The risk-taking channel of monetary policy in the USA: Evidence from micro-level data

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1 October 2011

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Abstract

There is a growing consensus that a prolonged period of low interest rates can exert a negative impact on financial stability through the risk-taking incentives of banks. Using micro-level datasets from the US banking sector, this paper finds evidence of a highly significant negative relationship between monetary policy rates and bank-risk taking. This finding remains robust across various specifications, sub-periods and subsamples, thereby confirming the presence of an active risk-taking channel of monetary policy since the 1990s. The results, therefore, support the new responsibilities of the Fed on macro-prudential supervision to monitor systemic risks.

JEL classification: G21; G01; E43; E52

Keywords: Bank risk; monetary policy; US commercial banks; Total loans; New loans

1. Introduction

A recent line of research suggests that there is a significant link between a monetary policy of low interest rates over an extended period of time and higher risk-taking by banks. This link points to a different dimension of the monetary transmission mechanism, the so-called risk-taking channel of monetary policy transmission (Borio and Zhu, 2008). In this paper we use balance sheet data as well as data on individual loan facilities to assess the potency of the risk-taking channel in the USA, the country where the financial turmoil of 2007-2008 initiated. In doing so, we propose solutions to some serious identification problems, related to the theoretical background of the risk-taking channel and its potency in the US banking sector.

The risk-taking channel might be at work through three main mechanisms. The first is the search-for-yield mechanism, with low (nominal) interest rates increasing incentives for bank-asset managers to take on more risks (Rajan, 2005). Generally speaking, when interest rates are low for a prolonged period of time, banks face a reduction in the margin between the lending and the deposit rate (i.e. the intermediation spread), thereby raising their incentives to switch to riskier assets with higher expected yields. A similar mechanism could be in place when managerial compensation is linked to absolute yields. Lower yields on safe assets (such as highly-rated government bonds) imply lower compensations for managers that opt for playing it safe, and vice versa.

Low interest rates can also induce more bank risk-taking through their impact on real valuations, incomes and cash flows. Low rates boost asset and collateral values and tend to reduce price volatility, which in turn downsize bank estimates of probabilities of default and encourage higher risk positions (Borio and Zhu, 2008). In a similar vein, Adrian and Shin (2010) argue that "continued low short rates imply a steep yield curve for some time, higher net interest margin in the future, and hence higher risk-taking capacity of the banking sector" (p. 5). Unlike the first mechanism, an essential element of this proposition is that the risk-taking channel involves not only new assets (loans), but also the valuation of assets already present in bank portfolios.

Monetary policy could also affect risk-taking through the reaction function of the central bank to negative shocks. The commitment, for example, of a central bank for lower (future) interest rates in the case of a threatening shock, reduces the probability of large downside risks, thereby encouraging banks to assume greater risk (transparency effect). This is a typical moral hazard problem. It should be emphasized here that this effect (also known as the Greenspan or Bernanke put) operates through the expected lower interest rates (should they be needed) rather than current low rates themselves. The magnitude of this effect, however, depends on the current level of the policy rate. Anticipated interest rate reductions tend to correspond to a higher risk position when there is greater room for monetary expansion, i.e. when current rates are high (De Nicolò et al., 2010). Likewise, risk-taking may also be influenced by the level of economic activity. During economic expansions, agents become less risk-averse due to the anticipation of higher profits in their investments. Therefore, monetary easing may, by boosting real economic activity, create incentives for asset managers to undertake higher risk positions (Altunbas et al., 2010).

The empirical literature that directly tests for the existence of a risk-taking channel in the USA is currently developing (De Nicolò et al., 2010; Maddaloni and Peydró, 2011; Buch et al., 2011). In this literature, two important identification challenges are recognized pertaining to (i) the fact that although the risk-taking channel describes the incentives to engage primarily in ex ante riskier projects, most data sources do not distinguish between new and outstanding loans and (ii) the endogeneity problem that concerns the potential joint identification of monetary policy and bank risk.

We address the first problem by using two alternative micro-level datasets. The first one consists of balance sheet data taken from the Federal Deposit Insurance Corporation (FDIC) Call Reports. This data set offers information about US commercial banks' overall risk and its high level of disaggregation allows for the control of unobserved time-invariant bank characteristics (De Nicolò et al., 2010). The second dataset provides information on individual syndicated loans sourced from the Dealscan database maintained by the Loan Pricing Corporation (LPC). The advantage of this micro-level dataset is that it allows examining banks' lending standards with first hand information from their primary activity of lending, taking into account borrower and instrument detailed information. This, in turn, should give a clear indication of how the terms of new business lending vary around changes in the monetary policy stance.

Concerning the endogeneity problem, the existing literature convincingly suggests that bank risk could influence the stance of monetary policy and that both these variables are affected by the general macroeconomic conditions. For example, during times of high financial uncertainty, monetary authorities may react by lowering interest rates (Ioannidou et al., 2009). In the USA, the Federal Reserve's concern with the orderly functioning of the financial markets stems largely from the adverse implications of financial instability for its primary long-run goals of price stability and sustainable economic growth.[1] Generally, the most common procedure for addressing the potential joint identification of monetary policy and bank risk is through instrumental variables methods. This requires at least one identifying restriction, i.e. at least one variable that is known to affect (and not to be affected by) interest rates and is known not to affect (or be affected by) the bank risk-taking variable, while this variable is independent of the general macroeconomic conditions. In the case of the risk-taking channel, it is extremely difficult to meet this identifying restriction.

To examine the impact of the US monetary policy on bank risk-taking, we focus on changes in monetary policy based on two measures – the change in the federal funds rate and the monetary policy shocks obtained from the procedure of Romer and Romer (2004). The federal funds rate is the primary tool used by the Federal Reserve for implementing monetary policy. The main drawback of this measure is that it may respond endogenously to other economic variables, thereby

[1] It should be emphasized here that financial stability does not always require a fundamental change in the overall direction of monetary policy (as implemented by a change in the federal funds rate target). The Fed can make temporary adjustments to day-to-day open market operations or to discount window lending in order to inject liquidity into the marketplace when the financial system is under stress. A change in monetary policy is only required when the financial sector problems can significantly harm the outlook for the broader economy (Plosser, 2007).

making it difficult to isolate the *real* impact of monetary policy on bank risk. In order to recover the unanticipated, exogenous component of monetary policy, we adopt the identification strategy developed by Romer and Romer (2004). This approach uses narrative evidence and the Fed's real-time information (as captured by the Greenbook forecasts) to achieve identification. To the extent that these data adequately summarize the Fed's private information set regarding its objectives and expectations, this approach eliminates much of the endogeneity between interest rates and economic conditions. As a robustness check, we also use a panel-data vector autoregression (PVAR) methodology. This technique combines the traditional VAR approach, which treats all variables in the system as endogenous thereby circumventing the issue of ad hoc identification restrictions, with the panel-data approach, which allows for unobserved individual heterogeneity. More specifically, we focus on the orthogonalized impulse response functions, which show the response of one variable of interest (i.e. bank risk) to an orthogonal shock in another variable (i.e. monetary policy rate). By orthogonalizing the response, we are able to identify the effect of one shock at a time, while holding other shocks constant.

This paper presents two further novelties. First and foremost, by employing quarterly micro-level data both for total and for new loans, we are better able to identify the impact of the short-term monetary-policy rates on bank risk-taking for the first time for the US banking sector. Second, the richness and the time frame of the databases allow us to investigate whether the risk-taking channel has been always present in the USA or it is a recent phenomenon. There are reasons to believe that the transformation of the financial landscape over the last three decades (as a result of financial liberalization and innovation) may have had an impact on the monetary policy transmission mechanism prior to 2000.

In a nutshell, the empirical findings from the FDIC Call Reports show that a statistically significant relationship prevails between the change in monetary policy rates and bank risk-taking. This relationship is initially positive, probably due to the impact of interest rates on outstanding loans, but turns negative in the medium term (after 9-13 quarters). This general finding is robust to (i) the monetary policy rate used, (ii) the proxy of bank risk-taking, and (iii) different sub-periods. Therefore, it implies that the risk-taking channel of monetary policy transmission has been in place since the 1990s, when financial innovation and a series of regulatory changes transformed the landscape of the US banking market. The results from the syndicated loan market are even more supportive for the presence of an active risk-taking channel in the US banking sector. They clearly indicate that banks tend to soften their lending standards right after expansionary policy shocks.

The remainder of the paper is organized as follows. Section 2 briefly outlines the recent developments of the US banking sector, as well as the related literature on the bank risk-taking channel and the identification issues at stake. Section 3 discusses the datasets and presents the empirical models to be estimated. Section 4 presents and discusses the empirical findings. Section 5 concludes the paper and provides some policy implications.

2. A brief overview of the US banking sector and related literature on the risk-taking channel

For many decades commercial banks in the USA operated under a very restrictive regulatory environment. The McFadden Act (1927) restricted commercial banks from intra- and inter-state expansion of their branch network without previous regulatory approval. Furthermore, the Glass-Steagall Act (1933) prohibited, among other things, commercial banks from offering investment services, such as corporate underwriting, securities brokerage, real estate sales or insurance. These Acts meant to increase competition, protect small banks and limit their risk-taking behavior. Eventually, both Acts were repealed by the end of the 1990s; this allowed commercial banks to freely expand their network across counties and states and to join their forces with other financial institutions. Whether the removal of these restrictions on US banking activity has led to a decrease or increase in banks' risk-taking behavior is an open debate in economic research. Mishkin (1999), for example, argues that the separation of the banking and securities industries restricted the ability of the banks to diversify, and thus to reduce risk. Then again, the demise of the Glass-Steagall Act led to large financial institutions and the well-known moral hazard problem created by a too-big-to-fail policy. This policy seems to have encouraged increased risk taking on the part of large US banks (Boyd and Gertler, 1993).

Regardless its (questionable) impact on banks' risk-taking behavior, the fact is that financial deregulation significantly reduced the number of insured US commercial banks from over 14,000 in 1985 to approximately 6,500 in 2010. At the same time, banking industry assets increased significantly from $2.73 trillion in 1985 to $12.1 trillion in 2010. However, this increase was not evenly distributed across the US banking industry and the sector became far more concentrated than during most of its past. For example, the asset share of the largest size group (i.e. organizations with more than $1 billion in assets) rose dramatically from 71% in 1992 to 90% in 2010.[2]

In this paper, we do not investigate the underlying factors of this consolidation trend. Instead, our focus is primarily on identifying how the gradual restructuring of the US banking industry (in its various manifestations), along with the varying macroeconomic conditions, have influenced the linkage between interest rates and bank risk-taking over time. Hence, adding a temporal dimension to the analysis allows us to better understand the dynamics of the risk-taking channel of the US monetary policy transmission over the last two decades. Throughout this period, the federal funds rate (the primary tool used for implementing monetary policy) varied significantly in accordance with the country's economic conditions. During the 2000s, the Fed adopted accommodative monetary policies. Following the bursting of the dotcom bubble in late 2000 and the subsequent recession in the US economy, the Federal Open Market Committee (FOMC) began to lower the target for the overnight federal funds rate. Rates fell from 6.5% in late 2000 to 1.75% in December 2001 and to 1% in June 2003. The target rate was left at about 1% for a year. At that time, the historically low federal funds rate resulted in a negative real federal funds rate from

[2] Data source: http://www.fdic.gov/bank/statistical

November 2002 to August 2005. Remarkably, since the first quarter of 2009 the level of federal funds rate has remained at its all-time low (0.25%). This exceptionally low level is likely to hold for an extended period of time as evidenced by the minutes of the FOMC's meeting April 27, 2011.

In forming its central-bank policy rates, the Fed, like other central banks, has the mandate of promoting price stability. However, unlike other banks, the Fed is additionally charged with promoting maximum employment. This dual mandate may well explain the Fed's recent decision to embark on quantitative easing schemes in an attempt to keep interest rates at low levels in order to promote employment. Although these monetary policy decisions may potentially impair the performance of the banking sector, or change the structure of its risk-taking activities, the Fed avoids taking actions against financial volatility *per se*, or against banks taking losses or failing. Such actions are believed to raise moral hazard problems, which could ultimately increase, rather than reduce, the risks to the financial system (Plosser, 2007). Thus, the current (and expected) accommodative monetary policy implies that the Fed is more concerned with liquidity injections that facilitate the orderly functioning of the financial markets, rather than protecting banks from the consequences of their financial choices.

So far, very few theoretical models have explicitly attempted to study the role of monetary policy in banks' risk-taking behavior. Agur and Demertzis (2010) and Valencia (2011) develop dynamic models to assess the impact of prolonged lax monetary policy on bank risk-taking and financial stability. Agur and Demertzis (2010) show that in order to ensure financial stability in a crisis, central banks need to reduce the policy rate sharply but for a short period of time. The reason is that banks adjust their portfolios of long-term assets towards riskier projects only if they foresee that interest rates will be kept at low levels for prolonged periods. This is, essentially, in line with the transparency effect outlined in the Introduction. Valencia (2011) shows that capital requirements can lessen (but not eliminate) the impact of banks' excessive risk-taking on financial stability and proposes the use of counter-cyclical regulatory policies. Finally, Dell'Ariccia et al.

(2010) approach the issue at hand within a static framework. They also show that prolonged periods of easy monetary conditions increase banks' appetite for risk. In their model, however, the monetary policy effect depends on the capital structure of the banking industry. When banks are allowed to adjust their capital structures, low interest rates increase bank leverage, which in turn lowers the incentives to monitor (i.e. risk increases). If the capital structure is instead fixed, the degree of bank capitalization plays a pivotal role: in well capitalized banks, risk increases with a lower policy rate; the reverse holds for highly levered banks.

There is also a recent empirical literature, using either aggregate data on bank risk or bank-level data, for countries other than the USA, which generally verifies the presence of a risk-taking channel. Jiménez et al. (2008) employ bank-level data of the Spanish Credit Register over the period 1984-2006 and find that an expansionary monetary policy affects the riskiness of banks' portfolios (prominently in the medium term) due to the higher collateral values and the search for yield. Ioannidou et al. (2009) use Bolivian bank-level data as a quasi-natural experiment of an exogenously-taken monetary policy. They find that banks not only increase the number of new risky loans, but also reduce the rates they charge for riskier borrowers relative to the safer ones. Maddaloni and Peydró (2011) take a more international perspective and use data for the European Union and the USA. They solve the endogeneity problem using Taylor-rule residuals and analyze changes in the banks' lending standards to examine the impact of monetary policy on new loans at the aggregate level. They report robust evidence for the softening impact of too-low-for-too-long monetary policy rates on banks' lending standards and the concomitant buildup of risk on their assets. Finally, Delis and Kouretas (2010) are more concerned with whether the low level of interest rates (and not a monetary policy change per se) cause banks to increase their risk-taking appetite and find that this was indeed the case for the EMU countries over the period 2001-2008.

Other studies suggest that the impact of monetary easing on risk-taking may not be uniform across time, banking systems or banking groups. De Nicolò et al. (2010) find that the risk-taking channel depends on banking market conditions and factors that affect these conditions. In good times, for example, when most banks' charter values and capitalization are sufficiently high, monetary-policy easing induces greater risk-taking. Nevertheless, this relationship is less pronounced in times of financial distress. Further, Buch et al. (2011) use US aggregate data and factor-augmented vector autoregressive models (FAVARs) to address the potential joint identification of monetary policy and bank risk. They show that different banking groups respond differently to expansionary monetary shocks. Small domestic banks tend to increase their risk exposure with respect to new loans, foreign banks seem to lower it, and large domestic banks do not significantly alter their risk profile.

With the exception of De Nicolò et al. (2010), none of the above studies uses micro-level data on banks to examine the risk-taking channel in the USA, the country where the credit problems of the late 2000s initiated. Given the stance taken in other recent studies of the risk-taking channel, the primary reasons for this seem to be the two identification problems. First, monetary policy is considered to be endogenous in bank risk equations and, second, a part of the literature suggests that the risk-taking channel is about new loans only. Therefore, this is the first study that (i) proposes an identification strategy that alleviates concerns about the endogeneity of monetary policy, and (ii) utilizes bank-level data from the FDIC Call Reports, as well as data on new loans from the syndicated market to examine the potency of the risk-taking channel.

3. Data and empirical identification

3.1. US FDIC call reports

Our empirical approach to assess the risk-taking channel of monetary policy relies on a series of panel regressions, where the baseline has the following functional form:

$$\Delta r_{it} = a + \sum_{k=1,5,9,13} \beta_k \times \Delta ir_{t\text{-k}} + \sum_{j=1}^{J} \gamma_j \times bank_{i,t\text{-}4} + \sum_{\phi=1}^{\Phi} \delta_{\phi} \times regdum_t + \lambda \times \Delta IP_{t\text{-}1} + \varepsilon_{it}\,, \qquad (1)$$

where Δr is the change in the risk variable of bank i at time t, α is a constant, Δir is the change in the monetary policy rate (in discrete lags up to thirteen quarters), *bank* is a set of bank-level control variables (lagged four quarters), *regdum(φ)* is a set of regulatory variables which are common to all banks, ΔIP is the lagged change of the log of the US industrial production index over the previous quarter and ε is the error term. Table 1 offers detailed variable definitions and data sources. In the baseline specification we also include time effects to control for unobservable time-varying common shocks that affect monetary policy decisions and bank risk-taking.

The sample comprises quarterly balance sheet information for US insured commercial banks taken from the FDIC Call Reports over the period 1985q1-2010q2. The use of quarterly data is considered to be sufficiently appropriate for measuring the short-term impact of monetary policy changes on bank risk (Altunbas et al., 2010). The original data set includes more than a million bank-level observations. However, we end up with a smaller number of observations, as we apply some selection criteria. First, we apply an outlier rule to the main variables corresponding to the 1st and 9th percentiles of the distribution of the variables under consideration. Second, we omit banks that either exited or were taken over during the full sample period in order to avoid any selection effects. Our final data set consists of 795,085 bank-quarter observations for which we have accounting data. Table A1 in the Appendix briefly describes all variables used in the empirical analyses as well as their data sources. Tables A2 and A3 in the Appendix provide summary statistics for the main variables and their bivariate correlation coefficients, respectively. The results indicate the absence of any serious multicollinearity among the exogenous variables.

3.1.1. Bank risk-taking

We proxy the risk-taking behavior of banks using primarily two alternative measures that are intuitive and easily implementable: *risky assets* and the *Z-index*.[3] Data for both measures are drawn from the FDIC Call Reports. Risky assets include all bank assets except cash, government securities (at market value) and balances due from other banks. Clearly, an increase in *risky assets* indicates a riskier position of banks. The mean value for this variable is 0.94. Figure 1 shows that *risky assets* gradually increased from a low of 0.9 in the late 1980s to a high above 0.96 just before the sub-prime crisis. This, in conjunction with the historical low of the US monetary policy interest rates in the 2000s, makes the examination of the risk-taking channel hypothesis interesting.

As a secondary variable we use the *Z-index*, which is calculated as follows:

$$Z\text{-}index = \frac{ROA + EA}{\sigma(ROA)}, \quad (2)$$

where *ROA* is the return on assets, *EA* is the equity-to-assets ratio and $\sigma(ROA)$ is the standard deviation of *ROA* over the last twelve quarters. For the calculation of $\sigma(ROA)$ we also experiment with a different number of quarters, the results being very similar. The *Z-index* decreases as the variability of the earnings increases or as the profits and capital decrease. Thus, there is a tradeoff between the *Z-index* and bank's probability of failure. In other words, the *Z-index* can be regarded as an inverse proxy of the bank's total risk-taking or risk of default. Note, however, that a higher probability of default may be due to the general macroeconomic conditions that affect the variables comprising the Z-index exogenously. Therefore, as this variable may not necessarily depict the risk-taking incentives of banks, we favor the risky-assets variable. The total number of observations for the Z-index variable is 787,355, with a mean value of 27.82.

3.1.2. Monetary policy interest rates

[3] As a sensitivity analysis, we also employed the ratio of risk-weighted assets to total assets (as in De Nicolò et al., 2010), which is available since 1997. We find no significant changes in the results for the period 1997-2010 when using this variable. We also experimented with the ratio of non-performing loans to total loans. This measure is probably inferior because it represents an ex post measure of credit risk (results are available on request). Finally, we employed σ(ROA), the results being similar to those for the Z-index.

The primary focus of this study lies on the effect that low interest rates could have on banks' risk-taking. We experiment with two alternative interest rates that enter the empirical model in Eq. (1) in discrete lagged form to account for (possible) lasting effects of monetary easing on the quality of banks' assets. The first obvious choice is the quarterly change in the real federal funds rate, computed as the difference between the nominal federal funds rate and the consumer price index (CPI) inflation rate (see De Nicolò et al., 2010). The federal funds rate is the primary tool used for implementing monetary policy and it is the interest rate at which banks trade reserves overnight, i.e. it reflects the actual cost of bank refinancing. However, it may be endogenous to the macroeconomic conditions in the US economy. If policy changes are endogenous to variables such as output growth, their estimated effect on bank risk-taking will in part reflect the way in which output affect banks' appetite for risk. We have already pointed out in the Introduction that a rise in real economic activity may create incentives for asset managers to undertake higher risk positions. To the extent that the federal funds rate is endogenous to output growth, the estimation results will be subject to simultaneity bias.

To identify the unanticipated and exogenous variation in the federal funds rate, we use the federal funds rate change targeted by the FOMC at their scheduled meetings. This is our second monetary policy measure. To this end, we extend the two-step procedure outlined by Romer and Romer (2004). In the first step, we derive a federal funds rate target series. Romer and Romer (2004) use narrative evidence to determine the change in the federal funds rate targeted by the FMOC during their scheduled meetings (approximately 8 per year). Their constructed series spans the period 1969-1996 and is allegedly unaffected from any transitory shocks to supply and demand in the reserve market. In this paper, we expand the original Romer and Romer (2004) target series by appending the FOMC's announced target federal funds rate changes for the 1997-2005 period.[4]

[4] Bluedorn and Bowdler (2011) argue that, although the narrative evidence used by Romer and Romer (2004) is informational richer than the announced target series, the pooling of the two is acceptable given the increasing transparency in policy intentions during the last two decades. The sample is restricted to meetings through the end of 2005 simply because the Greenbook forecasts are released with at least five years delay.

In the second step, the targeted federal funds rate change is regressed upon the Greenbook forecasts for real output (GNP/GDP) growth, inflation (GNP/GDP implicit deflator – chain weighted price index) and unemployment over horizons of up to two quarters.

In particular, we estimate the following equation:

$$\Delta ff_m = a + \beta \times ff_{m-1} + \sum_{i=-1}^{2} \gamma_i \Delta\hat{y}_{mi} + \sum_{i=-1}^{2} \delta_i \Delta\hat{\pi}_{mi} + \theta\hat{u}_{m0} + \sum_{i=-1}^{2} \lambda_i \left(\Delta\hat{y}_{mi} - \Delta\hat{y}_{m-1,i}\right) + \sum_{i=-1}^{2} \eta_i \left(\Delta\hat{\pi}_{mi} - \Delta\hat{\pi}_{m-1,i}\right) + \varepsilon_m \quad (3)$$

where the dependent variable is the change in the targeted funds rate around FOMC meeting *m*, *ff* is the level of the target federal funds rate prior any changes associated with meeting *m*, Δy is real output growth, π is inflation, u is the unemployment rate and ε is a white noise error.

The regression residuals are the targeted federal funds rate changes, which are orthogonal to the Federal Reserve's information set. Because the data used in equation (3) correspond to FOMC meetings, the residuals also correspond to FOMC meetings. Therefore, in order to use the shocks series in our analysis, we need to convert them to a quarterly series. Since we focus on the post-1985 period, we assign each shock to the quarter in which the corresponding FOMC meeting occurred. If there is more than one meeting in a quarter, we sum the shocks.

Figure 2 plots both the change in the actual funds rate and the unanticipated monetary policy shocks. Overall, the two series follow similar patterns.[5] Their contemporaneous correlation (see Table A3 in the Appendix) over the sample period (1985 – 2005) is positive (0.40). Furthermore, it is evident from Table A1 that the actual funds rate is substantially more volatile than the unanticipated monetary shocks. This difference in volatility may account for some of the difference in the estimated effects of monetary policy on bank risk-taking reported in Section 4.

[5] The behaviour of the two series is quite different in the early 1990s. The shock series shows a string of positive values, whereas the change in the actual funds rate shows a string of negative values. Therefore, what seems to be an expansion in the actual funds rate is actually a period of contraction according to the shock series. This likely reflects the lack of transparency in policy intentions during that period.

3.1.3. Other covariates

Although the link between bank risk and monetary policy is our main concern in this paper, it is necessary to control for a number of factors that may possibly cause changes in banks' risk (see Table A1 for formal definitions). At the bank-level, we control for balance sheet characteristics that indicate the capacity and willingness of banks to supply additional loans. Thus, we introduce into the baseline specification *capital surplus* (the distance of the ratio of total equity capital to total assets from the 8% level stipulated under Basel-II), *efficiency* (total income to total expenses), *provisions* (loan and lease losses to total loans), *non-traditionally activity* (non-interest income to total income), *profitability* (pre-tax profits to total assets) and *size* (natural logarithm of real total assets). All bank-specific characteristics enter the estimated equations in lagged form (lagged four quarters) primarily to avoid endogeneity bias. We resort to the fourth lag because data on most of the bank-level variables is seasonal. We do not add more lags since these lags are found to be highly collinear.[6]

All other things being equal, well-capitalized and technically efficient banks are considered to be more risk averse. The effect of size on bank risk-taking is ambiguous. On the one hand, large banks might take on a higher level of risky assets owing to better risk-diversification capability and easier access to funds when needed. On the other hand, these banks are more tightly supervised and have better access to capital markets, so one would expect their *Z-indices* to be higher. The allowance for credit losses (*provisions*) represents management's estimate of probable losses inherent in banks' lending activities. Banks that hold a high level of provisions at time *t*-4 are expected to decrease the level of their risky assets at time *t*, but also to have an overall higher probability of default. Similarly, higher *profitability* may give the incentive for banks to expand in the next year their portfolios to loans with higher volatility of cash flows thereby lowering their credit standards. Finally, the impact of *non-traditionally activity* on bank risk-taking is ambiguous.

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[6] For a similar set of bank-level controls in risk equations see *inter alia* Delis and Kouretas (2011) and Laeven and Levine (2009).

On the one hand, increasing the ratio of non-interest incomes to total income can reduce banks' risk through diversification of income sources. On the other hand, non-interest incomes generated from involving non-traditional activities are quite volatile, and thus risky (Stiroh and Rumble, 2006).

The second group of control variables can be labeled *regulatory conditions* and accounts for the main regulations in the US banking industry. Initially we used information on eight large regulatory changes that occurred in the US banking system, during our sample period.[7] However, primarily due to identification problems, we include only three of them that correspond to three regulatory shift dummy variables.[8] The first one (*regdum1*) takes the value of one from 1989q3 onwards to capture the effect of the Financial Institutions Reform, Recovery and Enforcement Act (FIRREA) enacted in August 1989 in the wake of the savings and loan crisis of the 1980s. FIRREA imposed a series of regulatory constraints designed to reduce bank risk-taking. The second dummy variable (*regdum2*) takes the value of one in the post-1994q4 period to account for the Riegle-Neal Interstate Banking and Branching Efficiency Act (IBBEA) of 1994, which permitted nationwide branching. IBBEA gave the US banking industry the incentives for the formation of large banking units, thus increasing the potential for severe moral hazard problems created by the *too-big-to-fail* paradigm. The last dummy variable *(regdum3)* takes the value of one from 2009q1 to capture the effect of the implementation of Basel II. There is the widespread view that Basel II imposes sufficient discipline on banking institutions, so that they would be deterred from taking on excessive risk.

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[7] In chronological order, these relate to: (i) the Financial Institutions Reform and Recovery Act, enacted on August, 1989; (ii) the Riegle-Neal Interstate Banking and Branching Efficiency Act, enacted on September, 1994; (iii) the reinterpretation of the Glass-Steagall Act, eventually allowing bank holding companies to earn up to 25 percent of their revenues in investment banking, enacted on December 1996; (iv) the formation of Citigroup on October, 1998, following the $140 billion merger of Citicorp and Travelers Group, on the expectation that Glass-Steagall would be repealed; (v) the Gramm-Leach-Bliley Act (Repeal of Glass-Steagall Act), enacted on November, 1999; (vi) the Commodity Futures Modernization Act (formal financial derivative deregulation), enacted on December, 2000; (vii) the Voluntary Regulation Act, which allowed investment banks to push their debt to-net capital ratio to as high as 40 to 1, relatively to less than 15 to 1 since 1975 (effective from 2004 until September 2008); (viii) the implementation of Basel II in January 2009.

[8] Identification problems refer here primarily to multicollinearity between the dummy variables. The choice for the inclusion of the three dummies rests on the assumption that those included relate to the most critical regulatory changes of the period 1985-2010. Inclusion of a different set of regulatory dummies does not alter the main findings.

Finally, we include in the econometric specification time-fixed effects to control simultaneously for macroeconomic and other unobserved shocks that may affect banks' risk behavior.

3.2. New loans

A caveat of the previous empirical strategy is that it deals with banks' total risk, and thus it does not allow distinguishing between realized risk (on outstanding loans) and new risk (on new loans). This distinction is crucial since the risk-taking channel, as described in the introduction, primarily refers to banks' incentives to engage in ex ante riskier projects. Therefore, it is important to examine how the terms of new business lending vary around changes in the monetary policy stance. To this end, we use data on all rated syndicated credit facilities granted to borrowers in the USA from 1988 to 2010. We source these data from the Dealscan database maintained by the LPC. While LPC provides comprehensive information on loan characteristics (amount, maturity, LIBOR spread, etc.), it does not provide information on borrower characteristics. Therefore, LPC is matched with Compustat database, which provides data on borrower financials, following the methodology adopted in Bharath et al., (2011). Finally, we enrich our dataset with respect to lead arranger bank financials by drawing statement data from the FDIC Call Reports. This matching process results in a final sample with detailed financial data for a maximum of 50,830 syndicated loan transactions from 1988 to 2010.

In order to investigate the link between monetary policy and bank lending standards, we use the pricing of newly issued syndicated loans (measured by the loan spread charged) as an ex ante proxy of distress risk.[9] Loan spreads reflect the market's consensus for the credit quality of the underlying asset. Therefore, loan spreads would allow us to investigate whether banks tend to relax their lending standards (i.e. fund riskier investments and charge higher spreads) in the event of a

[9] In the syndicated loan market, a loan is divided among more than one lender. Typically, the loan is originated by a lead bank which sells pieces of the loan to other (participant) banks. The lead bank acts as the manager of the loan responsible for ex ante due diligence and for ex post monitoring of the borrower (Ivashina, 2009).

monetary policy loosening. In other words, loan spreads can be viewed as a measure of banks' risk appetite after a change in monetary policy stance. Syndicated loan spreads are measured as the spread on basis points over LIBOR. We use the change in the logarithm of all-in-spread drawn (ΔAISD) which measures the interest rate spread plus any one-time and recurring associated with the loan.[10] While loan credit quality does indeed influence AISD, so do many other factors. Therefore, following Kara et al. (2011) and Ivashina (2009) we model ΔAISD as a linear function of a number of control variables as well as a variable accounting for the change in the monetary policy rate (Δir):

$$\Delta AISD_{it} = a + \beta \Delta ir_t + \sum_{j=1}^{J} \gamma_j \times controls_i + \varepsilon_{it} \qquad (4)$$

The control variables can be categorized in three broad groups: loan, borrower and lead bank characteristics. Under loan characteristics, we define the explanatory variables that are endogenous of the loan including the number of lenders, deal amount, time to maturity, the requirement of performance pricing and collateral provisions and the use of financial and general covenants. The first three variables are continuously quantifiable, while the last four are qualitative in nature. We calculate dummies for the qualitative variables, i.e. they take the value of 1 if there is any provision or covenant assigned to the loan and 0 otherwise. Loan size is the log of the loan amount in million dollars. The association between loan size and loan spreads is ambiguous. On the one hand, larger loans may potentially expose lenders to greater losses. On the other hand, larger loans may be granted to larger borrowers with better records of repayment, and hence lower credit risk as perceived by the lenders. Loan maturity is measured as the length in months between the facility activation date and maturity date. Loan maturity is expected to be positively associated with borrower risk (Flannery, 1986). The number of lenders measures the size of the loan syndicate. Following Ivashina (2009), a larger loan syndicate allows greater credit risk diversification among the lead lenders and participant banks. Thus, we expect syndicate size to be associated with lower

[10] See Bharath et al. (2011) and Ivashina (2009).

loan spreads. The dummy variables indicate whether a loan is secured, has performance pricing provisions or carries financial and/or general covenants. According to Strahan (1999) and Booth and Booth (2006), riskier borrowers are often required to provide collateral, which implies that secured loans could carry higher interest rates. Performance pricing provisions relate the interest rate charged on loans to measures of borrower performance, thereby reducing moral hazard problems and lowering loan spreads. Similarly, loan covenants are meant to protect lenders against moral hazard problems by constraining the borrowers' operating and financial flexibility. Therefore, loans with covenants are expected to face higher interest rates.

We also account for borrower credit quality and his repayment capability (Christodoulakis and Olupeka, 2010; Bharath et al., 2011). The borrower's default risk is measured by Altman's (1968) modified *Z-score*.[11] The repayment capability variables include the ratio of the market to the book value of the assets and the ratio of tangible assets to total assets.[12] The former variable proxies the borrower's growth opportunities, while the latter is frequently used by the empirical literature as a measure of liquidation value. It is widely accepted that more favourable debt ratings should be associated with lower loan spreads. Similarly, borrowers with better growth prospects and higher liquidation values should face lower interest rates since they are less likely to default.

Finally, we control for lead bank's risk appetite, by introducing a subset of the bank-specific variables outlined in Section 3.1.3. We expect all variables related to riskier attitude to be associated with higher loan spreads, and vice versa. Brief descriptions of all variables, along with their summary statistics, are provided in Tables A4 and A5 in the Appendix, respectively.

4. Empirical analysis and results

4.1. Evidence from US Call Reports

[11] As a robustness check, we also include the S&P's debt rating at the time of the loans' origination provided directly by Dealscan.

[12] We also experimented with many other indices capturing borrower characteristics (size, total debt and profitability). These variables turned to be statistically insignificant. In addition, the changes in the remaining results were negligible.

We start our analysis by considering the impact of changes in the real federal funds rate on bank risk (Table 1). We run panel fixed-effects regressions using quarterly data over the period 1985 – 2010. Since market-wide shocks are likely to induce correlation between banks at a moment in time, we compute cluster-robust standard errors. We report the results first without any control (columns I and III) and then introduce control variables as specified in Eq. (1) (columns II and IV).

In columns I and II, the dependent variable is *risky assets*, whereas in columns III and IV we replace it with the *Z-index*. The coefficients of the lagged federal funds rates are statistically significant in all, but one, instances, thereby confirming the importance of short-term interest rates on bank risk equations. However, their impact on risk (positive or negative) differs across specifications and lag dimensions. Analytically, the sign of the (statistically significant) first lag of the change in the federal funds rate indicates that softer monetary conditions actually decrease bank risk-taking (i.e. banks' *risky assets* decrease and banks' *Z-index* increases). This is consistent with the findings of Jiménez et al. (2009) and Altunbas et al. (2010) that lower interest rates reduce the credit risk of outstanding loans. The positive impact, however, turns negative when we consider further lags of the federal funds rate. Especially, the estimated coefficients of the 9^{th} and the 13^{th} lag indicate that monetary easing significantly increases banks' appetite for risk. This suggests that banks' risk-taking behavior responds with a certain delay to monetary policy rate cuts. Furthermore, the size of the coefficients of the lagged federal funds rate shows that the (negative) impact of low interest rates on banks' risk profile increases as interest rates continue to decrease.

We now turn to the control variables. Bank-level characteristics are statistically significant in most cases. The impact of *capital surplus* and *efficiency* on bank risk is negative confirming the expectation that well-capitalized and technically efficient banks are more risk averse. Similarly, the impact of *provisions* on *Z-index* is negative and highly significant (i.e. when credit losses increase, banks' risk also increases). The impact of *profitability* on *risky assets* is insignificant, whereas the impact of bank *size* is positive. The latter effect provides evidence in favor of the too-big-to-fail paradigm. Finally, the coefficient of *non-traditional activities* is positive when both *risky assets* and the *Z-index* are used as proxies of bank risk-taking. This indicates that banks engaging more in non-traditional activities tend to assume higher risks in their traditional activities (as evidenced by their *risky assets*) but, at the same time, manage to reduce their overall risk exposure (*Z-index*) possibly due to their income diversification.

Concerning the impact of the regulatory variables, we observe that both FIRREA (*regdum1*) and Basel II (*regdum3*) have somewhat succeeded in restricting banks' risk behavior. Therefore, regulations aiming at preventing poor investments and fraud and improving the transparency and market discipline of the banking system are important in controlling the risk-taking appetite of banks, even though these types of regulations did not prevent the financial turmoil of 2007.

Next, we replace the federal funds rate with Romer and Romer's (2004) measure of unanticipated monetary policy shocks. The prior identification of monetary policy means that the interest rate variable is now purely exogenous. The quarterly dataset now spans the period 1985 – 2005. Therefore, we exclude from the baseline specification the Basel II regulatory variable (*regdum3*). The empirical results (reported in Table 2) are qualitatively similar. Again, the coefficients of the 1st and 5th lag of the monetary policy shock are positive and highly significant (in the *risky assets* regressions), whereas the negative impact of monetary easing on banks' risk (both in *risky assets* and *Z-index* equations) becomes prominent with a delay of 9-13 quarters. The impact of the control variables remains basically the same as in Table 1.

All in all, the results in Tables 1 and 2 provide robust evidence that confirms the hypothesis that although low monetary policy rates reduce credit risk in banks' portfolios in the short term (probably because the volume of outstanding loans outweighs the volume of new loans), they raise it significantly in the medium term.

4.1.2. Evidence from different sub-periods

In this section, we empirically examine the view that the US easy monetary policy in the early 2000s played a crucial role in softening the lending standards of the US banks. To this end, we run multiple regressions across different sub-periods. The estimation results are presented in Table 3. Columns I and II show the results for the period preceding the late 2000s financial crisis. The unanticipated monetary policy shocks continue to exert a positive effect on bank risk in the short term, but in the medium term banks seem to increase their risk appetite, so that a highly significant, negative relationship between monetary policy and bank risk-taking prevails. This finding holds even when we extend the sample period and consider either the change in the real federal funds rate (column III), or when we only use observations where the federal funds rate is below its mean (columns IV and V). Therefore, the Fed's monetary policy easing in the 2000s does not seem to have significantly altered the impact of monetary policy rates on banks' risk-taking behavior. To put it differently, our results suggest that protracted periods of low interest rates have not alone induced risk-taking behavior by the US banks. It seems that the risk-taking channel of monetary policy has been in place since the 1990s when technological advances, as well as shifts in ideology and political power transformed the system of financial regulation in the US banking industry.[13]

4.1.3. Panel vector autoregressions

To confirm our main finding of a significantly negative effect of low monetary policy rates on banks' risk-taking in the medium term, we complement our analysis with panel vector autoregressions (PVAR). PVARs allow us to estimate dynamic responses to monetary policy innovations as measured by impulse response functions, where all variables are endogenous by assumption. To this end, we specify a first-order VAR model as follows:

$$Z_{it} = \Gamma_0 + \Gamma_1 Z_{it-1} + f_i + d_t + \varepsilon_{it} \quad (5)$$

[13] In fact, running the same regressions for the period before 2000 provides very similar results (available on request).

where Z is the vector of endogenous variables {*risky assets*, *bank characteristics*, *federal funds rate*}, f_i denotes fixed-effects which account for individual heterogeneity and d_t are time dummies to capture aggregate macroeconomic shocks that may affect all banks in the same way. In order to isolate the *monetary policy shocks* to *risky assets* we need to decompose the residuals in such a way that they become orthogonal. The usual convention is to adopt a particular ordering and allocate any correlation between the residuals of any two elements to the variable that comes first in the ordering. In other words, the identifying assumption is that the variables that appear later in the system are "more endogenous". Therefore, we opt for ordering the federal funds rate last and treating its innovations as the policy shocks.

We present graphs of the impulse response functions and the 5% error bands generated by Monte Carlo simulation. Figure 3a illustrates the impulse response of *risky assets* to a *monetary policy shock* for the model without bank-level variables, whereas Figure 3b graphs the corresponding response with bank-specific characteristics. Bear in mind that both figures show the response of risky assets to a one-time standard deviation *increase* in monetary policy rate (i.e., contractionary monetary policy shock). Therefore, the response to an expansionary monetary policy shock is the reverse from that illustrated in Figures 3a and 3b. We observe in both figures that risky assets initially respond negatively to expansionary monetary policy shocks. This is in accordance with the sign of the estimated coefficients of the 1st and 5th lag of the federal funds rate in Table 1. However, after the 9th quarter risky assets increase sharply reaching their maximum after roughly the 13th quarter. Afterwards, risky assets reduce again and stabilize (especially when bank-specific characteristics are taken into account) after nearly 20 quarters. This verifies the previous findings that the risk-taking channel of monetary policy transmission operates mainly in the medium term.

4.2. Evidence from syndicated loans

Table 4 analyzes in depth the impact of monetary conditions on the overall credit standards for new loans. We report the results first without any controls for borrower and lead bank characteristics. However, we include time fixed effect to control for unobservable time-variant common shocks. Columns I and II show the results when regressing loan spreads on monetary policy shocks along with loan-specific characteristics. In Columns III to V, we introduce a series of borrower and lead bank characteristics. In Column VI, we replace monetary policy shocks with the change in the federal funds rate. Finally, in Columns VII to IX we report the results of the baseline regression over different sub-periods and subsamples. Monetary conditions are primarily measured using the monetary policy shocks as advanced by Romer and Romer (2004) to deal directly with the endogeneity problem. Again, the prior identification of monetary policy means that the interest rate variable is exogenous. Thus, all alternative specifications are estimated using OLS with robust standard errors, except for specification II which is estimated using OLS with cluster-robust standard errors.

It is interesting to note that the coefficient of monetary conditions carries a highly significant negative sign across the different specifications, sub-periods and subsamples, becoming -31.217 in the most demanding specification (Column V). This clearly indicates that loan spreads increase with monetary policy expansion. Because we use the spread over LIBOR, the increase in spreads can be interpreted as an increase in the risk premium banks demand on risky investments. In other words, banks tend to soften their lending standards after an expansionary monetary policy shock, indicating increasing risk appetite. Thus, our results confirm the presence of an active risk-taking channel of monetary policy in the USA. Notably, for new loans the effect prevails right away, not with a lag as in the case for all loans. Thus, we confirm that following a monetary contraction, banks act instantaneously to increase their risk through their new loan deals.

Interestingly, we find evidence for risk taking effects for both the full sample period and different sub-periods and subsamples (Columns VII to IX). These effects are more pronounced in the post-2001 period (Column VII), but they do remain statistically significant in the pre-2001 era (Column VIII). Therefore, in line with the findings reported in Section 4.1.2, we suggest that the risk-taking channel has been in place since the early 1990s when financial innovation and deregulation transformed the US banking sector.

Next, we discuss how the control variables affect loan spreads. The results indicate that larger loans and loans with larger syndicate size are associated with lower loan spreads. The coefficient of loan maturity is generally positive but statistically insignificant indicating that longer tenured syndicated loans do not have a significant impact on loan pricing. In addition, the results for loan contract terms indicate that loans with performance pricing and loans with financial covenants have lower spreads, and that secured loans and loans with general covenants have higher loan spreads.

The variables describing borrowers' credit risk and repayment capability have also predicted associations with loan spreads. We find that borrowers with greater growth prospects, higher tangibility and more favorable debt ratings face lower loan spreads. Furthermore, bank-level characteristics are statistically significant in most instances. Our results show that risk premia are negatively related to lead bank's capital surplus indicating that well-capitalized banks charge lower spreads than their not so well-capitalized peers. This finding in a way may be suggesting that higher equity capital (that could be the result of stricter capital requirements) implies more prudent bank behavior. Similarly, bank size is negative and significant confirming the theory that larger banks prefer lending to borrowers with higher credit quality. Finally, risky assets are also negative and highly significant. At first glance, this finding is puzzling as it suggests that banks already retaining a higher share of risky assets in their portfolios, exhibit a more cautious behavior in the syndicated loan market and prefer to deal with higher quality borrowers. However, in loan announcement studies (Billet et al., 1995; Johnson, 1997), measures of the lender's risk have been also used as inverse proxies for the monitoring ability of a bank. With regard to pricing, banks with superior monitoring have the incentive to provide riskier loans since they are more confident in their ability to obtain the required return on the loan. This suggests a direct relationship between lender's monitoring ability and loan spreads, and thus an inverse relationship between risky assets and loan spreads.

5. Conclusions

Many commentators and researchers have recently argued that the prolonged period of low levels of interest rates in the 2000s is one main culprit for the excessive build up of risk in the US banking industry in the run up to the global financial crisis. Using a recent line of theoretical and empirical literature as a springboard, this paper sheds further light on the effects of the US monetary policy on the risk-taking decision of banks over the last 25 years. We exploit information on the total riskiness of US banks, as well as on the riskiness of their new loan origination. Overall, our empirical analysis reveals a strong negative relationship between bank risk-taking and monetary policy rates. Thus, an expansionary monetary policy unambiguously increases risk-related bank assets and alters the composition of bank portfolios toward a more risky position.

Nevertheless, the timing of banks' increased risk appetite differs according to the dataset used. Specifically, we find that low policy rates actually decrease the riskiness of banks' overall loan portfolios in the short term, and then significantly increase it in the medium term. Therefore, holding policy rates low for a short period of time may indeed improve the overall quality of banks' loan portfolios, but holding interest rates low for a prolonged period of time could substantially increase loan default risk over the medium term. This is in line with the predictions and findings of the theoretical and empirical research outlined in Section 2. The use of total loans may, however, underestimate the impact of monetary policy stance on loan portfolios since the risk-taking channel primarily refers to banks' incentives to engage in ex ante riskier projects. To complement our analysis, we employ data on the riskiness of new loans and find that banks tend to soften their lending standards right after expansionary policy shocks. Although, this effect is more pronounced in the 2000s, the empirical evidence suggests that the origins of the risk-taking channel of monetary policy in the USA can be traced back in the 1990s when financial deregulation and technological advancement changed the landscape of the US banking industry.

In terms of implications for macro-prudential supervision, our results suggest that the Fed should pay more attention to banks' risk behavior within a low interest rate environment, while banking supervision and regulation authorities should take into account monetary policy effects. The former implies that supervision should be integrated into a macroeconomic policy framework to meet the twin objectives (price and financial stability) of the Fed, while the latter calls for a more effective regulatory policy in limiting bank risk-taking. Our results, therefore, support the recent changes in the American financial regulatory environment (e.g. the Dodd-Frank Act and the establishment of the Financial Stability Oversight Council), which attempt to facilitate a macro-prudential approach to supervision and regulation and to monitor systemic risks. However, the question of how to implement this approach remains open as much work is needed in order to coordinate monetary and regulatory authorities, to understand the sources of systemic risk, to develop new monitoring tools and to implement policy measures to reduce macro-prudential risks.

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Tables

Table 1
Changes in the federal funds rate and bank risk

Dependent variable:	I Risky assets	II Risky assets	III Z-index	IV Z-index
L1 of Δ federal funds rate	0.004***	0.001***	0.069	-1.791***
	(18.998)	(7.851)	(0.246)	(-9.750)
L5 of Δ federal funds rate	0.005***	-0.001***	-2.240***	-0.594*
	(13.049)	(-4.199)	(-3.407)	(-1.796)
L9 of Δ federal funds rate	-0.002***	-0.004***	2.064***	0.936***
	(-5.646)	(-11.905)	(8.234)	(5.472)
L13 of Δ federal funds rate	-0.012***	-0.004***	5.537***	2.281***
	(-28.550)	(-13.561)	(6.660)	(9.155)
L4 of capital surplus		-0.014*		29.296***
		(-1.714)		(5.615)
L4 of efficiency		-0.001*		1.381
		(-1.677)		(1.345)
L4 of provisions		-0.043*		-63.995***
		(-1.883)		(-5.181)
L4 of non-traditional activity		0.009***		6.726***
		(2.769)		(2.628)
L4 of profitability		0.030		
		(1.197)		
L4 of size		0.001**		-0.341
		(2.039)		(-1.355)
Regulatory dummy 1		-0.002***		1.364***
		(-4.603)		(4.165)
Regulatory dummy 2		-0.001*		0.512
		(-1.906)		(1.402)
Regulatory dummy 3		-0.014***		5.737***
		(-20.470)		(5.009)
Constant	-0.003***	-0.001	3.577***	1.276
	(-11.107)	(-0.301)	(9.112)	(0.574)
Observations	390,702	390,702	390,038	390,038
Banks	12,531	12,531	12,521	12,521
R-squared	0.166	0.168	0.152	0.154

Notes: The table presents coefficients and t-statistics (in parentheses) from the fixed effects estimator with cluster-robust standard errors. Variables are defined in Table 1 and L denotes lag. The dataset spans the period 1985q1-2010q2. All equations include time effects. *, ** and ***denote statistical significance at the 10, 5 and 1%, respectively.

Table 2
Monetary policy shocks and bank risk

Dependent variable:	I Risky assets	II Risky assets	III Z-index	IV Z-index
L1 of monetary policy shock	0.006***	0.008***	0.005	3.723
	(13.627)	(14.175)	(0.003)	(0.761)
L5 of monetary policy shock	0.004***	0.005***	0.573	4.584
	(11.544)	(10.569)	(0.562)	(1.029)
L9 of monetary policy shock	-0.002***	-0.001***	2.311**	2.184**
	(-6.090)	(-3.164)	(2.360)	(2.006)
L13 of monetary policy shock	-0.007***	-0.006***	2.199**	2.805***
	(-15.808)	(-15.144)	(-1.965)	(2.711)
L4 of capital surplus		-0.013		21.970***
		(-1.541)		(4.809)
L4 of efficiency		-0.002*		-1.389
		(-1.740)		(-0.864)
L4 of provisions		-0.038		-46.379***
		(-1.617)		(-1.292)
L4 of non-traditional activity		0.011***		11.384**
		(3.327)		(2.020)
L4 of profitability		0.016		
		(0.591)		
L4 of size		0.001**		-1.658
		(2.359)		(-0.705)
Regulatory dummy 1		-0.006***		1.133***
		(-9.434)		(3.238)
Regulatory dummy 2		-0.001*		5.235
		(-1.687)		(1.436)
Constant	-0.000**	0.007**	1.636***	4.576
	(-2.177)	(2.162)	(12.515)	(0.605)
Observations	393,770	393,770	393,064	393,064
Banks	13,337	13,337	13,321	13,321
R-squared	0.162	0.163	0.140	0.139

Notes: The table presents coefficients and t-statistics (in parentheses) from the fixed effects estimator with cluster-robust standard errors. Variables are defined in Table 1 and L denotes lag. The dataset spans the period 1985q1-2005q4. All equations include time effects. *, ** and ***denote statistical significance at the 10, 5 and 1%, respectively.

Table 3
Monetary policy changes and bank risk: Results for different subperiods

	I	II	III	IV	V
Dependent variable:	Risky assets	Z-index	Risky assets	Risky assets	Z-index
Monetary policy variable:	Monetary policy shock	Monetary policy shock	Δ federal funds rate	Monetary policy shock	Monetary policy shock
L1 of monetary policy	0.008***	-2.017***	0.001*	0.006***	-0.084
	(9.182)	(-10.616)	(1.706)	(13.454)	(-0.527)
L5 of monetary policy	0.004***	0.120	0.002***	0.004***	0.253*
	(7.126)	(1.431)	(4.119)	(9.526)	(1.930)
L9 of monetary policy	-0.003***	0.346***	-0.005***	-0.002***	0.322***
	(-4.625)	(3.779)	(-8.953)	(-3.570)	(3.175)
L13 of monetary policy	-0.007***	1.262***	-0.001**	-0.006***	0.831***
	(-12.905)	(13.857)	(-2.191)	(-13.615)	(7.453)
L4 of capital surplus	-0.093***	69.091***	-0.072***	-0.030***	29.858***
	(-5.076)	(8.719)	(-3.819)	(-3.615)	(7.583)
L4 of efficiency	-0.002	-0.066	-0.002	-0.001	-0.382
	(-1.200)	(-0.812)	(-1.322)	(-1.544)	(-1.189)
L4 of provisions	-0.068*	-13.080*	-0.078**	-0.036	-16.443***
	(-1.702)	(-1.800)	(-2.316)	(-1.447)	(-2.759)
L4 of non-traditional activity	0.018***	0.305	0.019***	0.012***	-4.049
	(2.822)	(0.183)	(3.229)	(3.548)	(-1.544)
L4 of profitability	-0.070	10.713*	-0.046	0.003	9.278
	(-1.490)	(1.833)	(-1.136)	(0.112)	(1.014)
L4 of size	0.005***	-0.567*	-0.003***	0.000	0.197
	(3.273)	(-1.694)	(-2.634)	(0.266)	(1.292)
Regulatory dummy 2				-0.002***	-0.362
				(-4.535)	(-1.468)
Constant	0.060***	5.386	0.044***	0.002	-2.117
	(3.314)	(1.329)	(2.753)	(0.429)	(-1.452)
Observations	65,446	65,350	70,743	191,623	191,276
Banks	5,746	5,742	5,370	11,432	11,411
R-squared	0.182	0.167	0.191	0.194	0.194

Notes: The table presents coefficients and t-statistics (in parentheses) from the fixed effects estimator with cluster-robust standard errors. Variables are defined in Table 1 and L denotes lag. For columns I and II, the dataset spans the period 2001q3-2005q4. For column III the dataset spans the period 2001q3-2010q2. For columns IV and V, we only use observations where the federal funds rate variable is below its mean. All equations include time effects. *, ** and ***denote statistical significance at the 10, 5 and 1%, respectively.

Table 4
Monetary policy and the risk of loans: Evidence from new (syndicated) loans

	I	II	III	IV	V	VI	VII	VIII	IX
Monetary policy shock	-20.281***	-20.281***	-54.212***	-27.294***	-31.217***		-38.271***	-18.344***	-40.409***
	(-4.333)	(-12.707)	(-5.801)	(-4.906)	(-5.634)		(-4.374)	(-3.916)	(-6.840)
Δ federal funds rate						-10.983***			
						(-3.557)			
Number of lenders	-0.393***	-0.393**	-0.505***	-0.710***	-0.517***	-0.709***	-1.328***	0.152	-0.959***
	(-4.377)	(-2.419)	(-4.963)	(-5.613)	(-4.145)	(-7.343)	(-6.978)	(1.493)	(-6.541)
Deal amount	-15.190***	-15.190***	-9.136***	-12.383***	-12.706***	-12.388***	-5.199***	-20.194***	-12.966***
	(-23.989)	(-10.073)	(-8.231)	(-14.944)	(-15.298)	(-20.211)	(-3.860)	(-28.917)	(-12.687)
Time to maturity	0.920	0.920	5.823***	1.654	-1.639	0.584	2.904	-0.280	-0.292
	(0.810)	(0.420)	(3.665)	(1.177)	(-1.143)	(0.517)	(1.098)	(-0.224)	(-0.157)
Performance pricing provisions	-59.914***	-59.914***	-59.953***	-60.935***	-61.727***	-66.362***	-93.691***	-40.199***	-82.279***
	(-31.053)	(-13.769)	(-21.721)	(-25.354)	(-25.731)	(-36.169)	(-22.366)	(-19.915)	(-23.314)
Collateral provisions	137.151***	137.151***	117.718***	132.618***	124.267***	135.395***	144.574***	129.546***	142.381***
	(88.421)	(51.647)	(49.551)	(62.376)	(49.881)	(94.094)	(47.219)	(72.570)	(58.242)
Financial covenants	-11.712***	-11.712***	3.113	-10.407***	-14.451***	-15.426***	-18.340***	-7.959***	-17.866***
	(-4.035)	(-3.077)	(0.789)	(-2.987)	(-4.155)	(-5.561)	(-2.578)	(-2.786)	(-3.096)
General covenants	9.566***	9.566**	-0.659	12.226***	11.006***	9.138***	18.157***	7.599***	16.220***
	(4.118)	(2.445)	(-0.203)	(4.368)	(3.951)	(3.964)	(3.089)	(3.266)	(3.510)
Firm's rating by S&P			-8.142***						
			(-23.392)						
Firm's market to book value of assets				-3.545**	-3.890**				
				(-2.133)	(-2.053)				
Firm's tangibility				-4.909	1.107				
				(-1.076)	(0.243)				

Table 4 (continued)

	I	II	III	IV	V	VI	VII	VIII	IX
Firm's Z-score				-7.334***	-7.184***				
				(-6.611)	(-6.100)				
Bank's capital surplus					-4.135**				
					(-2.307)				
Bank's profitability					-0.205				
					(-0.103)				
Bank's size					-3.407**				
					(-2.550)				
Bank's risky assets					-5.710***				
					(-4.151)				
Constant	216.835***	216.835***	279.762***	217.849***	263.644***	259.853***	219.641***	234.968***	204.788***
	(38.930)	(20.622)	(25.932)	(24.790)	(23.417)	(26.244)	(18.858)	(40.632)	(27.136)
Observations	23,646	23,646	10,416	15,500	14,912	27,766	6,821	16,459	10,334
R-squared	0.380	0.380	0.492	0.405	0.542	0.384	0.377	0.396	0.365

Notes: The table presents coefficients and t-statistics (in parentheses). All specifications are estimated using OLS with robust standard errors, except from specification II, which is estimated using OLS with cluster-robust standard errors across time. Variables are defined in Table 1. For columns I-V, the dataset spans the period 1988q3-2005q4. For column VI the dataset spans the period 1988q3-2010q2. For column VII the dataset spans the period 2001q4-2005q4. For column VIII the dataset spans the period 1988q3-2001q2. Finally, in column IX we only use observations where the federal funds rate variable is below its mean. All equations include time effects. *, ** and ***denote statistical significance at the 10, 5 and 1%, respectively.

Figures

Figure 1
Average risky assets of banks over the period 1985q1-2010q2

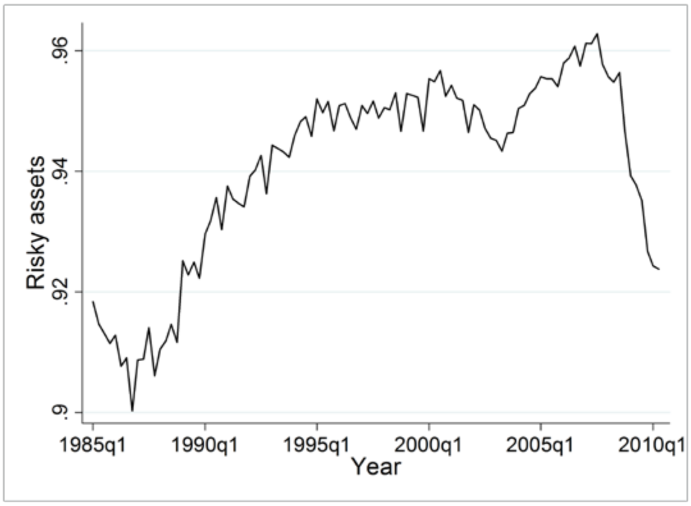


Figure 2
Change in the federal funds rate and unanticipated monetary policy shocks

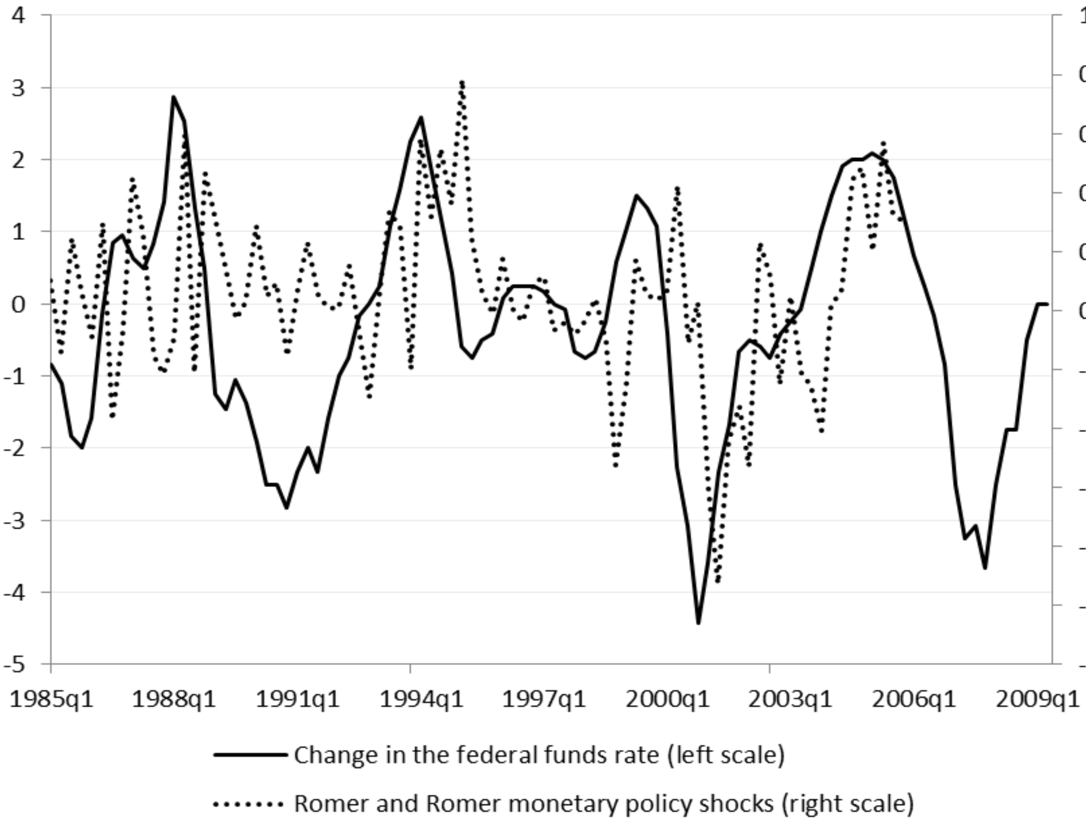
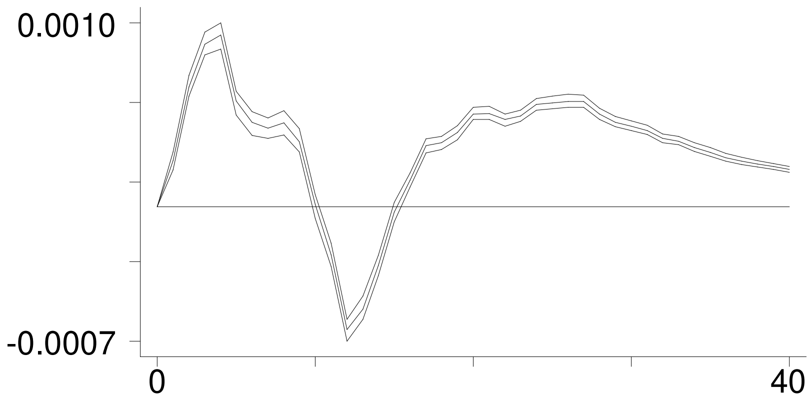
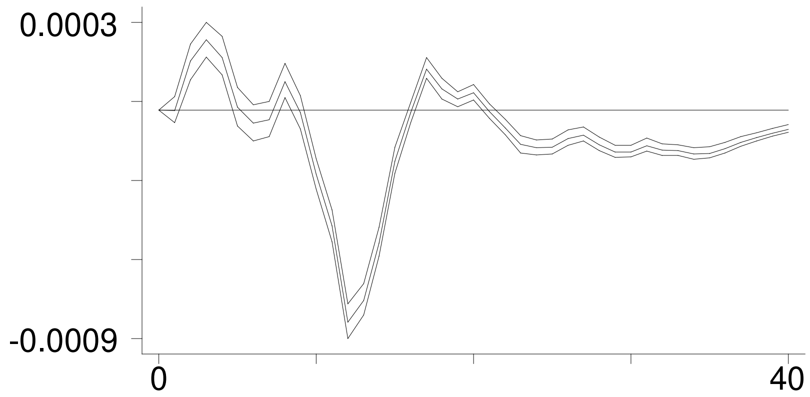


Figure 3
Impulse responses from a monetary policy shock

a. Response of risky assets to a monetary policy shock
(model without bank-level variables)



b. Response of risky assets to a monetary policy shock
(model with bank-level variables)



Notes: The figures present the impulse response of risky assets to a monetary policy shock with and without the use of bank-level variables (figures a and b, respectively). Both models also include the industrial production variable. The variables are defined in Table A1. The middle lines in all figures are the actual impulse responses and the two lines above and below are the 95% and 5% confidence intervals from Monte Carlo simulation.

Appendix

Table A1

Variable definitions and sources (analysis based on the Call Reports)

Notation	Measure
A. Dependent variables	
Risky assets	The change over the previous year (four quarters) of the ratio of risky assets (calculated as total assets minus cash and short-term securities)
Z-index	(roa+ea)/σ(roa), where roa is the ratio of the return on assets (i.e. profits before tax over total assets), ea is the ratio of total equity to total assets and σ(roa) is the variance of roa over 12 quarters

Both variables are calculated at the individual bank level, using data from the FDIC Call Reports. Other variables used for which results are not reported include ratios in terms of the risk-weighted assets and the expected default frequency. Data for these variables also come from the FDIC Call Reports.

B. Explanatory variables

a) Monetary policy variables

Δ federal funds rate	The change over the previous quarter of the real federal funds rate (federal funds rate minus the CPI inflation rate)
Monetary policy shock	The measure of unanticipated monetary policy shocks, constructed using the methodology proposed by Romer and Romer (2004)

These variables are common to all banks. Data are from Datastream. Additionally, we used the simple (nominal) federal funds rate and the non-borrowed reserves (i.e., the reserves supplied by the Fed to banks through open market operations).

b) Bank-level variables

Capital surplus	The distance of the ratio of total equity capital to total assets from 0.08
Efficiency	The ratio of total income to total expenses
Provisions	The ratio of provision for loan and lease losses to total loans
Non-traditional activity	The ratio of non-interest income to total income
Profitability	The ratio of pre-tax profits to total assets
Size	The natural logarithm of real total assets

All variables are calculated at the individual bank level and enter the estimated equations lagged four times. All data are from the FDIC Call Reports. Other variables used for which results are not reported are the interest income to the total value of loans, growth in real total assets, the ratio of loans to deposits, the ratio of commercial and industrial loans to total loans and the ratio of non-performing loans to total loans.

c) Variables characterizing the regulatory conditions

Regulatory dummy 1	Dummy variable obtaining a value 1 from 1989q3 onwards to capture the effect of the "Financial Institutions Reform and Recovery Act", enacted on August 9, 1989
Regulatory dummy 2	Dummy variable obtaining a value 1 from 1994q4 onwards to capture the effect of the "Riegle-Neal Interstate Banking and Branching Efficiency Act", enacted on September 29, 1994
Regulatory dummy 3	Dummy variable obtaining a value 1 from 2009q1 onwards to capture the effect of the implementation of Basel II, enacted on January 1, 2009

Other macroeconomic variables used (when not using time effects) are the change in industrial production, the unemployment rate, the consumer and CEO confidence and the GDP growth rate (data are from Datastream). In addition to the regulatory dummies mentioned above, we also used dummies pertaining to (i) the re-interpretation of the Glass-Steagal act on December 1996, (ii) the enactment of Gramm-Leach-Bliley Act (Repeal of Glass- Steagall Act) on November 1999, (iii) the enactment of the Commodity Futures Modernization Act (Formal financial derivative deregulation) on December, 2000 and the Voluntary Regulation Act of 2004. Information on the regulatory dummies is from the FDIC.

Table A2
Descriptive statistics of the main variables used in the empirical analysis based on the Call Reports

Variable	Obs.	Mean	Std. dev.	Min.	Max.
Risky assets	795,085	0.94	0.05	0.03	1.00
Z-index	787,355	27.82	495.30	-338.0	227,319
Federal funds rate	795,085	2.15	1.89	-3.30	5.17
Monetary policy shock	712,786	0.06	0.28	-0.93	0.78
Capital surplus	795,085	0.01	0.04	-0.66	0.91
Efficiency	795,085	1.26	0.29	0.06	62.67
Provisions	795,085	0.00	0.01	-0.55	0.97
Non-traditional activity	795,085	0.10	0.07	0.00	1.00
Profitability	795,085	0.01	0.01	-0.54	1.51
Size	795,085	11.31	1.38	6.86	21.29

Notes: The table reports the number of observations, along with the mean, standard deviation, minimum and maximum for the main variables used in the empirical analysis based on the Call Reports. Formal definitions of the variables are provided in Table A1.

Table A3
Correlation coefficients between the main explanatory variables of the empirical analysis based on the Call Reports

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Federal funds rate (1)	1.00							
Monetary policy shock (2)	0.40	1.00						
Capital surplus (3)	0.03	-0.03	1.00					
Efficiency (4)	0.05	0.01	0.24	1.00				
Provisions (5)	-0.05	-0.06	-0.15	-0.07	1.00			
Non-traditional activity (6)	0.02	0.00	-0.01	0.07	0.07	1.00		
Profitability (7)	0.04	-0.05	0.30	0.40	-0.50	0.11	1.00	
Size (8)	0.04	-0.03	-0.14	0.15	-0.05	0.29	0.12	1.00

Table A4
Variable definitions and sources (analysis based on new loans)

Notation	Measure
A. Dependent variable	
Spread over LIBOR	Describes the amount the borrower pays in basis points over LIBOR for each dollar drawn down. It adds the spread of the loan with any annual (or facility) fee paid to the bank group. The variable is calculated for each syndicated loan. Data are from Dealscan.
B. Explanatory variables	
a) Monetary policy variables	
See Table A1	
b) Firm-level variables	
Number of lenders	The total number of all lenders of the syndicated loan.
Deal amount	The deal's total amount in million dollars (in logs).
Time to maturity	A calculation of how long (in months) the facility will be active from signing date to expiration date (in logs).
Performance pricing provisions	A dummy variable representing whether the loan has performance pricing provisions.
Collateral provisions	A dummy variable representing whether the loan is secured with collateral.
Financial covenants	A dummy variable representing whether the loan has financial covenants.
General covenants	A dummy variable representing whether the loan has general covenants.
Firm's rating by S&P	The Standard and poor's debt rating of the firm. The rating scale is normalized on a linear basis to take values between 1 (D-rating) to 22 (AAA rating).
Firm's size	The firm's size, calculated as the log of the book value of total assets of the firm.
Firm's market to book	The ratio of the market value of assets to the book value of assets, which measures a firm's growth opportunities.
Firm's tangibility	The ratio of tangible assets to total assets, which measures the firm's opacity.
Firm's z-score	Z-score-is the modified Altman's (1968) Z-score (= (1.2 Working Capital+1.4 Retained Earnings+3.3 EBIT+0.999 Sales)/Total Assets), which measures the borrower's default risk.

The firm-level variables from the number of lenders to general covenants are from the Dealscan database. The rest of the variables are from Compustat. Other firm-level variables used are the primary purpose of the loan, the cash-flow volatility of firms and the book value of total debt of the borrowing firms. Adding these variables does not change the results.

c) Bank-level variables

See Table A1. The above variables are matched with bank-level data from the Call Reports.

Table A5
Descriptive statistics of the main variables used in the empirical analysis based on new loans

Variable	Obs.	Mean	Std. dev.	Min.	Max.
Spread over LIBOR	38,746	211.83	148.93	-95	1750
Monetary policy shock	37,151	0.04	0.30	-0.93	0.78
Number of lenders	43,284	6.82	8.62	1	176
Deal amount	43,284	4.76	1.82	-3.00	10.31
Time to maturity	43,229	3.52	0.81	0.00	6.01
Perf. pricing provisions	43,284	0.36	0.48	0	1
Collateral provisions	30,030	0.78	0.41	0	1
Financial covenants	43,284	0.50	0.50	0	1
General covenants	43,284	0.52	0.50	0	1
Firm's rating by S&P	21,763	11.33	4.11	1	22
Firm's size	40,694	6.33	2.20	-6.91	14.60
Firm's market to book	31,869	1.77	2.88	0.20	343.28
Firm's tangibility	39,432	0.33	0.24	0.00	1.00
Firm's z-score	32,579	1.36	15.92	-2654.58	16.64

Notes: The table reports the number of observations, along with the mean, standard deviation, minimum and maximum for the main variables used in the empirical analysis based on new loans. Formal definitions of the variables are provided in Table A4.

Table A6
Correlation coefficients between the main explanatory variables of the empirical analysis based on new loans

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
Spread over LIBOR (1)	1.00																	
Monetary policy shock (2)	-0.09	1.00																
Number of lenders (3)	-0.24	0.00	1.00															
Deal amount (4)	-0.25	-0.02	0.59	1.00														
Time to maturity (5)	0.11	0.14	0.07	0.10	1.00													
Perf. pricing provisions (6)	-0.30	-0.02	0.17	0.19	0.11	1.00												
Collateral provisions (7)	0.58	0.00	-0.18	-0.24	0.29	-0.17	1.00											
Financial covenants (8)	-0.01	-0.14	0.15	0.22	0.08	0.44	-0.02	1.00										
General covenants (9)	-0.04	-0.06	0.13	0.21	0.04	0.40	-0.05	0.57	1.00									
Firm's rating by S&P (10)	-0.47	-0.01	0.21	0.29	-0.16	0.13	-0.48	-0.03	0.02	1.00								
Firm's size (11)	-0.32	-0.05	0.45	0.71	-0.18	0.10	-0.42	0.09	0.12	0.40	1.00							
Firm's market to book (12)	-0.06	0.00	0.02	0.01	-0.01	0.03	-0.04	0.02	0.01	0.05	-0.01	1.00						
Firm's tangibility (13)	-0.02	0.00	0.00	0.00	-0.04	-0.05	-0.04	-0.06	-0.05	0.03	0.06	-0.05	1.00					
Firm's z-score (14)	-0.28	0.02	0.00	0.00	-0.02	0.12	-0.20	0.02	0.02	0.19	-0.06	0.06	-0.31	1.00				
Bank's capital surplus (15)	-0.07	0.01	-0.02	0.00	-0.01	0.05	-0.04	0.00	0.01	-0.02	0.03	0.02	0.00	0.03	1.00			
Bank's profitability (16)	-0.02	0.00	-0.01	0.00	-0.02	0.03	-0.06	0.01	0.00	-0.01	-0.01	0.00	0.04	0.00	0.27	1.00		
Bank's size (17)	-0.09	0.12	-0.04	0.07	-0.05	0.05	0.11	-0.03	0.00	-0.01	-0.10	0.06	-0.09	0.03	0.18	0.24	1.00	
Bank's risky assets (18)	-0.12	0.03	-0.05	0.06	0.00	0.07	-0.04	0.04	0.04	-0.05	0.01	-0.03	-0.11	0.02	-0.19	-0.15	0.18	1.00