49)
SLR Looser × Post	1.15	4.70*	0.56	0.70
	(1.72)	(2.65)	(8.79)	(1.08)
Controls:				
Ln(Assets)	79.05	-80.29	143.61	45.74
	(58.52)	(93.39)	(160.24)	(48.84)
$Ln(Assets)^2$	-2.44	2.04	-4.22	-1.28
	(1.54)	(2.55)	(4.42)	(1.35)
Capital	-1.13***	-0.12	-0.58	-0.23
	(0.29)	(0.27)	(0.56)	(0.28)
Liquidity	-0.71	-0.18	-2.37	-0.74
	(1.77)	(1.78)	(5.32)	(1.29)
Non-interest Income	-0.48	0.15	-2.20	1.64
	(0.77)	(0.77)	(2.01)	(2.13)
Non-bank Subs.	0.01	-0.00	0.02	0.01*
	(0.00)	(0.02)	(0.03)	(0.01)
Obs.	956	956	901	956
R^2	0.96	0.62	0.62	0.88
F-test p-value	0.01	0.98	0.41	0.80

Note: Reported are fixed effect (bank and year-quarter) OLS estimates using a balanced panel of 33 U.S. banks with assets of $50 billion or more over 2011:Q1 to 2018:Q4. Robust, bank-clustered standard errors are in parenthesis. The top two rows report the DD in RWA/A for SLR banks that were more or less constrained *ex ante* by the rule relative to control banks after SLR denominator was finalized in 2014:Q3. *SLR Tighter* banks had slack (actual leverage capital less minimum required) below the median among the SLR banks in 2013:Q4; *SLR Looser* had above median slack. The bottom row reports p-value of F-test for equivalence those DD estimates. See Table 2 note for detail on sample and definitions of control variables.

*, **, and *** indicate significance at the 10%, 5%, and 1% level.

Table 4: Alternative Treatment and Robustness Tests for RWA/A for Total Assets and Securities

	Proposal Treatment		*Compliance Treatment*		*Ex. Inv. & Custody Banks*		*Post × Capital*		*Post × Liquidity*		*Post × Size*	
	(1) Total Assets	(2) Securities	(3) Total Assets	(4) Securities	(5) Total Assets	(6) Securities	(7) Total Assets	(8) Securities	(9) Total Assets	(10) Securities	(11) Total Assets	(12) Securities
SLR × Post 2014:Q3	2.89*	4.90**	2.97*	5.49**	2.73	4.61*	3.07*	4.56*	2.80	3.88*	-1.90	-2.36
	(1.55)	(2.27)	(1.58)	(2.44)	(1.74)	(2.43)	(1.78)	(2.36)	(1.74)	(2.03)	(2.00)	(5.02)
SLR × Post 2012:Q2	-0.13	-0.84										
	(1.35)	(3.14)										
SLR × Post 2018:Q1			-0.69	-4.90								
			(1.27)	(3.14)								
Post 2014:Q3 × Ln(Assets)											43.11**	133.15
											(19.83)	(87.70)
Post 2014:Q3 × Ln(Assets)$_2$											-1.03**	-3.30
											(0.49)	(2.17)
Post 2014:Q3 × Capital							-0.15	0.08				
							(0.30)	(0.26)				
Post 2014:Q3 × Liquidity									-0.24	-3.42		
									(1.16)	(2.65)		
Ln(Assets)	98.63	-83.42	97.09	-94.57	94.58	-79.87	104.74	-83.59	97.17	-108.05	96.36*	-133.73
	(65.95)	(95.18)	(68.97)	(101.11)	(67.73)	(89.30)	(68.86)	(93.27)	(67.02)	(97.22)	(54.86)	(105.79)
Ln(Assets)$_2$	-3.00*	2.13	-2.96	2.41	-2.85	1.97	-3.16*	2.13	-2.96	2.78	-2.99*	3.34
	(1.75)	(2.60)	(1.83)	(2.75)	(1.82)	(2.44)	(1.83)	(2.55)	(1.79)	(2.65)	(1.50)	(2.82)
Capital	-1.17***	-0.12	-1.17***	-0.17	-1.09***	-0.31	-1.04***	-0.19	-1.16***	-0.01	-1.19***	-0.06
	(0.28)	(0.26)	(0.28)	(0.27)	(0.31)	(0.35)	(0.30)	(0.39)	(0.30)	(0.20)	(0.27)	(0.26)
Liquidity	-0.53	-0.17	-0.51	-0.04	-0.58	-0.63	-0.43	-0.24	-0.44	1.13	-0.10	0.65
	(1.70)	(1.75)	(1.70)	(1.76)	(1.94)	(1.83)	(1.81)	(1.68)	(1.46)	(2.71)	(1.66)	(2.03)
Non-interest Income	-0.61	0.21	-0.68	-0.26	-2.01	2.88*	-0.56	0.12	-0.62	0.07	-0.26	0.74
	(0.65)	(0.75)	(0.69)	(0.89)	(1.36)	(1.53)	(0.62)	(0.75)	(0.66)	(0.79)	(0.69)	(0.96)
Non-Bank Subs	0.00	-0.00	0.00	-0.00	0.00	0.01	0.00	-0.00	0.00	0.00	0.00	-0.01
	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)	(0.02)	(0.00)	(0.01)
Observations	956	956	956	956	801	801	956	956	956	956	956	956
R-Squared	0.96	0.62	0.96	0.62	0.93	0.72	0.96	0.62	0.96	0.62	0.96	0.64

Note: Top row reports the DD in RWA/A for total asset and securities using alternative treatments, samples, and specifications. These variations did not reveal any new significant findings for loans and trading assets so only results for total asset and securities are reported. Models (1) - (4) show no additional "treatment" effects when the SLR was first proposed in 2012:Q2 or when it took effect in 2018:Q1. Models (5) - (6) exclude two "pure" investment banks and three custody banks. Models (7) - (12) allow for a change in the relationship between RWA/A and the balance sheet variables after the 2014:Q3 treatment. See notes to table 3 for variable definitions and other model details.

*, **, and *** indicate significance at the 10%, 5%, and 1% level.

Table 5: Higher Yields on Securities Portfolio at SLR Banks after the Leverage Rule

	(1) Average Securities Yield	(2) Average Securities Yield
SLR Bank × *Post*	0.43***	
	(0.16)	
SLR Tighter × *Post*		0.45*
		(0.23)
SLR Looser × *Post*		0.41**
		(0.16)
Observations	456	456
R-squared	0.86	0.86
F-test p-value		0.87

Note: Reported are difference-in-differences in weighted average yields on securities portfolio estimated using panel data on all banks with at least $50 billion in assets over 2011:Q3 to 2016:Q2. Robust, clustered (by bank) standard errors are in parenthesis. Models include bank and year-quarter fixed effects and same controls as in Table 4. *Post* indicates post-SLR treatment (2014:Q3); *SLR* indicates banks covered by new leverage rule; *SLR Tighter* indicates that the SLR slack was below median among the SLR banks in 2013:Q4; *SLR Looser* is above median. The Wald test p-value of the equivalence of the two coefficients is reported in the last row. Yields are winsorized at 1/99 percentile.

*, **, and *** indicate significance at the 10%, 5%, and 1% level.

Table 6: SLR Banks Increased Holdings of High-Yield Securities

	Current High Yield		*Lagged High Yield*	
	(1)	(2)	(3)	(4)
SLR Bank × Post × High Yield	0.032**		0.040***	
	(0.015)		(0.012)	
SLR Tighter × Post × High Yield		0.080***		0.108***
		(0.022)		(0.019)
SLR Looser × Post × High Yield		0.008		0.007
		(0.013)		(0.010)
Observations	626260	626260	606430	606430
R-Squared	0.995	0.995	0.996	0.996
F-test p-value		0.000		0.000

Note: Top row reports DD in holdings of high yield securities by SLR banks after treatment in 2014:Q3. A security defined as high yield if in top quartile of all security yields in current quarter (columns 1 and 2) or previous quarter (columns 3 and 4). Models estimated using data and include bank x security and year-quarter fixed effects. Models estimated using balanced panel of banks with assets over $50 billion assets over 2011:Q3 to 2016:Q2. Robust standard errors (clustered by security) are in parenthesis. *Post* indicates post-SLR treatment (2014:Q3). *SLR* indicates banks subject to new leverage rule. Second and third row report DD for SLR banks that were more or less constrained ex ante by leverage rule; *SLR Tighter* indicates that the SLR slack was below median among the SLR banks in 2013:Q4; *SLR Looser* indicates slack above median. The Wald test p-value of the equivalence of the two coefficients is reported in the last row. Dependent variable is winsorized at the 1% and 99% levels .

*, **, and *** indicate significance at the 10%, 5%, and 1% level.

Table 7: Robustness Tests: High-Yield Securities Holdings

	(1) *Early Treatment*	(2) *Ex. Inv. & Custody*	(3) *Post × Capital Ratio*	(4) *Post × LCR Proxy*	(5) *Post × Log(Assets)*	(6) *Post × Controls*
SLR Bank × Post 2014:Q3 × High Yield	0.047***	0.059***	0.041***	0.040***	0.040***	0.041***
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
SLR Bank × Post 2012:Q2 × High Yield	-0.002					
	(0.018)					
Post 2014:Q3 × Capital			0.013***			0.013***
			(0.001)			(0.001)
Post 2014:Q3 × Liquidity				-0.047***		-0.050***
				(0.007)		(0.007)
Post 2014:Q3 × Log(Assets)					-1.044***	-0.016
					(0.364)	(0.010)
Post 2014:Q3 × Log(Assets)^2					0.025***	
					(0.009)	
Observations	606430	487211	606430	606430	606430	606430
R-Squared	0.996	0.996	0.996	0.996	0.996	0.996

Note: Top row reports the DD in high yield security holdings at SLR banks using alternative treatments, samples, and specifications. Models include bank x security FE and year-quarter FE. Models estimated usingsecurity holdings by all banks with assets over $50 billion assets over 2011:Q3 to 2016:Q2. Robust standard errors (clustered by security) are in parenthesis. Post indicates post-SLR treatment (2014:Q3); SLR indicates treated banks subject to new leverage rule. High yield indicates if yield on given security is in top quartile of yields all securities in current or previous quarter. Models (1) shows no additional "treatment" effects when the SLR was first proposed in 2012:Q2 . Model (2) excludes two ”pure” investment banks and three custody banks. Models (3) - (6) allow for a change in the relationship between dependent variable and balance sheet variable indicated after the 2014:Q3 treatment. Model includes all bank controls but main effects are not reported for brevity. See notes to table 3 for variable definitions and other model details. *,**, and *** indicate significance at the 10%, 5%, and 1% level.

Table 8: Means (St. Dev.) of Bank Default Risk Measures, By Treatment

	SLR		*Control:*	
	Post	*Pre*	*Post*	*Pre*
Z Score	134.12	94.84	128.31	92.11
	(87.54)	(82.79)	(79.18)	(44.23)
Equity vol.	1.38	1.67	1.50	1.64
	(0.14)	(0.32)	(0.14)	(0.30)
CDS spread	0.67	1.21	1.08	1.83
	(0.16)	(0.46)	(0.51)	(0.79)
Implied vol.	38.58	45.76	40.30	45.53
	(1.74)	(3.37)	(2.23)	(7.07)
Put option Delta	0.01	0.07	0.01	0.07
	(0.00)	(0.01)	(0.00)	(0.02)
Observations	234[1]	182[2]	214[3]	154[4]

Note: Statistics calculated over 2011:Q1-2018Q4 with post period beginning at treatment in 2014:Q3. All variables are winsorized at 1/99 percentile. Equity volatility equals the quarterly standard deviation of the log difference in daily stock price for public firms. CDS is spread on five-year swap. Implied volatilities are on a 50% out-of-the-money option expiring in 1 year. Deltas (reported in absolute value) are calculated using the Black-Scholes formula.

[1]270 for Z. [2]210 for Z; 196 for CDS. [3]304 for Z; 188 for CDS. [4]252 for Z.

Table 9: Difference-in-Differences in Overall Risk Measures

	Panel A: Main SLR Effect				
	Book Risk	Market Risk			
	(1) Zscore	(2) Equity Volatility	(3) 5-year CDS Spread	(4) Implied Vol.	(5) Put Option Delta
SLR Bank × Post	19.64	-0.09	0.22*	1.82	0.01**
	(26.75)	(0.08)	(0.12)	(1.09)	(0.00)
Ln(Assets)	891.74	-1.92	-19.86**	86.83**	0.10
	(1407.37)	(3.15)	(8.59)	(40.02)	(0.12)
$Ln(Assets)^2$	-25.99	0.07	0.53**	-1.98*	0.00
	(37.59)	(0.08)	(0.22)	(0.99)	(0.00)
Capital	4.90	-0.03***	0.01	-0.09	0.00
	(3.26)	(0.01)	(0.02)	(0.22)	(0.00)
Liquidity	-16.64	0.05	0.08	0.16	0.00
	(16.83)	(0.04)	(0.17)	(0.55)	(0.00)
Non-interest Income	-25.96*	0.03	0.03	-0.07	0.00
	(14.27)	(0.04)	(0.09)	(0.61)	(0.00)
Non-Bank Subs	0.18**	0.00*	0.00***	0.01***	0.00***
	(0.07)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	829	743	566	730	730
R-Squared	0.44	0.89	0.80	0.84	0.97

	Panel B: Effect by SLR "Tightness"				
	Book Risk	Market Risk			
	(1) Zscore	(2) Equity Volatility	(3) 5-year CDS Spread	(4) Implied Vol.	(5) Put Option Delta
SLR Tighter × Post	37.01	-0.18**	0.15	1.75	0.01*
	(28.20)	(0.08)	(0.16)	(1.30)	(0.00)
SLR Looser × Post	7.45	-0.02	0.27*	1.89	0.01**
	(30.48)	(0.09)	(0.15)	(1.32)	(0.00)
Ln(Assets)	729.90	-0.88	-18.89*	87.78*	0.12
	(1354.22)	(2.96)	(9.23)	(42.63)	(0.13)
$Ln(Assets)^2$	-21.37	0.04	0.50**	-2.01*	0.00
	(36.05)	(0.08)	(0.24)	(1.09)	(0.00)
Capital	5.24	-0.03***	0.00	-0.10	0.00
	(3.29)	(0.01)	(0.02)	(0.22)	(0.00)
Liquidity	-17.78	0.06	0.09	0.16	0.00
	(16.93)	(0.04)	(0.17)	(0.53)	(0.00)
Non-interest Income	-23.86	0.03	0.02	-0.07	0.00
	(14.46)	(0.04)	(0.09)	(0.58)	(0.00)
Non-Bank Subs	0.19**	0.00	0.00***	0.01***	0.00***
	(0.07)	(0.00)	(0.00)	(0.00)	(0.00)
Observations	829	743	566	730	730
R-Squared	0.44	0.89	0.80	0.84	0.97
F-test p-value	0.27	0.08	0.56	0.92	0.50

Note: Reported in Panel A are OLS estimates of δ from model (1) using panel data on all banks with at least \$50 billion in assets over 2011:Q1 to 2018:Q4. Reported in Panel B are OLS estimates of β_1 and β_2 from model (2) using the same panel. Robust, clustered (by bank) standard errors are in parenthesis. *Post* indicates post-SLR treatment (2014:Q3); *SLR* indicates treated banks (firms with at least \$250 billion in assets or over \$10 billion in foreign exposures). *SLR Tighter* indicates that the SLR slack was below median among the SLR banks in 2013:Q4; *SLR Looser* is above median. The Wald test p-value of the equivalence of the two coefficients is reported in the last row. The regression model includes log assets, the risk-based capital ratio, and a proxy for the liquidity coverage rule exposure, and business model controls (all lagged one quarter) and fixed effects (bank and year-quarter). Dependent variables are winsorized at the 1% and 99% levels. Put option delta measure in absolute value.

*, **, and *** indicate significance at the 10%, 5%, and 1% level.

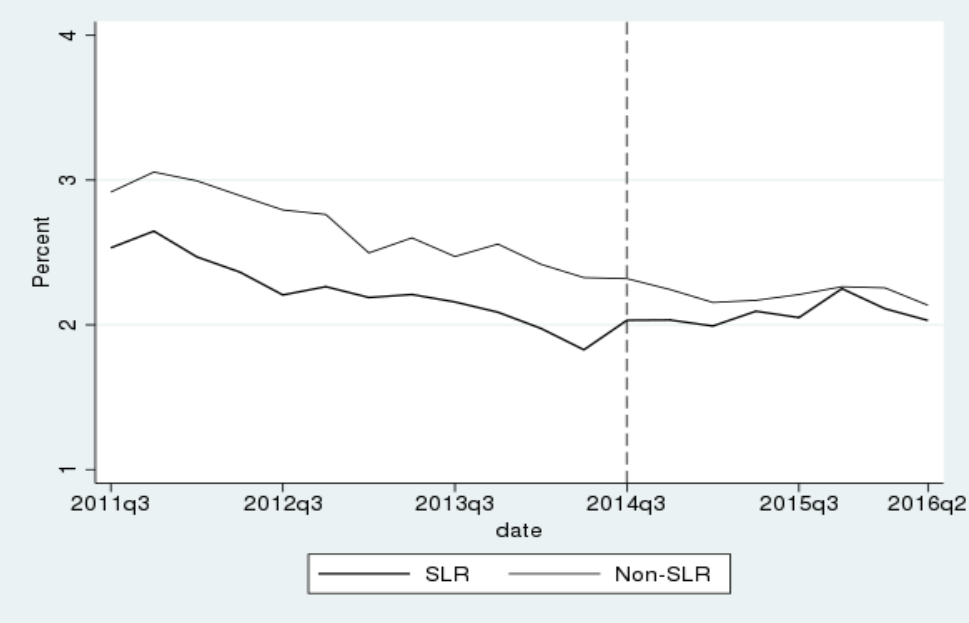
Table 10: Higher Leverage Capital at More Constrained SLR Banks

	(1) Leverage Ratio	(2) Leverage Ratio
SLR Bank × Post	0.78**	
	(0.31)	
SLR Tighter × Post		1.26***
		(0.31)
SLR Looser × Post		0.42
		(0.30)
Ln(Assets)	11.15	6.93
	(6.71)	(5.64)
$Ln(Assets)^2$	-0.32*	-0.20
	(0.18)	(0.15)
Capital	0.23***	0.24***
	(0.04)	(0.04)
Liquidity	0.01	-0.02
	(0.23)	(0.23)
Non-interest Income	-0.10	-0.07
	(0.15)	(0.16)
Non-Bank Subs.	0.00	0.00
	(0.00)	(0.00)
Observations	956	956
R-Squared	0.86	0.87
F-test p-value		0.001

Note: Reported in column (1) are DD estimates using panel data on all banks with at least $50 billion in assets over 2011:Q3 to 2018:Q4. Dependent variable, tier 1 capital/total assets, is winsorized at the 1% and 99% levels. Robust, clustered (by bank) standard errors are in parenthesis. Mean leverage pre-treatment was 7.6% at SLR bank (st. dev. of 1.7%) and 9.9% (1.5%) at control banks. *Post* indicates post-SLR treatment (2014:Q3); *SLR* indicates treated banks (firms with at least $250 billion in assets or over $10 billion in foreign exposures). *SLR Tighter* indicates that the SLR slack was below median among the SLR banks in 2013:Q4; *SLR Looser* is above median. The Wald test p-value of the equivalence of the two coefficients is reported in the last row.

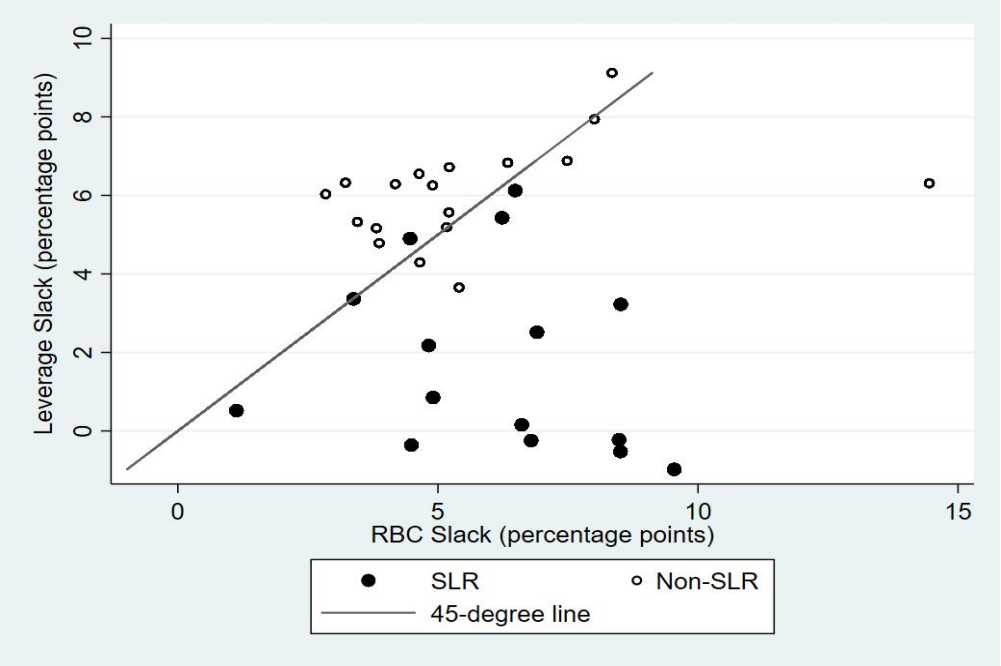
*, **, and *** indicate significance at the 10%, 5%, and 1% level.

Figure 1: Leverage Rule Leads to Reach for Yield?



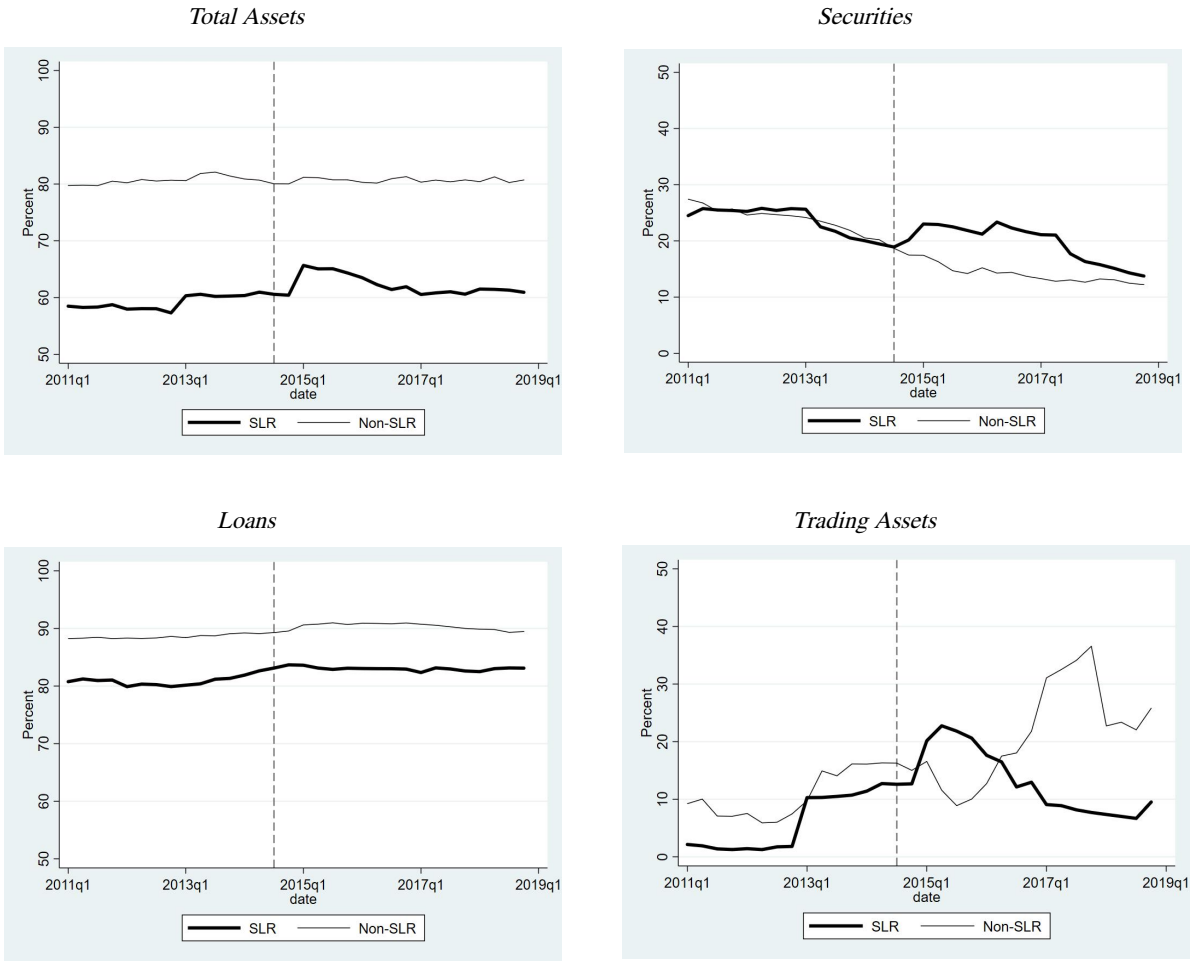
Note: Plotted are mean, volume weighted security portfolio yields at15 banks covered by supplementary leverage rule and the 18 next-largest, non-SLR banks. Yields measured at quarter end. Vertical line at 2014:Q3 when SLR finalized.

Figure 2: Leverage Ratio More Binding than Risk-Based Capital Ratio for Most SLR Banks



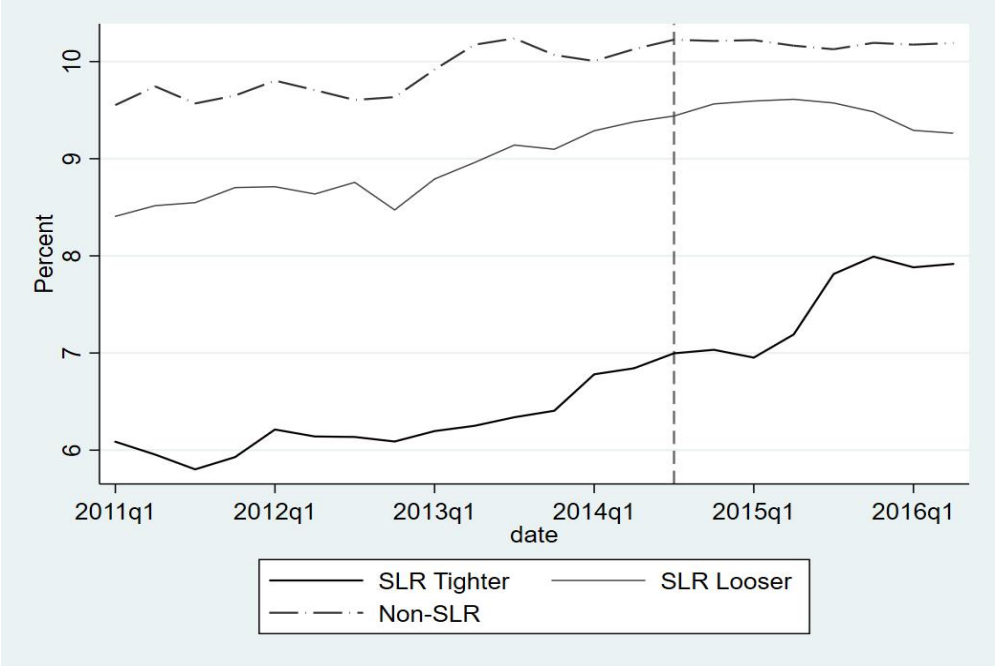
Note: SLR banks are the 15 banks subject to Supplementary Leverage Rule. Non-SLR banks are the next-largest 18 banks with total assets between $50 and $250 billion. "Slack" with respect to each capital requirement equals difference between each actual capital ratio at 2013:Q4 and required minimum. Leverage slack for non-SLR banks = tier 1 capital/ total assets - 0.04. For SLR banks, leverage slack = tier 1 capital/total leverage exposures - 0.03 (0.05 for G-SIBs). RBC Slack = tier 1 capital/RWA - 0.06. See https:// www.occ.gov/newsissuances/ news-releases/2013/2013-110a.pdf

Figure 3: Risk-weighted Assets/Assets (%), by Asset Class and Treatment



Note: Plotted is a mean RWA/A (in percent) for each period asset class and a set of banks indicated. Higher RWA/A indicates riskier assets. SLR banks are the 15 banks subject to supplementary leverage rule. Non-SLR banks are the next-largest 18 banks with assets between $50 and $250 billion. Vertical line at 2014:Q3 when SLR denominator is finalized.

Figure 4: More Constrained SLR Banks Increased Leverage Capital



Note: SLR banks are the 15 banks with at least $250 billion in total assets or $10 billion in foreign exposures. Non-SLR banks are the next-largest 18 banks with $50 to $250 billion in total assets. *SLR Tighter* indicates that the SLR slack was below median among the SLR banks in 2013:Q4; *SLR Looser* is above median. Leverage ratio = tier 1 capital divided by total assets. Vertical line at treatment date (2014:Q3).