Risk Taking and Interest Rates: Evidence from Decades in the Global Syndicated Loan Markets

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Abstract

While the literature on capital flows tends to focus on direction, magnitude, and timing of flows, little has been done on credit risk of capital flows and its determinants. To shed some light on these issues, we study risk taking in the markets for cross-border corporate loans over the period preceding the Global Financial Crisis and the period following it. To the extent that actions of a central bank affect short- and longer-term interest rates, we examine two risk taking channels of monetary policy—one that operates through cost of funds and another through returns on safer, longer-term assets. We find that, before the crisis, lenders invested in riskier loans in response to a decline in short-term U.S. interest rates, and, after it, in response to a decline in longer-term U.S. interest rates. We next examine the cross-border spillover effects of risk taking and find that lower interest rates in the United States lead to greater credit risk of loans made to borrowers in other countries. These results indicate limitations of foreign central banks' actions in affecting credit risk cycles in their jurisdictions.

Keywords: Credit risk; syndicated loans; cross-border corporate loans, cost of funds; search for yield; risk-taking channel of monetary policy; capital flows; international spillovers; limitations of monetary policy.
JEL classification: E40, E44, E52, E58, F30, F42, G11, G15, G20.

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1 Introduction

While the literature on capital flows tends to focus on direction, magnitude, and timing of flows, little has been done on credit risk of capital flows and its determinants. In this paper, we look at a market-based measure of flows' credit risk and consider a wide set of its determinants, including U.S. interest rates. In particular, we address several questions related to the effects of low U.S. interest rates on international financial markets. We look at whether low interest rates have encouraged greater risk taking by investors, whether this effect has been more prominent for U.S. investors than for foreign investors, and whether the effect has been greater on the supply of credit to U.S. borrowers than to foreign borrowers. To shed light on these issues, we examine the relationship between ex ante credit risk and U.S. interest rates in the global syndicated term loan markets, that is, the markets for cross-border corporate loans supplied by a wide range of financial intermediaries.

A growing theoretical literature analyzes the role of monetary policy in altering bank fragility in the presence of asymmetric information and funding liquidity risk. These models predict that banks may engage in riskier activities when monetary policy is expansive and agency problems are severe (that is, Adrian and Shin (2010), Freixas, Martin, and Skeie (2011), Diamond and Rajan (2012), Borio and Zhu (2012), Dell'Ariccia, Laeven, and Marquez (2014), and Acharya and Naqvi (2012).

However, we suggest that the incentives for taking additional ex ante credit risk may be more basic than those in the literature and that they may be understood in the context of a nearly standard model of portfolio choice. That is, we suggest that a decline in costs of funding or in returns on safer, longer-term assets is a sufficient reason for lenders, which are not necessarily banks, to originate riskier loans because the fall in the cost of funds induces investors to invest in riskier assets associated with a relatively higher marginal internal cost (for example, due to internal monitoring costs or capital constraints), while the fall in returns to safer, longer-term assets induces investors to seek a higher degree of expected rate of excess return from riskier asset (in excess of, or over and above, that on the riskless

asset).

To study the relationship between interest rates and risk-taking behavior, we look at the risk characteristics of syndicated term loans originated in the global syndicated markets over the last two decades, that is, over the period preceding the Global Financial Crisis, when longer-term rates were relatively high, and the period following it, when longer-term interest have been at historical lows. Thomson Reuters LPC's DealScan provides necessary risk information and market coverage. We use a loan spread as a proxy of a loan's credit risk, that is, loan losses expected at a loan's origination. For a subsample of loans, we provide evidence that loan spreads predict well Basel II-consistent risk parameters. Given that a typical loan has a maturity of few to several years, the loan spread captures the loan's credit risk smoothed (averaged) through the cycle. This consideration mitigates a concern that the results are driven by a latent factor affecting both credit risk and interest rates. Because we look at newly originated loans in the primary syndicated loan market, our results are not driven by rating migration, that is, by changes in the credit quality of outstanding loans.

For a given lender in a given quarter, the unit of analysis is the weighted average loan spread for loans made by that lender in that quarter. We regress these spreads on contemporaneous U.S. interest rates and various business and credit cycle and lender controls. We also estimate regressions capturing credit risk of loans made by foreign lenders to foreign borrowers in response to changes in the U.S. Treasury rates and regressions capturing other variations in locations of lenders and borrowers, and, hence, we highlight a causal link between lower interest rates and greater ex ante credit risk of new loans.

For the pre-crisis period, we find that as U.S. short-term interest rate declined, all else held equal, lenders of various types and nationalities tended to originate riskier loans to both U.S. and foreign borrowers. This channel is similar to that in a slightly tweaked standard portfolio choice model with one riskless and one risky asset, where a reduction in the cost of funds motivates investors to allocate more of their wealth towards riskier assets and away from risk-free assets. For the post-crisis period, we find that as U.S. longer-term

interest rate declined, all else held equal, lenders of various types and nationalities tended to originate riskier loans to both U.S. and foreign borrowers. Such behavior may well reflect the search-for-yield motive often discussed in this context.

As with any regression analysis, we need to address some identification challenges. Often, an estimated relationship between interest rates and ex ante credit risk may reflect some latent factor not controlled for in the analysis that affects the two variables simultaneously. To that we note that, because of the richness of our data, we can separate interest rate and credit cycles in a few ways. First, we regress credit risk proxies of portfolios of loans made to foreign borrowers (including those in emerging market economies) on in U.S. short- and longer-term interest rates. Second, we regress credit proxies of portfolios of loans made by foreign lenders to foreign borrowers U.S. short- and longer-term interest rates. Just like in Jimenez, Ongena, Peydro, and Saurina (2008) and Ioannidou, Ongena, and Peydro (2009), in our case, monetary policy in one country is exogenous to developments in another country. To show that our results are not driven by a possible downward, long-term trend in longer-term U.S. Treasury interest rates, we redo the analysis with shorter-term U.S. Treasury rates, which tend to be more volatile and do not show a long-term trend.

To the extent that the Federal Reserve controls short- and longer-term interest rates, our paper is about risk-taking channels of monetary policy that may operate, generally, through portfolio reallocations in response to interest rates, and, specifically, through a cost-of-funds channel and search-for-yield channel. By design, accommodative monetary policy—whether conventional or unconventional—supports economic activity in part by creating incentives for investors to take more risk. Such risk-taking can show up in domestic financial markets, in the international investments of U.S. investors, and even, ultimately, in general risk attitudes toward foreign financial markets.[1] In the pre-crisis period, the Federal Reserve set an explicit target for the federal funds rate and was very successful in achieving that target. In fact, the spread between the effective federal rate and its target averaged just a couple of basis points with a low variance. In the post-crisis period, the Federal Reserve

[1] Distinguishing between appropriate and excessive risk-taking is beyond the subject of this paper.

implicitly targeted longer-term rates, with the U.S. ten-year Treasury rate becoming a de facto target. While recent research, for example, by Krishnamurthy and Vissing-Jorgensen (2011), D'Amico, English, López-Salido, and Nelson (2012), and D'Amico and King (2013), suggests that the Federal Reserve's unconventional monetary policy actions have reduced U.S. longer-term interest rates on safer assets, one cannot contribute all of the movement in these rates to the Federal Reserve's actions. For example, safe haven inflows to safer U.S. assets, as a result, for example, of the European sovereign crisis, put additional downward pressures on U.S. longer-term interest rates. Hence, we are more confident that we identify the cost-of-funds channel of the risk taking channel of the U.S. monetary policy in the pre-crisis period than the search-for-yield channel of the U.S. monetary policy in the post-crisis period. In addition, because of little movement in short-term rates, such as the federal funds rate, we cannot reliably examine the cost of funds channel in the post-crisis period, but our results are implicitly conditional on U.S. short-term interest rates being low. Strictly speaking, the latter should be interpreted as the search-for-yield channel of low U.S. interest rates on safer assets.[2]

Our findings highlight international spillovers of risk taking when low interest rates in one country encourage lenders to originate riskier loans to borrowers in other countries. Such spillovers appear to reflect investor responses to changing differentials between rates of return abroad and in the United States and shifts in investor preferences for more risk. Such spillovers suggest limitations of foreign central banks' monetary policies in affecting risk taking in lending and, more broadly, credit cycles in their respective jurisdictions. For example, while a foreign central banks is tightening (to cool of the country's credit cycle), other foreign central banks may be loosening, and, hence, inadvertently encouraging internationally active lenders to lend to borrowers in that country. These limitations may be particularly acute in emerging market economies. In way, this is a side effect of market

[2]At roughly the same time, other central banks engaged in unconventional monetary policies, which might have provided an additional incentive for international investors to seek risker assets. We also note that some preliminary results indicated that actions of other central banks—for example, the European Central Bank—appear to affect the riskiness of loans denominated in currencies other than U.S. dollars—for example, the euro. This finding indicates that the Federal Reserve is not the only large central bank that may affect credit cycles outside its jurisdiction.

integration—an emergence of international lenders and international markets.

The outline of the paper is as follows. After a short literature review in the second section, we outline key features of syndicated loans in the third section, we argue for the syndicated loan market as a test case in the fourth section. We demonstrate that loan spreads, that is spreads over the benchmark interest rate used in pricing these loans, are reasonable proxies for ex ante credit risk metrics, for example, Basel II-consistent risk parameters, in the fifth section. We build a simple portfolio choice model to illustrate the narrative and motivate the empirical work in the sixth section. We describe our data sources and the ways we transformed the raw data in the seventh section. We go over our empirical strategy and econometric specification in the seventh section and present our estimation results in the eight and subsequent sections. We provide the summary of the results and list the caveats in the last section.

2 Literature review

Understanding the role of banks in lending and in financial markets more generally is important for explaining the broad supply of credit to the economy and the monetary policy transmission and for identifying financial stability vulnerabilities. While the paper contributes to few strands of literature, including those on the bank lending channel and capital flows and their determinants, this section focuses mostly the strand on the risk taking channel of monetary policy. The literature on the risk-taking channel has been growing, in part, because of prevalence of low interest rates around the world. In this section we mention just a few.

Jimenez, Ongena, Peydro, and Saurina (2008) show that banks in Spain take more risk in low interest rate environments. In particular, it induces lowly capitalized banks on the extensive margin to grant more loan applications to ex-ante risky firms and on the intensive margin to commit larger loan volumes with fewer collateral requirements to these firms. Ioannidou, Ongena, and Peydro (2009) show that banks take more risk and grant loans at low rates in Bolivia. In particular, banks with a lower capital ratio take more risks when

the funds rate is lower. Dell'Ariccia, Laeven, and Suarez (2013) find evidence using U.S. of a risk-taking channel that associates accommodative monetary policy (measured the target federal funds rate) to the origination of riskier loans by banks.

Finally, in contrast to the studies above that have analyzed the cost-of-funds risk-taking channel of monetary policy, Aramonte, Lee, and Stebunovs (2015) use U.S. syndicated loan data over the ongoing period of low longer-term interest rates to show that nonbank lenders, such as CLOs and investment funds, acquire riskier credits in response to a decline in spot and forward U.S. Treasury ten-year rates and in response to an increase in the expected extent and duration of the zero lower bound period. Aramonte, Lee, and Stebunovs (2015), use a database of loans primarily to U.S. borrowers but also to some foreign borrowers, and find that lenders have indeed originated an increased number of risky syndicated loans post-crisis, based on the Bael II-consistent assessed probability of default as reported to bank supervisors. Regression results confirm that the average probability of default is significantly negatively correlated with U.S. long-term interest rates. This increase in riskiness of syndicated loans post-crisis has been accompanied by a shift in the composition of loan holders: An increasing share is now held not by banks but by CLOs and other investment funds. These nonbank investors also tend to hold loans with higher average credit risk.

Also of note, while in Jimenez, Ongena, Peydro, and Saurina (2008) and Ioannidou, Ongena, and Peydro (2009) monetary policy is exogenous to the country (Spain is in the euro area and Bolivia is a dollarized economy, with a business cycle likely independent of the U.S.'), in Dell'Ariccia, Laeven, and Suarez (2013) it is not.[3] In Aramonte, Lee, and Stebunovs (2015), the panel structure of the data allows addressing potential endogeneity of credit risk and interest rates.

We, using a database with more-extensive coverage of loans to foreign borrowers, show a similar pattern of increased risky loan underwriting by international lenders, an increase that is also significantly inversely related to U.S. interest rates. Together, these results suggest a potential spillover from accommodative U.S. monetary policy through increased

[3] U.S. monetary policy is likely endogenous to the U.S. business cycle and financial stability.

risk-taking in syndicated loans globally. (Some preliminary results, though, indicate that investors require extra return for this extra risk.)

Our results on spillover effects of advanced economies' monetary policies and of limitations of emerging market economies monetary policies complement the literature on the bank lending channels. For example, Wu, Luca, and Jeon (2011) find that the rise in foreign bank penetration in emerging markets has been another factor weakening the lending channel, given that foreign banks respond less strongly than domestic banks in host countries to host country monetary policy shocks due to the foreign banks access to funding from their parent organizations, which can insulate them from an adverse liquidity shock in the host country.

3 Key features of the syndicated loan market

In order to analyze the different risk-taking channels of monetary policy, we focus on the syndicated loan markets, in part, because these markets are large, with lenders of various types and nationalities supplying credit lines and term loans to borrowers of varying credit quality from around the world. In addition, detailed loan-level data are available for these credits, allowing an in-depth analysis of their riskiness.

A syndicated loan is extended to a borrower by multiple lenders which form a syndicate for that purpose, and it is administered by an agent, typically a bank. The loan carries a floating interest rate that is indexed to a benchmark interest rate, such as U.S. dollar LIBOR, which stays constant to maturity unless covenants are violated.[4] The loan's interest rate includes a contractual loan spread over the benchmark rate—a premium—that is determined at origination and reflects lenders' judgments about the loan's credit risk. In the analysis, we study term loans, which are typically dispersed at origination, have a maturity of several years, and hence are more similar to corporate bonds than credit lines. We do

[4]LIBOR is the dominant interest-rate benchmark for trillions of dollars of conventional loans, many of which are retained on the balance sheets of banks and other intermediaries. For example, 97% of the $3.4 trillion syndicated loan market is tied to libor. Most Common tenors are one-month and three-month LIBOR.

not analyze credit-line loans a) because of the findings of Aramonte, Lee, and Stebunovs (2015) which suggest that a variety of different types of lenders acquire term loans, whereas predominantly banks acquire lines of credit and b) because of complexity of their pricing and drawdowns, the latter are more likely endogenous to the credit cycle.

As shown in Figure 1, originations of syndicated term loans (the blue bars), are comparable in size to issuance of nonfinancial corporate bonds (the red bars). By 2013, syndicated loan markets had recovered from the global financial crisis. There were about $2 trillion in term loan originations, of which roughly $700 billion made to U.S. borrowers (the dark blue portion of the bars) and $1.3 trillion to foreign borrowers (the light blue portion). In addition, syndicated lines of credit, extended mostly to borrowers in advanced economies (not shown), added over $2 trillion to originations in the overall syndicated loan markets. The syndicated loan markets have recovered from the slowdown during the global financial crisis and appear to have been unaffected by the spring 2013 turbulence, possibly because syndicated lenders do not generally bear interest rate risk.

Several types of lenders (identified by their primary activity rather than their entity type) are active in the syndicated term loan markets. In the DealScan data set, which captures ownership of loans at the moment of their origination, banks and bank holding companies (BHCs) account for about 85-90 percent of originations volume globally, see Figure 2. That is, mostly banks and BHCs originated syndicated loans: the share of non-bank institutions originating such loans is 10-15 percent globally. Moreover, among banks, originations are dominated by a group of select lenders. However, this is not an obstacle for our analysis. As a separate date source—the confidential supervisory Shared National Credit Program—suggests banks originated syndicated loans with intent to distribute to other lenders of other types that either pre-committed to buying shares in the loans being originated or likely to buy shortly after the origination. The median of banks' ownership shares of syndicated loans declines from about 80 percent to less than 20 percent in a few weeks since the origination moment, see Figure 3. Retaining a small but economically significant share of syndicated loans, banks address the principle-agent problem.

With these considerations in mind, in the U.S. market, as estimates in Figure 4 suggest, banks and bank holding companies (the blue bars) own over a third of all term loans. Non-bank lenders such as investment funds, including hedge and pension funds and structured finance products (the red bars), investment banks, including securities dealers and portfolio managers (the green bars), finance companies (the orange bars), and other types account for the rest. Notably, the share of ownership for banks and BHCs has been trending down in the past few years. In the global markets for syndicated loans, banks and BHCs are more dominant; their share of originations in 2013 was well over half. But this cannot be reliably estimated because compositions of syndicates are not known for all loans.

4 Loan spreads and ex ante credit risk

We argue that loan spreads in the primary syndicated loan market are reliable proxies for borrowers' ex ante credit risk, measured in terms expected losses. Indeed, Strahan (1999) shows that both the price and non-price terms of bank loans reflect observable components of borrower risk. Focusing on the price terms, as expected, he shows that riskier borrowers—smaller borrowers, borrowers with less cash, and borrowers that are harder for outside investors to value—pay more for their loans. As for the non-price terms, he shows that they are systematically related to pricing: small loans, secured loans, and short-maturity loans carry higher interest rates than other loans, even after controlling for publicly available measures of risk.[5] Moreover, Gaul (2014) shows that loan spreads at origination forecast future loan downgrades from pass to substandard and doubtful ratings, and that their predictive power is somewhat higher than that of a set of publicly available metrics of borrowers' credit risk.[6]

For a given loan, the loan spread, which tends to be fixed at origination for the duration

[5]This suggests that banks use both the price and non-price terms of loans as complements in dealing with borrower risk.

[6]Gaul and Stebunovs (2009) and many others: loan spreads also reflect private information about borrowers' risk characteristics. Finally, other market dynamics, market microstructure, overhead costs may contribute to the final determination of spreads. We try to see how such factors determine spreads later on in this section.

of the loan, can proxy for the ex ante probability of loan default cumulated (averaged) over the entire duration of the loan.[7] This follows from a basic loan pricing model. Consider a risk-neutral perfectly competitive lender which prices a loan which, for simplicity, has no guarantees or collateral. In this model, the loan spread is approximately the product of the probability of loan default and loss given default rate, the crucial components in expected loss calculations. In practice, syndicated term loans tend to have maturities of several years, many of these loans may have guarantees, collateral and covenants, and some of them may be not senior, so the pricing of syndicated loans may be much more complicated than the model lets to believe. The model, however, can be extended for risk-averse lenders with pricing power and with financing constraints of their own to show that other factors, such an increase in lender risk aversion, an increase in pricing power, and an increase in the cost of funds (in excess of an increase in the U.S. dollar LIBOR, the benchmark rate used in pricing), result in higher loan spreads.

In what follows, we show that variation in risk compensation explains little of variation in loan spreads, and, hence, we conclude that risk compensation contributes little to loan spreads. Unlike secondary bond spreads, such as the spreads for speculative-grade bonds, the primary spreads that tend to last through the life of the loan may be more reflective of credit risk than risk appetite or risk aversion.[8]

To examine how well a loan spread reflects a loss rate for a given loan, we merged the commercial DealScan and confidential supervisory Shared National Credit Program (SNC) quarterly data over the 2010-2014 period by loan terms (hard information) and then verified the matches using borrower names, which may be spelled differently in these two data sets (soft information). The sample is short because the quarterly data collection for the SNC program began only in 2009:Q4. For each loan in the merged sample, we regress its Basel II-consistent PD on its loan spread at origination. (Technically, in the light of the first approximation discussed above, we should regress loss rates (products of probabilities of

[7] Strictly speaking, some loans get refinanced and the new loan may have a different spread. In addition, if the quality of the loan deteriorates over time, then the spread may increase in a pre-determined fashion, as the syndicated loan contract may stipulate.

[8] In the empirical work presented in the next section, nevertheless, we control for these additional factors.

default and loss rates given default) on loan spreads, but the quality of loss rates in the data may be low. So, we limit our analysis to probabilities of default.)

We reproduce some figures from Aramonte, Lee, and Stebunovs (2015) which use similar data. Figure 5 shows that ex ante riskier loans command higher loan spreads and that the relationship between the two is highly nonlinear (note that both PDs and loan spreads on the axis are logged). Ratings appear to play a significant role in pricing of loans.[9] Borrowers with outstanding debt rated as investment grade generally pay significantly lower loan spreads than borrowers with either not rated or speculative grade debt. Figure 6 shows that the timing (the year) of origination does not appear to play a significant role in pricing of loans.[10] Table 1 shows some distribution statistics for the data presented in the figure. These statistics suggest that ex ante riskier loans command higher loan spreads (that is, are costlier to borrowers) and that loans to borrowers with non-rated and especially speculative-grade outstanding debt command higher loan spreads.

Table 1: Probabilities of default and loan spreads at origination, by borrower rating

The top panel shows summary statistics of the distribution of default probabilities and loan spreads over LIBOR, at origination and by loan rating. The sample includes loan originations with PDs in the SNC database that we were able to match with DealScan data.

	Default prob. percentile			Loan spread percentile			Obs
	10	50	90	10	50	90	
Borrower rating							
Investment	0.14	0.26	1.00	100	150	275	37
Speculative	0.33	1.82	7.95	200	325	600	145
Not rated	0.16	0.80	3.89	150	275	475	527

We demonstrate now more formally that loan spreads are reasonable proxies for ex ante credit risk. We estimate this benchmark model:

$$\log(SPR_{i,t}) = \alpha + \beta \log(PD_{i,t}) + \varepsilon_{i,t} \tag{1}$$

[9] Ratings are based on Moody's senior debt ratings at the moment of origination as reported in DealScan.
[10] Conditional correlations (not shown) suggest that too.

where $SPR_{i,t}$ is the all-in drawn spread of loan i originated in quarter t, $\log(PD_{i,t})$ is the log of probability of default, and $\varepsilon_{i,t}$ is a white noise error. We cluster errors by time because multiple loans originated in a given period are subject to the same macroeconomic and regulatory environment.

PDs appear to play an important role in pricing syndicated loans. There is a positive, statistically significant relationship between loan spreads and PDs; PDs explain about 40 percent of variation in loan spreads, as shown in column 1 of Table 2.

Next, in our second econometric specification, we include various macroeconomic and financial variables that can potential affect spreads through variables such as risk aversion (variance risk premium and high-yield bond spreads). Adding these (six) variables only improves the adjusted R-squared by 2 percentage points. Variance risk premium, a proxy for investor risk aversion changes, however, does come in significant with a positive sign. Our third specification adds agent-bank fixed effects (to account for possible overhead costs). This addition pushes up the adjusted R-squared to 0.48. In the fourth specification, we include various loan characteristics, even though that loan charactistics is likely highly correlated with measures of credit risk. As lenders choose from a menu of loan terms, this may reflect the choices of the lenders as much as it does the type of credit demand of the borrower. This increases the adjusted R-squared some more to about 0.62. Finally, the fifth and last specification includes variables that reflect credit demand using borrower-industry-year fixed effects and the microstructure of the market using the nonbank share of loans after origination. This only contributes to a marginal increase in the adjusted R-squared, but, with all of these variables, it reaches 0.67.

To demonstrate explanatory power of individual explanatory variables more comprehensively, we compute squared partial correlation coefficients between the loan spread and each explanatory variable. As a reminder, a squared partial correlation coefficient estimates the proportion of the variance of the explained variable that is explained by a given explanatory variable and not the other explanatory variables. We show the results of such computations in 3. In specification 2, a model with a limited set of explanatory variables and no fixed

effects, log(PD) explains about 40 percent of variation in loan spreads, but macroeconomic and financial variables explain very little variation. Similarly, in specification 5, a model with loan-specific, macroeconomic, and financial variables and a set of fixed effects, log(PD) and some other loan characteristics explain a significant portion of variation, but macroeconomic and financial variables do very poorly. These results highlight that loan spreads reflect mostly loan characteristics rather than variation in degrees of lenders risk aversion captured in the regressions, for example, by the variance risk premium.

There may be another concern that our approximation of loss rates with loan spreads introduces a measurement error to our left-hand side variable. As Hausman (2001) points out, econometrically, this may not be an issue. In regressions where the right-hand side variable is measured without error, the consequences of a mismeasured left-hand side variable are innocuous. In this case, the ordinary least squares estimator would be unbiased under a wide range of assumptions. To understand this point, think of an observed left-hand variable that is equal to the sum of the unobserved "true" left-hand variable and a measurement error term assumed to be uncorrelated with the error term in the regression. Thus, when the left-hand side variable is mismeasured, the result is actually an error term on the right-hand side with increased variance, since the new error term includes both a component for measurement error on the right-hand side and a component for the original error expected in the regression. Overall, the outcome will be an unbiased estimate of the regression coefficient, but reduced precision in the estimate, a lower t-statistic and a reduced R-squared.

Indicators of relatively loose underwriting standards—including the fraction of loans with covenant-lite structures or high-debt multiples—may provide another way of looking at risk taking by syndicated lenders. However, because such syndicated loan features get priced in, loan spreads should reflect risk stemming from these features.

5 Portfolio model with two risk-taking channels of monetary policy

A growing theoretical literature analyzes the role of monetary policy in altering bank fragility in the presence of asymmetric information and funding liquidity risk. These models predict that banks may engage in riskier activities when monetary policy is expansive and agency problems are severe or if capital constraints are binding (that is, Adrian and Shin (2010), Freixas, Martin, and Skeie (2011); Diamond and Rajan (2012); Dell'Ariccia, Laeven, and Marquez (2014); and Acharya and Naqvi (2012). In turn, we suggest that the effects of interest rates on short-term funds of financial intermediaries and on safer assets often held by financial intermediaries on risk taking may be tackled in a simple model of portfolio choice. In other words, while agency problems may affect risk taking by financial institutions, even in the absence of such problems, movements in key interest rates, including those driven by monetary policy, may induce risk taking by financial institutions.

We consider a constrained optimization problem with roots in a standard portfolio choice model, but with some tweaks to it to make it applicable to the broader set of financial intermediaries rather than just banks. Most studies in the literature, both theoretical and empirical, focus on the banking sector only, while ours covers a broad range of financial institutions. From a theoretical point of view, limited liability and banks capital structure play important roles in affecting banks risk taking decisions. In our model, we emphasized that even in the absence of these frictions, changes in interest rates could affect the risk taking behavior of financial intermediaries, either banks or nonbanks (shadow banks). From the empirical perspective, studying the investment decision of nonbanks is important, particularly given the rising importance of nonbanks in the financial markets over the last decades, in general, and since the global crisis, in particular.

We construct a one-period static, partial equilibrium model. Suppose a portfolio manager (which should be understood to be an institution representative of the financial sector rather than just the banking sector) is allotted one unit of investment and can invest it in

either a safe asset (for example, long-term Treasury securities) or a risky asset (for example, portfolios of syndicated term loans). The gross rate of return on the safe asset is given by r_F, while the rate of return on the risky asset, referred as loans from now on, is random because of possible loan defaults. Let r_L be the gross interest rate charged on loans. With a probability q, the loan borrowers default and, for simplicity, we assume portfolio managers receive nothing.[11] With a probability $1-q$, borrowers make the repayment of r_L.

In the model, we simplify pricing of syndicated loans. At origination, rates set on syndicated loans are equal to a benchmark rate (such as the U.S. dollar LIBOR) and a spread over the benchmark rate (which, as argued earlier, primarily reflects loan riskiness). Therefore, in the model, a high loan interest rate indicates a higher credit risk.

Suppose portfolio managers invest a fraction l of the unit on loans and the remaining fraction $1-l$ on the safe asset. Thus, the expected return on the portfolio is $\mu_p = (1-q)r_L l + r_F(1-l)$, and the variance of the return on the portfolio is $\sigma_p^2 = q(1-q)r_L^2 l^2$.

Suppose now that portfolio managers obtain their fund from a risk-neutral investor (such as a money market fund).[12]. For simplicity, we assume that the opportunity cost for the investor of investing one unit is r^*, which is the risk-free interest rate. As standard in the literature, there may be a principal-agent problem, in the sense that portfolio managers have incentives to take extra risks as investors will absorb the losses. Another way to think about the pricing of portfolio managers' funding is that of typical risk-based pricing where riskier portfolio managers face a higher funding cost in the market than their less risky peers. Either way, to ensure investors' participation, we assume that investors take l as given and require a return form lending to portfolio managers of r_C (the cost of portfolio managers' funds) such that $r_C \geqslant r^*(1-l) + \frac{r^*}{1-q}l$. The first term on the right hand side of the inequality represents payoffs from the risk free investment. The second term is to ensure investors receive enough return from the risky investment, given that the payoff only realizes with probability $1-q$. (We note that there is yet another, non-market interpretation

[11] We can introduce a loan loss rate, but it will unnecessary complicate the model without changing its salient predictions.

[12] We can introduce a risk-averse investor, but it will unnecessary complicate the model without changing its salient predictions

of the "participation" constraint. Many types of financial intermediaries have treasury departments or "internal" capital markets that determine allocations of funds (and their pricing) towards riskier activities. The "participation" constraint can be seen as an internal cost of funds allocated towards risky investments within a given financial intermediary.)

With this setup, portfolio managers now take q, r^*, and r_F as given and solve the following constrained optimization problem:

$$\max_{l,r_C} U = (1-q)r_L l + r_F(1-l) - r_C - \frac{1}{2}Aq(1-q)r_L^2 l^2 \quad \text{s.t.} \quad r_C \geqslant r^*(1-l) + \frac{r^*}{1-q}l \quad (2)$$

where A measures the managers' dislike of risk in relation to their liking for expected return.

It is straightforward to see that at optimum, portfolio managers will prefer a r_C as low as possible. Hence, the constraint is always binding. With this, the F.O.C. yields the following

$$\hat{l} = \frac{(1-q)r_L - r_F - \frac{q}{1-q}r^*}{Aq(1-q)r_L^2}. \quad (3)$$

From equation 3, holding everything else constant, a reduction in either a short-term or long-term risk free rate would lead to an increase in the portfolio's riskiness. The effects of changes in short-term rates work through a cost-of-fund channel in the sense that lower short-term interest rate reduces the relative cost of investing in risky assets, so portfolio managers will increase the portfolio allocation toward risky loans. On the other hand, a decrease in long-term interest rates will lead to a "search-for-yield" effect and a similar portfolio rebalancing toward risky assets. Here, however, the loan rate is also endogenous and their movement in reaction to a change in short-term or long-term interest rate will also affect the investor's risk taking.

This simple model generates a testable prediction about two risk-taking channels of interest rates and, to the extent that these rates are affected monetary policy, two risk-taking channels of monetary policy. One operates through costs of funds and another through returns on safer assets. The portfolio choice-based model shows that a fall in either a cost of funds or in a return of safer assets gives an incentive to portfolio managers to shift

towards riskier assets—loans.

We show next that this prediction is robust to considering demand for loans in a partial equilibrium setting. We now move to solve the equilibrium r_L. For simplicity, we assume portfolio managers face a negatively sloped demand function for loans, $l^D = \alpha - \beta r_L$.[13]. The supply function for loans is given by equation 3. To ensure the existence of a unique solution, $\hat{l}$ needs to be increasing in r_L, that is $\hat{l}'(r_L) > 0$ or $2r_F + \frac{2q}{1-q}r^* - (1-q)r_L > 0$. Market clearing implies that $l^D = \hat{l}$, through which we can derive the following condition for r_L:

$$(\alpha - \beta r_L)Aq(1-q)r_L^2 - (1-q)r_L + r_F + \frac{q}{1-q}r^* = 0. \tag{4}$$

To derive dr_L/dr^* and dr_L/dr_F, we define $T \equiv (\alpha - \beta r_L)Aq(1-q)r_L^2 - (1-q)r_L + r_F + \frac{q}{1-q}r^*$. Using the Implicit Function Theorem, $dr_L/dr^* = -\frac{\partial T/\partial r^*}{\partial T/\partial r_L}$ and $dr_L/dr_F = -\frac{\partial T/\partial r_F}{\partial T/\partial r_L}$. For the denominator, differentiating T with respect to r_L, we can get the following:

$$\frac{\partial T}{\partial r_L} = Aq(1-q)\left[-\beta r_L^2 + 2(\alpha - \beta r_L)r_L\right] - (1-q).$$

To determine the sign of $\partial T/\partial r_L$, we substitute equation 4 into the above equation. After some rearranging, we can get:

$$\frac{\partial T}{\partial r_L} = -\beta Aq(1-q)r_L^2 + \frac{1}{r_L}\left[(1-q)r_L - 2r_F - \frac{2q}{1-q}r^*\right].$$

From the assumption above, $2r_F + \frac{2q}{1-q}r^* - (1-q)r_L > 0$, hence $\partial T/\partial r_L < 0$. Next, given that $\partial T/\partial r^* = \frac{q}{1-q}$, we have

$$\frac{dr_L}{dr^*} = -\frac{\frac{q}{1-q}}{-\beta Aq(1-q)r_L^2 + \frac{1}{r_L}\left[(1-q)r_L - 2r_F - \frac{2q}{1-q}r^*\right]} > 0.$$

[13]Given the total investment is normalized to one unit, the fraction l is equal the nominal amount of loans

Similarly, we can derive:

$$\frac{dr_L}{dr_F} = -\frac{1}{-\beta Aq(1-q)r_L^2 + \frac{1}{r_L}\left[(1-q)r_L - 2r_F - \frac{2q}{1-q}r^*\right]} > 0,$$

That is, the equilibrium loan rate, r_L is increasing in both $r^*$and r_F. This presents another channel through which changes in risk-free rates affect the equilibrium risk taking behavior. The effects from the loan demand side however, operates in the opposite direction as the "cost-of-fund" and "search-for-yield" effects operated through the supply side.

To see the overall effect of changes in risk-free rates on $\hat{l}$, totally differentiating (2) with respect to r^* and r_F, and rearranging we get:

$$\frac{\partial \hat{l}}{\partial r^*} = -\frac{\beta Aq^2 r_L^3}{Aq(1-q)r_L^2\left[\beta Aq(1-q)r_L^3 - (1-q)r_L + 2r_F\right]} < 0.$$

$$\frac{\partial \hat{l}}{\partial r_F} = -\frac{\beta Aq(1-q)r_L^3}{Aq(1-q)r_L^2\left[\beta Aq(1-q)r_L^3 - (1-q)r_L + 2r_F\right]} < 0.$$

These results suggest that in equilibrium, the effects from the supply side will dominate that of the demand side. That is, this implies that a testable hypothesis for both the cost of funds risk taking channel of monetary policy (when either costs of funds or returns of safer assets decreases, portfolio managers' portfolios will tend to have more risky assets) still stands.

Again, portfolio managers should be understood to represent a broad set of financial intermediaries or the financial sector in general. Our simple framework is general enough to encompass the risk-taking incentives of all types of financial intermediaries, including banks, where limited liability creates principal-agent problems, investment banks, which may be more subject to Value-at-risk capital constraints, and yet other types of nonbanks. This is important because many different types of nonbanks are active participants in the syndicated term loan market. Although banks originate most of the loans, they usually end up holding a small share of the loans outstanding; the rest is sold off mostly to nonbank-type entities in this "originate to distribute" model. The empirical part that follows is framed in

terms of lenders in the global syndicated term loan markets originating portfolios of loans, where the riskiness of these loans is determined by a range of factors, including U.S. interest rates.

6 DealScan data: cleaning, aggregation, and economic significance

We focus on only term loans denominated in U.S. dollars and indexed to the U.S. dollar LIBOR. In this data set, the credit risk measure of a loan is a contractual loan spread over U.S. dollar LIBOR; loans seen as being riskier will have higher loan spreads. We aggregate lenders up to their parent organizations, as stated in the DealScan data. Hence, the location of lenders is determined by the location of their parent organizations. Similarly, we use locations of parent organizations to determine locations of syndicated term loan borrowers. Our approach should be thought of as capturing lending by ultimate lenders on an ultimate counterparty basis. We calculate the average loan spread of all term loans made by each lender in each quarter. (For many loans in DealScan, the ownership of shares in a loan is not available. To overcome this issue we either construct simple averages of loan spreads for loans where a particular lender participated or construct weighted averages of loan spreads based on assumptions often used in the literature where lead lenders are assigned larger shares than other lenders. The results are not affected by the averaging method.)[14]

In the analysis by type, to classify lenders by type, we rely on two-digit SIC codes for primary activity given in the DealScan data. The considered types of lenders include: finance companies, for example, General Electric Capital Corp. and Siemens Financial Services Inc.; investment banks, securities dealers, for example, Goldman Sachs and Morgan Stanley; banks and BHCs, for example, Bank of America Merrill Lynch and JP Morgan Chase; investment funds, for example, Pacific Investment Management Co.; insurance companies,

[14]To construct weighted average loan spreads for loans made by a given lender in a given quarter, we estimate shares of participants in syndicates for which detailed participation information is not available. As a robustness check, we also compute simple average loan spreads and re-estimate our models, which gives similar quantitative results.

and unclassified—mixed group.

As Figure 7 shows, since the trough in 2009, originations of term loans denominated in U.S. dollars to rated and unrated borrowers increased substantially and now exceed the pre-crisis highs. As shown in Figure 8, the DealScan data set suggests that nonbank lenders originated riskier loans than banks did, as contractual loan spreads for new loans made by these institutions were significantly wider than contractual loan spreads for loans made by banks. Consistently, as shown in Figure 9, the default probabilities of loans held by nonbanks (as identified in the SNC data), were much higher than those held by banks.

7 Empirical Approach

The analysis focuses on a panel of lenders originating U.S. dollar-denominated, U.S. dollar LIBOR-indexed loans. We regress the average loan spreads on loans made by each lender on a U.S. interest rate (or a combination of U.S. interest rates). We also include controls for the credit cycle (an actual credit default rate or a high-yield corporate bond CDS spread), the European sovereign crisis (a spread between core and peripheral sovereign yields), lender risk aversion (a VIX-derived variance risk premium), and lender fixed effects. Note that changes in interest rates may not only cause lenders to switch between borrowers with different risks and hence different spreads, they may also cause changes in the spreads themselves, for given levels of credit risk. To be sure, this measure of credit risk is subject to a problem not present with other risk proxies, such as default-probability measures. To help control for this possibility, we include spreads of U.S. high-yield corporate bonds over the U.S. Treasury rate in the regressions.[15] In addition, we include variance risk premium. However, as the earlier results for the loan spread regressions suggest, the effects of premiums related to risk aversion are likely rather small.

The benchmark model is a semi-log model, where loans spreads proxy for cumulative

[15]There is an analogy with the developments in the high-yield bond markets: Demand for junk bonds has skyrocketed in recent years, driving up prices and pushing yields to the lowest level on record.

loss rates ($PD \times LGD$) over the lifetime of loans:

$$log(SPR_{i,t}) = \alpha_i + \beta R_t + \gamma_{CDR} CDR_t + \gamma_{HYSPR} HYSPR_t + X_t \gamma_X + \varepsilon_t \tag{5}$$

where $SPR_{i,t}$ is the average loan spread for loans made by lender i in quarter t, R_t is a U.S. interest rate, CDR_t is a control for the stage of the credit cycle (Moody's global speculative grade borrower credit default rate), $HYSPR$ is a control for credit risk compensation (a U.S. high-yield bond spread), and lender fixed effects α_i. The regression also includes controls for investor risk aversion (a VIX-derived variance risk premium), the European sovereign crisis (a spread between core and peripheral sovereign yields), and the expected inflation (Michigan consumer survey-based expected inflation), all in X_t.

The interpretation of βs, the main coefficients of interest, is straightforward: βs capture the sensitivity of risk taking to changes in T_t. In the benchmark model, the hypothesis is:

$$H_1 : H_0 : \beta < 0,$$

that is, the sensitivity of risk taking is negative, indicating lenders load on risk in response to a decline a in U.S. interest rate.

Note that because we estimate a semi-log regression model, for a given lender i, the marginal effect around a given level of the loan portfolio's average loan spreads is:

$$\Delta(SPR_{i,t}) = SPR_{i,t} \beta \Delta R_t \; i \subset j.$$

In the regression output that follows, we focus on two channels of the risk-taking channel of monetary policy. First, for the cost of funds channel, R_t is the effective federal funds rate. We estimate Model 5 with the effective federal funds rate only for the pre-crisis period, because this rate was at a zero lower bound over the post-crisis period. Second, for the search for yield channel, R_t is the ten-year constant maturity U.S. Treasury rate. We estimate Model 5 with the U.S. Treasury rate for both the pre-crisis and post-crisis periods.

In addition, we estimate a version of Model 5 with both the federal funds rate (R^F) and the U.S. Treasury rate (R^T) included:

$$log(SPR_{i,t}) = \alpha_i + \beta_F R_t^F + \beta_T R_t^T + \gamma_{CDR} CDR_t + \gamma_{HYSPR} HYSPR_t + X_t \gamma_X + \varepsilon_t. \quad (6)$$

We estimate this model for the pre-crisis period to see whether the both risk taking channels were operational simultaneously.

In another version of Model 5, we estimate include both the federal funds rate (R^F) and the U.S. Treasury rate (R^T) and the interactions of these interest rates with a post-crisis dummy ($Post2008$):

$$log(SPR_{i,t}) = \alpha_i + \beta_F R_t^F + \beta_T R_t^T + \beta_{F08} Post2008 \times R_t^F + \beta_{T08} Post2008 \times R_t^T + \beta_{08} Post2008 + \gamma_{CDR} CDR_t + \gamma_{HYSPR} HYSPR_t + X_t \gamma_X + \varepsilon_t. \quad (7)$$

We also estimate an extended version of Models 5, 6, and 7, where we allow for each type of lender, a lender-type-specific β. This regression model should shows whether its both bank and nonbank lenders that originate riskier portfolios in response to a decline in U.S. interest rates. The results for both banks and nonbanks are similar to those for Model 5 for the pre-crisis period and differ for the post-crisis period, and are shown in the appendix.[16] (These results are delegated to the appendix because banks dominate loans originations and later sell these new loans to investors of other types, mostly to shadow bank entities, such as investment funds and CLOs. So, the negative β for banks does not indicate that just banks originate riskier loan portfolios, again, because they do so on behalf of investors of other types.)

[16]The results for the post-crisis period are sensitive to choices of controls for bond spreads (not shown). We show the weakest in terms of statistical significance of the obtained results.

8 Estimation results

We estimate the benchmark model with either the federal funds rate or the ten-year U.S. Treasury rate (or both) on a variety of subsamples: on the full sample, on the subsample of loans made to investment-grade borrowers, on the sample of loans made to foreign borrowers, on the sample of loans made by foreign lenders, and the sample of loans made by foreign borrowers to foreign lenders. In the appendix, we estimate additional models, for example, a model with lender-type-specific βs and a model with the three-year U.S. Treasury rate, as a robustness check for the results being driven by a potential trend in the ten-year U.S. Treasury rate. We break the sample into the pre- and post-crisis periods. It should be understood that the results for the post-crisis period are implicitly conditional on short-term rates being low and varying little.

8.1 Pre- and post-crisis periods

Before describing the estimation results, Figures 10 to 15 reviews some relevant developments over the pre- and post-crisis periods. The crisis period—from 2007:Q3 to 2009:Q2—is excluded from most of the estimation. In the pre-crisis period, both short- and longer-term U.S. interest rates varied, and the credit cycle around the Asian financial crisis and dotcom bust was similar in magnitude to the cycle around the financial crisis. In the post-crisis period, although short-term interest rates stayed near zero, the ten-year U.S. Treasury rates declined through much of the sample and then retraced these declines partially. In contrast, the credit risk of speculative grade firms, as measured by the global speculative-grade corporate default rate (Figure 11) and by the credit default swaps (CDS) spreads (Figure 12), fell, suggesting a moderation in the credit risk cycle.[17] Since the CDS spreads are not available over the entire sample period, we rely on realized credit default rates to control

[17] One may wonder when credit default swaps (CDS) spreads change, to what extent can we interpret that the credit risk of the entities has changed. The literature suggests that changes in firm-level fundamentals and market conditions are the most significant determinants of CDS spread changes. Among the explained portion of CDS spread changes (about 40 percent), two-thirds may be attributed to firm-level and market-wide fundamental variables, and the remaining one-third to supply-demand imbalance and CDS liquidity variables.

for the stage of the credit cycle.[18] Over the post-crisis period, a generally low variance risk premium suggested improved risk appetite (not shown).[19]Figure 13 shows that, according to Moody's data, recovery rates on syndicated loans tend to be much higher than those on senior and subordinated debt. Recovery rates on corporate loans (syndicated loans) averaged about 70 percent, while those on senior and subordinated corporate bonds were more volatile and generally were lower. Figure 14 shows that the number of first time borrowers in the global syndicated loan markets plummeted around the financial crisis, but then recovered over the next couple years.[20] These first time borrowers may be smaller and opaque than more established borrowers, and, hence, may likely pay higher loan spreads. In the post-crisis period, the share of covenant-lite loans increased substantially; these loans are being mostly originated in the United States (Bloomberg).

8.2 The full sample

We first estimate Models 5 to 7 on the sample of all borrowers and lenders, irrespective of their type or nationality. The estimation results are shown in Tables 4 and 5. For the pre-crisis period, column (1) in Table 4 shows the results for Model 5 for the effective federal funds rate, column (2) for the U.S. Treasury rate. It appears that the cost-of-funds channel was operational in that period: β for the effective federal funds rate is negative and statistically significant. It also appears that the search-for-yield channel was operational as well, with β for the U.S. Treasury rate being negative and statistically significant. However, this result may simply reflect positive correlation between the federal funds and U.S. Treasury rates. But this conjecture is a testable hypothesis. Column (3) in Table 4 shows the results for Model 6. The results suggest that, indeed, the search-for-yield channel was dormant in that period. For the post-crisis period, column 1 in Table 5 shows the estimation results

[18]As a robustness checks, we use CDS spreads, but these spreads are available only for more recent years of the sample period.

[19]Variance risk premium (VRP) is the compensation required by investors for holding assets that perform poorly when stock market volatility rises. VRP here is calculated from options prices as the difference between the expected realized variance and the squared VIX index, considered to be the most readily available proxy for fluctuations in investors' risk aversion.

[20]The first time borrowers are identified by name. Over time, since once-first-time borrowers keep coming back for new loans to the markets, the share of first time borrowers declines steadily.

of 5 for the U.S. Treasury rate. We do not include the federal funds rate in this model because this rate was at a lower zero bound over the period: this channel cannot be reliable estimated because of limited movement in the short-term rates. The results suggest that the search-for-yield channel was operational, with β for the U.S. Treasury rate being negative and statistically significant. Column (2) in Table 5 shows the results for Model 7 over the entire sample period of over two decades. The results are similar to those in other columns: the cost-of-funds channel was operational before the crisis and the search-for-yield channel after. The credit risk of speculative grade firms (global speculative-grade borrower credit default rate) got priced in to a lesser extent in the post-crisis period: the coefficient declined from 0.023 to 0.015 between the two periods.[21] The coefficient on the European sovereign yield spread remained unchanged (in the post-crisis period, it is nearly statistically significant). The estimation results do not point at the compression of loan spreads associated with improvements of investor appetite for term loans, as the coefficient on high-yield bond spreads is not statistically significant.[22]

Based on equation 7, Table 6 above summarizes marginal effects—which are not equal to regression coefficients because the regression models are in semi-log form—for the pre- and post-crisis periods calculated in the neighborhood of the average loan spreads at end-2007 and end-2013. The top panel shows the calculations for the pre-crisis period and the bottom panel for the post-crisis period. The post-crisis marginal effects are significantly higher the pre-crisis' because of both higher loan spreads and higher risk-taking sensitivities.

8.3 The sample of loans originated by the most active lenders

To highlight that most active lenders in the syndicated loan market—larger, more sophisticated institutions—may be different from less active lenders, we reestimate Models 5 to 7 on the sample of all borrowers and most active lenders. (Most active lenders are lenders that had originated loans in every quarter of the period under consideration.) The

[21] As a robustness check, we use either a proxy for expected speculative-grade credit default rate—a lag of the two-year cumulative speculative-grade credit default rate by year cohort—or high-yield CDS spreads.

[22] As investor appetite for high-yield corporate bonds improved, the spreads for these products fell. Similarly, loan spreads fell amid higher demand for these loans and more limited supply.

results presented in Tables 7 and 8, and contrasted with those in Tables 4 and 5, suggest that most active lenders' risk taking was more sensitive to the federal funds rate than that of all lenders in the pre-crisis period and more sensitive to the U.S. Treasury rate in the post-crisis period. In particular, β in column 1 of Table 7 is larger than β in column 1 of Table 4; same for the results in columns (1) of Tables 8 and 5. This parallels the results in Aramonte, Lee, and Stebunovs (2015), where risk taking by most active investors in the U.S. syndicated market in the post-crisis period was more sensitive to the U.S. Treasury rate than that of all investors.

8.4 The sample of loans to borrowers with outstanding investment-grade debt

To highlight that risk taking mostly occurs through origination portfolios of loans to riskier borrowers, we reestimate Models 5 to 7 on the sample of borrowers with outstanding investment-grade debt and all lenders.[23] The results are presented in Tables 9 and 10. As columns (1) through (3) in Table 9 and column(1) in Table 10 suggest, neither channel was operational in the pre-crisis period and post-crisis period. The results in column (2) in Table 10 may appear to suggest that over the two decade period, the cost-of-funds channel was operational, seemingly in conflict to the results in column (1) or (3) in Table 9. The former results appear to be driven by the turbulent crisis period, and, hence, may not be indicative of the existence of the cost-of-funds channel. Overall, risk-taking sensitivity to longer-term interest rates for such loans is absent, there is no search for yield. These results illustrate why we need to look at loans made to all or to below-investment grade borrowers to study the search for yield channel of the risk-taking channel of monetary policy.

8.5 The sample of loans to non-U.S. borrowers

Next, we focus on origination of portfolios of loans to other-than-U.S. borrowers for two reasons. First, we would like to examine any international spillover effects of risk taking

[23] In a way, this is our falsification test.

in response to U.S. interest rates. (We note that we do this analysis on the ultimate lender-ultimate borrower basis, so a loan to a U.S. subsidiary of a non-U.S. company is classified as a loan to a non-U.S. borrower.) Second, we would like to address potential endogeneity issues between ex ante credit risk and U.S. interest rates. Because we use data for the global syndicated loan market, where the shares of non-U.S. borrowers and lenders are significant, this concern may be rather weak to begin with. Nevertheless, by examining the riskiness of portfolios of loans to non-U.S. borrowers, we should be able to separate the U.S. credit cycle from the U.S. monetary policy cycle. It is less likely that credit risk of foreign borrowers and the ten-year U.S. Treasury rates were affected by a factor not controlled for in the above analysis, the estimation of these new specifications may be not subject to endogeneity concerns. Just like in Jimenez, Ongena, Peydro, and Saurina (2008) and Ioannidou, Ongena, and Peydro (2009), in our case, the U.S. monetary policy is exogenous to developments in other regions, including emerging market economies.[24] We reestimate Models 5 to 7 on the sample of non-U.S. borrowers and, as Tables 11 and 12 suggest, find that our results presented in Tables 4 and 5 hold, if not strengthened.

8.6 The sample of loans originated by non-U.S. lenders

Now, we focus on loans originated by non-U.S. lenders. This is another channel for international spillovers and another way to address potential endogeneity concerns. (We note that we do this analysis on the ultimate lender-ultimate borrower basis, so a loan originated by a U.S. subsidiary of a non-U.S. lender is classified as a loan by a non-U.S. lender.) Yet again, we reestimate Models 5 to 7 on the sample of non-U.S. lenders and, as Tables 13 and 14, find that our results presented in Tables 4 and 5 hold.

[24] Of note, in Jimenez, Ongena, Peydro, and Saurina (2008) and Ioannidou, Ongena, and Peydro (2009) monetary policy is exogenous to the country (Spain is in the euro area and Bolivia is a dollarized economy, with a business cycle likely independent of the U.S.'). In Aramonte, Lee, and Stebunovs (2015), the panel structure of the data allows addressing potential endogeneity of credit risk and interest rates.

8.7 The sample of loans to non-U.S. borrowers and lenders

Our ultimate way of identifying international spillover channels of the U.S. interest rates and monetary policy, and of addressing endogeneity concerns is that we focus on loan portfolios originated by non-U.S. lenders to non-U.S. borrowers. (We note, yet again, that we do this analysis on the ultimate lender-ultimate borrower basis, so a loan to a U.S. subsidiary of a non-U.S. company originated by a U.S. subsidiary of a non-U.S. lender is classified as a loan to a non-U.S. borrower by a non-U.S. lender.) It is less likely that credit risk of foreign borrowers and credit risk acquired by foreign lenders and the ten-year U.S. Treasury rates were affected by a factor not controlled for in the earlier analysis, the estimation of these models may be not subject to endogeneity concerns. The estimation results for Models 5 to 7 on the sample of non-U.S. borrowers and lenders, presented in Tables 15 and 16 suggest that our results presented in Tables 4 and 5 hold, if not strengthened.

9 Considerations of financial stability issues

The long-lasting low interest rate environment may create vulnerabilities in the financial system. Even if lenders may have hedged potential losses from syndicated loan defaults, other financial intermediaries would have to compensate for these losses if defaults were to occur. Hence, in aggregate, the financial system could be severely strained. In addition, lenders may have lent to borrowers with little ability to repay, leading to bankruptcies of lenders and waste of economic resources. That said, risk aversion was extreme during the worst of the crisis and an increase in risk taking during the sample period may have aided the economic recovery.

Our results for the international spillovers of risk taking indicate limitations of foreign central banks' monetary policies in affecting risk taking in lending and, more broadly, credit cycles in their respective jurisdictions. For example, while a foreign central bank is tightening (for example, to cool of the country's credit cycle), other foreign central banks may be loosening, and, hence, inadvertently encouraging internationally active lenders to

lend to riskier borrowers in that country. In way, this is a side effect of market integration—an emergence of international lenders and international markets.

10 Conclusions

In the pre-crisis period, as short-term interest rate declined, all else held equal, lenders of various types and nationalities tended to originate riskier loans to both U.S. and foreign borrowers. Such behavior may well reflect an operational cost-of-funds channel of the U.S. monetary policy.

In the post-crisis period, as longer-term interest rate declined, all else held equal, lenders of various types and nationalities tended to originate riskier loans to both U.S. and foreign borrowers. Such behavior may well reflect the reach-for-yield motive often discussed in this context.

As a final thought, an increase in risk-taking by lenders is one of the channels by which accommodative monetary policy is intended to spur economic activity. At the same time, of course, greater risk-taking may pose risks to financial stability domestically and globally. Assessing the trade-off between these effects is beyond the scope of this research project, but is clearly a high priority both at the Federal Reserve and at central banks around the world.

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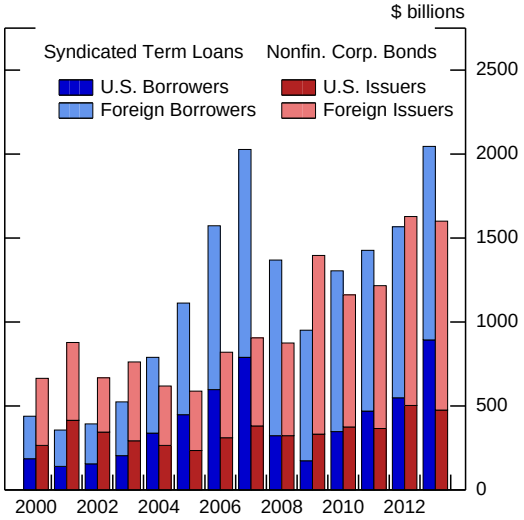
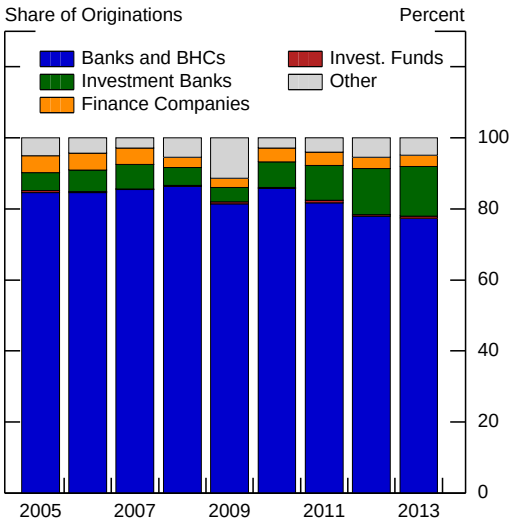


Note. Estimates based on DealScan and Thomson One data.

Figure 1: **Loan Originations and Bond Issuance**



Note. Estimates based on DealScan data. Types of lenders identified by primary activity of parent organization.

Figure 2: **Originations in U.S. Market by Type of Lender (DealScan)**

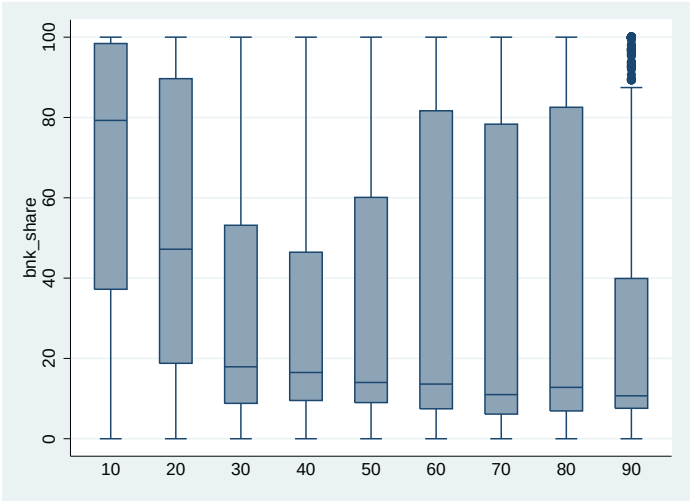


Figure 3: **Banks' ownership share of syndicated loans over time since origination 2010–2013 (SNC)**

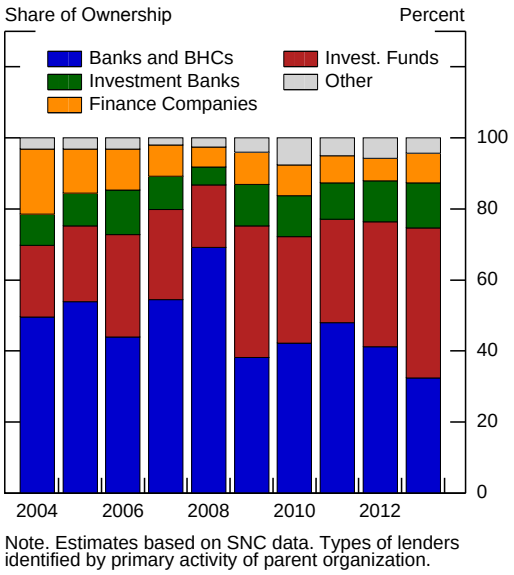
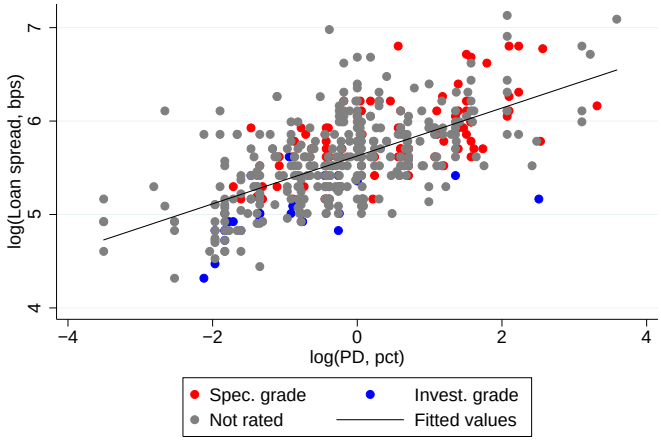
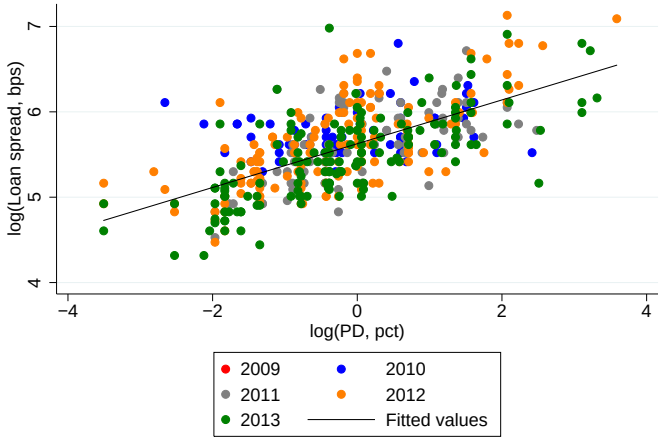


Figure 4: **Ownership shares in U.S. Market by Type of Lender (SNC)**



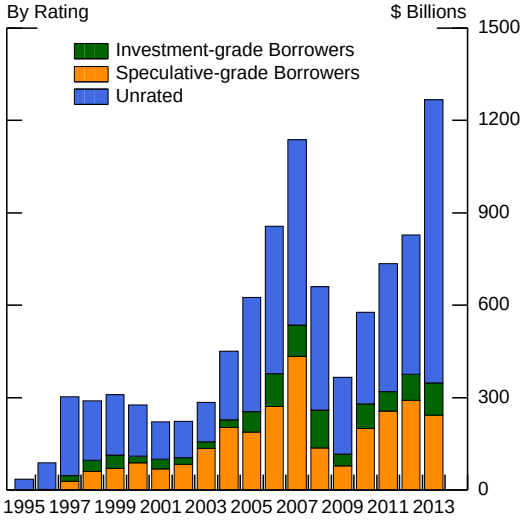
Note. Based on merged SNC and Dealscan data.

Figure 5: **PDs and loan spreads**



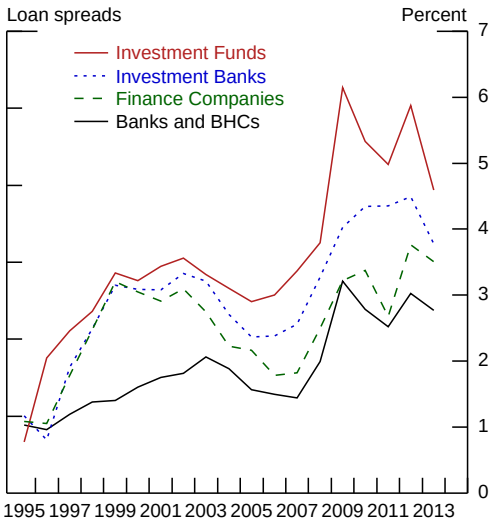
Note. Based on merged SNC and Dealscan data.

Figure 6: **PDs and loan spreads**



Note. Estimates are based on DealScan data.

Figure 7: **U.S. Dollar-denominated Loan Originations**



Note. Estimates are based on DealScan data.

Figure 8: **Credit Risk Proxy by Type of Lender**

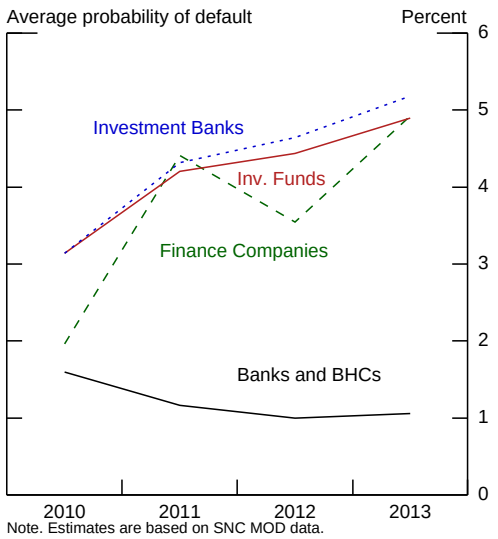


Figure 9: **Credit Risk Proxy by Type of Lender (SNC)**

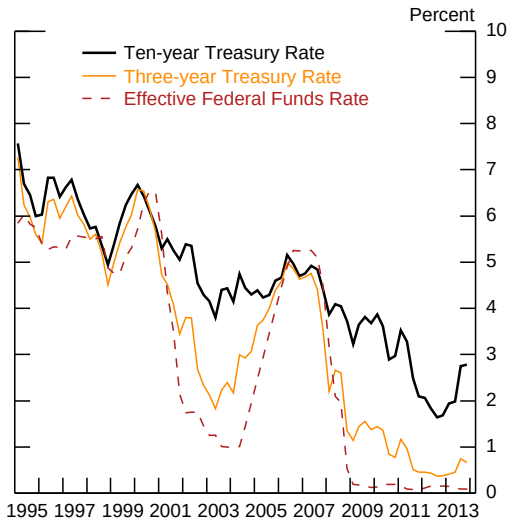


Figure 10: **U.S. Interest Rates**

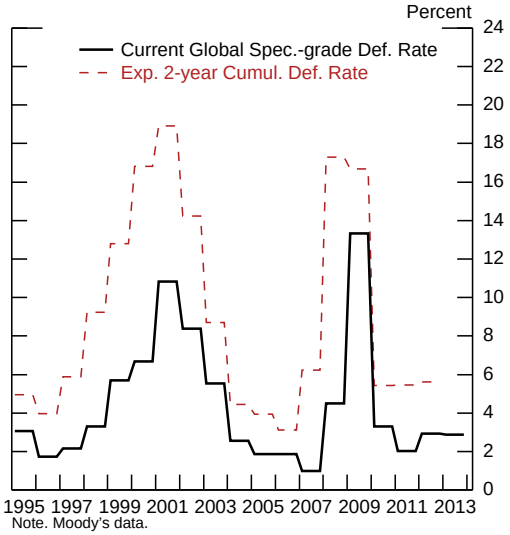


Figure 11: **Corporate Credit Risk—Credit Default Rates**

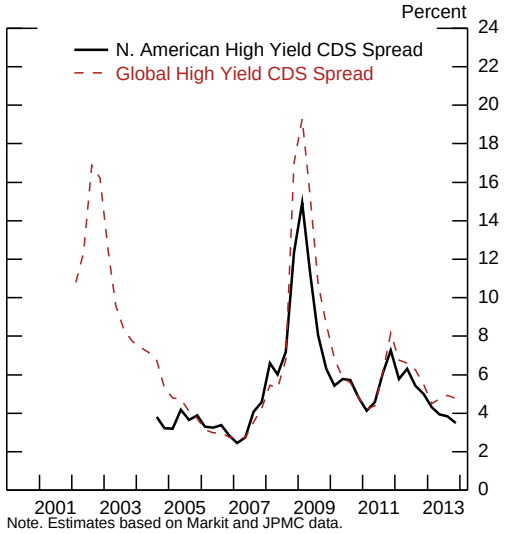


Figure 12: **Corporate Credit Risk—CDS Spreads**

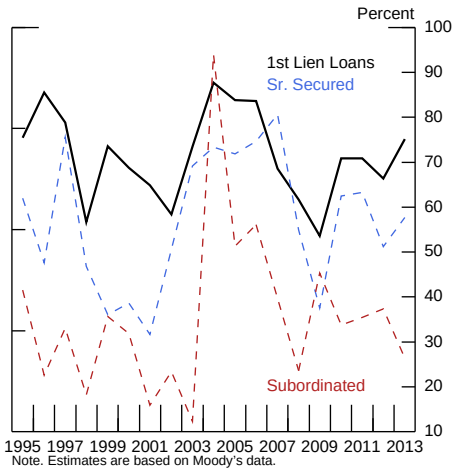


Figure 13: **Corporate Credit Risk—Loan and Bond Recovery Rates**

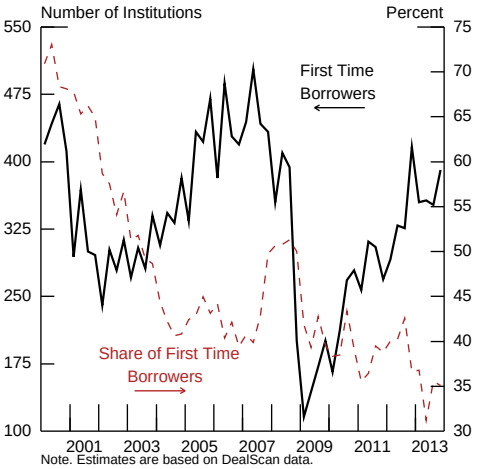


Figure 14: **The Number of First Time Borrowers in the Global Syndicated Loan Markets**

Table 2: Pricing models

	(1) nofe	(2) macro, nofe	(3) macro, repfe	(4) all, repfe	(5) all, allfe
log(PD, pct)	0.231***	0.229***	0.225***	0.164***	0.148***
	(10.773)	(10.372)	(11.935)	(13.426)	(12.498)
Spot 10-year T rate, pct		−0.158	−0.140*	−0.140**	−0.128**
		(−1.693)	(−2.079)	(−2.209)	(−2.257)
VRP, pct sq.		0.012**	0.011**	0.009*	0.006*
		(2.144)	(2.494)	(1.868)	(2.032)
High-yield CDX spread, pct		0.000	−0.000	0.000	0.001
		(0.311)	(−0.100)	(0.091)	(0.848)
Sovereign yield spreads, pct		−0.086**	−0.083***	−0.103***	−0.089*
		(−2.527)	(−3.567)	(−4.304)	(−1.861)
Expected inflation, pct		0.046	0.066	0.072	0.015
		(0.952)	(1.529)	(1.516)	(0.344)
High yield bond spread		−0.039	0.026	0.042	−0.074
		(−0.254)	(0.174)	(0.281)	(−0.540)
log(duration, days)				0.070**	0.037
				(2.460)	(1.320)
log(loan amount)				−0.082***	−0.073***
				(−8.097)	(−6.927)
LBO prime purpose				0.117*	0.101
				(1.819)	(1.396)
Nontraded loan				−0.048**	−0.034
				(−2.335)	(−1.259)
Listed borrower				−0.152***	−0.158***
				(−6.122)	(−5.510)
Nonbank share				0.577***	0.595***
				(12.199)	(16.455)
Num. of observations	709	709	709	709	708
R-sq. adj.	0.40	0.42	0.48	0.62	0.67
RMSE	0.37	0.36	0.34	0.29	0.27

t statistics in parentheses

Note: Errors clustered by quarters. Reporting bank fixed effects and borrower industry/year fixed effects included in some columns.

* $p < .1$, ** $p < .05$, *** $p < .01$

Table 3: Squared partial correlation coefficients

	Specification 2	Specification 5
log(PD, pct)	0.401	0.236
log(duration, days)		0.002
log(loan amount)		0.049
LBO prime purpose		0.004
Nontraded loan		0.003
Listed borrower		0.060
Nonbank share		0.204
Treasury rate, pct	0.006	0.005
VRP, pct sq.	0.009	0.003
CDX high yield	0.000	0.001
European sovereign yield spread	0.008	0.006
Expected inflation, pct	0.001	0.000
High yield bond spread	0.000	0.000

Table 4: The results for all borrowers and lenders for Equations 5 and 6 (errors clustered by quarter)

	(1) Pre-crisis	(2) Pre-crisis	(3) Pre-crisis
Fed. funds rate, pct	-0.028***		-0.029***
	(-3.346)		(-2.723)
Current global spec.-grade def. rate, pct	0.023**	0.025**	0.023**
	(2.326)	(2.360)	(2.220)
Variance risk premium, pct sq.	-0.001	-0.001	-0.001
	(-0.720)	(-1.071)	(-0.739)
Sovereign yield spreads, pct	0.054***	0.051***	0.054***
	(6.027)	(4.262)	(5.184)
Expected inflation, pct	0.030	0.002	0.029
	(0.838)	(0.044)	(0.840)
Overall uncertainty index	-0.000	0.001	-0.000
	(-0.127)	(0.379)	(-0.109)
High yield bond spread, pct	0.015	0.011	0.015
	(0.759)	(0.544)	(0.767)
Spot 10-year T rate, pct		-0.039*	0.002
		(-1.983)	(0.073)
Num. of observations	22306	22306	22306
Num. of clusters	50	50	50
R-sq. adj.	0.64	0.64	0.64
RMSE	0.41	0.41	0.41

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 5: The results for all borrowers and lenders for Equations 5 and 7 (errors clustered by quarter)

	(1) Post-crisis	(2) Full_Modified
Spot 10-year T rate, pct	-0.100*	-0.010
	(-2.103)	(-0.472)
Current global spec.-grade def. rate, pct	0.015***	0.017***
	(2.949)	(3.118)
Variance risk premium, pct sq.	0.001	-0.000
	(0.460)	(-0.653)
Sovereign yield spreads, pct	0.052	0.052***
	(1.628)	(5.793)
Expected inflation, pct	0.040	0.051***
	(1.326)	(4.424)
Overall uncertainty index	-0.002*	-0.000
	(-1.753)	(-0.494)
High yield bond spread, pct	0.066	0.029*
	(1.725)	(1.986)
Fed. funds rate, pct		-0.029***
		(-3.253)
Post-2008× Fed. funds rate, pct		0.392
		(1.049)
Post-2008× Spot 10-year T rate, pct		-0.094***
		(-2.792)
Post-2008		0.755***
		(5.630)
Num. of observations	5935	30872
Num. of clusters	18	76
R-sq. adj.	0.58	0.63
RMSE	0.34	0.42

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 6: Marginal effects on loan spreads from one percentage point increase in respective interest rates

	Pre-2007:Q3	Post-2009:Q2	1995-2013
Fed. funds rate	7 bps	—	7 bps
Spot 10-year T rate	insig.	23 bps	insig.

Table 7: The results for all borrowers and most active lenders for Equations 5 and 6 (errors clustered by quarter)

	(1) Pre-crisis	(2) Pre-crisis	(3) Pre-crisis
Fed. funds rate, pct	-0.040***		-0.035***
	(-3.291)		(-2.747)
Current global spec.-grade def. rate, pct	0.021	0.025	0.025
	(1.193)	(1.302)	(1.337)
Variance risk premium, pct sq.	-0.002	-0.003	-0.002
	(-1.496)	(-1.447)	(-1.104)
Sovereign yield spreads, pct	0.086***	0.078***	0.079***
	(5.268)	(3.268)	(3.457)
Expected inflation, pct	0.047	0.013	0.048
	(0.666)	(0.178)	(0.677)
Overall uncertainty index	0.001	0.001	0.000
	(0.246)	(0.442)	(0.087)
High yield bond spread, pct	0.026	0.021	0.024
	(0.819)	(0.648)	(0.756)
Spot 10-year T rate, pct		-0.065*	-0.021
		(-1.770)	(-0.546)
Num. of observations	1350	1350	1350
Num. of clusters	50	50	50
R-sq. adj.	0.61	0.60	0.61
RMSE	0.30	0.30	0.30

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 8: The results for all borrowers and most active lenders for Equations 5 and 7 (errors clustered by quarter)

	(1) Post-crisis	(2) Full_Modified
Spot 10-year T rate, pct	-0.166***	-0.012
	(-3.030)	(-0.370)
Current global spec.-grade def. rate, pct	0.009	0.022***
	(1.389)	(3.396)
Variance risk premium, pct sq.	0.002	-0.002*
	(0.551)	(-1.688)
Sovereign yield spreads, pct	0.104**	0.085***
	(2.849)	(5.461)
Expected inflation, pct	0.043	0.012
	(1.054)	(0.453)
Overall uncertainty index	-0.002*	-0.000
	(-1.965)	(-0.065)
High yield bond spread, pct	0.089*	0.018
	(1.789)	(1.153)
Fed. funds rate, pct		-0.035***
		(-2.868)
Post-2008×Fed. funds rate, pct		0.389
		(0.813)
Post-2008×Spot 10-year T rate, pct		-0.125**
		(-2.434)
Post-2008		0.841***
		(3.868)
Num. of observations	1656	1520
Num. of clusters	18	76
R-sq. adj.	0.63	0.70
RMSE	0.24	0.25

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 9: The results for all borrowers with investment-grade debt and all lenders for Equations 5 and 6 (errors clustered by quarter)

	(1) Pre-crisis	(2) Pre-crisis	(3) Pre-crisis
Fed. funds rate, pct	-0.014		-0.039
	(-0.541)		(-1.381)
Current global spec.-grade def. rate, pct	0.060*	0.042	0.034
	(1.803)	(1.163)	(0.852)
Variance risk premium, pct sq.	0.007**	0.004	0.005
	(2.427)	(1.583)	(1.605)
Sovereign yield spreads, pct	0.085	0.234	0.262
	(0.545)	(1.278)	(1.499)
Expected inflation, pct	0.017	-0.028	0.007
	(0.144)	(-0.244)	(0.063)
Overall uncertainty index	-0.002	0.001	0.000
	(-0.808)	(0.221)	(0.012)
High yield bond spread, pct	0.033	0.034	0.044
	(0.529)	(0.572)	(0.677)
Spot 10-year T rate, pct		0.079	0.151*
		(1.211)	(1.947)
Num. of observations	3141	3141	3141
Num. of lenders			
Particip., avg. qtr.			
Num. of clusters	43	43	43
R-sq. overall			
R-sq. within			
R-sq. between			

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 10: The results for all borrowers with investment-grade debt and all lenders for Equations 5 and 7 (errors clustered by quarter)

	(1) Post-crisis	(2) Full_Modified
Spot 10-year T rate, pct	0.047	0.125**
	(0.719)	(2.505)
Current global spec.-grade def. rate, pct	0.027*	0.025*
	(2.103)	(1.863)
Variance risk premium, pct sq.	-0.014	0.005*
	(-1.638)	(1.934)
Sovereign yield spreads, pct	0.106	0.077
	(1.419)	(1.251)
Expected inflation, pct	-0.136**	0.139***
	(-2.157)	(2.723)
Overall uncertainty index	0.001	-0.001
	(0.502)	(-0.383)
High yield bond spread, pct	0.154**	0.087***
	(2.534)	(2.759)
Fed. funds rate, pct		-0.055**
		(-2.371)
Fed. funds rate, pct×Post-2008		0.863
		(0.964)
Spot 10-year T rate, pct×Post-2008		-0.175
		(-1.651)
Post-2008		1.438***
		(2.905)
Num. of observations	1627	5398
Num. of lenders		
Particip., avg. qtr.		
Num. of clusters	18	69
R-sq. overall		
R-sq. within		
R-sq. between		

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 11: The results for non-U.S. borrowers and all lenders for Equations 5 and 6 (errors clustered by quarter)

	(1) Pre-crisis	(2) Pre-crisis	(3) Pre-crisis
Fed. funds rate, pct	-0.037***		-0.036***
	(-4.442)		(-3.642)
Current global spec.-grade def. rate, pct	0.031***	0.033***	0.032***
	(2.926)	(2.917)	(2.706)
Variance risk premium, pct sq.	0.000	-0.000	0.000
	(0.361)	(-0.403)	(0.376)
Sovereign yield spreads, pct	0.028***	0.025*	0.027**
	(2.750)	(1.799)	(2.119)
Expected inflation, pct	0.059	0.024	0.059
	(1.651)	(0.574)	(1.644)
Overall uncertainty index	0.000	0.001	0.000
	(0.142)	(0.673)	(0.085)
High yield bond spread, pct	-0.018	-0.023	-0.019
	(-0.814)	(-1.070)	(-0.848)
Spot 10-year T rate, pct		-0.049*	-0.004
		(-1.738)	(-0.120)
Num. of observations	12004	12004	12004
Num. of clusters	50	50	50

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 12: The results for non-U.S. borrowers and all lenders for Equations 5 and 7 (errors clustered by quarter)

	(1) Post-crisis	(2) Full_Modified
Spot 10-year T rate, pct	-0.179**	-0.028
	(-2.139)	(-1.082)
Current global spec.-grade def. rate, pct	0.021*	0.023***
	(1.909)	(2.880)
Variance risk premium, pct sq.	0.003	0.001*
	(0.586)	(1.805)
Sovereign yield spreads, pct	0.036	0.020*
	(0.634)	(1.837)
Expected inflation, pct	0.076	0.081***
	(1.100)	(4.887)
Overall uncertainty index	-0.003**	-0.001*
	(-2.168)	(-1.676)
High yield bond spread, pct	0.045	0.016
	(0.636)	(0.763)
Fed. funds rate, pct		-0.037***
		(-3.805)
Fed. funds rate, pct×Post-2008		0.619
		(1.059)
Spot 10-year T rate, pct×Post-2008		-0.122***
		(-2.793)
Post-2008		0.861***
		(5.044)
Num. of observations	3845	17489
Num. of clusters	18	76

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 13: The results for all borrowers and non-U.S. lenders for Equations 5 and 6 (errors clustered by quarter)

	(1) Pre-crisis	(2) Pre-crisis	(3) Pre-crisis
Fed. funds rate, pct	-0.038***		-0.035***
	(-5.439)		(-4.623)
Current global spec.-grade def. rate, pct	0.025**	0.028**	0.027**
	(2.342)	(2.435)	(2.389)
Variance risk premium, pct sq.	-0.000	-0.001	-0.000
	(-0.575)	(-0.902)	(-0.257)
Sovereign yield spreads, pct	0.049***	0.043***	0.045***
	(5.507)	(3.485)	(4.129)
Expected inflation, pct	0.059*	0.026	0.060*
	(1.714)	(0.644)	(1.715)
Overall uncertainty index	0.000	0.001	0.000
	(0.357)	(0.801)	(0.194)
High yield bond spread, pct	-0.003	-0.009	-0.004
	(-0.142)	(-0.389)	(-0.199)
Spot 10-year T rate, pct		-0.056**	-0.012
		(-2.388)	(-0.484)
Num. of observations	11476	11476	11476
Num. of clusters	50	50	50

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 14: The results for all borrowers and non-U.S. lenders for Equations 5 and 7 (errors clustered by quarter)

	(1) Post-crisis	(2) Full_Modified
Spot 10-year T rate, pct	-0.141**	-0.029
	(-2.203)	(-1.440)
Current global spec.-grade def. rate, pct	0.021**	0.022***
	(2.658)	(3.492)
Variance risk premium, pct sq.	0.002	0.001
	(0.439)	(0.972)
Sovereign yield spreads, pct	0.026	0.036***
	(0.598)	(3.871)
Expected inflation, pct	0.054	0.075***
	(1.110)	(5.676)
Overall uncertainty index	-0.002*	-0.001
	(-1.882)	(-1.098)
High yield bond spread, pct	0.046	0.017
	(0.877)	(1.000)
Fed. funds rate, pct		-0.036***
		(-4.771)
Fed. funds rate, pct×Post-2008		0.395
		(0.794)
Spot 10-year T rate, pct×Post-2008		-0.124***
		(-3.580)
Post-2008		0.863***
		(6.087)
Num. of observations	3689	16760
Num. of clusters	18	76

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 15: The results for non-U.S. borrowers and non-U.S. lenders for Equations 5 and 6 (errors clustered by quarter)

	(1) Pre-crisis	(2) Pre-crisis	(3) Pre-crisis
Fed. funds rate, pct	-0.042***		-0.041***
	(-5.062)		(-4.198)
Current global spec.-grade def. rate, pct	0.029**	0.031**	0.030**
	(2.616)	(2.638)	(2.466)
Variance risk premium, pct sq.	0.001	-0.000	0.001
	(0.976)	(-0.029)	(0.970)
Sovereign yield spreads, pct	0.024**	0.020	0.021*
	(2.406)	(1.438)	(1.779)
Expected inflation, pct	0.064*	0.025	0.064
	(1.681)	(0.567)	(1.673)
Overall uncertainty index	-0.000	0.001	-0.000
	(-0.047)	(0.600)	(-0.115)
High yield bond spread, pct	-0.016	-0.022	-0.017
	(-0.691)	(-0.954)	(-0.730)
Spot 10-year T rate, pct		-0.057**	-0.007
		(-2.120)	(-0.230)
Num. of observations	10747	10747	10747
Num. of clusters	50	50	50

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 16: The results for non-U.S. borrowers and non-U.S. lenders for Equations 5 and 7 (errors clustered by quarter)

	(1) Post-crisis	(2) Full_Modified
Spot 10-year T rate, pct	-0.171*	-0.030
	(-2.054)	(-1.279)
Current global spec.-grade def. rate, pct	0.024**	0.023***
	(2.342)	(2.899)
Variance risk premium, pct sq.	0.002	0.002**
	(0.340)	(2.491)
Sovereign yield spreads, pct	0.027	0.014
	(0.472)	(1.344)
Expected inflation, pct	0.069	0.083***
	(0.999)	(4.750)
Overall uncertainty index	-0.003**	-0.002*
	(-2.125)	(-1.794)
High yield bond spread, pct	0.044	0.014
	(0.626)	(0.644)
Fed. funds rate, pct		-0.041***
		(-4.353)
Fed. funds rate, pct×Post-2008		0.438
		(0.743)
Spot 10-year T rate, pct×Post-2008		-0.127***
		(-3.047)
Post-2008		0.895***
		(5.394)
Num. of observations	3420	15639
Num. of clusters	18	76

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Appendix: Risk taking by type of lender

We analyze risk taking by type of lender subject to the point raised earlier that banks. This analysis is delegated to the appendix because banks dominate loans originations and later sell these new loans to investors of other types, mostly to shadow bank entities, such as investment funds and CLOs. In other words, just because risk taking by nonbank lenders at the moment of loan origination is not sensitive to U.S. interest rates, does not mean that risk taking by the same institutions at the moment of distribution is not neither. In fact, Aramonte, Lee, and Stebunovs (2015) find that mostly nonbank lenders load on credit risk as U.S. longer-term interest rates decline.

To study which types of lenders primarily drive the results, we tweak Model 5. Model 8, a more advanced model, extends Model 5 by allowing for a separate regression coefficient for each type of lender:

$$log(SPR_{i,t}) = \alpha_i + \sum_J I(j)\beta_j R_t + \gamma_{CDR} CDR_t + \gamma_{HYSPR} HYSPR_t + X_t \gamma_X + \varepsilon_t \qquad (8)$$

where j indexes a type of lender.

The interpretation of βs, the main coefficients of interest, is straightforward: βs capture the sensitivity of risk taking to changes in T_t. In Model 8, the hypothesis is:

$$H_1 : H_0 : \beta_j < 0; \exists\, j,$$

that is, some types of lenders have a negative sensitivity, indicating that these types of lenders load on risk in response to a decline in U.S. Treasury ten-year rates. Generally, risk-taking sensitivity of some lender types might be higher in absolute terms than others'. For example, the sensitivity of nonbank lenders might be higher than that of banks because the latter may face more strict regulatory and supervisory constraints.

Note that because we estimate a semi-log regression model, for a given lender i of type

j, the marginal effect around a given level of loan portfolios average loan spread is:

$$\Delta(SPR_{i,t}) = SPR_{i,t}\beta_j \Delta R_t \; i \subset j.$$

As a first cut, we classify the lenders in the sample either as banks or nonbanks based on their two-digit SIC codes. The estimation results for Model 8 are shown in Tables 1 and 2. As column (1) in Table 1 suggests, lenders of both types originated riskier loans in response to declines in the federal funds rate before the crisis. However, this result for nonbank lenders is not robust to inclusion of the ten-year U.S. Treasury rate in column (3). Overall, the regression output suggests that activities of lenders, which primary activity is banking, drive the results for the pre-crisis period. As for the post-crisis period, as Table 2 suggests, that activities of lenders, which primary activity is banking, drive the results too.

As a second, more detailed cut, we repeat the same exercise but now break down nonbank lenders into finer types. The estimation results (not shown) suggest that, in addition to banks, finance companies, investment banks, and investment funds increased in the both periods higher loan spreads (implying an increase in risk-taking) as U.S. interest rates declined (in specifications with other region-specific controls such as included).

Appendix: Additional checks

We perform a few additional robustness checks. First, we reestimate Models 5 and 8 (and their variants) with a common trend included and get even stronger results (not shown). The point of this exercise is to show that our results are not driven by a possible downward, long-term trend in longer-term U.S. Treasury interest rates, we redo the analysis with shorter-term U.S. Treasury rates, which tend to be more volatile and do not show a long-term trend. Second, we re-estimate the models on the sample of loans to all borrowers with the three-year U.S. Treasury rate as a regressor. The point of this exercise is to show that the earlier results for the pre-crisis period are not driven by a possible trend in the ten-year U.S. Treasury rate—and as the estimation results (not shown), they are not. The

estimation results for the regressions with separate coefficients estimated for each type of lender (not shown) are similar to the earlier results.

Table 1: The estimation results for Equation **??** for the pre-crisis period (errors clustered by quarter)

	(1) Pre-crisis	(2) Pre-crisis	(3) Pre-crisis
Bank×Fed. funds rate, pct	-0.035***		-0.031***
	(-4.406)		(-3.744)
Nonbank×Fed. funds rate, pct	-0.019*		-0.027
	(-1.744)		(-1.589)
Current global spec.-grade def. rate, pct	0.023**	0.025**	0.022**
	(2.314)	(2.312)	(2.167)
Variance risk premium, pct sq.	-0.001	-0.001	-0.001
	(-0.645)	(-0.974)	(-0.614)
Sovereign yield spreads, pct	0.052***	0.048***	0.051***
	(5.922)	(3.890)	(4.753)
Expected inflation, pct	0.029	-0.000	0.028
	(0.811)	(-0.007)	(0.797)
Overall uncertainty index	-0.000	0.001	-0.000
	(-0.124)	(0.429)	(-0.068)
High yield bond spread, pct	0.014	0.010	0.015
	(0.721)	(0.510)	(0.729)
Bank×Spot 10-year T rate, pct		-0.054**	-0.012
		(-2.501)	(-0.517)
Nonbank×Spot 10-year T rate, pct		-0.013	0.027
		(-0.613)	(0.866)
Num. of observations	22306	22306	22306
Num. of clusters	50	50	50
R-sq. adj.	0.64	0.64	0.64

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 2: The estimation results for Equation **??** for the post-crisis period (errors clustered by quarter)

	(1) Post-crisis	(2) Full_Modified
Bank×Spot 10-year T rate, pct	-0.112**	-0.022
	(-2.412)	(-1.124)
Nonbank×Spot 10-year T rate, pct	-0.070	0.016
	(-1.352)	(0.516)
Current global spec.-grade def. rate, pct	0.015***	0.018***
	(2.969)	(3.252)
Variance risk premium, pct sq.	0.001	-0.000
	(0.477)	(-0.469)
Sovereign yield spreads, pct	0.052	0.047***
	(1.642)	(5.241)
Expected inflation, pct	0.041	0.047***
	(1.347)	(4.192)
Overall uncertainty index	-0.002*	-0.000
	(-1.761)	(-0.502)
High yield bond spread, pct	0.067	0.027*
	(1.737)	(1.928)
Bank×Fed. funds rate, pct		-0.032***
		(-4.257)
Nonbank×Fed. funds rate, pct		-0.027*
		(-1.835)
Bank×Fed. funds rate, pct×Post-2008		0.248
		(0.550)
Nonbank×Fed. funds rate, pct×Post-2008		0.769**
		(2.460)
Bank×Spot 10-year T rate, pct×Post-2008		-0.085**
		(-2.617)
Nonbank×Spot 10-year T rate, pct×Post-2008		-0.100**
		(-2.422)
Bank×Post-2008		0.738***
		(5.446)
Nonbank×Post-2008		0.662***
		(4.128)
Num. of observations	5935	30872
Num. of clusters	18	76
R-sq. adj.	0.58	0.63

t statistics in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$