Shocks to Bank Lending, Risk-Taking, Securitization, and Their Role for U.S. Business Cycle Fluctuations

Peersman, G.; Wagner, W.B.

Publication date:
2014

Citation for published version (APA):
Peersman, G., & Wagner, W. B. (2014). *Shocks to Bank Lending, Risk-Taking, Securitization, and Their Role for U.S. Business Cycle Fluctuations*. (CentER Discussion Paper; Vol. 2014-019). Economics.

CentER Discussion Paper

No. 2014-019

SHOCKS TO BANK LENDING, RISK-TAKING, SECURITIZATION, AND THEIR ROLE FOR U.S. BUSINESS CYCLE FLUCTUATIONS

By

Gert Peersman, Wolf Wagner

This is also an European Banking Center Discussion Paper No. 2014-002

February, 2014

ISSN 0924-7815
ISSN 2213-9532

TILBURG UNIVERSITY

Shocks to Bank Lending, Risk-Taking, Securitization, and their Role for U.S. Business Cycle Fluctuations*

Gert Peersman
Ghent University
gert.peersman@ugent.be

Wolf Wagner
Tilburg University
w.wagner@uvt.nl

February 2014

Abstract

Shocks to bank lending, risk-taking and securitization activities that are orthogonal to real economy and monetary policy innovations account for more than 30 percent of U.S. output variation. The dynamic effects, however, depend on the type of shock. Expansionary securitization shocks lead to a permanent rise in real GDP and a fall in inflation. Bank lending and risk-taking shocks, in contrast, have only a temporary effect on real GDP and tend to lead to a (moderate) rise in the price level. Furthermore, there is evidence for a strong search-for-yield effect on the side of investors in the transmission mechanism of monetary policy. These effects are estimated with a structural VAR model, where the shocks are identified using a model of bank risk-taking and securitization.

JEL classification: C32, E30, E44, E51, E52
Keywords: Bank lending, risk-taking, securitization, SVARs

*We acknowledge financial support from the Europlace Institute of Finance (EIF). Gert Peersman worked on this paper while visiting the ECB as a Duisenberg Research Fellow. We thank seminar participants at the ECB and the Europlace Institute of Finance for useful comments and suggestions. All remaining errors are ours.

1 Introduction

The experiences of recent years have emphasized the need for a better understanding of the links between the financial sector and the real economy. While substantial effort has been devoted to this topic, some key questions remain. One of them is the importance of shocks originating from within the financial sector relative to shocks from the real side of the economy, as well as the question of what the sources of these financial shocks are.

Many observers, for instance, agree that increased risk-taking at banks resulted in excessive lending in the early 2000s, subsequently contributing to the crisis of 2007-2008. However, it is less clear what led to this increased appetite for risk. One view is that it was caused by changes in the financial system, such as greater risk-shifting opportunities coupled with skewed incentive schemes (see e.g. Rajan 2005). An alternative interpretation is that the risk-taking behavior of banks was mainly driven by developments external to the banking sector. For example, loose monetary policy has been blamed for providing banks with incentives to take on excessive risk prior to the crisis, the so-called "risk-taking channel" of monetary policy (e.g. Adrian and Shin 2010; Jiménez *et* al. 2009; Ioannidou *et* al. 2009; Maddaloni and Peydró 2011).

Similarly, there is a broad understanding that securitization was an important driver of the lending boom prior to the crisis, as well as a major factor contributing to the subprime crisis. For example, Keys *et* al. (2010) and Purnanandam (2011) have shown that the widespread use of securitization affected bank behavior both in terms of amount and quality of loans. Again, it is not clear what triggered the changes in securitization markets. On the one hand, it may be due to financial innovation which made it easier for banks to transfer risks to investors. On the other hand, securitization may also have been driven by changes outside securitization markets, such as shifts in the stance of monetary policy that altered investors' appetite for risky assets.[1]

[1] Borio and Zhu (2008) argue that low interest rates lead to a higher appetite and demand for securitization products by investors, which is often called the "search for yield" effect of monetary policy. On the other hand, banks typically use securitization to buffer the effects of monetary policy. In particular, lower interest rates reduce the supply of securitization by banks because it is cheaper and easier to finance the loans on-balance sheet (Kuttner 2000; Estrella 2002; Loutskina

Separating shocks which originate in banks and securitization markets from other shocks is clearly important for understanding how the financial system interacts with the macro-economy. It should help us in assessing the overall role of the financial system in creating as well as amplifying shocks, which is an important input into the design of financial regulation. For example, the scope for regulation is more limited if fluctuations in financial variables mainly arise in response to shocks to the real economy. Furthermore, isolating different types of financial shocks is a prerequisite for studying the macroeconomic consequences of these shocks. Different types of financial shocks may affect output and prices differently, and hence require different policy responses.

In this paper, we analyze the link between the banking sector, securitization markets and the macro-economy with a structural vector autoregressive (SVAR) model. The advantage of an SVAR approach is that it requires us to impose only a limited structure on the data. Since we are interested in isolating shocks that can be clearly attributed to the financial system, we restrict the analysis to a set of financial shocks that are orthogonal to real economy disturbances and monetary policy innovations. The shocks are identified with restrictions that are obtained from a parsimonious theoretical model of bank risk-taking and securitization. Specifically, we identify three financial shocks. A *risk-taking shock* alters banks' cost - real or perceived - of holding risks on their balance sheet. It may arise for instance due to an underpricing of risk or moral hazard caused by bailout expectations.[2] A *securitization shock* makes it more attractive for banks to securitize loans. It can be the result, for instance, of financial innovation or a change in the demand for securitized assets. Finally, a *lending shock* is a shock that makes it more profitable for banks to extend loans, for example, because of a reduction in monitoring costs or because of a rise in the demand for loans which is not caused by developments in the real economy.

We estimate the SVAR for the United States (U.S.) over the sample period 1970-2008. The results show that the identified financial shocks are an important source of macroeconomic fluctuations. Together, they account for more than 30 percent of

and Strahan 2009; Loutskina 2011).

[2] Our modeling approach does not require us to take a stance on the precise nature of a given shock; it thus captures the diversity of reasons why a shock may occur.

U.S. output variation. The dynamic effects are, however, very different. Expansionary securitization shocks lead to a permanent rise in real GDP accompanied by a fall in inflation. In other words, a pattern which is typically found for technology or cost-push shocks (despite the fact that securitization shocks are orthogonal to real economy innovations on impact). Lending shocks and risk-taking shocks, in contrast, only have a temporary effect on economic activity and they tend to lead to a (moderate) rise in the price level. Different financial shocks may thus require different policy responses.

Within the SVAR, we also estimate the effects of monetary policy shocks on bank lending and securitization markets. The estimations reveal that there is a surge in the volume of securitization on impact after an expansionary monetary policy shock, suggesting a strong search-for-yield effect on the side of investors in the transmission mechanism of monetary policy. Another interesting finding of our analysis is that changes in securitization and retained loans by banks are predominantly driven by shocks unrelated to risk-taking and securitization markets. This suggests that a large part of the observed fluctuations in securitization and risk-taking in the data is in fact an endogenous response to developments elsewhere in the economy.

The present study is related to the literature that focuses on modeling the interactions between the financial system and the macro-economy. In recent years, substantial effort has been devoted to incorporating financial frictions in macroeconomic models. While standard RBC-models do not have an explicit role for the financial sector, following Bernanke and Gertler (1989), the literature has emphasized the role of the financial system as an accelerator of shocks (e.g. Kiyotaki and Moore 1997; Carlstrom and Fuerst 1997; Bernanke *et* al. 1999). More recent papers have emphasized that the financial accelerator itself can be a source of shocks. Nolan and Thoenissen (2009) consider shocks to the efficiency of financial intermediation, Gilchrist *et* al. (2009) allow for shocks to the financial accelerator itself, while Jermann and Quadrini (2012) incorporate shocks that affect the borrowing capacity of firms. Besides shocks to the financial accelerator, the literature has emphasized other types of financial shocks. For instance, Christiano *et* al. (2010) allow for a financial wealth shock (a shock to the value of capital in the economy) and a risk-shock (a shock to the distribution of returns). Caldara *et* al. (2013) separately identify financial shocks and uncertainty shocks. Our paper contributes to this literature by considering a set of financial shocks that have not been explicitly analyzed before, i.e. securitization, risk-taking and lending shocks.

The paper proceeds as follows. The next section presents the benchmark SVAR, as well as the model-based identification strategy to disentangle the shocks. The estimation results are presented in section 3, while section 4 discusses the robustness of the results. Section 5 concludes and considers some implications for financial regulation and macroeconomic policies.

2 Identification of financial shocks

Isolating different types of financial shocks is challenging because financial variables interact with each other and also depend on the state of the economy. The challenge is to identify movements in financial variables that are not reactive to other variables, that is, to identify exogenous movements. In this section, we explain our approach to isolate such exogenous movements.

In our analysis we will use SVAR models. Such models are often used to estimate the effects of monetary policy shocks. They capture the dynamic relationships between macroeconomic variables within a linear model. By imposing a minimum set of restrictions on the model, they allow decomposition of the innovations to the variables into mutually orthogonal shocks with a structural interpretation. Once the shocks are identified, the dynamic effects on all the variables in the model can be measured, controlling for other changes in the economic environment that may have an independent effect on the variables.

Our SVAR has the following representation:

$$Z_t = \alpha + A(L)Z_{t-1} + B\varepsilon_t \tag{1}$$

where Z_t is a vector of endogenous variables containing respectively output (y_t), inflation (π_t), the federal funds rate (i_t) and a set of so-called *flow of funds* variables from the Flow of Funds database: the amount of bank lending (l_t), the amount of loans securitized by banks (s_t) and the amount of loans retained by banks (r_t).[3]

[3]Notice that the sum of retained and securitized loans is equal to bank lending. However, since

The term α is a vector of constants, $A(L)$ is a matrix polynomial in the lag operator L, and B the contemporaneous impact matrix of the mutually uncorrelated disturbances ε_t.

We are interested in identifying three financial shocks (lending, securitization and risk-taking), but also monetary policy shocks, as this allows us to analyze how such shocks affect financial variables. In order to isolate the four shocks, we use a combination of zero and sign restrictions on the contemporaneous impact matrix B of equation (1). The set of restrictions to uniquely disentangle the disturbances is summarized in Table 1.

Table 1: Identification of structural shocks

	y_t	π_t	i_t	l_t	s_t	r_t
Monetary policy shock	0	0	-	?	?	?
Bank lending shock	0	0	0	+	+	+
Securitization shock	0	0	0	+	+	-
Risk-taking shock	0	0	0	+	-	+

y_t = output, π_t = inflation, i_t = federal funds rate, l_t = lending, s_t = securitization, r_t = retained loans

We follow Christiano *et* al. (1996) in order to separate real economy shocks from monetary policy and financial shocks. First, we assume that real economy and monetary policy shocks can have an immediate effect on the *flow of funds* variables (bank lending, securitization and retained loans), whereas shocks in banking and securitization markets do not affect the real economy and monetary policy actions on impact (we later analyze the robustness of the results by also allowing for an immediate response of the federal funds rate to the financial shocks). Second, monetary policy shocks are assumed to have no contemporaneous impact on output and inflation, but may affect the financial variables on impact. Taken together, this implies that any contemporaneous correlation between the VAR disturbances to the *flow of funds* variables and the other variables is assumed to reflect causation from the latter to the *flow of funds* variables, and not the other way around. This assumption is conservative in our context, because it may lead us to underestimate the

we use logarithms for the estimations, this does not lead to collinearity in the SVAR.

importance of financial shocks. The advantage of this approach, however, is that it allows us to identify shocks in a simple and tractable way.[4]

Table 1 contains various (sign) restrictions that allow us to disentangle the financial shocks from each other. These restrictions are generated from a simple model of a profit maximizing bank, which we discuss below.

2.1 A model of bank lending and securitization

We consider the representative bank of an economy. In the previous section we have assumed that financial variables react contemporaneously to innovations in the real economy and shifts in the monetary policy rate, but cannot influence real economy variables and the policy rate on impact. Consistent with this, we analyze the behavior of the representative bank, keeping constant the real economy and monetary policy. Since we are also interested in the impact of monetary policy, we will nonetheless also derive the reactions of the bank to monetary policy shocks.

In our simple model, the bank has to make two decisions. First, it decides how many loans to extend to households and firms. Second, it decides how many of these loans it wants to securitize. The remaining loans are funded on balance sheet through deposits. Retaining loans on balance sheet subjects the bank to costs, which we take as an (inverse) measure of the bank's appetite for risk.

The bank faces a linear demand for loans given by (all parameters take positive values):

$$L = l_0 - l_1(r_L - \varepsilon_L), \tag{2}$$

where l_0 is a constant affecting the demand for loans (it may, for instance, depend on economic activity), r_L is the lending rate charged by the bank and ε_L is a lending shock. This shock is an expansionary one as it permits banks charging higher rates r_L for given lending L.[5] The lending shock can also be given a supply-side interpretation as it may arise from a reduction in the cost of making loans for banks (in section

[4] Isolating the various shocks while allowing for a contemporaneous effect between all variables, would require a much richer fully-fledged dynamic general equilibrium model with a banking and securitization market. This is clearly beyond the scope of this paper.

[5] Alternatively, one may model a shift in loan demand as an increase in demand for a given interest rate. However, this specification is less suitable for solving the model.

2.3 we provide an extensive discussion and examples of lending and other financial shocks). In this case, $r_L - \varepsilon_L$ should be interpreted as the net return on lending for the bank (net of any lending costs).

The bank also faces demand for securitized loans by investors:

$$S = s_0 + s_1(r_S + \varepsilon_S) - s_2 r_F, \tag{3}$$

where s_0 is a constant affecting the demand for securitization, r_S is the return on securitized loans, ε_S is a securitization shock and r_F is the risk-free rate set by the central bank. The securitization shock is expansionary as it allows the bank to charge higher rates for a given amount of securitization. The shock could reflect changes in investors' appetite for securitization products (e.g. because of underpricing of credit risk). It may also reflect reductions in the cost of securitization (e.g. due to financial innovation), in which case $r_S + \varepsilon_S$ is the banks' net-return (after costs) from securitization. The risk-free rate r_F affects securitization demand (negatively) by increasing investors' opportunity costs. This captures the search for yield channel of monetary policy (Borio and Zhu 2008).

The costs of retaining a unit of loan on balance sheet consist of two parts. First, there is the cost of financing the loan with deposits. We assume that the cost of deposit financing is equal to the risk-free rate, r_F. Second, there is an extra cost which captures all costs (direct and indirect) of holding loans on balance sheet:

$$r_B = r_0(S - L) - \varepsilon_B. \tag{4}$$

Such costs may for instance occur due to forced liquidation in the event of stress. We assume that the marginal cost of financing on balance sheet increases in the amount of loans retained. Appendix A provides a microfoundation for this. Specifically, we introduce bank runs that force costly liquidation of loans. Bank loans are assumed to be heterogenous in their liquidation costs. The bank – aware of the risk of runs – will hence first securitize the more illiquid loans. This implies that the quality of retained loans falls when the bank keeps more of them, resulting in a higher (marginal) cost of loan retention.[6] The term ε_B in (4) is a risk-appetite shock,

[6]Convex on balance sheet costs create a link between optimal lending and securitization. Note

which alters the (real or perceived) cost of holding risk on balance sheet.

Finally, the risk-free rate r_F is determined by the monetary policy stance f_0, and an (expansionary) policy shock ε_F:

$$r_F = f_0 - \varepsilon_F. \tag{5}$$

Consistent with our assumption made in the previous section, f_0 is exogenous for the representative bank, and hence a constant in our analysis (in section 4 we will allow the policy rate to also respond to the financial shocks).

The timing is as follows. There are two dates, date 0 and 1. At date 0, monetary policy and financial shocks are revealed. Thereafter, lending and securitization decisions take place. In particular, the bank decides upon how much to lend L, and how many loans to securitize S. Securitization takes place by placing the loans in a special purpose vehicle (SPV) which issues securities with a face value of S to investors. The part of the loans that are not securitized are financed by borrowing B at rate r_F. The bank's budget constraint at date 0 is therefore:

$$L = S + B. \tag{6}$$

At date 1, the SPV distributes the return on the securitized loans, $(1 + r_L)S$, to investors minus a management fee for the bank, $(r_L - r_S)S$. Thus, investors receive a net return of $r_S S$ and the bank receives $(r_L - r_S)S$.

The bank's profits at date 1 consist of the repayment on retained loans, $(1 + r_L)(L - S)$, the securitization fee, $(r_L - r_S)S$, minus the repayment to depositors, $(1+r_F)B$, and the cost of retaining loans, $r_B(L-S)$. Using equation (6) to substitute for B we obtain for bank profits:

$$\Pi(L, S) = r_L L - r_S S - (r_B + r_F)(L - S). \tag{7}$$

The optimization problem of the bank can hence be written as:

$$\max_{L,S} \quad \Pi(L, S), \text{ subject to } L \geq S \geq 0. \tag{8}$$

that such costs also arise when the supply of funds is inelastic for the bank.

2.2 Comparative statics

In this section we derive the (qualitative) impact of each of the four shocks (the lending shock ε_L, the securitization shock ε_S, the risk-taking shock ε_B and the policy shock ε_F) on bank lending L, securitization S and retained lending R ($R = L - S$). For this we presume that the parameters of the model are such that interior solutions obtain.

We can use equations (2)-(5) to substitute r_L, r_S, r_B and r_F in the profit function, i.e. equation (7). We obtain:

$$\Pi(L,S) = (\frac{l_0 - L}{l_1} + \varepsilon_L)L - (\frac{S - s_0 + s_2(f_0 - \varepsilon_F)}{s_1} - \varepsilon_S)S - (-\varepsilon_B + r_0(L-S) + f_0 - \varepsilon_F)(L-S). \quad (9)$$

The first-order conditions for L and S are:

$$\Pi'(L) = \frac{l_0 - 2L^*}{l_1} + \varepsilon_L + \varepsilon_B - 2r_0(L^* - S^*) - f_0 + \varepsilon_F = 0 \quad (10)$$

$$\Pi'(S) = \frac{s_0 - s_2(f_0 - \varepsilon_F) - 2S^*}{s_1} + \varepsilon_S - \varepsilon_B + 2r_0(L^* - S^*) - f_0 + \varepsilon_F = 0. \quad (11)$$

From (10) and (11), we obtain for L^*, S^* and R^* ($= L^* - S^*$):

$$L^* = \frac{l_0 + l_1(\varepsilon_L + \varepsilon_B - f_0 + \varepsilon_F) + r_0 l_1 \left(s_0 - s_2(f_0 - \varepsilon_F) + s_1(\frac{l_0}{l_1} + \varepsilon_L + \varepsilon_S)\right)}{2(1 + r_0(l_1 + s_1))} \quad (12)$$

$$S^* = \frac{s_0 + s_1(\varepsilon_S - \varepsilon_B + f_0 - \varepsilon_F) - s_2(f_0 - \varepsilon_F) + s_1 r_0 \left(l_0 + l_1(\frac{s_0 - s_2(f_0 - \varepsilon_F)}{s_1} + \varepsilon_L + \varepsilon_S)\right)}{2(1 + (l_1 + s_1)r_0)} \quad (13)$$

$$R^* = \frac{l_0 - s_0 + s_2(f_0 - \varepsilon_F) + l_1(\varepsilon_L + \varepsilon_B - f_0 + \varepsilon_F) - s_1(\varepsilon_S - \varepsilon_B + f_0 - \varepsilon_F)}{2(1 + (l_1 + s_1)r_0)}. \quad (14)$$

Propositions 1-4 characterize the comparative statics with respect to the four shocks.

Proposition 1 *An expansionary bank lending shock* ε_L

(i) increases bank lending L^**,*

(ii) increases securitization S^**,*

(iii) increases retained loans R^**.*

Proof. From equations (12)-(14), we obtain $L^{*\prime}(\varepsilon_L) = \frac{l_1(1+r_0 s_1)}{2(1+(l_1+s_1)r_0)} > 0$; $S^{*\prime}(\varepsilon_L) = \frac{s_1 r_0 l_1}{2(1+(l_1+s_1)r_0)} > 0$; $R^{*\prime}(\varepsilon_L) = \frac{l_1}{2(1+(l_1+s_1)r_0)} > 0$ ■

The intuition behind these results is as follows. First, an increase in the lending rate for a given amount of loans (an expansionary lending shock), makes it optimal for the bank to increase lending. Higher lending, ceteris paribus, increases the amount of retained loans. As this increases the marginal costs of retaining risk, it becomes desirable for the bank to securitize part of the additional loans. As a result, securitization increases as well.[7] All bank variables thus increase following a lending shock.

Proposition 2 *An expansionary securitization shock* ε_S

(i) increases bank lending L^**,*

(ii) increases securitization S^**,*

(iii) decreases retained loans R^**.*

Proof. From equations (12)-(14), we obtain $L^{*\prime}(\varepsilon_S) = \frac{l_1 r_0 s_1}{2(1+(l_1+s_1)r_0)} > 0$; $S^{*\prime}(\varepsilon_S) = \frac{s_1(1+r_0)}{2(1+(l_1+s_1)r_0)} > 0$; $R^{*\prime}(\varepsilon_S) = \frac{-s_1}{2(1+(l_1+s_1)r_0)} < 0$ ■

The proposition shows that a securitization shock increases equilibrium securitization, which is because such a shock increases the return for the bank from securitizing, making it profitable for the bank to securitize more loans. Higher securitization, ceteris paribus, reduces the loans retained by the bank. As a consequence, the bank's (marginal) cost of on balance sheet risk falls, making it attractive for the bank to partially offset the reduction in retained risk through an expansion in lending. Hence, lending increases.

Proposition 3 *An expansionary risk-taking shock* ε_B

(i) increases bank lending L^**,*

(ii) decreases securitization S^**,*

(iii) increases retained loans R^**.*

[7] Note that if the costs of retaining loans were constant ($r_0 = 0$), securitization would be unchanged. In the empirical analysis, we will use weak sign restrictions to accommodate this.

Proof. From equations (12)-(14), we obtain $L^{*\prime}(\varepsilon_B) = \frac{l_1}{2(1+(l_1+s_1)r_0)} > 0$; $S^{*\prime}(\varepsilon_B) = \frac{-s_1}{2(1+(l_1+s_1)r_0)} < 0$; $R^{*\prime}(\varepsilon_B) = \frac{l_1+s_1}{2(1+(l_1+s_1)r_0)} > 0$ ■

Proposition 3 shows that the effect of a higher risk appetite of the bank, i.e. a reduced cost of retaining risk, is to increase lending and lower securitization. This is because a bank then desires to have more loans on its balance sheet, which it achieves by increasing lending and lowering the amount of securitization. In other words, the profit-maximizing bank uses both possible channels (lending and securitization) to expand balance sheet risk.

Proposition 4 *An expansionary monetary policy shock* ε_F

(i) increases bank lending L^**,*

(ii) has an ambiguous impact on securitization S^**,*

(iii) has an ambiguous impact on retained loans R^**.*

Proof. From equations (12)-(14), we obtain $L^{*\prime}(\varepsilon_F) = \frac{l_1(1+r_0 s_2)}{2(1+(l_1+s_1)r_0)} > 0$; $S^{*\prime}(\varepsilon_F) = \frac{s_2(1+r_0 l_1)-s_1}{2(1+(l_1+s_1)r_0)} \lesseqgtr 0$; $R^{*\prime}(\varepsilon_F) = \frac{l_1+s_1-s_2}{2(1+(l_1+s_1)r_0)} \lesseqgtr 0$ ■

The reason why an expansionary policy shock (a reduction in the risk-free rate) increases equilibrium lending is due to two, independent, channels that are operating in our model. First, a lower policy rate makes it more attractive for the bank to finance loans on balance sheet, and in order to achieve this, it will increase lending. This is the so-called “risk-taking channel” of monetary policy (Adrian and Shin 2010). Second, a lower interest rate reduces the opportunity costs for investors. As a result, they demand more securitization assets, which increases the bank’s optimal lending amount for the same reason as when a securitization shock hits. This is the “search-for-yield” effect on the side of investors (Borio and Zhu 2008). Note that these effects of monetary policy are distinct from risk-taking and securitization shocks which arise independently of monetary policy.

The impact of a monetary policy shock on securitization and retained loans, however, is undetermined. The reason is that there are two offsetting effects. On the one hand, a lower policy rate lowers the cost of funding on balance sheet for the bank. This increases the incentives for risk-taking, while reducing the incentive to securitize loans. On the other hand, a lower policy rate increases the demand for securitization assets by investors. This increases the bank's profits from securitization, leading to more securitization and less risk-taking. The net effect depends on the parameters of the model. The estimations will determine which effect dominates.

The sign restrictions delivered by Propositions 1-4 are the ones presented in Table 1. There is one exception. In the empirical analysis, we will not impose that a monetary policy shock increases lending (as suggested in Proposition 4). This is because this restriction is not needed to identify the shock, which allows us to evaluate whether the (estimated) lending impact of the shock conforms to the one predicted by the model. Note also that our model uniquely allows us to disentangle all shocks (that is, no two shocks can have the same responses).[8]

2.3 What are lending, risk-taking and securitization shocks?

The model provides a structure for interpreting the shocks that we identify in the empirical section. Recall that all three financial shocks are (contemporaneously) orthogonal to general macroeconomic conditions (output, inflation and the monetary policy rate). A lending shock hence refers to a shock that makes bank lending more attractive, taking as given macroeconomic conditions, the risk-taking appetite of banks and securitization markets. Similarly, a securitization shock refers to a change in securitization markets unrelated to macroeconomic conditions, lending markets and the risk appetite of banks. A risk-taking shock, finally, is a shock that affects bank risk-taking at given macroeconomic conditions and taking as given conditions in lending and securitization markets. In this section we provide some examples for the three shocks.

Lending shocks

- *Reduction in monitoring and screening costs.* When the cost of extending loans declines (for example, because of technological progress), banks will find it more attractive to extend loans.

[8]Our model permits the identification of financial shocks using balance sheet information only – this is a key advantage since quality data on lending rates and prices of securitization products is not available for a longer horizon.

- *Increase in house prices.* An (exogenous) rise in house prices can increase the demand for bank loans due to a wealth effect, and the supply of loans since higher collateral value alleviates borrowing constraints (see e.g. Dell'Ariccia *et* al. 2012).

- *Rise in expected economic activity.* When households and firms anticipate a future increase in economic activity, this can lead to an increase in the demand for loans. Similarly, the supply of loans could increase because the expected default rate on the loans declines.

Securitization shocks

- *Financial innovation that improves securitization technologies.* Transferring risks off the balance sheet causes moral hazard and adverse selection problems. Securitization techniques, such as the tranching and pooling of loans or the provision of liquidity lines to SPV have the potential to reduce costs stemming from asymmetric information (see e.g. DeMarzo 2005). Notably, this was the dominant view prior to the crisis of 2007-2008. By reducing inefficiencies associated with securitization, financial innovation may thus lead to a securitization shock.

- *Development of securitization markets.* Securitization on a large scale requires well-functioning markets. Improvements in securitization markets are thus a source of (positive) securitization shocks. By contrast, a breakdown of securitization markets (as observed during the crisis of 2007-2008) constitutes a negative securitization shock.

- *Higher risk-appetite by investors or underpricing of credit risk by investors.* A leading explanation for the surge in securitization in the years before the crisis is that investors did not fully understand the risks involved and hence accepted an insufficient compensation for taking on risks. Consistent with such an investor-driven explanation, Nadauld and Sherlund (2009) show that demand in the secondary market for mortgages has led to a higher supply of credit in the primary mortgage market.

- *Savings glut.* The increase in securitization activity is often attributed to an increased supply of funds by investors from outside the U.S.. Bernanke (2005) coined this phenomenon the global "savings glut". Shin (2009) provides for instance evidence that emerging markets funds were largely channeled towards mortgage debt securities, and not predominantly U.S. government securities.

- *Regulatory arbitrage.* The Basel II treatment of securitization for the calculation of capital requirements was favorable. It has been argued that this was a key driver behind securitization as it allowed banks to lower required capital.

Risk-taking shocks

- *Decline in liquidation risk.* If the risk of stress at banks declines, it becomes desirable for banks to hold more risk on balance sheet as they then face a lower likelihood of costly fire-sales.

- *Risk-shifting.* The put-option associated with equity gives bank managers and shareholders incentives to take on excessive risks (Jensen and Meckling 1976). Increases in the value of the put-option (for example, because of higher leverage) will incentivize banks to take on more risk. Risk-shifting incentives also become more pronounced when debtors underprice default risk, allowing the bank to finance risk at lower rates.

- *Capital requirements.* Regulators require banks to hold capital depending on the risk of their balance sheets. Since holding capital is costly for banks, variations in capital requirements will change the risk appetite of the bank. For instance, the introduction of the advanced approach for calculating capital requirements under Basel II allowed large banks to lower their capital, lowering their costs of risk-taking.

- *Cost of capital.* Any change in the economy (orthogonal to output and monetary policy innovations) that either changes the availability or costs of funding for banks will affect the extent to which banks can (and want to) take on new risks, and hence constitutes a risk-taking shock.

- *Bail-out expectations.* Financial development in the decades before the crisis of 2007-2008 has led to an increase in systemic risk because of factors such as higher bank size and interconnectedness. This has arguably raised the expectation of government bail-outs, increasing risk-taking incentives at banks.

- *Compensation of bank managers and traders.* The increasing dominance of skewed compensations (such as through options or bonuses) leads to higher payoffs in good states but limits losses in bad states. This makes it (privately) optimal to take on more risk (see e.g. Rajan 2005).

3 Empirical evidence

3.1 Data and estimation

Our empirical model includes real GDP, GDP deflator inflation, the federal funds rate and the amount of bank lending, securitization and retained loans. All variables are seasonally adjusted natural logarithms (multiplied by 100), except the interest rate, which is in percent. Estimation in (log) levels allows for implicit cointegrating relationships in the data (Sims *et* al. 1990). The sample period is 1970Q1-2008Q4. 2008Q4 is the quarter in which the federal funds rate hit the zero lower bound. From that quarter on the FED resorted to non-standard policy measures, which could distort the identification and estimation results. The estimations include four lags of the endogenous variables, based on standard likelihood ratio tests and the usual lag-length selection criteria.[9]

Real GDP, the GDP deflator and the federal funds rate are obtained from the FRED database. The Flow of Funds database provides the information on lending and securitization activities. Due to data constraints, we focus the analysis on mortgages and consumer credits, which represent the dominant form of securitization activities (at the end of our example, they cover about 88% of the stock of total securitization activities). Lending is the total amount of mortgage and consumer loans outstanding, while securitization is the total outstanding stock of securitized

[9] Most criteria suggest even less lags. The results are however robust to different choices of the lag length.

mortgage and consumer credits (in the case of mortgages this includes commercial mortgages as well as government-sponsored mortgages).[10]

Figure 1 shows the fraction of loans securitized over the sample period. While the propensity to securitize was very limited at the beginning of the sample (less than 1% of lending), we can see a clear increase in securitization during the sample period. At the end of the sample, nearly half of the loans are securitized. We also note that there are significant deviations from the trend, which may reflect securitization shocks.

We estimate an SVAR for model (2) using the restrictions on the contemporaneous impact matrix B of Table 1. Estimation and inference uses the Bayesian approach developed in Peersman (2005) or Uhlig (2005) (see these papers for a detailed explanation). The prior and posterior distributions of the reduced form VAR belong to the Normal-Wishart family. To draw the "candidate truths" from the posterior, we take a joint draw from the unrestricted Normal-Wishart posterior for the VAR parameters as well as a random possible decomposition B of the variance-covariance matrix, which allows the construction of impulse response functions. If the impulse response functions from a particular draw satisfy the imposed restrictions, the draw is kept. Otherwise, the draw is rejected by giving it a zero prior weight. We only impose the sign restrictions on the contemporaneous effects. Each draw is required to satisfy the restrictions of all identified shocks simultaneously. Finally, a total of 10000 successful draws from the posterior are used to produce the figures.

3.2 Dynamic effects of bank lending, securitization and risk-taking shocks

Figures 2-4 show the impulse responses to a one standard deviation innovation in bank lending, securitization and risk-taking shocks. The shaded (light blue) areas

[10] Securitization data for consumer loans is only available from 1989 onwards. Since consumer loan securitization is only about 5% of total securitization in our data, we do not adjust our analysis for this (moreover, when we exclude consumer credits from our analysis, the results remain very similar). Note also that securitization is only one form of credit risk transfer, although the dominant one (for example, at the end of our sample, the net-positions of U.S. commercial banks in credit derivatives was only about 2% of their assets).

represent the 68 percent posterior probability regions of the estimated effects, and the dotted (red) line the median of the posterior distribution.

Lending shocks are identified as those shocks that shift bank lending, securitization and retained loans on impact in the same direction, whilst being orthogonal to innovations in output, inflation and monetary policy. As shown in Figure 2, the joint rise in all three *flow of funds* variables after an expansionary lending shock is very persistent. Furthermore, there is a hump-shaped (and significant) change in economic activity, which only returns to baseline after approximately five years. There is a positive but insignificant effect on the price level, whereas the federal funds rate temporarily increases.[11]

The dynamic effects of securitization shocks are quite different, as can be seen from Figure 3. On the one hand, there is a significant and permanent rise of real GDP. On the other hand, inflation declines shortly after the shock, resulting in a permanent fall of the price level in the long run. Thus, a securitization shock has the properties typically associated with technology or permanent cost-push shocks. Notably, this is despite the fact that the shocks are orthogonal to innovations in output and prices. The magnitudes are economically relevant. A typical securitization shock raises the amount of securitization by 1 percent, leading to a permanent rise in real GDP of 0.3 percent, and a fall of the price level by 0.3 percent.

Figure 4 shows that a shock to risk-taking has a significant impact on output as well, but the pattern is similar to that of an aggregate demand shock. Specifically, a positive risk-taking shock is followed by a rise in economic activity that peaks after one year, and gradually returns to baseline afterwards. There is a modest (insignificant) rise in the price level. The expansion of the amount of retained loans is also temporary.

The different macroeconomic effects of securitization and risk-taking shocks is striking. Securitization shocks over the sample period have arguably been driven to a large extent by financial innovation. As such, they reflect a technological process and hence can be expected to be similar to productivity shocks in the economy. Since they are orthogonal to economic activity, these are productivity shocks originating

[11] Impulse responses of inflation have been accumulated in the figures, in order to better assess the effect on the price level.

from within the financial system. Our findings that are suggestive of technology shocks originating from within the financial system add to the debate on the contribution of the financial system to the economy.[12] Risk-taking shocks, in contrast, probably fit better the notion of *animal spirits*. They seem to be driven by changes in sentiment that can drive output – without having a lasting effect.

3.3 Monetary policy and risk-taking in the financial system

The impact of monetary policy shocks on standard macroeconomic variables is in line with the existing evidence (e.g. Bernanke and Blinder 1992; Christiano *et* al. 1999; Peersman and Smets 2003). Figure 5 shows that there is a hump-shaped effect on economic activity, and a persistent rise of prices after an expansionary monetary policy shock. There is also a deflationary effect of monetary policy in the short run, the so-called "price-puzzle". Note that monetary policy shocks also increase lending – which is predicted by our model but was not imposed in the SVAR.

More interestingly, our analysis can also be used to shed some light on the role of securitization and risk-taking in the monetary transmission mechanism. The literature has emphasized two different channels. Borio and Zhu (2008) argue that monetary policy affects the risk-taking incentives of investors ("search for yield"), as lower interest rates increase their appetite for higher-yielding securitization assets. Separate from this channel (which operates through investors and the demand for securitization), a fall in the risk-free interest rate reduces the cost of financing loans on balance sheet, leading to more lending by banks. This is the risk-taking channel of monetary policy (Adrian and Shin 2010).[13]

The two channels have different implications in our model. A search-for-yield effect has an impact similar to a securitization shock (as it increases the demand for securitization). It hence leads to higher securitization and less loan retention

[12] It should be noted that we cannot assess whether the overall contribution of securitization shocks was positive or negative – since all securitization shocks add to zero by definition.

[13] Using Spanish credit registry data, Jiménez *et* al. (2009) find that lower interest rates increase risk-taking at banks by causing banks to lend to borrowers with higher default risk. Ioannidou *et* al. (2009) find evidence for the risk-taking channel in Bolivia. Maddaloni and Peydró (2011) show that low short-term interest rates soften lending standards at banks. They also find that this effect is related to securitization activities.

(Proposition 2). The risk-taking channel is equivalent to a (positive) shock to risk-taking, and has the opposite impact: less securitization and higher loan retention (Proposition 3).[14] We can hence use the empirical estimates to learn about the relative importance of the two channels.

As can be seen in Figure 5, following a monetary policy shock, there is a strong increase in the volume of securitization on impact, whereas the volume of retained loans only starts to rise after some quarters. This suggests the existence of a search-for-yield channel of monetary policy or, to be precise, a search-for-yield channel that dominates the risk-taking channel in the short-run.

3.4 Macroeconomic relevance

While impulse responses show how the economy responds to various shocks, they do not tell us how important these shocks are for explaining macroeconomic fluctuations. To assess the macroeconomic relevance, Figure 6 shows the posterior distributions of the long-run forecast error variance decompositions of, respectively, output, securitization and retained loans. For each variable, we show the contribution of the four shocks that we have identified, as well as the sum of bank lending, securitization and risk-taking shocks to assess the overall relevance of financial disturbances. The figure also reports the medians of the distributions.[15]

The output variance decompositions in Figure 6 show that the macroeconomic relevance of shocks specific to the financial system is considerable. The three financial disturbances together explain approximately one-third of output variation. Lending and securitization shocks are each equally important drivers of the U.S. business cycle as monetary policy shocks. Risk-taking shocks are less important,

[14] Formally, this can be derived by setting $s_2 = 0$ and taking the derivative of S^* and R^* (equations (12) and (13)) with respect to ε_F. Note that an additional effect of monetary policy may arise through the demand side (see e.g. Himmelberg, Mayer and Sinai 2005, who argue that monetary policy prior to the crisis has led to higher housing demand).

[15] We show the entire distribution of the contribution to the forecast error variance to take into account the issues raised in Fry and Pagan (2007). Fry and Pagan criticize the use of median values (and percentiles) for variance decompositions on the grounds that reported values across variables and shock are not simultaneously generated by a single model in the case of sign restrictions, but come from different models. A consequence is that the contribution of the shocks may not sum up to one. Notice also that the median of the sum of the three shocks is mostly higher than the sum of the medians.

explaining approximately 5-6 percent of the variability. The overall importance of financial shocks is noteworthy, given our conservative identification strategy that attributes any contemporaneous movements in real variables to the real side of the economy.

Another interesting question is what the drivers of fluctuations in financial variables are. Are they caused by the financial shock itself, by other financial shocks, or developments outside the financial system? The decompositions of the forecast error variance for securitization and retained loans in Figure 6 show that surprisingly little is explained by the shock itself. In particular, securitization shocks only explain less than 10 percent of the long-run variability of the amount of securitization, while risk-taking shocks explain somewhat more than 10 percent of the long-run variability of retained loans. Fluctuations in these variables are hence mainly driven by other shocks. These are bank lending shocks and other shocks to the real economy that we do not identify in our analysis. Bank lending shocks in particular contribute approximately 40 percent to the variability of the amount of securitization and retained loans. Interestingly, monetary policy shocks explain little of the variability of both variables.

These findings suggest that securitization activities and on balance sheet risk at banks are mainly a response to other developments in the economy, including developments in lending markets. This is important to keep in mind when analyzing observed changes in the financial system. For example, while one may naively interpret a surge in securitization activities as originating in securitization markets, it may really reflect higher demand for financing in the economy. Notwithstanding this “passivity” of securitization and on balance sheet risk, shocks to these markets are of large macroeconomic importance – as the output decompositions have shown.

4 Contemporaneous monetary policy response

Following Christiano *et* al. (1996), we have assumed that monetary policy does not react on impact to the financial shocks. In this section, we analyze the case where the central bank can contemporaneously react to the disturbances in the financial sector. In order to incorporate this into the model of section 2.1, we have to make assumptions about the central bank's reaction function. Specifically, we assume that the central bank reacts to shocks in order to stabilize lending, that is, it systematically raises the interest rate on impact when there is a shock that increases lending (and lowers it in response to a contractionary shock).[16] A second assumption we make is that the demand for securitized assets is more sensitive to the return on the asset itself than to the return on the alternative safe investment (i.e. the monetary policy rate). This assumption implies that $s_1 \geq s_2$ in equation (3) of the benchmark model and ensures that the sign predictions for securitization shocks are unambiguous. Appendix B shows that this assumption is fulfilled for a standard portfolio problem of a risk-averse investor who allocates his wealth between different assets (two of them being securitized loans and the safe asset).

Appendix C contains the derivations for the comparative statics of the modified model. Table 2 summarizes the results.

Table 2: Comparative statics when monetary policy is endogenous

	i_t	l_t	s_t	r_t
Monetary policy shock	-	+	?	+
Bank lending shock	+	+	+	?
Securitization shock	+	+	+	-
Risk-taking shock	+	+	-	+

i_t = federal funds rate, l_t = lending, s_t = securitization, r_t = retained loans

The signs are identical to those of the baseline model, except in three instances. First, monetary policy now reacts to all expansionary financial shocks with an increase in the interest rate. Second, the impact of a lending shock on loan retention is ambiguous. The reason is that monetary authorities stabilize lending following a lending shock by raising the policy rate, which may reduce loan retention through the risk-taking channel. A lending shock can hence no longer be separated from a securitization shock. However, the model delivers an alternative restriction to disentangle both shocks. As shown in Proposition 8 in Appendix C, the proportion of

[16]This is the only internally consistent stabilization policy since our model is one of banking (and not of output and inflation).

securitized loans, S^*/L^*, increases more after an (expansionary) securitization shock than after an (expansionary) lending shock. The last change is that the effect of a monetary policy shock on retained loans is now an unambiguously positive one. This is, however, solely the result of the assumption that $s_1 \geq s_2$ and has no bearing on our analysis as monetary policy shocks are already identified uniquely. We can hence let the data decide on the monetary policy impact for retained loans.

We rerun the analysis using the sign restrictions in Table 2, dropping the restriction on the impact of monetary policy on retained lending, and adding the condition that S/L responds more to a securitization shock than a lending shock. We also add the zero contemporaneous restrictions on output and prices already used in the benchmark estimations. Figure 7 shows the estimated impulse response functions. As can be seen, the dynamic effects of securitization, risk-taking and monetary policy shocks are very similar to the benchmark analysis. The impact of lending shocks on GDP, however, declines and is now insignificant. A reduced impact of lending shocks is probably due to the (imposed) policy tightening on impact.

5 Summary and policy implications

This paper has considered the macroeconomic importance of shocks to bank lending, risk-taking and securitization. Bank lending shocks arise from changes in the economy that affect banks' incentives to extend loans, keeping constant the real side of the economy. Shocks to risk-taking increase the incentives for banks to retain loans on balance sheet, while securitization shocks raise the demand for securitized assets or lower the cost of securitization. Importantly, monetary policy is distinct from these shocks and has a separate impact on both bank risk-taking and securitization.

A simple model of a profit-maximing representative bank delivered identifying conditions for each shock. The model-implied restrictions were then used to estimate a structural VAR for the U.S. economy over the sample period 1970-2008. The estimations show that bank lending, securitization and risk-taking shocks have important consequences for the macro-economy. In particular, they explain together around one-third of U.S. output variability. Bank lending and risk-taking shocks have a temporary effect on economic activity, while the impact of securitization shocks is permanent.[17] Securitization shocks also lead to a decline in inflation. We also find evidence for a strong search-for-yield effect on the side of investors in the monetary transmission mechanism.

There are important messages for macroeconomic policies. Given that financial shocks are a significant source of macroeconomic fluctuations, policy makers need to take into account the role of the financial system. This may imply attempts to reduce the scope for the financial system to be a source of shocks. Current regulatory efforts, in particular aimed at curbing risk-taking at banks and reducing systemic risk in securitization markets, already go in that direction. In addition, policy makers need to consider the potential for the financial system to be the origin of shocks when reacting to fluctuations in the economy. In particular, our results indicate that for the optimal policy response, the source of the shock is critical. For instance, expansionary shocks originating in securitization markets resemble productivity shocks with deflationary tendencies, while shocks caused by higher risk-appetite, in contrast, tend to lead to higher inflation. On a practical level, this implies that central banks should not only pay attention to changes in total lending in the economy, but should also consider the contribution of banks (loan retention) and markets (securitization) to such changes.

Finally, our results provide a cautionary note for interpreting changes in the financial sector too readily. For example, it seems only natural to attribute fluctuations in securitization to securitization markets themselves, with implications for financial regulation. However, we find that only a small part of changes in securitization and risk-taking are caused by shocks to the respective variables themselves. The fluctuations are hence largely a response to developments taking place elsewhere in the economy. This emphasizes the need for clearly distinguishing between shocks and endogenous responses in the financial system when undertaking policy analysis. Our framework provides a simple means for doing this.

[17] We found that risk-taking shocks are relatively less important than securitization shocks. This may be different in bank-based systems, such as continental Europe, where the importance of shocks orginating from within banks may be larger, while securitization shocks play a more limited role.

References

[1] Adrian, T. and H. Shin (2010), "Financial intermediaries and monetary economics", in: B. M. Friedman and M. Wordford (eds.) *Handbook of Monetary Economics*, Chapter 12, pages 601-650

[2] Altunbas, Y., Gambacorta, L. and D. Marques-Ibanez (2009), "Securitisation and the bank lending channel", *European Economic Review*, 53 (8), 996-1009.

[3] Bernanke, B. (2005), "The global saving glut and the U.S. current account deficit", Remarks at the Sandridge Lecture, March 10, 2005.

[4] Bernanke, B. and A. Blinder (1992), "The federal funds rate and the channels of monetary transmission", *American Economic Review*, 82(4), 901-921.

[5] Bernanke, B. and M. Gertler (1989), "Agency costs, net worth and business fluctuations", *American Economic Review*, 79, 14-31.

[6] Bernanke, B., Gertler, M. and S. Gilchrist (1996), "The financial accelerator and flight to quality", *Review of Economics and Statistics*,.78, 1-15.

[7] Bernanke, B., Gertler, M. and S. Gilchrist (1999), "The financial accelerator in a quantitative business cycle framework," in: J. B. Taylor & M. Woodford (ed.), *Handbook of Macroeconomics*, edition 1, volume 1, chapter 21, pages 1341-1393.

[8] Borio, C. and H. Zhu (2008), "Capital regulation, risk-taking and monetary policy: a missing link in the transmission mechanism?", *BIS Working Paper Series*, 268.

[9] Caldara, D., Fuentes-Albero, C., Gilchrist, S. and E. Zakrajšek (2013), "On the identification of financial and uncertainty Shocks", *manuscript*, Federal Reserve Board.

[10] Carlstrom, C., and T. Fuerst (1997), "Agency costs, net worth, and business fluctuations: A computable general equilibrium analysis". *American Economic Review,* 87, 893-910.

[11] Christiano, L., Eichenbaum, M. and C. Evans (1996), "The effects of monetary policy shocks: Evidence from the flow of funds", *The Review of Economics and Statistics*, 78(1), 16-34.

[12] Christiano, L., Eichenbaum, M. and C. Evans (1999), "Monetary policy shocks: What have we learned and to what end?", in J. Taylor and M. Woodford (eds), *Handbook of Macroeconomics*, North-Holland, Amsterdam, p 65-148.

[13] Christiano, L., Motto, R. and M. Rostagno (2010), "Financial factors in economic fluctuations", Working Paper No. 1192, ECB.

[14] De Graeve, F. and A. Karas (2010), "Identifying VARs through heterogeneity: An application to bank runs", Working Paper Series No. 244, Sveriges Riksbank.

[15] Dell'Ariccia, G., Deniz I. and L. Laeven (2012), "Credit booms and lending standards: Evidence from the subprime mortgage market", *Journal of Money, Credit and Banking*, 44, 367-384.

[16] DeMarzo, P. (2005), "The pooling and tranching of securities: A model of informed intermediation", *Review of Financial Studies*, 18(1), 1-35.

[17] Diamond, D. and P. Dybvig (1983), "Bank runs, deposit insurance, and liquidity", *Journal of Political Economy*, 91(3), 401-19.

[18] Estrella, A. (2002), "Securitization and the efficacy of monetary policy", *Economic Policy Review*, Federal Reserve Bank of New York, May issue, pages 243-255.

[19] Fry, R. and A. Pagan (2007), "Some issues in using sign restrictions for identifying structural VARs", *NCER Working Paper Series*, 14.

[20] Gilchrist, S., Ortiz, A. and E. Zakrajšek, (2009), "Credit risk and the macroeconomy: Evidence from an estimated DSGE model", *manuscript*, Boston University.

[21] Gilchrist, S. Yankov, V. and E. Zakrajšek (2009), "Credit market shocks and economic fluctuations: Evidence from corporate bonds and stock markets", *Journal of Monetary Economics*, 56(4), 471-493.

[22] Himmelberg, C., Mayer, C. and T. Sinai (2005), "Assessing high house prices: Bubbles, fundamentals and misperceptions", *Journal of Economic Perspectives*, 19(4), 67-92.

[23] Ioannidou, V., Ongena, S. and J. Peydrò (2009), "Monetary policy, risk-taking and pricing: Evidence from a quasi-natural experiment", *manuscript*, Tilburg University.

[24] Jensen, M. and W. Meckling (1976), "Theory of the firm: Managerial behavior, agency costs, and ownership structure", *Journal of Financial Economics*, 3, 305-360.

[25] Jermann, U. and V. Quadrini (2012), "Macroeconomic effects of financial shocks", *American Economic Review*, 102(1), 238-71.

[26] Jiménez, G., Ongena, S., Peydrò J., and J. Saurina (2009), "Hazardous times for monetary policy: What do twenty-three million bank loans say about the effects of monetary policy on credit risk-taking?", *Bank of Spain Working Paper Series*, 833.

[27] Kiyotaki, N. and Moore, J. (1997), "Credit cycles", *Journal of Political Economy*, 105(2), 211-248.

[28] Keys, B., Mukherjee, T., Seru A., and V. Vig (2010), "Did securitization lead to lax screening? Evidence from subprime loans", *The Quarterly Journal of Economics*, 125(1), 307-362.

[29] Loutskina, E. (2011), "The role of securitization in bank liquidity and funding management", *Journal of Financial Economics*, 100, 663-684.

[30] Loutskina, E. and P. Strahan (2009), "Securitization and the declining impact of bank finance on loan supply: Evidence from mortgage originations," *Journal of Finance*, 64(2), 861-889.

[31] Maddaloni, A. and J. Peydro (2011), "Bank risk-taking, securitization, supervision, and low interest rates: Evidence from the Euro area and U.S. lending standards", *Review of Financial Studies*, Vol. 24, 2121-65.

[32] Nadauld, T. and S. Sherlund (2009), "The role of the securitization process in the expansion of subprime credit", Finance and Economics Discussion Series 2009-28. Board of Governors of the Federal Reserve System.

[33] Nolan, C. and C. Thoenissen (2009), "Financial shocks and the US business cycle", *Journal of Monetary Economics*, 56(4), 596-604.

[34] Peersman, G. (2005), "What caused the early millennium slowdown? Evidence based on vector autoregressions", *Journal of Applied Econometrics*, 20, 185-207.

[35] Peersman, G. (2011), "Bank lending shocks and the Euro area business cycle", *Ghent University Working Paper,* 11/766.

[36] Peersman, G. and F. Smets (2003), "The monetary transmission mechanism in the euro area: evidence from VAR analysis", in: I. Angeloni, A.K. Kashyap and B. Mojon (eds.), *Monetary Policy Transmission in the Euro Area*, Cambridge University Press, chapter 2, 56-74.

[37] Purnanandam, A. (2011), "Originate-to-distribute model and the subprime mortgage crisis," *Review of Financial Studies*, 24(6), 1881-1915.

[38] Rajan, R. (2005), "Has financial development made the world riskier?", *NBER Working Paper* No. 11728.

[39] Shin, H. (2009), "Leverage, securitization and global imbalances", *Hong Kong Institute for Monetary Research Occasional Paper* No.5.

[40] Sims, C., Stock J. H., and M. Watson, "Inference in linear time series models with some unit roots", *Econometrica*, 58(1), 113-44.

[41] Uhlig, H. (2005), "What are the effects of monetary policy on output? Results from an agnostic identification procedure", *Journal of Monetary Economics*, 52(2), 381-419.

Appendix A: A model of bank risk-appetite

We modify the baseline model as follows. Suppose that there is also an intermediate date $t = \frac{1}{2}$ and that bank depositors face uncertainty about when they have to consume (akin to Diamond and Dybvig 1983). In particular, with probability $\frac{1}{2}$ all depositors find out at date $t = \frac{1}{2}$ that they can only consume at this date, while with probability $\frac{1}{2}$ they find out that they have to consume at $t = 1$. The deposit contract gives depositors the right to withdraw at either $t = \frac{1}{2}$ or $t = 1$.

If consumers in the economy turn out to be late consumers, there is no problem at $t = \frac{1}{2}$ as there is no incentive to run on the bank. The economy then proceeds as in the baseline model. If consumers are of the early type, all consumers run on the bank, which forces liquidation of the bank. Such liquidation (effectively, calling in the loans the bank has made) is costly. In particular, we assume that a bank loses γ per unit of loan where γ depends on the type of firm it has financed. We assume that a firm's type i is uniformly distributed on $[0, 1]$ and that the liquidation cost for firm i takes the form

$$\gamma(i) = 4r_0 L \cdot i + 2 - \varepsilon_B, \tag{A1}$$

where we have $r_0 > 0$ and ε_B denotes a risk-taking shock. Dependence on L captures the idea that if the bank makes more loans, the average quality of loans suffers and hence liquidation costs increase (dependence on L ensures that the cost function becomes quadratic but is not necessary to produce convex costs).

We assume that firms are of infinitesimal small size and require one unit of funds each. A firm's type is discovered by the bank upon making the loan at date 0 but is unknown to either bank or firm prior to this. A bank that lends to a measure L of firms hence has a portfolio of types that is uniformly distributed on $[0, 1]$ with density L. Investors who buy securitized assets do not suffer from a liquidation problem and do not care about which type they buy. It is hence optimal for the bank to always securitize the loans with the highest liquidation costs. As a consequence, for a securitization amount of S, the bank will retain a portfolio of firms whose types are distributed with density L on $[0, 1 - \frac{S}{L}]$. This implies that the more the firm securitizes, the lower are the average liquidation costs of its remaining portfolio.

The payoffs from on balance sheet loans are as follows. With probability $\frac{1}{2}$, there is no run at date $t = \frac{1}{2}$ and the bank can collect $r_L(L-S)$ from firms at date 1. With probability $\frac{1}{2}$ there is a run at date 1. The bank then liquidates its loan portfolio and its revenue from doing so is

$$\int_0^{1-\frac{S}{L}} ((1 + r_L - \gamma(i))Ldi = (1 + r_L)(L - S) - 2(r_0(L - S)^2 - \varepsilon_B(L - S)), \quad \text{(A2)}$$

which the bank stores for date $t = 1$. The total expected revenue from retained loans is hence $(1 + r_L)(L - S) - r_0(L - S)^2 + \varepsilon_B(L - S)$. The per-unit extra costs of retaining loans are thus $r_0(L - S) - \varepsilon_B$.

Variations in risk appetite in this setting are captured by the parameter ε_B. Lower liquidation costs lead to lower cost of retaining loans, and hence increased risk appetite. Alternatively, risk appetite may also fall when the likelihood of runs increases or when bail-outs become less likely (bailouts can be interpreted in the model as an action by the government that eliminates a run at $t = \frac{1}{2}$ and lets the bank continue until $t = 1$).

Appendix B: The risk-free rate and the demand for securitization

Suppose each investor is endowed with one unit of wealth. He can invest this wealth either in a (risk-free) bond yielding a safe return of r_F, in securitized assets (with expected return r_S and variance σ_S^2) or in an alternative risky asset (with expected return r_E and variance σ_E^2). The latter may for instance be an equity investment. The correlation between the two assets is ρ and positive ($\rho \in (0,1]$).

Denoting that share of wealth invested in securitized assets and alternative assets with s and e, we obtain for the expected return and the variance of the investor's portfolio:

$$\mu = 1 + sr_S + er_E + (1-s-e)r_F \tag{B1}$$

$$\sigma^2 = s^2\sigma_S^2 + e^2\sigma_S^2 \tag{B2}$$

Assuming mean-variance preferences with risk-aversion parameter α, we have for the investor's utility:

$$U = 1 + sr_S + er_E + (1-s-e)r_F - \frac{\alpha}{2}(s^2\sigma_S^2 + e^2\sigma_E^2 + 2se\rho\sigma_S\sigma_E) \tag{B3}$$

The first-order conditions for s and e are

$$r_S - r_F - \alpha(s^*\sigma_S^2 + e^*\rho\sigma_S\sigma_E) = 0 \tag{B4}$$

$$r_E - r_F - \alpha(e^*\sigma_E^2 + s^*\rho\sigma_S\sigma_E) = 0 \tag{B5}$$

Combining both equations to eliminate e^* yields for the optimal investment in securitized assets:

$$s^* = \frac{r_S - r_F(1-\rho\frac{\sigma_S}{\sigma_E}) - r_E\rho\frac{\sigma_S}{\sigma_E}}{\alpha\sigma_S^2(1-\rho^2)} \tag{B6}$$

We have $s'(r_S) > 0$ and $s'(r_F) < 0$ (as long as $\rho\frac{\sigma_S}{\sigma_E} \leq 1$), that is, an increase in the return on securitized assets increases demand for the asset, while an increase in the risk-free rate reduces investment in securitization assets. More importantly, we have that $|s'(r_S)| \geq |s'(r_F)|$. Hence, the demand for a securitization asset depends more on the return on the asset itself than on the risk-free rate.

Appendix C: A model with endogenous monetary policy

In this appendix, we derive the sign predictions of the model when we allow for the central bank to (contemporaneously) react to lending, securitization and risk-taking shocks. We assume that the central bank (partially) stabilizes lending, that is, it raises the interest rate when there is a shock that increases lending (and lowers it in response to a contractionary shock). This can be motivated by output stabilization objectives of central banks.

It is instructive to first consider an economy in which the central bank fully stabilizes lending. Let us denote the target level of lending with $\overline{L}$. Following a shock, the central bank will adjust its monetary policy stance f_0 such that the resulting risk-free rate r_F leads to lending of $\overline{L}$ by the bank. The (post-shock) policy stance can be obtained by considering the equation for equilibrium lending L^* (equation (12)). This equation shows how bank lending depends on the various shocks and the policy stance f_0. Under full stabilization, the central bank will set f_0 such that L^* in (12) becomes identical to $\overline{L}$. The post-shock monetary policy stance can hence be obtained by setting $L^* = \overline{L}$ in (12) and solving for f_0. This yields:

$$f_0(L = \overline{L}) = \frac{\frac{l_0}{l_1} + \varepsilon_L + \varepsilon_B + 2r_0\left(\frac{s_0}{2} + \frac{s_1}{2}(\frac{l_0}{l_1} + \varepsilon_L + \varepsilon_S)\right) - 2\overline{L}(\frac{1+r_0 s_1}{l_1} + r_0)}{1 + r_0 s_2} + \varepsilon_F. \tag{C1}$$

As is to be expected, the policy stance increases in all four (expansionary) shocks, that is, the central bank reacts in a contractionary manner to an expansionary shock.

Corollary 5 characterizes the comparative statics for securitization and loan retention in the full stabilization economy.

Corollary 5 *If the central bank were to fully stabilize lending, the equilibrium amount of securitization S^* (retained loans R^*)*

(i) increases (decreases) in the lending shock ε_L,

(ii) increases (decreases) in the securitization shock ε_S,

(iii) decreases (increases) in the risk-taking shock ε_B,

(iv) is independent (independent) of the policy shock ε_F.

Proof. *Substituting f_0 in the expression for securitization (13) using equation (C1), we obtain for equilibrium securitization when the central bank stabilizes lending at $\overline{L}$:*

$$S^*_{L=\overline{L}} = \frac{s_0}{2} + \frac{s_1}{2}(\frac{l_0 - 2\overline{L}}{l_1} + \varepsilon_L + \varepsilon_S) \tag{C2}$$

$$-\frac{s_2}{2}\frac{\frac{l_0}{l_1} + \varepsilon_L + \varepsilon_B + 2r_0\left(\frac{s_0}{2} + \frac{s_1}{2}(\frac{l_0}{l_1} + \varepsilon_L + \varepsilon_S)\right) - \overline{L}(\frac{2}{l_1} + 2r_0 + 2r_0\frac{s_1}{l_1})}{1 + r_0 s_2}. \tag{C3}$$

From (C3) we have that $S^{*\prime}{}_{L=\overline{L}}(\varepsilon_L) = \frac{s_1 - s_2}{2(1+r_0 s_2)} > 0$ (since $s_1 \geq s_2$), $S^{*\prime}_{L=\overline{L}}(\varepsilon_S) = \frac{s_1}{2(1+r_0 s_2)} > 0$, $S^{*\prime}_{L=\overline{L}}(\varepsilon_B) = \frac{-s_2}{2(1+r_0 s_2)} < 0$ and $S^{*\prime}_{L=\overline{L}}(\varepsilon_F) = 0$. Noting that $dR_{L=\overline{L}} = -dS_{L=\overline{L}}$ when L is fixed at $\overline{L}$, it follows that $R^{*\prime}_{L=\overline{L}}(\varepsilon_L) = \frac{s_2 - s_1}{2(1+r_0 s_2)} < 0$, $R^{*\prime}_{L=\overline{L}}(\varepsilon_S) = \frac{-s_1}{2(1+r_0 s_2)} < 0$, $R^{*\prime}_{L=\overline{L}}(\varepsilon_B) = \frac{s_2}{2(1+r_0 s_2)} > 0$ and $R^{*\prime}_{L=\overline{L}}(\varepsilon_F) = 0$. ■

The corollary shows that the predictions of the baseline model are reversed (in the sense that the sign of the comparative statics becomes the opposite one) in one case. While previously a lending shock led to more retained loans, it now decreases loan retention. The reason is that following an expansionary lending shock, the central bank raises the policy rate. This reduces the incentives to retain loans (see Proposition 5), leading to an overall fall in loan retention when the central bank raises the interest rate such that lending returns to its original level.

We can now derive the implications for the (more plausible) case of partial stabilization, that is, following an expansionary shock the central bank still raises the interest rate – but not by as much to make lending return fully to its pre-shock level.

Proposition 6 *Partial stabilization does not alter the results of Propositions 1-3 except for the impact of a lending shock ε_L on retained loans R (Proposition 3). A lending shock can now either decrease or increase retained loans.*

Proof. *Given that the impact of a change in the policy stance f_0 on bank lending is (strictly) negative (from (12)) we have that $L^{*\prime}(f_0) < 0$), partial stabilization implies that following an expansionary shock the central bank raises the policy stance f_0 by less than in the full stabilization case. Following an expansionary shock ε_i ($i \in \{L, B, S, F\}$), we thus have that $0 < \frac{\partial f_0^P}{\partial \varepsilon_i} < \frac{\partial f_0(L=\overline{L})}{\partial \varepsilon_i}$ (where f_0^P denotes the* *policy stance under partial stabilization). Given the monotonic dependence of L, S and R on the policy stance f_0 (see equations (12), (13) and (14)), this implies that the new equilibrium values of L, S and R lie strictly between the equilibrium values under no stabilization and full stabilization. Using the comparative statics in Corollary 5, we can then see that the results of Propositions 1-3 only change in the case of a lending shock, which may now also reduce loan retention.* ■

The endogeneity of monetary policy adds additional predictions, arising from how the policy rate reacts to the various shocks. In the case of expansionary non-policy shocks, the interest rate will obviously rise as the central bank tries to control the economy. By contrast, in the case of a expansionary monetary policy shock, interest rates fall as the central bank only partially offsets the negative shock to rates:

Proposition 7 *Under partial stabilization, the equilibrium risk-free rate r_F^**

(i) increases in the lending shock ε_L,

(ii) increases in the securitization shock ε_S,

(iii) increases in the risk-taking shock ε_B,

(iv) decreases in the policy shock ε_F.

Proof. *Parts (i)-(iii) follow from the fact that after an expansionary shock ε_L, ε_S or ε_B, lending L rises (Proposition 1) and hence the central bank has to increase f_0 in order to stabilize L (from equation (12) we see that $dL < 0$ requires $d\varepsilon_F > 0$). Part (iv): equation (12) for equilibrium lending shows that following an expansionary policy shock (fall in ε_F), f_0 rises by less if L is partially stabilized. Hence, r_F $(= f_0 - \varepsilon_F)$ falls.* ■

Proposition 8 *Under partial stabilization, the ratio of securitization to lending, S^*/L^*, always increases more after an expansionary securitization shock than after an expansionary lending shock.*

Proof. Suppose that we observe a change in lending of dL^* in the economy. Denote the degree of (lending) stabilization by the central bank with γ $(\gamma \in (0.1))$, where $\gamma = 0$ denotes no stabilization and $\gamma = 1$ denotes full stabilization. We then have that the lending response in the absence of stabilization is $\frac{dL^*}{1-\gamma}$. This implies that the change in the policy stance ($= df_0$) fulfills $dL^* - \frac{dL^*}{1-\alpha} = \frac{\partial L}{\partial f_0} df_0$, which gives $df_0 = \frac{dL^*}{(1-\alpha)(-\frac{\partial L}{\partial f_0})}$.

Consider first the case of the change in lending being brought about by a securitization shock. We then have that $dL^* = \frac{\partial L}{\partial \varepsilon_S} d\varepsilon_S + \frac{\partial L}{\partial f_0} df_0$, that is, the total change in lending has to equal the direct effect from the securitization shock plus the indirect one, coming from monetary policy. Solving for $d\varepsilon_S$ allows us to determine the size of the securitization shock: $d\varepsilon_S = \frac{1}{\frac{\partial L}{\partial \varepsilon_S}}(dL^* - \frac{\partial L}{\partial f_0} df_0)$. The change in securitization can then be calculated by

$$dS(d\varepsilon_S) = \frac{\partial S}{\partial \varepsilon_S} d\varepsilon_S + \frac{\partial S}{\partial f_0} df_0 = \frac{\partial S}{\partial \varepsilon_S} \frac{1}{\frac{\partial L}{\partial \varepsilon_S}} (dL^* - \frac{\partial L}{\partial f_0} df_0) + \frac{dL^*}{(1-\alpha)(-\frac{\partial L}{\partial f_0})} dL^*. \quad \text{(C4)}$$

In the case of a lending shock, the change in securitization can be similarly calculated as:

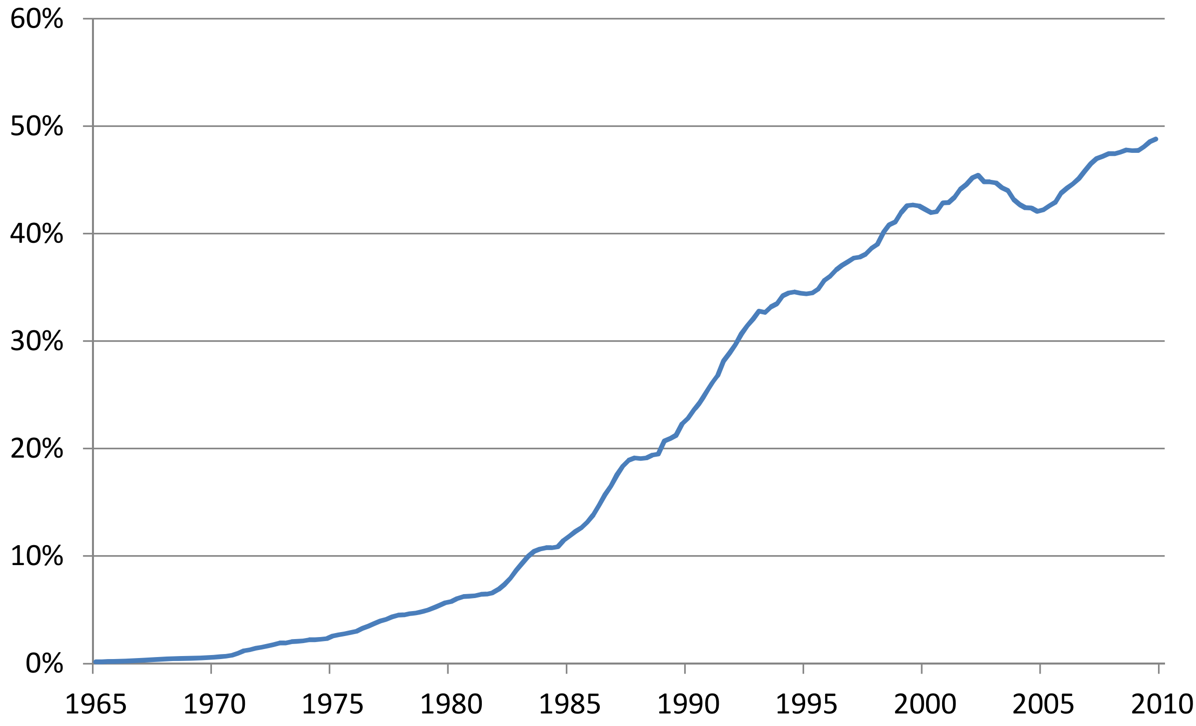
$$dS(d\varepsilon_L) = \frac{\partial S}{\partial \varepsilon_L} d\varepsilon_L + \frac{\partial S}{\partial f_0} df_0 = \frac{\partial S}{\partial \varepsilon_L} \frac{1}{\frac{\partial L}{\partial \varepsilon_L}} (dL^* - \frac{\partial L}{\partial f_0} df_0) + \frac{dL^*}{(1-\alpha)(-\frac{\partial L}{\partial f_0})} dL^*. \quad \text{(C5)}$$

Using that $dL^* - \frac{\partial L}{\partial f_0} df_0 = \frac{dL^*}{1-\alpha}$, we obtain for the difference in the change of securitization under both shocks:

$$dS(d\varepsilon_S) - dS(d\varepsilon_L) = (\frac{\frac{\partial S}{\partial \varepsilon_S}}{\frac{\partial L}{\partial \varepsilon_S}} - \frac{\frac{\partial S}{\partial \varepsilon_L}}{\frac{\partial L}{\partial \varepsilon_L}}) \frac{dL^*}{1-\alpha}. \quad \text{(C6)}$$

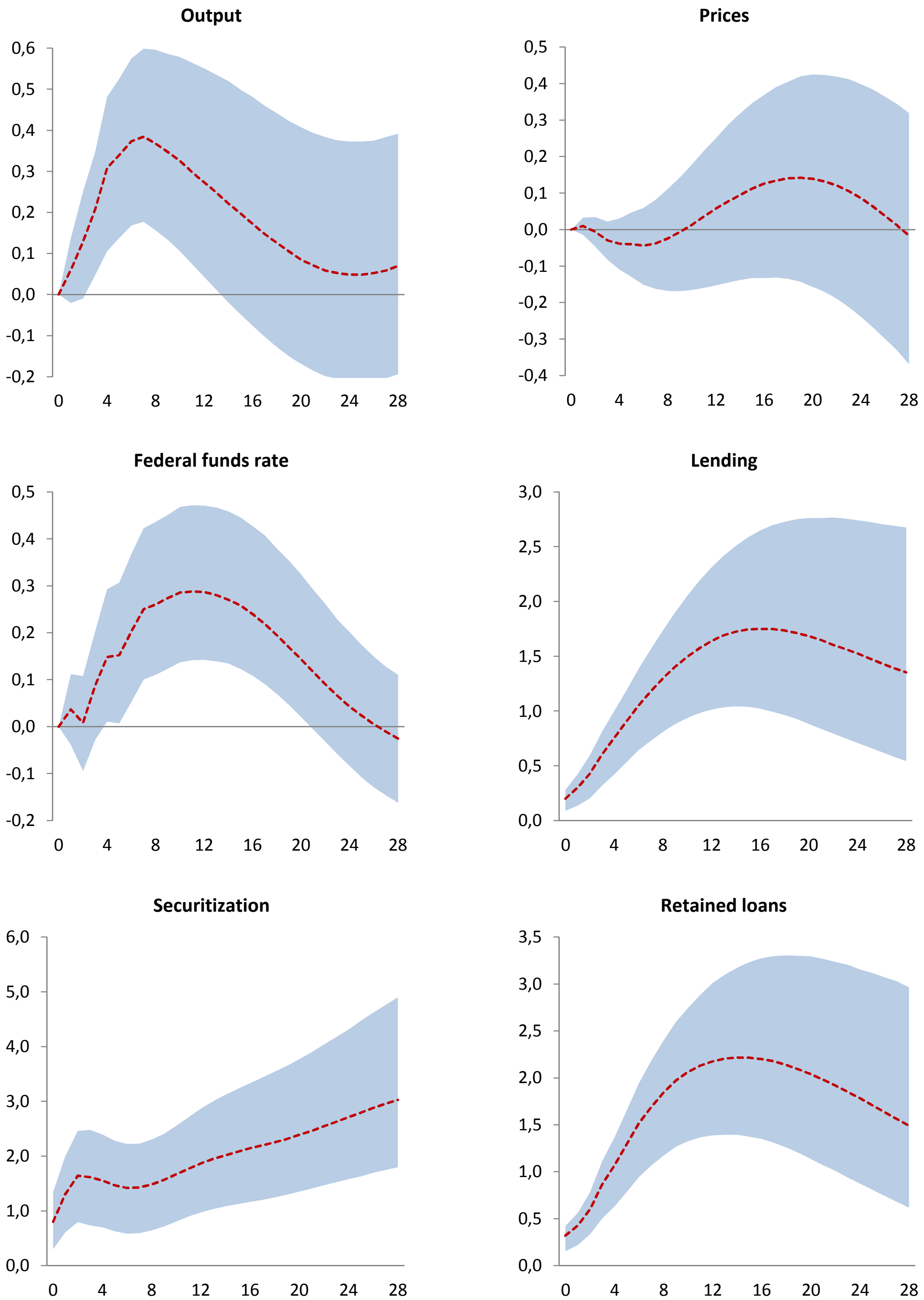
From (12) and (14) we have that $\frac{\frac{\partial S}{\partial \varepsilon_S}}{\frac{\partial L}{\partial \varepsilon_S}} > \frac{\frac{\partial S}{\partial \varepsilon_L}}{\frac{\partial L}{\partial \varepsilon_L}}$ and hence $dS(d\varepsilon_S) > dS(d\varepsilon_L)$. This means that for a given change in lending in the economy, a securitization shock increases securitization more than a lending shock. ■

Figure 1 - Securitization of mortgage and consumer credits (% of lending)



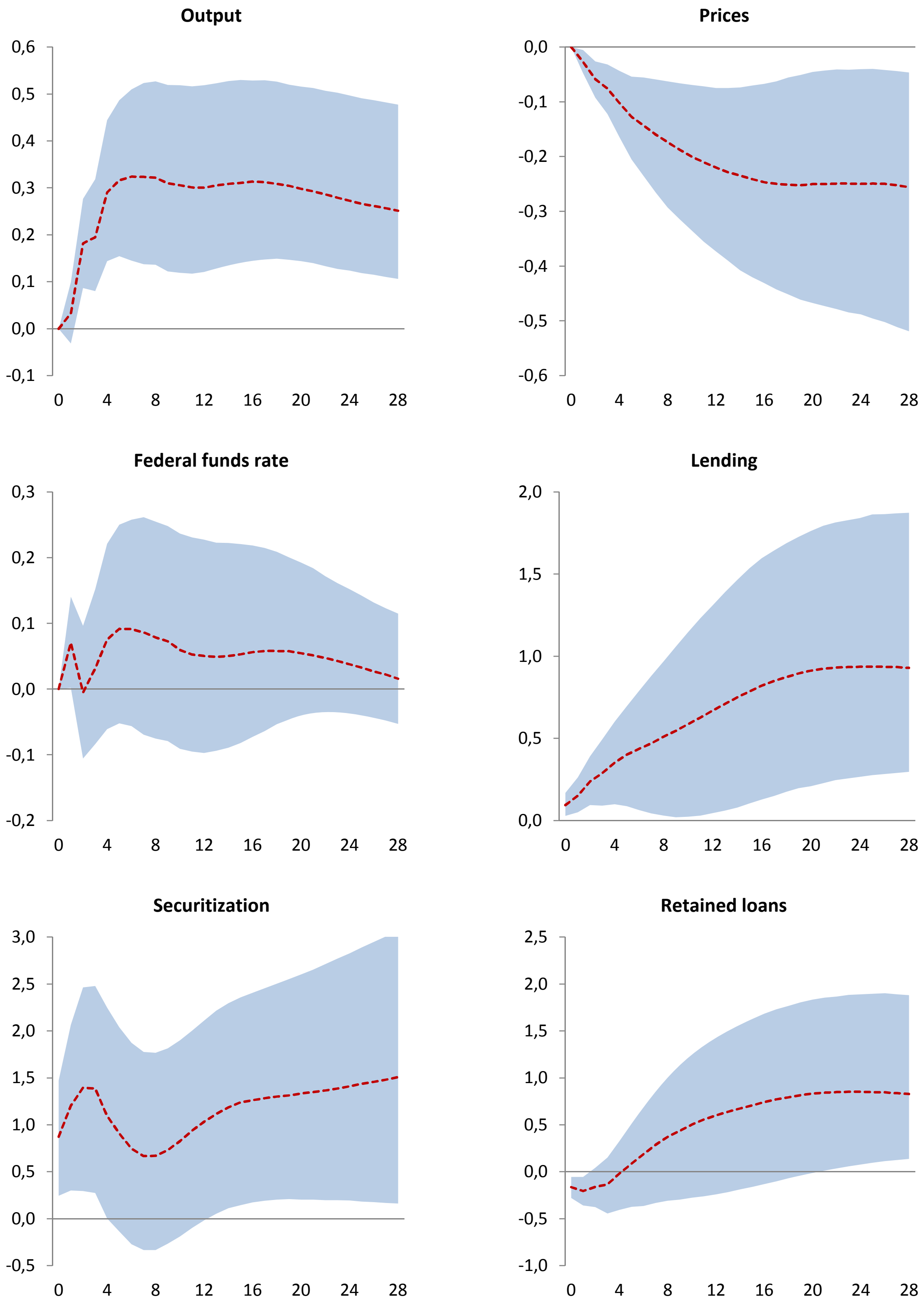
Source: Flow of Funds database

Figure 2 - Impulse responses to bank lending shocks



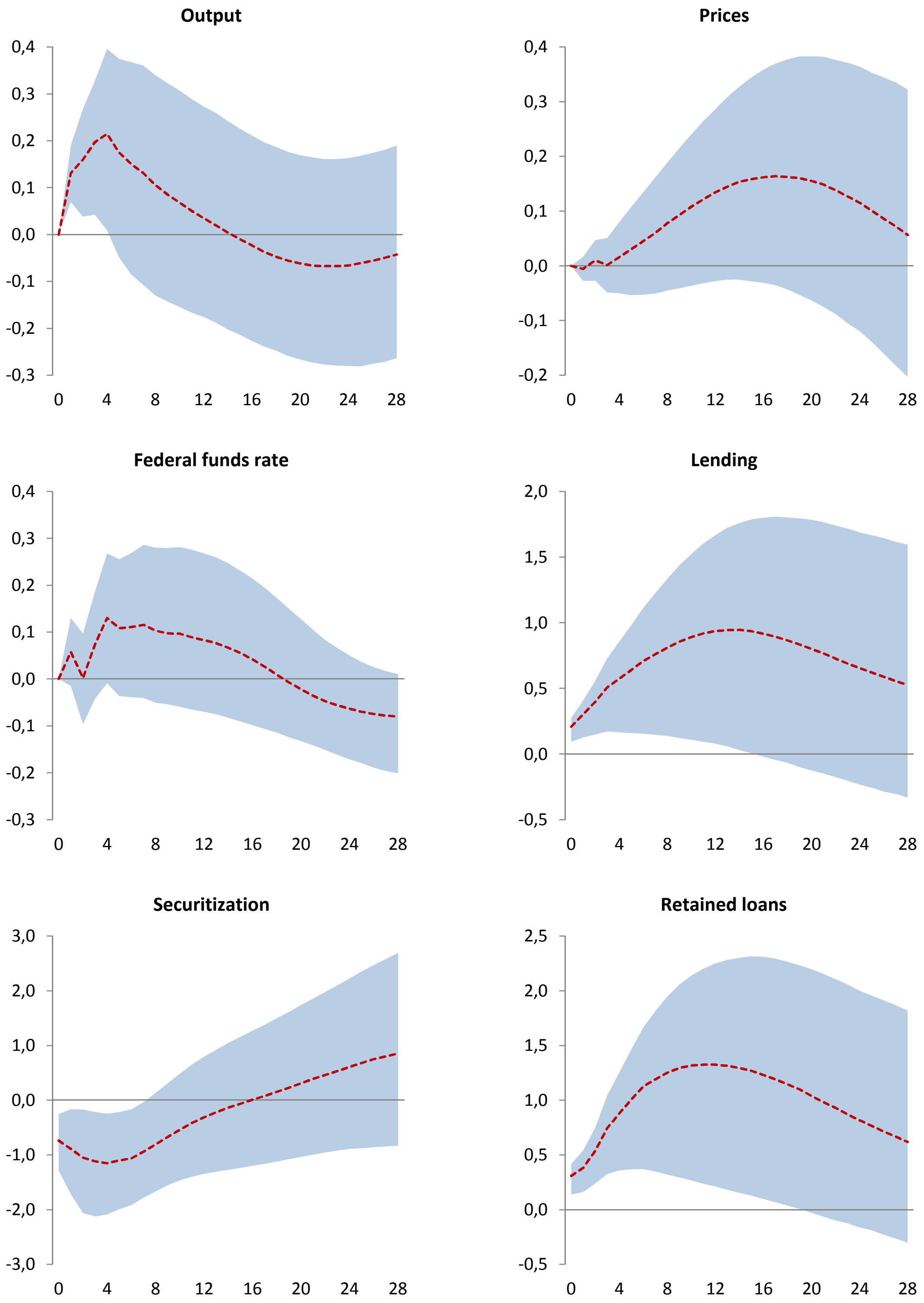
Note: *Median of posterior distribution, together with 68 percent probability regions; horizon is quarterly*

Figure 3 - Impulse responses to securitization shocks



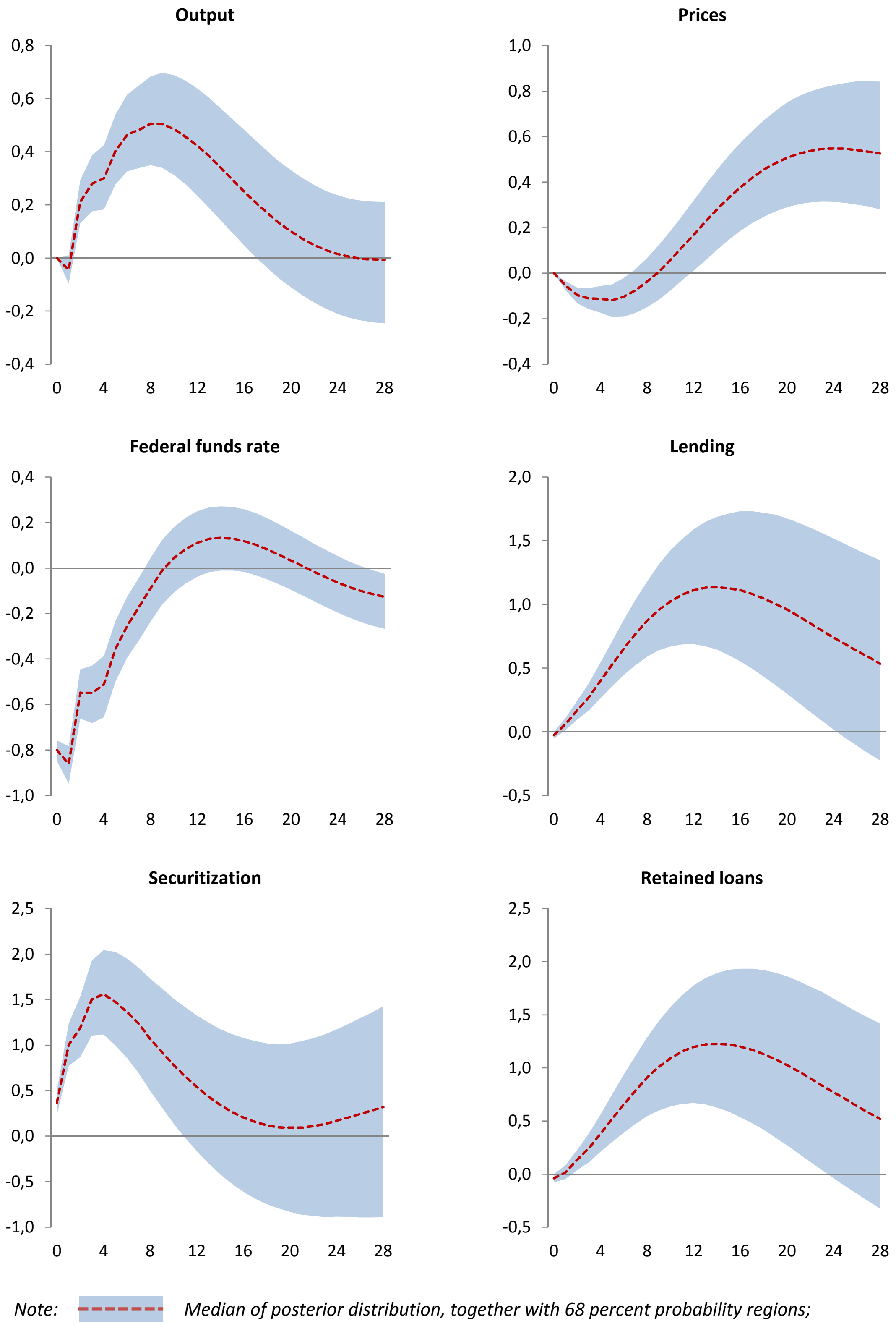
Note: *Median of posterior distribution, together with 68 percent probability regions; horizon is quarterly*

Figure 4 - Impulse responses to bank risk-taking shocks



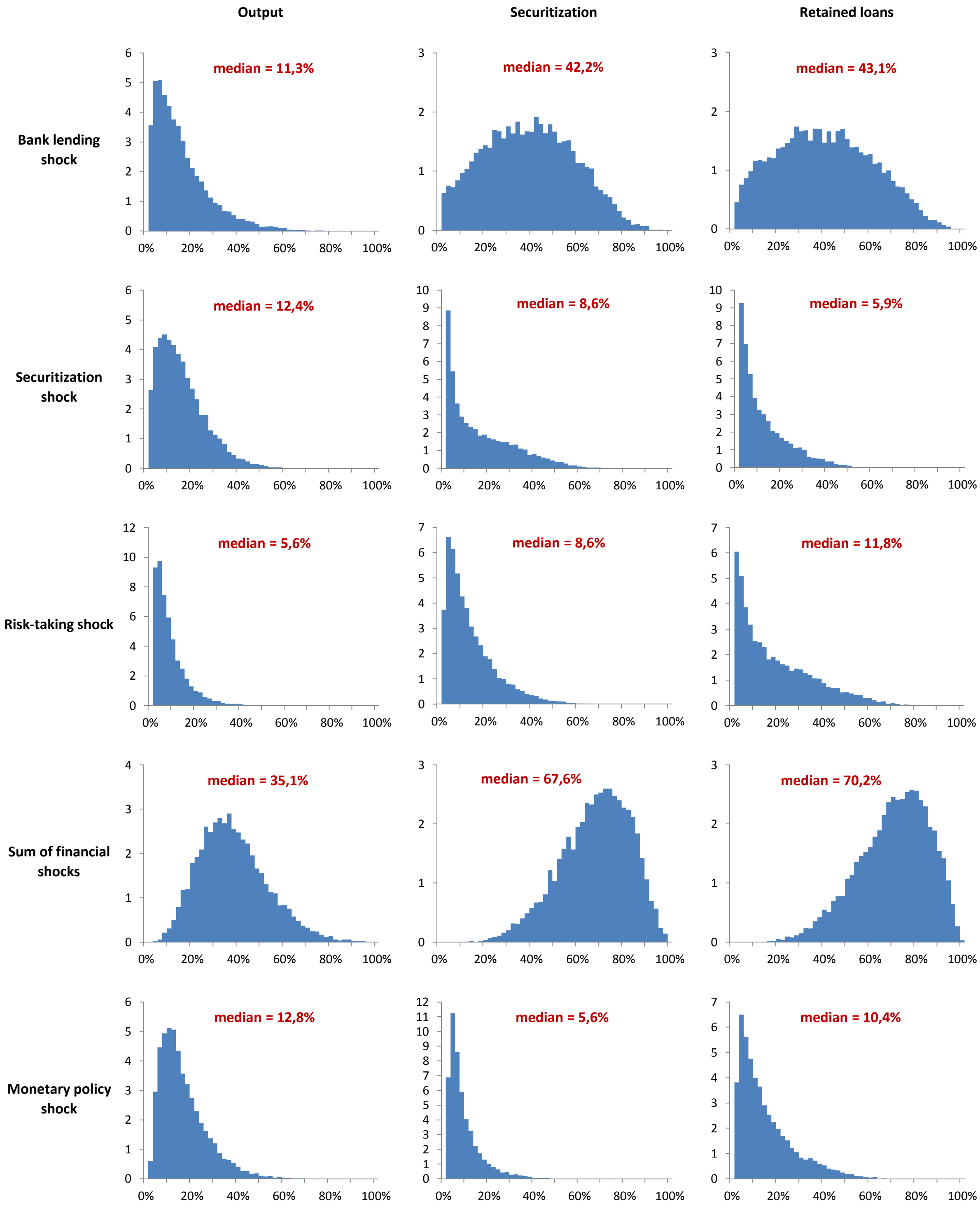
Note: *Median of posterior distribution, together with 68 percent probability regions; horizon is quarterly*

Figure 5 - Impulse responses to montary policy shocks



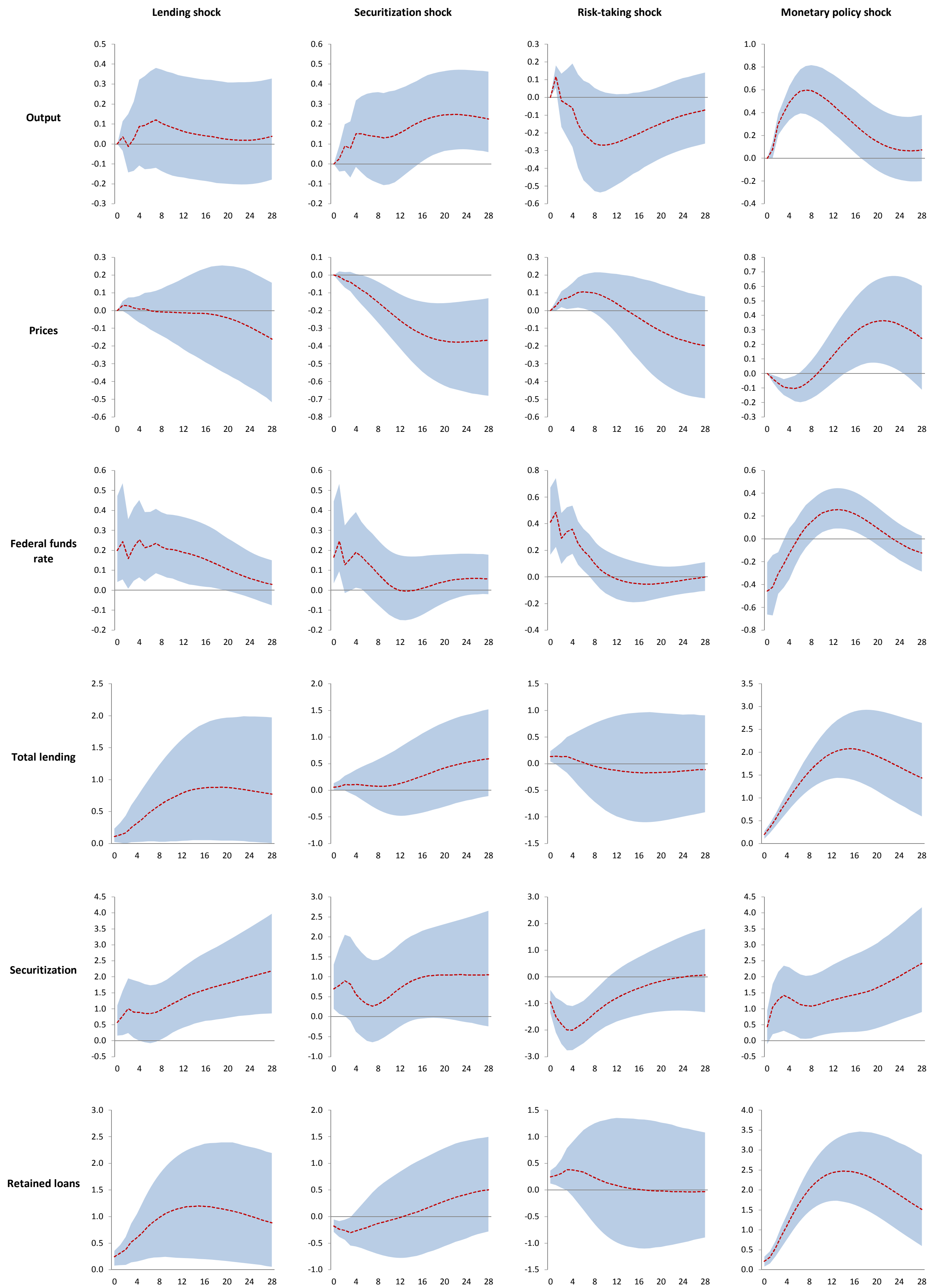
Note: *Median of posterior distribution, together with 68 percent probability regions; horizon is quarterly*

Figure 6 - Forecast error variance decompositions



Note: posterior density functions of forecast error variance decompositions (histogram based on 10000 draws of posterior); horizon is 40 quarters

Figure 7 - Impulse responses with endogenous monetary policy on impact



Note: *Median of posterior distribution, together with 68 percent probability regions; horizon is quarterly*