Stressed Banks*

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Abstract

We investigate the risk taking incentives of "stressed banks" — the banks that are subject to annual regulatory stress tests in the U.S. since 2011. We document that stress tests effectively prevent excessive risk taking by bringing additional scrutiny on risk management and capital planning processes of stressed banks. Higher capital requirements (regulation) are not a substitute for scrutiny (supervision) to promote prudent lending. However, the correction in regulatory capital charges originating from stress tests effectively reduces risky lending. Overall, our results highlight the importance of enhanced supervision of banks in parallel to setting more stringent capital requirements.

Keywords: Capital Regulation, Dodd-Frank Act, Stress Tests, Supervision.

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1 Introduction

Stress tests are the cornerstone of the enhanced supervision of large and systemically important institutions since their adoption in the post-crisis regulatory reforms. In the U.S., the Dodd-Frank Wall Street Reform and Consumer Protection Act introduced annual stress tests, as part of the Comprehensive Capital Analysis and Review (CCAR), for bank holding companies with over $50 billions in assets. Stress tests administered by the Federal Reserve are an intrusive form of bank supervision that goes beyond compliance with regulation, and can constrain the investment decisions of profit-maximizing banks. Stress test supervision can even qualify as "stressful". The banks enduring this intrusive form of supervision — the "stressed banks" — do not know with certainty the criteria to pass the test. In addition, stressed banks are subject to severe corrective actions whenever they are deemed deficient, and more information about their soundness is disclosed to the public.

Given their intrusive nature, stress tests require considerable costs and efforts.[1] At the same time, the effectiveness of stress tests in reducing bank risk has been put under the spotlight. For example, Sarin and Summers (2016) observe that financial market measures of risk of large U.S. financial institutions did not decline compared to pre-crisis levels.[2] Recently, the Financial CHOICE Act proposed by the U.S. House on Financial Services Committee casts for an off-ramp from regulatory stress tests for banks with capital greater than 10% of their assets, *de facto* regarding capital requirements as substitutes for stress test supervision. In this context, Sarin and Summers's report and the prospected regulatory innovation come as a clarion call to study the effectiveness of bank supervision, and in particular of stress tests, to encourage prudent bank policies. Nevertheless, studies dealing with this matter are yet scarce. In this paper, we take a step in this direction and focus on how stress test supervision influences the riskiness of bank investments.

In this paper, we highlight stress tests as the emblematic example of the interplay between capital regulation and supervision. We argue that, because regulation and supervision are intertwined, the accurate identification of the specific effect of stress test supervision on bank risk taking cannot

[1] The 2016 Annual Report of the Federal Reserve Board reports that the 2017 budget for supervision and regulation is $1,533 million out of $5,057 million, with a large share of it devoted to "continue to implement expanded responsibilities mandated by the Dodd-Frank Act".

[2] Sarin and Summers document that the equity beta of the six largest U.S. banks was 1.23 in 2015, compared with a pre-crisis value of 1.18, while their CDS spreads sharply surged.

bypass the interaction between bank capital structure and its investment decisions. On average, stressed banks face more stringent capital requirements than "non-stressed banks", namely 7.5% versus 4.7% of assets in 2016.[3] From a theoretical perspective, there is a large consensus on the existence of a strict link between capital regulation and bank risk taking. Deviations from the Modigliani-Miller theorem make investment decisions dependent on their financing, although different theories predict different relationships.[4] At the same time, stressed banks are subject to considerably more intrusive supervision in the CCAR that includes both a quantitative exercise affecting the level of the capital requirement, and a qualitative exercise. The qualitative part of the stress test features a thorough supervisory review of risk management processes. This form of supervision does not directly affect the level of the capital requirement but has been the most constraining part for some banks.[5] Is the enhanced supervision of large banks effective in preventing excessive risk taking? Is the effect of supervision subsumed by the one of higher capital requirements, as the Financial CHOICE Act suggests? Do capital requirements considerably influence the riskiness of bank lending, and confound the identification of the effect of stress test supervision if not properly accounted for? This work attempts at providing an empirical answer to these questions.

We rely on a difference-in-differences analysis to gauge the differential effect of Dodd-Frank Act on the risk taking of stressed banks compared to a control group of "non-stressed banks" in the syndicated loan market. The syndicated loan market serves as a lab for our analysis to observe the amounts that multiple banks in a syndicate lend to the exact same borrowing firm in a given period of time. The assignment of banks to the treatment and control groups is based on the pre-determined $50 billion threshold of bank total assets defined under Dodd-Frank Act. Our "non-stressed banks" are the next largest bank holding companies (above $10 billion of assets) that have never participated in a regulatory stress test but are active in the syndicated loan market. Thus, the regulator does not actively "cherry pick" the banks to be included in stress tests and, conditional on size, the treatment status is not determined by the outcome variable. Given this assignment rule, controlling for bank size is necessary to account for possible differential trends affecting small and large banks.

[3]Our sample of non-stressed banks includes public U.S. bank holding companies with consolidated assets over $10 billion that are subject to internal stress tests under Dodd-Frank Act, but never participated in a regulatory stress test conducted by the Federal Reserve.

[4]Section 2 reviews theoretical studies on the relationship between capital requirements and bank risk taking.

[5]Between 2014 and 2016, all banks that failed the regulatory stress test did so based on qualitative grounds.

The credible empirical identification of the effect of stress test supervision on bank risk taking involves two major challenges. First, enhanced supervision goes hand in hand with changes in capital requirements for banks subject to stress tests. Specifically, within the current regulatory framework, the capital requirement of a stressed bank is risk-sensitive because (i) the regulator imposes requirements on banks' risk-weighted assets, and (ii) stress tests impose additional risk-sensitive capital requirements to ensure stressed banks have a sufficient buffer of capital to withstand losses in a severe supervisory stress scenario. As for (i), the bank can derive its risk-sensitive capital requirement based on its own models (internal rating based approach). As for (ii), the regulator determines the bank-specific requirements on the basis of its assessment of the riskiness of the assets of each bank under the stress scenario. The capital requirement therefore has a component determined and known by the bank, and a "surprise" component revealed every year by the regulator for stressed banks. In contrast, the risk-sensitive capital requirement of a "non-stressed" bank is only determined by its risk-weighted assets. We collect data on bank capitalization, risk-weighted assets, total assets, and data disclosed in the regulatory stress tests to back out the risk-sensitive capital requirement for each bank. As we detail in Section 3, we express all capital requirements a banks faces at a given point in time (based on different capital ratios), in a form where Tier 1 capital over assets does not exceed a threshold, to which we refer to as the risk-sensitive capital requirement in the remainder of the paper.[6] Measuring the risk-sensitive capital requirement serves as a control to isolate the effect of stress test supervision on bank risk taking. Our difference-in-differences analysis becomes a triple difference-in-differences analysis allowing stressed banks to respond differently, compared to non-stressed banks, to increases in their capital requirement after Dodd-Frank Act. The residual differential risk taking response to Dodd-Frank Act after controlling for the response to capital requirements is attributed to the effect of stress test supervision. Observe that, in our empirical setting, "stress test supervision" captures all additional efforts of the Federal Reserve to limit risk taking of treated banks after Dodd-Frank Act that are not related to the level of their risk-sensitive capital requirement.

Second, to highlight the effect of stress test supervision, stressed banks need to be compared to a control group of non-stressed banks. The treatment, albeit based on a fixed bank size threshold, is

[6]Specifically, the risk-sensitive capital requirement is the most stringent (i.e. the maximum) of the eight requirements that banks need to comply with. The threshold is bank specific, and reflects the fact that banks have different ratios of risk weighted assets to total assets, and different sensitivities to the stress scenario.

non-randomly assigned as typical with banking regulation. Our concern is that stressed banks lend more on the syndicated loan market than non-stressed banks, and that non-stressed banks include regional banks and therefore face different loan demands. Controlling for heterogeneity in credit supply and credit demand in order to isolate portfolio reallocation effects at the bank becomes possible because of the structure of the syndicated loan market. After a manual consolidation procedure we retain all members of the syndicate in our dataset such that we observe the amounts that multiple banks in a syndicate lend to the exact same borrowing firm in a given period of time. Such dataset allows the inclusion of a strict set of controls, namely bank*time and firm*time fixed effects, for the variation in the credit supply of banks of different size and the variation in the credit demand of firms with different risk levels (Kwaja and Mian (2008), Jimenez, Ongena, Peydro, and Saurina (2012), Jimenez, Ongena, Peydro, and Saurina (2014)). This set of indicator variables absorbs all individual bank and firm time-varying heterogeneity in loan amounts, and controls for the level of supply and demand for credit of each firm and each bank that could affect bank risk taking incentives in each period. The remaining variation therefore pertains to the bank-firm matching process resulting in a different risk allocation of bank credit. In addition, we control for bank-level variables (including bank size) interacted with firm variables in order to control for bank characteristics in the bank-firm matching process. Reassuringly enough, we do not find evidence of non-parallel trends in the loan portfolio composition of stressed banks compared to non-stressed banks before the Dodd-Frank Act.

To measure the riskiness of bank investments in a given quarter, we collect data on *new* loans banks grant to firms from LPC DealScan, *after* they learn their capital requirement from the stress test. Starting from Dealscan data, we construct a comprehensive dataset matching loan data with stress test data and quarterly financials from regulatory reports of banks (available from SNL) on one hand, and quarterly financials and ratings of firms from Compustat on the other hand. Our dataset covers all subsidiaries of the bank holding companies in our sample that participated in the syndicated loan market, leading to a total of 227,074 lender-borrower relationships. Observe that, unlike previous studies, we do not restrict our sample to lead arrangers only. This choice requires, for each bank in the syndicate and for each quarter, to reconstruct the exhaustive list of directly or indirectly controlled subsidiaries using organization hierarchy data from the National Information

Center (NIC). We manually match these subsidiaries to Dealscan by name, time, and location.[7]

Our results highlight the effectiveness of stress test supervision in encouraging prudent lending. Stress test supervision results in a relative improvement of the average borrower rating by 0.7 classes. In other words, stressed banks lend to risky firms relatively less than non-stressed banks after Dodd-Frank Act as a result of enhanced supervision. This result is obtained holding the volume of credit demand and credit supply fixed and controlling for the differential response of stressed banks to increases in their capital requirements after Dodd-Frank Act. The results show that the effect of stress test supervision is indeed confounded when banks' heterogenous responses to capital requirements is not appropriately taken into account.[8] Thus, disregarding the differential response to risk-sensitive capital requirements of stressed and non-stressed banks after Dodd-Frank Act leads to a misleading assessment of the effectiveness of stress test supervision.

We complement our analysis of the effect of stress test supervision by considering another bank-level measure of risk taking, namely the (ex-ante) promised yield on the portfolio of new loans of a bank in a given quarter. Like the firm rating, the promised yield captures the ex-ante risk taking behavior of the bank at the time of its investment decision, and not the realized (ex-post) performance. Although higher promised yields could be associated not only with riskier loan portfolios, but also with higher bank-specific markups due to imperfect competition in the syndicated loan market, the results are in line with those about loan portfolio composition. Controlling for the differential response of stressed banks to capital requirements, the average yield on the portfolio of new loans increased for all banks after Dodd-Frank Act, but by 186 to 197 bps less for stressed banks.

The stress test supervision effect is robust to excluding the largest banks and the smallest banks from the sample. We show in a placebo test that the supervision effect cannot be found if we replace the size cutoff from $50 billion to the average bank size in our sample. Decomposing the post Dodd-Frank Act period by year, we find the stress test supervision effect to be significant in years related to major supervisory changes in stress tests. We also find evidence of more intensive supervision

[7]Although data matching requires a considerable effort, the reason for it is twofold. First, a bank can engage in risky lending both by originating a syndicated loan as the lead arranger and by participating to it as a member bank. Second, our identification strategy relies on the inclusion of bank*quarter and firm*quarter fixed effects, and therefore requires observations on a given firm borrowing from multiple banks in a given quarter.

[8]The sensitivity of bank lending risk to capital requirements decreases for all banks after Dodd-Frank Act, but by a smaller extent for stressed banks.

within the group of stressed banks for banks using their own models ("advanced approach") when assessing capital adequacy. Our results are not driven by capital requirements reflecting the rating on previous syndicated loans, rather they stem from banks responding differently to increases in their past average risk weights. Finally, we inspect the external validity to our results by analyzing income statement variables reflecting risk taking on the whole balance sheet of the bank.

Motivated by the recent literature on regulatory arbitrage, we present additional analyses in which we dissect the risk-sensitive capital requirement by isolating the adjustment originating from the quantitative part of the stress testing process. Acharya, Schnabl, and Suarez (2013), Acharya and Steffen (2015), and Kirschenmann, Korte, and Steffen (2016) show that bank investment decisions reflect the inadequacy of risk weights to set capital charges that capture the actual riskiness of bank exposures. However, if regulatory stress tests provide a more accurate assessment of a bank asset riskiness, the "correction" to capital requirements determined by the stress test plausibly has a mitigating effect on bank risk taking behavior. We find that the extent to which capital requirements are determined by the stress test, rather than their level, induces banks to reallocate their loan portfolios towards safe borrowers. Thus, our results suggest that both the qualitative and quantitative forms of supervision in the stress test are effective in preventing risk taking.

Remarkably, our evidence should not be interpreted as against a better capitalization of the banking sector. Our findings suggest that higher capital requirements are not a substitute to stress test supervision in containing risk taking on the asset side of banks' balance sheets, but instead might be more effective when accompanied with enhanced bank supervision. To this end, tools like the CCAR, an extensive supervisory exercise that includes both quantitative and qualitative tests, appears to be more effective than linking capital requirements to risk-weighted assets or resorting to internal stress tests only. In light of recent trends reducing supervision initiatives in the U.S.,[9] our results shed light on the role of stress test supervision in reducing the risk of large banks.

[9]The smallest stressed banks were exempted from the qualitative part of the stress test in 2017. Recent debates hint to an exemption from the qualitative portion for all banks. Finally, the "off-ramp" rule proposed in the Financial CHOICE Act gives a full exemption from the stress for banks with capital greater than 10% of their assets. See Schnabl (2017) for a discussion of the off-ramp rule in the Financial CHOICE Act.

2 Related Literature

Our paper contributes to the strands of literature on stress tests, on capital requirements (more broadly, regulation), and on the interface between regulation and supervision.

The literature on stress tests has recently developed as regulatory stress tests only became a major bank supervision tool after the financial crisis of 2008-09. The literature on stress tests has focused on providing empirical evidence on the market response to information produced by stress tests (Bayazitova and Shivdasani (2012), Petrella and Resti (2013), Morgan, Peristiani, and Savino (2014), and Flannery, Hirtle, and Kovner (2016)). Our paper represents the *trait-d'union* between Acharya, Berger, and Roman (2018) and Cortes, Demyanyk, Li, Loutskina, and Strahan (2019) in that it centers around the interplay between capital regulation and stress test supervision. These studies consider banks subject to regulatory stress tests since the financial crisis to investigate, in isolation, the overall effect of stress tests (Acharya, Berger, and Roman (2018)) and the specific effect of capital requirements from stress tests (Cortes, Demyanyk, Li, Loutskina, and Strahan (2019)) on bank credit supply. Specifically, Acharya, Berger, and Roman (2018) compare stressed and non-stressed banks, and find that stressed banks reduce their aggregate supply of credit, but stressed banks increase ex-ante loan spreads more than non-stressed banks after the Dodd-Frank Act. Cortes, Demyanyk, Li, Loutskina, and Strahan (2019) focus on credit supply to small businesses, and find that stressed banks subject to larger increases of their capital requirements in the stress test reduce lending, increase interest rates and rebalance their loan portfolios toward safer loans. Our primary focus is on the effect of stress test supervision on risk taking rather than on aggregate credit supply. In this context, we highlight the importance to appropriately account for the differential response to risk-sensitive capital requirements of stressed and non-stressed banks after Dodd-Frank Act. We show that backing out post-stress capital requirements for each bank from bank-level data disclosed in regulatory stress tests is key to assess the effectiveness of stress test supervision. We find that disregarding the effect of risk-sensitive capital requirements leads to a severe omitted variable problem, which ultimately results in a misleading assessment of the effectiveness of stress test supervision. While the results of Acharya, Berger, and Roman (2018) are also based on data on syndicated loans, our empirical strategy is based on data collected for all banks participating in syndicated loans, instead of for the lead banks only. This allows us to identify the effect of banks' characteristics of different banks lending to the same firm during one quarter.

The literature on capital requirements points out to different effects on bank investment behavior. From a theoretical perspective, a link between capital regulation and bank risk taking has already been established. Several studies show that tighter capital requirements increase bank cost of funding and possibly lead to an increase in risk taking, including Koehn and Santomero (1980), Kim and Santomero (1988), Rochet (1992), and more recently in the general equilibrium model of Gale (2010).[10] Other studies, such as Cooper and Ross (2002) and Admati, DeMarzo, Hellwig, and Pfleiderer (2013), instead argue that tighter capital requirements provide shareholders with a larger equity stake in a bank ("skin in the game"), and reduce their incentives to engage in risky lending. Finally, two recent studies, Harris, Opp, and Opp (2017) and Bahaj and Malherbe (2018), predict a hump-shaped relationship between the amount and the riskiness of lending and capital requirements. Our empirical strategy relies on the hypothesis that the level of capital requirements is an important determinant of bank investment behavior, consistent with the empirical evidence (Gambacorta and Mistrulli (2004), Aiyar, Calomiris, Hooley, Korniyenko, and Wieladekc (2014), Fraisse, Le, and Thesmar (2015), De Jonghe, Dewachter, and Ongena (2016), Jimenez, Ongena, Peydro, and Saurina (2017), Gropp, Mosk, Ongena, and Wix (2018)).

Our paper relates to the literature studying the interface between regulation and supervision (Dewatripont and Tirole (1994), Bhattacharya, Plank, Strobl, and Zechner (2002), Decamps, Rochet, and Roger (2004), Prescott (2004), Harris and Raviv (2014)). Capital adequacy and supervisory review are two "Pillars" of the Basel Accords. While regulation relies on rules that are hard coded, supervision is most of the time discretionary and contingent on non-verifiable information. This literature is relevant to us as the CCAR exemplifies "the gray area between regulation and supervision" (Eisenbach, Lucca, and Townsend (2016)). A number of papers provide empirical evidence of the effect of supervision (outside stress test supervision) using explicit measures of supervision intensity, such as the number of hours of supervision at a bank (Eisenbach, Lucca, and Townsend (2016)), enforcement actions (Delis and Staikouras (2011)), or an index of regulatory oversight of bank capital (Laeven and Levine (2009), Maddaloni and Peydró (2011)). Similar to us, Hirtle, Kovner, and Plosser (2018) examine changes in risk taking resulting from more intensive supervision

[10]These studies are not necessarily in contradiction with Admati, DeMarzo, Hellwig, and Pfleiderer (2013), who concludes that bank equity is not *socially* expensive. Banks' *private* funding costs, instead, depend on their funding mix because bank debt carries benefits from tax subsidies and government guarantees (see Kisin and Manela (2016) for an estimation of the shadow cost of capital requirements).

without explicitly measuring supervision intensity as many aspects of supervision are confidential or difficult to quantify. Instead, their identification strategy relies on the structure of supervision at the Federal Reserve (in the same spirit as Agarwal, Lucca, Seru, and Trebbi (2014)), but they exclude the largest bank holding companies and system-wide programs like the CCAR from their analysis. Our paper extends the literature on bank supervision by showing the effect of additional supervision embedded in the CCAR that does not affect the level of capital requirements.[11]

Finally, and more broadly, our paper relates to the large literature that links regulation and policy to banks' riskiness and lending activity. Recent contributions include Jimenez, Ongena, Peydro, and Saurina (2012), Ellul and Yerramilli (2013), Jimenez, Ongena, Peydro, and Saurina (2014), De Jonghe, Dewachter, Mulier, Ongena, and Schepens (2016), Lambertini and Mukherjee (2016), Heider, Saidi, and Schepens (2017), Acharya, Eisert, Eufinger, and Hirsch (2017), Acharya, Eisert, Eufinger, and Hirsch (2018), Célérier, Kick, and Ongena (2018), Juelsrud (2018), and Neuhann and Saidi (2018).

3 Institutional Background and Data

3.1 Dodd-Frank Act and CCAR

The Dodd-Frank Wall Street Reform and Consumer 29 Protection Act (Pub.L. 111–203, H.R. 4173) or "Dodd-Frank Act" (DFA), signed into law on July 21, 2010, required enhanced prudential standards for bank holding companies "with total consolidated assets of $50 billion or more and any nonbank financial firms that may be designated systemically important companies by the FSOC" (Financial Stability Oversight Council)'.[12] The act requires annual stress tests conducted by the regulator in addition to stress tests ran by the banks (DFA Section 165(i)). These annual stress tests, called Dodd-Frank Act Stress Test or "DFAST", are the quantitative component of a broader supervisory exercise called the Comprehensive Capital Analysis and Review (CCAR), which demands that banks also submit their capital plans for regulatory review and go trough a qualitative assessment of their risk management and capital planning processes. In their capital

[11] Goldsmith-Pinkham, Hirtle, and Lucca (2016) note that "inclusion in the stress testing programs is associated with a significantly higher number of issues, above and beyond the difference associated with asset size, consistent with the increased attention of banking authorities to these institutions (section 165 of the 2010 Dodd-Frank Act)".

[12] https://www.federalreserve.gov/newsevents/press/bcreg/20111220a.htm, visited on 11/02/2017.

plans, bank holding companies describe all capital issuances and distributions (e.g., issuance of capital instruments, dividend payments, share repurchases) they would undertake under a baseline scenario defined by the banks for the next nine quarters. The Federal Reserve then assesses banks' ability to pursue such capital plans and maintain post-stress capital ratios that are above the regulatory capital requirements in effect during each quarter of the planning horizon.[13]

The ultimate outcome of the CCAR exercise is a decision by the Federal Reserve concerning banks' capital plans in light of the stress test results and the qualitative assessment. The decision is publicly disclosed in the CCAR summary report. Since 2013, the Federal Reserve can give an objection, a conditional non-objection, or a non-objection to a bank's capital plans. In the Appendix (Table A1), we report the number of banks failing stress tests, i.e., the banks that received an objection or a conditional non-objection to their capital plans. If banks do not meet the supervisory criteria (quantitative or qualitative), the objection to their capital plans usually prevents the bank from making any capital distribution in the following quarters until the next CCAR.

3.2 Sample of Bank Holding Companies

The first CCAR was conducted in 2011 for the 19 bank holding companies that previously participated in the Supervisory Capital Assessment Program (SCAP) in 2009 under the Trouble Asset Relief Program (TARP). All domestic bank holding companies with year-end 2008 assets exceeding $100 billion were required to participate in the SCAP.[14] In 2014, the bank size threshold to be subject to the CCAR reduced to $50 billion in consolidated assets. In the Appendix (Table A1), we provide the list of all participating banks — the "stressed banks" — in the SCAP, as well as in each annual CCAR until 2016. The list of stressed banks includes 33 bank holding companies that participated in the 2016 CCAR.

In our difference-in-differences analyses, the sample of treated banks consists of the 18 bank holding companies that have been subject to the CCAR every year since 2011.[15] Our control group

[13] https://www.federalreserve.gov/bankinforeg/stress-tests/CCAR/201503-comprehensive-capital-analysis-review-capital-plan-assessment-framework-and-factors.htm, visited on 11/02/2017.

[14] The SCAP was launched in February 2009 as a response to the 2008 financial crisis. This stress test of 19 bank holding companies led to a substantial recapitalization of the U.S. financial system by forcing banks to raise a $75 billion capital buffer.

[15] MetLife, Inc. is excluded from the sample. MetLife, Inc. was not considered as a bank holding company in 2013, and therefore got exempted from CCAR.

includes public U.S. bank holding companies with consolidated assets of $10 billion or more that have never been subject to a regulatory stress test (including CCAR 2017).[16] For comparability reasons, we only consider the next largest bank holding companies in the control group that are active in the syndicated loan market. Eisenbach, Lucca, and Townsend (2016) also indicate that banks below the $10 billion assets threshold are allocated considerably less supervisory hours (about 100 hours) compared to institutions above the threshold (1,500 hours).

Importantly, the assignment of banks to the treatment and control groups is based on the predetermined $50 billion threshold of banks' total assets specified in DFA. Thus, the regulator does not actively "cherry pick" the banks to be included in stress tests and, conditional on size, the treatment status is not determined by the outcome variable. Controlling for bank size is however desirable to account for possible differential trends affecting small and large banks after DFA for other reasons than stress tests.[17]

The other banks subject to CCAR not considered in the treatment group are referred to as "new entrants" in the paper throughout. Given their alternative treatment during the 2011-2013 period,[18] the new entrants are only considered in robustness tests in that we do not observe their capital requirements during the period of alternative treatment.

3.3 Syndicated Loans: Data and Descriptive Statistics

To study the risk taking behavior of stressed and non-stressed banks in our sample, we rely on loan data from the LPC DealScan dataset.[19] For each bank holding company in our sample and each quarter, we reconstruct the exhaustive list of, directly or indirectly, controlled subsidiaries using

[16]Under DFA, non-stressed banks are also required to conduct their own internal stress tests each year and to publicly disclose the results of these internal stress tests under the severely adverse scenario. However, they are not subject to the regulatory stress test (see https://www.federalreserve.gov/bankinforeg/ccar-and-stress-testing-as-complementary-supervisory-tools.htm, visited on 11/02/2017.)

[17]An alternative identification strategy could rely on a Regression Discontinuity Design (RDD) around the bank size threshold. However, a challenge to implement RDD is the limited number of bank holding companies in our sample.

[18]Those banks were previously subject to the Capital Plan Review (CapPR). Under CapPR, banks were required to conduct internal stress tests based on the supervisory scenarios, but were not subject to a regulatory stress test (i.e., the Federal Reserve was not conducting its own stress test by projecting the supervisory scenarios on banks' regulatory data).

[19]Carey and Hrycray (1999), estimate that the share of corporate covered by Dealscan in the U.S. is between 50% and 75% of the value of all commercial loans during the early 1990s, although biased towards larger loans (Acharya, Almeida, Ippolito, and Perez-Orive (2016)). Chava and Roberts (2008) suggest that such fraction has been increasing in the recent years.

organization hierarchy data from the National Information Center (NIC).[20] This results in a total of 48,113 unique lending companies in our sample period, from December 2000 to September 2016. We manually match these lender names to DealScan lenders (19,291 unique lending companies in our sample period), to determine for each quarter all loans that the 54 bank holding companies in our sample include in their portfolios. We complement the loan data with quarterly public regulatory accounting data on bank holding companies from SNL (originally collected from FR-Y9C reports).

DealScan contains information on syndicated loans, which have a unique borrower but can have multiple lenders. In DealScan, syndicated loans are also referred to as facilities. Because a bank can engage in risky lending both by originating a syndicated loan as the lead arranger and by participating to it as a member bank, unlike previous studies (e.g. Bharath, Dahiya, Saunders, and Srinivasan (2011)), we do not restrict our sample to lead arrangers only. We exclude all deals whose status is not completed or that are syndicated outside the United States, for a total of 227,074 lender-borrower relationships, 67,554 syndicated loans, and a total amount of $22 trillion lent over our sample period.

Some analyses require accounting information regarding borrowers, that we ascertain by matching DealScan to the Compustat Quarterly Industrial Files. We link DealScan and Compustat using the DealScan-Compustat Linking Database provided by Chava and Roberts (2008). Finally, we link every deal in the resulting merged dataset to the most recent S&P long-term credit ratings available for the borrower from Compustat Ratings. The sub-sample for which both borrower accounting and rating information is available consists of 119,383 lender-borrower relationships.

The amount banks have committed to each facility is missing for around 75% of lender-borrower relationships. We rely on this restricted sample (55,187 lender-borrower relationships and 42,479 lender-borrower relationships for the database linked to Compustat) in our analysis of bank risk taking since the bank allocation is key to measure bank's exposure to risk.[21]

In Table 1, we report descriptive statistics on the portfolios of new syndicated loan exposures. The table reports averages of the portfolio measures separately for our group of treated banks

[20]Available at www.ffiec.gov/nicpubweb/nicweb/nichome.aspx (visited on 11/02/2017).

[21]Such sample selection contributes to an increase in the average facility amount, and decreases in the average yield and maturity of facilities kept in our sample. Additional filters exclude observations for which the all-in-drawn spread is missing, the capital requirement is missing, the bank total assets reported in SNL are missing, and loan facilities starting before 2001, leaving 45,995 lender-borrower relationships. On the database linked to Compustat, the same additional filters restrict the sample to 34,875 lender-borrower relationships.

that participated in all stress tests ("Stressed Banks"), and for our control group ("Non-Stressed Banks"), before and after Dodd-Frank Act. The table reflects the investment decisions of banks on the syndicated loan market based on the information the banker has access to when she makes her decision to take a stake in a new syndicated loan facility.

[INSERT TABLE 1 HERE]

DealScan reports the 'all-in-drawn" spread, in basis points, that the borrower agrees to pay over the LIBOR rate (plus any annual, or facility-related, fee paid to the bank group) to the bank for each dollar drawn down at loan origination. We consider the weighted average all-in-drawn spread on the portfolio of new syndicated loans (new facilities) bank b participates to in a given quarter t, with weights given by the bank's dollar loan amounts to each firm within the quarter. Formally, the portfolio yield on new loans of bank b in quarter t is defined as

$$portfolio\,yield_{bt} = \sum_{f,\tau \in t} \frac{bankallocation_{bf\tau} * facilityamount_{f\tau} * exchangerate_{f\tau} * allindrawn_{f\tau}}{\sum_{f,\tau \in t} bankallocation_{bf\tau} * facilityamount_{f\tau} * exchangerate_{f\tau}},$$

where, for all dates $\tau \in t$ (DealScan item "FacilityStartDate"), $bankallocation_{bf\tau}$ is the fraction of the loan amount allocated by bank b in the syndicated loan to firm f, $facilityamount_{f\tau}$ is the total amount the syndicate lends to firm f at date τ, $exchangerate_{f\tau}$ is the exchange rate applied to the amount lent to firm f at date τ (equal to one if the loan is denominated in USD), and $allindrawn_{f\tau}$ is the all-in-drawn spread charged to firm f at date τ.

The average rating and average maturity on the portfolio of new loans of a bank are derived using the same weights, and firm ratings are converted into numerical ratings (where AAA=1; D=23). We also report statistics on the fraction of secured loans, the fraction of loans for which the bank is a lead bank (as defined by Acharya, Berger, and Roman (2018)), and the average bank allocation in a syndicated loan.

Despite the lower participation of non-stressed banks in the syndicated loan market (8 percent of facilities in our sample), and the smaller amounts they lend on average in a new loan ($15 million compared to $43 million by stressed banks before DFA), the portfolios of new syndicated loans of stressed and non-stressed banks are not dramatically different. The pre-DFA portfolios of non-stressed banks have higher yields compared to the portfolios of stressed banks (resp. 181 and

133 bps), worse ratings (resp. 8.6 and 6.6), and longer maturities (resp. 43 and 37 months). Non-stressed banks also engage in secured lending more compared to stressed banks (resp. 52 and 33 percent of loans), hold a lead bank role in the syndicate less often (resp. 9 and 13 percent of loans), and the average bank allocation in a new syndicated loan is almost the same for the two groups of banks. The post-DFA trends in portfolio characteristics of stressed and non-stressed banks are also similar. Average portfolio yields, ratings and maturities increase, the average amount lent in a new loan increases too, while the proportion of secured lending, lead bank lending and the average bank allocation decrease.

In Figure 1, we present the average portfolio yield of stressed and non-stressed banks. The figure shows an increase in the average portfolio yield for both stressed and non-stressed banks after DFA, and no clear differential trends.[22]

[INSERT FIGURE 1 HERE]

3.4 Risk-Sensitive Capital Requirements

To assess the capital adequacy of a bank, the Federal Reserve examines four different capital ratios, whose exact definitions are provided in the Appendix (Section A). The capital ratios are typically defined as a measure of equity divided by a measure of assets. The regulator employs both total assets and "risk-weighted assets" as a measure of assets. In the definition of risk-weighted assets, individual asset holdings are multiplied by corresponding regulatory "risk weights". Capital requirements are risk-sensitive precisely because the regulator imposes banks to hold a minimum capital ratio based on their risk-weighted assets. For example, the capital requirement of a bank with large holdings of treasury securities will be lower than the capital requirement of a bank holding primarily risky loans. Note that, since the Federal Reserve examines risk-based capital ratios for all banks (stressed and non-stressed), all banks have risk-sensitive capital requirements and the capital requirements vary over time to reflect variations in bank risk. Our definition of the capital requirement therefore embeds the required capitalization for the average risk exposure of the bank.

In addition to capital requirements based on the actual balance sheet of the bank, stressed banks are required to hold an additional buffer of capital to absorb estimated losses in a stress scenario.

[22] We formally examine in Section 5.3 the presence of a differential trend in the portfolio yield of stressed and non-stressed banks after controlling for their risk-sensitive capital requirements, as relevant in our empirical strategy.

The additional required capital buffer resulting from the stress test increases the capital requirement for the stressed bank. For example, in the 2012 CCAR, one of Citigroup Inc.'s regulatory capital ratios — the Tier 1 Leverage ratio — dropped from 7% to a minimum 2.9% projected under the stress scenario (roughly by 60 percent). The minimum Tier 1 Leverage ratio allowed at that time was 3%. If Citigroup were not a stressed bank, its only constraint would be to keep its actual Tier 1 Leverage ratio (7%) above 3%. But because Citigroup is a stressed bank, its "stressed" capital ratio of 2.9% has to be above 3%. Equivalently, Citigroup's capital requirement can be expressed in terms of Citigroup's actual Tier 1 leverage ratio. Specifically, because its capital ratio goes down by 60% in the stress scenario, the effective Tier 1 Leverage ratio requirement of Citigroup can be backed out as 3/(1-0.6)=7.24%. The capital requirement increase resulting from the stress test is also risk-sensitive as it reflects the sensitivity of Citigroup's asset values to the stress scenario. Therefore, the capital requirement of stressed banks is risk-sensitive not only because of regulatory risk weights, but also because of the effect of stress tests. While regulatory risk weights are derived and known by the bank, the losses under the stress scenario contain a "surprise component" as they are estimated by the Federal Reserve with a methodology unknown to the bank.

We detail the procedure to back out the risk-sensitive capital requirement from annual CCAR summary reports in the Appendix (Section A). Our capital requirement definition describes the required fraction of Tier 1 capital for the average exposure of the bank, recognizing that the requirements on all regulatory capital ratios (stressed and actual) are active at the same time and considering the most stringent. The most stringent requirement is identified after expressing all ratios and requirements in the same units — where actual Tier 1 capital over actual total assets does not exceed a threshold.

Figure 2 shows the evolution of the average risk-sensitive capital requirement for our sample of banks (including both stressed and non-stressed banks), and how the average capital requirement changed after stressed banks became subject to the CCAR. The average capital requirement of all banks increases from 4.5 percent before the DFA to a maximum of 6.5 percent in 2015. The figure also shows that the average capital requirement in 2015 and 2016 would be roughly two percentage points lower if stressed banks were not required to use more equity to absorb potential losses under the stress scenario in the CCAR.[23]

[INSERT FIGURE 2 HERE]

[23] In Table A2, we show the effect of the stress test on the capital requirement of stressed banks only. On the

4 Empirical Strategy

In our analyses, we consider two measures that likely reflect the ex-ante risk of new loans granted after innovations in capital requirements: (i) the average (ex-ante) promised yield on the portfolio of new syndicated loans of a bank, and (ii) the proportion a bank lends to borrowers with a certain level of risk in its portfolio of new syndicated loans after it learns its stressed capital ratio.

Our empirical strategy is designed to account for deviations from the Modigliani-Miller theorem, that is bank investment decisions not being decoupled from their financing. Thus, if the capital requirement is a quantitatively important determinant of bank investment decisions, stressed and non-stressed banks likely react differently to innovations in their capital requirements. As documented in Section 3.4, the two groups of bank are subject to different regimes of capital requirements, and stress tests affect the level of capital requirements to a large extent. For this reason, after DFA, stressed and non-stressed banks might differ in the sensitivity of their risk taking behavior to increases in capital requirements. After we account for the differential risk taking response of stressed banks to capital requirements, the residual differential response to DFA plausibly reflects DFA supervision initiatives that target stressed banks but do not directly affect the level of their capital requirements.

4.1 Effect on Portfolio Yield

To start with, we study the effect of DFA on stressed banks compared to non-stressed banks using a difference-in-differences analysis on the (ex-ante) promised yield on the portfolio of *new* loans banks issue *after* they learn their capital requirement from the stress test, as described in Section 3.3. The promised yield is available to the bank at the time of its decision to invest in a new loan, and therefore reflects the required premium for borrower risk.

We adopt a triple difference-in-differences analysis to account for a different capital requirement regime for our group of treated banks and a different response to increases in their capital requirements after DFA. The following specification allows to test the differential effect of DFA on the

subsample of banks subject to stress tests, the average capital requirement reached a maximum of 7.8 percent in 2015.

portfolio yield of stressed versus non-stressed banks, after controlling for the different sensitivities of their portfolio yield to increases in their risk-sensitive capital requirement:

$$\begin{aligned} portfolio\,yield_{bt} &= \alpha_b + \delta_t + \beta_1 stressed_b * DFA_t + \beta_2 stressed_b * DFA_t * Cap\,req_{bt} \\ &+ \beta_3 Cap\,req_{bt} + \beta_4 stressed_b * Cap\,req_{bt} \\ &+ \beta_5 DFA_t * Cap\,req_{bt} + \gamma' controls_{bt} + \epsilon_{bt}, \end{aligned} \tag{1}$$

where α_b are bank fixed effects, δ_t are time (quarter) fixed effects, $stressed_b$ is a dummy variable equal to one if bank b is subject to CCAR, DFA_t is a dummy variable equal to one if quarter t is after the fourth quarter of 2010, $Cap\,req_{bt}$ is the risk-sensitive capital requirement of bank b in quarter t (as defined in the Appendix), and $controls_{bt}$ are bank-specific control variables described below.

In specification (1), the estimate of β_2 can be interpreted as a difference-in-differences estimate that gauges the effect of DFA on the sensitivity of the portfolio yield to the risk-sensitive capital requirement of stressed banks compared to non-stressed banks. After controlling for the differential response of stressed banks to their capital requirement after DFA, the remaining differential response (β_1) of stressed banks to DFA compared to non-stressed banks plausibly captures the effect of supervision initiatives targeting stressed banks that are not directly related to the level of risk-sensitive capital requirements. Such supervision initiatives could take different forms as it is the case in the CCAR (i.e., qualitative assessments of banks' assets, capital planning and risk management processes, market discipline due to investors' reactions to stress test results disclosure). The parameter β_1 will however not reflect the effect of the quantitative assessment that affects the level of the capital requirement.

The panel dataset is composed of quarterly data of stressed and non-stressed banks. We take advantage of the stress test timeline and consider the risk taking response of banks after they learn their new capital requirement from the regulatory stress test. The "surprise" component of the capital requirement determined by the Federal Reserve is revealed at the disclosure date of the stress test, and banks respond to it in the following quarters until the disclosure of the next regulatory stress test. In addition, the capital requirement of all banks is updated each quarter with information provided by the bank — average total assets, risk-weighted assets, and the different measures of capital (consistent with the definition of $Cap\,req_{bt}$ in the Appendix) — based on data at the end of the *previous* quarter.

The control variables include bank-level variables measured in the previous quarter, namely bank size (measured by the logarithm of bank's total assets), bank liquid assets (ratio of cash, securities available for sale, and Fed funds and reverse repurchase agreements, to total assets), bank profitability (ratio of net income to total assets), bank trading activity (ratio of trading assets to total assets), and contemporaneous portfolio-level variables, namely the weighted average portfolio maturity (as described in Section 3.3), and the percentage of secured loans of the bank in quarter t. Controlling for bank fixed-effects and bank-level variables capturing differences in bank business models should mitigate additional concerns regarding the lack of comparability of treated and control banks in our sample, and the interpretation of the difference-in-differences parameters. We further address the lack of comparability issue of our two groups of banks in the loan portfolio composition analysis, controlling for a stricter set of fixed effects in loan-level regressions.

4.2 Effect on Loan Portfolio Composition

The analysis of the portfolio allocation of banks based on measures of firm risk mitigate the concern that the portfolio yield of the bank reflects not only the average risk of the loan portfolio, but also bank-specific markups due to the absence of perfect competition in the syndicated loan market. The dependent variable $\log(amount_{fbt})$ is the logarithm of the USD amount lent by bank b to firm f in a facility issued at date t, where $amount_{fbt} = bankallocation_{bft} * facilityamount_{ft} * exchangerate_{ft}$. Working with loan-level data allows to consider a saturated regression with bank*quarter and firm*quarter fixed effects, in which the amount a bank lends to firms and the amount a firm borrows from banks in a quarter are fixed. Similarly to Jimenez, Ongena, Peydro, and Saurina (2014), we look at the changes in the composition of credit flowing from banks to firms.

We rely on the same assumptions described for the portfolio yield analysis. Controlling for the differential response of stressed banks to increases in capital requirements in the allocation of their loan portfolio towards risky firms, the remaining differential effect (β_1) of DFA on risky lending for stressed banks compared to non-stressed banks is attributed to more invasive supervision of stressed banks. The triple difference-in-differences regression for the loan portfolio composition is:

$$\begin{aligned} \log(amount_{fbt}) &= \alpha_{bt} + \alpha_{ft} + \beta_1 stressed_b * DFA_t * Firm\,risk_{ft} \\ &+\beta_2 stressed_b * DFA_t * Cap\,req_{bt} * Firm\,risk_{ft} + \beta_3 Cap\,req_{bt} * Firm\,risk_{ft} \\ &+\beta_4 stressed_b * Cap\,req_{bt} * Firm\,risk_{ft} + \beta_5 DFA_t * Cap\,req_{bt} * Firm\,risk_{ft} \\ &+\beta_6 stressed_b * Firm\,risk_{ft} + \gamma' controls_{fbt} + \epsilon_{fbt}, \end{aligned} \tag{2}$$

where α_{bt} are bank*quarter fixed effects, α_{ft} are firm*quarter fixed effects, $Firm\,risk_{ft}$ is a measure describing the risk of borrower f at date t (as described in detail in Section 5.2), $stressed_b$ is a dummy variable equal to one if bank b is subject to CCAR, and DFA_t is a dummy variable equal to one if the facility is issued after the fourth quarter of 2010, $Cap\,req_{bt}$ is the capital requirement of bank b at date t (defined as for the portfolio yield regressions), and $controls_{fbt}$ are contemporaneous loan-level control variables (including loan maturity, a dummy variable indicating whether the loan is secured, and loan fixed effects), and lagged bank-level control variables (i.e. bank size, liquidity, profitability, and trading activity) interacted with firm risk. Equation (2) translates the identification strategy of Jimenez, Ongena, Peydro, and Saurina (2014) in a difference-in-differences set up.

In specification (2), the bank*quarter and firm*quarter fixed effects absorb all bank and firm time-varying heterogeneity in loan amounts such that we control for the level of supply and demand for credit, and rather concentrate on the bank-firm matching process resulting in a different composition of credit. The remaining variation in amounts lent comes from the bank*firm dimension in a given quarter. The variation reflects the decision of the bank given that firms in the syndicated market generally do not chose the names of member banks in the syndicated loan (outside of the lead arranger bank).

Importantly, we do not restrict our analysis to the lead arranger in syndicated loans. This makes our identification strategy feasible. While a bank lends to multiple firms in a quarter, we also observe multiple banks lending to the same firm in a given loan syndicate. Our identification strategy precisely relies on multiple banks lending to the same firm in a given quarter (and multiple firms borrowing from the same bank). Such strategy helps addressing the lack of comparability of our groups of treated and control banks. First, bank*quarter fixed effects account for the fact that treated banks lend larger amounts on the syndicated loan market (as documented in Section 3.3). Second, firm*quarter fixed effects account for the fact that treated banks are global banks and therefore exposed to more geographically-diversified loan demands on the syndicated loan market than control banks that are more regional. In addition, we consider bank-level variables interacted with firm risk in order to control for bank characteristics in the bank-firm matching process. We further investigate the lack of comparability of the two groups of banks in a battery of robustness tests in Section 5.4.

5 Stress Tests and Risk Taking: the Interface Between Supervision and Regulation

In this section, we present the empirical results highlighting the effect of stress test supervision on banks' portfolio yield (Section 5.1), portfolio risk composition (Section 5.2). We provide evidence of the absence of a differential trend in bank risk taking between stressed and non-stressed banks in Section 5.3. In Section 5.4, we describe additional analyses and robustness tests. Finally, we provide evidence of the effect of supervision connected to the quantitative exercise in the stress test in Section 5.5.

5.1 Effect on Portfolio Yield

Table 2 reports the estimation results of regression (1). The parameter β_1 in this regression captures the differential change in the average portfolio yield of stressed banks compared to non-stressed banks after DFA. The first two columns of Table 2 report the estimate of β_1 in a restricted regression where $\beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$, in which the channel of risk taking incentives originating from capital requirements is deliberately neglected. Within each specification, we report two columns to assess the effect of including control variables in the regression.

[INSERT TABLE 2 HERE]

The results show that the effect of stress tests is confounded when banks' heterogeneous responses to capital requirements is not taken into account. The estimates of β_1 suggest that the average portfolio yield spread increased by roughly 8 to 10 bps more for stressed banks after DFA, but these estimates are not statistically significant. Overall, the combined effect of stress test supervision and changes in capital requirements on the risk-taking response of stressed banks does not appear to be different from the one of non-stressed banks.

The three rightmost columns of Table 2 report the estimates of β_1 (stress test supervision) and β_2 (differential response to capital requirements) of the unrestricted regression (1). In columns three and four, we report the results of our benchmark specifications, with the difference that we include control variables in column four. The effect of stress test supervision initiatives not related to capital requirements is visible once controlling for the different responses of stressed banks to risk-sensitive capital requirements. The estimate of β_1 is significant at the 1% level when we hold the capital requirement constant, and while the corresponding average portfolio yield increased for all banks after DFA, it did by 193 to 197 bps less for stressed banks due to stress test supervision. Setting the capital requirement at the average level before DFA and at the average level after DFA for all banks, the estimates predict an increase of the average portfolio yield of approximately 21 bps and 51 bps for stressed and non-stressed banks, respectively, after DFA.

Figure 3 depicts the difference in the average portfolio yield of stressed banks compared to non-stressed banks, after we removed the effect of capital requirements on banks' portfolio yields. The residual portfolio yields we use in this figure are orthogonal to capital requirements in the sense they are based on residuals and fixed effects from regression (1). The figure shows that the difference in the average residual portfolio yield between stressed and non-stressed banks was about 200 bps before DFA. After DFA, the difference falls to almost zero. The fall in the residual yield difference of around 200 bps is consistent with our estimates of β_1 that we interpret as the effect of stress test supervision.

[INSERT FIGURE 3 HERE]

The sensitivity of the portfolio yield to capital requirements is captured by the parameters β_2, β_3, β_4 and β_5, which jointly describe the yield increase or decrease, expressed in basis points, resulting from an increase by one percentage point of the risk-sensitive capital requirement. We report the estimates of risk sensitivities to capital requirements for each group of banks (stressed and non-stressed), before and after DFA in Table A3 in the Appendix. The sensitivity of yields to capital requirements decreased for all banks after DFA, but the differential effect (β_2), which is significant at the 1% level, indicates that the sensitivity of stressed banks' portfolio yield to capital requirements decreased by 42 to 43 bps less than for non-stressed banks after DFA. Importantly, this positive coefficient does not mean that higher capital requirements systematically lead to more risk taking. Instead, a possible explanation for the lower sensitivity of bank risk taking to capital requirements after DFA stems from the larger buffers of capital banks held above the capital requirements after the financial crisis. Stressed banks however, are subject to an additional innovation in their capital requirements from the "surprise component" from stress test, making them less insensitive to changes in their capital requirements.

Finally, the last column of Table 2 checks the robustness of results to some persistence in bank risk taking. More specifically, endogeneity could become a concern for the very reason that the definition of capital requirements might reflect a portion of banks' asset risk which is not captured by controls and fixed effects. Although our difference-in-differences analyses are based on the riskiness of new loans, banks might be persistent in their level of risk taking. For example, each bank might overweight each quarter the same group of firms, specific to its business model. Thus, the effect of the capital requirement based on asset risk in the previous quarter could just be an artifact of an autoregressive component in banks' portfolio yield. In order to address this concern we test whether the capital requirement Granger-causes the yield on the portfolio of new loans of the bank. We find that the stress test supervision effect (β_1) remains significant at the 1% level. Holding the capital requirement and the riskiness of previous loans constant, the average portfolio yield increased for all banks after DFA, but by 186 bps less for stressed banks.[24]

5.2 Effect on Loan Portfolio Composition

Table 3 reports difference-in-differences estimates of regression (2), where $Firm\,risk_{ft}$ is the numerical rating ($rating_{ft}$) of the firm available from Compustat (where AAA=1; D=23). In this

[24] In the Online Appendix, we consider an additional test addressing the concern of persistence in bank risk taking, originating for example from relationship lending. On a subsample of loans to new borrowers only, results are qualitatively the same. In addition, observe that if capital requirements would mechanically reflect the riskiness of both banks' existing and new loans, they should always have a positive effect on our risk measure both before and after DFA, which as discussed above is not the case.

table we consider a saturated regression, which includes bank*quarter and firm*quarter fixed effects to respectively absorb the level of credit supply for a bank and the level of credit demand for a firm in a given quarter. In addition, the results reported in the second and fourth columns are based on a regression that includes contemporaneous loan-level controls, and lagged bank-level controls interacted with the firm rating.

As for the portfolio yield analysis, the two leftmost columns of Table 3 report estimates of a simple difference-in-differences analysis where $\beta_2 = \beta_3 = \beta_4 = \beta_5 = 0$, ignoring the channel of risk taking incentives originating from capital requirements. The estimates of β_1 reported in the restricted regressions suggest that stressed banks tilt their portfolios towards less risky firms after DFA compared to non-stressed banks, but, similar to the results on the portfolio yield, the estimates are not significant at the 5% level.

[INSERT TABLE 3 HERE]

The two rightmost columns of Table 3 report the estimates of β_1 (stress test supervision) and β_2 (differential response to capital requirements) from the unrestricted regression (2). For a given capital requirement, stressed banks lend to risky firms less than non-stressed banks after DFA. Both specifications include firm*time and bank*time fixed effects, while the last column also includes loan term controls and bank controls*firm risk. The estimate of β_1 in the last column is -0.69 and suggests that stress test supervision improve the average borrower rating by 0.7 classes. In fact, a coefficient of -0.69 indicates that, relative to non-stressed banks, stressed banks lend roughly seventy percent more to firms in one better rating class. The reported estimates are significant at the 1% level and imply different expected amounts a bank would lend to an investment grade firm depending on its capital requirement and on whether the bank is subject to CCAR. Conditional on being subject to the average capital requirement before and after DFA, our estimates in the last column predict that non-stressed banks would reduce the amount they lend to an investment grade firm by $0.97 million on average after DFA. Instead, stressed banks would increase the loan amount granted to an investment grade firm by $6.36 million on average.

5.3 Identification Assumption: Absence of Differential Trends in Risk Taking Between Stressed and Non-Stressed Banks before DFA

In the context of the difference-in-differences identification strategy described in the previous sections, we inspect the parallel trend assumption in risk taking of stressed and non-stressed banks on their portfolio yields and loan portfolio composition before DFA. The parallel trend assumption in the context of our triple difference-in-differences analysis requires no differential trend in risk taking between stressed and non-stressed banks in the absence of DFA, holding the level of banks' risk-sensitive capital requirements constant.

Portfolio Yield. In the Appendix (Table A4), we report statistical tests to inspect the presence of a differential trend in the portfolio yield of stressed and non-stressed banks on a sample restricted to the pre-DFA period. The two rightmost columns of Table A4 report the results, controlling for the level of the bank capital requirement. The reported t-statistic in the rightmost column of the panel shows no significant differential trend in the portfolio yield of stressed banks before DFA, after controlling for bank fixed effects and bank-level variables. However, our difference-in-differences results for the portfolio yield that do not include bank control variables need to be interpreted carefully, as we cannot reject the presence of a differential trend in the portfolio yield before DFA when bank control variables are not included.

Loan Portfolio Composition. In Table A5 in the Appendix, we report a test for the presence of a differential trend in the loan portfolio composition of stressed and non-stressed banks before DFA. The two rightmost columns of the table report the t-statistics holding the capital requirement of banks constant. The tests show that there is no differential trend in the loan portfolio allocation towards risky firms between stressed and non-stressed banks before DFA.

A comparison of the results of the differential trend analysis for the yield and the loan portfolio composition highlights the importance of saturating our loan-level specification with firm*time and bank*time fixed effects. Despite the descriptive statistics of Table 1 suggest that stressed and non-stressed banks are not dramatically different on several dimensions in the syndicated loan markets, the analyses in Table A4 and Table A5 hint that our identification strategy helps account for the non-comparability of stressed and non-stressed banks.

5.4 Robustness

Although the saturated specification of Table 3 captures a large share of observed and unobserved heterogeneity, we further assess the effect of omitted variable bias on the estimate of β_1 due to unobserved variables influencing the matching between banks and firms. To do so, we employ an approach in Altonji, Elder, and Taber (2005) and Oster (2017). We report the results of this analysis in Table 4. The estimates of β_1 in the four rightmost columns are stable between -0.74 and -0.95 over specifications adding bank role in the syndicated loan fixed effects and bank*firm fixed effects. At the same time, the additional set of controls contributes to increase the R^2 from 75% to 85%. Thus, as in Oster (2017), if selection on observables is informative about selection on unobservables, a stable coefficient accompanied by an increase in the R^2 after the inclusion of controls can be taken as a sign that omitted variable bias is limited.

[INSERT TABLE 4 HERE]

To address concerns that results are instead driven by differences between large and small banks, and our strict set of controls does not address the non-random assignment of banks into stressed and non-stressed groups, we provide two additional robustness checks. First, we show that our results are not driven by the tails of the size distribution of banks, but are robust to excluding the largest banks (Bank of America Corporation, JPMorgan Chase & Co., Citigroup Inc., Wells Fargo & Company, Goldman Sachs Group, Inc., Morgan Stanley) and the smallest banks (below 20 USD billion of assets) in Table 5. Second, in a placebo test, we show that the results do not hold if we replace the pre-determined DFA size threshold of 50 USD billion of assets to assign banks in the treatment group by the average size of banks in our sample (in Appendix Table A6).

[INSERT TABLE 5 HERE]

In Table 6, we decompose our stress test supervision effect β_1 for each post-DFA year. We find that our effect is significant in years related to major supervisory changes in stress tests. The first CCAR was implemented in 2011 and the supervision effect β_1 for that year is -4.66, while β_1 is -0.63 in 2012, which corresponds to the first year the Federal Reserve published the results of the CCAR. The latter estimate is closer to our benchmark estimate of -0.69 for the post-DFA period. Then, the β_1 estimate of -0.71 is also significant in 2014, which corresponds to major changes in stress tests including the participation of the so-called "new entrants" in the CCAR, and new capital requirements due to the implementation of Basel III regulatory capital reforms.

[INSERT TABLE 6 HERE]

Basel III allows some banks to use their own models to derive risk weights under an "advanced approach" internal rating-based system. The use of advanced approach capital rules is usually accompanied with a higher intensity of supervision compared to banks using the standardized approach. In our sample of stressed banks, 12 out of 18 banks use the advanced approach to derive their regulatory risk weights. We exploit the advanced approach to show how supervision reduces risk taking within the group of stressed banks, and further investigate the possible non-comparability of stressed and non-stressed banks in the syndicated loan market. We report the results of a triple difference-in-differences analysis within the sample of stressed banks after DFA, where the treatment corresponds to the use of the advanced approach to derive risk weights after 2014. Evidence in Table 7 suggests that stressed banks using the advanced approach lend to safer borrowers compared to stressed banks using the standard regulatory risk weights after 2014, after controlling for their different response to capital requirements.

[INSERT TABLE 7 HERE]

In Table 8, we replace the risk-sensitive capital requirement $Cap\,req_{bt}$ in the triple difference-in-differences analysis with the capital requirement ignoring the effect of the stress test $Cap\,req^*_{bt}$, the average regulatory risk weight (ratio of risk-weighted assets of the bank to its total assets), and the average rating on the portfolio of previous syndicated loans. The table shows that the stress test supervision effect β_1 is also visible when we control for banks' different responses to increases in their average risk weights. Contrastingly, the absence of a significant β_1 when we replace the capital requirement by the previous average borrower rating of a bank suggests that our effect is not only driven by banks always lending to the same rating category.

[INSERT TABLE 8 HERE]

Finally, we inspect the external validity to our results based on the portfolio of syndicated loans of the bank by analyzing its income on its whole portfolio (asset income), as available from financial statements. Note that the type of investments that contribute to changes in banks' income are substantially heterogeneous, and increases in income that are realized (ex-post) after innovations to capital requirements can not necessarily be interpreted as the immediate outcome of risk taking.[25] However, high asset income in good times is an indicator of systematic tail risk exposure (Meiselman, Nagel, and Purnanandam (2018)) and the evidence in this section is suggestive that banks are not taking risks "somewhere else" on their balance sheet as a result of enhanced supervision. We measure asset income as the part of bank income that is not directly affected by the bank's own funding costs $((Net\,income + Interest\,expenses)/Total\,Assets)$. In Table 9, we report the results of a difference-in-differences regression as in the analysis of portfolio promised yields in the syndicated loan market (Table 2). This time, the dependent variable is the measure of asset income described above. The results are qualitatively in line with the ones for the portfolio yield on new syndicated loans. Thus, the estimates in Table 9 suggest that banks are not able to substitute the reduction in risk taking in the syndicated loan market by taking more risks elsewhere on their balance sheets.

[INSERT TABLE 9 HERE]

Online Appendix. The Online Appendix reports an additional set on analyses and robustness checks, showing the robustness of our stress test supervision effect on a sample including new borrowers only, a sample including loans syndicated outside the U.S., a sample excluding crisis observations, and on a sample including the "new entrants" in the group of stressed banks. We show the robustness of our regression results on the loan portfolio composition to alternative measures of firm risk. We propose placebo tests in the difference-in-differences analyses. Finally, we show that our results on the loan portfolio composition are only valid in terms of an interpretation of banks' portfolio reallocation. The effect of stress test supervision is not significant when we relax the bank*quarter fixed effects (but keep the firm*quarter fixed effects) in order to analyze the amounts different banks lends to a risky firm, instead of focusing on the compositional changes in bank portfolios.

[25] In particular, several concerns arise when interpreting the asset income measures reported in quarterly income statements as proxies for risk taking behavior during that quarter. For example, asset income can decrease due to non-performing loans when existing borrowers do not pay interests in a timely fashion. When the quality of existing borrowers deteriorates, asset income measures might decrease because the bank fails at collecting interest payments.

5.5 Dissecting the Effect of Capital Requirements of Stressed Banks

Compared to non-stressed banks, stressed banks are subject to more stringent capital requirements. The additional equity capital that stressed banks are required to hold might more closely track the riskiness of bank assets and, all else equal, dampen excessive risk taking of stressed banks and regulatory arbitrage. To test this hypothesis, we implement a test in which, holding the level of the capital requirement fixed, we investigate banks' response to the "correction" to their capital requirement due to the quantitative exercise in the stress test.

We define the variable $Correction_{bt}$ as the ratio between the capital requirement in stress tests ($Capreq_{bt}$) and the standard capital requirement that bank b would be subject to if it were not subject to the stress test ($Capreq^*_{bt}$) in quarter t.[26] The larger this "correction" to the capital requirement, the larger the extent to which the capital requirement reflects the sensitivity of the bank's assets to the regulatory stress scenario.

Panel A of Table 10 reports the results of a difference-in-differences analysis on the yield on the bank's portfolio of new loans (regression (1)) to assess the effect of the variable $Correction_{bt}$, holding the regulatory capital requirement ($Capreq_{bt}$) constant. Observe that, in a difference-in-differences analysis, it is not necessary to interact $Correction_{bt}$ with the treatment group and post-treatment dummies given that this variable is only different from one for stressed banks after DFA. While $Correction_{bt}$ is not significant in the portfolio yield analysis, the other estimates are similar to the results reported for our benchmark specification in Section 5.1.

[INSERT TABLE 10 HERE]

For the loan portfolio composition analysis, we first consider a simple regression in Panel B of Table 10 showing the effect of $Correction_{bt}$ and $Capreq_{bt}$ on the portfolio allocation of banks towards risky firms. In the two leftmost columns, we show the effect of the level of the capital requirement ($Capreq_{bt}$) only. We find that, holding the volume of credit demand and credit supply fixed, a bank increases its portfolio share by an additional 0.7% to 1.3% to a firm with a S&P rating in the next worse class when the bank capital requirement increases by 1 percentage point.

[26] Formally, following the notation of the Appendix, $Correction_{bt} = Capreq_{bt}/Capreq^*_{bt}$, where $Capreq_{bt} = \max(k_{1bt}, k_{2bt}, k_{3bt}, k_4, k'_{1bt}, k'_{2bt}, k'_{3bt}, k'_{4bt})$, and $Capreq^*_{bt} = \max(k_{1bt}, k_{2bt}, k_{3bt}, k_4)$.

In the two rightmost columns of Panel B of Table 10, we consider the joint effect of $Correction_{bt}$ and $Capreq_{bt}$. We find that, holding the volume of credit demand and credit supply fixed, as well as the level of capital requirement constant, banks tilt their loan portfolio towards safer firms when their capital requirement better reflects the sensitivity of bank's assets to the regulatory stress scenario. Holding the capital requirement ($Capreq_{bt}$) constant, a bank decreases by 3.5% to 6.6% its share of lending to a firm that has a rating in the next worse class when $Correction_{bt}$, the ratio between the capital requirement in the CCAR and the capital requirement the bank would be subject to if it were not stressed, increases by one percentage point. Similarly, keeping $Correction_{bt}$ constant, a bank increases its lending to a firm in the next worse rating class by 1.3% to 1.9% when the bank capital requirement increases by one percentage point. To summarize, banks do not have additional incentives to take risk when the increase in their capital requirement results from being subject to the regulatory stress test.

Panel C of Table 10 reports the results of a difference-in-differences analysis showing the effect of $Correction_{bt}$ on the amount banks lend to risky firms (regression (2)). This regression reports jointly the effect of stress test supervision not directly affecting the level of capital requirements and the effect of the correction to the capital requirement from the stress test. First, after controlling for the level of the capital requirement ($Capreq_{bt}$), the parameter of $Correction_{bt}$ indicates the extent to which a bank reduces risk taking when its capital requirement reflects the sensitivity of the bank's assets to the regulatory stress scenario. Second, after controlling for the capital requirement and the composition of the capital requirement ($Correction_{bt}$), the remaining variation between stressed and non-stressed banks could be attributed to other regulatory efforts to encourage prudent investments embedded in the CCAR exercise (e.g., qualitative assessment), or any other reason stressed banks have to reduce risk that is unrelated to their level of capital requirements. The two estimates that capture stress test supervision and the correction to the capital requirement in stress tests are significant at the 5% level in the first column of Panel C (without controlling for bank-specific variables explaining the portfolio composition). $Correction_{bt}$ is however not significant when we include bank control variables that could also explain the reduction in risk taking.

Overall, the results of this section indicate that, after controlling for the capital requirement level ($Capreq_{bt}$), the correction to the capital requirement resulting from the stress test ($Correction_{bt}$) does not lead to more risk taking, and even induces banks to tilt their loan portfolios towards safe borrowers. The extent to which capital requirements are determined by the stress test, rather than their level, induces banks to reallocate their loan portfolios towards safe borrowers. The negative correlation of $Correction_{bt}$ with the average yield and rating of new loans is also visible in Figure 4, illustrating the reduction in risk taking incentives of stressed banks induced by the correction to their capital requirements in stress tests.

[INSERT FIGURE 4 HERE]

6 Discussion and Conclusions

We study the risk taking behavior of "stressed banks" — the banks that are subject to annual regulatory stress tests in the U.S. since 2011. In all, our results highlight the importance of bank supervision in parallel to setting more stringent capital requirements.

We find that stress tests are effective in preventing excessive risk taking by increasing the level of supervision of stressed banks. We show that, under the Dodd-Frank Act, the effect of supervision is confounded when bank heterogeneity in capital requirements, which themselves affect bank risk taking incentives, is not appropriately accounted for. In fact, more supervision goes hand in hand with changes in capital charges for banks subject to stress tests, for which the regulator determines bank-specific requirements on the basis of their riskiness under a supervisory stress scenario. Our results suggest that higher capital requirements do not substitute bank supervision in promoting prudent lending. Rather, stress tests help setting regulatory capital charges that dampen excessive risk taking and regulatory arbitrage.

Importantly, our evidence should not be interpreted as against a better capitalization of the banking sector. Rather, our results highlight an empirically relevant channel — stress test supervision — induced by Dodd-Frank Act that reduce the risk taking incentives of large banks and should be taken into account in the design of new regulations to promote financial stability. To this end, tools like the Comprehensive Capital Analysis and Review, an extensive monitoring exercise by the regulator that includes both quantitative and qualitative tests, appears to be more effective than linking capital requirements to risk-weighted assets or resorting to internal stress tests only. Our results contribute to the debate on the substitutability between capital requirements and bank supervision (Anginer, Demirguc-Kunt, and Mare (2018)), particularly relevant in light of recent trends to reduce bank supervision in the U.S. (e.g., exempting banks from the qualitative portion of the CCAR, and the proposal of an off-ramp rule from stress tests in the Financial CHOICE Act). In this respect, our results highlight the peculiar risk-taking response of banks to the regulatory *status quo*, in which stress test supervision and capital regulation are intertwined.

Clearly, our results do not substitute full-blown quantitative or welfare analyses which, as Admati (2014) argues, are desirable in the design of new regulatory policies. Rather, this paper echoes Admati's clarion call for future research directed to develop quantitative banking models that capture the relevant economic tradeoffs that affect banks' decisions, and serve as laboratories to thoroughly evaluate (counterfactual) regulatory proposals in comparison to the status quo.

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Table 1

Syndicated Loans: Before and After Dodd-Frank Act

The table reports descriptive statistics of syndicated loans characteristics of stressed banks compared to non-stressed banks before ("Before DFA") and after ("After DFA") Dodd-Frank Act. Stressed banks are the banks subject to annual regulatory stress tests in the U.S. Statistics reported in this table include all loans for which a bank is a member bank (not only lead arranger), and are weighted by the percentage of the facility loan amount allocated by the bank. Yield is the "All-in-Drawn Spread" in DealScan, i.e. the spread, in basis points, paid by the borrower over the LIBOR rate (plus any annual, or facility-related, fee paid to the bank group) to the bank for each dollar drawn down. Rating is the firm's numerical rating (1 is AAA; 23 is D). Maturity is the maturity of the loan in months. Secured indicates whether the loan is collateralized. Lead Bank indicates whether the bank has a major role in the syndicated loan (as defined by Acharya, Berger, and Roman (2018)). Bank Allocation is the percentage of the facility loan amount allocated by the bank. Loan amount is 0.01*Bank allocation*Facility amount (in $ mn). All other variables are self-explanatory. The sample includes stressed bank holding companies that participated in all CCARs and non-stressed banks participating in syndicated loans, as described in Sections 3.2 and 3.3.

	Stressed Banks			Non-Stressed Banks		
Variable	Before DFA	After DFA	Change	Before DFA	After DFA	Change
Average Yield (bps)	133.25	154.77	21.53	181.18	194.52	13.34
Average Rating	6.57	7.71	1.15	8.63	9.36	0.73
Average Maturity (Months)	37.72	50.13	12.40	43.35	55.64	12.29
Proportion of Secured Loans (%)	33.27	27.75	-5.52	51.94	49.52	-2.42
Proportion of Lead Bank Loans (%)	12.75	9.85	-2.90	9.22	0.44	-8.79
Average Bank Allocation (%)	11.36	8.25	-3.10	12.31	5.64	-6.67
Average Loan Amount ($ mn)	42.83	72.24	29.41	15.05	18.95	3.90

Table 2

STRESS TEST SUPERVISION: EFFECT ON PORTFOLIO YIELD

The table reports estimates from the regression:

$$\begin{aligned} portfolio\,yield_{bt} &= \alpha_b + \delta_t + \beta_1 stressed_b * DFA_t + \beta_2 stressed_b * DFA_t * Cap\,req_{bt} \\ &+ \beta_3 Cap\,req_{bt} + \beta_4 stressed_b * Cap\,req_{bt} \\ &+ \beta_5 DFA_t * Cap\,req_{bt} + \gamma' controls_{bt} + \epsilon_{bt}, \end{aligned}$$

where $portfolio\,yield_{bt}$ is the weighted average all-in-drawn spread on the portfolio of new syndicated loans (new facilities) bank b participates to in a given quarter t, with weights given by the bank's dollar loan amounts to each firm within the quarter, α_b are bank fixed effects, δ_t are time (quarter) fixed effects, $stressed_b$ is a dummy variable equal to one if bank b is subject to CCAR, DFA_t is a dummy variable equal to one if quarter t is after the fourth quarter of 2010, $Cap\,req_{bt}$ is the capital requirement of bank b in quarter t as defined by Equation (5) and Equation (6) for stressed banks after DFA, and $controls_{bt}$ are bank-specific control variables. Control variables include the logarithm of bank's total assets, the ratio of liquid assets to total assets, the ratio of bank net income to total assets, the ratio of trading assets to total assets, the weighted average portfolio maturity, and the percentage of secured loans of the bank in quarter t. $\triangle$E($portfolio\,yield_{bt}|stressed_b = 0, \overline{Capreq_{bt}}$) and $\triangle$E($portfolio\,yield_{bt}|stressed_b = 1, \overline{Capreq_{bt}}$) denote the change in the average portfolio yield for non-stressed and stressed banks, respectively, setting the capital requirement at the average level before DFA and at the average level after DFA for all banks in the sample. The sample includes stressed bank holding companies that participated in all CCARs and non-stressed banks participating in syndicated loans, as described in Sections 3.2 and 3.3. T-statistics based on clustered standard errors at the bank level are in parentheses.

	Portfolio Yield				
$stressed_b * DFA_t$	9.70	8.31	-196.75	-192.77	-185.60
	(1.15)	(1.16)	(-4.16)	(-3.69)	(-3.67)
$stressed_b * DFA_t * Cap\,req_{bt}$			42.96	42.22	41.05
			(4.18)	(3.60)	(3.58)
Controls	N	Y	N	Y	Y
Bank and Time FE	Y	Y	Y	Y	Y
$stressed_b * DFA_t * portfolio\,yield_{bt-1}$	N	N	N	N	Y
R^2 (%)	69.49	72.23	71.17	73.63	73.78
Adj. R^2 (%)	66.89	69.68	68.59	71.09	71.14
$\triangle$E($portfolio\,yield_{bt}\|stressed_b = 0, \overline{Capreq_{bt}}$)	39.43	39.43	51.37	50.08	45.95
$\triangle$E($portfolio\,yield_{bt}\|stressed_b = 1, \overline{Capreq_{bt}}$)	21.37	21.37	21.54	21.53	21.50
Observations	1084	1084	1084	1084	1084
Banks	29	29	29	29	29

Table 3

STRESS TEST SUPERVISION: EFFECT ON LOAN PORTFOLIO COMPOSITION

The table reports estimates from the regression:

$$\begin{aligned}\log(amount_{fbt}) &= \alpha_{bt} + \alpha_{ft} + \beta_1 stressed_b * DFA_t * Firm\,risk_{ft} \\ &+\beta_2 stressed_b * DFA_t * Cap\,req_{bt} * Firm\,risk_{ft} + \beta_3 Cap\,req_{bt} * Firm\,risk_{ft} \\ &+\beta_4 stressed_b * Cap\,req_{bt} * Firm\,risk_{ft} + \beta_5 DFA_t * Cap\,req_{bt} * Firm\,risk_{ft} \\ &+\beta_6 stressed_b * Firm\,risk_{ft} + \gamma' controls_{fbt} + \epsilon_{fbt},\end{aligned}$$

where $\log(amount_{fbt})$ is the logarithm of the USD amount lent by bank b to firm f in a facility issued at date t, α_{bt} are bank*quarter fixed effects, α_{ft} are firm*quarter fixed effects, $Cap\,req_{bt}$ is the capital requirement of bank b at date t as defined by Equation (5) and Equation (6) for stressed banks after DFA, and $Firm\,risk_{ft}$ is the firm's numerical rating (1 is AAA; 23 is D). The loan-level control variables include loan maturity, a dummy variable indicating whether the loan is secured, and fixed effects for loan types and purposes. The bank-level control variables include the logarithm of bank's total assets, the ratio of liquid assets to total assets, the ratio of bank net income to total assets, and the ratio of trading assets to total assets. Regressions are saturated with bank*quarter and firm*quarter fixed effects. $\triangle \text{E}(amount_{fbt}|stressed_b = 0, speculative_{ft} = 0, \overline{Capreq_{bt}})$ and $\triangle \text{E}(amount_{fbt}|stressed_b = 1, speculative_{ft} = 0, \overline{Capreq_{bt}})$ denote the change in the average amount that non-stressed and stressed banks, respectively, would lend to investment grade firms, setting the capital requirement at the average level before DFA and at the average level after DFA for all banks in the sample. The sample includes stressed bank holding companies that participated in all CCARs and non-stressed banks participating in syndicated loans, as described in Sections 3.2 and 3.3. T-statistics based on clustered standard errors at the bank*quarter and firm*quarter level are in parentheses.

	log(amount)			
$stressed_b * DFA_t * Firm\,risk_{ft}$	-0.09	-0.05	-1.47	-0.69
	(-1.31)	(-0.95)	(-4.72)	(-3.16)
$stressed_b * DFA_t * Cap\,req_{bt} * Firm\,risk_{ft}$			0.30	0.14
			(4.56)	(3.01)
Loan-Level Controls	N	Y	N	Y
Bank-Level Controls*Firm risk	N	Y	N	Y
Firm*Time FE	Y	Y	Y	Y
Bank*Time FE	Y	Y	Y	Y
Loan Characteristics FE	N	Y	N	Y
R^2 (%)	73.04	74.50	73.25	73.32
Adjusted R^2 (%)	66.92	68.64	67.17	67.26
$\triangle \text{E}(amount_{fbt}\|stressed_b = 0, speculative_{ft} = 0, \overline{Capreq_{bt}})$	0.06	0.05	-0.67	-0.97
$\triangle \text{E}(amount_{fbt}\|stressed_b = 1, speculative_{ft} = 0, \overline{Capreq_{bt}})$	0.96	0.32	0.98	6.36
Observations	21174	21174	21174	21174
Bank*Time	894	894	894	894
Firm*Time	3018	3018	3018	3018

Table 4

Stress Test Supervision: Effect on Loan Portfolio Composition - Altonji et al. (2005) and Oster (2017)

The table is a replica of Table 3 in which we include additional controls and fixed effects, and study the stability of estimated parameters. The sample includes stressed bank holding companies that participated in all CCARs and non-stressed banks participating in syndicated loans, as described in Sections 3.2 and 3.3. T-statistics based on clustered standard errors at the bank*quarter and firm*quarter level are in parentheses.

	log(amount)				
$stressed_b * DFA_t * Firm\,risk_{ft}$	-1.75	-0.77	-0.74	-0.95	-0.95
	(-9.02)	(-3.17)	(-3.15)	(-3.18)	(-3.29)
$stressed_b * DFA_t * Cap\,req_{bt} * Firm\,risk_{ft}$	0.35	0.15	0.14	0.23	0.19
	(8.52)	(2.92)	(2.82)	(3.15)	(2.67)
Loan-Level Controls	N	Y	Y	Y	Y
Bank-Level Controls*Firm risk	N	Y	Y	Y	Y
Firm*Time FE	Y	Y	Y	Y	Y
Bank*Time FE	Y	Y	Y	Y	Y
Loan Characteristics FE	N	Y	Y	Y	Y
Lender Role FE	N	N	Y	N	Y
Bank*Firm FE	N	N	N	Y	Y
R^2 (%)	73.28	74.66	79.87	82.98	84.92
Adjusted R^2 (%)	66.88	68.51	74.96	68.04	71.65
Observations	18144	18144	18144	18144	18144
Bank*Time	840	840	840	840	840
Firm*Time	2658	2658	2658	2658	2658
Bank*Firm	-	-	-	4940	4940

Table 5

Stress Test Supervision: Effect on Loan Portfolio Composition without Largest and Smallest Banks

The table is a replica of Table 3 in which the larger and the smaller banks in our sample have been excluded. Specifically, we exclude banks with more than 800 billion assets at the end of 2010 (Bank of America Corporation, JPMorgan Chase and Co., Citigroup Inc., Wells Fargo and Company, Goldman Sachs Group, Inc., Morgan Stanley), as well as banks with total assets below 20 billions. T-statistics based on clustered standard errors at the bank*quarter and firm*quarter level are in parentheses.

	log(amount)	
$stressed_b * DFA_t * Firm\,risk_{ft}$	-1.11	-1.11
	(-3.98)	(-4.66)
$stressed_b * DFA_t * Cap\,req_{bt} * Firm\,risk_{ft}$	0.24	0.25
	(3.98)	(4.68)
Loan-Level Controls	N	Y
Bank-Level Controls*Firm risk	N	Y
Firm*Time FE	Y	Y
Bank*Time FE	Y	Y
Loan Characteristics FE	N	Y
R^2 (%)	73.37	74.85
Adjusted R^2 (%)	60.13	62.07
Observations	6997	6997
Bank*Time	541	541
Firm*Time	1776	1776

Table 6

STRESS TEST SUPERVISION: EFFECT ON LOAN PORTFOLIO COMPOSITION OVER TIME

The table is a replica of Table 3 in which we have replaced the post-DFA dummy variable by a different dummy variable for each year after DFA. The sample includes stressed bank holding companies that participated in all CCARs, new entrants, and non-stressed banks participating in syndicated loans, as described in Sections 3.2 and 3.3. Sample excludes observations after 2015 (given that we do not have a full year of data collected for 2016). T-statistics based on clustered standard errors at the bank*quarter and firm*quarter level are in parentheses.

	log(amount)			
$stressed_b * 2011 * Firm\,risk_{ft}$	-0.04	-0.05	-4.94	-4.66
	(-0.70)	(-0.88)	(-1.97)	(-1.96)
$stressed_b * 2012 * Firm\,risk_{ft}$	0.01	0.02	-0.68	-0.63
	(0.27)	(0.46)	(-3.46)	(-2.99)
$stressed_b * 2013 * Firm\,risk_{ft}$	-0.02	-0.01	-0.35	-0.32
	(-0.19)	(-0.09)	(-1.08)	(-0.94)
$stressed_b * 2014 * Firm\,risk_{ft}$	-0.35	-0.09	-1.67	-0.71
	(-1.46)	(-0.95)	(-8.75)	(-3.02)
$stressed_b * 2015 * Firm\,risk_{ft}$	-0.05	-0.04	-0.52	-0.44
	(-0.94)	(-0.88)	(-1.18)	(-0.99)
$stressed_b * 2011 * Cap\,req_{bt} * Firm\,risk_{ft}$			1.14	1.08
			(1.92)	(1.91)
$stressed_b * 2012 * Cap\,req_{bt} * Firm\,risk_{ft}$			0.15	0.14
			(3.82)	(3.34)
$stressed_b * 2013 * Cap\,req_{bt} * Firm\,risk_{ft}$			0.08	0.07
			(1.36)	(1.18)
$stressed_b * 2014 * Cap\,req_{bt} * Firm\,risk_{ft}$			0.32	0.13
			(6.92)	(2.53)
$stressed_b * 2015 * Cap\,req_{bt} * Firm\,risk_{ft}$			0.11	0.09
			(1.16)	(0.96)
Loan-Level Controls	N	Y	N	Y
Bank-Level Controls*Firm risk	N	Y	N	Y
Firm*Time FE	Y	Y	Y	Y
Bank*Time FE	Y	Y	Y	Y
Loan Characteristics FE	N	Y	N	Y
R^2 (%)	73.28	74.62	73.53	74.68
Adjusted R^2 (%)	67.80	69.34	68.08	69.40
Observations	25322	25322	25322	25322
Bank*Time	1267	1267	1267	1267
Firm*Time	3041	3041	3041	3041

Table 7

Supervision within Stressed Banks: the Advanced Approach

This table reports estimates from the regression:

$$\begin{aligned}\log(amount_{fbt}) &= \alpha_{bt} + \alpha_{ft} + \beta_1 Advanced_b * Firm\,risk_{ft} \\ &+\beta_2 Advanced_b * Cap\,req_{bt} * Firm\,risk_{ft} + \beta_3 Cap\,req_{bt} * Firm\,risk_{ft} \\ &+\gamma' controls_{fbt} + \epsilon_{fbt},\end{aligned}$$

where $Advanced_b$ is equal to one for a bank using the advanced internal rating based approach to determine its regulatory risk weights. The sample is restricted to post-DFA observations for stressed bank holding companies that participated in all CCARs. T-statistics based on clustered standard errors at the bank*quarter and firm*quarter level are in parentheses

	log(amount)		
$Advanced_b * Firm\,risk_{ft}$	-0.03	-0.11	-0.48
	(-2.95)	(-1.70)	(-2.28)
$Advanced_b * Cap\,req_{bt}$		-0.01	0.00
		(-0.66)	(0.21)
$Advanced_b * Cap\,req_{bt} * Firm\,risk_{ft}$		0.01	0.00
		(1.35)	(0.35)
Loan-Level Controls	N	N	Y
Bank-Level Controls*Firm risk	N	N	Y
Firm*Time FE	Y	Y	Y
Bank*Time FE	Y	Y	Y
Loan Characteristics FE	N	N	Y
R^2 (%)	69.48	69.53	71.69
Adjusted R^2 (%)	63.68	63.72	66.14
Observations	8728	8728	8728
Bank*Time	354	354	354
Firm*Time	1040	1040	1040

Table 8

Stress Test Supervision: Capital Requirements, Regulatory Risk Weights, and Past Ratings

The table is a replica of Table 3 in which we subsequently replace the capital requirement $Cap\,req_{bt}$, by the capital requirement without the effect of stress tests $Cap\,req^{*}_{bt}$, the average regulatory risk weight of the bank, and its average rating on its previous portfolio of syndicated loans. The capital requirements are defined by $Cap\,req_{bt} = \max(k_{1bt}, k_{2bt}, k_{3bt}, k_4, k'_{1bt}, k'_{2bt}, k'_{3bt}, k'_{4bt})$, and $Cap\,req^{*}_{bt} = \max(k_{1bt}, k_{2bt}, k_{3bt}, k_4)$. The average regulatory risk weight of a bank is its ratio of risk-weighted assets to total assets, and the average rating on the bank portfolio of syndicated loans is defined in a similar fashion as its average portfolio yield. The sample includes stressed bank holding companies that participated in all CCARs and non-stressed banks participating in syndicated loans, as described in Sections 3.2 and 3.3. T-statistics based on clustered standard errors at the bank*quarter and firm*quarter level are in parentheses.

	log(amount)							
	$Cap\,Req_{bt}$		$Cap\,Req^{*}_{bt}$		$\frac{RWA_{bt}}{TA_{bt}}$		$Avg.Firm\,risk_{bt}$	
$stressed_b * DFA_t * Firm\,risk_{ft}$	-1.47	-0.69	-1.53	-0.71	-1.61	-0.82	-0.79	-0.21
	(-4.70)	(-3.14)	(-5.01)	(-3.28)	(-5.76)	(-3.82)	(-1.90)	(-1.06)
$stressed_b * DFA_t * Cap\,Charge_{bt} * Firm\,risk_{ft}$	0.30	0.14	0.32	0.14	2.15	1.08	0.07	0.02
	(4.53)	(2.97)	(4.88)	(3.19)	(5.70)	(3.75)	(1.88)	(1.03)
Loan-Level Controls	N	Y	N	Y	N	Y	N	Y
Bank-Level Controls*Firm risk	N	Y	N	Y	N	Y	N	Y
Firm*Time FE	Y	Y	Y	Y	Y	Y	Y	Y
Bank*Time FE	Y	Y	Y	Y	Y	Y	Y	Y
Loan Characteristics FE	N	Y	N	Y	N	Y	N	Y
R^2 (%)	73.23	74.52	73.26	74.53	73.25	74.53	73.10	74.49
Adjusted R^2 (%)	67.15	68.66	67.20	68.67	67.18	68.67	67.00	68.63
Observations	21164	21164	21164	21164	21164	21164	21164	21164
Bank*Time	890	890	890	890	890	890	890	890
Firm*Time	3018	3018	3018	3018	3018	3018	3018	3018

Table 9

Stress Test Supervision: Effect on Asset Income

The table reports estimates from the regression:

$$\begin{aligned} asset\,income_{bt} &= \alpha_b + \delta_t + \beta_1 stressed_b * DFA_t + \beta_2 stressed_b * DFA_t * Cap\,req_{bt} \\ &+ \beta_3 Cap\,req_{bt} + \beta_4 stressed_b * Cap\,req_{bt} \\ &+ \beta_5 DFA_t * Cap\,req_{bt} + \gamma' controls_{bt} + \epsilon_{bt}, \end{aligned}$$

where $asset\,income_{bt}$ is the asset income of bank b in a given quarter t with respect to the previous quarter, α_b are bank fixed effects, δ_t are time (quarter) fixed effects, $stressed_b$ is a dummy variable equal to one if bank b is subject to CCAR, DFA_t is a dummy variable equal to one if quarter t is after the fourth quarter of 2010, $Cap\,req_{bt}$ is the capital requirement of bank b in quarter t as defined by Equation (5) and Equation (6) for stressed banks after DFA, and $controls_{bt}$ are bank-specific control variables. Control variables include the logarithm of bank's total assets, the ratio of liquid assets to total assets, the ratio of bank net income to total assets, the ratio of trading assets to total assets, the weighted average portfolio maturity, and the percentage of secured loans of the bank in quarter t. The sample includes stressed bank holding companies that participated in all CCARs and non-stressed banks participating in syndicated loans, as described in Sections 3.2 and 3.3. T-statistics based on clustered standard errors at the bank level are in parentheses.

	Asset Income				
$stressed_b * DFA_t$	-0.01	-0.01	-0.43	-0.40	-0.56
	(-0.22)	(-0.29)	(-2.01)	(-1.94)	(-1.97)
$stressed_b * DFA_t * Cap\,req_{bt}$			0.10	0.09	0.13
			(2.08)	(1.99)	(1.96)
Controls	N	Y	N	Y	Y
Bank and Time FE	Y	Y	Y	Y	Y
$stressed_b * DFA_t * asset\,income_{bt-1}$	N	N	N	N	Y
R^2 (%)	60.62	60.74	61.11	61.24	67.20
Adj. R^2 (%)	57.99	57.92	58.39	58.33	64.59
Observations	1420	1420	1420	1420	1358
Banks	33	33	33	33	33

Table 10

Dissecting the Effect of the Capital Requirement

The table reports estimates from regressions of portfolio yield (Panel A) and loan amounts (Panels B and C) on variables described in Tables 2 and 3, and including the effect of the correction to the capital requirement $Correction_{bt}$ due to the stress test, defined as follows:

$$Correction_{bt} = Capreq_{bt}/Capreq^{*}_{bt},$$

where $Capreq_{bt} = \max(k_{1bt}, k_{2bt}, k_{3bt}, k_4, k'_{1bt}, k'_{2bt}, k'_{3bt}, k'_{4bt})$, $Capreq^{*}_{bt} = \max(k_{1bt}, k_{2bt}, k_{3bt}, k_4)$. The variable $Correction_{bt}$ is the ratio between the capital requirement in stress tests and the standard capital requirement that bank b would be subject to if it were not stressed in quarter t. All variables are defined as in Tables 2 and 3. $\triangle \mathrm{E}(portfolio\,yield_{bt}|stressed_b = 0, \overline{Capreq_{bt}}, Correction_{bt} = 1)$ and $\triangle \mathrm{E}(portfolio\,yield_{bt}|stressed_b = 1, \overline{Capreq_{bt}}, Correction_{bt} = 1)$ denote the change in the average portfolio yield for non-stressed and stressed banks, respectively, setting the capital requirement at the average level before DFA and at the average level after DFA, and setting $Correction_{bt} = 1$ for all banks in the sample. $\triangle \mathrm{E}(amount_{fbt}|stressed_b = 0, speculative_{ft} = 0, \overline{Capreq_{bt}}, Correction_{bt} = 1)$ and $\triangle \mathrm{E}(amount_{fbt}|stressed_b = 1, speculative_{ft} = 0, \overline{Capreq_{bt}}, Correction_{bt} = 1)$ are defined analogously. The sample includes stressed bank holding companies that participated in all CCARs and non-stressed banks participating in syndicated loans, as described in Sections 3.2 and 3.3. T-statistics based on clustered standard errors at the bank level (Panel A), and at the bank*quarter and firm*quarter level (Panel B and C) are in parentheses.

Panel A: Portfolio Yield

$stressed_b * DFA_t$	-197.32	-194.81	-186.74
	(-4.16)	(-3.69)	(-3.69)
$Correction_{bt}$	-3.22	-6.84	-8.90
	(-0.18)	(-0.41)	(-0.56)
$stressed_b * DFA_t * Capreq_{bt}$	43.16	42.80	41.70
	(4.18)	(3.61)	(3.60)
Controls	N	Y	Y
Bank and Time FE	Y	Y	Y
$stressed_b * DFA_t * portfolio\,yield_{bt-1}$	N	N	Y
R^2 (%)	71.18	73.64	73.79
Adjusted R^2 (%)	68.56	71.07	71.12
$\triangle \mathrm{E}(portfolio\,yield_{bt}\|stressed_b = 0, \overline{Capreq_{bt}}, Correction_{bt} = 1)$	51.36	50.15	46.02
$\triangle \mathrm{E}(portfolio\,yield_{bt}\|stressed_b = 1, \overline{Capreq_{bt}}, Correction_{bt} = 1)$	22.80	24.21	24.99
Observations	1084	1084	1084
Banks	29	29	29

Panel B: log(amount)				
$Cap\,req_{bt} * Firm\,risk_{ft}$	0.013	0.007	0.019	0.013
	(4.38)	(2.23)	(5.93)	(2.60)
$Correction_{bt} * Firm\,risk_{ft}$			-0.066	-0.035
			(-4.32)	(-1.96)
Loan-Level Controls	N	Y	N	Y
Bank-Level Controls*Firm risk	N	Y	N	Y
Firm*Time FE	Y	Y	Y	Y
Bank*Time FE	Y	Y	Y	Y
Loan Characteristics FE	N	Y	N	Y
R^2 (%)	73.12	74.50	73.18	74.52
Adjusted R^2 (%)	67.03	68.65	67.10	68.67
Observations	21174	21174	21174	21174
Bank*Time	894	894	894	894
Firm*Time	3018	3018	3018	3018

Panel C: log(amount) (diff-in-diff)		
$stressed_b * DFA_t * Firm\,risk_{ft}$	-1.496	-0.694
	(-4.99)	(-3.17)
$Correction_{bt} * Firm\,risk_{ft}$	-0.054	-0.024
	(-3.88)	(-1.43)
$stressed_b * DFA_t * Cap\,req_{bt} * Firm\,risk_{ft}$	0.309	0.139
	(4.85)	(3.05)
Loan-Level Controls	N	Y
Bank-Level Controls*Firm risk	N	Y
Firm*Time FE	Y	Y
Bank*Time FE	Y	Y
Loan Characteristics FE	N	Y
R^2 (%)	73.27	74.54
Adjusted R^2 (%)	67.21	68.68
$\triangle$E$(amount_{fbt} \| stressed_b = 0, speculative_{ft} = 0, \overline{Capreq_{bt}}, Correction_{bt} = 1)$	-0.86	-1.10
$\triangle$E$(amount_{fbt} \| stressed_b = 1, speculative_{ft} = 0, \overline{Capreq_{bt}}, Correction_{bt} = 1)$	2.31	9.92
Observations	21174	21174
Bank*Time	894	894
Firm*Time	3018	3018

Figure 1

AVERAGE PORTFOLIO YIELD OF STRESSED AND NON-STRESSED BANKS

The figure shows the evolution of the average portfolio yield on syndicated loans issued each quarter by stressed banks and non-stressed banks. The solid line refers to the average yield for stressed banks, while the dashed line refers to the average yield for non-stressed banks. The vertical thick line is in correspondence of Dodd-Frank Act. Our sample is selected as described in Sections 3.2 and 3.3.

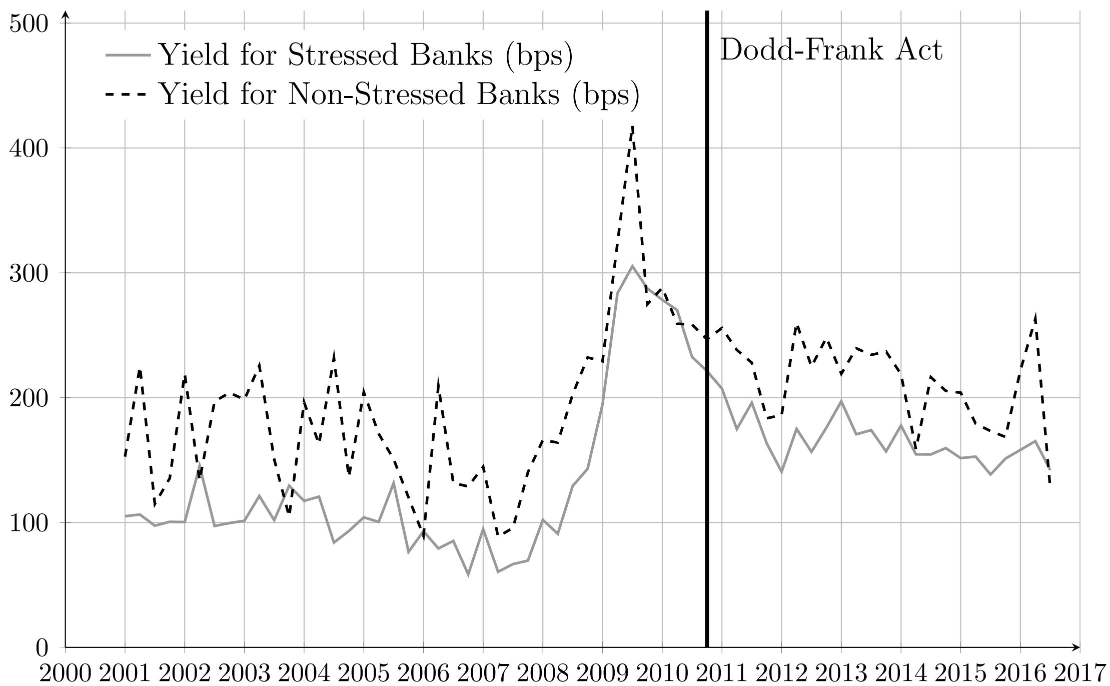


Figure 2
Evolution of Average Risk-Sensitive Capital Requirement

The figure shows the evolution of the risk-sensitive capital requirement as defined in the Appendix (Section A) and described in Section 3.4. The solid thick line refers to the average capital requirement for the entire sample of banks, while the dashed line refers to the average regulatory capital requirement banks would face if they were not subject to stress tests after Dodd-Frank Act. The vertical dotted lines indicate the stress-test disclosure dates. Our sample includes 18 stressed banks participating in all stress test, 15 new entrants, and 21 non-stressed banks and is selected as described in Section 3.2.

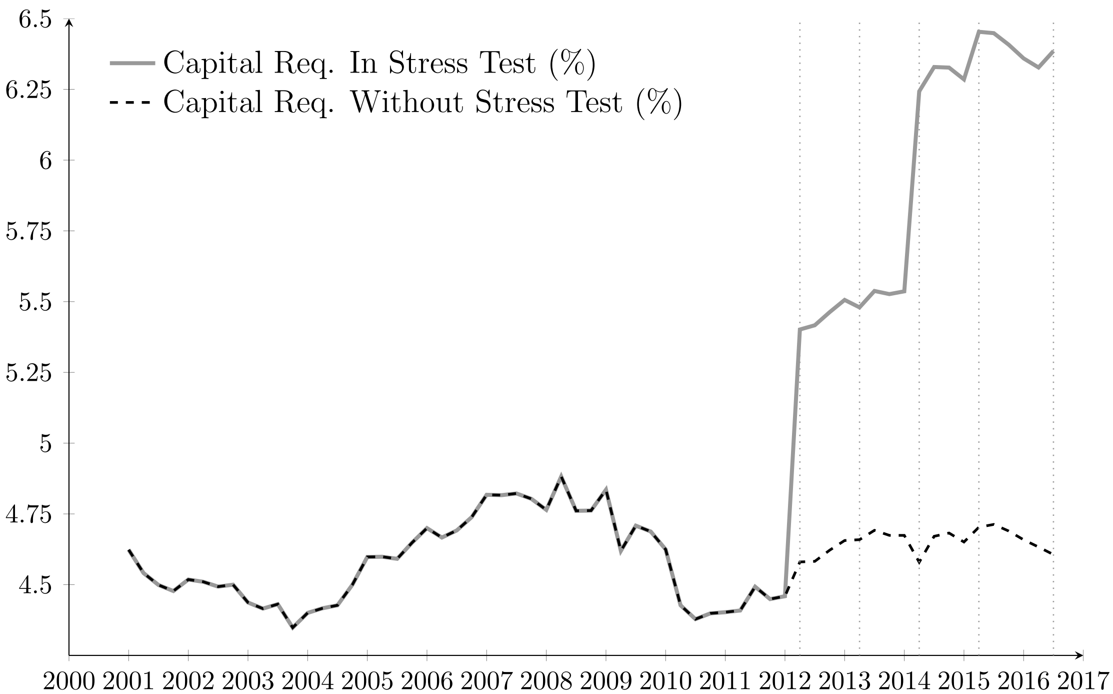


Figure 3

PORTFOLIO YIELD: SUPERVISION EFFECT

The figure shows the evolution of the difference in the average "residual" portfolio yield of stressed banks compared to non-stressed banks. The "residual" portfolio yield is obtained by substracting the effect of the capital requirement on the portfolio yield (from regression (1)) from the observed portfolio yield of a bank. The vertical thick line is in correspondence of Dodd-Frank Act. Our sample is selected as described in Sections 3.2 and 3.3.

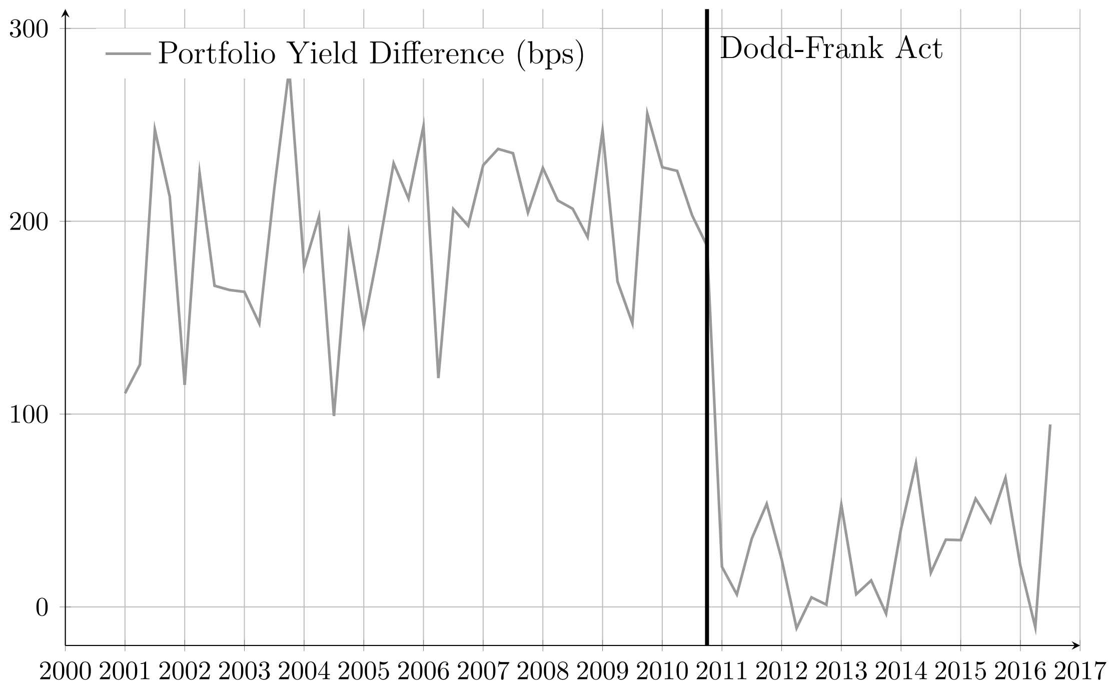
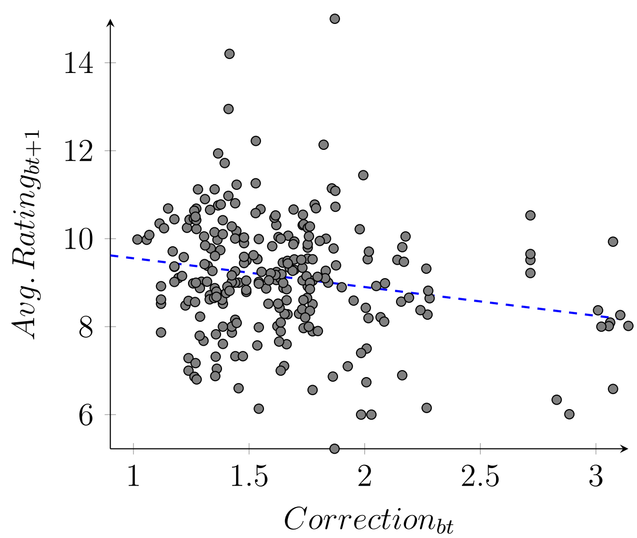


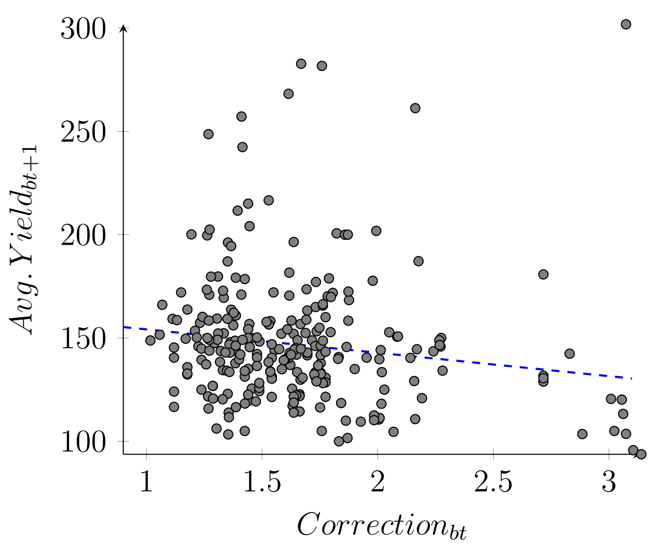
Figure 4
Dissecting the Effect of the Capital Requirement

The figures show the correlation between the correction to the capital requirement due to the stress test ($Correction_{bt}$ as defined in Table 10) and measures of bank risk taking in the next period, namely the average rating ($Avg.\,Rating_{bt+1}$) in Panel A, and the average yield ($Avg.\,Yield_{bt+1}$) in Panel B, on the portfolio of new loans of the bank. The sample includes all post-DFA observations for stressed banks that participated in all stress tests.

Panel A: Average Rating vs. Correction



Panel B: Average Yield vs. Correction



Appendix

The appendix contains the following parts. In Section A we describe the procedure to derive risk-sensitive capital requirements. In Section B we provide additional tables with: the list of stressed banks in our sample (Table A1); average risk-sensitive capital requirements of stressed banks (Table A2); estimates of the sensitivities of bank risk taking to capital requirements (Table A3); inspections of the parallel trend assumption for the yield (Table A4) and the loan portfolio composition (Table A5) analyses; placebo tests (Table A6); and the definitions of the variables used in the analyses (Table A7).

A Risk-Sensitive Capital Requirements Under DFA

In this section, we describe how the risk-sensitive capital requirements that serve as controls in our analyses are measured. We first describe how regulatory capital requirements for all banks, stressed and non-stressed, are set. Then we turn to how the post-stress capital requirements for each bank subject to stress tests can be backed out using the bank-level data disclosed in regulatory stress tests. Finally, to the extent that banks simultaneously face multiple minimum capital requirements based on different capital ratios, we show how all the requirements can be expressed in terms of a single accounting ratio and made comparable. Ultimately, all capital requirements can be combined in a unique measure that captures the tightest capital constraint each bank is subject to for each quarter.

Capital Requirements of Bank Holding Companies. The capital requirements of U.S. bank holding companies are defined using four regulatory capital ratios

$$\begin{array}{rccl} CET1R: & \frac{CET1_b}{RWA_b} & \geq & k_1, \\ T1R: & \frac{T1_b}{RWA_b} & \geq & k_2, \\ TotalR: & \frac{Total_b}{RWA_b} & \geq & k_3, \\ LVGR: & \frac{T1_b}{Assets_b} & \geq & k_4, \end{array} \tag{3}$$

where, for bank b, $CET1_b$ is common equity Tier 1 capital, $T1_b$ is Tier 1 capital, $Total_b$ is Total regulatory capital, RWA_b denotes risk-weighted assets, and $Assets_b$ denotes average total assets (i.e., the time-series average of the bank's total assets over the quarter).[27] In Table A2 (Panel A), we report the four regulatory thresholds (k_1, k_2, k_3, k_4) for each capital ratio in each CCAR exercise. The thresholds are collected from annual CCAR summary reports available on the Federal Reserve website.

[INSERT TABLE A2 HERE]

[27] Descriptive statistics for the four regulatory ratios of stressed banks participating in all stress tests, new entrants, and non-stressed banks are reported in the Online Appendix (Table A10).

Capital Requirements of Stressed Banks. Stressed banks generally face higher capital requirements than non-stressed banks. Intuitively, for stressed banks, bank's capital is supposed to absorb the projected losses also under the stress scenario. To assess capital adequacy for all banks subject to the CCAR, the regulator uses as a capital ratio the minimum projected capital ratio under the supervisory stress scenario. This minimum capital ratio is lower than the actual bank capital ratio.[28] Specifically, under adverse economic conditions, the decline in value of bank's assets translates into a hypothetical loss under the stress scenario. As a result, the buffer of post-stress capital reduces by this hypothetical loss for each quarter of the stress test horizon, as if the bank had less equity capital under severe economic conditions. In addition, the riskiness of the bank's assets increases in the hypothetical stress scenario, resulting in higher regulatory risk weights assigned to risky exposures and lower post-stress capital ratios defined as a percentage of risk-weighted assets.[29]

Denote as $CET1R_{b,stress}$, $T1R_{b,stress}$, $TotalR_{b,stress}$, and $LVGR_{b,stress}$ the minimum projected capital ratios of bank b under the supervisory stress scenario, as available in the data disclosed in regulatory stress tests. These projected ratios can be used to back out thresholds that are applicable to the actual capital ratios of each bank, as follows:

$$
\begin{aligned}
k_{1b}^{s} &= \frac{k_1}{1 + \frac{CET1R_{b,stress} - CET1R_b}{CET1R_b}}, \\
k_{2b}^{s} &= \frac{k_2}{1 + \frac{T1R_{b,stress} - T1R_b}{T1R_b}}, \\
k_{3b}^{s} &= \frac{k_3}{1 + \frac{TotalR_{b,stress} - TotalR_b}{TotalR_b}}, \\
k_{4b}^{s} &= \frac{k_4}{1 + \frac{LVGR_{b,stress} - LVGR_b}{LVGR_b}}.
\end{aligned} \tag{4}
$$

Therefore, a bank subject to the regulatory stress test equivalently faces bank-specific capital requirements, in which thresholds are determined based on the bank's riskiness under the stress scenario. Because $CET1R_{b,stress} \leq CET1R_b$, $T1R_{b,stress} \leq T1R_b$, $TotalR_{b,stress} \leq TotalR_b$, $LVGR_{b,stress} \leq LVGR_b$, the denominators used to define the thresholds of stressed banks in Equation (4) are expected to be lower than one, and the bank-specific post-stress thresholds of stressed banks are expected to be higher than the regulatory thresholds (k_1, k_2, k_3, k_4). Importantly, the difference between post-stress thresholds and the regulatory thresholds is a function of the sensitivity of the bank assets to the supervisory stress scenario *as assessed by the Federal Reserve*. The capital requirement of a stressed bank increases by the extent to which the bank is vulnerable to the supervisory stress scenario. The increase is a "surprise component" of the capital requirement since, by opposition to stress tests ran by the banks, the increase in the capital requirement from regulatory stress test is determined by the Federal Reserve using its own confidential model, and revealed at the disclosure of stress tests results. A comparison of the regulatory thresholds in Panel

[28] In principle, it might be the case that the stress scenario loosens capital requirements, but this situation is never empirically observed.

[29] Bank's capital ratios can also decrease when the bank has planned net capital distributions over the planning horizon.

A to the average post-stress thresholds in Panel B of Table A2 shows the more stringent capital requirements that stressed banks face.

Although some banks fail the regulatory stress test each year, the average actual capital ratios of stressed banks, reported in Panel C of Table A2, are above the average post-stress thresholds.[30] While, after 2014, banks did not fail the CCAR based on quantitative capital inadequacy, the distance between the actual capital ratios of the bank and its post-stress regulatory capital requirements reflects the tightness of the regulatory capital constraint, as well as the probability of the bank of failing the stress test, and having to raise additional equity in the future.

The Most Stringent Capital Requirement. To describe the capital requirements of non-stressed banks with a single measure, we re-write the capital requirement based on the four regulatory capital ratios of Equation (3) as a single Tier 1 leverage ratio requirement, i.e. a Tier 1 capital requirement as a percentage of average total assets. To do so, we recognize that the most stringent capital constraint can be written as

$$\frac{T1_b}{Assets_b} \geq Cap\,req_b,$$

where after some algebraic manipulation of regulatory capital requirements in Equation (3):

$$Cap\,req_b = max(k_{1b}, k_{2b}, k_{3b}, k_4), \tag{5}$$

with $k_{1b} = \left[k_1 - \frac{CET1_b - T1_b}{RWA_b}\right] \frac{RWA_b}{Assets_b}$, $k_{2b} = k_2 \frac{RWA_b}{Assets_b}$, and $k_{3b} = \left[k_3 - \frac{Total_b - T1_b}{RWA_b}\right] \frac{RWA_b}{Assets_b}$. The capital shortfall or the amount of Tier 1 capital a bank needs to raise in order to meet the capital requirement of Equation (5) is $max(0, Cap\,req_b * Assets_b - T1_b)$.

Similarly, the most stringent Tier 1 leverage ratio requirement for the subset of stressed banks is

$$Cap\,req_b = \max(k_{1b}, k_{2b}, k_{3b}, k_4, k'_{1b}, k'_{2b}, k'_{3b}, k'_{4b}), \tag{6}$$

where $k'_{1b} = \left[k^s_{1b} - \frac{CET1_b - T1_b}{RWA_b}\right] \frac{RWA_b}{Assets_b}$, $k'_{2b} = k^s_{2b} \frac{RWA_b}{Assets_b}$, $k'_{3b} = \left[k^s_{3b} - \frac{Total_b - T1_b}{RWA_b}\right] \frac{RWA_b}{Assets_b}$, and $k'_{4b} = k^s_{4b}$. In the last column of Panel B of Table A2, we report the cross-sectional average single Tier 1 leverage ratio requirement ($Cap\,req_b$) of stressed banks.[31]

[30] After the crisis, the average capital ratios have increased for all groups of banks, and especially for stressed banks (see descriptive statistics in Table A10 in the Online Appendix). The average Tier 1 capital ratio increased by 4% for stressed banks, compared to an increase of 2.1% for non-stressed banks. This difference is explained by the low level of capitalization of stressed banks before the crisis compared to non-stressed banks. In Figure A1 (in the Online Appendix), we observe an upward shift in banks' regulatory capital ratios during the fourth quarter of 2008, which coincides with the launch on October 14, 2008 of the Capital Purchase Program (CPP) and the Temporary Liquidity Guarantee Program (TLGP) under the TARP. Under the CPP, the Treasury Department injected $205 billion capital into banks by buying warrants, common shares, and preferred shares. The SCAP also led to a substantial recapitalization of the U.S. financial system (an additional $75 billion capital buffer).

[31] Note that given the change in the regulatory definition of the common equity Tier 1 ratio and the different resulting thresholds used in the CCARs, we do not consider k_{1b} and k'_{1b} when deriving the most stringent capital requirement in Equations (5) and (6).

From 2012 to 2016, we collect the bank-specific stress test data disclosed in each annual CCAR summary report available from the Federal Reserve website.[32] In the panel dataset, the post-stress bank-specific thresholds (k^s_{1bt}, k^s_{2bt}, k^s_{3bt}, k^s_{4bt}) of Equation (4) used to derive $Cap\,req_{bt}$ of stressed banks after DFA are held constant between the quarter of the stress test disclosure until the quarter before the next stress test disclosure. In addition, the single bank-specific capital requirement $Cap\,req_{bt}$ is updated each quarter with information provided by the bank — average total assets, risk-weighted assets, and the different measures of capital — based on end of *previous* quarter $(t-1)$ data.

[32] In November 2011, the Federal Reserve proposed a rule to implement the DFA requirements specifying that a summary of the stress tests results should be made public. Only for the 2011 CCAR, the Federal Reserve did not disclose any bank-specific result from the stress test.

B Additional Tables

Table A1
STRESSED BANKS

The table lists the banks subject to annual regulatory stress tests in the U.S.. A cross indicates whether a bank participated in a regulatory stress test exercise for a given year (SCAP 2009, CCAR 2011, 2012, 2013, 2014, 2015 and 2016). "Fail" indicates the number of banks that did not satisfy the regulatory criteria in each regulatory stress test exercise (except for CCAR 11, for which bank-specific results are not available).

Bank	2009	2011	2012	2013	2014	2015	2016
Ally Financial Inc.	×	×	×	×	×	×	×
American Express Company	×	×	×	×	×	×	×
Bank of America Corporation	×	×	×	×	×	×	×
BB&T Corporation	×	×	×	×	×	×	×
The Bank of New York Mellon	×	×	×	×	×	×	×
Capital One Financial Corporation	×	×	×	×	×	×	×
Citigroup Inc.	×	×	×	×	×	×	×
Fifth Third Bancorp	×	×	×	×	×	×	×
The Goldman Sachs Group, Inc.	×	×	×	×	×	×	×
JPMorgan Chase & Co.	×	×	×	×	×	×	×
KeyCorp	×	×	×	×	×	×	×
MetLife, Inc.	×	×	×				
Morgan Stanley	×	×	×	×	×	×	×
The PNC Financial Services Group, Inc.	×	×	×	×	×	×	×
Regions Financial Corporation	×	×	×	×	×	×	×
State Street Corporation	×	×	×	×	×	×	×
SunTrust Banks, Inc.	×	×	×	×	×	×	×
U.S. Bancorp	×	×	×	×	×	×	×
Wells Fargo & Company	×	×	×	×	×	×	×
BBVA Compass Bancshares, Inc.					×	×	×
BMO Financial Corp.					×	×	×
Comerica Incorporated					×	×	×
Discover Financial Services					×	×	×
HSBC North America Holdings Inc.					×	×	×
Huntington Bancshares Incorporated					×	×	×
M&T Bank Corporation					×	×	×
Northern Trust Corporation					×	×	×
Citizens Financial Group, Inc.					×	×	×
Santander Holdings USA, Inc.					×	×	×
MUFG Americas Holdings Corporation					×	×	×
Zions Bancorporation					×	×	×
Deutsche Bank Trust Corporation						×	×
BancWest Corporation							×
TD Group US Holdings LLC							×
Sample	19	19	19	18	30	31	33
Fail	10		4	4	5	3	3

Table A2

Capital Requirements of Stressed Banks

The table reports regulatory thresholds used for each regulatory ratio in the CCAR (Panel A), the cross-sectional average post-stress bank-specific thresholds (Panel B), and the cross-sectional average actual capital ratios (Panel C). $Cap\,req_b$ is the risk-sensitive capital requirement as defined in Equation (6). k^s_{1b}, k^s_{2b}, k^s_{3b}, k^s_{4b} are the bank-specific capital requirements for the CET1R, T1R, TotalR, and LVGR, respectively, as defined in Equation (4). T1CR is the ratio of common equity Tier 1 capital to risk-weighted assets (Basel I definition), CET1R is the ratio of common equity Tier 1 capital to risk-weighted assets (Basel III definition), T1R is the ratio of Tier 1 capital to risk-weighted assets, TotalR is the ratio of Total capital to risk-weighted assets, LVGR is the ratio of Tier 1 capital to average total assets. Our sample is selected as described in Section 3.2.

Panel A: CCAR Regulatory Thresholds (%)

	T1CR (k_1)	CET1R (k_1)	T1R (k_2)	TotalR (k_3)	LVGR (k_4)
2016	-	4.5	6	8	4
2015	5	4 to 4.5	5.5 to 6	8	3 to 4
2014	5	4 to 4.5	4 to 6	8	3 to 4
2013	5	-	4	8	3 to 4
2012	5	-	4	8	3

Panel B: Average Bank-Specific Thresholds (%)

	T1CR (k^s_{1b})	CET1R (k^s_{1b})	T1R (k^s_{2b})	TotalR (k^s_{3b})	LVGR (k^s_{4b})	$Cap\,req_b$
2016	-	7.6	9.5	11.5	6.4	7.5
2015	7.8	-	9.9	12.1	6.2	7.8
2014	8.1	-	9.4	11.5	5.9	7.6
2013	9.1	-	6.8	12.2	5.3	6.9
2012	8.5	-	6.8	11.9	5.1	6.8

Panel C: Average Actual Capital Ratios (%)

	T1CR	CET1R	T1R	TotalR	LVGR
2016	-	12.5	13.6	15.8	9.8
2015	12.7	-	14.1	16.6	9.9
2014	11.7	-	13.1	15.7	9.7
2013	11.3	-	13.1	15.6	8.8
2012	10.4	-	12.7	15.6	8.7

Table A3

ESTIMATED RISK SENSITIVITIES TO CAPITAL REQUIREMENTS

The table reports the estimates of the sensitivity of the portfolio yield to $Capreq_{bt}$ in the panels referring to Tables 2 and 10A, and the sensitivity of the logarithm of loan amount to $Capreq_{bt} * Firmrisk_{ft}$ in the panels referring to Tables 3 and 10C. The regressions reported in these tables allow for different sensitivities of risk taking to capital requirements, depending on whether banks are stressed or non-stressed, and before or after DFA. T-statistics based on clustered standard errors at the bank level (Tables 2 and 10A), and at the bank*quarter and firm*quarter level (Tables 3 and 10C) are in parentheses.

	Table 2			Table 3		Table 10A			Table 10C	
Stressed After DFA	-0.29 (-0.18)	-0.25 (-0.17)	-0.15 (-0.10)	0.01 (2.36)	0.00 (1.51)	0.32 (0.08)	1.05 (0.27)	1.53 (0.41)	0.01 (4.07)	0.01 (1.87)
Stressed Before DFA	2.92 (0.71)	3.48 (0.89)	4.06 (1.04)	0.02 (4.45)	0.01 (1.25)	3.42 (0.64)	4.50 (0.94)	5.35 (1.13)	0.02 (4.45)	0.01 (1.62)
Non-Stressed After DFA	15.94 (1.94)	14.56 (2.37)	10.15 (1.23)	-0.18 (-3.10)	-0.02 (-0.62)	15.93 (1.95)	14.65 (2.37)	10.24 (1.24)	-0.17 (-3.19)	-0.02 (-0.63)
Non-Stressed Before DFA	62.12 (4.47)	60.51 (3.81)	55.41 (3.32)	0.14 (4.30)	0.12 (3.25)	62.19 (4.46)	60.91 (3.82)	55.75 (3.33)	0.15 (4.29)	0.12 (3.26)

Table A4

Stress Test Supervision: Parallel Trend Assumption (Portfolio Yield)

The table reports estimates from the regression:

$$\begin{aligned} portfolio\,yield_{bt|DFA_t=0} &= \alpha_b + \beta_1 stressed_b * trend_t + \beta_2 trend_t \\ &\quad + \beta_3 Cap\,req_{bt} + \beta_4 stressed_b * Cap\,req_{bt} \\ &\quad + \gamma' controls_{bt} + \epsilon_{bt}, \end{aligned}$$

where $portfolio\,yield_{bt}$ is the weighted average all-in-drawn spread on the portfolio of new syndicated loans (new facilities) bank b participates to in a given quarter t, with weights given by the bank's dollar loan amounts to each firm within the quarter, α_b are bank fixed effects, $trend_t$ is a linear trend, $stressed_b$ is a dummy variable equal to one if bank b is subject to CCAR, DFA_t is a dummy variable equal to one if quarter t is after the fourth quarter of 2010, $Cap\,req_{bt}$ is the capital requirement of bank b in quarter t as defined by Equation (5) and Equation (6) for stressed banks after DFA, and $controls_{bt}$ are bank-specific control variables. Control variables include the logarithm of bank's total assets, the ratio of liquid assets to total assets, the ratio of bank net income to total assets, the ratio of trading assets to total assets, the weighted average portfolio maturity, and the percentage of secured loans of the bank in quarter t. The sample includes stressed bank holding companies that participated in all CCARs and non-stressed banks participating in syndicated loans, as described in Sections 3.2 and 3.3. T-statistics based on clustered standard errors at the bank level are in parentheses.

	Portfolio Yield (Before DFA)			
$stressed_b * trend_t$	2.40	2.13	2.36	1.85
	(1.64)	(1.50)	(2.14)	(1.60)
$trend_t$	2.30	2.93	2.34	3.09
	(1.64)	(2.33)	(2.21)	(2.94)
$Cap\,req_{bt}$			2.93	21.91
			(0.11)	(0.82)
$stressed_b * Cap\,req_{bt}$			-19.30	-24.89
			(-0.59)	(-1.03)
Controls	N	Y	N	Y
Bank and Time FE	Y	Y	Y	Y
R^2 (%)	46.27	61.37	46.90	61.58
Adjusted R^2 (%)	43.53	58.96	43.98	59.02
Observations	578	578	578	578
Banks	27	27	27	27

Table A5

Stress Test Supervision: Parallel Trend Assumption (Loan Portfolio Composition)

The table reports estimates from the regression:

$$\begin{aligned}\log(amount_{fbt|DFA=0}) \quad = \quad & \alpha_{bt} + \alpha_{ft} + \beta_1 stressed_b * trend_t * Firm\,risk_{ft} \\ & + \beta_2 stressed_b * Firm\,risk_{ft} + \beta_3 Cap\,req_{bt} * Firm\,risk_{ft} \\ & + \beta_4 stressed_b * Cap\,req_{bt} * Firm\,risk_{ft} + \gamma' controls_{fbt} + \epsilon_{fbt},\end{aligned}$$

where $\log(amount_{fbt})$ is the logarithm of the USD amount lent by bank b to firm f in a facility issued at date t, α_{bt} are bank*quarter fixed effects, α_{ft} are firm*quarter fixed effects, $Cap\,req_{bt}$ is the capital requirement of bank b at date t as defined by Equation (5) , and $Firm\,risk_{ft}$ is the firm's numerical rating (1 is AAA; 23 is D). Loan- and bank-level control variables are defined as in Table 3. Regressions are saturated with bank*quarter and firm*quarter fixed effects. The sample includes stressed bank holding companies that participated in all CCARs and non-stressed banks participating in syndicated loans, as described in Sections 3.2 and 3.3. T-statistics based on clustered standard errors at the bank*quarter and firm*quarter level.

	log(amount) (Before DFA)			
$stressed_b * trend_t * Firm\,risk_{ft}$	0.002	0.003	0.005	0.006
	(0.32)	(0.75)	(1.06)	(1.27)
$stressed_b * Firm\,risk_{ft}$	0.022	0.021	0.504	0.291
	(0.15)	(0.17)	(2.58)	(1.13)
$Cap\,req_{bt} * Firm\,risk_{ft}$			0.144	0.088
			(4.41)	(2.23)
$stressed_b * Cap\,req_{bt} * Firm\,risk_{ft}$			-0.122	-0.072
			(-3.69)	(-1.71)
Loan-Level Controls	N	Y	N	Y
Bank-Level Controls*Firm Risk	N	Y	N	Y
Firm*Time FE	Y	Y	Y	Y
Bank*Time FE	Y	Y	Y	Y
Loan Characteristics FE	N	Y	N	Y
R^2 (%)	74.01	75.46	74.27	75.51
Adjusted R^2 (%)	67.49	69.17	67.80	69.23
Observations	12253	12253	12253	12253
Bank*Time	480	480	480	480
Firm*Time	1977	1977	1977	1977

Table A6

STRESS TEST SUPERVISION: PLACEBO TESTS (ROBUSTNESS)

The table is a replica of Table 2 (Panel A) and Table 3 (Panel B) using the date of introduction of Basel III instead of the date of DFA, using the average bank size as the bank size threshold defining stressed banks, and using the firm size instead of a measure of firm risk.

	Placebo Tests: Average Bank Size Threshold				
	Panel A: Portfolio Yield			Panel B: log(amount)	
$large_b * DFA_t$	-5.65	-1.61	-1.34	0.02	0.02
	(-0.47)	(-0.15)	(-0.05)	(0.35)	(0.54)
$large_b * DFA_t * Cap\,req_{bt}$	42.95	-0.24	-0.73	-0.00	-0.00
	(4.13)	(-0.12)	(-0.39)	(-0.43)	(-0.49)
Bank-Level Controls	N	Y	Y	-	-
Bank and Time FE	Y	Y	Y	-	-
$large_b * DFA_t * portfolio\,yield_{bt-1}$	N	N	Y	-	-
Loan-Level Controls	-	-	-	N	Y
Bank-Level Controls*Firm risk	-	-	-	N	Y
Firm*Time FE	-	-	-	Y	Y
Bank*Time FE	-	-	-	Y	Y
Loan Characteristics FE	-	-	-	N	Y
R^2 (%)	69.70	72.38	72.43	73.17	74.51
Adjusted R^2 (%)	66.98	69.73	69.66	67.08	68.65
Observations	1084	1084	1084	21174	27462
Banks	29	29	29	29	29
Bank*Time	-	-	-	894	894
Firm*Time	-	-	-	3018	3018

Table A7

Variable Definitions

Variable	Definition	Source
CET1R	Ratio of common equity Tier 1 capital to risk-weighted assets	Fed, SNL
T1R	Ratio of Tier 1 capital to risk-weighted assets	Fed, SNL
TotalR	Ratio of Total capital to risk-weighted assets	Fed, SNL
LVGR	Ratio of Tier 1 capital to average total assets	Fed, SNL
$CET1R_{stress}$	Minimum ratio of common equity Tier 1 capital to risk-weighted assets over the stress scenario horizon	Fed
$T1R_{stress}$	Minimum ratio of Tier 1 capital to risk-weighted assets over the stress scenario horizon	Fed
$TotalR_{stress}$	Minimum ratio of Total capital to risk-weighted assets over the stress scenario horizon	Fed
$LVGR_{stress}$	Minimum ratio of Tier 1 capital to average total assets over the stress scenario horizon	Fed
CET1	Common equity Tier 1 capital	SNL
T1	Tier 1 capital	SNL
Total	Total capital	SNL
Assets	Average total assets	SNL
RWA	Risk-weighted assets	SNL
Asset income	Net income plus interest expenses divided by total assets	SNL
All-in-drawn spread	Amount the borrower pays in bps over LIBOR for each dollar drawn down	DealScan
Facility amount	Actual amount of the facility commited by the facility's lender pool	DealScan
Bank allocation	Amount a particular lender has committed to the given facility	DealScan
Exchange rate	The current exchange rate compared to USD based on the exchange rate date of the company's native currency	DealScan
Maturity	A calculation of how long (in months) the facility will be active from signing date to expiration date	DealScan
Rating	Firm's numerical rating (1 is AAA; 23 is D)	Compustat
Rated	Binary variable that indicates if the firm has a rating assigned in Compustat	Compustat
Speculative	Binary variable that indicates if the firm's rating is worse than BBB	Compustat
Z-Score	Altman's Z-Score	Compustat