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In Search for Yield? New Survey-Based Evidence on Bank Risk Taking

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Abstract

There is growing consensus that the conduct of monetary policy can have an impact on financial and economic stability through the risk-taking incentives of banks. Falling interest rates might induce a "search for yield" and generate incentives to invest into risky activities. This paper provides evidence on the link between monetary policy and commercial property prices and the risk-taking incentives of banks. We use a factor-augmented vector autoregressive model (FAVAR) for the U.S. for the years 1997-2008. We include standard macroeconomic indicators and factors summarizing information provided in the Federal Reserve's *Survey of Terms of Business Lending*. These data allow modeling the reactions of banks' new lending volumes and the riskiness of new loans. We do not find evidence for a risk-taking channel for the entire banking system after a monetary policy loosening or an unexpected increase in property prices. This masks, however, important differences across banking groups. Small domestic banks increase their exposure to risk, foreign banks lower risk, and large domestic banks do not change their risk exposure.

JEL-Code: E440, G210.

Keywords: FAVAR, bank risk taking, macro-finance linkages, monetary policy, commercial property prices.

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1 Motivation

There is growing consensus that the conduct of monetary policy can have an impact on financial and economic stability through the risk-taking incentives of banks (Rajan 2005, Borio and Zhu 2008). Falling interest rates might induce a "search for yield" and generate incentives to invest into risky activities such as in the years preceding the global financial crisis. This can have implications for optimal central bank policy which may want to take into consideration aspects of financial stability (see, e.g., Stein 2010). Conducting optimal central bank policy, however, requires a thorough understanding of banks' attitude towards risk taking following monetary policy actions. Providing evidence on the link between monetary policy as well as commercial property prices and the risk-taking incentives of banks is the purpose of this paper.

We use the theoretical setup by Dell'Ariccia et al. (2010) to show the conditions under which banks increase risk following a decline in the monetary policy rate. In their model, banks hold a portfolio of risky loans, financed with deposits and equity. Monitoring can increase the probability of loan repayment. The deposit rate is fixed at the policy rate, but equity requires paying a mark-up over the policy rate. In this baseline model, there is a *pass-through effect* in the sense that lower policy rates decrease loan rates. This pass-through effect lowers the incentives to monitor (i.e. risk increases) and it can be interpreted as a "search for yield" effect.[1] In addition, there is a *risk-shifting effect* because risk can be shifted from depositors to equity-holders. The importance of the risk-shifting effect depends on the degree of leverage of the bank. If bank equity is low, monitoring increases with a lower policy rate; if bank equity is high, monitoring decreases.

Besides monetary policy actions, developments in the real estate markets affect collateral values, and this has implications for banks' risk-taking choices. We thus modify the model by allowing lending to be backed by collateral. An increase in the liquidation

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[1] The link between low interest rates, risk taking, and "search for yield" has been described as follows: "*[…] These behaviors can be compounded in an environment of low interest rates. Some investment managers have fixed rate obligations which force them to take on more risk as rates fall. Others like hedge funds have compensation structures that offer them a fraction of the returns generated, and in an atmosphere of low returns, the desire to goose them up increases. Thus not only do the incentives of some participants to "search for yield" increase in a low rate environment, but also asset prices can spiral upwards, creating the conditions for a sharp and messy realignment.*" (Quoted from: Raghuram G. Rajan, The Greenspan Era: Lessons for the Future, Saturday, August 27, 2005, Jackson Hole, Wyoming) Of course, incentives to take risks are also shaped by the regulatory and institutional environment (Hellwig 2008). As we focus only on banks that are active in the U.S., we cannot investigate the impact of differences in regulations across countries.

value of the collateral reduces the gains from monitoring. Intuitively, banks optimally choose to reduce monitoring efforts, ending up with a riskier loan portfolio. The model shows the importance of modeling collateral shocks and the degree of collateralization of loans.

We use a small-scale vector autoregressive model (VAR) and a factor-augmented VAR (FAVAR) for the U.S. to analyze the reaction of banks' risk taking to monetary policy and commercial property price shocks. The empirical models comprise GDP growth, GDP deflator inflation, commercial property price inflation, the monetary policy interest rate, and information on business lending provided in the Federal Reserve's *Survey of Terms of Business Lending* (STBL). The STBL questionnaire asks banks, classified into small domestic, large domestic and foreign banks, to rate the risk of new loans based on the borrower's credit history, cash flow, credit rating, access to alternative sources of finance, management quality, collateral, and quality of the guarantor. Hence, we can control for contract terms that potentially affect the riskiness of loans. The STBL survey focuses on *new* loans, unlike other data sources that do not allow separating new and outstanding loans. This distinction is important if the goal is to analyze risk taking by banks.[2]

In the VAR, we use only a small subset of the series contained in the STBL. Specifically, we look at reactions of risk-weighted loans and loan spreads to shocks and compare them with reactions of unweighted loans and spreads. Compared to the VAR, the FAVAR allows exploiting a much larger amount of data. All information contained in the survey are condensed into common factors which are, in turn, included in the FAVAR. The FAVAR thus enables us to test the theoretical predictions concerning the heterogeneous responses of banks to monetary policy and collateral shocks.

Our main findings are as follows. There is no evidence of a risk-taking channel for the entire banking system after expansionary monetary policy shocks. This masks, however, important differences across banking groups. Small domestic banks take on more new risk, while foreign banks lower risk, and large domestic banks do not change their exposure to new risk. From a theoretical point of view, these differences can be traced to differences in the degree of capitalization and in the monitoring technologies across banks. Shocks to commercial property prices, our proxy for the collateral value of business lending, lead to higher risk across all banking groups, confirming the theoretical

[2] The paper does not consider the existing loans. One cannot exclude that the riskiness of those loans changes after the shocks considered with consequences for the total risk (i.e. risk of new and outstanding loans) of banks.

prediction. Lending rates move closely in line with policy rates after the two shocks. This response of lending rates is very similar across banks and risk categories, indicating a high degree of price competition in U.S. banking.

Our paper is related to recent empirical studies analyzing the link between monetary policy and bank risk. Table 1 provides an overview of this literature, and we include evidence on the impact of fluctuations in house prices on risk. This literature does not come to a consistent conclusion on how monetary policy affects risk. A first set of papers finds that lower interest rates increase bank risk. This branch of the literature includes studies using bank-level data (Altunbas et al. 2010, Ioannidou et al. 2009, Jiménez et al. 2010),[3] time series (FAVAR and VAR) evidence for the U.S. (Eickmeier and Hofmann 2010, Angeloni et al. 2010, or Lang and Nakamura 1995), or univariate regressions (De Nicolò et al. 2010).

Another set of studies finds that risk falls following expansionary monetary policy (and house price) shocks. Again, this literature uses different empirical techniques such as the FAVAR methodology to micro-level data from U.S. banks (Buch et al. 2010) or an integrated micro-macro model for Germany (De Graeve et al. 2008).

These studies differ in various respects. First, they differ in the way they measure bank risk. The risk-taking channel as advanced by Rajan (2005) and Borio and Zhu (2008) describes the incentives to engage in *ex ante* riskier projects. Some studies focus explicitly on (*ex post*) risk (Buch et al. 2010, De Graeve et al. 2008) and find – as expected – a decline in risk to the extent that the value of the underlying collateral increases. Studies that distinguish between realized risk (on existing loans) and new risk (on new loans) are Ioannidou et al. (2009) and Jiménez et al. (2010), who use confidential data at the bank-borrower level. De Nicolò et al (2010) also rely on data from the STBL.[4] They use a measure of average internal risk rating assigned to loans by the bank and the loan spread over the Federal Funds rate, which are similar to the measures we use in our VAR, but they use a univariate regression framework.

Second, the studies surveyed in Table 1 differ in the way they model the interaction between banks and the macroeconomy and in the way they define monetary policy shocks. The panel studies regress risk measures on monetary policy interest rates and additional explanatory variables. These studies allow interest rates and other

[3] In addition, according to Altunbas et al. (2010), bank risk increases with positive house price growth.

[4] Lang and Nakamura (1995) also use STBL data but focus on the sample period 1979-1992 when banks were not yet asked to assign new loans to different risk categories.

macroeconomic factors to affect banks, but generally do not take into account feedback from banks to the macroeconomy. The VAR- or FAVAR-based studies allow for mutual interaction between banks and the macroeconomy. In addition they focus on identified, mutually orthogonal, macroeconomic shocks.

Our main contribution stems from the fact that we combine different aspects of the above research. First, we jointly analyze the effect of identified monetary policy and commercial property price shocks on bank risk taking with respect to *new* loans. Second, our model allows for mutual feedback between the macroeconomy and the banking sector. Third, we derive impulse responses of more and less risky bank loans to commercial property price shocks which have not been investigated much before.

In Section 2, we briefly review the theoretical mechanism we have in mind based on Dell'Ariccia et al. (2010). In Section 3, we describe our data. In Sections 4 and 5, we present our empirical results from the VAR and the FAVAR, respectively. In Section 6, we conclude.

2 The Theoretical Mechanism

The theoretical banking literature has only recently started to explicitly analyze the role of monetary policy in banks' risk-taking decisions (Agur and Demertzis 2010, Dell'Ariccia et al. 2010).[5] In the model by Dell'Ariccia et al. (2010), which we summarize in Table 2, monitoring of loan applicants is the only channel through which risk can be reduced. Alternatively, banks can require borrowers to pledge collateral (Bester and Hellwig 1987).

In Dell'Ariccia et al. (2010), banks recover nothing from a borrower in case a project does not succeed. To capture the effects of collateral without changing the basic structure of their model, we assume that the value of the project is backed by some collateral value.

[5] Our focus in this section is on partial equilibrium models of the banking sector. Recently, dynamic stochastic general equilibrium models have been modified to include an active banking sector. While these models have similar qualitative implications for lending volumes in response to changes in the stance of monetary policy, implications for risk differ. The models of Angeloni et al. (2010) and Angeloni and Faia (2009) predict a risk-taking channel of monetary policy, while models such as those of Zhang (2009) and Dib (2010) predict a risk-reducing effect of cuts in the monetary policy instrument. See Buch et al. (2010) for a detailed discussion.

Other than that, our model is identical to theirs.[6] Profits of a representative bank are given by:

$$\Pi = \left[q\left(r_L - r_D(1-k)\right) + (1-q)w - r_E k - \frac{1}{2}cq^2 \right] L(r_L) \qquad (1)$$

where loans are the bank's only assets. $L(r_L)$ is loan demand as a negative function of the loan rate: $\partial L(r_L)/\partial r_L < 0$. Banks can influence the probability that a project succeeds – which happens with probability q – by monitoring the borrower. Monitoring costs are quadratic in the intensity of monitoring $\frac{1}{2}cq^2$. In case the project fails – which happens with probability $1-q$ – banks recover a liquidation value from the project w which is strictly smaller than the risk free rate $w < r$ and proportional to the volume of lending.

Banks fund themselves with deposits and equity, which are a fixed fraction k of total assets. The deposit rate is identical to the refinancing rate $r_D = r$. Depositors are repaid only in case of success, but they are covered by a fairly priced deposit insurance. Risk has thus no impact on the deposit rate. The rate of return on equity depends on the refinancing rate, and on an equity risk premium which decreases linearly in the probability of success of the project: $r_E = r + \xi - aq$.[7]

The model is solved by backward induction in two steps. In a first step, banks optimally choose the lending rate. In a second step, and given the lending rate, banks choose the probability of monitoring. Banks choose the optimal monitoring intensity according to:

$$\frac{\partial \Pi}{\partial q} = \left[r_L - r_D(1-k) - w + ak - cq \right] L(r_L) = 0 \qquad (2)$$

or $\quad \hat{q} = \frac{1}{c}\left(r_L - r_D(1-k) - w + ak\right).$

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[6] Literature on the use of screening and sorting through collateral as two devices to control the risk of banks' asset portfolios is based on the seminal paper by Stiglitz and Weiss (1981). In this paper, higher lending rates lead to an increase in risk because of adverse selection and moral hazard effects. In the banking literature, the solution to banks' optimization problem involves the specification of optimal contracts which take the participation and incentive constraints of borrowers and/or lenders into account. The model we use here is much simpler since it simply serves to illustrate the main theoretical intuition behind our empirical model.

[7] The liquidation value of the collateral could be used to capture bankruptcy costs. Even if the liquidation value would accrue to the equity holders, equity holder would still be subject to some downside risk because the return from liquidation is lower than the risk free rate. This rationalizes the assumption that equity holders demand a risk premium over the risk free rate when providing capital.

Optimal monitoring decreases in the costs of monitoring, in the policy rate (because $r_D = r$), and in collateral values. It increases in lending rates and in the degree of capitalization. For given interest rates, banks with high monitoring costs respond more to a change in collateral values or the policy rate than banks with low monitoring costs: $\frac{\partial \hat{q}}{\partial w} = -\frac{1}{c}$ and $\frac{\partial^2 \hat{q}}{\partial w \partial c} = \frac{1}{c^2}$.[8]

The effect of an increase in the policy rate is given by: $\left.\frac{\partial \hat{q}}{\partial r}\right|_{dr_L=0} = -\frac{1}{c}(1-k)$. This is the same result as in Dell'Arriccia et al. (2010). Banks with higher monitoring costs also respond more to a change in the policy rate: $\frac{\partial^2 \hat{q}}{\partial r \partial c} = \frac{1}{c^2}(1-k)$.

Yet, banks also adjust their lending rate in response to changes in the policy rate and collateral values. Solving for the first stage of the model, hence endogenizing the response of lending rates, it can be shown that well-capitalized banks lower monitoring if the policy rate decreases while poorly capitalized banks increase monitoring.[9] Intuitively, for low levels of capitalization, the risk-shifting effect dominates. Lower policy rates imply an increase in intermediation margins ($r_L - r_D$), thus banks predominantly funded with insured deposits have an incentive to monitor in order to realize the gains from higher margins. Monitoring increases (risk decreases). For high levels of capital, the pass-through effect dominates since for those banks the gains from the higher margins are relatively modest due to the high share of funding via equity capital. Monitoring decreases (risk increases).

Dell'Ariccia et al. (2010) model two extensions of their baseline framework. In the first extension, banks endogenously choose their capital structure. In this case, leverage decreases with the policy rate and monitoring always increases when the policy rate increases. In our empirical model below, we focus on the adjustment of banks to macroeconomic shocks at business cycle frequency. The impact effect of macroeconomic shocks thus resembles the situation with exogenous capital. Over time, banks can adjust their capital structures, and the response to shocks should become more similar across banking groups.

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[8] This specification assumes that second-order effects on the costs of capital can be ignored, i.e. $\frac{\partial^2 r_E}{\partial q \partial r}, \frac{\partial^2 r_E}{\partial q \partial w} = 0$.

[9] The formal proofs are very similar to those presented in Dell'Ariccia et al. (2010).

In the second extension, Dell'Ariccia et al. (2010) model adjustment of banks under the assumption of perfect competition versus monopoly power of banks. The greater the degree of competition, the faster is the pass-through of changes in policy rates onto lending rates. Hence, margins are less sensitive to changes in policy rates in more competitive markets, the risk-shifting effect becomes less important, and the pass through effect starts to dominate.

Overall, the model shows that lower policy rates lead to more risk-taking in environments where banks can adjust their capital structure. If the adjustment of the capital structure is limited, the risk-taking channel of monetary policy is less pronounced for poorly capitalized banks and/or banks with market power.

The baseline model assumes a representative bank, but an extension accommodating differences across banks would be straight forward. For instance, different banks (such as domestic and foreign banks) can have different monitoring costs. High monitoring costs indicate low productivity and thus impede asset growth. Hence, the monitoring costs of small banks are higher than those of large banks: $c^{small} > c^{l\arg e}$. (Note that this specification does not distinguish between the costs of acquiring soft versus hard information. Hence, it is not inconsistent with a relative cost advantage of small banks in the acquisition of soft information.)

Moreover, if screening costs involve a fixed component, small banks, are *ceteris paribus*, less likely to screen than large banks, and they are more likely to use collateral as an alternative sorting mechanism. Consistent with this interpretation, our data show that, on average, 77% of the loan portfolio of small banks is backed by collateral as compared to 39% for the large domestic banks and only 22% for the foreign banks.[10] This pattern is quite consistent across the different risk categories: in the highest risk category (acceptable risk), 88% of loans given out by small banks are backed by collateral, compared to 63% for the domestic and 23% for the foreign banks. The shares of loans in the high risk category are more similar with 24% for the large banks, 31% for small banks, and 34% for foreign banks. A priori, we thus expect lending of small banks to be relatively more sensitive to changes in collateral values.

Finally, one could modify the model to accommodate the fact that foreign banks are also affected by the foreign monetary policy rate $r*$ by specifying the deposit rate as $r_D = r_D(r, r*)$. Because foreign banks are able to raise loanable funds in foreign markets,

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[10] See Section 3.2 for a more detailed description of the STBF data.

for instance via internal capital markets (Cetorelli and Goldberg forthcoming), it is reasonable to assume that the elasticity of foreign banks' funding costs with respect to the domestic interest rate is lower than that of domestic banks: $\frac{\partial r_D^{Dom}}{\partial r} = r_{D,r}^{Dom} > r_{D,r}^{For}$. Hence, foreign banks can be expected to respond less to domestic shocks.

In sum, the model yields the following hypotheses concerning the impact of monetary policy and collateral shocks:

(i) *Impact of monetary policy shocks*: Monitoring and lending rates depend on the policy rate. If capital is exogenous, monitoring declines (i.e. risk-taking increases) if refinancing rates fall for well-capitalized banks and increases for poorly capitalized banks. If banks adjust leverage, monitoring unambiguously decreases (risk increases). The impact of changes in monetary policy rates on risk taking also depends on the market power of banks: Banks with monopoly power lower risk; banks operating in competitive markets increase risk. Optimal lending rates increase in the policy rate.

(ii) *Impact of collateral shocks*: Banks use monitoring and collateral as substitute mechanisms to control risk. If collateral values increase, the intensity of monitoring falls. Banks with higher monitoring costs react more to changes in collateral. Optimal lending rates decrease in collateral shocks. In the empirical model, we will capture these shocks through commercial property price shocks.

3 Data

3.1 Macroeconomic Data

Our set of macroeconomic variables comprises the differences of the logarithms of GDP, of the GDP deflator, and of real commercial property prices as well as the level of the effective Federal Funds rate. Commercial property prices approximate the value of collateral. Since our focus lies on business loans, we use commercial property prices instead of residential property prices which are more relevant for consumer loans. Real commercial property prices are measured as the transactions-based price index constructed based on data from the National Council of Real Estate Investment Fiducaries (NCREIF) by the MIT Center for Real Estate, divided by the GDP deflator. Data on the Federal Funds rate are retrieved from freelunch.com, a free Internet service provided by Moody's Economy.com. Data on GDP and the GDP deflator are taken from the Bureau of Economic Analysis. GDP, the GDP deflator and the policy rate are variables which are commonly included in small-scale macroeconomic VARs. The macroeconomic series are plotted in Figure 1a.

3.2 Banking Data

Our source for banking data is the Federal Reserve's quarterly *Survey of Terms of Business Lending* (STBL).[11] This survey collects data on gross new loans made during the first full business week in the mid-month of each quarter. The panel for the survey is a stratified sample of more than 400 institutions. The STBL contains information on loan volumes and on loan contract terms. This information is available for all commercial banks as well as for three banking groups: large domestic banks, small domestic banks, and U.S. branches and agencies of foreign banks. For foreign banks, the data do not distinguish between large and small banks. However, it is well known that internationally active firms and banks are larger than their domestic counterparts (e.g. Cetorelli and Goldberg forthcoming).

The STBL provides information on riskiness of new loans. Banks are asked to classify new business loans extended during the survey week into one of the following four categories of increasing risk: ”minimal risk”, ”low risk”, ”moderate risk”, and ”acceptable risk”. The classification of loans is based on a number of indicators which are condensed into a risk rating for loans. This classification takes hard information (cash flow, credit history, credit ratings, quality of collateral) as well as soft information (management quality) and, hence, practically all aspects of loan quality into account. Therefore, a shift in the composition of bank loans across different risk categories reflects changes in the credit standards. On average, moderate risk loans have been the most important category (41% of total loans), followed by loans in the highest risk category “acceptable” risk (28%), low risk loans (23%), and minimal risk loans (8%).

As regards information on contract terms, the STBL survey additionally includes information on the shares of loans made under commitment, secured by collateral, subject to prepayment penalty, loan size, the loan rate, and the loan maturity. We include this information for the entire banking sector, for the subgroups of banks, and for the four different risk categories. This accounts for the fact that banks can change the risk and the return of their loan portfolio in a number of ways. They can vary the intensity of

[11] See Brady et al. (1998) for a detailed discussion of the structure of the STBL. We choose not to combine the STBL data with information from other sources on U.S. banks such as the Call Reports. Our information on the sample composition underlying the STBL survey is insufficiently detailed, and we want to avoid introducing additional measurement or aggregation errors.

monitoring, they can change the degree of collateralization, they can charge penalty rates, or they can modify the maturity structure. While the monitoring choice cannot be observed, including other choice variables minimizes omitted variables problems and allows isolating the effects of macroeconomic shocks on bank lending, bank risk taking, and lending rates.

How does the classification of loans according to these criteria match the definition of bank risk in the theoretical model by Dell'Arricia et al. (2010)? The data classify loans into different risk categories based on observed contract terms. Monitoring, which is the main determinant of bank risk in the theoretical model, cannot be observed. Given the observed terms in loan contracts, any shift in the structure of loans across risk categories must thus be due to changes in the monitoring intensity of banks.

Our panel of banking data contains 140 variables.[12] Loan volumes are divided by the GDP deflator and, hence, enter in real terms. The sample period is 1997Q2 to 2008Q2. The beginning of the sample is restricted by the availability of the information on loan riskiness which starts with the May 1997 survey. We exclude the period after the second quarter of 2008 because unconventional monetary policy measures weaken the usefulness of the Federal Funds rate to identify monetary policy shocks.

The VAR analysis (Section 4) includes, besides the macro variables, summary measures of the lending and risk-taking behavior of the U.S. commercial banking system. These measures are unweighted loans and loan spreads and, alternatively, risk-weighted loans and loan spreads. The risk-weighted measures are constructed in the spirit of Basel II based on information from the STBL. The weights for loans of minimal, low, moderate and acceptable risk are 0.06, 0.16, 0.31, and 0.47, respectively.[13] This produces a loan index and a loan spread that increase in risk. The (unweighted and weighted) loan indices enter in differences in the VAR. The spreads enter in levels. The weighted index' growth rate and the spread as well as their unweighted counterparts are plotted in Figure 1b. The figure shows that risky loans indeed increased considerably in the years before the latest crisis (2004-2005) while growth of unweighted loans was somewhat lower over this

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[12] Two of the 140 series have missing values in one quarter each. We use the EM algorithm to interpolate these series. See for details Stock and Watson (2002).

[13] According to the Basel II guidelines (BIS 2005), the standard risk weight for unrated claims on corporates is 100%. For rated firms, the risk weights are 20% (AAA to AAA+), 50% (A+ to A-), 100% (BBB+ to BB-), and 150% for ratings below BB-. We have rescaled the weighted 0.2, 0.5, 1 and 1.5 to sum up to 1 which yields the weighted presented in the main text. Our measure of risk-weighted loans is not identical to risk-weighted assets because we consider business loans only.

period. Interestingly, the risk-weighted spreads have exceeded the unweighted spreads in particular since 2003.

For the FAVAR analysis (Section 5), we exploit all information provided in the STBL. We treat the banking data as usual for factor analysis. All series are seasonally adjusted. Stationarity of the 20 loan series in the dataset is ensured by taking differences of their logarithms. The time series on loan rates, the percentage share of loans made under commitment, and the percentage share of loans secured by collateral can be considered to be stationary in levels. Hence, we do not (log) difference them. The stationary series are then demeaned and standardized to have unit variance. Finally, we remove outliers, defined as observations with absolute median deviations larger than three times the interquartile range. They are replaced by the median value of the preceding five observations (Stock and Watson 2005). All series from the survey are then summarized in a $\boldsymbol{N}(=140)\times 1$ vector $\mathrm{X}_{\boldsymbol{t}}=\left[\boldsymbol{x}_{1\boldsymbol{t}} \quad ... \quad \boldsymbol{x}_{\boldsymbol{Nt}}\right]'$, and $\mathrm{X}_{\boldsymbol{t}}$ enters the FAVAR model.

4 Evidence from the VAR

Before carrying out the FAVAR analysis, we estimate two small-scale VARs to gain first insights into the dynamics of aggregate bank risk. The main advantage of a parsimonious VAR compared to a large-dimensional FAVAR approach is that we save on degrees of freedom because we only include two additional variables to our set of macroeconomic variables as opposed to four factors as we will determine below. This might be particularly useful because our sample is short.

Our two VARs take the following form:

$$\begin{bmatrix} \Delta \boldsymbol{y}_t \\ \Delta \boldsymbol{p}_t \\ \Delta \boldsymbol{cpp}_t \\ \Delta \boldsymbol{l}_t \\ \boldsymbol{ls}_t \\ \boldsymbol{ffr}_t \end{bmatrix} = \mathrm{d} + \Psi(\boldsymbol{L}) \begin{bmatrix} \Delta \boldsymbol{y}_{t-1} \\ \Delta \boldsymbol{p}_{t-1} \\ \Delta \boldsymbol{cpp}_{t-1} \\ \Delta \boldsymbol{l}_{t-1} \\ \boldsymbol{ls}_{t-1} \\ \boldsymbol{ffr}_{t-1} \end{bmatrix} + \mathrm{w}_{\boldsymbol{t}}, \quad (4)$$

where Δy_t is GDP growth, Δp_t is GDP deflator inflation, $\Delta \boldsymbol{cpp}_t$ is real commercial property price inflation, and ffr_t is the Federal Funds rate. $\Delta \boldsymbol{l}_t$ denotes the growth rate of loans, and $\boldsymbol{ls}_t$ is the loan rate over the Federal Funds rate. In the first VAR, $\boldsymbol{l}_t$ and $\boldsymbol{ls}_t$ capture the risk-weighted loan index and the risk-weighted loan spread as described above. In the second VAR, the risk-weighted measures are replaced by their unweighted counterparts. A comparison between the weighted and the unweighted measures will give us some first indication on risk taking by banks: If risk-weighted loans rise more than unweighted loans, this indicates risk taking by the banks. d comprises constants, $\Psi(\boldsymbol{L})$ is a lag polynomial of finite order $\boldsymbol{q}$, and w_t is an error term which is i.i.d. with zero mean and covariance matrix Ω. We set $\boldsymbol{q} = 1$ as suggested by the BIC.

Monetary policy and commercial property price shocks shocks are identified by applying a Cholesky decomposition. We assume that GDP, aggregate prices and property prices do not react contemporaneously to shock to bank loans, loan spreads, and the monetary policy rate, which is fairly standard in SVAR studies. GDP and the overall price level react with a delay to property price movements (see, e.g., Jarociński and Smets 2008). Moreover, we allow the monetary policy instrument to respond contemporaneously to all shocks.

While it is relatively common to use a Cholesky decomposition to identify housing shocks (see, e.g., Giuliodori 2005 and Iacoviello 2005), alternative identification schemes for the house price shock such as a combination of zero contemporaneous and long-run restrictions as, e.g., employed by Bjørnland and Jacobsen (2008) yield similar results.

By ordering the policy instrument below loans and loan spreads, we follow most of the SVAR literature which jointly models macroeconomic and credit variables (Ciccarelli et al. 2010). The identification scheme implies that monetary policy can react instantaneously to bank loan and spread shocks, but not *vice versa*. The STBL is collected in order to inform the Federal Reserve's monetary policy decisions. Insofar, the information in the survey should be part of information of the Fed, which supports our identification assumption.

It is somewhat more questionable whether banks might not be able to react immediately in their decision to extend new loans (or adjust loan rates) in response to unexpected movements in the policy rate. Berrospide and Edge (2010), for instance, assume that banking variables can react contemporaneously to innovations in the Federal Funds rate. Yet, reasons for sluggish adjustment of the banking sector to monetary policy could be the need to renegotiate existing contracts or close customer relationships that banks do not want to interrupt. The finding by the empirical banking literature that lending rates of banks are sticky and do not react quickly to market interest rates (Berger and Hannan 1991) further supports our choice to order loan spreads before the Federal Funds rate. To test robustness with respect to the ordering, we have also ordered the monetary policy rate before the loan index and the spread, but the qualitative results do not change.

Figures 2a and 2b show the responses of the endogenous variables to one standard deviation monetary policy and property price shocks, respectively. The solid black lines represent the median impulse responses obtained from the VAR which includes the risk-weighted loan and spread measures while the dark (light) blue shaded areas correspond to the confidence bands at the 68 (90)% significance level which were constructed based on the bootstrap-after-bootstrap method proposed by Kilian (1998). The dotted-dashed black lines represent the 68% confidence bands of impulse responses of the unweighted loan and spread measures. (We omit 90% confidence bands and median impulse responses for better visibility.)

Following a monetary policy shock, we find an adjustment of macroeconomic indicators which is roughly in line with expectations. The Federal Funds rate drops on impact by roughly 25 basis points before gradually returning to zero after a bit more than a year. The point estimates show an increase in GDP, but the effect is only marginally significant. The GDP deflator and property prices rise permanently,[14] with a maximum effect reached after about two years. Reactions of macro variables to the shock are almost indistinguishable in both VARs.

Banks' risk-weighted and unweighted loans rise gradually[15] The delayed reactions suggest that second-round effects from movements in other macroeconomic variables after the monetary policy shock contribute to an increase in both loan measures. The induced rise in commercial property prices increases the value of collateral which may, in turn, affect overall lending and also induce a "flight *out of* safety". Confidence bands overlap which suggests that differences between the loans' reactions are not statistically significant.

Figure 2a also shows that the loan spreads increase slightly after the monetary policy shock, suggesting that the loan rates decline a bit less than the Federal Funds rate, but overall follows it very closely. This confirms the negative link between the Federal Funds rate and lending spreads found by De Nicolò et al. (2010). Our results are, however. not in line with Ioannidou et al. (2009) who find a positive link between the Federal Funds rate and Bolivian lending spreads. The figure, again, reveals that responses of the risk-weighted and the unweighted spreads do not differ significantly.

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[14] Eickmeier and Hofmann (2010) also find a very sluggish and long-lasting reaction of commercial property prices to monetary policy shocks.

[15] The increase of the risk-weighted loan index is in line with De Nicolò et al. (2010) who use a similar risk measure.

Following the commercial property price shock, the two price variables and the Federal Funds rate increase, and this is could be responsible for the observed decline in GDP.[16] Loans rise, and the difference between the reactions of weighted and unweighted measures is, again, not statistically significant. The spreads' reactions are negative and very small in absolute terms; the confidence bands between the reactions of the risk-weighted spread and the unweighted spread overlap.

In sum, we find positive reactions of risk-weighted and unweighted loans to a monetary policy loosening and an unexpected increase in the commercial property price. The responses of risk-weighted and unweighted loans do probably not differ significantly. We should also take into account that the VAR approach does not allow us to disentangle supply from demand effects which is crucial if one aims at assessing whether a risk-taking channel exists. Hence, the VAR results do not provide evidence in favor of the existence of a risk-taking channel.

5 Evidence from the FAVAR

We now move to the FAVAR model which allows exploiting all information available from the STBL and looking at heterogeneous effects on loans (and loan rates) across risk categories and banks. The FAVAR also allows testing more directly the theoretical predictions concerning the differential effects monetary policy shocks and shocks to the collateral value across banking groups

5.1 The FAVAR Model

The model assumes that our vector of banking variables collected from the STBL (X_t) follows an approximate dynamic factor model (Stock and Watson 2002, Bai and Ng 2002) where each series $\boldsymbol{x}_{it}$ is driven by the $\boldsymbol{r}\times 1$ vector of common factors F_t and an idiosyncratic (series-specific) component $\boldsymbol{e}_{it}$:[17]

$$\boldsymbol{x}_{it} = \lambda_i \text{'} F_t + \boldsymbol{e}_{it} . \qquad (5)$$

where λ_i is a $\boldsymbol{r}\times 1$ vector of factor loadings. The number of common factors is typically much smaller than the number of variables in X_t, hence $r << N$. Common and series-

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[16] Other studies which identify house price shocks based on residential property prices, find an increase in GDP. If we replace the commercial property price by the Freddie Mac residential property price, we also find an increase in GDP which is, however, only marginally significant.

[17] For a more thorough discussion of the empirical framework, see Bernanke et al. (2005) and Buch et al. (2010).

specific components are orthogonal, the common factors are mutually orthogonal; idiosyncratic components can be weakly mutually and serially correlated in the sense of Chamberlain and Rothschild (1983).

F_t can be decomposed into two parts: a set of observable factors G_t and a set of latent (or unobservable) factors H_t which both drive X_t: $F_t = [G_t' \quad H_t']'$. We assume that G_t comprises the macroeconomic variables already used in the VAR, i.e. Δy_t, Δp_t, $\Delta \boldsymbol{cpp}_t$ and ffr_t. The unobserved "banking" factors (H_t) need to be estimated. They summarize the banking variables and are orthogonal to the observable macroeconomic factors. The factors are assumed to follow a VAR($\boldsymbol{p}$) model:

$$\begin{pmatrix} \Delta \boldsymbol{y}_t \\ \Delta \boldsymbol{p}_t \\ \Delta \boldsymbol{cpp}_t \\ H_t \\ \boldsymbol{ffr}_t \end{pmatrix} = c + \Phi(\boldsymbol{L}) \begin{pmatrix} \Delta \boldsymbol{y}_{t-1} \\ \Delta \boldsymbol{p}_{t-1} \\ \Delta \boldsymbol{cpp}_{t-1} \\ H_{t-1} \\ \boldsymbol{ffr}_{t-1} \end{pmatrix} + v_t, \tag{6}$$

where c comprises constants, $\Phi(L)$ is a lag polynomial of finite order $\boldsymbol{p}$, and v_t is an error term which is i.i.d. with zero mean and covariance matrix Q. H_t thus replaces $\Delta \boldsymbol{l}_t$ and $\boldsymbol{ls}_t$ from equation (4).

For identification of monetary policy and commercial property price shocks, we adopt a Cholesky ordering: $\Delta y_t \rightarrow \Delta p_t \rightarrow \Delta \boldsymbol{cpp}_t \rightarrow H_t \rightarrow ffr_t$. We verify whether our results are sensitive to the ordering, and we re-estimate the model with the ordering of the banking factors and the policy rate reversed. The main messages remain valid, and we make the results available upon request.

5.2 Estimation and Specification

The model is estimated in four steps. First, we regress each of the banking series $\boldsymbol{x}_{it}$ on G_t. Second, we estimate the "banking factors" H_t as the first $\boldsymbol{m} = \boldsymbol{r} - 4$ principal components from the residuals. Third, we model the joint dynamics of G_t and the estimate of H_t in a VAR which we estimate equation-wise with OLS. Fourth, we identify monetary policy and commercial property price shocks as described above.

Only two parameters need to be set: the number of common (latent and observable) factors ($\boldsymbol{r}$), (or $\boldsymbol{m}$, the number of common (latent) banking variables), and the VAR order ($\boldsymbol{p}$). $\boldsymbol{m}$ is set to 4 (and, hence, $\boldsymbol{r}$ equals 8) which is suggested by the IC_{p1} and the IC_{p2} of Bai and Ng (2002) when applied to the regression residuals. We rely on the IC_{p1}

and IC_{p2} since these criteria have been shown to perform well in small samples. $\boldsymbol{p}$ is set to 1, as suggested by the BIC. We experimented with a larger number of factors[18] and with $\boldsymbol{p} = 2$, but results (available upon request) remain basically unaffected. Given the short sample, we adopt the sparser parameterization. The latent banking factors are shown in Figure 1c.

5.3 Commonality Among the Banking Variables

One common concern is that factor models can be applied only if the data exhibit a factor structure (Boivin and Ng 2006). If the commonality, i.e. the variance share explained by the common factors, is low, the factors cannot be accurately estimated with principal components. In our model, the 8 (observable and latent) factors explain 58% of the overall variance in the banking dataset. This degree of comovement is similar to shares of 60% or more usually found in macroeconomic datasets for the U.S. (e.g. Boivin et al. 2009, Eickmeier and Hofmann 2010). This result is comforting given that, in survey data, reporting errors add to measurement error inherent in every dataset. The STBL data are based on the reported answers of the surveyed banks, and the Federal Reserves' Staff generates estimates for the entire banking sector, which adds an additional estimation error.

To nevertheless address concerns related to the existence of a factor structure in our data, we follow Boivin and Ng (2006). We estimate latent financial factors H_t as before as the first 4 principal components from the regression residuals. We weight each series in X_t by the inverse of the standard deviation of its idiosyncratic component. We then repeat the regression and the principal component steps described above on the weighted data. Results (available upon request) barely change, and we proceed with our benchmark factor estimates extracted from unweighted data.

We now analyze the commonality of the variables of interest, i.e. loan growth and loan spreads. Table 3 shows variance shares explained by all latent (banking) and observed factors and by the observed macroeconomic factors. (The differences between these are the shares explained only by the latent banking factors.) The factors explain 57% of the variation in the growth of loans for all loans. There is some heterogeneity across banking groups and risk categories. The commonality tends to be higher for large than for small banks. One explanation is that local and regional conditions unrelated to macroeconomic developments play a more important role for smaller banks. The result may, however,

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[18] See Boivin et al. (2009) for a similar approach.

also reflect that shocks contained in H_t first hit large, systemically relevant, banks and are then transmitted to the macroeconomy and/or other banks in the system. Both explanations are supported by our additional finding that the shares of loan growth explained by common latent (banking) factors are much larger for large banks than for small banks. The shares explained by the common macroeconomic factors for small banks exceed those for large banks in most of the risk categories.

For loan rates, the commonality is much higher than for loan volumes. The commonality for all banks and all loans amounts to 97%. This indicates a high degree of pass through from policy to lending rates as suggested by the very large shares explained by the observed factors (which include the policy rate). Another possible explanation is high degree of price competition.

5.4 Empirical Results

Figure 3 presents impulse responses of the macroeconomic variables to the monetary policy shock (Figure 3a) and the commercial property price shock (Figure 3b). The reactions of the macroeconomic variables to the two shocks look very similar to those obtained from the VAR. A few differences are worth mentioning. First, the monetary policy shock is smaller, leading to a decline in the policy rate only by about 17 basis points (compared to 25 basis points in the VAR). One possible explanation is that shocks to factors which were omitted from the VAR were (mistakenly) attributed to monetary policy shocks. As a consequence, the impact on property prices and on the GDP deflator is also smaller. Second, the positive effect of a monetary policy shock on GDP is clearly significant between quarters 1 to 4 after the shock before turning back to zero, consistent with long-run real neutrality of monetary policy. Third, as regards the response following the commercial property price shock, the only notable difference between the VAR and FAVAR results is that, in the FAVAR, the positive interest rate response is less persistent and only marginally significant. Again, movements in other (banking) factors which were not included in the VAR might have been captured by movements in the Federal Funds rate.

5.4.1 Reaction of New Loans and Loan Spreads to Monetary Policy Shocks

Figure 4 shows the reactions of new loans (Figure 4a) and loan spreads (loan rate over the Federal Funds rate) (Figure 4b) to an expansionary monetary policy shock. The first row shows responses of all loans and in different risk categories made by all banks. Rows 2-4 show responses of loans and loan spreads by small domestic, large domestic and foreign banks. Table 4 then allows assessing whether differences in the reactions between loans to high-risk and low-risk borrowers within the same banking group and differences across risk categories are significant. Numbers in bold indicate significance at the 90% level.

From Figure 4a it is apparent that total new business loans increase following the monetary policy shock. The increase is quite persistent, possibly because property prices and thus collateral values also rise quite persistently following the shock. While an increase in aggregate business loans is in line with the theoretical set-up presented above as well as larger-scale macroeconomic models (Christiano et al. 2010, Gerali et al. 2010),[19] empirical (time-series) studies typically find the opposite, i.e. that business loans decrease after a monetary policy loosening (or increase after a monetary policy tightening). Two main reasons have been suggested for this "perverse" reaction of business loans. Bernanke and Gertler (1995) argue that firms raise their loan *demand* to finance the increase in inventories triggered by an interest rate hike. Den Haan et al. (2007), by contrast, suggest that banks substitute long-term consumer and real estate loans by relatively safe, short-term business loans after a monetary policy tightening. Hence, it is an increase in business loan *supply* that can explain the finding.

How can we explain our results in the light of this discussion? One interpretation of our results is that the increase in loans primarily reflects loan supply rather than loan demand effects. This would be encouraging since the risk-taking channel concerns loan supply, not loan demand. Since we have only loans to firms in our dataset, we cannot check whether reactions of consumer or real estate loans differ from those of business loans. From Figure 4a, we do not see a shift in the composition of banks' portfolios from relatively safe to less safe (i.e. relatively risky) business loans for the aggregate of all banks after an expansionary monetary shock. This also holds true for the groups of large domestic and (mostly large) foreign banks. By contrast, such a shift is indeed observed for small banks. After the monetary policy shock, small banks strongly and significantly extend relatively risky loans, but not loans with minimal risk.

Surprisingly, the aggregate of all banks extends their lending to high-risk borrowers significantly less (not more) than their lending to low-risk borrowers (Table 4a). This response is driven by the foreign banks. By contrast, small banks on impact extend their lending to high-risk firms significantly more than their lending to low-risk firms after monetary policy shocks. The differential impact effect is also positive and statistically

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[19] See Zhang (2009) for a theoretical model in which lending temporarily increases after contractionary monetary policy shocks.

significant for large firms, but it is tiny in magnitude. After 4 quarters, differences are not statistically significant for any of the subgroups of banks. We also find that, on impact, small banks increase loans to high-risk and moderate-risk borrowers significantly more strongly than large and foreign banks (Table 4b). Lending to low-risk borrowers by small banks is, by contrast, significantly smaller than that by large and foreign banks. After one year, only differences in lending to high-risk and moderate-risk borrowers are significant.

The fact that smaller banks increase new lending to higher risk borrowers significantly more than large and foreign banks would be consistent with theoretical priors derived in Section 2 if smaller banks were more highly capitalized, faced higher monitoring costs and/or had smaller monopoly power than larger and foreign banks.

As concerns capitalization of banks, we find, based on individual bank data from the U.S. Call Reports, a negative and significant correlation between the size of banks and the capital ratio: we ran a cross-section regression of the size of banks, captured by the logarithm of assets, on the capital ratio, i.e. equity capital divided by total capital, (both averaged over the period 1997-2008) and a constant; we find a negative, highly significant relation (regression coefficient: -0.005, *t*-statistic: -18.4) between size and capitalization. Another piece of evidence is provided by Cetorelli and Goldberg (forthcoming). They document that small domestic banks are, on average, more highly capitalized than large domestic banks. Also, large domestic banks are better capitalized than large global banks. In their Table 1, Cetorelli and Goldberg provide capitalization ratios for different banking groups over the period 1980-2006: large domestic banks (7.2%), large global banks (6.4%), small banks in domestic bank holding companies (8.0%), and small banks in global bank holding companies (7.6%), respectively.

Monitoring costs are unobserved, but one could argue that monitoring involves fixed costs which large banks can shoulder more easily. The fact that small banks have a much higher share of collateralized loans (see Section 2) points into this direction.

Finally, Berger (1995: 429) has argued that "*only the larger firms in the market […] are able to exercise market power in pricing well-differentiated products through advertising, locational, or other advantages*". This suggests that all three factors, capitalization, monopoly power and monitoring costs help indeed explain our finding of the differential effects between small and large banks.

Importantly, the result that smaller banks react differently to monetary shocks than large banks also suggests that growth in lending to high-risk borrowers is indeed supply driven, thereby indicating the presence of an active risk-taking channel of monetary policy. Kashyap and Stein (2000) and Angeloni et al (2002) argue that differences among banks in the response of loans to a monetary policy shock can be labeled as supply driven, provided that bank customers of the different banks are similar. Our data provide a breakdown of loans by borrower characteristics. Because borrowers in the same risk category are likely to be fairly homogeneous, this enables us to identify supply effects and, hence, the risk-taking channel.

Another finding is worth emphasizing. Foreign banks do not change or increase relatively safe loans, but they significantly reduce risky loans. Foreign banks, similar to large domestic banks, have on average lower capitalization ratios than small banks (Cetorelli and Goldberg forthcoming). In this sense, our result is consistent with the theoretical model by Dell'Ariccia et al. (2010). Also, foreign banks can be expected to react less to changes in the policy rate since their funding structure allows shielding their lending decision from changes in the domestic policy rate. Foreign banks might also have superior investment possibilities. Following a reduction in the policy rate, foreign banks might be able to shift loanable funds more easily across countries in order to compensate low interest rate in the U.S.. It should be noted though that we do not model developments on foreign variables since our data do not provide a classification of foreign banks by country of origin.

Figure 4b shows rather small impulse responses of loan spreads, and the impulse responses of loan rates look very much like those of the Federal Funds rate. Loan rates decline after the monetary policy shock, as predicted by Dell'Ariccia et al. (2010), and they do so by less than the Federal Funds rate. This confirms the negative link between the Federal Funds rate and lending spreads found already in the VAR. Differences across different banking groups and risk categories are not visible from the graphs. Although a formal analysis shows us that differences are in some cases statistically significant, they are likely to be economically negligible. Hence, we refrain from presenting differences and significance levels in detail as we did for loans in Table 4.

5.4.2 Reaction of New Loans and Loan Spreads to Commercial Property Price Shocks

In Figure 5, we show impulse responses of new loans and loan spreads to the property price (collateral) shock. Average lending significantly increases in response to the shock, in line with our VAR results. Small domestic, large domestic, and foreign banks all raise lending to high-risk borrowers, consistent with the theoretical prediction. At the same time small domestic banks lend less, and large banks do not change their lending to low-risk borrowers, while foreign banks increase lending to low-risk borrowers.

Table 4a reveals that the impact reaction of loans to low-risk borrowers is significantly smaller (larger) than the reaction of loans to high-risk borrowers for small (foreign) banks. Reactions of lending by large banks and by all banks do not significantly differ across risk categories. This indicates additional risk taking only by small banks after property price shocks.

Table 4b shows that small banks react more to the commercial property price shock than large domestic and foreign banks. This indicates the presence of a risk-taking channel of commercial property prices. Lending spreads barely change, indicating that lending rates move very much like the Federal Funds rate. We do, again, not observe differences across banking groups and risk categories.

5.4.3 Discussion of Results

The FAVAR methodology allows analyzing the risk-taking channel in more detail than the VAR by decomposing the data across banking groups and loan categories and by controlling for theoretically important loan contract terms such as interest rates and the degree of collateralization.

We find that small banks take on additional new risk after monetary policy shocks, and that foreign banks lower their lending to high-risk borrower. Large domestic banks do not significantly change their risk-taking behaviour. These patterns are not inconsistent with the hypothesis that the degree of leverage is of importance in determining the effect of expansionary monetary policy shocks and that well capitalized banks take on more risk. The stylized facts that have been reported in this paper and in previous literature suggest that small banks in the U.S. are better capitalized than foreign banks. Hence, for the smaller banks, the pass-through effect stressed in the model by Dell'Ariccia et al. (2010) is likely to dominate the risk-shifting effect.

With respect to the collateral shock, theory predicts an unambiguously risk-increasing effect because collateral and monitoring are substitute technologies to control risk. We find that all banking groups increase lending into the highest risk category following the identified commercial property price shock. However, only small banks significantly load additional new risk. This is consistent with these banks having higher monitoring cost. According to theory, especially inefficient banks will reduce monitoring effort following an increase in the value of the underlying collateral. Similar to the findings of the monetary policy shock, small banks increase new lending to high-risk borrowers significantly more than large and foreign banks after the commercial property price shock. This points towards a risk-taking channel of collateral shocks.

6 Conclusion

Many observers have argued that loose monetary policy is one main culprit for the excessive build up of risk in the U.S. banking industry in the run up to the global financial crisis. This observation has led to the recommendation that monetary authorities should explicitly consider aspects of financial, and in particular banking sector, stability when deciding on monetary policy actions. Yet, previous literature has not given a clear answer to the question whether loose monetary policy increases or decreases the risk of banks. Differences across studies partly owe to the level of aggregation of the data and partly owe to the measurement of risk.

With this paper, we inform the debate about the effects of monetary policy on the risk-taking decision of commercial U.S. banks. To capture changes in collateral values we include commercial property prices as an additional factor. Using a VAR and a FAVAR setup, we exploit information on the riskiness of banks' *new* loan origination provided by the Federal Reserve's Survey of Terms of Business Lending. These data have the advantage that they allow for an analysis of new loans and thus risk-taking behavior of banks. In this sense, we realign previous micro-level studies, which allow measuring risk taking of banks, with macro studies, which identify different macroeconomic shocks. In addition, we can analyze heterogeneity in the response to monetary policy and property price shocks across different banking groups. This takes into account recent theoretical insights that the risk-taking effects depend, *inter alia*, on the degree of capitalization, monopoly power and monitoring costs of banks.

Our results suggest that there is no evidence for a risk-taking channel for the entire banking system after expansionary monetary policy and commercial property price shocks. This masks, however, important differences across banking groups. Small domestic banks increase their exposure to risk, while foreign banks lower risk, and large domestic banks do not significantly change their risk exposure after both shocks. We also find that lending rates move closely in line with policy rates. The response of lending rates after the two macroeconomic shocks is very similar across banks and risk categories, indicating a high degree of price competition in U.S. banking.

It would be tempting to interpret our results in terms of the current discussion on risks in banking and the regulatory initiatives to increase the required capitalization of banks. We have argued that the risk-taking incentives of banks might be linked to their degree of capitalization. Our findings suggest that small and well-capitalized U.S. banks increase risk following a monetary contraction while foreign and less well-capitalized banks in the

U.S. lower risk. These patterns in the data correspond to the predictions of the baseline model in Dell'Ariccia et al. (2010) in which leverage is exogenous.

However, our findings should not be interpreted in terms of higher capitalization being causal for an increase in risk taking for two main reasons. First, we have not estimated a structural model of bank capital and risk. In order to identify a particular theoretical mechanism on the link between capitalization and risk taking, it would be necessary to endogenize the degree of capitalization of banks and to model this explicitly. With endogenous leverage, risk unequivocally increases following an expansionary monetary policy shock in the model by Dell'Ariccia et al. (2010). Second, the link between bank capital and risk is driven by a number of additional factors including changes in equity risk premia or changes in corporate governance structures of banks, all of which are not captured in our theoretical or empirical models

Overall, the FAVAR methodology used in this paper provides a powerful tool for analyzing heterogeneity across banking groups and loan market segments with regard to responses to macroeconomic shocks. It shows, most importantly, that ignoring the feedback between the banking sector and the macroeconomy or ignoring heterogeneous responses may lead to erroneous conclusions concerning the link between risks in banking and the macroeconomy. Hence, applying this methodology to further questions of systemic risk in banking or for the analysis on changed capital requirements for the risk-bearing capacity of the banking system would be an important step for future research.

7 References

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8 Data Appendix

This appendix provides the classification of loan risk according to the *Survey of Terms of Business Lending*. The following information is based on the instructions (FR 2028A), last updated December 11, 2008.[20]

Minimal Risk
Loans in this category have virtually no chance of resulting in a loss. They would have a level of risk similar to a loan with the following characteristics:
- The customer has been with your institution for many years and has an excellent credit history.
- The customer's cash flow is steady and well in excess of required debt repayments plus other fixed charges.
- The customer has an AA or higher public debt rating.
- The customer has excellent access to alternative sources of finance at favorable terms.
- The management is of uniformly high quality and has unquestioned character.
- The collateral, if required, is cash or cash equivalent and is equal to or exceeds the value of the loan.
- The guarantor, if required, would achieve approximately this rating if borrowing from your institution.

Low Risk
Loans in this category are very unlikely to result in a loss. They would have a level of risk similar to a loan with the following characteristics:
- The customer has an excellent credit history.
- The customer's cash flow is steady and comfortably exceeds required debt repayments plus other fixed charges.
- The customer has a BBB or higher public debt rating.
- The customer has good access to alternative sources of finance at favorable terms.
- The management is of high quality and has unquestioned character.
- The collateral, if required, is sufficiently liquid and has a large enough margin to make very likely the recovery of the full amount of the loan in the event of default.
- The guarantor, if required, would achieve approximately this rating if borrowing from your institution.

Moderate Risk
Loans in this category have little chance of resulting in a loss. This category should include the average loan, under average economic conditions, at the typical lender. Loans in this category would have a level of risk similar to a loan with the following characteristics:
- The customer has a good credit history.

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[20] See http://www.ny.frb.org/banking/reportingforms/FR_2028a_s.html for details.

- The customer's cash flow may be subject to cyclical conditions but is adequate to meet required debt repayments plus other fixed charges even after a limited period of losses or in the event of a somewhat lower trend in earnings.
- The customer has limited access to the capital markets.
- The customer has some access to alternative sources of finance at reasonable terms.
- The firm has good management in important positions.
- Collateral, which would usually be required, is sufficiently liquid and has a large enough margin to make likely the recovery of the value of the loan in the event of default.
- The guarantor, if required, would achieve approximately this rating if borrowing from your institution.

Acceptable Risk/Others

Loans in this category have a limited chance of resulting in a loss. They would have a level of risk similar to a loan with the following characteristics:

- The customer has only a fair credit rating but no recent credit problems.
- The customer's cash flow is currently adequate to meet required debt repayments, but it may not be sufficient in the event of significant adverse developments.
- The customer does not have access to the capital markets.
- The customer has some limited access to alternative sources of finance possibly at unfavorable terms.
- Some management weakness exists.
- Collateral, which would generally be required, is sufficient to make likely the recovery of the value of the loan in the event of default, but liquidating the collateral may be difficult or expensive.
- The guarantor, if required, would achieve this rating or lower if borrowing from your institution.

Table 1: Overview of Previous Empirical Evidence on the Risk-Taking Channel of Monetary Policy

Paper	Data	Measure of bank risk	Method	Macroeconomic explanatory variables and controls	Effects of a decline in monetary policy rates
Altunbas et al. (2010)	Publicly available data for listed U.S. and EU banks	Moody's expected default frequency	Panel regressions	Deviation of the interest rate from a benchmark (either Taylor rule rate or natural interest rate) used to measure banks' incentive to load on *new* risk Other controls are changes in the policy rate, nominal GDP, the slope of the yield curve, house and stock prices.	A decline in changes in policy rates lowers (ex post) bank risk. A negative deviation of the interest rate from the benchmark, i.e. expansionary monetary policy, leads to more risk taking. Positive house price growth raises bank risk.
Angeloni et al. (2010)	Time series evidence for the U.S. and the euro area	Stock market volatility Consumer and mortgage loans/total loans Bank leverage (defined as assets/deposits)	VAR	Industrial production, employment, inflation monetary policy rate	Positive reactions of various bank balance sheet risk in the U.S. and the euro area and of bank leverage in the U.S. No significant reactions of bank leverage in the euro area and of stock market volatility in the U.S. and the euro area.
Buch et al. (2010)	Time series and bank-level panel data for the U.S. from the Call Reports	Share of non-performing loans Banks' degree of capitalization	FAVAR	Identification of monetary policy and other macroeconomic (supply, demand, house price) shocks imposing sign restrictions and contemporaneous zero restrictions on impulse responses	Negative reaction of risk in banks' balance sheets. Negative response does not depend on bank size, but is smaller in absolute terms if a bank is highly capitalized. Negative reaction of risk after an expansionary house price shock. Reaction does not depend on the size of a bank and its capitalization.

Paper	Data	Measure of bank risk	Method	Macroeconomic explanatory variables and controls	Effects of decline in monetary policy rates
De Graeve et al. (2008)	Micro-macro model for the German banking sector	Banks' probability of default (*ex post*), estimated from a logit model including CAMEL ratings	Hazard model for bank distress, VAR	GDP growth, inflation, interest rate	Negative reaction of risk. Distress responses are larger in absolute terms for small (cooperative) banks and for banks which are not highly capitalized.
De Nicolò et al. (2010)	Survey of Terms of Business Lending (U.S.)	Weighted average risk rating Weighted average spread over the Federal Funds rate	OLS regressions	Real Federal Funds rate, real GDP growth, dummy for low capitalization of the banking system	Positive reaction of risk rating and spread. If the banking sector is characterized by low capitalization, the spread declines.
	Call Reports (U.S.)	Risk-weighted assets-to-total assets ratio	Panel regressions	Real Federal Funds rate, real GDP growth, leverage ratio, dummy for low capitalization of the bank	Increase in risk-weighted assets which is larger in absolute terms if the bank is highly capitalized (i.e. the leverage ratio is low).
Eickmeier and Hofmann (2010)	U.S. time series evidence	Credit spreads, including the spread of the C&I loan rate over the 2-year T-Bill rate	FAVAR	Identification of monetary policy shocks based on sign and contemporaneous zero restrictions on impulse responses. Model controls for GDP, the GDP deflator and other financial factors.	Negative reaction of various credit risk spreads
Ioannidou et al. (2009)	Individual bank data from the public credit registry of Bolivia and bank balance sheet and income statements	Probability of default on individual (new) bank loans estimated based on a hazard model Loan spread	Time-varying duration models	U.S. Federal Funds rate as measure of the monetary policy Controls are GDP growth, inflation and other bank characteristics.	Positive reaction of probability of default on new loans. Reaction is larger for more liquid banks and less funds from foreign financial institutions. Negative reaction of probability of default on outstanding loans and of loan spread.

Paper	Data	Measure of bank risk	Method	Macroeconomic explanatory variables and controls	Effects of decline in monetary policy rates
Jiménez et al. (2010)	Confidential data from the Spanish Credit Register (individual loans at the bank-borrower level) on outstanding loans and loan applications	Firms' credit risk: (i) ex ante bad credit history, and (ii) future credit defaults	OLS, linear probability models	Spanish interbank rate/EONIA Controls are GDP growth, inflation and individual banks' characteristics	Intensive margin (outstanding loans) and extensive margin (new loans): weakly capitalized banks expand credit to riskier firms more than highly capitalized banks.
Lang and Nakamura (1995)	Survey of Terms of Business Lending (U.S.)	Loan quality defined as percentage of loans made at or below the prime rate plus 1%. Risk is inversely related to loan quality.	VAR	Identification of shocks to the Federal Funds rate and GDP	Negative reaction of loan quality
Lown and Morgan (2006)	Senior Loan Officer Survey (SLO) (U.S.)	Lending standards as reported by loan officers of large U.S. banks Capital-to-asset ratio	VAR	GDP, prices, commodity prices , Federal Funds rate, commercial loans	No change in standards, lenders change loan rates broadly with the Federal Funds rate Increase in the capital-to-asset ratio.
Maddaloni and Peydró (2010)	Bank Lending Survey (BLS) (Euro Area) Senior Loan Officer Survey (SLO) (U.S.)	Lending standards that apply to firms and households	Panel regressions	Taylor rule residuals as a proxy of monetary policy Controls are long-term interest rates, GDP growth, inflation, securitization, supervision standards for bank capital.	Softening of lending standards for households and firms Degree of securitization and weak supervision for bank capital strengthens the effect.
Maddaloni et al. (2009)	Bank Lending Survey (BLS) (Euro Area)	Lending standards and conditions in terms of changes in spreads on average loans, collateral requirements, covenants, loan amount, maturity .	GLS panel regressions	EONIA Controls are GDP growth, inflation, country risk, and characteristics of the banking sector	Weaker lending standards for average and for riskier loans Stronger absolute impact in case of securitization. Larger banks tend to react less in absolute terms.

Table 2: The Link Between Lower Policy Rates and Bank Behaviour in Dell'Arricia et al. (2010)

Model version	Interest rates	Monitoring	Lending	Leverage
Baseline model (exogenous leverage)	Loan rates and deposit rates decrease	Low capitalization: monitoring increases, risk decreases High capitalization: monitoring decreases, risk increases	Increase	Constant
Endogenous leverage	Lending rates decrease	Monitoring decreases (risk increases)	Increase	Increases
Perfect competition	Lending rates decrease more the more competitive the market Margins are less sensitive to policy rates in more competitive markets	Monitoring decreases (risk increases)	Increase	Increases
Monopoly power		Monitoring increases (risk falls)		

Table 3: Variance Explained by the Common (Observed and Latent) Factors

		All Loans	Minimal Risk	Low Risk	Moderate Risk	Acceptable Risk
Loan Growth						
All Banks	All factors	0.57	0.32	0.35	0.44	0.32
	Observed factors	0.04	0.11	0.04	0.03	0.04
Large Banks	All factors	0.66	0.33	0.52	0.53	0.27
	Observed factors	0.08	0.06	0.05	0.06	0.07
Small Banks	All factors	0.24	0.12	0.19	0.33	0.14
	Observed factors	0.06	0.04	0.11	0.11	0.10
Foreign Banks	All factors	0.64	0.11	0.12	0.54	0.24
	Observed factors	0.02	0.02	0.09	0.03	0.05
Loan Rates						
All Banks	All factors	0.97	0.96	0.96	0.97	0.96
	Observed factors	0.71	0.72	0.67	0.74	0.66
Large Banks	All factors	0.97	0.93	0.96	0.97	0.96
	Observed factors	0.71	0.72	0.66	0.73	0.69
Small Banks	All factors	0.95	0.83	0.83	0.94	0.96
	Observed factors	0.73	0.65	0.66	0.74	0.74
Foreign Banks	All factors	0.96	0.96	0.95	0.97	0.93
	Observed factors	0.72	0.71	0.67	0.77	0.61

Table 4: Difference Between Impulse Responses of Loans and Loan Spreads After Monetary Policy and Commercial Property Price Shocks

The table displays differences in impulse responses after expansionary monetary policy shocks and an unexpected increase in commercial property prices. Entries in bold indicate that the differences are significant at the 90% level.

(a) Differences Between Acceptable and Minimum Risk Categories

	All Banks	Small Banks	Large Banks	Foreign Banks
Loans				
Monetary policy shock				
Impact effect	**-0.006**	**0.006**	**0.000**	-0.003
Four quarters	**-0.038**	0.019	-0.012	-0.026
Property price shock				
Impact effect	0.010	**0.104**	0.018	**-0.014**
Four quarters	0.026	**0.067**	-0.006	-0.014
Loan spreads				
Monetary policy shock				
Impact effect	**-0.003**	**-0.014**	**0.011**	**-0.005**
Four quarters	0.005	-0.001	0.005	0.005
Property price shock				
Impact effect	-0.032	**-0.108**	**-0.062**	-0.028
Four quarters	0.010	0.012	0.002	0.013

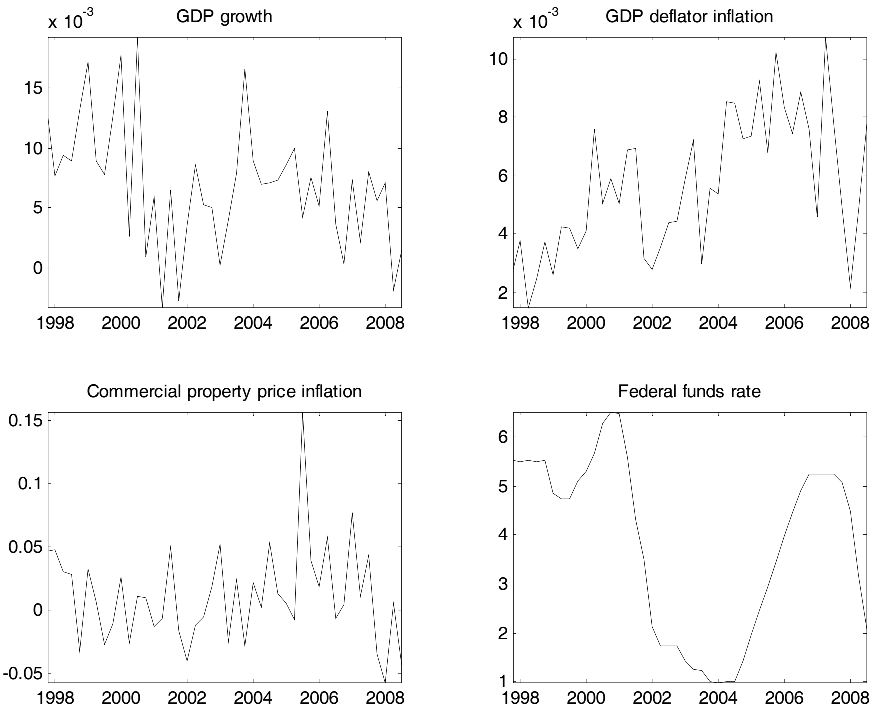
(b) Differences Across Banking Groups

	Minimum Risk	Low Risk	Moderate Risk	Acceptable Risk
Loans				
Monetary policy shock				
		Impact effect		
Small – Large	**-0.003**	**0.004**	**0.004**	**0.003**
Small – Foreign	**-0.001**	**0.006**	**0.000**	**0.009**
Large – Foreign	**0.002**	**0.002**	**-0.004**	**0.005**
		Four quarters		
Small – Large	-0.016	0.011	0.008	**0.017**
Small – Foreign	0.006	0.027	-0.005	**0.051**
Large – Foreign	0.020	0.015	**-0.013**	**0.033**
Property price shock				
		Impact effect		
Small – Large	**-0.079**	**-0.073**	**-0.038**	**0.006**
Small – Foreign	**-0.099**	**-0.154**	0.003	**0.018**
Large – Foreign	-0.019	**-0.084**	**0.041**	**0.013**
		Four quarters		
Small – Large	-0.072	**-0.071**	**-0.058**	0.000
Small – Foreign	**-0.087**	**-0.134**	-0.029	-0.008
Large – Foreign	-0.017	**-0.064**	**0.029**	-0.008
Loan spreads				
Monetary policy shock				
		Impact effect		
Small – Large	**0.024**	**0.028**	**0.014**	**0.000**
Small – Foreign	**0.020**	**0.025**	**0.031**	**0.011**
Large – Foreign	**-0.004**	**-0.004**	**0.016**	**0.012**
		Four quarters		
Small – Large	0.015	0.032	0.013	**-0.031**
Small – Foreign	**0.069**	-0.001	**0.033**	-0.012
Large – Foreign	**0.054**	**-0.032**	**0.020**	0.020
Property price shock				
		Impact effect		
Small – Large	0.000	-0.005	-0.003	**-0.006**
Small – Foreign	-0.002	-0.004	0.003	-0.008
Large – Foreign	-0.002	0.000	0.006	-0.002
		Four quarters		
Small – Large	-0.008	-0.019	-0.002	0.001
Small – Foreign	-0.008	-0.010	-0.013	-0.009
Large – Foreign	0.000	0.008	-0.011	-0.010

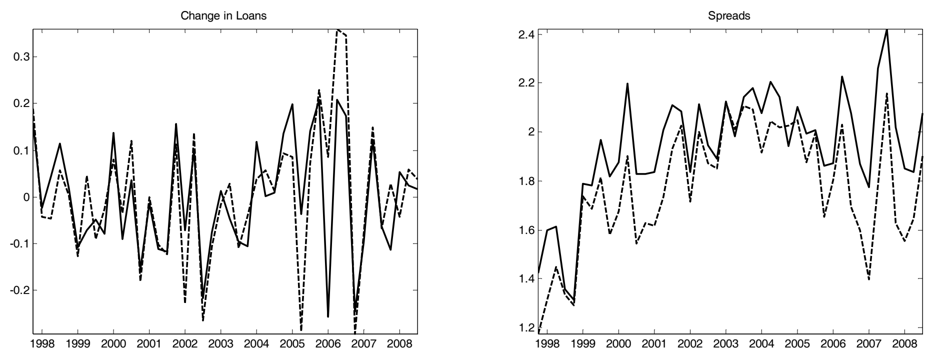
Figure 1: Macroeconomic Variables, Risk-Weighted Loans, and Latent "Banking" Factors

The solid (dotted) lines in panel b refer to the risk-weighted (unweighted) loan and spread measures.

(a) Macroeconomic Variables



(b) Loan Growth and Loan Spreads (Risk-Weighted and Unweighted)



(c) Latent "Banking" Factors

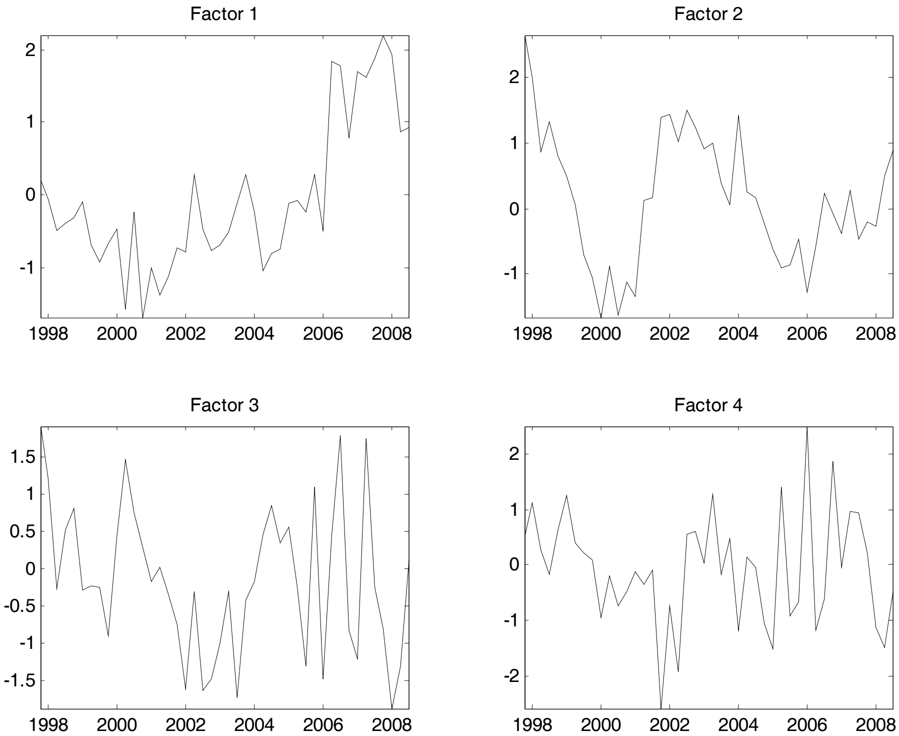
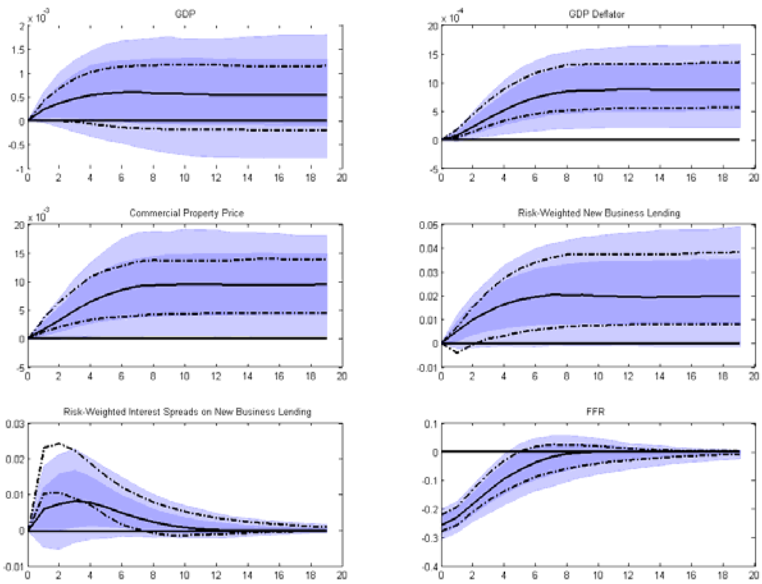


Figure 2: Effect of Monetary Policy and Commercial Property Price Shocks – VAR Analysis

This figure shows median impulse responses (black solid lines) together with 68% confidence bands (dark blue shaded area) and 90% confidence bands (light blue shaded area) to a one standard deviation monetary policy shock (panel (a)) and a one standard deviation property price shock (panel (b)) estimated from a VAR which includes the growth of risk-weighted loans and risk-weighted loan spreads. The black dotted-dashed lines are 68% confidence bands of impulse responses obtained from a VAR which includes the growth of unweighted loans and unweighted loan spreads.

(a) Monetary Policy Shock



(b) Property Price Shock

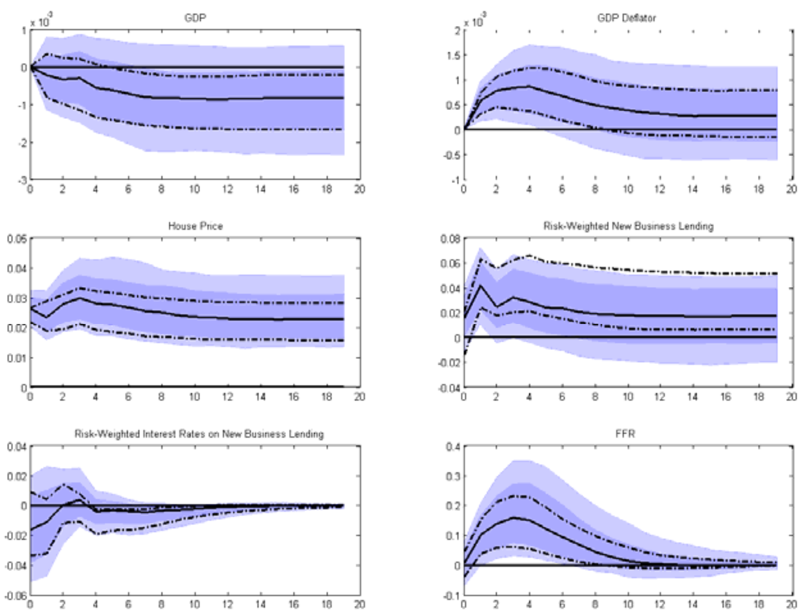
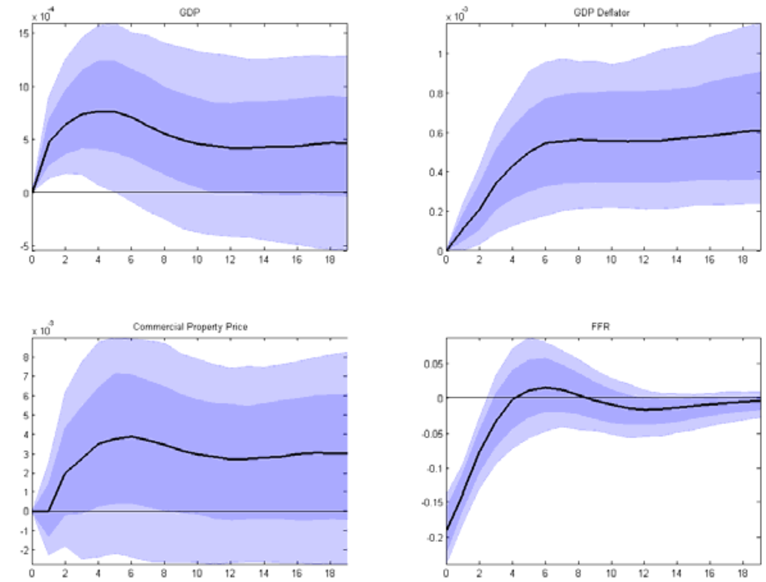


Figure 3: Effect of Monetary Policy and Commercial Property Price Shocks on Macroeconomic Variables – FAVAR Analysis

This figure shows median impulse responses (black lines) together with 68% confidence bands (dark blue shaded area) and 90% confidence bands (light blue shaded area) to a one standard deviation monetary policy shock (panel (a)) and a one standard deviation property price shock (panel (b)).

(a) Monetary Policy Shock



(b) Property Price Shock

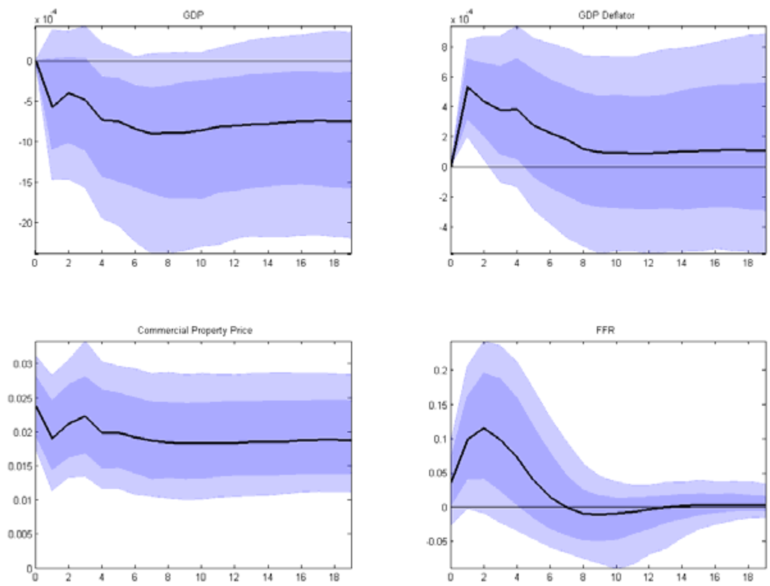
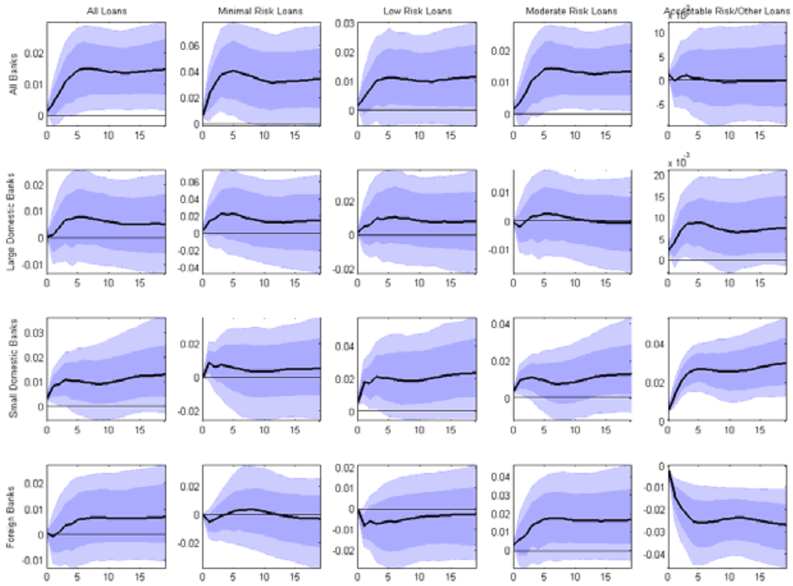


Figure 4: Effect of Monetary Policy Shocks on New Lending and Loan Spreads

This figure shows median impulse responses (black lines) together with 68% confidence bands (dark blue shaded area) and 90% confidence bands (light blue shaded area) of new lending (panel (a)) and loan rates (panel (b)) to a one standard deviation monetary policy shock.

(a) Reaction of New Loans



(b) Reaction of Loan Spreads

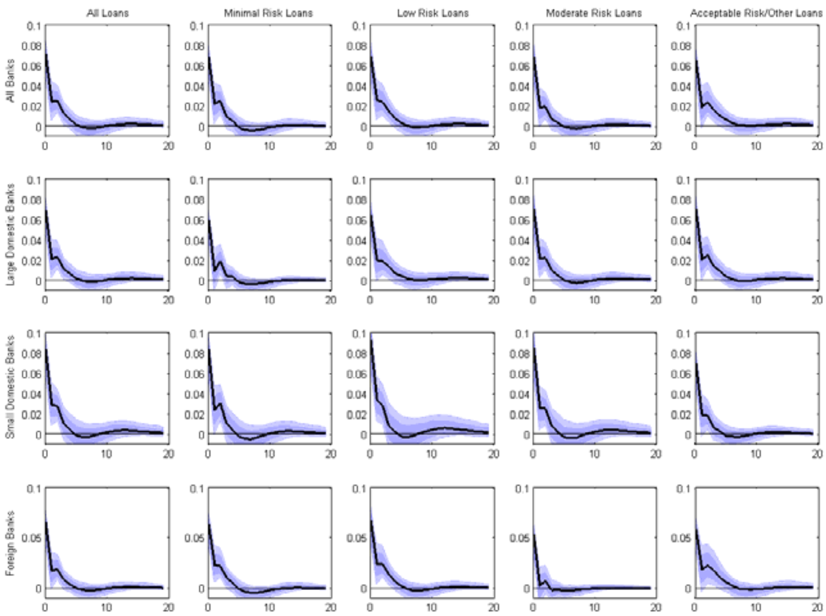
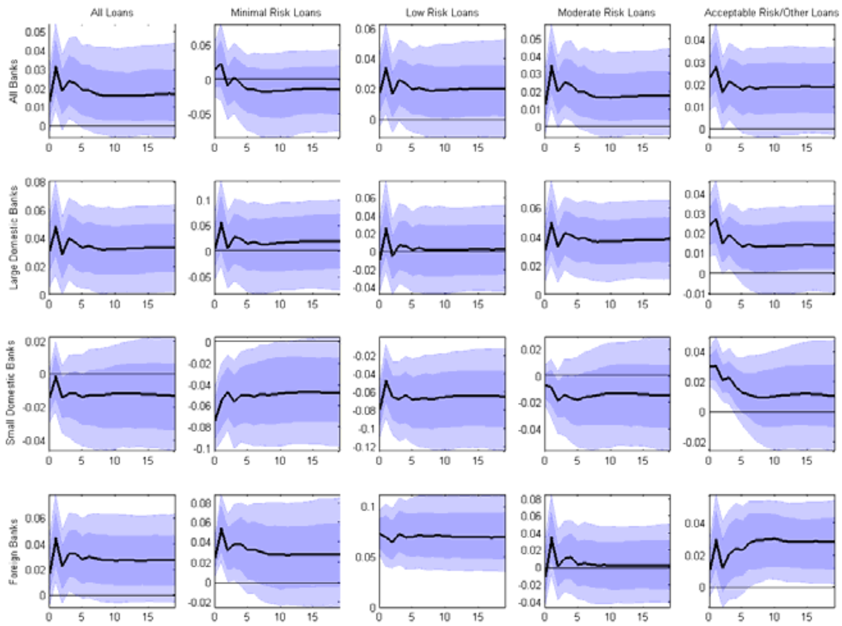


Figure 5: Effect of Commercial Property Price Shocks on New Lending and Loan Spreads

This figure shows median impulse responses (black lines) together with 68% confidence bands (dark blue shaded area) and 90% confidence bands (light blue shaded area) of new lending (panel (a)) and loan rates (panel (b)) to a one standard deviation property price shock.

(a) Reaction of New Loans



(b) Reaction of Loan Spreads