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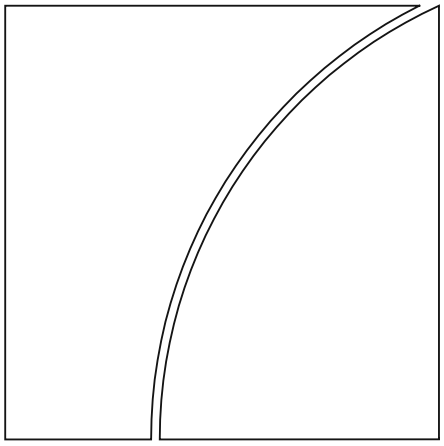

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by Stijn Claessens, Andy Law and Teng Wang

Monetary and Economic Department

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JEL classification: G21, G28

Keywords: ratings, bank capital, regulation, loan conditions

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How Do Credit Ratings Affect Bank Lending Under Capital Constraints?[1]

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Abstract

Through the lens of credit risk ratings, we investigate how banks determine loan terms under capital constraints. Using a unique and comprehensive supervisory dataset of individual corporate loans in the US, we show that unexpected adjustments to banks' internal rating systems, which only alter how outsiders assess the riskiness of borrowers, trigger changes in loan terms. The effects are asymmetric: downward adjustments to ratings increase spreads by some 40 bps and decrease committed loan sizes and maturities, but upward adjustments lead to much weaker (yet opposite) effects. Importantly, we find effects to be strong for smaller, riskier, and capital constrained banks as well as for borrowers with poorer credit quality and for non-guaranteed loans. Our findings, robust in several ways, highlight the important role of regulatory capital in loan terms.

Keywords: ratings, bank capital, regulation, loan conditions

JEL classification: G21, G28

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1. Introduction

Credit ratings are a critical tool for banks to assess the default risk of their corporate borrowers (Carey and Tracey, 1998). A deterioration in a bank's ratings of a corporate borrower, for instance, reflects a perceived elevated default risk of the firm, which in turn negatively affects the loan terms that the firm receives. An improvement in the rating, conversely, may lead to more favorable loan terms. Ratings can often be used to communicate externally as well the overall riskiness of banks' assets, and different risk weights are assigned to assets with different ratings according to Basel capital rules. Fluctuations in ratings affecting many borrowers can then change outsiders' assessment of the overall riskiness of a bank's assets, and thereby influence the required level of regulatory capital.

Despite the importance of credit ratings, little evidence exists on how rating adjustments affect corporate loan terms. How does the price (ie, spread) charged and the volume of loans move correspondingly after banks change a borrower's rating? Importantly, little is known about the interplay between banks' credit ratings and capital and other balance sheet positions. Is any heterogeneity in the effects among banks related to different characteristics? Are certain banks more sensitive to changes in borrowers' ratings, and do they adjust loan terms more aggressively than other banks do? If so, is that because these banks are more susceptible to potential market discipline or regulatory pressure, with the latter related to their size, capitalization, portfolio composition, overall riskiness, or other balance sheet positions?

The limited empirical evidence on the role of credit ratings related to these questions reflects the many data and identification challenges to examining the questions. For one, detailed data on borrowers' internal ratings are often managed within banks, confidentially guarded, and not available to outside researchers. Second, even when available, ratings are set in response to many internal and external factors that are also used to set loan terms. For example, both its rating and spread will reflect a borrower's intrinsic riskiness. Additionally, the general demand for loans and the degree of competition are likely to affect both borrowers' ratings and spreads; for instance, firms in sun-setting industries may demand fewer loans and banks may contemporaneously adjust downwards their expected prospects of such borrowers. This simultaneity makes it challenging to identify the independent effect of borrowers' ratings on loan terms and to isolate if and how a bank's financial position influences these effects.

In this paper, we tackle both the data and the identification challenges. Specifically, we use a unique, comprehensive supervisory data set of 1.6 million loans that covers 78% of corporate loans in the US. The data includes specific terms of loans as well as banks' credit risk ratings of the corporate borrowers. One unique feature of the database is that it not only provides information on the loans at issuance but also allows us to track changes in their terms over time. To identify the effects of ratings, we exploit a series of quasi-natural experiments by looking at events in which unexpected adjustments in banks' rating systems occur. To be specific, we look at events involving changes in the conversion of banks' internal credit risk ratings to

external ratings of a uniform scale.[1] An adjustment in banks' rating systems changes the external rating that reflects the *perceived* riskiness of the loans, while borrowers' *intrinsic* default risk stays unchanged. Since external ratings are often used to communicate the overall riskiness of banks' assets, and different risk weights are assigned to assets with different ratings according to Basel capital rules, upon a downward rating adjustment, for instance, the bank likely sees a rise in the risk weight of its assets and a decline in its risk-based capital ratio. The setting of looking at adjustments in the rating system is ideal for isolating the causal effects of credit rating change on loan terms.[2] Changes in borrowers' loan terms can be attributed to banks' reactions to the adjustment (of an entire internal rating category), rather than to changes in a specific borrower's risk profile. In other words, we effectively hold the borrowing firm's characteristics, including its demand for external financing, constant. As such, we can perform a cleaner test that shows how supply effects change loan terms.

Exploiting the natural experiment of rating adjustments across banks and over time, we use a difference-in-difference approach to identify the causal relationships between ratings adjustments and banks' changes in loan terms. Following events of a rating adjustment, a bank may then take several complementary actions regarding those loans to maintain its risk-based capital ratio. We study changes in loan terms from a variety of perspectives, including pricing, volume, and maturity. For instance, facing a downward rating adjustment, a bank may attempt to increase its income (thereby increasing its retained earnings and capital base), by raising the interest rate (spread) charged on the loans with external rating downwardly adjusted. It could also decrease its exposure to rating-adjusted loans (ie, the loan size), which would reduce its risk-weighted assets and possibly its required loan-loss provisioning, thereby increasing its capital ratio. Furthermore, the bank could shorten the maturity of the rating-adjusted loans to again reduce required capital and loan-loss provisioning (shorter maturity loans require lower loan loss allowances) and boost its capital.

We expect banks' loan terms to be more sensitive to downward adjustment of ratings than to upward adjustments. A downward adjustment can bring a bank closer to its minimum requirements, thereby possibly triggering greater market discipline and stricter regulatory scrutiny such as potential supervisory actions, which can make lending to borrowers with downward-adjusted loans more costly. In contrast, these effects do not apply to upward rating adjustments. Here, the bank has more freedom on how much of the benefits of an upward rating adjustment to pass on to borrowers, with competitive conditions to play a role in the degree of pass-through.[3]

We find that rating adjustments trigger asymmetric changes in loan terms: for instance, banks charge higher interest rate spreads by some 40 basis points following downward rating adjustments on those loans, while spreads only decline some 27 to

[1] To communicate credit risk externally, including in the context of underwriting or renegotiating loans with borrowers, or of disclosing ratings to market participants, banks convert the internal ratings to an externally comparable, uniform rating scale, such as those used by credit agencies.

[2] Changes are usually marginal (ie, in an adjustment, a bank's specific rating category typically moves only to the next-higher or-lower rating category). But even such a marginal change can have large effects as it can mean that the loan falls in a rating category with a higher risk weight, as set by capital adequacy requirements.

[3] Discussions with credit risk banking experts, including bank examiners, confirm these hypotheses and indicate that banks are more sensitive to downward adjustments in resetting loan terms than to upward adjustments.

28 basis points after upward rating adjustments. Similarly, volumes lent decline and maturities shorten more with downward adjustments, but remain statistically similar or increase marginally with upward adjustments. This asymmetry suggests that in downward rating adjustments, banks change loan terms to prevent adverse market or regulatory actions, including those related to capital falling below regulatory thresholds. In contrast, the limited response to upward adjustments suggests that banks not faced with pressures pass little of the benefits on to borrowers.

We expect the effects of the adjustments to vary by bank characteristics. Exploiting the cross-sectional variation in our sample of banks, we find that larger banks increase their spreads less when the external rating of borrowers is adjusted downwards, since the percentage of affected assets relative to total assets is smaller for larger banks. For "riskier" banks (ie, with higher loan-loss provisions), downward rating adjustments more adversely affect loan terms, possibly because such banks now more likely face market or regulatory scrutiny. Banks that are capital constrained also display larger responses, again suggestive of possibly binding capital constraints. In addition, banks adjust loan terms most aggressively for riskier loans and borrowers (ie, non-government guaranteed loans and non-investment grade borrowers). These results are robust to changes in regression specification and other (econometric) permutations.

Our analysis principally relates to two strands in the literature. The first analyzes the effects of banks' credit ratings of borrowers on banks' loan terms, such as spreads. Most studies rely on proprietary datasets from banks in Europe. Machauer and Weber (1998) analyze small- and medium-sized German firms and find that borrowers with riskier internal credit ratings tend to have higher interest rate premiums. Nakamura and Roszbach (2016) use Swedish commercial banking data and find that credit ratings include useful private information on loans and that such information revelation varies with loan size. Additionally, some recent papers analyze the relationships between internal rating and bank lending by focusing on the syndicated loan market (eg, Aramonte, Lee, and Stebunovs, 2014; Balasubramanyan, Berger and Bouwman, 2016; see also Berg, Puri, and Rocholl (2014).

Our work differs from the aforementioned and other related papers in several critical ways. Most papers focus on small segments of the lending market. For example, many papers focus on syndicated loans, which are generally accessed by relatively larger corporations and not representative of broader credit markets. Indeed, the number of observations in these studies typically ranges from two to ten thousand, and cover limited overall volumes of lending. In contrast, our dataset has six million observations and covers almost 80% of the US corporate loan market in dollar terms, mainly bilateral loans. Other studies, also of the syndicated loan market, mainly use DealScan data, but questions about the role of internal credit ratings of corporate loans cannot be addressed using this data alone. Not only does it not reveal banks' rating of those loans, but it also does not follow changes in the terms of issued loans over time. In addition, most other papers use *external* ratings that are standardized and converted from a bank's *internal* rating,[4] making it difficult to control for the endogeneity of ratings and loan terms. Lastly, few papers specifically

[4] Different from banks' internal ratings, "external rating" refers to a rating that is obtained by converting a bank's internal rating to an external rating on a uniform scale. See section 2.1 for a further description.

analyze how the impact of regulatory effects varies by bank-specific factors, mostly because they do not have access to data from a cross-section of banks.

Some research that looked at how public ratings affect lending markets and the pricing of various types of external financing broadly relates too. Weinstein (1977) finds that public ratings on corporate bonds do not affect pricing in the months before and after a rating change announcement, as such events are typically foreseen, given publicly available firm data. Cantor and Packer (1996) do find, however, that public rating changes can affect the pricing of non-investment-grade sovereign bonds. In addition, Kliger and Sarig (2000) find that announcements of downgrades of Moody's ratings tend to decrease bond valuations. The focus of these studies differs from ours, however, as they typically involve public information and broad dissemination, while in our case the information tends to be of a private nature, even if some of it may later become more widely disseminated.

The second strand is the literature on the effects of (adjustments in) capital and liquidity positions and requirements on lending and the price and volume of credit, in general and for various borrowers. Thakor (2014), in his review, concludes that the higher capital requirements of Basel II led to moderate increases in spreads and small reductions in lending, especially during the transition, but with very heterogeneous effects across banks. Papers such as Repullo and Suarez (2004), Ruthenberg and Landskroner (2008), suggest that the implementation of Basel II, which intended loan pricing to become more risk-sensitive, could have led banks to reduce loan rates for highly-rated firms, while lower-rated firms could have avoided price increases by moving to banks using less risk-sensitive measures. Simultaneity and omitted variables can make it hard, however, to separate the effects of borrower and capital and other banks' characteristics from macroeconomic, regulatory, and other factors also affecting loan riskiness and loan terms. For example, Hirtle, Kovner, and Plosser (2016) find that more robust, better capitalized banks tend to also have less risky loan portfolios and more conservative loan pricing practices, suggesting one cannot easily make a causal link from (changes in) bank capitalization to loan pricing.

Importantly, the challenges arise due to limited availability of granular data. Some analyses rely on data aggregated at the bank level. To the extent that granular data are used, it is often from public sources that cover a subsample of firms (eg, Bridges et al 2014). While many of those studies report that higher capital increases the cost and reduce the volume of lending, estimates of the effects vary greatly in size and are not always reliable (Basel Committee on Banking Supervision, 2016). We contribute to this literature by clearly identifying the role of bank capitalization in loan terms.

The paper proceeds as follows. In section 2, we provide institutional background, an overview of our data and summary statistics. Section 3 presents our methodology and the results of our empirical analyses. Section 4 provides our robustness tests, and section 5 concludes.

2. Institutional Background and Data

2.1 Banks' internal risk rating and adjustments in ratings

A bank typically assesses the credit quality of its borrowers using its own internal credit risk rating scale, which can vary between banks. To communicate credit risk

externally, including in the context of underwriting or renegotiating loans with borrowers, or to disclose ratings to market participants, banks convert the internal credit ratings to an externally comparable, uniform rating scale. This conversion typically involves comparing the default experience of loans in their own internal credit rating categories to assets with similar default experience and public ratings. The converted, externally-comparable rating allows for cross-bank comparison of credit quality of bank assets. For example, if one loan with an internal rating of "1" from one bank and another loan from another bank with internal rating of "a1" share similar probability of default and are within the range of default probability of public-rated AAA securities, then the internal rating of both securities could be converted externally with the external rating of AAA. As the default probability ranges in both internal rating and external rating buckets may change over time, the conversion between banks' internal rating category (which represents a particular rating tranche) and external compatible rating category will be adjusted as a means to enhance default risk comparability. More specifically, internal rating categories are initially converted to an external rating scale by cross-comparing the ranges of the probability of default (PD) associated with internal and public rating categories. However, the PD ranges associated with public rating categories may shift in the future due to market's reassessment of riskiness of publicly traded assets within each category, and this change in PD ranges will result in either a downward or upward adjustment of internal rating categories to external ratings. A simple hypothetical example of the adjustments of banks' credit rating system is illustrated in Appendix I. Note that regulatory scrutiny is warranted for the accuracy of the conversion since external ratings are often used to assess banks' portfolio riskiness and capital adequacy. In total, there are 119 rating adjustments (63 upward and 56 downward adjustments) across all banks, which apply to 12% of all loans in our sample.

The adjustment in the conversion of banks' internal ratings creates a unique setting to study the supply-side effects of corporate loan rating changes. Upon adjustments in the rating system, the *perceived riskiness* of the corporate borrowers in an entire rating tranche (captured by *external* rating) is shifted while the fundamentals for each individual borrower (captured by *internal* rating) remains constant. By exploiting adjustments in the conversion between each bank-specific scale and the uniform external scale, we can identify any changes in loan terms following the events that were directly caused by credit rating changes, rather than demand-side shifts from the borrowers.

An interesting observation is that we do see banks are more likely to reverse the ratings on affected loans following a downward adjustment in the rating system, as compared to an upward adjustment.[5] The presence of rating reversions following downward adjustments provides additional support for the exogenous nature of rating adjustments, as it shows that banks may take action to avoid potential consequences related to the unexpected increase in the perceived riskiness of its loan portfolios.[6]

[5] As reported in Table 1, upwards offsets affect 8.1% of a bank's portfolio, while downward offsets affect 2.6% of loans.

[6] Such reversals occur only in a very small fraction of up- or downward adjustments and the main results remain robust excluding these observations (see the robustness section).

2.2 Data on loans and bank characteristics

One primary data source comes from the Federal Reserve's Y-14Q reports, a quarterly collection of banks' holding of commercial and industrial (C&I) loan data collected by the Federal Reserve beginning in the fall of 2011.[7] Our data cover all C&I loans in excess of $1 million originated and held by the 35 largest bank holding companies by assets. Loan sizes range from the $1 million reporting threshold to billions of dollars, thus covering the full spectrum from loans to SMEs to those to large listed corporations. Each loan-level observation contains the issuing bank's internal rating and loan characteristics (eg, interest rate spread, committed amount, and maturity) as well as identification of the borrowers. The data not only cover information on loans that are newly originated, but also tracks the changes in characteristics of the loans and their related borrowers over time. The sample contains 7.4 million observations over the period of September 2011 to December 2016, with a maximum number of 906,678 in a given quarter. At the end of 2016, the loans accounted for $1.52 trillion or about 78% of total corporate lending in the United States.

Additionally we use the Federal Reserve's Y-9C for the basic financial data of the bank holding and US intermediate holding companies to derive measures of capitalization and other prudential measures. This quarterly dataset allows us to investigate how down- and upward rating adjustments affect loan terms for banks with different characteristics. The combination of detailed loan and rating data, rating adjustments, and the cross section of banks provides a unique way to identify how banks adjust loan terms in response to shocks.

Table 1, Panel A provides raw statistics on the main variables for the full sample. Panel A shows the large dispersion in the loan terms as interest rate spreads, volumes, and maturities display wide ranges. In terms of bank characteristics, Panel A shows that the greater variability in size and loan-loss provisioning ratios, while capital ratios vary in a narrow range. The proxy for banks' business model, reliance on interest income as a fraction of total income, has considerable variance—for some banks, lending is the main business, while for others, it is a much smaller part (ie, they are more like investment rather than commercial banks).

Panel B compares the samples for observations for which there was an adjustment in the rating system in a specific quarter (ie, the treated sample) to those that did not experience an adjustment. We do so first at the loan-level characteristics, displaying t-tests using standard error clustered at the bank level. We find statistically significant differences between the two groups in the size of the committed exposure. Panel B also compares those banks that had rating changes with those that did not, except the comparison is now done at the bank-period level. The t-tests show no significant differences; the treatment and control group of banks do not vary systematically from each other. This is very reassuring as it suggests that any differences we may find are not due to the difference in the sample of treated vs non-treated banks. The comparisons between treated and non-treated observations, however, so far do not control for loan and bank characteristics that possibly also contribute to these differences. For this, we use multivariate regressions.

[7] More information on the data, including all sources and definitions, is provided in Appendix Table A1.

3. Methodology and Empirical Results

This section discusses the methodology and provides the main regression results.

3.1 Methodology

For our tests, we use a difference-in-differences approach. As the rating adjustments are unexpected, this controls for any other (observed or unobserved) factors that may explain the pricing, volume and other characteristics of loans, including possible demand-side. In other words, the intrinsic risk of loans within the internal rating category are unchanged by rating adjustments. One event indicator, DD_rating_changes, is a dummy variable whose value increases by one when the external rating of a certain loan is adjusted upward in a quarter, and decreases by one when the external rating of that loan is adjusted downward. To study the possible asymmetric reactions of upward and downward adjustments, we create two additional dummy variables, DD_upward_adjustment and DD_downward_adjustment, which become one in the quarter in which external ratings are adjusted upwards and downwards respectively, and zero for all quarters preceding. We study three dimensions of loan terms: the rate spread, committed exposure, and maturity. In its most general form, the specification we use is as follows:

$$\text{Loan\_terms}_{l,b,r,t} = \alpha + \beta_1 \text{DD\_upward\_adjustment}_{r,b,t-1} + \beta_1' \text{DD\_downward\_adjustment}_{r,b,t-1} + \beta_2 \text{Bank Controls}_{b,t-1} + \text{Firm Industry FE} + \text{Loan Type FE} + \text{Bank FE} + \text{Year and Quarter FE} + \varepsilon_{l,b,r,t} \quad (1)$$

where *loan_term*$_{l,b,r,t}$ is one of the three loan term dimensions, and l represents loan, b represents bank, r represents internal rating category, and t represents combination of year and quarter. We control for various lagged bank characteristics, including bank size, capitalization, loan-loss provisioning, and banks' reliance on lending business, proxied by that quarter's share of bank interest income in total income. In one specification, we use bank-year-quarter fixed effects, thus controlling for all changes in bank characteristics. In addition, we include fixed effects for borrower industry, loan type, bank, and year-quarter, to control for both time-invariant unobservable factors related to internal rating category, borrowers and types of loan, as well as nationwide shocks that may have happened during a particular year-quarter, which could affect loan terms. As the rating adjustments occur at the bank level, standard errors are clustered two ways: at both the bank and year-quarter level to address potential concerns of within-bank correlations of the regression residuals. We are then interested in the coefficients β_1 and β_1', which provide the (differential) effect of the rating adjustments on affected bank(s)' loan terms.

3.2 Rating adjustments and Banks' Changes in Loan terms

Table 2A presents the difference-in-differences regression results for the three variables that we use to proxy loan terms. We start each set of regressions with DD_rating_changes and bank controls as the sole explanatory variables (column 1), and then expand the model by progressively adding fixed effects until we reach the fullest set of fixed effects in column 5, as described in model (1). The fixed effects control for possible influences of unobservable characteristics (eg, firm-industry fixed effects for industry-specific shocks, loan-type or bank fixed effects for loan- or bank-

specific characteristics). The results consistently show that after a change in the loan ratings, the interest spread tends to increase, while the committed exposure decreases. Effects are highly statistically significant and have large economic significance. For example, in the specification with all fixed effects, rating adjustments lead to some 33 basis points change in the interest spread charged and an 18% change in the committed exposure. Thus, rating adjustments have strong treatment effects on loan pricing and size. We also find significant changes in loan maturity following any rating adjustments, after controlling for the unobservable characteristics at bank, borrower, time, and loan level.

Since changes in risk rating likely have asymmetric effects on loan terms, we next study differences between effects of up- and downward adjustments. The regression results in Table 2B show strong evidence for asymmetric responses to upward versus downward rating adjustments on banks' loan terms, in which we use regressions with all fixed effects included. We find that banks react to a downward rating adjustment by increasing spreads charged by some 41 basis points and reducing committed exposures by 29%. The maturity of loans also decreases by some 25%. The impact of upwards adjustments on loan terms is smaller. Only the spread and size of commitment have statistically significant results; even then, the magnitude of the effects is smaller for spreads and much smaller for exposures than their downward-adjustment counterparts. The differential effects suggest that the impact of rating adjustments arises during downward adjustments when banks respond to consequences related to capital constraints.

In terms of control variables, the bank's reliance on interest income is most consistently significant in the regressions in Table 2, suggesting that the business model matters for the bank's propensity to adjust loan terms. Besides controlling for these and other individual time-varying bank characteristics, as shown, regression results are also generally consistent for different combinations of bank, rating, time, and other fixed effects. Overall, we can thus state that results are not likely driven by other, time-invariant bank characteristics, including those not observable. This also confirms that such unobservable characteristics do not play a large role in the results, as suggested by Altonji et al (2005).

3.3 Bank Characteristics and Differential Effects of Rating Adjustments

We next study how banks differ in their responses to rating adjustments in borrowers' credit rating. We expect differential treatment effects since, besides a borrower's risk rating, loan terms also depend on bank characteristics, such as size, general business model (including lending specialization), riskiness as measured by degree of loss provisions, and capitalization, which can be subject to market and regulatory disciplines. For example, smaller and less well capitalized banks likely face more pressure and can thus be expected to adjust their terms more aggressively upon a downward adjustment than larger banks with healthier balance sheets do, especially with regard to loans to riskier borrowers. In addition, rating adjustments could be greater for non-investment grade borrowers and non-government guaranteed loans.

To explore the role of these bank characteristics, we create four indicator variables that equal one if a bank belongs to the top tercile of all BHCs based on asset size, loan-loss provisioning, and reliance on lending business, and bottom tercile based on capital ratio in the past year, respectively, and that equal zero otherwise. We also construct a variable that equals one if the borrower is investment grade or if the loan is guaranteed by the US government or its agencies. We interact these

indicator variables with various bank, borrower, and loan characteristics and the two DD indicators, and include these in regression model (1), differentiating between up- and downward adjustment. All the control variables and fixed effects in model (1) are also included (but no longer reported), with robust standard errors clustered in two ways (at the bank and year-quarter levels).

Table 3 reports how the various bank factors influence changes in loan pricing, size, and maturity after rating changes. Specifically, for spreads, we find the adverse effects of downward adjustments to be statistically significantly greater for smaller banks and banks with more loan-loss provisioning, more non-interest income, or lower capital. For committed exposures, effects of downward adjustments are stronger for banks that have already incurred a higher level of losses, proxied by a higher level of loan-loss provisioning. For maturities, the picture is more mixed: less capitalized banks and banks with greater non-interest income shares tend to shorten maturities, but at the same time results from loan-loss provisioning indicate that banks with higher losses extend maturities in response to downward adjustments. The differences in responses may reflect, on one hand, the regulatory treatment of maturity in risk weighting, which penalizes longer maturities, and on the other hand incentives of weaker banks to accommodate the downward-adjusted borrowers with an extension of their loan maturities.

Consistent with our earlier conjectures, the table shows that downward adjustments generally have a higher impact on lending terms for banks that are smaller, have higher loan-loss provisioning, greater reliance on interest income, and lower capital ratios. Larger banks increase spreads less when loans of some of their borrowers are adjusted downwards, since the overall adverse consequences on capital positions are more limited as they hold more other non-affected assets. For a bank with a riskier loan profile (ie, one that is already provisioning more for risky loans), the downgrading of a rating category can mean more market and regulatory governance pressures, making the bank's loan pricing more sensitive. In terms of costs and maturity, the effects of downward adjustments are largely absent for solid borrowers that are investment grade and loans that are government guaranteed as such loans largely or fully escape changes in risk weights. Many of these differential impacts suggest that the main effect of the downward adjustments arise for banks that have a relatively weaker balance sheet or a lower capital adequacy because such banks are more subject to market and regulatory pressures. This in turn then leads to stronger reactions to changes in borrowers' credit risk ratings.

Upward adjustments disproportionally reduce spreads for weaker capitalized banks, and increase committed amounts for large banks. Maturities are disproportionally lengthened in case of large banks and banks with more loan-loss provisioning and shortened for banks that are more reliant on interest income and more weakly capitalized. These maturity effects again likely reflect a mixture of incentives.

However, these bank characteristics are often less significant in terms of upward adjustments. The more limited effect of upward adjustments is expected as the regulatory and market discipline channels are largely absent. However, competition could still potentially transmit the effects of upward adjustments. The rating change can potentially be communicated to the borrower; for example, she is made aware of the upward adjustment and then asks for more favorable terms or a greater loan because of competitive effects, as documented in another context by Carey and Tracey (1998). There is some evidence of this: upward-adjustments have more of an

impact on spreads for less well capitalized banks, which can now more easily lower spreads. And in terms of exposures, the effects of upward adjustments are significantly more so for banks that are larger, which can more easily accommodate such competitive requests.

We also looked the differential treatment effects of loans with various characteristics and found that downward and upward adjustments have less impact on loans to investment-grade borrowers or loans that are government guaranteed, even to the point that there is no economic impact of a downward adjustment (the coefficients on the interaction with the borrower and loan characteristics almost offset the general coefficients). The finding suggests that banks are especially sensitive to deterioration in the perceived risk of already risky borrowers with poor credit quality, while safer loans from borrowers of good credit quality are mostly shielded from the external rating fluctuations.

Overall, results suggest that banks make changes to the lending terms in reaction to unexpected shifts in the perceived riskiness of its loan portfolios. We find banks' loan terms to be more sensitive to downward adjustment of ratings than to upward adjustments. The effects are stronger for small and weaker banks with lower capital ratios, and for riskier loans to borrowers with poor credit quality, suggesting the importance of capital base and higher quality assets in stabilizing bank lending.

3.4 Rating adjustments across Basel risk-weight edges

We next estimate whether the effects of the rating adjustments vary by the level of the rating. If banks' incentive to mitigate regulatory pressure drives loan terms, one would expect sharper changes in loan terms at ratings that also mark the borderline between the standardized risks weight under the Basel II capital adequacy requirements, which uses a relatively coarse grid for risk weights of only four categories. In other words, if a rating adjustment were to lead to a borrower being adjusted up- or downwards to a category with a lower or higher risk weight, then one can expect a stronger reaction in loan terms, as the bank would see its capital adequacy requirements more affected.

To address this point, we look at borrowers' external rating prior to adjustments by rerunning the regressions but now allowing the coefficients to vary by the specific rating category of borrowers. The idea is that we expect a stronger effect on loan terms when credit rating of borrowers are adjusted across the Basel risk-weight boundaries. Regression results (not reported) in Table 4 confirm our conjecture. It is clear that the effects tend to be stronger when rating adjustments cause external rating to move across those rating categories that also border the change in risk weights. For example, an upward adjustment from A to AA, which implies a reduction in risks weights from 50% to 20%, comes along with a reduction in spreads of some 39 basis points. And a downward adjustment from BB to B, which implies an increase in risks weights from 50% to 100%, comes with a 94 basis points increase in spread. This provides further evidence that the effects of rating adjustments manifests through changes in the bank's capital adequacy requirements.

4. Further analysis and robustness checks

4.1 Effects of other time-varying bank characteristics

Although we already explored if the effects of rating adjustments are correlated with banks' balance sheet and business model structures (ie, those bank characteristics that we used to tease out the role of regulatory and market discipline), a potential concern could still be that certain time-varying supply-side bank characteristics that are omitted might affect both adjustments in banks' rating system and the loan terms. We perform this test by adding bank-quarter fixed effects and dropping all the (observable) bank characteristics that we have used before. This test rules out the potential effect of any omitted time-varying supply-side banks characteristics on the adjustments in the rating system (for example, a bank with better internal systems that has more intention after an adjustment of its rating system to adjust loans down- or upward). The results, reported in Appendix Table A2, fail to depict any different relationship between adjustment in loan terms and the occurrence of rating adjustments. As such, we can rule out the possibility that the effects from rating adjustments are in some systematic way correlated to supply-side changes of banks conditions.

4.2 Rating adjustments and bank characteristics

While the adjustments are not anticipated, and the difference-in-difference technique thus controls for many contemporaneous effects, one might suspect that banks with certain characteristics may be more prone to adjusting ratings. For example, rating adjustments may be correlated with bigger banks, or weaker banks are less inclined to adjust their rating system downwardly. If any of those were true, then rating adjustments would not be exogenous and would not be causally attributable to the documented effects. To address this concern, we investigate whether the rating adjustments can be predicted on the basis of bank-specific characteristics including balance sheet information using standard logit models. Logit regression results are reported in Appendix Table A3. We find no evidence whatsoever of predictive power of any of these balance sheets data (in fact, none are statistically significant), further supporting the exogenous nature of events across banks and time.

4.3 Tests with loans to firms borrowing from multiple banks

We can rule out the possibility that rating adjustments and their corresponding effects are in some systematic way correlated to bank characteristics. However, this test cannot rule out the potential effect of omitted time-varying demand-side factors on the rating adjustments. For example, certain industry-wide trends might influence firms' appetites for loans with certain terms and may be correlated with adjustments in the rating system, leading to spurious relations. Although it is unlikely that specific trend/time varying factors only affect borrowers in one specific rating bucket, we employ a technique pioneered by Khwaja and Mian (2008) that aims to mitigate concerns of the residual effects from omitted demand-side changes. To be specific, we compare the changes in terms of loans from *different* banks to the *same* borrowers while controlling for individual firm-level shocks that may have occurred around the time of the rating adjustments. It is appropriate to apply this method given that our sample contains a fairly large share of borrowers (about 25%) borrow from more than one bank. This identification strategy involves including *firm*period* fixed effects in

the regressions and has been used by many other papers in domestic studies (eg, Jiménez, Ongena, Peydró, and Saurina, 2012) and cross-border banking analyses (eg, Popov and Udell, 2012; Kalemli-Ozcan et al, 2013).[8] Searching for possible differences in terms of loans from different banks to the same borrower after rating adjustments happened in one of banks, we control for any residual shock arising from borrower's demand and riskiness. It amounts here to a double difference-in-difference test as we investigate how in the response to adjustments in a rating system that affects one bank, loan pricing and other characteristics vary across banks for the same borrower. For this test, the specification for all loan terms then becomes:

$$\begin{aligned}\text{Loan\_terms}_{l,b,t} = {} & \alpha + \beta_1 \text{DD\_upward\_adjustment}_{r,b,t-1} + \\ & \beta_1 \text{DD\_downward\_adjustment}_{r,b,t-1} + \beta_2 \text{Controls}_{b,t-1} + \text{Industry FE} \quad + \\ & \text{Loan Type FE} \quad + \text{Bank-FE} \quad + \text{Year and Quarter FE} \quad + \text{Firm} \times \\ & \text{Year and Quarter FE} \quad + \varepsilon_{l,r,b,t} \qquad (2)\end{aligned}$$

The model specification is similar as model (1), except for the vector of *firm i × year and quarter t* dummies added to control for any shocks to individual firm-specific demand or changes in riskiness in a given quarter.[9] We do not expect the exact same patterns from with the new model since the sample of changes in loan terms is different given we only focus on firms that borrow from multiple banks.

Results shown in Table A4 confirms the robustness of our main finding. Notably, there is an increase in the spread and a decrease in committed exposure of the loan upon a downward adjustment. These effects are again highly statistically significant and have a large economic impact. Consistent with our main result, we also find weaker effects related to upward rating adjustments and banks increase committed exposure as a result. Importantly, as these regressions control for firm-specific demand and other shocks, we can be assured that any such shocks do not affect the main results.

Together with the tests involving time-varying bank characteristics, these test results using firms with multiple banks help address concerns arising from either time-varying, supply-side bank characteristics or demand-side firm characteristics that might affect rating adjustments.

4.4 Possible offsetting following adjustment to rating adjustments

We next exclude from the sample those firms whose rating is reversed within a quarter of a rating adjustment. Since adjustments in the rating system affect the perceived risks of those loans and may cause material changes, banks may have an incentive to modify the internal rating of the borrowers affected back and "offset" the changes made to the external rating. In other words, banks adjust borrowers' credit risk in opposite directions so that the changes in the perceived riskiness of the borrowers could be neutralized. For example, a bank could reverse a downward (upward)

[8] See further Jakovljević, Degryse, and Ongena (2015) for a review of empirical research on how best to assess the impact of regulations in the banking sector.

[9] Multi-bank firms differ from firms for which there is only one lender: these borrowers are on average larger and have greater loan balances and tend to be more highly rated. This may explain why the effects for these borrowers need not mimic those of single-bank firms in which the lending may be more based on relationship and information. Thus, the multi-bank test is best seen as a robustness test.

adjustment of the external rating by upgrading (downgrading) internal ratings for a specific borrower afterwards. This makes it less likely to find significant regression results (as loan terms would less likely experience any change even though the difference-in-difference indicators would identify the loans as having had its rating adjusted). As such, the bias is likely to go against finding results. Nevertheless to address this concern, we identify those loans that are in tranches with rating adjustments, but have their rating changed in the direction opposite of the rating adjustments within one quarter. We then re-estimate the baseline regression without the rating-offset loans, with results reported in Table A5. Consistent with this being a small fraction of the total sample, the overall regression results do not change in any material way.

4.5 Nonlinearity of the pricing curve

Another, related concern may be that any asymmetric effects on the interest rate spread from rating down- and upward adjustments are due to the inherent nonlinearity of the pricing curve. If the pricing curve related internal rating is concave, for example, moving down in ratings would inherently have a larger effect in magnitude than would from an upward adjustment. We address this concern by re-estimating model (1), replacing the dependent variable with its log-transformation (in this case just the interest rate spread, as the volume amounts are already in log terms). As is clear from Appendix Figure A1, a log-transformation is very suitable as the actual pricing curve follows closely the logarithmic curve. The results of the re-estimation, reported in Appendix Table A6, show similar findings to those results reported in Table 2B. Importantly, as before, the effects of downward adjustments are larger in magnitude than the effect of upward adjustments as the spread increases by 22 basis points (in log terms) on a downward adjustment and decreases by 13 basis points on an upward adjustment. This confirms that the nonlinearity of the pricing curve is not driving the effects we observe.

5. Conclusion

Banks determine terms on their loans based on the internal rating of the borrower and under internal and external constraints. Rating changes in banks' portfolios can directly affect loan terms by changing the size of capital buffers banks are required to hold. Yet there has been little evidence that clearly identifies the independent effects of ratings on loan terms as ratings are often set in response to factors similar to those of loan terms; furthermore, it is challenging to isolate the supply effects of banks' sensitivity to changes in rating from changes in firms' demand and riskiness. Through the usage of a unique, supervisory dataset and a series of identification strategies that exploit changes in borrowers' external ratings due to the adjustments in the conversion between each bank-specific scale and the uniform external scale, we find that banks react to downward adjustments in the credit ratings by increasing the interest charged on the loan, and reducing the size of the loan and its maturity. We show that the effects are highly asymmetric, such that we find limited effect of upward adjustments on rating changes.

Importantly, we find that downward adjustments generally have more impact on loan terms for banks that are smaller, have higher loan-loss provisioning and higher capital ratios, and have less impact for loans to borrowers with investment grade and

loans that are government guaranteed. This differential effect is consistent with the explanation that downward adjustments are potentially capital binding, whereas upward adjustments are not. Other tests confirm that the risk weighting under the capital adequacy requirements, which are in part based on ratings, help explain the effects. All our regression results are robust to controlling for bank characteristics, other shocks, and various changes in samples, as well as to other economic and econometric robustness tests. Our findings highlight the interplay between borrowers' ratings and banks' capital adequacy in driving corporate loan terms.

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Table 1. Descriptive Statistics

Table 1 reports summary statistics for the loan and bank characteristics used in this paper. For each variable, we show summary statistics of each variable for the whole period of analysis from September 2011 to December 2016. Panel A shows the summary statistics of the whole sample. Panel B shows the summary statistics of the sample, separated into a treatment and control group. Detailed description of the variables is presented in Appendix Table A1. All continuous variables are winsorized at the 1st and 99th percentiles. All dollar amounts are transformed using logarithms. The t-statistics are clustered at the bank-quarter level to account for within-bank correlations in regression residuals and are shown in parentheses. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel A: General Summary Statistics

Variable	*Mean*	*Sd*	*Median*	*P25*	*P75*
Loan Characteristics					
Interest rate spread (percent)	2.106	6.845	1.800	0.999	2.750
Committed exposure (dollars)	13.487	3.178	14.328	11.513	15.522
Maturity (days)	8.191	2.679	7.512	6.819	8.236
Bank Characteristics					
Bank size (dollars)	20.103	1.269	19.732	18.964	21.394
Bank capital ratio (percent)	12.155	1.280	11.950	11.110	12.820
Bank loan loss provision (percent)	4.459	13.324	1.431	0.841	2.601
Bank's reliance on interest income (percent)	0.153	0.087	0.179	0.099	0.216
Portfolio Characteristics					
Percentage of upward-adjusted loans reversed downwards	0.044	0.052	0.026	0.003	0.075
Percentage of downward-adjusted loans reversed upwards	0.120	0.153	0.081	0.000	0.205

Panel B: Summary Statistics for Control and Treatment Groups

Dep. var.	Control Group				Treatment Group				Mean Differences	T-Stat
	N	*Mean*	*SD*	*Median*	*N*	*Mean*	*SD*	*Median*		
Loan Characteristics										
Interest rate spread	2226087	2.031	6.059	1.759	915347	2.289	8.455	1.900	-0.258	-1.225
Committed exposure	4594964	13.088	3.357	14.143	1367192	14.828	1.960	14.845	-1.74**	-2.275
Maturity	4637923	8.086	2.703	7.510	1367438	8.546	2.565	7.846	-0.46	-1.039
Bank Characteristics										
Bank size	4637073	20.087	1.276		1368984	12.045	0.890		-8.042	-0.138
Bank capital ratio	4637073	12.188	1.373		1358636	4.063	14.157		-8.125	0.438
Bank loan loss provision	4599054	4.577	13.065		1368984	0.151	0.107		-4.426	0.291
Bank's reliance on interest income	4637073	0.154	0.080		1368984	12.045	0.890		11.891	0.088

Table 2A. Difference-in-Differences Analysis of Changes in Firms' Ratings

Table 2A presents estimated coefficients from difference-in-differences (DiD) analyses of the effects of changes in loan ratings for firms. The dependent variables are the interest rate spread of the loan, total committed exposure, and maturity. We measure the firms' adjustment of their external ratings using one general DiD shock variables that capture the cumulative changes in upward and downward rating adjustments. We control for lagged bank characteristics, loan characteristics, firm industry fixed effects, bank fixed effects, and quarter fixed effects in all regressions. The analyses are conducted using quarterly panel data that cover the period from September 2011 to December 2016. Detailed description of the variables is presented in Appendix Table A1. All continuous variables are winsorized at the 1st and 99th percentiles. Robust standard errors are clustered at the bank-quarter level to account for within-bank correlations in regression residuals and are shown in parentheses. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

Dep. Var.:	Interest rate spread					Committed exposure					Loan maturity				
DD_Rating Changes	-0.446***	-0.301***	-0.308***	-0.316***	-0.326***	0.618***	0.665***	0.202***	0.133***	0.180***	0.086	0.000	-0.028	0.133***	0.139***
	(0.095)	(0.042)	(0.062)	(0.063)	(0.066)	(0.129)	(0.152)	(0.037)	(0.031)	(0.025)	(0.075)	(0.136)	(0.069)	(0.048)	(0.046)
Controls															
Bank size$_{t-1}$		0.128**	2.645***	2.525***	2.568***		0.209	0.409	-0.380	-0.229		-0.135	0.098	1.089**	-0.062
		(0.054)	(0.888)	(0.887)	(0.867)		(0.188)	(0.580)	(0.514)	(0.510)		(0.120)	(0.703)	(0.446)	(0.481)
Bank capital ratio$_{t-1}$		-0.199***	-0.204***	-0.205***	-0.200**		0.873***	-0.015	0.006	-0.077*		0.118	0.124**	0.136***	0.068
		(0.058)	(0.078)	(0.077)	(0.083)		(0.161)	(0.057)	(0.051)	(0.046)		(0.153)	(0.050)	(0.039)	(0.048)
Bank loan loss provision$_{t-1}$		0.001	0.009	0.009	0.008		0.031***	0.002	0.001	0.001		0.008	-0.001	0.001	-0.000
		(0.005)	(0.008)	(0.008)	(0.008)		(0.008)	(0.002)	(0.002)	(0.002)		(0.008)	(0.002)	(0.001)	(0.002)
Bank's reliance on interest income$_{t-1}$		-5.668***	-2.406**	-2.434**	-2.756**		10.715***	2.523***	2.367***	2.599***		1.972	4.627***	3.843***	3.942***
		(1.553)	(1.161)	(1.166)	(1.192)		(3.004)	(0.853)	(0.731)	(0.607)		(2.287)	(0.941)	(0.865)	(0.999)
Bank FE	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Year and quarter FE	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	No	Yes	Yes	Yes
Firm industry FE	No	No	No	Yes	Yes	No	No	No	Yes	Yes	No	No	No	Yes	Yes
Loan type FE	No	No	No	No	Yes	No	No	No	No	Yes	No	No	No	No	Yes
Obs.	3,141,434	3,098,825	3,098,825	3,068,928	2,969,415	5,962,156	5,905,712	5,905,712	5,682,055	5,504,259	6,005,361	5,927,273	5,927,273	5,706,957	5,528,944
Adj. R2	0.001	0.010	0.018	0.020	0.021	0.004	0.226	0.621	0.627	0.654	0.000	0.013	0.386	0.327	0.349

Table 2B. Difference-in-Differences Analysis of Changes in Ratings: Upward vs Downward Adjustments

Table 2B presents estimated coefficients from difference-in-differences (DiD) analyses of the effects of changes in loan ratings for firms. The dependent variables are the interest rate spread of the loan, total committed exposure, and maturity. We measure firms' adjustment of their external ratings using two DiD shock variables that measure the upward and downward rating adjustments separately. We control for lagged bank characteristics, loan characteristics, firm industry fixed effects, bank fixed effects, and quarter fixed effects in all regressions. The analyses are conducted using quarterly panel data that cover the period from September 2011 to December 2016. Detailed description of the variables is presented in Appendix Table A1. All continuous variables are winsorized at the 1st and 99th percentiles. Robust standard errors are clustered at the bank-quarter level to account for within-bank correlations in regression residuals and are shown in parentheses. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

Dep. Var.:	Interest rate spread	Committed exposure	Loan maturity
DD_upward_adjustment	-0.279**	0.090***	0.022
	(0.124)	(0.026)	(0.084)
DD_downward_adjustment	0.414***	-0.290***	-0.253***
	(0.086)	(0.057)	(0.075)
Controls			
Bank size$_{t-1}$	2.555***	-0.187	-0.006
	(0.851)	(0.506)	(0.464)
Bank capital ratio$_{t-1}$	-0.199**	-0.077*	0.068
	(0.083)	(0.046)	(0.048)
Bank loan loss provision$_{t-1}$	0.008	0.001	-0.000
	(0.008)	(0.002)	(0.001)
Bank's reliance on interest income$_{t-1}$	-2.811**	2.682***	4.035***
	(1.179)	(0.611)	(1.011)
Bank FE	Yes	Yes	Yes
Year and quarter FE	Yes	Yes	Yes
Firm industry FE	Yes	Yes	Yes
Loan type FE	Yes	Yes	Yes
Obs.	2,969,415	5,504,259	5,528,944
Adj. R2	0.021	0.654	0.349

Table 3. Differential effects of rating changes by bank characteristics

Table 3 presents estimated coefficients from difference-in-differences (DiD) analyses of the effects of changes in loan ratings for firms using panel data regressions interacted with different bank characteristics. The dependent variables are the interest rate spread of the loan, total committed exposure, and maturity. We measure firms' adjustment of their external ratings using two DiD indicators that capture upward and downward adjustments of the rating changes separately. We control for lagged bank characteristics, loan characteristics, firm industry fixed effects, bank fixed effects, and quarter fixed effects in all regressions. The analyses are conducted using quarterly panel data that cover the period from September 2011 to December 2016. Detailed description of the variables is presented in Appendix Table A1. All continuous variables are winsorized at the 1st and 99th percentiles. Robust standard errors are clustered at the bank-quarter level to account for within-bank correlations in regression residuals and are shown in parentheses. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

Dep. var.	Interest rate spread					Committed Exposure					Loan maturity				
DD_upward_adjustment × top tercile Bank size	0.170					0.169***					0.513***				
	(0.242)					(0.062)					(0.120)				
DD_downward_adjustment × top tercile Bank size	-0.420**					-0.041					0.367***				
	(0.197)					(0.107)					(0.120)				
DD_upward_adjustment × top tercile Bank loan loss provisioning		0.057					-0.151**					0.405***			
		(0.361)					(0.075)					(0.153)			
DD_downward_adjustment × top tercile Bank loan loss provisioning		0.458**					-0.335***					0.257**			
		(0.231)					(0.092)					(0.126)			
DD_upward_adjustment × top tercile Bank's reliance on interest income			0.282					-0.052					-0.580***		
			(0.194)					(0.060)					(0.146)		
DD_downward_adjustment × top tercile Bank's reliance on interest income			0.245*					-0.062					-0.380***		
			(0.131)					(0.115)					(0.126)		
DD_upward_adjustment × bottom tercile Bank capital ratio				-0.271**					-0.045					-0.358**	
				(0.133)					(0.067)					(0.140)	
DD_downward_adjustment × bottom tercile Bank capital ratio				0.237*					-0.011					-0.404***	
				(0.143)					(0.091)					(0.143)	
DD_upward_adjustment × Investment grade borrower/Government guaranteed loans					0.038					0.021					0.237***
					(0.210)					(0.104)					(0.073)
DD_downward_adjustment × Investment grade borrower/Government guaranteed loans					-0.917***					0.142					0.396***
					(0.172)					(0.142)					(0.134)
DD_upward_adjustment	-0.363**	-0.273***	-0.386**	-0.172	-0.080	0.023	0.120***	0.112***	0.111***	-0.082	-0.155	-0.077	0.256***	0.185***	-0.087
	(0.141)	(0.053)	(0.192)	(0.138)	(0.221)	(0.035)	(0.030)	(0.034)	(0.043)	(0.050)	(0.100)	(0.082)	(0.063)	(0.064)	(0.101)
DD_downward_adjustment	0.636***	0.226***	0.314***	0.347***	0.582***	-0.259***	-0.200***	-0.266***	-0.284***	-0.309***	-0.417***	-0.311***	-0.095	-0.124	-0.380***
	(0.100)	(0.069)	(0.120)	(0.119)	(0.084)	(0.066)	(0.048)	(0.077)	(0.077)	(0.086)	(0.071)	(0.087)	(0.087)	(0.081)	(0.070)
Bank controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year and quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Loan type FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	2,969,415	2,969,415	2,969,415	2,969,415	2,969,415	5,504,259	5,504,259	5,504,259	5,504,259	5,504,259	5,528,944	5,528,944	5,528,944	5,528,944	5,528,944
Adj. R2	0.021	0.022	0.021	0.021	0.023	0.654	0.654	0.654	0.654	0.659	0.350	0.350	0.351	0.350	0.350

Table 4: the effects of upward and downward rating adjustments by rating level

Table 4 presents estimated coefficients from difference-in-differences (DiD) analyses of the effects of changes in loan ratings from certain tranches. The dependent variables are the interest rate spread of the loan, total committed exposure, and maturity. We measure firms' adjustment of their external ratings using one general DiD shock variables that capture the cumulative changes in upward and downward rating adjustments. We control for loan characteristics, firm industry fixed effects, bank and quarter fixed effects, and quarter fixed effects in all regressions. The analyses are conducted using quarterly panel data that cover the period from September 2011 to December 2016. Detailed description of the variables is presented in Appendix Table A1. All continuous variables are winsorized at the 1st and 99th percentiles. Robust standard errors are clustered at the bank-quarter level to account for within-bank correlations in regression residuals and are shown in parentheses. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

Initial rating	Basel risk weights	Interest rate spread	
		Up	Down
AAA	20%		-0.896**
			(0.368)
AA		0.000	0.985***
		(0.000)	0.213
A	50%	-0.392***	0.789***
		(0.144)	(0.208)
BBB	100%	-0.300***	0.025
		(0.039)	(0.143)
BB		-0.416***	0.941***
		(0.080)	(0.184)
B	150%	-0.174	0.276
		(0.201)	(0.152)
CCC		-0.637	0.691***
		(0.544)	(0.134)
CC		1.556***	0.693***
		(0.214)	(0.132)
C		0.130	2.327***
		(0.509)	(0.341)
Unrated		0.097	
		(0.104)	
Controls		Yes	Yes
Year and quarter FE		Yes	Yes
Firm industry FE		Yes	Yes
Loan type FE		Yes	Yes

Appendix

Table A1: Variable Description and Sources

Loan Characteristics	Data Source: FR Y-14Q (Corporate Loan Schedule)
Committed exposure	Logarithm of dollar amount that a borrower contractually can borrow
Interest rate spread	Spread over risk-free rate
Maturity	Logarithm of days from date of origination to date of maturity
Bank Characteristics	Data Source: FR Y9-C
Bank size	Natural log of total assets
Bank capital ratio	Tier 1 capital ratio
Bank loan loss provision	Allowance for loan loss / loans and leases held for sale
Bank's reliance on interest income	Net interest income / (interest income + noninterest income)
Portfolio characteristics	Data Source: FR Y-14Q (Corporate Loan Schedule)
Proportion of portfolio that experienced rating adjustments (either upward or downward)	Refers to upward-adjusted or downward-adjusted rating tranches. A higher proportion indicates a bank has a higher volume of loan amounts that are exposed to rating adjustments. This variable is set to zero prior to the rating adjustments and remains constant after the adjustment.
Percentage of upward (downward) adjusted loans that are reversed downwards (upwards)	Refers to percentage of loans that exhibit rating reversal behavior, which is identified if the rating of a loan is revised in the opposite direction relative to the direction of the rating adjustment (ie, a tranche in which a loan resides is upward adjusted, but that loan is downward adjusted). We look for rating reversal 1Q after the adjustment.

Table A2. Alternative model specifications using bank-time fixed effects

Table A2 presents estimated coefficients from difference-in-differences (DiD) analyses of the effects of changes in loan ratings for firms. The dependent variables are the interest rate spread of the loan, total committed exposure, and maturity. We measure firms' adjustment of their external ratings using one general DiD shock variables that capture the cumulative changes in upward and downward rating adjustments. We control for loan characteristics, firm industry fixed effects, bank and quarter fixed effects, and quarter fixed effects in all regressions. The analyses are conducted using quarterly panel data that cover the period from September 2011 to December 2016. Detailed description of the variables is presented in Appendix Table A1. All continuous variables are winsorized at the 1st and 99th percentiles. Robust standard errors are clustered at the bank-quarter level to account for within-bank correlations in regression residuals and are shown in parentheses. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

Dep. Var.:	Interest rate spread	Committed exposure	Maturity
DD_upward_adjustment	-0.119*	0.168***	0.219***
	(0.072)	(0.018)	(0.039)
DD_downward_adjustment	0.261***	-0.192***	-0.096
	(0.071)	(0.052)	(0.060)
Year and quarter FE	Yes	Yes	Yes
Bank and quarter FE	Yes	Yes	Yes
Firm industry FE	Yes	Yes	Yes
Loan type FE	Yes	Yes	Yes
Obs.	3,011,434	5,559,875	5,604,727
Adj. R2	0.036	0.681	0.410

Table A3. Bank characteristics and adjustments in rating system

Table A3 presents estimated coefficients from logistic analyses of the effects of bank characteristics on rating adjustment outcomes. The dependent variables are the dummy variable that equals to one when the external rating of a specific tranche in a loan quarter is adjusted upward or downward. We use bank size, capital ratio, loan loss provisioning, and reliance on interest income as the main explanatory variables and control for year and quarter fixed effects in all regressions. The analyses are conducted using quarterly panel data that cover the period from September 2011 to December 2016. Detailed description of the variables is presented in Appendix Table A1. All continuous variables are winsorized at the 1st and 99th percentiles. Robust standard errors are clustered at the bank level to account for within-bank correlations in regression residuals and are shown in parentheses. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

Dep. var.	(1)	(2)
	Upward rating adjustments	Downward rating adjustments
	-0.151	0.161
Bank size	(0.146)	(0.190)
	-0.175	-0.084
Tier 1 capital ratio	(0.145)	(0.158)
Ratio of bank loan loss provision of total loan amount	-0.008	-0.016
	(0.007)	(0.015)
Bank's reliance on interest income	2.194	2.803
	(3.080)	(2.811)
Constant	4.617	-1.370
	(3.208)	(3.827)
Year-Quarter FE	Yes	Yes
Observations	279	259
Pseudo R2	0.124	0.180

Table A4. The effects of rating changes for firms with multi-bank relationships

Table A4 presents estimated coefficients from difference-in-differences (DiD) analyses of the effects of changes in loan ratings for firms borrowing from multiple banks using panel data regressions. The dependent variables are the interest rate spread of the loan, total committed exposure, and maturity. We measure firms' adjustment of their external ratings using two DiD indicators that capture upward and downward adjustments of the rating changes separately. We control for lagged bank characteristics, loan characteristics, bank fixed effects, and firm by year quarter fixed effects in all regressions. The analyses are conducted using quarterly panel data that cover the period from September 2011 to December 2016. Detailed description of the variables is presented in Appendix Table A1. All continuous variables are winsorized at the 1st and 99th percentiles. Robust standard errors are clustered at the bank-quarter level to account for within-bank correlations in regression residuals and are shown in parentheses. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

	Interest rate spread	Committed exposure	Loan maturity
DD_upward_adjustment	-0.111	0.096**	0.069
	(0.126)	(0.037)	(0.112)
DD_downward_adjustment	0.289***	-0.390***	-0.128
	(0.082)	(0.056)	(0.099)
Controls			
Bank size$_{t-1}$	3.662***	-0.766	-0.874*
	(1.058)	(0.549)	(0.517)
Bank capital ratio$_{t-1}$	-0.058	-0.193***	-0.046
	(0.074)	(0.067)	(0.051)
Bank loan loss provision$_{t-1}$	-0.003	0.005***	0.001
	(0.008)	(0.002)	(0.001)
Bank's reliance on interest income$_{t-1}$	-1.732	4.643***	4.010***
	(1.153)	(0.951)	(0.817)
Bank FE	Yes	Yes	Yes
Firm * year quarter FE	Yes	Yes	Yes
Loan type FE	Yes	Yes	Yes
Obs.	1,115,592	2,619,594	2,645,625
Adj. R2	0.020	0.745	0.337

Table A5. Regressions excluding offsetting loans

Table A5 presents estimated coefficients from difference-in-differences (DiD) analyses of the effects of changes in loan ratings for firms, excluding loans that experience rating reversal behavior. The dependent variables are the interest rate spread of the loan, total committed exposure, and maturity. We measure firms' adjustment of their external ratings using two DiD shock variables that measure the upward and downward rating adjustments separately. We control for lagged bank characteristics, loan characteristics, firm industry fixed effects, bank fixed effects, and quarter fixed effects in all regressions. The analyses are conducted using quarterly panel data that cover the period from September 2011 to December 2016. Detailed description of the variables is presented in Appendix Table A1. All continuous variables are winsorized at the 1st and 99th percentiles. Robust standard errors are clustered at the bank-quarter level to account for within-bank correlations in regression residuals and are shown in parentheses. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

Dep. Var.:	Interest rate spread	Committed exposure	Maturity
DD_upward_adjustment	-0.264**	0.087***	0.020
	(0.127)	(0.027)	(0.085)
DD_downward_adjustment	0.393***	-0.284***	-0.255***
	(0.087)	(0.057)	(0.077)
Controls			
Bank size$_{t-1}$	2.521***	-0.171	-0.009
	(0.847)	(0.508)	(0.462)
Bank capital ratio$_{t-1}$	-0.200**	-0.078*	0.068
	(0.083)	(0.046)	(0.048)
Bank loan loss provision$_{t-1}$	0.008	0.001	-0.000
	(0.008)	(0.002)	(0.002)
Bank's reliance on interest income$_{t-1}$	-2.777**	2.699***	4.030***
	(1.181)	(0.613)	(1.007)
Bank-specific rating category FE	Yes	Yes	Yes
Year and quarter FE	Yes	Yes	Yes
Firm industry FE	Yes	Yes	Yes
Loan type FE	Yes	Yes	Yes
Obs.	2,928,242	5,446,126	5,470,810
Adj. R2	0.021	0.655	0.352

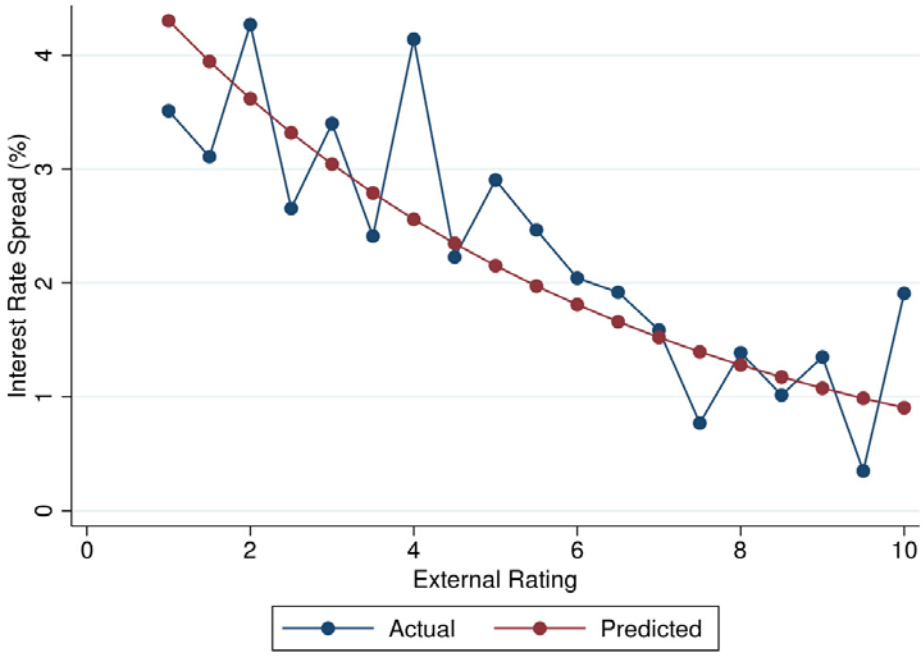
Table A6. Effect of rating adjustments using a non-linear loan pricing curve

Table A6 presents estimated coefficients from difference-in-differences (DiD) analyses of the effects of changes in loan ratings for firms. The dependent variables are the logarithm of interest rate spread of the loan. We measure firms' adjustment of their external ratings using one general DiD shock variables that capture the cumulative changes in upward and downward rating adjustments. We control for lagged bank characteristics, loan characteristics, firm industry fixed effects, bank fixed effects, and quarter fixed effects in all regressions. The analyses are conducted using quarterly panel data that cover the period from September 2011 to December 2016. Detailed description of the variables is presented in Appendix Table A1. All continuous variables are winsorized at the 1st and 99th percentiles. Robust standard errors are clustered at the bank-quarter level to account for within-bank correlations in regression residuals and are shown in parentheses. ***, **, and * correspond to statistical significance at the 1%, 5%, and 10% levels, respectively.

Dep. var.:	Log of interest rate spread
DD_upward_adjustment	-0.132***
	(0.038)
DD_downward_adjustment	0.221***
	(0.058)
Bank size$_{t-1}$	1.358***
	(0.452)
Bank capital ratio$_{t-1}$	-0.020
	(0.042)
Bank loan loss provision$_{t-1}$	0.011***
	(0.004)
Bank's reliance on interest income$_{t-1}$	-0.484
	(0.347)
Constant	-26.612***
	(8.923)
Year and quarter FE	Yes
Loan type FE	Yes
Firm industry FE	Yes
Observations	2,554,020
Adjusted R-squared	0.166

Figure A1. Fitting the pricing curve with a log transformation

This chart shows the average interest rate spread at each credit rating, with 10 as AAA, 9 as AA, etc. The blue line shows the actual average interest rate spread at each credit rating, while the red line shows the corresponding best-fit log curve.



Appendix I. Hypothetical example of an adjustment in bank's credit rating system

We analyze a hypothetical case of an adjustment in a bank's credit rating system through reinterpreting internal ratings to the external rating categories below. The tables below list the ranges of probability of default (PD) of bank X's loans and their associated internal rating categories, as well as the PD ranges for publicly traded assets and their associated public rating categories. At initial period *t*, the internal rating category 3 is converted to external rating of category AA by matching the ranges of the PD associated with the internal and public rating categories. In period *t+1*, the PD ranges associated with the public rating categories are assumed to have shifted due to market's reassessment of the riskiness of publicly traded assets within each category. This change in PD ranges then results in a need for a downward adjustment of the internal rating category 3 from AA to the external rating category A. This adjustment means that the loans affected appear riskier afterwards on the external rating scale while their intrinsic risk (captured by internal rating) remain unchanged.

Period *t*

Bank X's loan portfolio		
internal rating categories	PD ranges	Converted external rating categories
…	…	
3	0.25–0.29	AA
…	…	

Publicly traded assets	
Public rating categories	PD ranges
…	…
AA	0.20–0.30
A	0.30–0.40
…	…

Period *t+1*

Bank X's loan portfolio		
internal rating categories	PD ranges	Converted external rating categories
…	…	
3	0.25–0.29	A
…	…	

Publicly traded assets	
Public rating categories	PD ranges
…	…
AA	0.10–0.20
A	0.20–0.30

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