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In search for yield?
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 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, commercial property prices, and bank risk taking. We use a factor-augmented vector autoregressive model (FAVAR) for the U.S. for the period 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 prices as well as the riskiness of new loans. We do not find evidence for increased risk taking 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 codes: E44, G21

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

Non-technical summary

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, as has been observed 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. 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 and, as an additional factor, 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. We make a small extension to that model and show that bank risk increases with the value of collateral for loans. Empirically, this will be captured by considering commercial property price shocks.

We then use a Factor-Augmented Vector Autoregressive model (FAVAR) for the U.S. which comprises GDP growth, GDP deflator inflation, commercial property price inflation, the monetary policy interest rate, and a set of factors summarizing information on business lending provided in the Federal Reserve's *Survey of Terms of Business Lending* (STBL). The STBL questionnaire asks the banks to rate the risk of new loans each week 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. This 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. The FAVAR has the advantage that all information contained in the survey, especially information on new business loans associated with different risk categories, can be exploited. We then assess the reaction of banks' risk taking to monetary policy and property price shocks.

We do not find evidence for 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. We provide evidence that small domestic banks are more highly capitalized, face higher monitoring costs, and have less market power than large domestic and foreign banks. These features may, from a theoretical point of view, indeed explain the differential response of banks to the shocks. Shocks to commercial property prices lead to higher risk across all banking groups, but only small banks load additional new risk. Changes in risk after the two shocks materialize not only through the volume of lending but also through the pricing of risk: banks shift their (new) loan portfolio towards higher risk loans, *and* they charge a lower risk premium.

Nichttechnische Zusammenfassung

Derzeit entsteht ein Konsens darüber, dass die Geldpolitik die Stabilität auf den Finanzmärkten und in der Realwirtschaft über das Risikoverhalten der Banken beeinflussen kann („risk-taking channel“). Ein Rückgang der Zinsen kann zu einem “search for yield” führen und Anreize für Banken schaffen, in riskante Projekte zu investieren, wie zuletzt in den Jahren vor der globalen Finanzkrise deutlich wurde. Dies hat möglicherweise Implikationen für eine optimale Zentralbankpolitik, die Aspekte von Finanzmarktstabilität mit berücksichtigen will. Optimale Zentralbankpolitik erfordert allerdings ein tieferes Verständnis des Risikoverhaltens der Banken nach geldpolitischen Veränderungen. Ziel dieser Arbeit ist es, den Zusammenhang zwischen Geldpolitik sowie gewerblicher Immobilienpreise und dem Risikoverhalten der Banken zu beleuchten.

Wir nutzen den theoretischen Rahmen von Dell’Ariccia und anderen (2010) und zeigen, unter welchen Bedingungen Banken ihr Risiko nach einem Rückgang des geldpolitischen Zinses erhöhen. Wir erweitern das Modell geringfügig und machen deutlich, dass das Risikoverhalten der Banken ebenfalls mit dem Wert der Sicherheiten für Kredite steigt. Empirisch berücksichtigen wir diesen Aspekt, in dem wir gewerbliche Immobilienpreise in unsere Analyse einbeziehen.

Wir verwenden dann ein “Factor-Augmented Vector Autoregressive Model“ (FAVAR) für die USA. Das Modell enthält den Zuwachs des Bruttoinlandsprodukts, die Veränderungen des allgemeinen Preisniveaus, die Veränderungen der Immobilienpreise, den geldpolitischen Zins, sowie ein paar wenige Faktoren, die Informationen über die Kreditvergabe an Unternehmen, die wir dem *Survey of Terms of Business Lending* (STBL) der Federal Reserve entnehmen, zusammenfassen. Der Fragebogen des STBL befragt Banken wöchentlich zu den Risiken ihrer Neukreditvergabe. Die Antworten beeinhalten Angaben über die Historie der Kreditnehmer, Cash-Flow, Beurteilung der Kreditwürdigkeit, Zugang zu alternativen Finanzierungsmöglichkeiten, Qualität des Managements, Sicherheiten sowie Qualität der Bürgschaftsträger. Die Umfrage bezieht sich auf die *Neu*kreditvergabe, wohingegen andere Datenquellen eine Trennung von neuen und ausstehenden Krediten nicht ermöglichen. Eine solche Unterscheidung ist allerdings notwendig, wenn das Risikoverhalten von Banken analysiert werden soll. Das FAVAR erlaubt uns, alle Informationen, die im STBL enthalten sind, zu nutzen. Insbesondere enthält die Umfrage Angaben über die Neukreditvergabe an

Unternehmen, aufgegliedert in verschiedene Risikokategorien. Wir untersuchen die Reaktionen des Risikoverhaltens der Banken nach unerwarteten Änderungen in der Geldpolitik und der gewerblichen Immobilienpreise.

Für das gesamten Bankensystem finden wir keine Evidenz für eine Zunahme des Risikos nach expansiven geldpolitischen Schocks. Dies verdeckt allerdings bedeutende Unterschiede zwischen einzelnen Bankengruppen. Kleine US-amerikanische Banken erhöhen, und ausländische Banken verringern das Risiko in ihrem Portfolio. Große US-Banken verändern die Risikostruktur ihrer Kredite nicht signifikant. Aus theoretischer Sicht können diese Unterschiede auf Unterschiede in der Marktmacht, des Monitorings und der Kapitalisierung der Banken zurückgeführt werden. Wir zeigen, dass kleine US-Banken stärker kapitalisiert sind, bei Ihnen höhere Monitoringkosten anfallen und sie über weniger Marktmacht verfügen als große US-Banken und ausländische Banken. Schocks, die die gewerblichen Immobilienpreise erhöhen, führen zu einem erhöhten Risiko über alle Bankengruppen hinweg. Allerdings nehmen lediglich kleine Banken zusätzliches Risiko auf. Veränderungen im Risikoverhalten nach beiden Schocks lassen sich nicht nur am Volumen der Kreditvergabe, sondern auch an der Preissetzung festmachen: Banken verändern ihr Neukreditportfolio, in dem sie riskantere Kredite vergeben, *und* verlangen eine geringere Risikoprämie.

Contents

Tables and Figures

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. Conducting optimal central bank policy requires a thorough understanding of banks' attitude towards risk taking following monetary policy actions and other macroeconomic developments. Providing evidence on the link between monetary policy, commercial property prices and bank risk taking 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 this 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, and equity is priced at 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,

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[1] The link between low policy 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.

monitoring increases with a lower policy rate; if bank equity is high, monitoring decreases.

Besides monetary policy actions, developments in 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 value of collateral reduces the gains from monitoring. Intuitively, banks optimally reduce monitoring and end up with a riskier loan portfolio. Overall, the model shows that the degree of capitalization of banks, monitoring costs, and the degree of market power affect banks' responses to macroeconomic shocks.

Empirically, we use a factor-augmented vector autoregressive model (FAVAR) for the U.S. to analyze the reaction of banks' risk taking to monetary policy and commercial property price shocks. The model comprises GDP growth, GDP deflator inflation, commercial property price inflation, the monetary policy interest rate, and factors summarizing information on business lending provided in the Federal Reserve's *Survey of Terms of Business Lending* (STBL). The STBL questionnaire asks 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. This information is used to classify the loans into different risk categories, and shifts across categories thus reflect changes in risk taking of banks. The survey also distinguishes domestic, large domestic and foreign banks.

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. We provide evidence that small domestic banks are more highly capitalized, face higher monitoring costs, and have less market power than large domestic and foreign banks. These features may, according to the theoretical model, indeed explain the differential response of banks to macroeconomic shocks. Shocks to commercial property prices, our proxy for the collateral value of business lending, lead to higher risk across all banking groups, confirming theoretical predictions, but only small banks load additional new risk. Changes in risk after the two shocks materialize not only through the volume of lending but also through the pricing of risk: banks shift their (new) loan portfolio towards higher risk loans, *and* they charge a lower risk premium.[2]

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[2] This is how the risk-taking channel is defined in Borio and Zhu (2008): banks are willing to take on more risk, and this is not compensated by an increase in the risk premium.

Our paper contains three features which we consider crucial for identification of the risk-taking channel.[3]

First, the STBL provides information on *new* loans, not on outstanding loans. The risk-taking channel as advanced by Rajan (2005) and Borio and Zhu (2008) describes the incentives to engage in *ex ante* riskier projects. Hence, a clear distinction between new and outstanding loans is important. Except for the panel regressions by Ioannidou et al. (2009) and Jiménez et al. (2010), who use confidential data at the bank-borrower level, previous studies do not distinguish between realized risk (on existing loans) and new risk (on new loans). While previous studies find evidence in favor of the existence of the risk-taking channel of monetary policy, they most likely underestimate the effect. This is indirectly suggested by evidence from studies that focus on *ex post* risk and that find a *decline* in risk after a monetary policy loosening to the extent that the value of the underlying collateral increases (Buch et al. 2010, De Graeve et al. 2008). This effect is driven by valuation changes for outstanding bank loans, and it is thus reminiscent of the balance sheet effect of monetary policy.

Second, the FAVAR allows exploiting a large amount of information and analyzing heterogeneity in the banking system. As we will show, the impact of macroeconomic shocks on lending and pricing behavior differs across banks. This allows us to separate credit supply from demand effects and to test theoretical predictions on the determinants of risk taking by banks. A bunch of previous papers analyzing the risk-taking channel of monetary policy has used detailed bank-level data and applied panel regressions to them (Altunbas et al. 2010, Ioannidou et al. 2009, Jiménez et al. 2010). By contrast, work based on small-scale time series (VAR) models (Eickmeier and Hofmann 2010, Angeloni et al. 2010, or Lang and Nakamura 1995) or univariate regressions (De Nicolò et al. 2010) cannot assess heterogeneity. Our information set is certainly not as rich as information sets used by bank-level panel studies. Yet, we model the dynamics perhaps more accurately.

Third, like other multivariate time series analyses on the risk-taking channel of monetary policy, our empirical model allows for interaction between macroeconomic factors and the banking system and looks at the impact of identified, mutually orthogonal, macroeconomic shocks. By contrast, panel studies typically regress risk measures on monetary policy interest rates and additional explanatory variables. These studies allow interest rates and other macroeconomic factors to affect banks, but generally do not take

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[3] Table 1 overviews previous empirical work on bank risk or risk taking after monetary policy actions, and we include also evidence on the effect of house price developments.

into account feedback from banks to the macroeconomy. Moreover, macroeconomic indicators are reduced-form constructs and a convolution of different types of shocks. Finally, we are able to distinguish expected from unexpected monetary policy. The transmission may be different for different types of shocks and expected versus unexpected monetary policy which we can account for.

To summarize, the paper makes four main contributions. 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 allow for and explicitly analyze heterogeneity in the banking system. Fourth, we derive impulse responses of loans in different risk categories to commercial property price shocks, which have not been investigated much before.[4]

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 Section 4, we present and discuss our empirical results from the FAVAR. In Section 5, we interpret our results in light of the theoretical model. In Section 6, we conclude.

2 The Theoretical Mechanism

The theoretical banking literature has only recently started to 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).[6] In Dell'Ariccia et al. (2010), banks recover nothing from a borrower in case a

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[4] Altunbas et al. (2010) also look at the impact of house price growth on bank risk taking.

[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.

[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.

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. Other than that, our model is identical to theirs.[7]

Profits of a representative bank are given by:

$$\Pi = \left[\boldsymbol{q}\left(\boldsymbol{i}_L - \boldsymbol{i}_D(1-\boldsymbol{k})\right) + (1-\boldsymbol{q})\boldsymbol{w} - \boldsymbol{i}_E\boldsymbol{k} - \frac{1}{2}\boldsymbol{c}\boldsymbol{q}^2 \right] \boldsymbol{L}(\boldsymbol{i}_L) \tag{1}$$

where loans are the bank's only assets. $\boldsymbol{L}(\boldsymbol{i}_L)$ is loan demand as a negative function of the loan rate: $\partial \boldsymbol{L}(\boldsymbol{i}_L)/\partial \boldsymbol{i}_L < 0$. 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 $1/2 \cdot cq^2$. In case the project fails – which happens with probability $1-q$ –, banks recover a proportional liquidation value from the project w which is strictly smaller than the risk free rate $\boldsymbol{w} < \boldsymbol{i}$ and proportional to the volume of lending.

Banks fund themselves with deposits and equity, which are a fixed fraction $\boldsymbol{k}$ of total assets. The deposit rate is identical to the refinancing rate $\boldsymbol{i}_D = \boldsymbol{i}$. 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: $\boldsymbol{i}_E = \boldsymbol{i} + \boldsymbol{\xi} - \boldsymbol{a}\boldsymbol{q}$.[8]

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:

$$\frac{\partial \Pi}{\partial \boldsymbol{q}} = \left[\boldsymbol{i}_L - \boldsymbol{i}_D(1-\boldsymbol{k}) - \boldsymbol{w} + \boldsymbol{a}\boldsymbol{k} - \boldsymbol{c}\boldsymbol{q} \right] \boldsymbol{L}(\boldsymbol{i}_L) = 0 \tag{2}$$

or $$\boldsymbol{q}^* = \frac{1}{\boldsymbol{c}}\left(\boldsymbol{i}_L - \boldsymbol{i}_D(1-\boldsymbol{k}) - \boldsymbol{w} + \boldsymbol{a}\boldsymbol{k}\right).$$

The model we use here is much simpler since it simply serves to illustrate the main theoretical intuition behind our empirical model.

[7] See also Allen et al. (2011) for a similar model setup.

[8] 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 $\boldsymbol{i_D} = \boldsymbol{i}$), 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: $\frac{\partial \boldsymbol{q}^*}{\partial \boldsymbol{w}} = -\frac{1}{\boldsymbol{c}}$ and $\frac{\partial^2 \boldsymbol{q}^*}{\partial \boldsymbol{w} \partial \boldsymbol{c}} = \frac{1}{\boldsymbol{c}^2}$.[9]

The partial effect of an increase in the policy rate is given by: $\left.\frac{\partial \boldsymbol{q}^*}{\partial \boldsymbol{i}}\right|_{d\boldsymbol{i_L}=0} = -\frac{1}{\boldsymbol{c}}(1-\boldsymbol{k})$.

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: $\frac{\partial^2 \boldsymbol{q}^*}{\partial \boldsymbol{i} \partial \boldsymbol{c}} = \frac{1}{\boldsymbol{c}^2}(1-\boldsymbol{k})$.

Results presented so far ignore that 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 and 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.[10] Intuitively, for low levels of capitalization, the risk-shifting effect dominates. Lower policy rates imply an increase in intermediation margins ($\boldsymbol{i_L} - \boldsymbol{i_D}$), 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 because the gains from higher margins are relatively modest due to the high share of funding via equity capital. Monitoring decreases (risk increases). In contrast, following an increase in the value of the underlying collateral banks unambiguously reduce monitoring efforts.

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 in the short run. The impact effect of macroeconomic shocks thus resembles the situation with exogenous capital. Over time, banks can adjust their capital structure, and the response to shocks should become more similar across banking groups.

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[9] We assume that second-order effects on the costs of capital can be ignored, i.e. $\frac{\partial^2 \boldsymbol{i_E}}{\partial \boldsymbol{q} \partial \boldsymbol{i}}, \frac{\partial^2 \boldsymbol{i_E}}{\partial \boldsymbol{q} \partial \boldsymbol{w}} = 0$.

[10] The formal proofs are very similar to those presented in Dell'Ariccia et al. (2010) and are available upon request.

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.

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

(i) *Impact of monetary policy shocks*: Monitoring intensity and lending rates depend on the policy rate. If capital is exogenous, monitoring declines (i.e. risk increases) if refinancing rates fall for well capitalized banks, and it 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 market 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.

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 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 banks. 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 the 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" (8% on average over the sample for all banks), "low risk" (23%), "moderate risk" (41%), and "acceptable risk" (28%). The classification of loans is based on a large number of indicators which are condensed into a risk rating for loans. This classification takes into account hard information (cash flow, credit history, credit ratings, quality of collateral) as well as soft information (management quality).

Our identification of risk taking is based on differences across banks in terms of shifts across loan risk categories in response to macroeconomic shocks. The categories represent a measure of loan risk. If a worsening of one aspect of loan quality is fully compensated by an improvement along another dimension, the overall classification of the loan would not change. A shift in the composition of bank loans across different risk categories thus reflects changes in the overall credit standards for new loans.

Our analysis is not only based on changes in loan volumes but also on changes in loan spreads. In the theoretical model, the spread between the lending rate and the deposit rate (which equals the policy rate) can be interpreted as an intermediation spread. In the data, the spread between the loan rate and the policy rate contains not only a risk premium but also a term premium because the policy rate applies to shorter maturities. To isolate the risk premium, we subtract from the risky lending rate the corresponding riskless rate 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.

the same maturity, i.e. the 1-year Treasury bill rate, and we include this spread in the empirical model. We use the 1-year Treasury bill rate since one year roughly corresponds to the average maturity of business loans in the STBL over our sample.

The STBL additionally contains information on the shares of loans made under commitment, secured by collateral, subject to prepayment penalty, on loan size, and on loan maturity. Including these variables when estimating banking factors minimizes omitted variables problems and allows isolating the effects of macroeconomic shocks on bank lending, bank risk taking, and lending spreads. Moreover, loans secured by collateral and loan maturity may not just represent control variables but also choice variables, which contain information on risk taking by banks. We will take up this issue in Section 5.2

We include each of these variables for the entire banking sector, for the subgroups of banks, and for the four different risk categories.

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.

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 $\mathrm{X}_t = [\boldsymbol{x}_{1t} \quad ... \quad \boldsymbol{x}_{Nt}]'$, and X_t enters the FAVAR model.

[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).

4 Evidence from a FAVAR Model

4.1 The FAVAR Model

We analyze the link between monetary policy shocks and property price shocks, on the one hand, and the response of banks to these shocks, on the other hand, using a FAVAR which extends a standard VAR for the U.S. economy. We assume 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 $\boldsymbol{x}_{jt}$ is driven by the $\boldsymbol{r}\times 1$ vector of common factors F_t and an idiosyncratic (series-specific) component $\boldsymbol{e}_{jt}$:[13]

$$\boldsymbol{x}_{jt} = \lambda_j{}'\mathrm{F}_t + \boldsymbol{e}_{jt}\,. \tag{5}$$

where λ_j 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-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: $\mathrm{F}_t = [\mathrm{G}_t{}' \quad \mathrm{H}_t{}']'$. We assume that G_t comprises the differences of the logarithms of GDP (Δy_t), of the GDP deflator (Δp_t), of real commercial property prices ($\Delta \boldsymbol{cpp}_t$) as well as the level of the effective Federal Funds rate 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. Banking factors are thus included in the policy reaction function. The factors are assumed to follow a VAR($\boldsymbol{p}$) model:

$$\begin{pmatrix} \Delta \boldsymbol{y}_t \\ \Delta \boldsymbol{p}_t \\ \Delta \boldsymbol{cpp}_t \\ \mathrm{H}_t \\ \boldsymbol{ffr}_t \end{pmatrix} = \mathrm{z} + \Phi(\boldsymbol{L}) \begin{pmatrix} \Delta \boldsymbol{y}_{t-1} \\ \Delta \boldsymbol{p}_{t-1} \\ \Delta \boldsymbol{cpp}_{t-1} \\ \mathrm{H}_{t-1} \\ \boldsymbol{ffr}_{t-1} \end{pmatrix} + \mathrm{v}_t\,, \tag{6}$$

where z 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.

For identification of monetary policy and commercial property price shocks, we adopt a Cholesky ordering: $\Delta y_t \rightarrow \Delta p_t \rightarrow \Delta \boldsymbol{cpp}_t \rightarrow \mathrm{H}_t \rightarrow ffr_t$. I.e. we assume that GDP,

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

aggregate prices and property prices do not react contemporaneously to shocks to the banking factors and to 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 as we will discuss below.

By ordering the policy instrument below the factors summarizing the banking variables, 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 banking 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 the information set of the Fed, which supports our identification assumption.

It is somewhat more questionable whether banks react with a lag 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) supports our choice to order banking factors before the Federal Funds rate. 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.

4.2 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 (r), (or m, the number of common (latent) banking variables), and the VAR order (p). m is set to 4 (and, hence, r equals 8) which is suggested by the information criteria IC_{p1} and IC_{p2} of Bai and Ng (2002) when applied to the regression residuals. We rely on the IC_{p1} and the IC_{p2} since these criteria have been shown to perform well in small samples. p is set to 1, as suggested by the BIC. We experiment with a larger number of factors[14] and with $p = 2$, 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 1b.

4.3 Commonality Among the Banking Variables

In our model, the 8 (observable and latent) factors explain 55% 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 high number 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.

Table 3 shows variance shares explained by all (latent banking and observed macroeconomic) factors and by the observed macroeconomic factors only of the variables of interest, i.e. loan growth and loan spreads. (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. 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 conditions unrelated to macroeconomic developments play a more important role for smaller banks. The result may, however, 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 higher 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 spreads, commonality is with an average of 92% much higher than for loan volumes. Commonality is again smaller for small than for large and foreign banks. The

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

common macroeconomic factors explain a larger share of the loan spread dynamics of large and foreign banks compared to small banks.

4.4 *Empirical Results*

Figures 2a and 2b present impulse responses of the macroeconomic variables to one standard deviation monetary policy and commercial property price shocks. The black lines represent the median impulse responses while the dark (light) blue shaded areas correspond to the confidence bands at the 68 (90)% significance level which are constructed based on the bootstrap-after-bootstrap method proposed by Kilian (1998).

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 about 10 basis points before gradually returning to zero after a bit more than a year. The point estimates show an increase in GDP; the effect is significant at the one standard deviation level between quarters 1 and 6 after the shock before turning back to zero, consistent with long-run real neutrality of monetary policy. The GDP deflator and property prices rise permanently,[15] with a maximum effect reached after about two years. Following the commercial property price shock, the two price variables increase. The Federal Funds rate drops on impact significantly before turning positive after two quarters. The reaction of GDP is never statistically significantly different from zero.[16]

4.4.1 Reaction of New Loans to Monetary Policy Shocks

Figure 3 shows the reactions of new loans (Figure 3a) and loan spreads (the loan rate minus the 1-year Treasure Bill rate) (Figure 3b) to an expansionary monetary policy shock. The first row shows responses for all banks; rows 2-4 show results for the banking groups. Table 4 shows 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. We show the effects on impact and after one year. The impact effects reflect direct risk taking by banks while the effects after one year include effects of movements in other (macroeconomic) variables induced by the shocks.

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

[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.

Total new business loans increase following the monetary policy shock (Figure 3a). The increase becomes significant after six quarters following the shock and turns insignificant in the longer run. The quite persistent response is possibly due to endogenous increases of property prices and thus collateral values. This 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).[17] Yet, empirical (time-series) studies typically find the opposite, i.e. business loans (temporarily) 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, according to the authors, an increase in business loan *supply* can explain the finding.

One interpretation of our results is that the increase in loans primarily reflects loan supply rather than loan demand effects. This would be encouraging because the risk-taking channel concerns loan supply, not loan demand. Since the STBL contains information on business loans only, we cannot assess whether shifts between the different loan categories (consumer, real estate and business) have taken place. Our analysis suggests, that the average bank does not shift from safe to risky business loans after expansionary monetary shocks (Figure 3a). This also holds true for large domestic and foreign banks. By contrast, small banks significantly extend relatively risky loans, but not loans with minimal risk. In that sense, our results do not stand against the Den Haan et al. (2007) argument. To get a sense of the magnitude, a one standard deviation monetary policy shock triggers a rise in high-risk loans by small banks by more than 2% after one year. Loans by all banks rise by less than 1%. High-risk loans made by all banks rise even less (by 0.5%).

The difference between lending by all banks to high-risk borrowers and lending to low-risk borrowers is significantly negative (Table 4a). If a risk-taking channel was operating, we would rather expect a positive effect. The negative overall effect for the aggregate is due to 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 one year, the differential effect is significant only for small banks. On impact, small banks increase

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

lending to high-risk and moderate-risk borrowers significantly more than larger banks (Table 4b). Lending to low-risk borrowers by small banks increases as well but this increase is significantly smaller than for large banks.

Kashyap and Stein (2000) and Angeloni et al (2002) argue that differences across banks in the response of loans to a monetary policy shock can be labeled as supply driven, provided that customers of the different banks are similar. The result that smaller banks react differently to monetary shocks than large banks suggests that the differential effect in lending growth to high-risk borrowers is indeed supply driven. This indicates the presence of an active risk-taking channel of monetary policy.

This finding of no evidence for a risk-taking channel for the entire banking system is confirmed when we compare the outcomes from two simple VARs. Unlike in the FAVAR setup, the VAR does not allow to look at the differential impact on the lending behavior by specific types of banks and, hence, to disentangle credit supply from demand. In the first VAR, we replace the four banking factors with growth of risk-weighted real bank loans and loan spreads; in the second VAR, we replace them with growth of unweighted real bank loans and loan spreads. The risk-weighted measures are constructed based on information on loans of minimal, low, moderate and acceptable risk from the STBL, and weights are proportional to the Basel II weights. We do not find significant differences between the responses of risk-weighted and unweighted loans and loan spreads to monetary policy and commercial property price shocks. Details on the VAR and the results are available upon request.

4.4.2 Reaction of Loan Spreads to Monetary Policy Shocks

Loan spreads decline after the monetary policy shock (Figure 3b). Because we use the difference between the risky business lending rate and the risk free Treasury Bill rate of roughly the same maturity, the decline in the spreads can be interpreted as a reduction in the risk premium banks demand on risky investments.[18] The monetary policy shock boosts economic activity and property prices. These effects should indeed reduce the risk of borrowers. Insofar, the reduction in risk spreads is not surprising. The reduction in risk spreads also suggests that supply effects dominate after the shocks. Demand effects would instead be reflected in an increase in the spreads. Small and foreign banks reduce

[18] Changes in the risk spreads may also reflect changes in banks' market power and sluggishness in the adjustment of lending rates to movements in the policy rate. We focus on adjustment at business cycle or shorter frequencies for which market power can reasonably be assumed not to change much. Sluggish adjustment of lending rates to the policy rate would, ceteris paribus, lead to an increase in the spread after an expansionary monetary policy shock. Hence, the decline of the spread is due to a decline in the risk premium.

the risk spread on impact more strongly for high-risk than for low-risk customers (Table 4a), indicating increasing risk appetite. Moreover, small banks reduce their risk spreads charged on high-risk borrowers more than large banks (Table 4b).

We have re-estimated the model with the loan spread defined as the lending rate minus the Federal Funds rate and find, in line with our theoretical prior, an increase of this intermediation spread after a monetary policy loosening.

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

Average lending significantly increases in response to the property price (collateral) shock (Figure 5). All banks raise lending to high-risk borrowers, consistent with the theoretical prediction. Lending to low-risk borrowers declines for small banks, increases for foreign banks, and remain unchanged for large domestic banks. A one standard deviation commercial property price shock which raises property prices on impact by roughly 2% leads to an increase of high-risk loans by small banks by a maximum of 4% after one year. This is slightly more than the impact on high-risk loans by other banking groups. For other banks, relatively safe loans tend to rise to a similar extent as risky loans while low-risk loans decline for small banks.

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 (Table 4a). 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. Small banks also react more to the shocks than large domestic and foreign banks.

Spreads mostly drop after the property price shocks. Small and large banks reduce risk spreads especially for high-risk borrowers, and small banks reduce the risk premium the most (Tables 4a and 4b). When we re-estimate the model with intermediation spreads (lending rates minus the policy rate), we find, as for the monetary policy shock, an increase, which is in line with our theoretical prior from Section 2.

4.4.4 Summary of Results

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

Three findings suggest that the observed effects are indeed supply-driven. First, all business loans increase after the shocks. Second, the reaction of loans differs across banking groups. Third, loan spreads decline after the shocks.

As regards risk taking, we do not find evidence for increased risk taking for the entire banking system after monetary policy shocks, but only for small banks. After collateral shocks, 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.

5 Discussion of Results

The theoretical model outlined in Section 2 provides us with a set of determinants of bank risk. It shows that risk taking by banks depends on the monitoring technology, the degree of capitalization, and the degree of market power. The STBL does not contain information on these specific characteristics. Instead, it distinguishes between small domestic, large domestic, and foreign banks. In this section, we ask whether there are systematic differences between these banking groups with respect to capitalization, market power, and monitoring costs. This will enable us to interpret our empirical findings in the light of the theoretical model. We also look at changes in the degree of collaterization and in the maturity of loans as additional indicators of bank risk which are also contained in the survey.

5.1 Reconciling Theory and Empirics

As concerns the capitalization of banks, individual bank data from the U.S. Call Reports show a negative and significant correlation between the size of banks and the capital ratio. Small banks are, on average, better capitalized than large and global banks: over our sample period, small banks had a median capitalization ratio of 9.5%. Large and global banks had lower median capitalization ratios of 8.6% and 8.4%, respectively.[19] We also run a cross-section regression of the size of banks (log assets) on the capital ratio (equity capital divided by total capital in %), (both averaged over the period 1997-2008) and a

[19] Small banks (large banks) are defined as banks with total assets below (above) the 95th percentile of the total asset distribution. A bank is defined as "global" if it has foreign affiliates, i.e. it comprises the groups of foreign and domestic global banks. See Cetorelli and Goldberg (forthcoming) for equivalent definitions and descriptive statistics.

constant; we find a negative, highly significant relation (regression coefficient: -0.49, *t*-statistic: -19.02) between size and capitalization

Monitoring costs are unobservable, but we have reasons to believe that costs are higher for smaller than for larger banks. First, monitoring involves fixed costs, which large banks can shoulder more easily. Second, high variable monitoring costs indicate low productivity. Low-productivity banks, in turn, are likely to grow less rapidly. Hence, observed sized differences across banks can be taken as indirect evidence of differences across banks in terms of monitoring costs or, more generally, cost efficiency. Hence, large banks are likely to have cost advantages. This is consistent with results in Bos and Kolaris (2005) which reveal that small banks are in general less cost efficient than their larger counterparts in the U.S. and in Europe. Note that this interpretation is not inconsistent with a relative cost advantage of small banks in the acquisition of soft information.

Consistent with the interpretation that small banks have higher monitoring costs and thus use collateral as a substitute mechanism to control risk, 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. 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. Of course, differences in the degree of collateralization could also reflect differences in borrower characteristics. If small banks predominantly have small (and risky) customers, this would affect the probability that lending is backed by collateral.

As regards differences in market power across banks, 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*". More recent evidence suggests that this positive relation between market power and bank size has not changed substantially for the more recent period. In a comprehensive study Bikker et al. (2005) find that market power increases with banks' size. They show that this relation also holds for different countries, including the U.S. Koetter et al. (forthcoming) provide similar evidence based on U.S. bank-level data from the U.S. Call Reports. Their Table 8 reveals that especially the largest banks are able to set high markups over their marginal costs, indicating higher pricing power among larg banks compared to smaller banks

Hence, all three factors – capitalization, market power and monitoring costs – might explain our finding that risk-taking effects are most pronounced for small banks. For small banks, the pass-through effect stressed in the model by Dell'Ariccia et al. (2010) is likely to dominate the risk-shifting effect. The finding that, following a collateral shock, only small banks take on additional risk can be rationalized with their higher monitoring cost as well. According to theory, especially banks with an inefficient monitoring technology will reduce monitoring effort following an increase in the value of the underlying collateral.

An additional difference between large and small banks is that larger banks are potentially less dependent on the domestic market for refinancing. Because foreign banks are able to raise loanable funds in foreign markets, 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: $\partial \boldsymbol{i}_{\boldsymbol{D}}^{\boldsymbol{Dom}} / \partial \boldsymbol{i} = \boldsymbol{i}_{\boldsymbol{D},i}^{\boldsymbol{Dom}} > \boldsymbol{i}_{\boldsymbol{D},i}^{\boldsymbol{For}}$. Hence, foreign banks can be expected to respond less to domestic shocks. 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 rates in the U.S.

5.2 Additional Evidence on Risk Taking

So far, our focus has been on changes in lending across risk categories and on the risk spread as proxies for changes in the risk taking of banks. Our dataset provides us with two additional variables which can be used to assess changing risk patterns. These variables are the degree of collateralization and the maturity structure of bank lending. The classification of loans into the different risk categories which we have used so far is based on the quality, not the quantity of collateral (see the Data Appendix for details). Also, the maturity of loans is not reflected in the risk rating. We show in Figure 5 reactions of the degree of collateralization and the maturity of loans after monetary policy and commercial property price shocks. We focus on lending to high-risk borrowers by small banks for which the risk-taking channel was found to be active. Results for other banking groups and risk categories are available upon request.

Increased collateralization or shorter maturities could make loan portfolios less risky, and it is even plausible that banks require more collateral or lower the maturity in order to – subsequently – take on more risk (see, e.g., Strahan 1999). Seen in this light it is striking that small banks lower the maturity of and increase the collateral for high-risk loans, possibly as a pre-requisite for risk taking. This interpretation is supported by the timing of the effects. While the effect on loans only gradually builds up, the reactions of collateral and maturity are rather frontloaded.

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 decisions of commercial banks. To capture changes in collateral values, we include commercial property prices as an additional factor. Using 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, market power, and monitoring costs of banks.

Our main results are based on a comparison of reactions to shocks of new loans that fall into different risk categories and corresponding risk spreads. We find no evidence for a risk-taking channel for the entire banking system after expansionary monetary policy shocks or an unexpected increase in commercial property prices. 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.

In terms of implications for macroprudential supervision, our insignificant results for the entire banking system indicate that worries that expansionary monetary policy and increases in property prices increases risk-taking incentives might be overstated. At the same time, there is a substantial number of banks, i.e. small banks, that increase risk-taking following expansionary policy shocks. These banks might not be important for the macroeconomy, but the market segment of small- and medium-sized enterprises might be affected. At the same time, we find that small banks compensate, at least to some extent, additional risk taking by requiring more collateral and lowering the maturity of loans.

We have also presented indirect evidence that differences across banks in terms of market power, efficiency, and the degree of capitalization of banks help explain differences in banks' responses to monetary policy shocks. We leave it for future research to shed more light on relative importance of these factors. Small and well capitalized U.S. banks, for instance, 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) and are consistent with empirical studies on banks' capital buffer adjustment (e.g. Jokipii and Milne 2011). However, our results should not be used as an argument against an increase in capital requirements. Our theoretical model suggests that, in equilibrium, the riskiness of banks *declines* with the degree of capitalization (although better capitalized banks take more risk after shocks). Moreover, the link between bank capital and risk is driven by a number of additional factors and also depends on the time horizon. Additional factors may be changes in equity risk premia or changes in corporate governance structures of banks, which are not captured in our theoretical or empirical models. In addition, higher capital ratios have other beneficial effects not captured in our paper. They reduce the maturity mismatch in banks' balance sheets which lowers the banks' exposure to liquidity shortages. Furthermore, in the long run, better capitalized banking systems have a significantly lower probability of banking crises, and higher capitalization reduces output fluctuations in normal times (BIS 2010).

One caveat to our analysis is that we focus on (new) business loans only. We have no information on real estate or consumer loans. This limits the general applicability of our results. At the same time, it may be advantageous since we focus on a loan market segment that has not been much under the influence of government policies to promote risk taking, unlike in the subprime residential mortgages loan segment; see, e.g., Calomiris (2009) for an overview of the government measures taken to encourage risk taking in the mortgage market. Also, our focus on balance sheet business loans only implies that off-balance sheet activities and other credit substitutes are not covered. These activities might be particularly important for foreign and large banks. Moreover, while we have information about banks' lending decision based on its current perception about the loan's future performance, we do not have knowledge about the extent to which this perception is correct. Hence, we can only look at the former aspect of the risk-taking channel in our paper, not the latter one. If a bank underestimates loan risk, we would underestimate the risk-taking channel. Finally, we make again clear that our focus is on *new* loans. This implies that we do and cannot assess the total effect of changes in the risk of bank loan portfolios which additionally stem from the balance sheet channel, but, at the same time, allows us to isolate the risk-taking channel.

Overall though, the FAVAR methodology used in this paper provides a powerful tool for analyzing heterogeneity across banking groups and loan market segments with regard to banks' responses to macroeconomic shocks. It shows, most importantly, that ignoring heterogeneous responses or ignoring the feedback between the banking sector and the macroeconomy may lead to erroneous conclusions concerning the link between risks in banking and the macroeconomy. Hence, applying this methodology to questions of systemic risk in banking or for the analysis on changed capital requirements 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]

<u>*Minimal Risk*</u>
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.

<u>*Low Risk*</u>
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.

<u>*Moderate Risk*</u>
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

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 a 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 a 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	<u>Low capitalization</u>: monitoring increases, risk decreases <u>High capitalization</u>: 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

The differences between the variance shares explained by all factors and the variance shares explained by the observed factors are the variance shares explained by the latent "banking" factors.

		All Loans	Minimal Risk	Low Risk	Moderate Risk	Acceptable Risk
Loan Growth						
All Banks	All factors	0.57	0.31	0.45	0.45	0.26
	Observed factors	0.04	0.11	0.04	0.03	0.04
Large Banks	All factors	0.64	0.31	0.55	0.50	0.24
	Observed factors	0.08	0.06	0.05	0.06	0.07
Small Banks	All factors	0.21	0.10	0.22	0.29	0.14
	Observed factors	0.06	0.04	0.11	0.11	0.10
Foreign Banks	All factors	0.66	0.14	0.16	0.52	0.19
	Observed factors	0.02	0.02	0.09	0.03	0.05
Loan Spreads						
All Banks	All factors	0.92	0.76	0.78	0.92	0.77
	Observed factors	0.18	0.13	0.19	0.21	0.27
Large Banks	All factors	0.89	0.63	0.79	0.88	0.78
	Observed factors	0.21	0.26	0.23	0.18	0.25
Small Banks	All factors	0.86	0.42	0.68	0.83	0.78
	Observed factors	0.15	0.08	0.11	0.19	0.20
Foreign Banks	All factors	0.84	0.64	0.59	0.84	0.62
	Observed factors	0.24	0.22	0.13	0.43	0.25

Table 4: Difference Between Impulse Responses of Loans 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

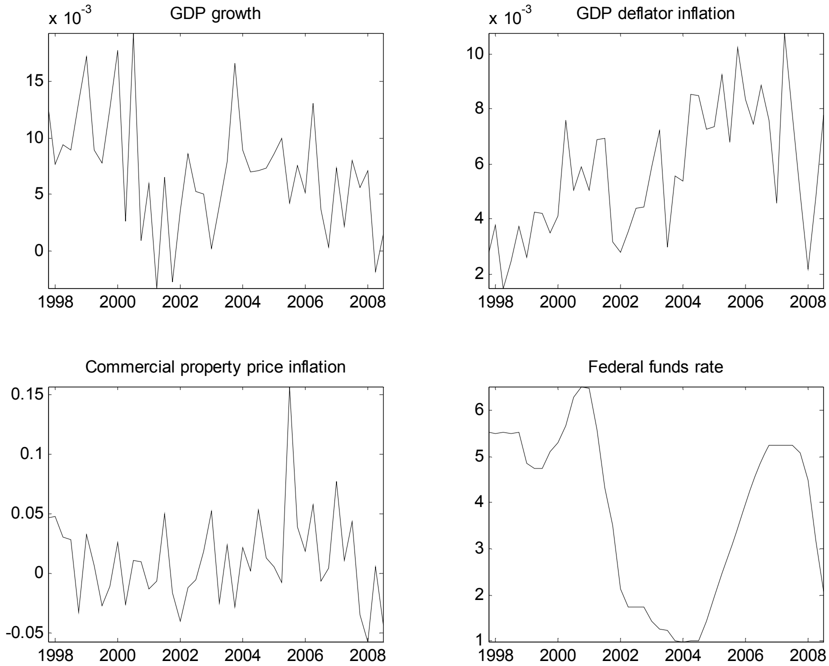
	All Banks	Small Banks	Large Banks	Foreign Banks
Loans				
Monetary policy shock				
Impact effect	**-0.003**	**0.004**	0.000	**-0.002**
Four quarters	-0.015	**0.016**	-0.004	-0.004
Property price shock				
Impact effect	0.004	**0.094**	0.012	**-0.023**
Four quarters	0.007	**0.083**	-0.024	-0.009
Loan spreads				
Monetary policy shock				
Impact effect	**-0.002**	**-0.008**	0.006	**-0.003**
Four quarters	0.005	**0.002**	0.005	0.001
Property price shock				
Impact effect	-0.036	**-0.111**	-0.026	**-0.010**
Four quarters	0.012	**0.012**	0.001	0.006

(b) Differences Across Banking Groups

	Minimum Risk	Low Risk	Moderate Risk	Acceptable Risk
Loans				
Monetary policy shock				
		Impact effect		
Small – Large	**-0.002**	**0.002**	**0.002**	**0.002**
Small – Foreign	0.000	**0.003**	**0.000**	**0.005**
Large – Foreign	**0.001**	**0.001**	**-0.002**	**0.003**
		Four quarters		
Small – Large	-0.008	**0.025**	0.006	**0.012**
Small – Foreign	0.010	**0.026**	-0.001	**0.030**
Large – Foreign	**0.018**	0.002	-0.008	**0.018**
Property price shock				
		Impact effect		
Small – Large	-0.075	**-0.075**	**-0.036**	**0.007**
Small – Foreign	**-0.098**	**-0.144**	-0.002	**0.020**
Large – Foreign	-0.021	**-0.071**	**0.034**	**0.014**
		Four quarters		
Small – Large	**-0.099**	-0.048	**-0.056**	**0.005**
Small – Foreign	-0.084	**-0.105**	-0.034	0.010
Large – Foreign	0.017	-0.055	**0.022**	0.005
Loan spreads				
Monetary policy shock				
		Impact effect		
Small – Large	**0.056**	**0.029**	**0.015**	**-0.029**
Small – Foreign	**0.012**	**0.015**	**0.019**	**0.006**
Large – Foreign	-0.002	-0.002	0.010	0.007
		Four quarters		
Small – Large	0.003	0.000	0.001	**-0.004**
Small – Foreign	0.002	-0.001	0.007	-0.001
Large – Foreign	-0.001	0.000	**0.006**	0.003
Property price shock				
		Impact effect		
Small – Large	**0.056**	0.029	0.015	**-0.029**
Small – Foreign	**0.068**	-0.003	**0.043**	-0.035
Large – Foreign	**0.012**	**-0.031**	**0.030**	-0.005
		Four quarters		
Small – Large	**-0.013**	-0.025	**-0.007**	**-0.003**
Small – Foreign	-0.010	**-0.018**	-0.015	-0.005
Large – Foreign	0.002	0.006	**-0.009**	-0.002

Figure 1: Macroeconomic Variables and Latent “Banking” Factors

(a) Macroeconomic Variables



(b) Latent “Banking” Factors

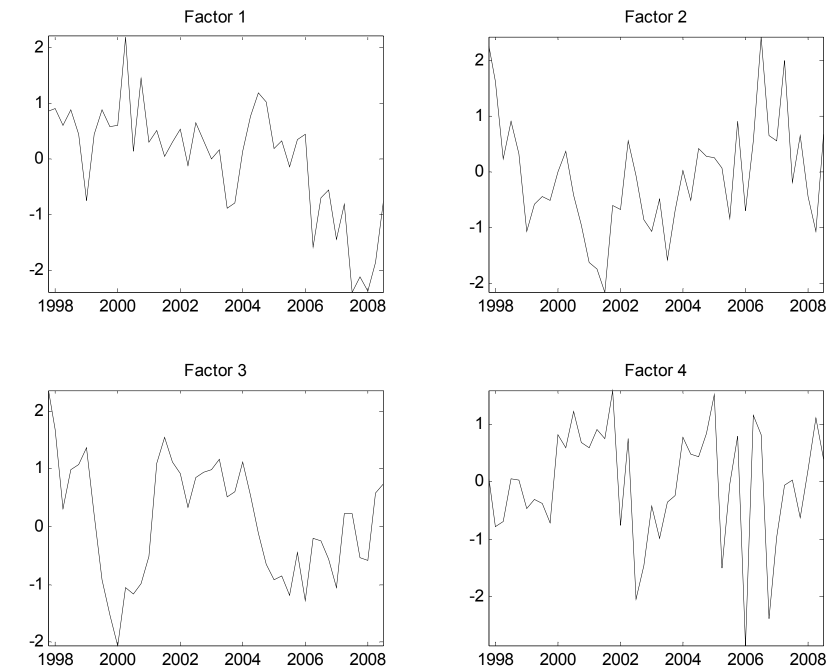
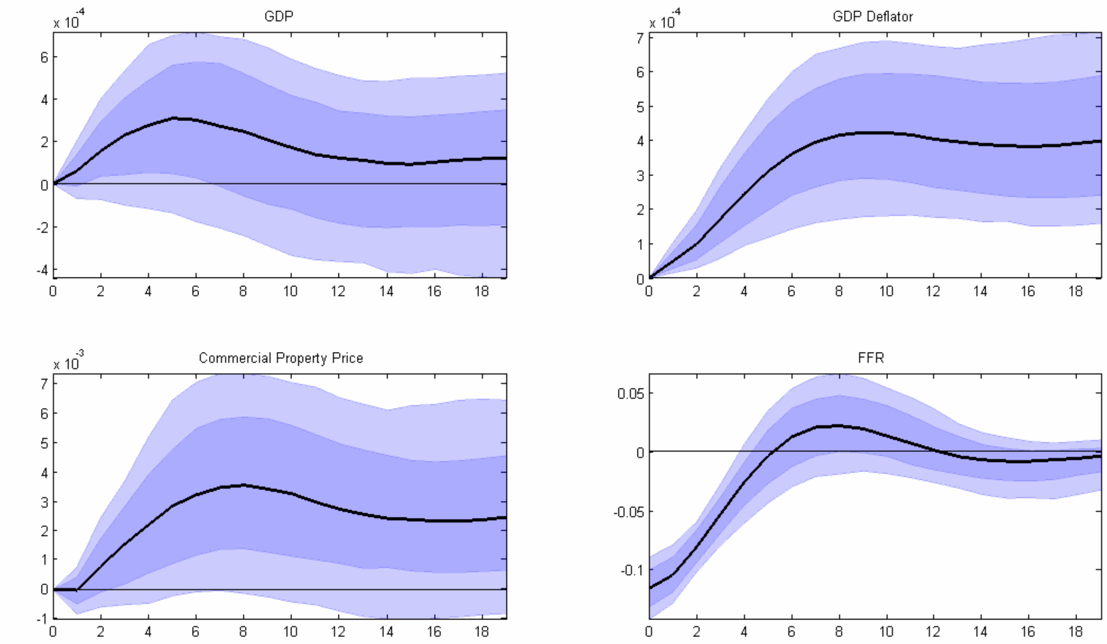


Figure 2: Effect of Monetary Policy and Commercial Property Price Shocks on Macroeconomic Variables

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

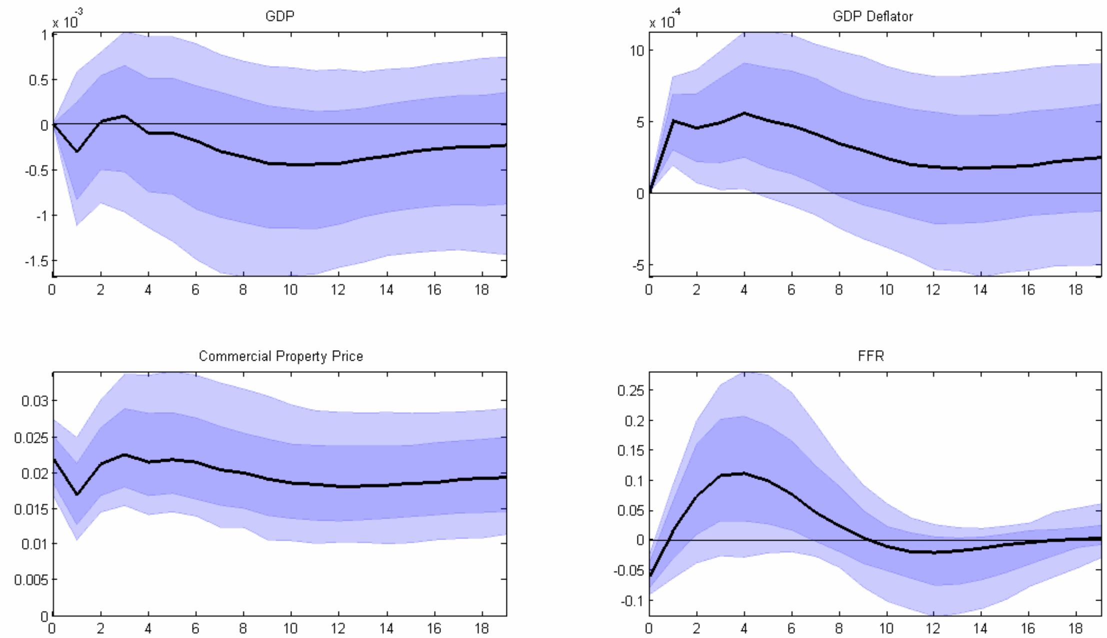
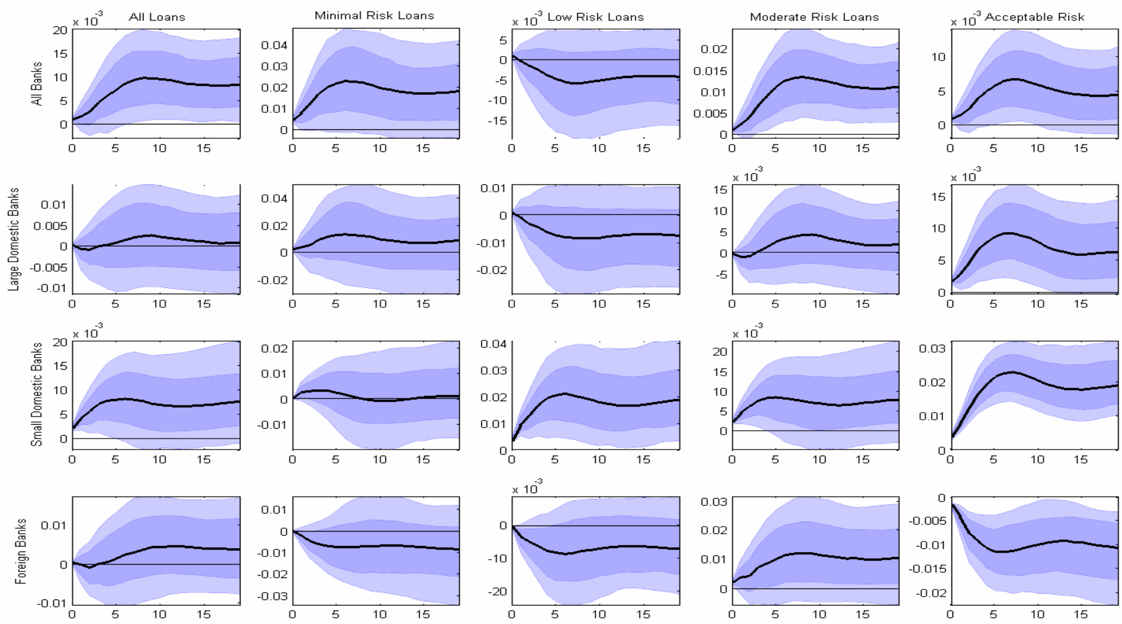


Figure 3: Effect of Monetary Policy Shocks on New Lending and Loan Spreads

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

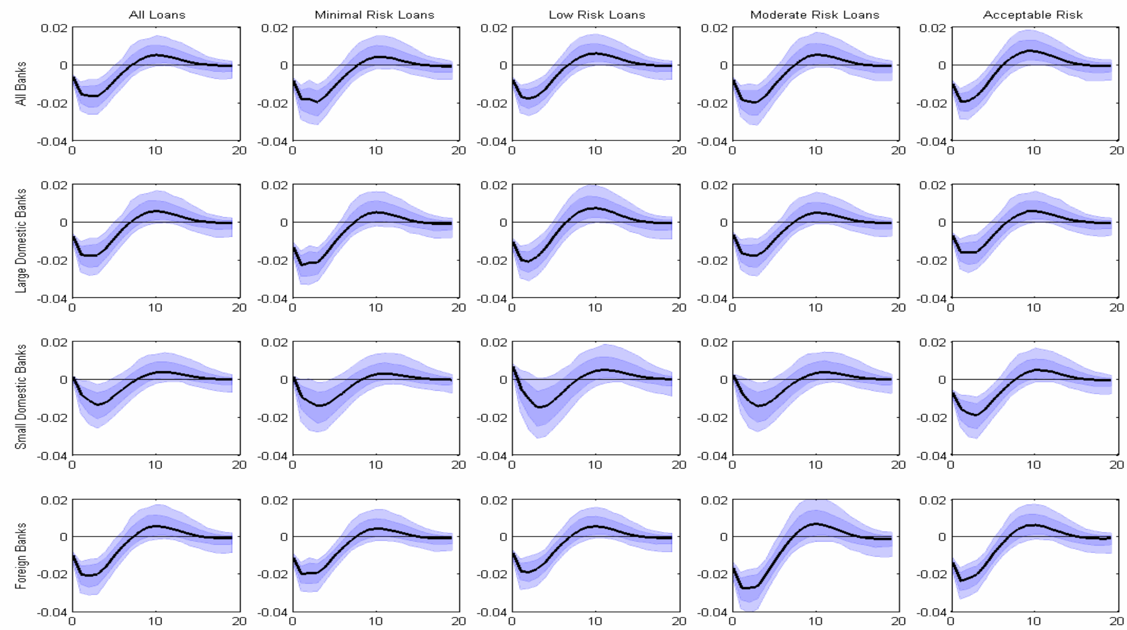
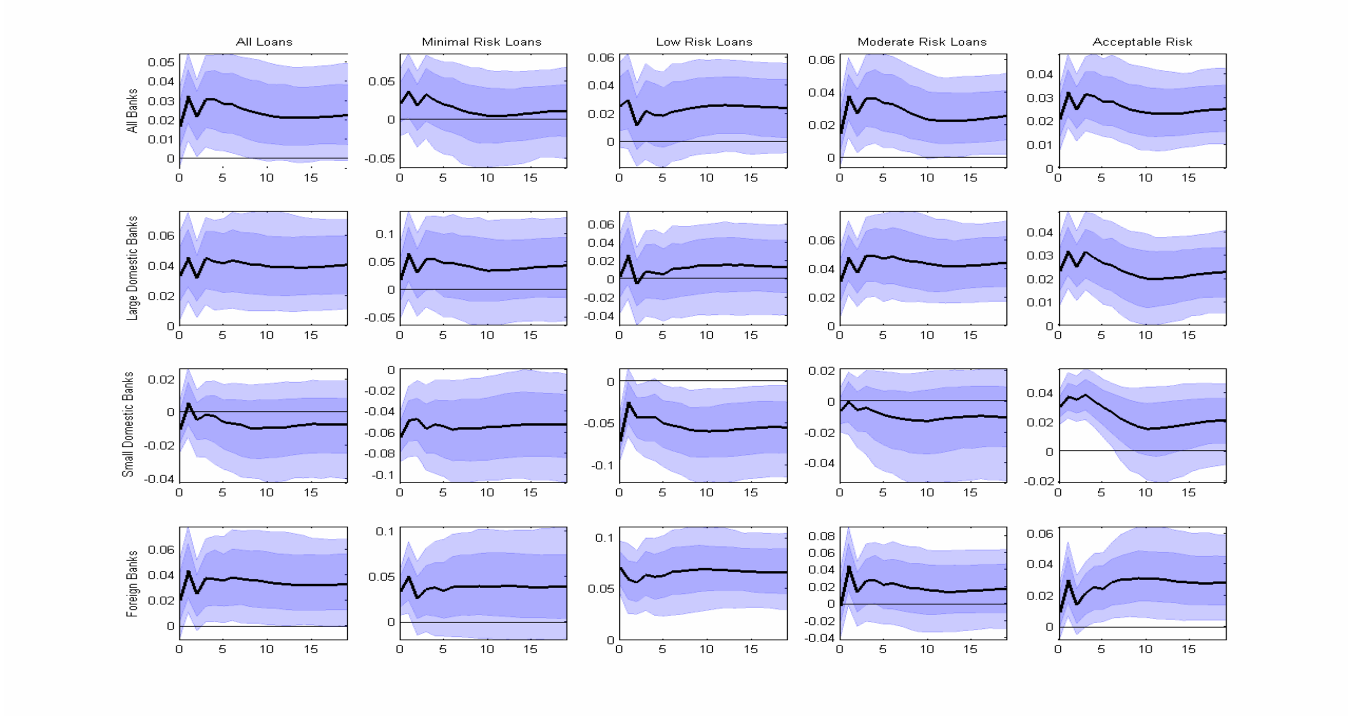


Figure 4: Effect of Commercial Property Price Shocks on New Lending and Loan Spreads

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

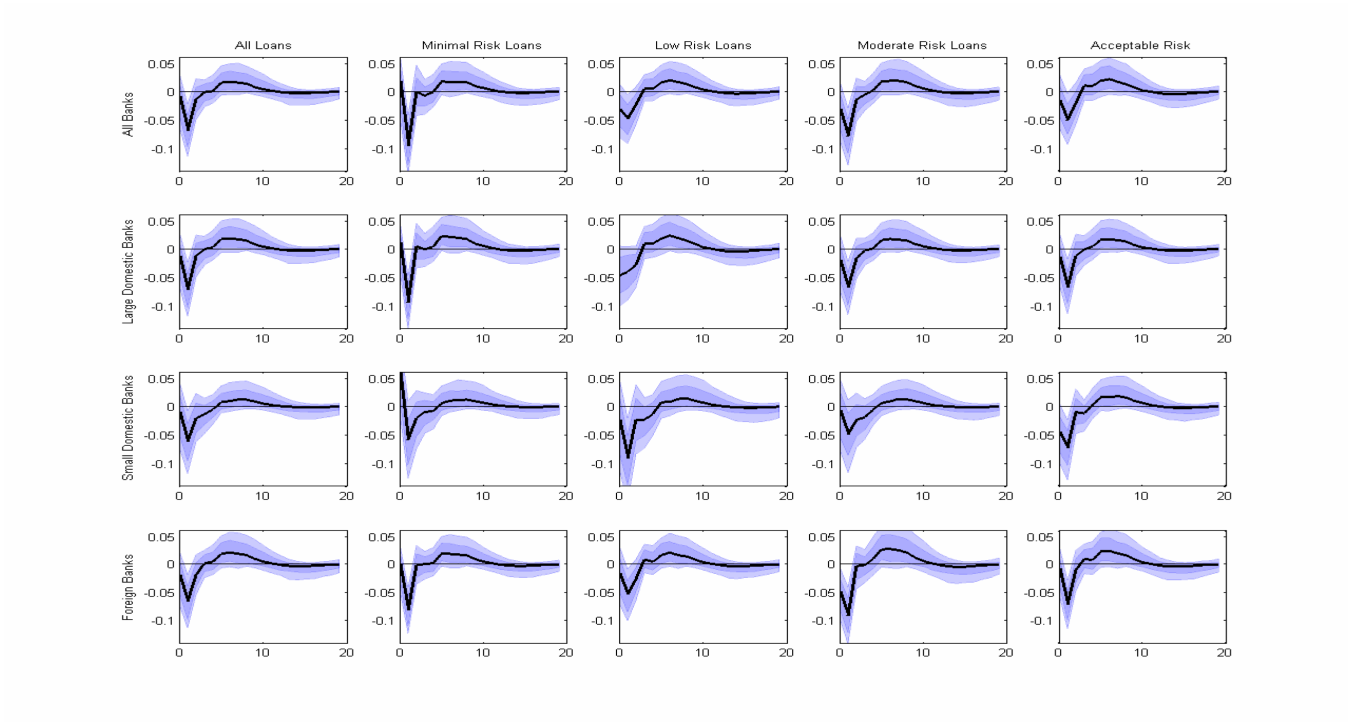
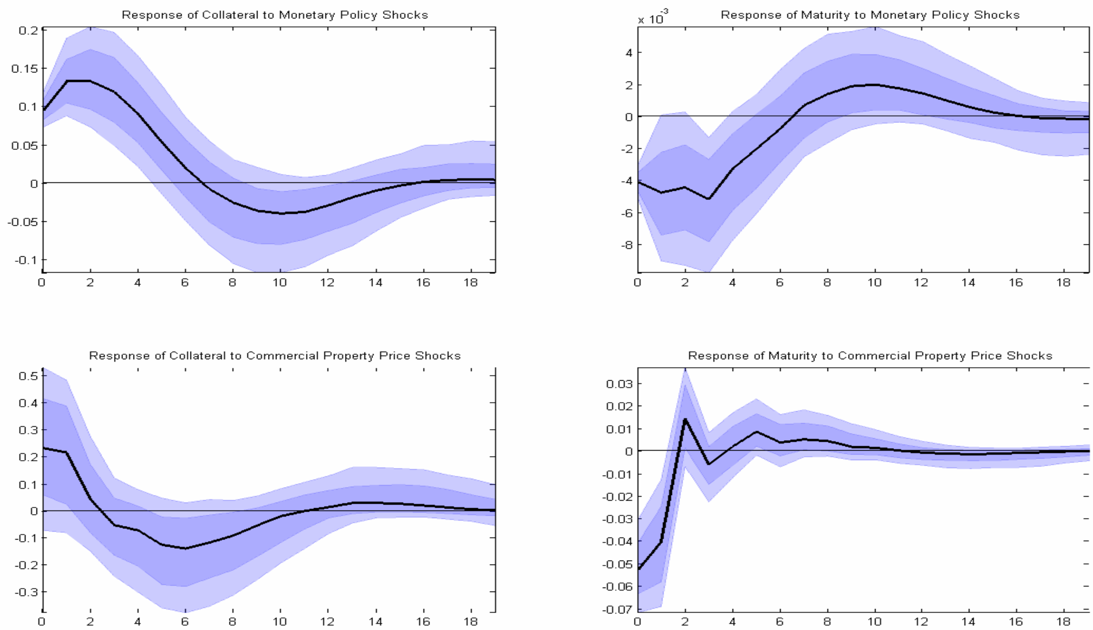


Figure 5: Effect of Commercial Property Price and Monetary Policy Shocks on Collateralization and Loan Maturity of New High-Risk Lending by Small Banks

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 collateral (panel (a)) and maturity (panel (b)) to a one standard deviation monetary policy shock (upper plots) and a one standard deviation commercial property price shock (lower plots).



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