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Do contractionary monetary policy shocks expand shadow banking?

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Abstract

Using vector autoregressive models with either constant or time-varying parameters and stochastic volatility for the United States, we find that a contractionary monetary policy shock has a persistent negative impact on the asset growth of commercial banks, but increases the asset growth of shadow banks and securitisation activity. To explain this 'waterbed' effect, we propose a standard New Keynesian model featuring both commercial and shadow banking, and we show that the model comes close to explaining the empirical results. Our findings cast doubt on the idea that monetary policy can usefully 'get in all the cracks' of the financial sector in a uniform way.

Key words: Monetary policy, financial intermediaries, shadow banking, VAR, DSGE.

JEL classification: E5, E43, E52, G2, G21.

(1) Bank of England. Email: benjamin.nelson@bankofengland.co.uk
(2) Bank of England. Email: gabor.pinter@bankofengland.co.uk
(3) Bank of England. Email: konstantinos.theodoridis@bankofengland.co.uk

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Publications Team, Bank of England, Threadneedle Street, London, EC2R 8AH
Telephone +44 (0)20 7601 4030 Fax +44 (0)20 7601 3298 email publications@bankofengland.co.uk

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Summary

Was monetary policy an important driver of financial intermediaries' balance sheet dynamics in the run-up to the global financial crisis? Should monetary policy have been 'leaning against the wind' of the rapid build-up in financial sector leverage that preceded the crisis – including that in the shadow banking sector? A popular narrative is that low US interest rates post 2001 fuelled leverage growth and prepared the ground for the global calamity of 2007-08. And as a result, it is argued, monetary policy should have been tighter, particularly because its effects extend beyond the reach of more targeted regulatory tools, 'getting in all the cracks'.

This paper contributes to the literature related to this debate in two ways. First, we document evidence pertaining to the effects of monetary policy surprises on the balance sheet growth of financial intermediaries, distinguishing their effects on commercial banks from those on entities in the shadow banking sector. Using vector autoregressive models (statistical models consisting of a set of dynamic linear regressions) we find that the contribution of monetary policy shocks on asset growth in the financial sector as a whole has been small. Less than 10% of the variation in the quarterly asset growth of US commercial and shadow banks over the period 1966-2007 was accounted for by monetary surprises. In the period since 2001, unexpectedly loose monetary policy contributed little to the balance sheet expansion of US financial intermediaries.

Second, in line with intuition, we find that surprise monetary contractions tended to reduce the asset growth of commercial banks. But in contrast to the conventional view, we find that surprise monetary contractions tended to expand shadow bank asset growth, rather than reduce it. We find this 'waterbed effect' to be robust across a number of model specifications and assumptions regarding the identification of monetary policy shocks. And using our estimated shock series, we find corroborative evidence that securitisation activity tends to rise following monetary contractions. We shed light on this empirical finding by extending a standard monetary dynamic stochastic general equilibrium model (a structural economic model that derives a dynamic system of equations from microeconomic optimisation theory) to include a commercial and a shadow banking sector. The model can replicate the waterbed effect we find in the data.

Taken together, these findings highlight potential challenges associated with using monetary policy to lean against financial sector activity in pursuit of financial stability goals. First, the size of the monetary policy response needed to curtail rapid commercial bank asset growth would be large relative to the non-systematic component of US policy rates observed in the past. Second, the tendency for there to be leakages through securitisation activity casts doubt on the idea that monetary policy can usefully 'get in all the cracks' of the financial sector in a uniform way. Our results suggest that the sign of the monetary response needed to lean against financial sector leverage varies with the component of the financial sector in question.

Instead, both points tend to reinforce the case made elsewhere for the development of regulatory tools that address the build-up of leverage in the regulated sector more directly than monetary policy does, and which extend oversight to the parts of the shadow banking sector that are most

prone to excessive risk-taking. That would leave monetary policy to retain its relative focus on addressing the consequences of nominal rigidities in goods and labour markets.

1 Introduction

> "*Balance sheet dynamics imply a role for monetary policy in ensuring financial stability.*" (pp. 605., Adrian and Shin, 2009)

Was monetary policy an important driver of financial intermediaries' balance sheet dynamics in the run-up to the global financial crisis? Should monetary policy have been 'leaning against the wind' of the rapid build-up in financial sector leverage that preceded the crisis – including that in the shadow banking sector? A popular narrative is that low US interest rates post 2001 fuelled leverage growth and prepared the ground for the global calamity of 2007-8. And as a result, it is argued, monetary policy should have been tighter, particularly because its effects extend beyond the reach of more targeted regulatory tools, 'getting in all the cracks' (Stein, 2013).

This paper contributes to the literature related to this debate in two ways. First, we document evidence pertaining to the effects of monetary policy surprises on the balance sheet growth of financial intermediaries, distinguishing their effects on commercial banks from those on entities in the shadow banking sector. Using VAR models we find that the contribution of monetary policy shocks on asset growth in the financial sector as a whole has been small. Less than 10% of the variation in the quarterly asset growth of US commercial and shadow banks over the period 1966-2007 was accounted for by monetary surprises. In the period since 2001, unexpectedly loose monetary policy contributed little to the balance sheet expansion of US financial intermediaries. (This leaves a prominent role for other explanations, including financial innovation, as emphasised by Bernanke (2009) and Honkapohja (2014) amongst others.)

Second, in line with intuition, we find that surprise monetary contractions tended to reduce the asset growth of commercial banks. But in contrast to the conventional view, we find that surprise monetary contractions tended to *expand* shadow bank asset growth, rather than reduce it. We find this 'waterbed effect' to be robust across a number of model specifications and assumptions regarding the identification of monetary policy shocks. And using our estimated shock series, we find corroborative evidence that securitisation activity tends to rise following monetary contractions. We shed light on this empirical finding by extending the monetary DSGE model of Gertler and Karadi (2011) to include a shadow banking sector, as in Meeks, Nelson, and Alessandri (2014). The model can replicate the waterbed effect we find in the data.

Taken together, these findings highlight potential challenges associated with using monetary policy to lean against financial sector activity in pursuit of financial stability goals. First, the size of the monetary policy response needed to curtail rapid commercial bank asset growth would be large relative to the non-systematic component of US policy rates observed in the past. Second, the tendency for there to be leakages through securitisation activity gives pause to the idea that monetary policy can usefully 'get in all the cracks' of the financial sector in a uniform way. Our results suggest that the sign of the monetary response needed to lean against financial sector leverage varies with the component of the financial sector in question. Instead, both of these points tend to reinforce the case made elsewhere (Hanson, Kashyap, and

Stein, 2011) for the development and application of regulatory tools that address the build-up of leverage in the regulated sector more directly than monetary policy does, and which extend oversight to the parts of the shadow banking sector that are most prone to excessive risk-taking (FSB, 2013). That would leave monetary policy to retain its relative focus on addressing the consequences of nominal rigidities in goods and labour markets (Svensson, 2013).

The paper is organised as follows. Section 2 provides a short review of the literature on monetary policy shocks; Section 3 provides a brief discussion on those parts of the US financial sector that will be subject to the subsequent empirical analysis; Section 4 presents the empirical model and the results together with robustness checks, including the analysis of the role of asset prices, time-varying parameters and stochastic volatility. In addition, this section provides evidence on the impact of monetary policy shocks on securitisation activity. Section 5 presents a quantitative monetary DSGE model with financial intermediation and securitisation to provide an explanation of the empirical evidence. Section 6 discusses some of the policy implications of our results. Section 7 concludes.

2 Literature on Monetary Policy Shocks

Since the seminal work of Sims (1980), the majority of the literature studying monetary policy shocks has been concerned with the impact on the macroeconomy as in Christiano, Eichenbaum, and Evans (1999), Bernanke, Boivin, and Eliasz (2005) and Uhlig (2005). Taken together, these studies found that the peak impact of a 100 basis point shock on GDP is relatively modest and is likely to be between 0.3 and 0.8 percent. This result is robust to the chosen identification schemes, estimation methods, lag structure and time period.[1] Subsequent papers such as Rigobon and Sack (2004), Bernanke and Kuttner (2005), Gurkaynak, Sack, and Swanson (2005) and Gertler and Karadi (2014) found relatively large effects of monetary policy surprises on asset prices, spreads and the yield curve as well.

Since the outbreak of the financial crisis, there has been an increasing interest in how monetary policy may affect the balance sheet dynamics of financial intermediaries. The recent findings by Adrian and Shin (2008) and Adrian and Shin (2010a) suggest that monetary policy might be an important factor in affecting financial intermediary balance sheets. A related strand of literature has studied the 'risk-taking channel' as an additional channel of monetary policy transmission beyond the standard interest rate channel (Borio and Zhu, 2012). In spite of the growing interest in the relationship between monetary policy and financial intermediaries' balance sheets, there have been few studies that provided a detailed quantitative analysis of this relationship. The exceptions include the study by Angeloni, Faia, and Lo Duca (2013) that used an orthogonalised VAR model to show that monetary policy shocks have significant and protracted impact on various bank risk measures. These results are in line with those found in micro studies (Altunbas, Gambacorta, and Marques-Ibanez, 2010; Jimenez, Ongena, Peydro,

[1] An important exception is the study by Romer and Romer (2004), which found a substantial impact of about 4.3 percent by using narrative measures. The review paper by Coibion (2012) explains how the differences between the estimated effects are driven by various factors.

and Saurina, 2014).

We regard our analysis as complementary to these papers, by focusing on aggregate balance sheet quantities rather than prices. One of the closest paper to ours is by Den Haan and Sterk (2011) which uses a recursive identification scheme to estimate the impact of monetary policy shocks on home mortgages and consumer credit prior to and during the Great Moderation. They find an asymmetric impact of monetary policy shocks in the two sub-samples. Moreover, they find that following a monetary contraction non-bank mortgages increase during the Great Moderation.

3 Banks and Non-banks in the US

3.1 Definitional Issues

Given the relatively new literature on shadow banks, it is useful to make a few conceptual clarifications before proceeding with the empirical analysis. Until the 1980s, traditional banks were the dominant institutions in intermediating funds between savers and borrowers. However, since the savings and loan crisis, the role of market-based intermediaries steadily increased. Following the early comparative work by Boyd and Gertler (1993) on bank and nonbank intermediation, a recent paper by Pozsar, Adrian, Ashcraft, and Boesky (2010) provides a detailed mapping of the shadow banking system, defined as a provider of sources of funding for credit by converting opaque, risky, long-term assets into money-like, short-term liabilities. In their view, shadow banks are clearly distinguished from traditional banks in their lack of access to public sources of liquidity such as the Federal Reserve's discount window, or public sources of insurance such as the Federal Deposit Insurance.

In addition, high leverage has been cited as an other important characteristic of shadow banks, and their balance sheets have been pro-cyclical as shown by Adrian and Shin (2009, 2010b). Shadow bank leverage during the 2000s trended upwards compared to commercial banks, for which there was no visible increase (Kalemli-Ozcan, Sorensen, and Yesiltas, 2011). Moreover, heavy reliance on short-term financing exposed shadow banks to "run-on-the-bank" behaviour in the form of the flight of short-term creditors and various cash-draining actions by derivatives counterparties (Duffie, 2010).

Even though market-based intermediaries have long performed many of the functions of the traditional banking sector, it is important to note that the shadow banking sector involves a web of financial institutions and a range of securitisation and funding techniques, and these activities are often closely intertwined with the traditional banking and insurance institutions. These interlinkages involved back-up lines of credit, implicit guarantees to special purpose vehicles and asset management subsidiaries (Brunnermeier, 2009; Adrian and Ashcraft, 2012). It is therefore not obvious whether one could talk about shadow banking as a homogenous, well-defined category.

Our definition of shadow banks follows Adrian, Moench, and Shin (2010) and proxies shadow banking activity by summing over three types of intermediaries: asset-backed (ABS) issuers, finance companies, and funding corporations.[2] ABS issuers are special purpose vehicles that hold pools of loans and use them as collateral for the issuance of ABS. Finance companies originate loans similar to commercial banks. Traditionally, finance companies have intermediated to more information-problematic borrowers and were involved with more excessive risk-taking than commercial banks, as explained in detail by Carey, Post, and Sharpe (1998). Funding corporations include subsidiaries of foreign bank and nonbank financial firms that raise funds in the commercial paper market and transfer the proceeds to foreign parent companies abroad or to foreign banking offices in the US. Figure 9 in the Appendix shows the evolution of the composition of the shadow banking sector. Prior to the 1980s, finance companies were the only dominant force in nonbank intermediation (see Boyd and Gertler, 1993 for further details). However, since the middle of 1980s, the share of ABS issuers started to increase rapidly, and by the outbreak of the recent crisis, their assets amounted to 50% of that of the total shadow banking sector.

3.2 Some Stylised Facts

In this subsection, we present some stylised facts about the historical dynamics of financial intermediation in the US. Figure 1 shows the annual growth of total financial assets of the total financial sector as well as bank and non-bank intermediaries. The figure encompasses the four major financial crises over the last 40 years in the US: (i) the commercial bank capital squeeze in 1973-1975; (ii) the savings and loan crisis (S&L) in 1984-1991[3]; (iii) the burst of the dotcom bubble in 2000-2001; and (iv) the recent financial crisis in 2007-2008. Reinhart and Rogoff (2008) and Lopez-Salido and Nelson (2010) provide a detailed account of these historical events. Our interpretation of Figure 1 is that while the first three crises had fairly similar effects across sectors, the recent crisis and the pre-crisis build-up following the dotcom bubble featured some heterogeneity.

The most striking difference is the immediate impact of the crisis: while the asset growth of the total financial system and commercial banks fell slightly below zero, the asset growth of broker-dealers and shadow banks fell by 45% points and 25% points respectively. This is in line with the findings of He, Khang, and Krishnamurthy (2010) who also note the asymmetric effects of the recent crisis on the balance sheet dynamics of financial intermediaries.[4]

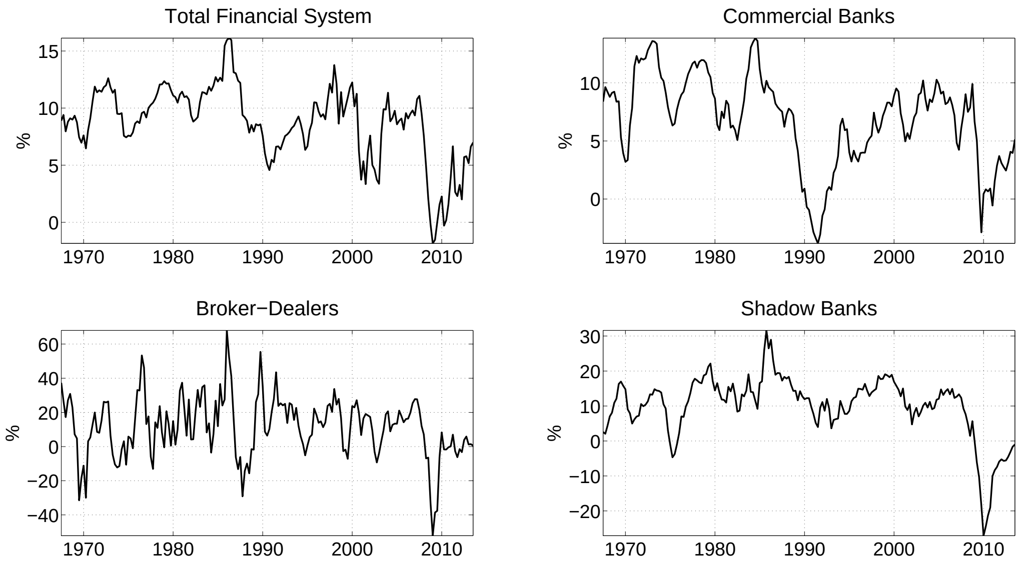
A second observation is that during the pre-crisis build-up, and especially during the low interest rate environment, assets of commercial banks grew rapidly, while asset of non banks grew at more subdued rates relative to the past, and seems only to have resumed a rapid

[2]The official definitions from Flow of Funds are presented in the Appendix.

[3]Reinhart and Rogoff (2008) dates the S&L crisis to 1984-1999, however Lopez-Salido and Nelson (2010) proposes the alternative dating of 1988-1991 given much empirical support on the intense deterioration in the S&L industry being concentrated in these years.

[4]More specifically, they show that sectors dependent on repo financing, mainly hedge funds and broker-dealers, reduced asset holdings, whereas commercial banks that had access to more stable funding sources increased their asset holdings. However, it is still an open question (which we aim to address in this paper) whether monetary policy may be able to exert such a heterogeneous impact on the balance sheets of different types of financial intermediaries.

Figure 1: Annual Growth of Total Financial Assets



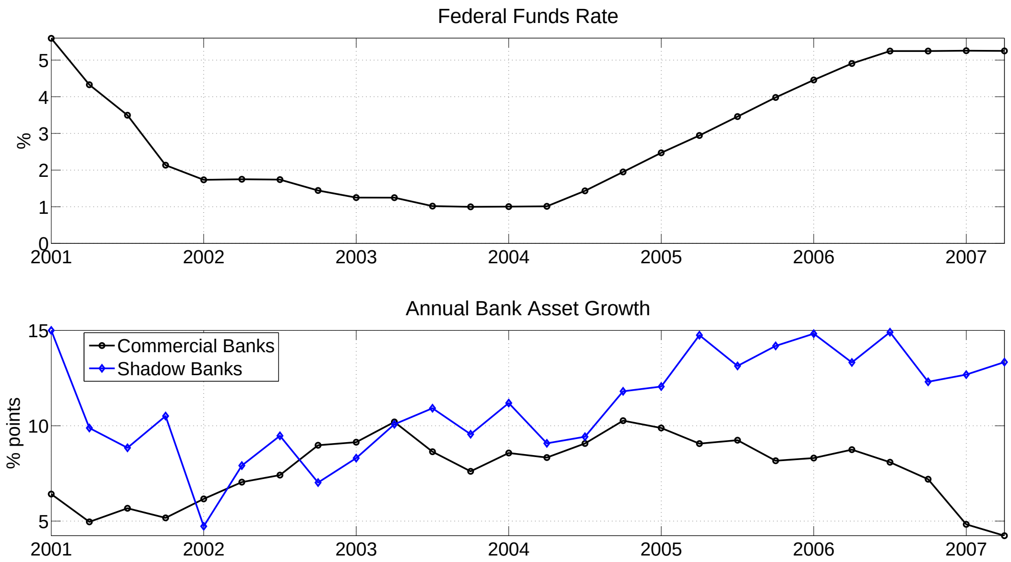
Source: Flow of Funds. Shadow banks are defined as in Adrian, Moench, and Shin (2010). The data are in nominal terms. The data runs from 1967Q3 through 2013Q3.

expansion after policy had tightened. Figure 2 shows that US monetary policy in the run-up to the crisis can be characterised by two phases. In the first phase, the Fed cut rates from 5.6% in 2001Q1 to 1% by 2003Q4. In the second phase, the Fed increased rates in 2004Q2 up to 5.25% by 2006Q3. The rapid expansion of commercial bank asset growth took place during the first phase, in contrast to the decline in the second phase, while shadow banks continued to expand their assets in spite of seemingly tighter policy.[5]

This is in line with a recent discussion of Woodford (2010) who also points out that spreads were unusually low and credit growth was at its highest after the Fed Funds rate had already returned to high levels. He argues that the increase in the riskless short-term rate did reduce demand and checkable deposits of households and firms, but this did not prevent a net increase in the overall liabilities of financial intermediaries, including shadow banks, as shown in Figure 2. Given these considerations, the purpose of the next section is to provide an empirical framework based on Christiano, Eichenbaum, and Evans (1999) in order to give a more causal interpretation of interest rate and balance sheet dynamics so that we can assess the relative importance of monetary policy shocks in the data.

[5]Of course, Figure 2 does not necessarily imply a causal relationship, and at least three possible stories would be consistent with these observations: (1) It might be that the drastic fall and the subsequent rise in the interest rate was a result of a positive and then a negative monetary policy shock which affected commercial (shadow) banks pro-cyclically (counter-cyclically). (2) An alternative narrative is that the decline in the interest rate was an endogenous response to falling demand after 9/11, and following the sharp recovery, monetary policy did not tighten fast enough and the rise in the interest rate was an effective "loosening" of monetary policy to which shadow banking responded pro-cyclically. (3) Another explanation is that both the fall and rise in the interest rate was a completely systematic response of policy to other demand and supply type shocks, which had an asymmetric impact on financial balance sheet dynamics, and monetary policy shocks have not been a driving force.

Figure 2: Pre-crisis US Monetary Policy and Balance Sheet Expansion



Source: Flow of Funds. The plot covers the period from 2001Q1 through 2007Q2.

4 Empirical evidence

4.1 Data, Estimation and Identification

To construct data on financial assets for deposit-taking institutions and shadow banks, we follow Adrian and Shin (2010b), Adrian and Shin (2010a) and Berrospide and Edge (2010) in using the Flow of Funds data of the Federal Reserve Board. The definition of shadow banks covers three types of financial intermediary: finance companies (FinComp), issuers of asset-backed securities (ABS) and funding corporations (FundCorp). Security broker-dealers are treated separately. The definition of deposit-taking institutions (commercial banks) includes credit unions and US-chartered depository institutions. A detailed description of each category of financial intermediaries can be found in Appendix A. The sample period is 1966Q3-2007Q2. Data on the macroeconomic variables (GDP, CPI and the Federal Fund Rate) are used as in Stock and Watson (2012). The CPI is used to deflate all the balance sheet variables to transform nominal assets into real assets.

The empirical model is written as a simple VAR model:

$$Y_t = c + B_1 y_{t-1} + \cdots + B_p y_{t-p} + u_t \qquad t = 1, \ldots, T. \tag{4.1}$$

where y_t is an $n \times 1$ vector of observed endogenous variables, and c is an $n \times 1$ vector of constants; B_i, $i = 1, \ldots, p$ are $n \times n$ matrices of coefficients; u_t is an $T \times n$ matrix of reduced-form errors with a variance-covariance matrix Σ that is multivariate normal. Given that Σ is positive definite, there exists a non-unique decomposition $AA' = \Sigma$ such that the relationship between the reduced-form and structural errors can be written as:

$$u_t = A\varepsilon_t \tag{4.2}$$

where ε_t is a $T \times n$ matrix of structural errors.

The first difference of the logarithms of all the variables except the interest rates are used for the benchmark estimation, but robustness checks will include the estimation of the VAR in levels. In the benchmark model, we use one lag, but will also estimate the models using two lags as a robustness check. The model is estimated with Bayesian methods as in Banbura, Giannone, and Reichlin (2010) with a tightness parameter $\lambda = 1$. Details about the estimation can be found in Section B of the Appendix.

Our benchmark method to identify a monetary policy shock builds on CEE99 with the following ordering of the variables: output, price level, interest rates and the balance sheet variables, implying that the identified monetary policy shock is related to the third orthogonalised vector in the structural variance covariance matrix.[6]

To ensure the robustness of our identification scheme, we compare our estimated monetary policy shock series to those implied by more structural models. We have chosen the DSGE model of Smets and Wouters (2007), given it is by now an established toolbox for monetary policy analysis in both academic and policy circles.[7] To provide further robustness checks, we also use sign restrictions as an alternative identification scheme as described by Uhlig (2005). We use sign restrictions for the first quarter to a monetary policy shock as described in Section B.2 of the Appendix. As an additional robustness check, we will control for the effect of time-variation in the model parameters and of possible heteroscedasticity in the error structure.

4.2 The Impact on Commercial Banks and Shadow Banks

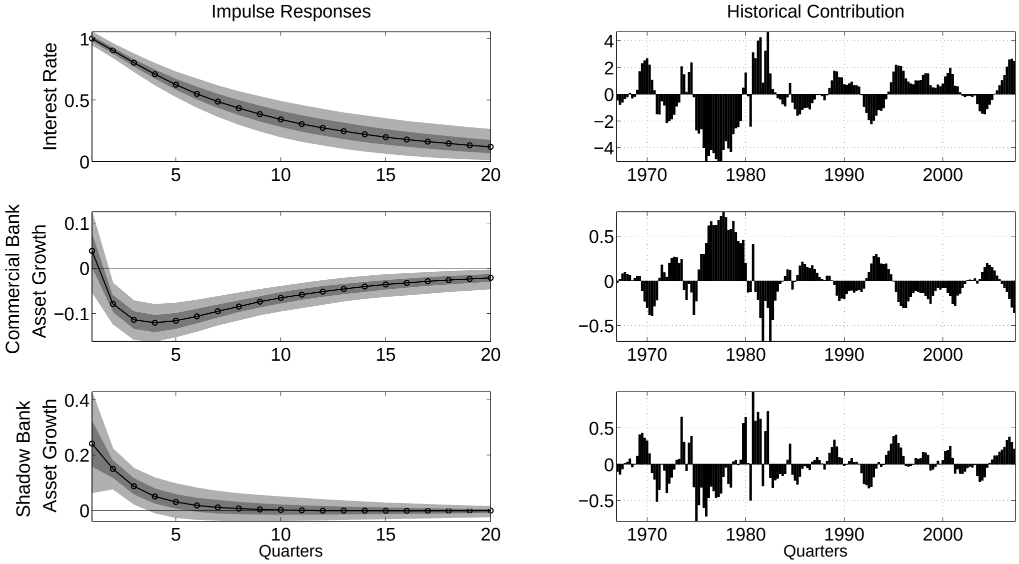
The first column of Figure 3 shows the impact of an unexpected 100 basis point increase in the Federal Funds rate on the size of the balance sheets of the two types of intermediaries. The impact on commercial bank asset growth is persistently negative and peaks at around -0.1% after one year. The policy shock has an immediate $+0.2\%$ effect on shadow bank asset growth.

The second column of Figure 3 shows that monetary policy shocks seemed to have been more important in the first half of the sample than during the Great Moderation. More specifically, monetary policy shocks had the largest impact in the late 1970s and the early 1980s. During the low interest rate environment post 9/11, policy shocks contributed positively to commercial bank asset growth, but shadow banking activity that expanded rapidly due to increasing securitisation seemed to have been curbed by expansionary monetary policy shocks. However, given that the contribution of monetary policy surprises to the growth rates in this period ranged between -0.3 and 0.3 % points, and considering that quarterly growth of real assets of commercial and shadow banks during the 2001Q3-2007Q2 period averaged about 1.5 and 2.3 % points, respectively, we argue that the overall importance of unexpectedly loose policy in

[6] A detailed explanation of the identification assumption is provided by Section 3 of CEE99.

[7] The shocks series are taken from the dataset of Stock and Watson (2012). The comparison will be done for the overlapping time period 1966Q3-2004Q4.

Figure 3: The Impact of a 100bp Contractionary Monetary Policy Shock on Financial Intermediaries



Notes: The identification is with Choleski ordering. The vertical axes are in % points. The sample period is 1966Q3 - 2007Q2. Each plot shows the pointwise median, 32nd-68th and 16th-84th percentiles of 1000 draws (after burning the first 5000 draws) from the posterior distribution of the impulse responses.

the pre-crisis build up was small relative to other contributing factors. This is also confirmed by the forecast error variance decomposition shown in Figure 13 of the Appendix, suggesting that monetary policy shocks contributed by 4-8% and 1-2% to the forecast error variance of the quarterly asset growth of commercial and shadow banks, respectively.

The full set of impulse responses depicted by panel *a* of Figure 10 of the Appendix reveal that the price puzzle is present for Choleski identification. Despite that the identified monetary policy shock time series has a high correlation (+83%) with that implied by the DSGE model of SW as shown in Figure 12 in the Appendix. Further, increasing the number of lags to two does not materially change the results. The figure also shows that identifying the monetary policy shock with sign restrictions corroborates the pro-cyclical effect on commercial banks and a countercyclical effect on shadow banks. Some papers such as Meeks, Nelson, and Alessandri (2014) include government-sponsored enterprises (GSEs) and agency- and GSE- backed mortgage pools (MtgPools) in the definition of shadow banks. To check whether the results are robust to this definitional issue, the VAR model is re-estimated after augmenting the asset coverage of shadow banks with these entities. Panel *b* of Figure 10 of the Appendix reveals that, using Choleski ordering, the counter-cyclical response of shadow bank asset growth to monetary shocks is even stronger and statistically more significant after including GSEs and MtgPools in the definition of shadow banking.

To further check robustness, Figure 11 of the Appendix shows the IRF results after re-estimating the model in levels instead of first differences. The peak impact of a 1% contractionary monetary policy shock is about −1.2% on the level of commercial bank assets, irrespective of which identification method is used. The counter-cyclical impact on shadow banking is preserved, though after about two years the effect becomes statistically insignificant (according to sign restrictions) and even procyclical (according to Choleski identification).

The heterogeneous impact on commercial banks and shadow banks is in line with the results of Den Haan and Sterk (2011) who found that following a monetary policy contraction non-bank mortgages increase as opposed to standard bank mortgages that exhibit a significant reduction.[8] The financing and liquidity position of banks has been cited as a key determinant of the impact of monetary policy shocks on the balance sheets of commercial banks. Empirical (Stein and Kashyap, 2000) as well as theoretical papers (Freixas and Jorge, 2008) studying the credit channel of monetary policy emphasised how the policy transmission is influenced by banks' liquidity and financing positions. One of the lessons from this literature is that in the presence of problems associated with asymmetric information, the financial system may be unable to channel liquidity to solvent but illiquid intermediaries. As a result, when monetary policy tightens and commercial banks face a higher cost of funding, they are forced to reduce lending.

The counter-cyclical impact on shadow bank activity (consistent with previous empirical findings of Den Haan and Sterk (2011) and Loutskina (2011)), suggests that there might be a 'waterbed' effect, whereby commercial banks can circumvent tighter funding liquidity constraints following a contractionary policy shock by possibly increasing their securitisation activity, leading to a migration of lending activity beyond the regulatory perimeter to the shadow banking sector. As discussed in Loutskina and Strahan (2009), this allows them to transform illiquid loans into more liquid securities, which, once removed from their balance sheets, are financed by the issuance of tradable securities rather than with bank deposits. The theoretical framework proposed in Section 5 aims to conceptualise this 'waterbed' effect in a DSGE model with heterogeneous banking.

4.3 Further Robustness and Extensions

4.3.1 The Role of Asset Prices

A number of recent papers such as Adrian and Shin (2010a) argued that fluctuations in the balance sheet of market-based financial intermediaries arise from the interactions between risk-taking and the market risk premium. They link balance sheet expansion to the expected profitability of intermediaries which could be proxied by the term spread.

Other structural models of financial intermediaries such as Gertler and Kiyotaki (2010) emphasised the role of asset prices in affecting intermediaries' net worth hence their ability to intermediate funds. In a similar vein, Brunnermeier (2009) explains how falling asset prices during the recent crisis played a key role in deteriorating the value of collateral that financial intermediaries used to obtain short-term funding. The ensuing deleveraging of the sector led to a further reduction of asset prices and impairment of the capital of intermediaries requiring

[8] In a different context, He, Khang, and Krishnamurthy (2010) found that during the recent crisis there has been a large substitution between asset holdings of commercial banks and other financial sectors more dependent on repo financing such as broker dealers.

further deleveraging giving rise vicious credit cycles as in Kiyotaki and Moore (1997). As for the relationship with monetary policy, Gertler and Karadi (2011) show that the presence of credit constraints in the financial system substantially amplifies the impact of policy shocks on asset prices and on the balance sheet dynamics.

Moreover, the finance literature emphasises that asset price dynamics are ultimately driven by changes in the wealth of the marginal investor. The importance of broker-dealers has been emphasised by Adrian, Etula, and Muir (2014) who present strong empirical evidence that the marginal value of wealth of broker-dealers provides a more informative stochastic discount factor (SDF) than that of the representative consumer.[9] In addition, a number of recent papers have pointed at the interaction between the housing market and the macroeconomy (Liu, Wang, and Zha 2013) and the role of monetary policy in affecting pre-crisis real estate dynamics (Eickmeier and Hofmann 2013).

Given these considerations, we re-estimate our benchmark model with four additional financial variables: the quarterly asset-growth of broker-dealers, the term spread (the difference between 10-year and 3-month government bond yields), the quarterly growth of SP500 Stock and Case-Shiller Home Price indices. Figure 14 of the Appendix shows that the impact of a 100 basis point shock continues to be pro-cyclical for commercial bank asset growth with a peak median impact of -0.2% and countercyclical for shadow bank asset growth with a peak median impact of $+0.2\%$. Broker-dealer asset growth contracts sharply by about 2%, consistent with the pro-cyclicality of broker-dealer leverage (Adrian and Shin, 2010b; Adrian, Etula, and Muir, 2014). As expected, the term spread and asset prices fall sharply, which is in line with previous studies such as Rigobon and Sack (2004), Bernanke and Kuttner (2005) and Gurkaynak, Sack, and Swanson (2005). The impact on house prices is persistent which is consistent with recent evidence presented in Eickmeier and Hofmann (2013).

4.3.2 Time-varying Parameters and Stochastic Volatility

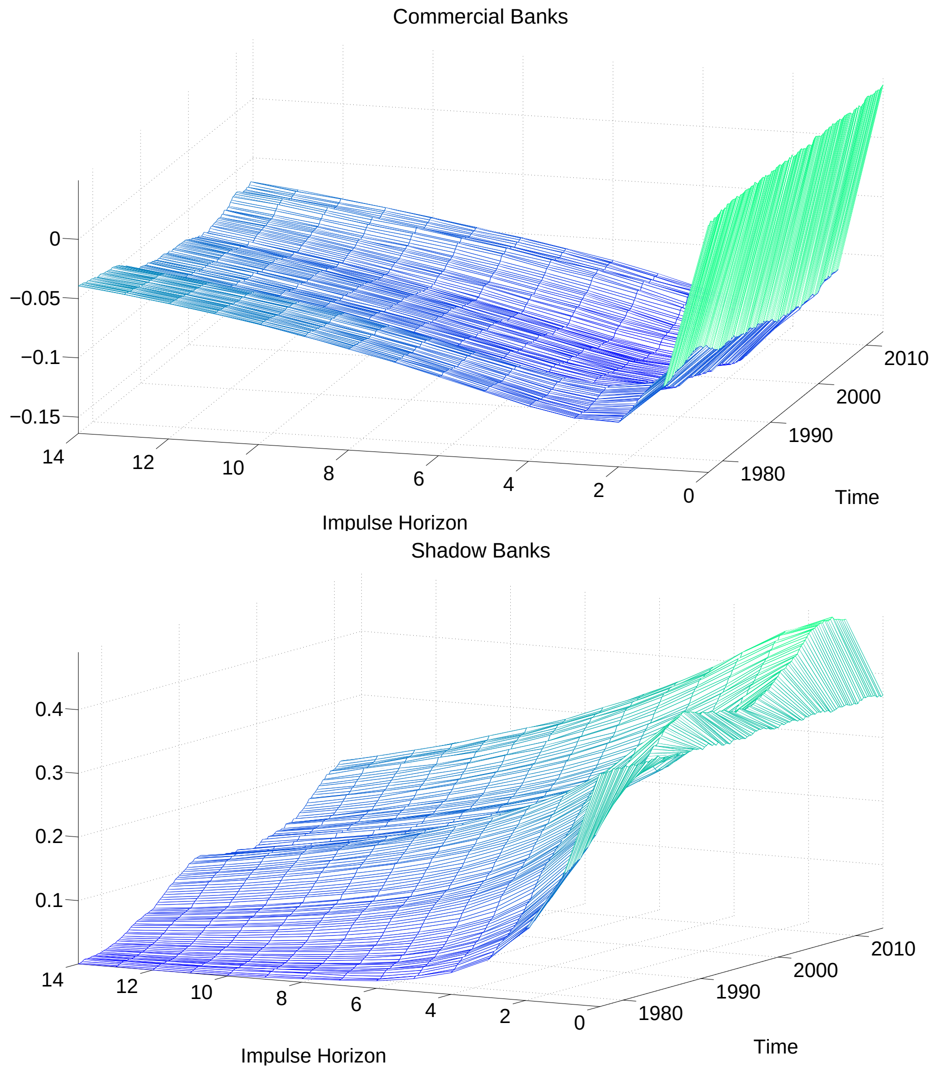
One could make at least three criticisms about the results so far: (i) the results from the constant parameter VAR are all conditional on a time-invariant monetary policy rule being in place[10], (ii) the shocks are assumed to be homoscedastic during the sample period, and (iii) we stop the dataset at 2007Q2, and therefore exclude potentially useful information contained in the last seven years of data. To address these criticisms, we follow Primiceri (2005) in making the parameters of the benchmark model 4.1 time-varying, and introducing stochastic volatility (TVP-VAR model). In addition, we augment the dataset all the way to 2013Q3, because the proposed TVP-VAR model could naturally model the recent crisis period characterised with heightened uncertainty.

Estimating the time-varying parameter VAR model with stochastic volatility and applying Choleski identification to identify monetary policy shocks yields the impulse response functions

[9] Duffie (2010) provides an excellent summary of broker-dealers, defined as banks that intermediate markets for securities and derivatives.

[10] This is particularly important given the potential structural shifts in the conduct of monetary policy during the Great Moderation – see Benati and Surico (2009) for a detailed analysis.

Figure 4: The Impact of Monetary Policy Shock is Stable over Time



Notes: The vertical axes are in % points. The sample period is 1966Q3 - 2013Q3, with the first 40 observations used as training sample. The pointwise median is calculated from 10000 posterior draws of the impulse responses after burning the first 9000 draws.

for the asset growth of the total financial system as depicted in Figure 4. The impact of the shock is normalised to give the same (100bp) impact on the interest rate at each point in time. The results suggest a stable relationship between monetary policy shocks and commercial bank asset growth. Similarly, the counter-cyclical impact on shadow bank asset growth found by the constant parameter VAR is confirmed by the TVP-VAR model.

Given the posterior median of the parameter estimates of the TVP-VAR model, the historical decomposition is constructed as plotted in Figure 16 of the Appendix. The results confirm that during times of surprise policy contractions, commercial bank asset growth fell but shadow banks balance sheets expanded. The Volcker-period continues to be the episode of the largest policy shocks; the unexpectedly low interest environment during 2001-2005 and the subsequent tightening still had some non-negligible impact as well. In addition, Figure 17 plots the estimated time-varying standard deviation of the Choleski-identified monetary policy shocks. The results are in line with those presented in Primiceri (2005), suggesting that monetary policy shocks were more volatile before 1983 than in the subsequent Great Moderation period and during the recent Great Recession.

4.3.3 Monetary Policy and Securitisation

The evidence on the counter-cyclical impact of monetary policy shocks on shadow banking activity is intriguing. To get a deeper understanding on what is driving the results, here we discuss the relationship between monetary policy and securitisation. Estrella (2002) was one of the first papers studying this relationship, and found that securitisation has lowered the interest elasticity of output and thereby decreased the efficacy of monetary policy. Moreover, Loutskina and Strahan (2009) and Loutskina (2011) offer extensive micro-evidence on how securitisation has provided banks with an additional source of funding, hence making bank lending less sensitive to cost of funds shocks, leading to a reduced ability of the monetary authority to affect banks' lending activity.

To check whether the counter-cyclical impact of monetary policy shocks on shadow banking works through increased securitisation activity, we quantify the impact of monetary policy shocks on the asset growth of issuers of asset-backed securities – a subcategory of the adopted definition of shadow banks of Adrian and Shin (2010a).

In addition, we estimate the impact on the quarterly growth of the sum of total real financial assets of GSEs and MtgPools.[11] These include Fannie Mae, Freddie Mac and Farmer Mac that ended up holding a large fraction of the mortgages originated by commercial banks, and financed these activities by issuing mortgage-backed securities (MBS). Given that more than 60% of all US outstanding mortgages are securitised (Loutskina and Strahan, 2009), and GSEs have traditionally held a large fraction of these mortgages (Lehnert, Passmore, and Sherlund, 2008), estimating the impact of policy shocks on GSE asset growth provides a natural robustness check on the counter-cyclical impact of policy shocks on securitisation.

Because of data limitations, the sample on ABS-issuers starts in 1985Q1. Given the short sample period, we use a small-scale BVAR. We estimate separate bivariate BVAR(1) models: one including the monetary policy shock series of Smets and Wouters (2007) and the other using the measure constructed by Romer and Romer (2004).[12] The impulse responses are scaled to give a 100bp increase in the monetary policy innovation. For GSEs, data is available since 1966Q3, which we pick as the starting value for the estimation, and we estimate two separate BVAR models as described above.

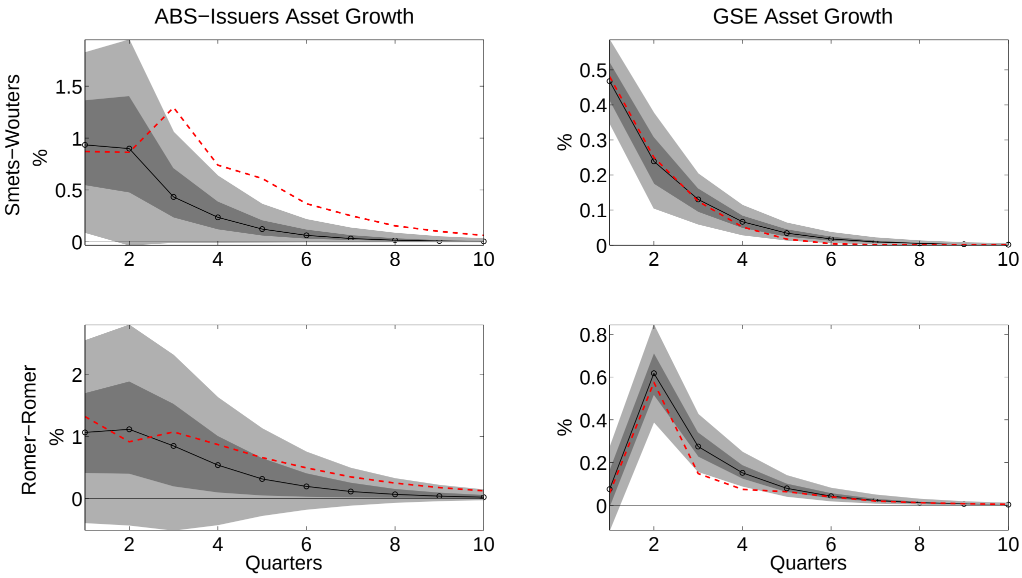
Figure 5 shows the results from the four separate bivariate BVAR models, confirming the counter-cyclical impact of policy shocks on securitisation activity.[13] The median impact on the

[11] See Sections A.7–A.8 of the Appendix for a detailed definition.

[12] Because of the potential endogeneiety problems related to using the Federal Funds rate as an indicator of monetary policy, Romer and Romer (2004) proposed a novel method of constructing a measure of monetary policy shocks by regressing the Fed's intentions for the policy rate around FOMC meetings on the Fed's internal forecasts. The obtained residual is orthogonal to current expectations about future economic developments, thereby captures movements in the Fed Funds rate that are likely to be "more exogenous" than shocks constructed from within a VAR. We thank Olivier Coibion for sharing the extended shock series with us.

[13] The impulse responses functions for the shocks (the first variable in each BVAR model) are available upon

Figure 5: The Impact of a 100bp Contractionary Monetary Policy Shock on Securitisation



Notes: The identification is with Choleski ordering. The vertical axes are in % points. The sample period starts in 1985Q1 for ABS-issuers and starts in 1966Q3 for GSEs. The sample period with the Smets and Wouters (2007) (Romer and Romer (2004)) series ends in 2004Q4 (2008Q4). Each plot shows the pointwise median, 32nd-68th and 16th-84th percentiles of 1000 draws (after burning the first 5000 draws) from the posterior distribution of the impulse responses using one lag. The red dashed lines plot the pointwise medians using two lags.

asset growth of ABS-issuers is about 1%, which is robust to the monetary policy measure used and to lag selection. The median impact on GSE asset growth is around 0.5%, which is also robust to lag length, though the model using the Romer and Romer (2004) measure gives a slightly delayed peak impact than the model with the Smets and Wouters (2007) shock. The counter-cyclical impact of monetary policy shocks on the assets of ABS and GSEs is preserved when we estimate the model in levels with a linear trend as shown in Figure 15 of the Appendix.

These findings are in line with previous studies showing that securitisation has reduced the sensitivity of aggregate lending supply to traditional bank funding conditions (Loutskina, 2011), and has generally weakened the credit channel of monetary policy (Altunbas, Gambacorta, and Marques-Ibanez, 2009).

5 A Theoretical Model of Heterogeneous Banking

To explain the differential impact of monetary policy shocks on the balance sheet dynamics of commercial banks and shadow banks, we extend the work of Gertler and Karadi (2011) (GK henceforth) by introducing securitisation, building on the RBC model of Meeks, Nelson, and Alessandri (2014) (MNP henceforth). We thereby propose a standard New Keynesian model featuring deposit-taking banks as well as ABS-issuers.

The economy is populated by six agents: households, intermediate goods producers, retailers, capital goods producers, ABS-issuers and commercial banks. Households are assumed to

request.

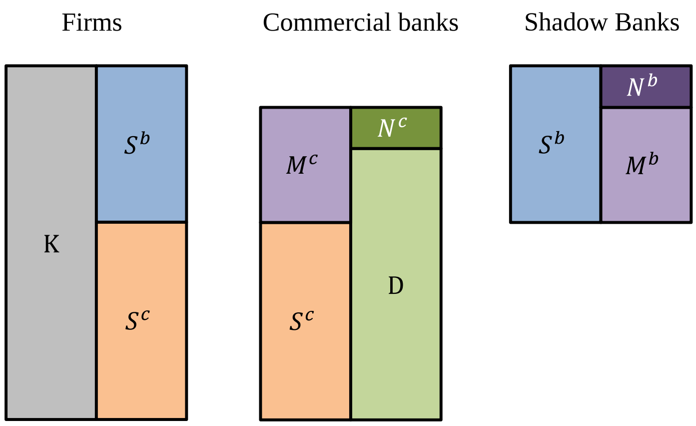
be limited to saving via commercial banks owing to prohibitively large costs associated with direct lending to firms. Intermediate goods producers, in turn, are dependent on bank loans to finance the purchase of physical capital, sold by capital producers, who are subject to investment adjustment costs. Intermediate goods producers combine capital with labour, provided by households, to produce wholesale goods, that are bought and repackaged by monopolistically competitive retailers. Retailers are subject to Calvo-type pricing frictions and backward indexation rules. All profits in the economy are ultimately repaid to households.

In the model, financial intermediation takes a centre stage, and the modelling of the banking sector follows MNP. Because households are unable to lend directly to firms, the banking sector plays a vital role in intermediating funds from the ultimate lenders to the ultimate borrowers. However, a key aspect of the model is that banks are unable to completely pledge the assets held on their balance sheets as collateral when raising funds from outside investors. This leads to a limited provision of funding by bank creditors to banks. ABS-issuance provides a way around this problem by allowing collateral to be used more efficiently, transforming illiquid loans into tradable asset backed securities – an essential function of shadow banking (Gennaioli, Shleifer, and Vishny, 2013).

5.1 Banks

Following MNP, Figure 6 illustrates the balance sheet positions of the two types of financial intermediary. Commercial banks originate loans S^c to firms, and some of these originated loans are sold to ABS-issuers. ABS-issuers hold these assets S^b on their balance sheets, and finance them with their own net worth N^b , together with issuing ABS, M^b. ABS, in turn, are held by commercial banks M^c, together with the remaining fraction of their originated loans S^c. Commercial banks are financed with household deposits D and their own net worth N^c. In equilibrium, the amount of ABS issued by ABS-issuers is equal to the ABS amount held by commercial banks, $M^c = M^b$.

Figure 6: Aggregate Balance Sheet Position of Firms, Commercial Banks and ABS-issuers



Note: A stylised representation of sectoral balance sheets in the steady state equilibrium.

The aggregated balance sheet identity of commercial banks is written as:

$$Q_t S_t^c + M_t^c = D_t + N_t^c, \tag{5.1}$$

where Q_t is the market price of the primary claim on firms, and M_t^c is the total ABS portfolio held by commercial banks. Following MNP, we distinguish between 'debt-like' and 'equity-like' ABS. Equity-like ABS offers pass-through exposure to an underlying collateral pool, which has historically been the main mode of financing securitised assets such as mortgages. Debt-like ABS represents fixed, non-contingent claims on the underlying cash-flow, hence making shadow banking more vulnerable to adverse fluctuations in asset prices. This mode of financing was more widespread during the run-up of the recent financial crisis. To keep the modelling framework general, we allow both equity-like and debt-like ABS, and write total ABS as:

$$M_t^c = q_t^m M_t^{PT,c} + M_t^{D,c}, \tag{5.2}$$

where $M_t^{PT,c}$ denotes equity-like, pass-through ABS with the corresponding market price q_t^m,[14] whereas $M_t^{D,c}$ is debt-like ABS. The franchise value of the commercial banking sector at the end of period $t-1$ is:

$$V_{t-1}^c = \mathbb{E}_{t-1}\Lambda_{t-1,t}\left[(1-\sigma)\,N_t^c + \sigma V_t^c\right], \tag{5.3}$$

where each period $(1-\sigma)$ fraction of commercial banks exit the market and are replaced with new bankers.[15] The evolution of the aggregate commercial bank net worth is given by the accumulation of retained earnings, consisting of the interest spread banks can earn on their assets compared to their liabilities:

$$N_t^c = (\sigma + \xi_c)\left(R_t^K Q_{t-1} S_{t-1}^c + R_t^M M_{t-1}^c\right) - \sigma R_t D_{t-1}, \tag{5.4}$$

where R_t^K is the real return on loans to firm, and R_t is the real deposit rate. The parameter σ is the fraction of continuing commercial bankers, and ξ_c is the fraction of the total assets that newly created commercial banks get from households. Moreover, R_t^M is the real return on the total ABS portfolio determined by the relative weights on equity-like and debt-like securities in the portfolio:

$$R_t^M = \eta R_t^{PT,M} + (1-\eta)\,R_t^{D,M}, \tag{5.5}$$

where the parameter $\eta \in [0,1]$ controls for the relative importance of equity-like ABS in the total ABS portfolio. The parameter η will be crucial in determining whether commercial banks or shadow banks bear losses from potential falls in assets prices following an adverse aggregate shocks.

An additional key feature of the model is the endogenous limit on the amount of external

[14] The determination of the market price of ABS is similar in nature to that of equity claims in Gertler, Kiyotaki, and Queralto (2012). See MNP for further details.

[15] See Gertler and Kiyotaki (2010) for a detailed discussion on why exogenous bank exit is needed for purposes of model tractability and aggregation.

finance commercial banks can access, formally written as:

$$V_t^c \geq \theta_c \left[Q_t S_t^c + (1-\omega) M_t^c\right], \tag{5.6}$$

where $\{\theta_c, \omega\} \in [0,1]$. Following Gertler and Kiyotaki (2010), banks are able to divert θ_c fraction of their assets, so incentive compatibility requires that the franchise value of the bank should exceed the value of divertible assets. The degree of divertibility of loans relative to that of ABS is captured by the parameter ω. We assume that banks have private information on the quality of loans that is difficult to credibly communicate to outsider investors. In contrast, the cash flow from ABS is dependent on the quality of a bundled pool of loans, hence private information is destroyed in the process of bundling (Kiyotaki and Moore, 2005). As a result, standardised, tradable ABS backed up by a pool of loans serves as a better collateral and it is less divertible than loans that are opaque and thereby hard to evaluate by outsiders, implying $\omega > 0$.

Intuitively, the higher the value of ω, the higher the potential gain commercial banks receive from securitising loan portfolios, when an adverse aggregate shock such as an unexpected monetary policy contraction leads to higher funding costs, lower profits and tighter credit constraints. Accordingly, as the impulse response analysis will show, the higher the value of ω, the higher the counter-cyclical impact monetary policy shocks exert on the aggregate quantity of ABS. The incentive constraint 5.6 together with the definition of the franchise value 5.3 implies that the net worth of commercial banks plays a crucial role in determining the amount lending they can supply. In turn, equation 5.4 shows that their net worth crucially depends on the interest income they can earn on loans and ABS.

ABS-issuers also hold loan pools comprised of primary security bundles acquired from originating commercial banks, financed by a combination of ABS-issuance and net worth:

$$Q_t S_t^b = N_t^b + M_t^b. \tag{5.7}$$

Moreover, aggregate shadow bank net worth accumulates as:

$$N_t^b = (\sigma + \xi_b) R_t^K Q_{t-1} S_{t-1}^b - \sigma R_t^M M_{t-1}^b, \tag{5.8}$$

where ξ_b is the fraction of the total assets that newly created ABS-issuers get from the household. Shadow banks have the same survival probability σ as commercial banks. The franchise value of shadow banks V_{t-1}^b is written as:

$$V_{t-1}^b = \mathbb{E}_{t-1} \Lambda_{t-1,t} \left[(1-\sigma) N_t^b + \sigma V_t^b\right]. \tag{5.9}$$

ABS-issuers are also able to divert θ_b fraction of their assets, which gives rise to an endogenous incentive constraint:

$$V_t^b \geq \theta_b Q_t S_t^b, \tag{5.10}$$

where we assume that $\theta_b < \theta_c$, that is, commercial banks have a superior ability to monitor the quality of collateral held by ABS-issuers compared to the ability of depositors to monitor the collateral held by commercial banks. Securitisation therefore provides an efficient way of holding bundled loan pools by generating better collateral (Gennaioli, Shleifer, and Vishny, 2013). As in the case of commercial banks, the net worth of ABS-issuers is a key determinant of the amount of lending shadow banking can supply, as implied by equations 5.7 – 5.10.

A major difference between the two types of financial intermediary is the exposure of their net worths to aggregate risk through ABS prices. This exposure is captured by the parameter η in equation 5.5. When $\eta = 1$, the return on ABS is fully contingent on the cash flows from the underlying loan pools, therefore the partial impact of an adverse movement in the ABS price is to reduce the asset value of commercial banks and the return on ABS (captured by the term $R_t^M M_{t-1}^c$ in equation 5.4), and to reduce the cost of funding of ABS-issuers (captured by the term $\sigma R_t^M M_{t-1}^b$ in equation 5.8). This, ceteris paribus, leads to a decrease in the profits and loan supply of commercial banks and to an increase in the profits and loan supply of ABS-issuers.

The modelling assumption that ABS offers pass-through exposure to the underlying loan pool ($\eta = 1$) is key to generate the observed 'waterbed' effect. The assumption is consistent with the traditional form of securitisation, whereby the originating banks have ensured funding liquidity for the special purpose vehicles issuing ABS by granting credit lines to them. As a result, commercial banks still bear the aggregate risk from holding long-term loans even though they are removed from their balance sheets (Brunnermeier, 2009).

5.2 The rest of the economy

5.2.1 Household and Production

The remainder of the economy resembles a standard NK model. Household preferences are described using an external habit formulation common in the recent DSGE literature (Smets and Wouters, 2007):

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[\log(c_t - hC_{t-1}) - \frac{\chi L_t^{1+\varphi}}{1+\varphi} \right], \tag{5.11}$$

where c_t is household consumption (and C_t is its aggregate counterpart), and L_t is household labour hours. Consumption preferences contain external habits h, while parameter φ is the inverse labour supply elasticity and χ is a scale paramter. The household chooses consumption, labour supply and riskless debt (C_t, L_t, D_t) to maximize expected discounted utility 5.11 subject to the flow of funds constraint:

$$c_t + D_t = R_t D_{t-1} + W_t L_t + \Pi_t, \tag{5.12}$$

where W_t is the real wage and Π_t denotes the total of profits from banks and capital good producers returned lump-sum to the household.

The production function operated by firms is of the standard Cobb-Douglas form, with capital intensity α, such that in aggregate:

$$Y_t = K_t^{\alpha} L_t^{1-\alpha}, \tag{5.13}$$

where K_t is the aggregate physical capital stock. Capital goods are produced subject to flow adjustment costs, captured by the function $\Phi\left(I_t/I_{t-1}\right)$, satisfying $\Phi'(\cdot) > 0$, $\Phi''(\cdot) > 0$, $\Phi(1) = 0$. Capital goods producers maximise profits, resulting in the following standard expression for Tobin's Q:

$$Q_t = 1 + \Phi\left(\frac{I_t}{I_{t-1}}\right) + \frac{I_t}{I_{t-1}}\Phi'\left(\frac{I_t}{I_{t-1}}\right) - \mathbb{E}_t \Lambda_{t,t+1}\left(\frac{I_{t+1}}{I_t}\right)^2 \Phi'\left(\frac{I_{t+1}}{I_t}\right), \tag{5.14}$$

where $\Lambda_{t,t+1}$ is stochastic discount factor of the household. The law of motion for physical capital is:

$$K_{t+1} = (1-\delta)K_t + I_t, \tag{5.15}$$

where δ is the depreciation rate. Retail firms package final output as a CES composite of retail goods. The final output composite is given by:

$$Y_t = \left[\int_0^1 Y_{f,t}^{\frac{\varepsilon-1}{\varepsilon}} df\right]^{\frac{\varepsilon}{\varepsilon-1}}, \tag{5.16}$$

where $Y_{f,t}$ is output of retailer f. Given the aggregate price index, $P_t = \left[\int_0^1 P_{f,t}^{1-\varepsilon} df\right]^{\frac{1}{1-\varepsilon}}$, the demand faced by retailer f is:

$$Y_{f,t} = \left(\frac{P_{f,t}}{P_t}\right)^{-\varepsilon} Y_t, \tag{5.17}$$

where $P_{f,t}$ is the retailer's price. Each firm can adjust its price with probability $1-\gamma$ each period. When prices cannot be adjusted, they can be indexed to the lagged rate of inflation, captured by parameter ψ. The optimal reset price P_t^* of firm f solves:

$$\max_{P_t^*} \mathbb{E}_t \sum_{i=0}^{\infty} \gamma^i \beta^i \Lambda_{t,t+i}\left[\frac{P_t^*}{P_{t+i}}\prod_{k=1}^{i}(1+\pi_{t+k-1})^{\psi} - \mu P_{m,t+i}\right] Y_{f,t+i} \tag{5.18}$$

where π_t is the rate of inflation, $\mu \equiv \varepsilon/\left(\varepsilon-1\right)$ is the steady-state markup, and $P_{m,t}$ is the marginal cost term. Given the solution to 5.18, aggregate price dynamics follow:

$$P_t = \left[(1-\gamma)\left(P_t^{\star}\right)^{1-\varepsilon} + \gamma\left(\Pi_{t-1}^{\psi} P_{t-1}\right)^{1-\varepsilon}\right]^{1/(1-\varepsilon)}. \tag{5.19}$$

5.2.2 Market Equilibrium and Policy

Credit market clearing requires that the total value of primary securities equals the value of the physical capital stock in the economy:

$$K_t = S_t^b + S_t^c. \tag{5.20}$$

ABS market clearing requires that the supply of ABS by brokers equals the demand of commercial banks:

$$M_t^c = M_t^b. \tag{5.21}$$

Finally, the aggregate resource constraint in the economy requires that the quantity of final goods satisfies:

$$Y_t = C_t + \left[1 + \Phi\left(\frac{I_t}{I_{t-1}}\right)\right] I_t. \tag{5.22}$$

We follow Gertler and Karadi (2011) and assume that monetary policy is characterised by the following Taylor rule:

$$R_t^n = \left[R_{t-1}^n\right]^{\rho_m} \left[\frac{1}{\beta}\left(\Pi_t\right)^{\phi^\Pi}\left(\frac{\varepsilon - 1}{\varepsilon}X_t\right)^{\phi^X}\right]^{1-\rho_m} \varepsilon_t^m, \tag{5.23}$$

where R_t^n is the nominal interest rate, ρ_m is the interest rate smoothing parameter, ϕ^Π and ϕ^X are the Taylor coefficients on inflation and on the inverse of the marginal cost, $X_t = 1/P_{m,t}$, which is used as a proxy for the output gap. The term ε_t^m denotes a monetary policy shock, which is a standard i.i.d innovation with standard deviation σ^m.

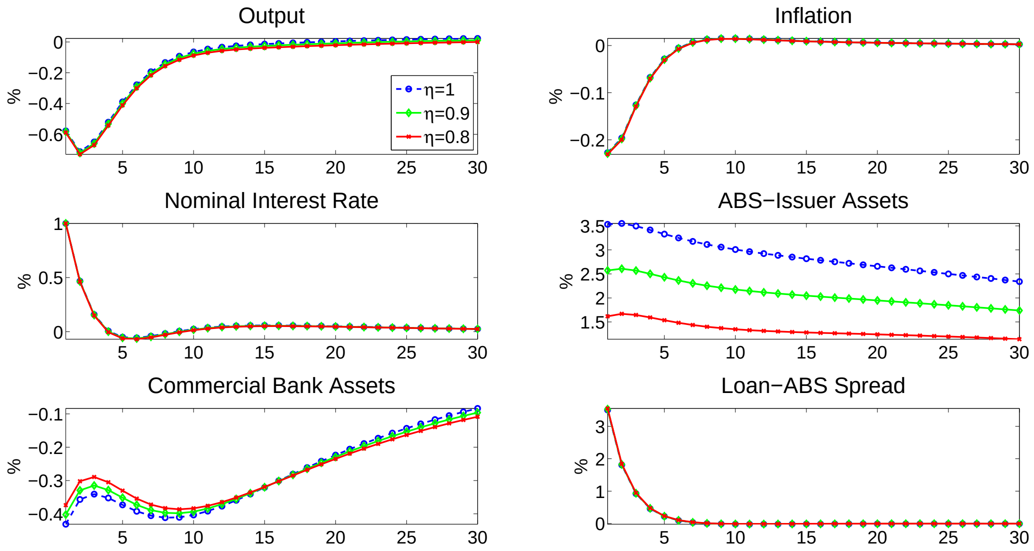
5.3 Model Dynamics

The model is solved using local perturbation methods. The set of model equations is summarised in tables 2–3 of the Appendix, and further details of the equilibrium conditions and the sticky-price block can be found in GK, and further discussion on shadow banking and ABS-issuance is in MNP. The parameter values are summarised in table 4 of the Appendix. The parameter values related to the sticky-price block, the monetary policy rule, investment adjustment costs are taken from GK. The rest of the parameter values are borrowed from MNP which also provides an extensive discussion about the calibration of the shadow banking block.

Figure 7 shows the impact of an annualised 100bp monetary policy shock in the model economy. The effect on the short-term interest rate is persistent due to interest rate smoothing ($\rho_m = 0.8$). As standard in models with banking frictions, the impact on output and inflation is amplified compared to standard NK models because of the impact of the shock on asset prices (see pp. 27 of GK). Commercial banks realise losses on their loan and ABS portfolios that are marked to market, leading to a peak fall of about -0.4% in their assets, which is somewhat smaller than suggested by VAR evidence shown in Figure 11.

In contrast, ABS-issuance increases substantially and the magnitude of the response could be considerably larger than in the case of commercial banks, which is consistent with the VAR evidence for ABS, shown in Figures 5 and 15. Despite its simplicity, the model helps to give a structural interpretation of the impact of the identified monetary policy shock. A monetary contraction raises the commercial banks' funding costs, while also reducing asset prices, and so the value of their collateral. These two effects both put downward pressure on commercial bank net worth. To maintain their intermediation capacity, commercial banks seek out pledgeable

Figure 7: The Impact of a 100bp Contractionary Monetary Policy Shock in the DSGE Model: The role of Equity vs. Debt Nature of ABS (η)



Notes: The magnitude of the shock is normalised to trigger a 100 basis point increase in the annualised nominal interest rate. The horizontal axes are quarters.

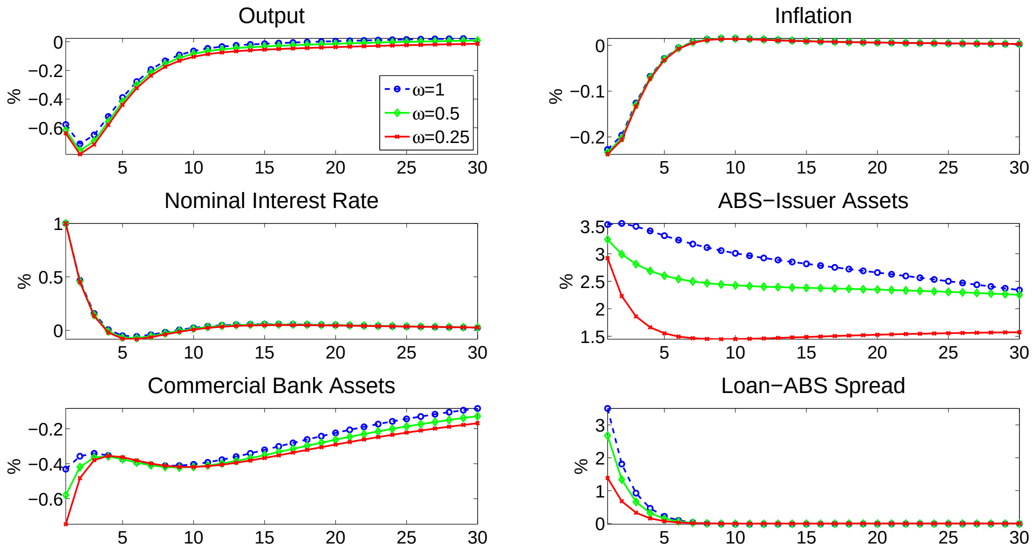
collateral in response. Holding more pledgeable collateral, while switching out of illiquid loans, helps to mitigate the contraction in their balance sheets and maintain profitability.

This pledgeable collateral is manufactured in the shadow banking sector, which pools loans and issues ABS against them. As such, monetary contractions result in an increase in the demand for securitised assets relative to loans, reflected in the increase of loan-ABS spread. At the same time, because shadow banks ultimately pass their returns back through to their investors, their balance sheets are hedged against the fall in asset prices that a monetary contraction engineers. This mitigates the fall in shadow bank net worth, underpinning their capacity to meet increased ABS demand from commercial banks in the event of a monetary tightening.

As mentioned earlier, the value of η determines whether commercial banks or shadow banks bear losses from holding ABS. When ABS is perfectly equity-like ($\eta = 1$), the decline in the mark-to-market value of ABS implies a decline in the liabilities of shadow banks, thereby providing partial protection of their net worth and their borrowing capacity. Consistent with this, the profits and lending capacity of commercial banks fall by more as their exposure to aggregate risk through ABS prices is larger. When ABS is more debt-like ($\eta < 1$), shadow banks too absorb some of the losses from falling asset values, and their capacity to supply ABS is decreased.

A second key parameter of the model is ω which captures the divertibility of ABS relative to that of standard loans in the incentive constraint of commercial banks (equation 5.6). The larger the value of ω, the more pledgeable ABS is and the more efficient the collateral production of the shadow banking sector is, which increases the incentive of commercial banks to rebalance

Figure 8: The Impact of a 100bp Contractionary Monetary Policy Shock in the DSGE Model: The role of relative 'divertibility' of ABS (ω)



Notes: The magnitude of the shock is normalised to trigger a 100 basis point increase in the annualised nominal interest rate. The horizontal axes are quarters.

their portfolios away from loans towards ABS when facing deteriorating financing conditions.

Figure 8 shows the quantitative results for three different parameter values for $\omega = [0.25, 0.5, 1]$. The higher the value of ω, the higher the increase in demand of commercial banks for ABS following a contractionary monetary policy shock, which is reflected in the larger increase in the loan-ABS spread. The ability of commercial banks to securitise loans in a more efficient way in turn somewhat insulates the overall supply of credit from the adverse impact of tighter policy. As a result, the fall in aggregate credit and output is smaller, when the value of ω is higher.

To sum up, the theoretical model suggests that the 'waterbed' effect implied by the VAR evidence is an outcome of commercial banks demanding more pledgeable collateral in the form of ABS when financing constraints within the banking sector tighten in response to a surprise monetary policy contraction. In future work, we plan to rigorously test this demand channel empirically. A number of challenges lie ahead. First, sufficiently long time-series on relevant prices such as the loan-ABS spread is not available. Second, aggregate measures of profitability and net worth of shadow banks are notoriously difficult to construct. Third, some of these data have become more readily available following the recent crisis, however the identification of standard monetary policy effects has become problematic given problems of the zero lower bound. We aim to address these issues in future research.

6 Implications for Policy

Our findings have important implications for the debate on the role of monetary policy in addressing financial stability concerns. This is relevant both in the academic literature related to the leaning against the wind debate (Christiano, Ilut, Motto, and Rostagno, 2010; Woodford, 2010; Gambacorta and Signoretti, 2014; Gali, 2014) and the surrounding policy discussion (Bean, 2014; Stein, 2013). As pointed out in the introduction, one line of argument is that monetary policy is a powerful tool for tackling financial excess because it 'gets in all the cracks'. Our results are consistent with this claim – monetary policy shocks do seem meaningfully to affect the balance sheets of both commercial banks and their unregulated counterparts in the shadow banking sector.

But our results point to an important caveat to that conclusion: a monetary contraction aimed at reducing the asset growth of commercial banks would tend to cause a migration of activity beyond the regulatory perimeter to the shadow banking sector. The monetary response needed to lean against shadow bank asset growth is of opposite sign to that needed to lean against commercial bank asset growth. That casts doubt on the ease with which monetary policy could be used in this way.

It would tend to reinforce the case for having monetary policy as the last line of defense against financial instability concerns made by others (Svensson, 2013). And it suggests instead that authorities should continue to develop a set of regulatory tools, complementary to monetary policy, that (a) seek to moderate excessive swings in risk-taking by commercial banks, as embodied in recent macroprudential frameworks, and (b) seek to strengthen oversight and regulation of the shadow banking sector (as suggested by the recent proposal of the FSB (2013)).

7 Conclusion

A number of papers have recently pointed to the importance of banks' and shadow banks' balance sheets in affecting asset price and business cycle dynamics. However, the literature empirically quantifying the impact of monetary policy shocks on the balance sheets of these institutions is scant. This paper has aimed to fill this gap by providing empirical evidence on the impact of policy shocks on the asset growth of the commercial and shadow banking sectors.

We provided evidence of a 'waterbed' effect whereby a policy shock has a persistent procyclical effect on commercial bank asset growth, whereas the effect on the growth of shadow banking and on securitisation activity is countercyclical. These results seem robust to including the stock price index, house prices and the term spread in the VAR, to changing the lag lengths of the model, and to using alternative identification schemes. Moreover, the results are robust to allowing time-variation in the VAR parameters and to incorporating heteroscedasticity in the error structure. We have shown that this 'waterbed' effect could be explained in a standard monetary DSGE model with heterogeneous banking.

Given the increasing concern in policy circles about the shadow banking sector and their regulation (Economist, 2014), the question remains whether traditional interest rate policy is at all effective in curbing excessive credit booms fueled by shadow banks. Our results point to a possible leakage ailing the transmission of monetary policy due to the presence of shadow banking activity and securitisation. Recent studies such as Aiyar, Calomiris, and Wieladek

(2014) found similar evidence regarding the impact of macroprudential policies. The challenge remains for policy makers to find an optimal mix of monetary and financial instruments to ensure the stability of the financial system and of the real economy.

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A Definition of Financial Intermediaries

The following definitions are taken from the Flow of Funds website:
http://www.federalreserve.gov/releases/Z1/about.htm

A.1 Finance Companies

This sector includes both finance companies and mortgage companies. Data for this sector are based on a Federal Reserve survey where finance companies are defined as companies in which 50 percent or more of assets are held in any of the following types of loan or lease assets: (1) liens on real estate, which are outstanding balances on loans or leases, for any purpose, secured by liens on real estate; and (2) loans and leases not secured by real estate: (a) business loans and leases, which are outstanding balances on loans and on leases for commercial and industrial purposes to sole proprietorships, partnerships, corporations, and other business enterprises; and (b) consumer loans and leases, which are outstanding balances on loans and on leases for household, family, and other personal expenditures. In the flow of funds accounts, liens on real estate are mortgages, business loans and leases are classified as other loans and advances, and consumer loans are consumer credit. Finance companies do not include U.S.-chartered depository institutions, cooperative banks, credit unions, investment banks, or industrial loan corporations. However, subsidiaries of a holding company or foreign banking organization may be considered finance companies. Captive finance companies, which are subsidiaries of nonfinancial companies that provide financing to customers of the parent company's products, are also included in this sector. Finance companies own motor vehicles that are leased to consumers. The acquisition of the vehicles by finance companies is recorded as fixed investment, and the debt used to finance the purchase of the vehicles is reported as a liability. However, the leases themselves are neither financial assets of the lessors (finance companies) nor liabilities of lessees (households). Lease payments are treated as consumer expenditures by the lessee and as current income to the lessor. Consumer leases are shown as a memorandum item at the bottom of this table. Beginning with the 2006:Q2 release of the flow of funds accounts, the mortgage company sector was combined with the finance company sector. Mortgage companies primarily originate loans to households or businesses for the purchase of residential or commercial properties and then sell most of them in the secondary market. Prior to the financial crisis that began in 2007, many mortgage companies derived a significant portion of their business from subprime and alt-A mortgages. Since then, the number of mortgage companies has dropped dramatically.

A.2 Security and Broker Dealers

Security brokers and dealers are firms that buy and sell securities for a fee, hold an inventory of securities for resale, or do both. The firms that make up this sector are those that submit information to the Securities and Exchange Commission on one of two reporting forms, either the Financial and Operational Combined Uniform Single Report of Brokers and Dealers (FOCUS) or the Report on Finances and Operations of Government Securities Brokers and Dealers (FOGS). Brokers and dealers are an important link in the transmission of funds from savers to investors because they are a means of distributing both new security issues and those being resold on the secondary market. Dealers in U.S. government securities (FOGs reporters) that stand ready to buy from or sell to the Federal Reserve System assist in the implementation of monetary policy conducted through open market operations.

The major assets of the sector are collateral repayable from funding corporations in connection with securities borrowing (included in miscellaneous assets), securities held for redistribution, and security credit provided to customers. Sector operations are financed largely by net transactions with parent companies, customer credit balances, security repurchase agreements, and security credit from private depository institutions.

A.3 Issuers of Asset-Backed Securities

Issuers of asset-backed securities (ABS) are special purpose vehicles (SPVs) that hold pools of assets (usually loans) in trust and use them as collateral for issuance of ABS. Most of these SPVs are formed by depository institutions, real estate investment trusts (REITs), and finance companies to move assets off their balance sheets into bankruptcy-remote entities. These originators often continue to act as servicers of the loans after the SPV is formed to earn fee income. This sector includes all off-balance-sheet SPVs, except those in the sector for agency- and GSE-backed mortgage pools and those in the REIT sector (shown as a memo item at the bottom of this table). Assets in the pools include home, multifamily, and commercial mortgages; consumer credit (such as automobile and student loans and credit card receivables); trade credit; Treasury securities; agency- and GSE-backed securities; and other loans and advances. The instrument "other loans and advances" includes nonfinancial business loans securitized by depository institutions and finance companies and syndicated loans to nonfinancial corporate businesses. Liabilities of this sector are the securities issued by the SPVs and are typically medium- to long-term corporate bonds and commercial paper. These securities are largely pass-through securities, in which purchasers receive any interest, amortization, and principal payments on the underlying collateral.

Also included in this sector are consumer motor vehicle leases that were originally held by finance companies but have now been securitized. Acquisition of the motor vehicles by issuers of ABS occurs when the lease is securitized and is shown as fixed investment on this table. The leases themselves are not financial assets of this sector or of the original finance company lessor and are not liabilities of the household sector; rather, lease payments are treated as consumer expenditures by the household sector and as current income of the issuers of the ABS sector. The securitized consumer leases are shown as a memo item at the bottom of this table. Instruments comprised of asset-backed securities, such as collateralized debt obligations (CDOs) and structured investment vehicles (SIVs), are not included in the flow of funds accounts because of limited source data. In the ABS table, CDOs and SIVs, which are comprised of outstanding securities, are not included on the asset side. Similarly, the bonds issued by CDOs and SIVs are not included on the liabilities side of the ABS sector balance sheet.

A.4 Funding Corporations

The sector for funding corporations consists of five types of financial institutions and entities: 1. Subsidiaries of foreign bank and nonbank financial firms that raise funds in the U.S. commercial paper market and transfer the proceeds to foreign banking offices in the United States or to foreign parent companies abroad. In the flow of funds accounts, this transfer of funds is reported as negative foreign direct investment (FDI) in the United States since by convention, FDI is reported as an asset of the parent and a liability of the subsidiary. The treatment of these transactions in the flow of funds accounts is under review. 2. Financial holding companies, other than holding companies shown on tables F.128 and L.128, are included where data are available. The issuance of preferred shares to the federal government under the Troubled Asset Relief Program, or TARP, by American International Group, Inc. (AIG), a holding company, is recorded as a corporate equities liability with no specific corresponding asset. 3. Custodial accounts are bookkeeping entities established to hold cash collateral put up by security dealers to back securities they borrow to cover short sales and delivery failures. In the flow of funds accounts, these security transactions are listed as securities loaned (net). The collateral is returned to the dealers when the borrowed securities are returned. While held in custody, the collateral is invested in money market mutual fund shares, commercial paper, and corporate bonds. 4. Beginning in 2008, the Federal Reserve created a number of limited liability companies (LLCs) to which loans were extended to help stabilize the financial system. These LLCs included (1) Maiden Lane LLC to facilitate the arrangements associated with JPMorgan Chase & Co.'s acquisition of the Bear Stearns Companies, Inc.; (2) Maiden Lane II LLC to purchase residential mortgage-backed securities from the U.S. securities lending reinvestment portfolio of AIG subsidiaries; (3) Maiden Lane III LLC to purchase collateralized debt obligations on which AIG had written credit default swap contracts; and (4) Commercial Paper Funding Facility LLC. Loans were also made to AIG. Loans in the funding corporation sector are recorded as depository institution loans n.e.c., with corporate and foreign bonds and open market paper serving as the corresponding assets. AIA Aurora LLC and ALICO Holdings LLC, two limited liability companies created to hold all the outstanding common stock of American International Assurance Company, Ltd. (AIA), and American Life Insurance Company (ALICO), which are two life insurance subsidiaries of AIG, are also included in this sector. The stocks of AIA and ALICO are shown as an asset, and the monetary authority sector's holdings of preferred shares in AIA Aurora LLC and ALICO Holdings LLC are shown as a liability. 5. Loans extended by the federal government to the Term Asset-Backed Securities Loan Facility, or TALF, LLC and to funds associated with the Public-Private Investment Program (PPIP) are recorded as an "other loans and advances" liability. The funding corporation sector's equity interest under PPIP is also shown as a liability.

A.5 Credit Unions

Credit unions are federally or state-chartered savings institutions open to members who share a so-called common bond, such as employment, geographic proximity, or organization membership. At the end of 2011 there are about 7,400 credit unions in the United States, including the U.S. territory of Puerto Rico, offering primarily consumer-oriented financial services; most are fairly small institutions, although a few are very large and operate in the national financial arena. The National Credit Union Share Insurance Fund (NCUSIF) insures deposits in federal credit unions and federally insured state-chartered credit unions. Almost 7,100 credit unions are federally-insured. The credit union industry has a hierarchical structure. Local credit unions belong to 23 corporate credit unions. The corporate credit unions accept deposits from and make loans to member credit unions; they also provide wholesale financial and payments services to their credit union constituency. In the sector statement for credit unions, intrasector transactions are netted out, but the investments of the corporate credit unions with institutions outside the credit union sector are included in the sector's total assets. Federally insured credit unions pay an annual premium into the NCUSIF, which holds only securities issued by the U.S. government; in the flow of funds accounts, in the sector for credit unions, total holdings of Treasury securities include an amount equal to the accumulated contributions of insured credit unions shown on the NCUSIF's balance sheet.

A.6 US-Chartered Depository Institutions, Excluding Credit Unions

U.S.-chartered depository institutions are financial intermediaries that raise funds through demand and time deposits as well as from other sources, such as federal funds purchases and security repurchase agreements, funds from parent companies, and borrowing from other lending institutions (for example, the Federal Home Loan Banks); they use the funds to make loans, primarily to businesses and individuals, and to invest in securities. U.S.-chartered depository institutions include national commercial banks chartered by the Controller of the Currency, state-chartered commercial banks (chartered by one of the 50 states or the District of Columbia), federal savings banks, state-chartered savings banks, cooperative banks, and savings and loan associations. In recent years, this sector has undergone significant consolidation as a result of both the gradual removal of prohibitions on interstate banking arrangements and the growing similarity of the functions provided by different types of financial institutions. At the end of 2011, there were approximately 7,400 U.S.-chartered depository institutions insured by the FDIC, down from almost 14,000 twenty years ago. The sector's assets and liabilities are reported on a consolidated basis; that is, intrasector deposit and loan balances are netted out. Foreign branches and foreign subsidiaries of U.S.-chartered depository institutions are not included in the consolidation; their assets and liabilities are included in the rest of the world sector. However, domestic nonbanking subsidiaries of U.S.-chartered depository institutions are consolidated with their parents. Note: Because of accounting rule changes established by Statements of Financial Accounting Standards Nos. 166 and 167 in 2010:Q1, depository institutions consolidated back onto their balance sheets the assets and liabilities of certain special purpose vehicles that had previously been off balance sheet. This shift primarily increased loans on the asset side and corporate bonds and open market paper on the liability side.

A.7 Government-Sponsored Enterprises (GSEs)

Government-sponsored enterprises (GSEs) are financial service corporations created by the U.S. Congress to ensure or enhance the flow of credit to certain sectors of the economy, such as housing and agriculture. The sector is composed of the Federal Home Loan Banks (FHLBs), the Federal National Mortgage Association (Fannie Mae), the Federal Home Loan Mortgage Corporation (Freddie Mac), the Federal Agricultural Mortgage Corporation (Farmer Mac), the Farm Credit System, the Financing Corporation (FICO), and the Resolution Funding Corporation (REFCORP). The Student Loan Marketing Association, or Sallie Mae, was included until it was fully privatized in the fourth quarter of 2004.

This sector consists of a diverse group of enterprises, not only in terms of their mission, but also in terms of their relationship with the federal government. The FHLBs are a system of 12 regional banks that lend funds to U.S.-chartered depository institutions, credit unions, and life insurance companies. Both Freddie Mac and Fannie Mae, two agencies devoted to housing finance, were placed in conservatorship (a device used to maintain public confidence in an endangered financial institution) in September 2008; the conservator is the federal government, which legally controls both agencies. Farmer Mac is a private corporation that purchases and then securitizes loans on farms and farm land. The Farm Credit System is a network of borrower-owned lenders that makes loans to farmers and other rural concerns. The FICO and the REFCORP were established as a result of the 1980s savings and loans crisis to serve as financing vehicles for the Federal Savings and Loan Insurance Corporation Resolution Fund and the Resolution Trust Corporation, respectively. In the flow of funds accounts, securities issued by the GSEs are not included in government debt.

A.8 Agency- and GSE-Backed Mortgage Pools

Mortgage pools are a group of mortgages used as collateral for a mortgage-backed security. These pools are held in special purpose vehicles, which allow an originator to move mortgages off its balance sheet into a bankruptcy-remote vehicle.

Agency- and GSE-backed mortgage pools include mortgage pools backed by four types of properties: (1) pools consisting of one to four-family mortgages, issued by the Government National Mortgage Association (Ginnie Mae), the Federal National Mortgage Association (Fannie Mae), and the Federal Home Loan Mortgage Corporation (Freddie Mac); (2) pools of multi-family loans issued by Ginnie Mae, Fannie Mae, and Freddie Mac; (3) pools of commercial mortgages issued by the Farmers Home Administration (FmHA), which wound down all of its commercial mortgage pools at the end of 1996 (FmHA also formed one to four-family, multifamily, and farm mortgage pools, but withdrew completely from that business by the end of the 1990s); and (4) pools of farm mortgages issued by the Federal Agricultural Mortgage Corporation (Farmer Mac).

Securities issued by the agencies to fund these pools are known as mortgage-pool securities. These obligations are largely pass-through securities, in which purchasers receive interest, amortization, and principal payments on the underlying mortgages. In the flow of funds accounts, these securities are part of the instrument category of agency- and GSE-backed securities and are equal to the unpaid balances of the mortgages in the pools.

B VAR Model

B.1 Estimation of the Constant Parameter VAR

The starting point of our empirical analysis is a vector autoregressive model of order K – VAR(K)

$$y_t = \sum_{i=1}^{K} \Theta_i y_{t-i} + u_t \tag{B.1}$$

where u_t is the $N \times 1$ vector of reduced-form errors that is normally distributed with zero and Σ variance-covariance matrix. The regression-equation representation of the latter system is

$$Y = X\Psi + V$$

where $Y = [y_{h+1}, .., y_T]$ is a $N \times T$ matrix containing all the data points in y_t, $X = Y_{-h}$ is a $(NK) \times T$ matrix containing the h-th lag of Y , $\Theta = \begin{bmatrix} \Theta_1 & \cdots & \Theta_K \end{bmatrix}$ is a $N\times$ (NK) matrix, and $U = [u_{h+1}, .., u_T]$ is a $N \times T$ matrix of disturbances. Because of the large number of parameters to be estimated, classical inference techniques would deliver estimates that are subject to enormous uncertainty, suggesting the need for Bayesian procedures. Priors are used to shrink the number of the estimated parameters. An obvious choice can be Minnesota type priors, since they shrink the VAR(K) model towards independent autoregressive of order one – AR(1) – models. Furthermore, evidence provided by Banbura, Giannone, and Reichlin (2010) suggests that large VAR models achieve very good forecasting properties when they are combined with Minnesota type priors.

The posterior inference is obtained as follows. It is assumed that the prior distribution of the VAR parameter vector has a Normal-Wishart conjugate form

$$\theta|\Sigma \sim N(\theta_0, \Sigma \otimes \Omega_0), \ \Sigma \sim IW(v_0, S_0). \tag{B.2}$$

where θ is obtained by stacking the columns of Θ. The prior moments of θ are given by

$$E[(\Theta_k)\, i, j] = \begin{cases} \delta_i & i = j, k = 1 \\ 0 & \text{otherwise} \end{cases}, \ Var[(\Theta_k)\, i, j] = \lambda \sigma_i^2 / \sigma_j^2,$$

and as it is explained by Banbura, Giannone, and Reichlin (2010), they can be constructed using the following dummy observations

$$Y_D = \begin{pmatrix} \frac{diag(\delta_1\sigma_1 ... \delta_N\sigma_N)}{\lambda} \\ 0_{N\times(K-1)N} \\ .... \\ diag\,(\sigma_1 ... \sigma_N) \\ .... \\ 0_{1\times N} \end{pmatrix} \text{ and } X_D = \begin{pmatrix} \frac{J_K \otimes diag(\sigma_1 ... \sigma_N)}{\lambda} \\ 0_{N\times NK} \\ .... \\ 0_{1\times NK} \end{pmatrix} \tag{B.3}$$

where $J_K = diag\,(1, 2, ..., K)$ and $diag$ denotes the diagonal matrix. The prior moments of (B.2) are functions of Y_D and X_D, $\Theta_0 = Y_D X_D' \left(X_D X_D'\right)^{-1}$, $\Omega_0 = \left(X_D X_D'\right)^{-1}$, $S_0 = (Y_D - \Theta_0 X_D)\,(Y_D - \Theta_0 X_D)'$ and $v_0 = T_D - NK$. Finally, the hyper-parameter λ controls the tightness of the prior.

Since the normal-inverted Wishart prior is conjugate, the conditional posterior distribution of this model is also normal-inverted Wishart :

$$\theta|\Sigma, Y \sim N(\bar{\theta}, \Sigma \otimes \bar{\Omega}), \ \Sigma|Y \sim IW(\bar{v}, \bar{S}), \tag{B.4}$$

where the bar denotes that the parameters are those of the posterior distribution. Defining $\hat{\Theta}$ and $\hat{U}$ as the OLS estimates, we have that $\bar{\Theta} = (\Omega_0^{-1}\Psi_0 + YX')(\Omega_0^{-1} + X'X)^{-1}$, $\bar{\Omega} = (\Omega_0^{-1} + X'X)^{-1}$, $\bar{v} = v_0 + T$, and $\bar{S} = \hat{\Theta}XX'\hat{\Theta}' + \Theta_0\Omega_0^{-1}\Theta_0 + S_0 + \hat{U}\hat{U}' - \bar{\Theta}\bar{\Omega}^{-1}\bar{\Theta}'$.

The values of the persistence – δ_i – and the error standard deviation – σ_i – parameters of the AR(1) model are obtained from its OLS estimation. The parameter λ has been set equal to 1, a value typically used for the US.

B.2 Identification with Sign Restrictions

Identification with sign restrictions follows Uhlig (2005) and Blake and Mumtaz (2012). Given draws θ_0 and Σ_0 from the posterior distribution of the dynamic parameter and reduced-form variance-covariance matrices, calculate the impact matrix A_0 as follows:

1. Draw a $N \times N$ matrix K from the standard normal distribution
2. Calculate the matrix Q from the QR decomposition of K, where Q by definition is orthonormal, i.e.$Q'Q = I$

3. Calculate the Cholesky decomposition of the draw of $\Sigma_0 = \tilde{A}_0' \tilde{A}_0$

4. Calculate the candidate A_0 matrix as $A_0 = Q\tilde{A}_0$ (because of the orthonormality of Q, the produced $A_0' A_0$ is still equal the reduced-form matrix Σ_0

5. Accept the draws, if any of the columns of the matrix A_0 satisfy the sign restrictions imposed by economic theory

Table 1: Sign-Restrictions

Variables	Monetary Policy Shock
GDP	-
Inflation	-
Interest Rate	+
Balance Sheet Indicator(s)	

The sign restrictions are summarised in table 1, implying that a positive/contractionary shock to the policy rate lowers output and the price level. Regarding the balance sheet indicators, we are agnostic and make no assumption about the impact of the policy shock on these variables. The sign restrictions are applied for two horizons.

B.3 Time-Varying Parameter VAR with Stochastic Volatility

The modified empirical model featuring time-varying parameters and stochastic volatility is therefore written as:

$$Y_t = c_t + B_{1,t} y_{t-1} + \cdots + B_{p,t} y_{t-p} + u_t \qquad t = 1, \ldots, T. \tag{B.5}$$

where u_t are heteroscedastic shocks with a variance-covariance matrix Ω_t defined as:

$$VAR(u_t) = \Omega_t = A_t^{-1} H_t \left(A_t^{-1}\right)' \tag{B.6}$$

where the time-varying matrices H_t and A_t are defined as:

$$H_t = \begin{bmatrix} h_{1,t} & 0 & \dots & 0 \\ 0 & h_{2,t} & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \dots & 0 & h_{n,t} \end{bmatrix} \qquad A_t = \begin{bmatrix} 1 & 0 & \dots & 0 \\ \alpha_{21,t} & 1 & \ddots & 0 \\ \vdots & \ddots & \ddots & 0 \\ \alpha_{n1,t} & \dots & \alpha_{nn-1,t} & 1 \end{bmatrix} \tag{B.7}$$

where the log of $h_{i,t}$ and $\alpha_{i,t}$ evolve as geometric random walks:

$$\ln h_{i,t} = \ln h_{i,t-1} + \nu_t \qquad \alpha_{i,t} = \alpha_{i,t-1} + \tau_t \tag{B.8}$$

which can be represented more compactly by stacking the right-hand-side coefficients into a vector Φ_t as follows:

$$Y_t = X_t'\Phi_t + A_t^{-1}H_t\varepsilon_t \tag{B.9}$$

where the data matrix is written as $X_t' = I_n \otimes \left[1, y_{t-1}', \ldots, y_{t-p}'\right]$, and $\Phi_t = vec\left([c_t, B_{1,t}, \ldots, B_{p,t}]\right)$, and structural variance-covariance matrix $VAR\left(\varepsilon_t\right) = I$. Following the literature, we model the dynamics of the parameter matrix as a random walk:

$$\Phi_t = \mu + \Phi_{t-1} + \nu_t \tag{B.10}$$

where μ is a constant and the innovation η_t is normal with mean zero and variance Q. The distributional assumptions of the errors are summarised as follows:

$$A_t = \begin{bmatrix} u_t \\ \eta_t \\ \tau_t \\ \nu_t \end{bmatrix} \sim N\left(0, V\right), \; V = \begin{bmatrix} \Omega & 0 & 0 & 0 \\ 0 & Q & 0 & 0 \\ 0 & 0 & S & 0 \\ 0 & 0 & 0 & G \end{bmatrix}, \; G = \begin{bmatrix} \sigma_1^2 & 0 & \ldots & 0 \\ 0 & \sigma_2^2 & \ddots & 0 \\ \vdots & \ddots & \ddots & 0 \\ 0 & \ldots & 0 & \sigma_n^2 \end{bmatrix} \tag{B.11}$$

The VAR model with time-varying parameters B.5 – B.10 is estimated with Bayesian methods described in Blake and Mumtaz (2012). The basic algorithm involves the following steps:

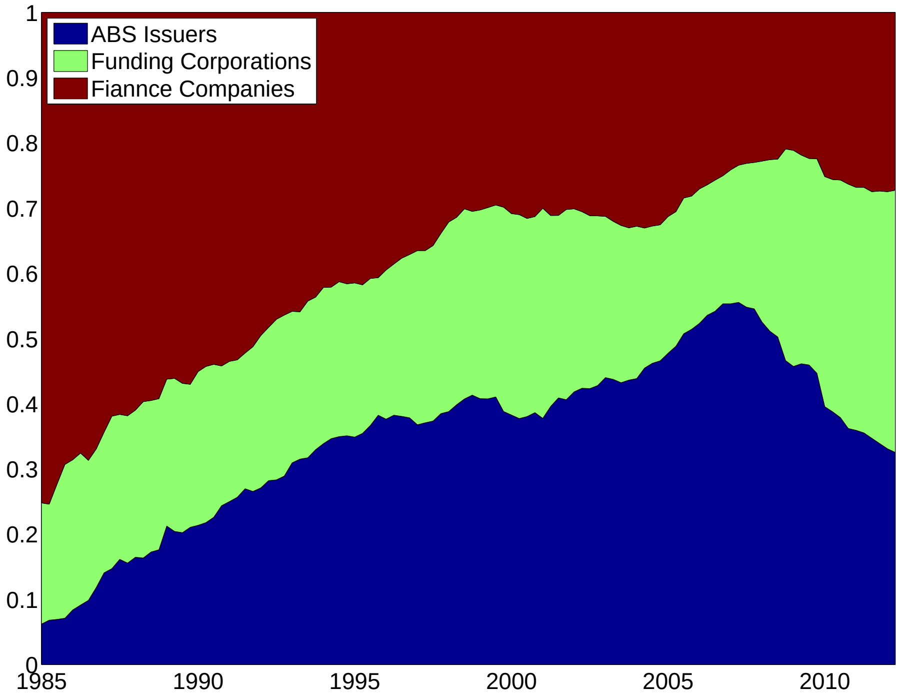
1. Simulate the VAR coefficients Φ_t and the elements of the variance-covariance matrix A_t.
2. Draw the volatilities of the reduced-form shocks H_t.
3. Draw the hyperparameters Q and S from an inverse Wishart distribution and simulate the elements of G from an inverse Gamma distribution.

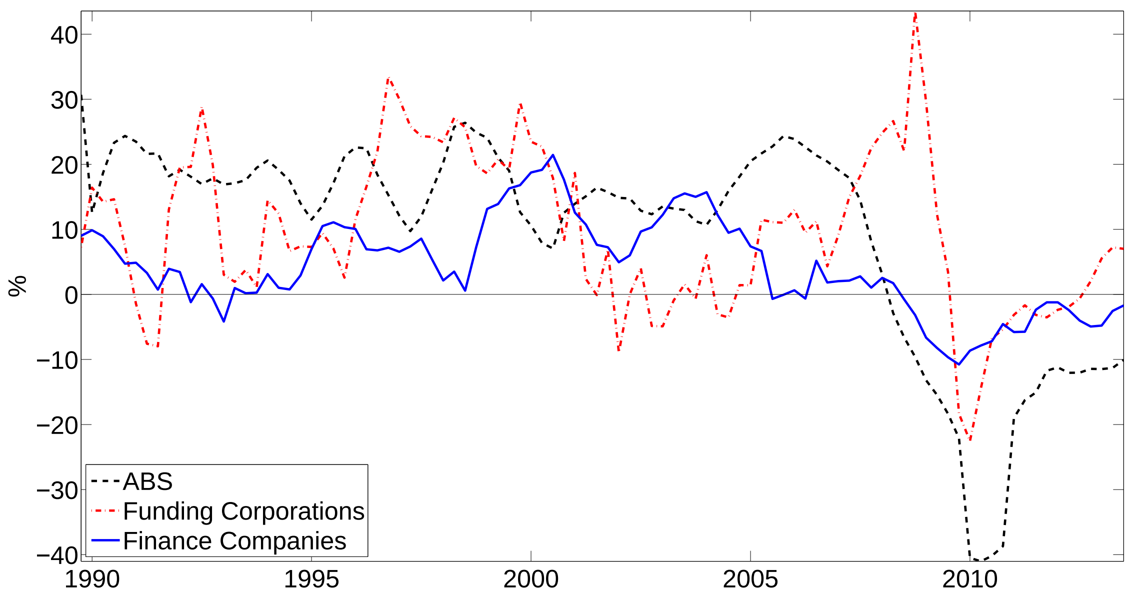
C Figures

C.1 Shadow Banks

Figure 9: Data on Shadow Banks

(a) Evolution of the Composition of Shadow Bank Assets





(b) Annual Asset Growth of the Shadow Banking Sector

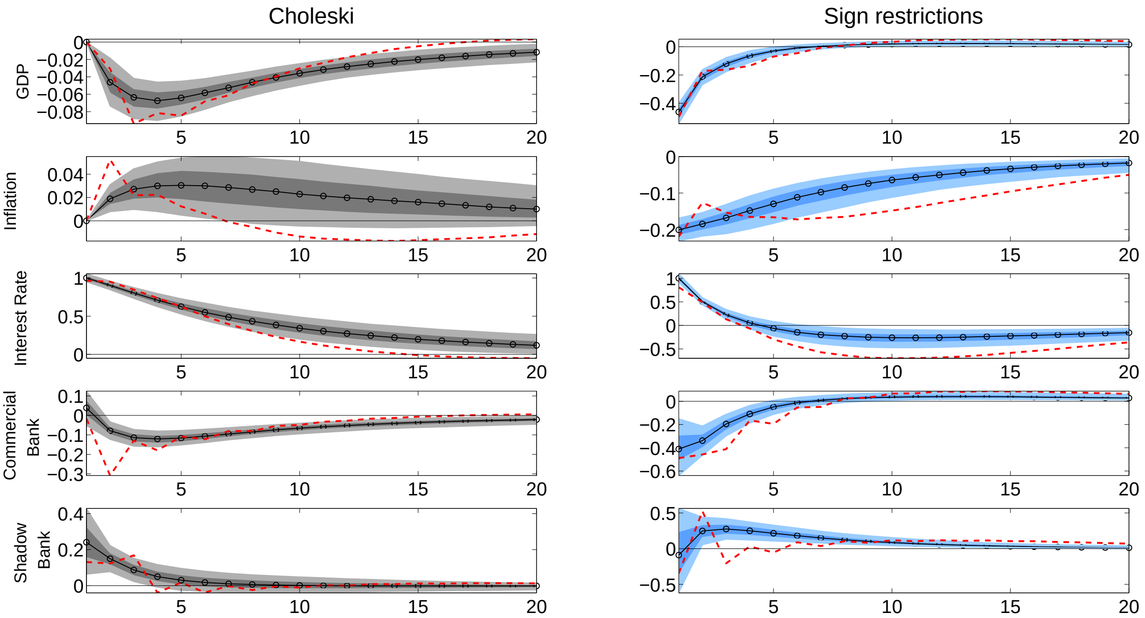
Source: Flow of Funds.

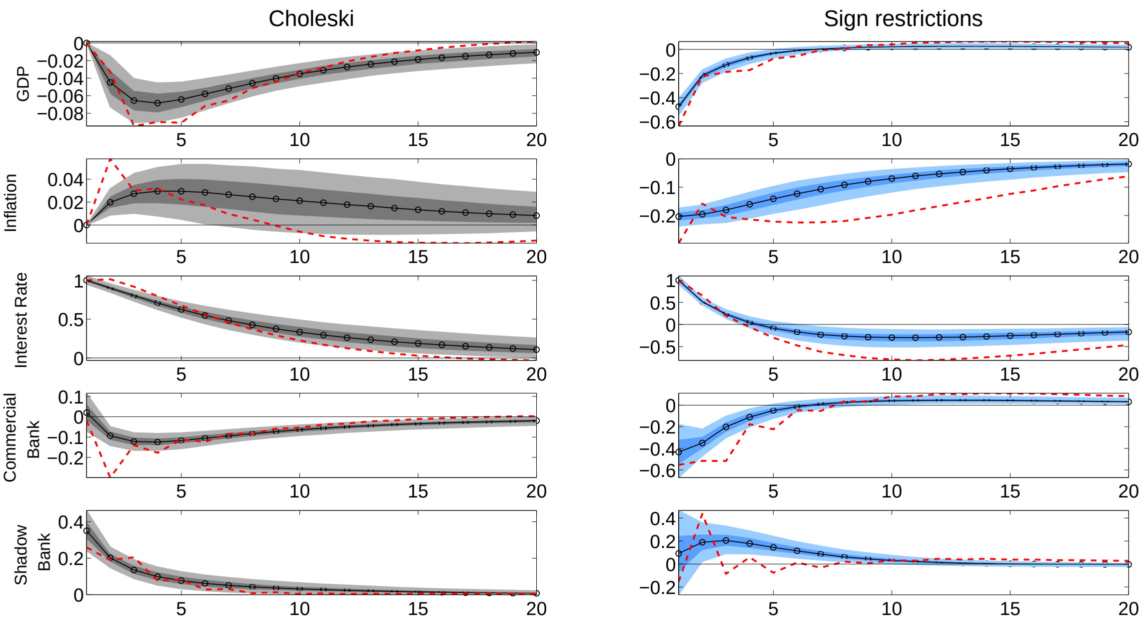
C.2 Robustness Checks

C.2.1 5-variable VAR

Figure 10: The Impact of a 100bp Contractionary Monetary Policy Shock on the *Quarterly* Asset Growth of Commercial and Shadow Banks

(a) Shadow Bank = ABS+FinComp+FundCorp



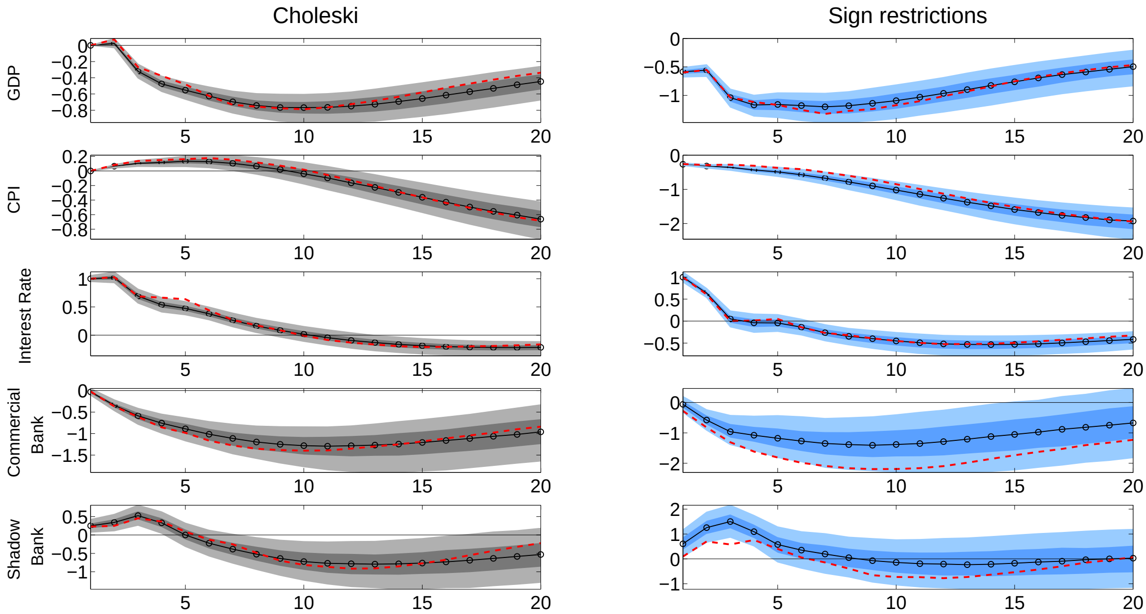


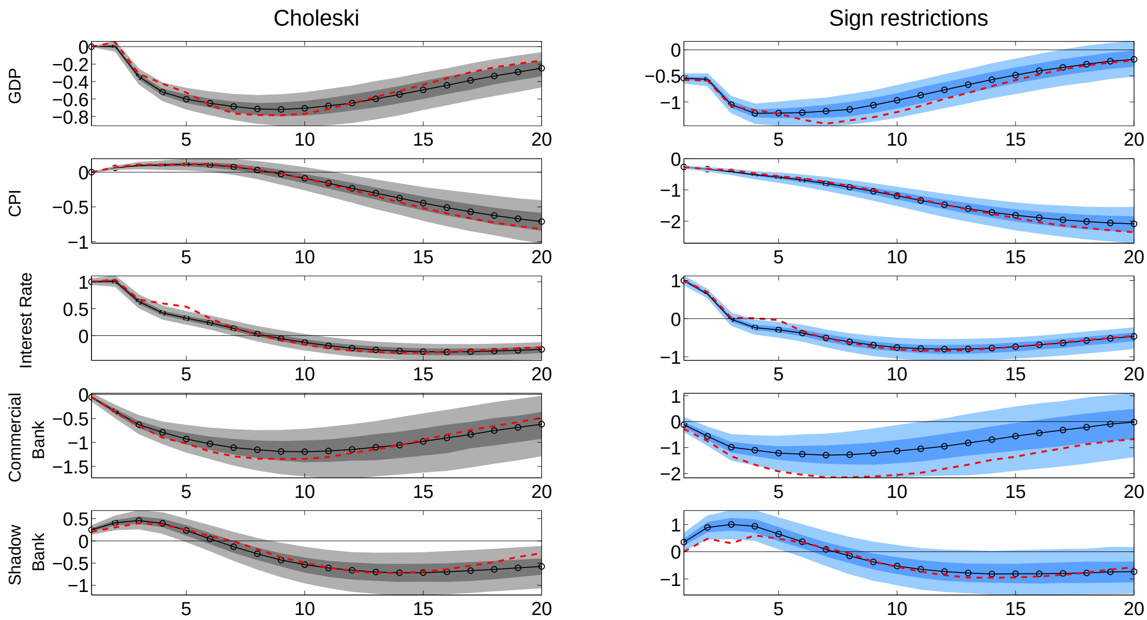
(b) Shadow Bank = ABS+FinComp+FundCorp+GSEs+MtgPools

Notes: Identification with Choleski ordering and Sign Restriction. The sample period is 1966Q3 - 2007Q2. Each panel shows the pointwise median, 32nd-68th and 16th-86th percentiles of 1000 draws (after burning the first 5000 draws) from the posterior distribution of the impulse responses, using one lag. The red dashed lines plot the pointwise medians using two lags. The left (right) column shows results from Choleski (Sign Restrictions) identification.

Figure 11: The Impact of a 100bp Contractionary Monetary Policy Shock on the *Level* of Assets of Commercial and Shadow Banks

(a) Shadow Bank = ABS+FinComp+FundCorp

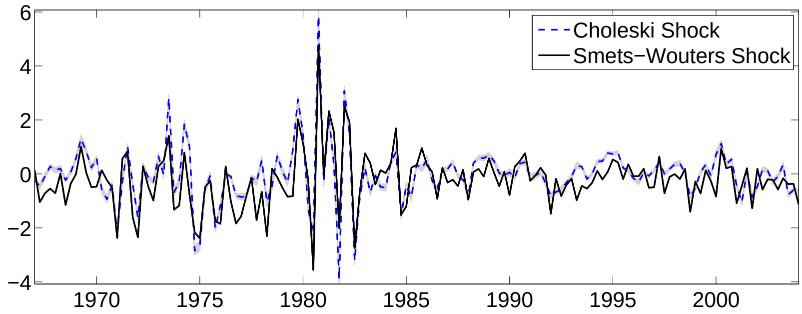




(b) Shadow Bank = ABS+FinComp+FundCorp+GSEs+MtgPools

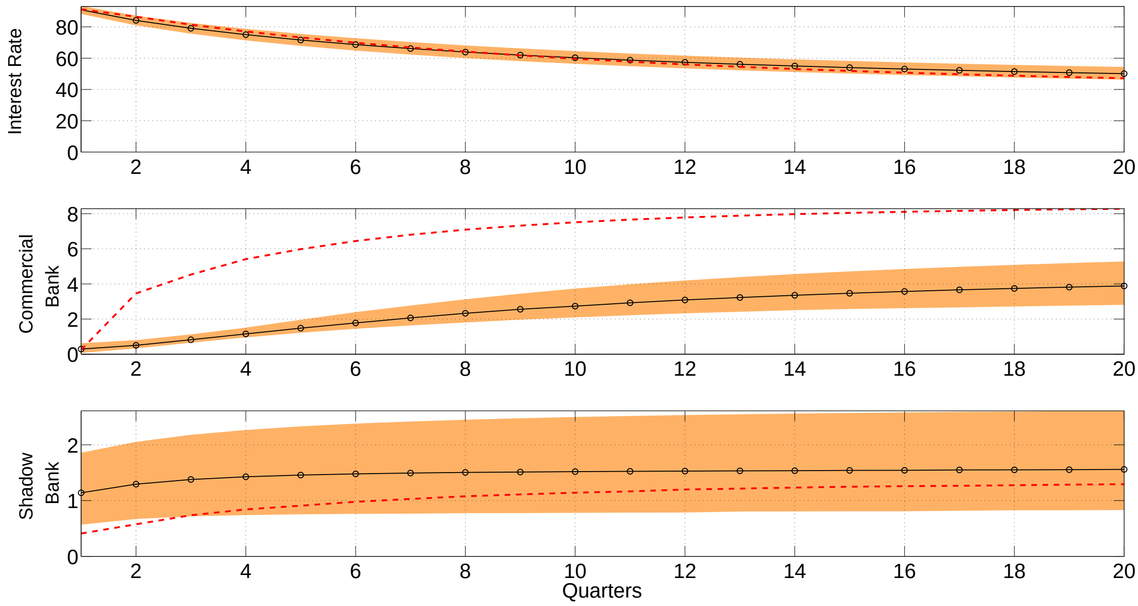
Notes: Identification with Choleski ordering and Sign Restriction. The sample period is 1966Q3 - 2007Q2. Each panel shows the pointwise median, 32nd-68th and 16th-86th percentiles of 1000 draws (after burning the first 5000 draws) from the posterior distribution of the impulse responses, using three lags. The red dashed lines plot the pointwise medians using four lags. The left (right) column shows results from Choleski (Sign Restrictions) identification.

Figure 12: Comparing the Implied Monetary Policy Shock Series (Choleski) to that in SW07



Notes: The 5-variable VAR is run on the sample 1966Q3 - 2007Q2, using quarterly asset growth. The black line is the monetary policy shock series from SW07. The shaded are the shock series associated with the pointwise 32nd and 68th percentiles of 5000 draws from the posterior distribution. The blue line is the pointwise median. The correlation between the blue and the black lines is **83.5%**.

Figure 13: Forecast Error Variance Decomposition – The Importance of Monetary Policy Shocks for Asset Growth

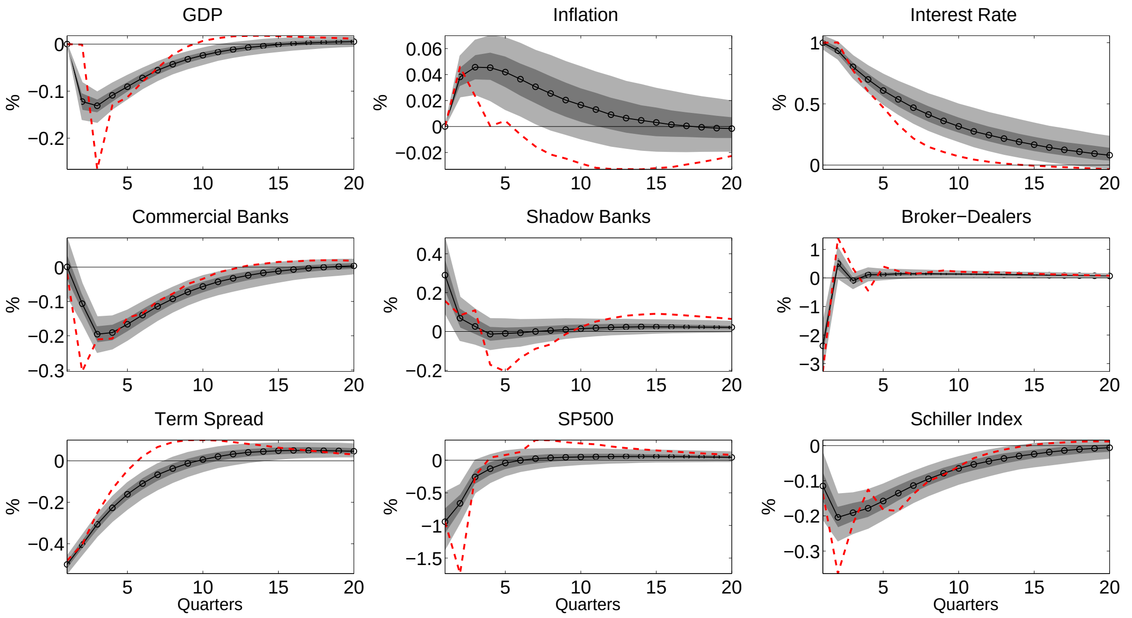


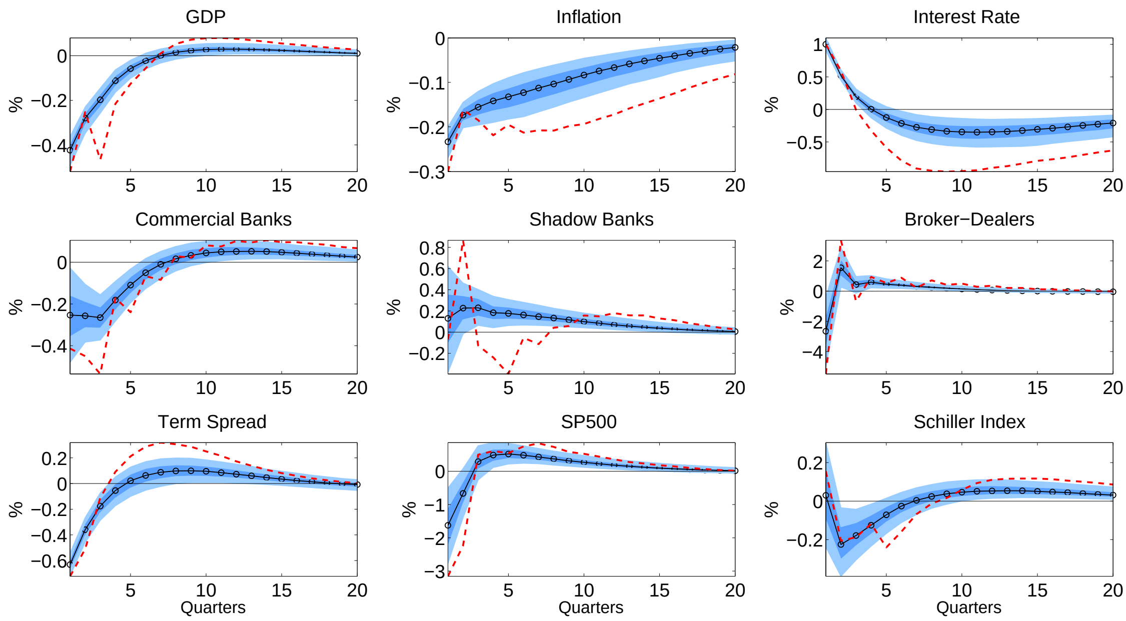
Notes: The 5-variable VAR is run on the sample 1966Q3 - 2007Q2, using quarterly asset growth. The identification is done with Choleski-ordering. Each panel shows the pointwise median, and the 32nd-68th percentiles of 1000 draws (after burning the first 5000 draws) from the posterior distribution of the forecast decompositions, using one lag. The red dashed lines plot the pointwise medians using two lags.

C.2.2 9-variable VAR

Figure 14: Asset Prices and the Impact of 100bp Monetary Policy Shock in the Large-scale VAR

(a) Choleski Ordering



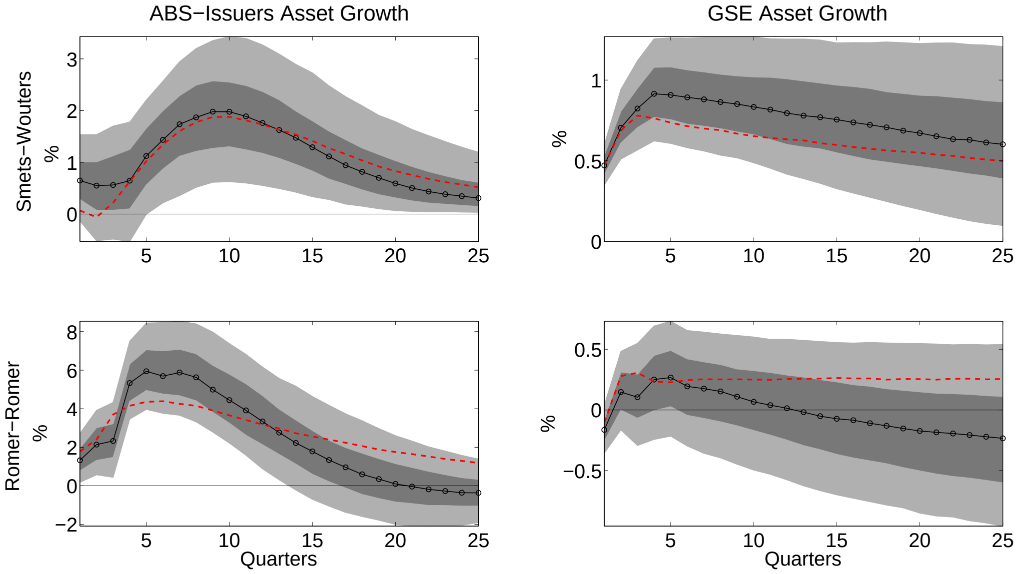


(b) Sign Restrictions

Notes:The sample period is 1966Q3 - 2007Q2. The sample period is 1966Q3 - 2007Q2. Each panel shows the pointwise median, 32nd-68th and 16th-86th percentiles of 1000 draws (after burning the first 5000 draws) from the posterior distribution of the impulse responses, using one lag. The red dashed lines plot the pointwise medians using two lags. *Quarterly* growth rates are used for all the variables except for the interest rate and the term spread that are in levels.

C.3 The Impact of Monetary Policy Shocks on ABS and GSEs

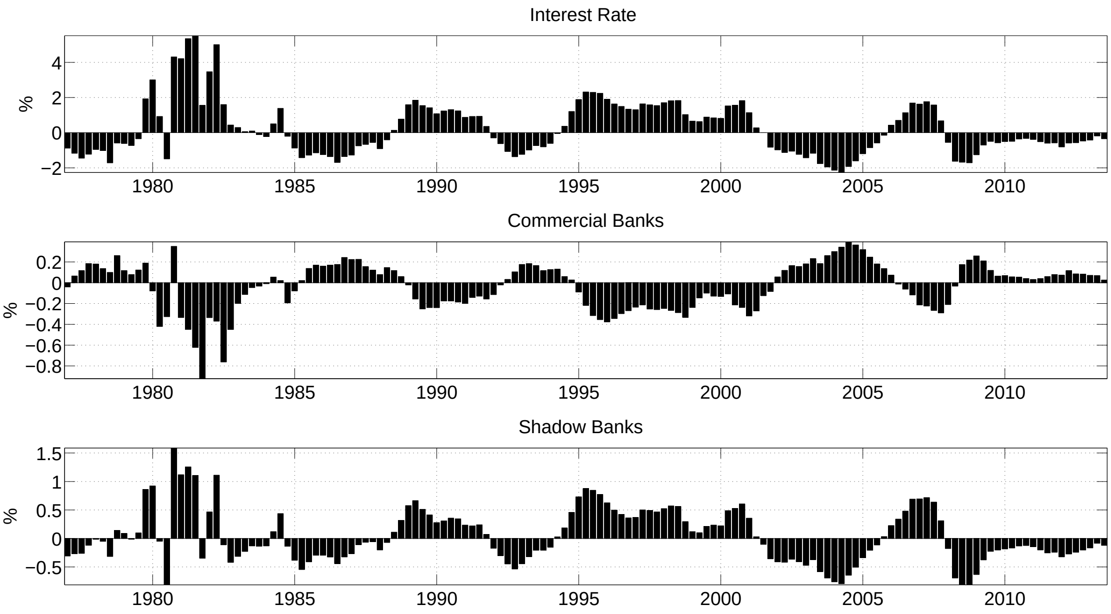
Figure 15: The Impact of a 100bp Contractionary Monetary Policy Shock on the *Level* of ABS and GSEs



Notes: The identification is with Choleski ordering, the model includes a linear time-trend. The vertical axes are in % points. The sample period starts in 1985Q1 for ABS-issuers and starts in 1966Q3 for GSEs. The sample period with the Smets and Wouters (2007) (Romer and Romer (2004)) series ends in 2004Q4 (2008Q4). Each plot shows the pointwise median, 32nd and 68th percentiles of 1000 draws (after burning the first 5000 draws) from the posterior distribution of the impulse responses using one lag. The red dashed lines plot the pointwise medians using two lags. The panels show the IRFs from four individual bivariate BVAR models. The results regarding the impact on the shocks series are available upon request.

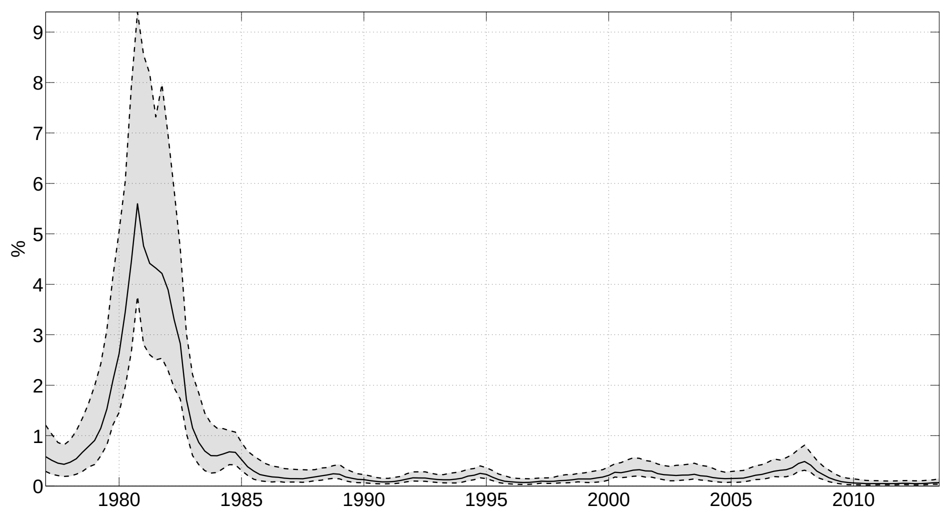
C.4 Time-Varying Parameter VAR with Stochastic Volatility

Figure 16: The Contribution of Monetary Policy Shocks from the TVP-SV VAR Model



Notes: The sample period is 1966Q3 - 2013Q3, and the lines depict the pointwise median contributions of monetary policy shocks identified with Choleski-ordering.

Figure 17: Time-varying Standard Deviations of Monetary Policy Shocks



Notes: The sample period is 1966Q3 - 2013Q3, using the first 40 observations as training sample. The figure shows the median estimate of the time-varying standard deviation together with the 16th-84th percentiles of the posterior distribution.

D Theoretical Model

Table 2: Equations of the DSGE Model with Equity-like ABS

Description	Equation
Households and Production	
Marginal Utility of Consumption	$\lambda_t = (C_t - hC_{t-1})^{-1}$
Marginal Disutility of Labour	$u_t^L = \chi L_t^{\varphi}$
Euler-equation	$\mathbb{E}_t \Lambda_{t,t+1} R_t = 1$
Labour-supply Condition	$W_t = u_t^L / \lambda_t$
Stochastic Discount Factor	$\Lambda_{t,t+1} = \mathbb{E}_t \beta \lambda_{t+1} / \lambda_t$
Production Function	$Y_{m,t} = K_{t-1}^{\alpha} L_t^{1-\alpha}$
Labour Demand	$P_{m,t} (1-\alpha) \frac{Y_{m,t}}{L_t} = W_t$
Investment Demand	$Q_t = 1 + \frac{\eta_i}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 + \eta_i \left(\frac{I_t}{I_{t-1}} - 1\right)\frac{I_t}{I_{t-1}} - \mathbb{E}_t \Lambda_{t,t+1} \eta_i \left(\frac{I_{t+1}}{I_t} - 1\right)\left(\frac{I_{t+1}}{I_t}\right)^2$
Return on Capital	$R_{t+1}^K = \mathbb{E}_t \left[P_{m,t} \alpha \frac{Y_{m,t+1}}{K_t} + Q_{t+1}\right] / Q_t$
Wholesale Output	$Y_t = Y_{m,t} J_t$
Price Dispersion	$J_t = \gamma J_{t-1} \Pi_{t-1}^{-\psi\varepsilon} \Pi_t^{\varepsilon} + (1-\gamma)\left(\frac{1-\gamma \Pi_{t-1}^{\psi(1-\gamma)} \Pi_t^{\gamma-1}}{1-\gamma}\right)^{-\frac{\varepsilon}{1-\gamma}}$
Mark-up	$X_t = 1/P_{m,t}$
CPI Inflation	$\Pi_t^{1-\varepsilon} = (1-\gamma)(\Pi_t^{\star})^{1-\varepsilon} + \gamma \left(\Pi_{t-1}^{\psi}\right)^{1-\varepsilon}$
Inflation I	$f_{1,t} = Y_t P_{m,t} + \mathbb{E}_t \Lambda_{t,t+1} \gamma \left(\Pi_t^{-\psi\varepsilon} / \Pi_{t+1}^{-\varepsilon}\right) f_{1,t+1}$
Inflation II	$f_{2,t} = Y_t + \mathbb{E}_t \Lambda_{t,t+1} \gamma \left(\Pi_t^{\psi(1-\varepsilon)} / \Pi_{t+1}^{1-\varepsilon}\right) f_{2,t+1}$
Inflation III	$\Pi_t^{\star} = \frac{\varepsilon}{\varepsilon-1} \frac{f_{1,t}}{f_{2,t}} \Pi_t$
Fisher-equation	$R_t^n = R_t \mathbb{E}_t \Pi_{t+1}$
Monetary Policy Rule	$R_t^n = \left[R_{t-1}^n\right]^{\rho_m} \left[\frac{1}{\beta} (\Pi_t)^{\phi^{\Pi}} \left(\frac{\varepsilon-1}{\varepsilon} X_t\right)^{\phi^X}\right]^{1-\rho_m} \varepsilon_t^m$
ABS-Issuers	
Balance Sheet Identity	$Q_t S_t^b = N_t^b + M_t^b$
Net Worth Accumulation	$N_t^b = (\sigma + \xi_b) R_t^K Q_{t-1} S_{t-1}^b - \sigma R_t^M M_{t-1}^b$
FOC I (Lagrange Multiplier)	$\left(\theta^b - \mu_t^b\right) \lambda_t^b = \mu_t^b$
FOC II (Optimal Leverage)	$\left(\theta^b - \mu_t^b\right) Q_t S_t^b = v_t^b N_t^b$
Discount Factor	$\Omega_t^b = 1 - \sigma + \sigma(1 + \lambda_t^b) v_t^b$
Value Function Coefficient I	$v_t^b = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{t+1}^b R_{t+1}^M$
Value Function Coefficient II	$\mu_t^b = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{t+1}^b \left(R_{t+1}^K - R_{t+1}^M\right)$
Return on ABS	$R_{t+1}^M = \mathbb{E}_t \left[P_{m,t} \alpha \frac{Y_{m,t+1}}{K_t} + q_{t+1}^m\right] / q_t^m$

Table 3: DSGE Model Equations (continues)

Description	Equation
Commercial Banks	
Balance Sheet Identity	$Q_t S_t^c + M_t^c = D_t + N_t^c$
Net Worth Accumulation	$N_t^c = (\sigma + \xi_c)\left(R_t^K Q_{t-1} S_{t-1}^c + R_t^M M_{t-1}^c\right) - \sigma R_t D_{t-1}$
FOC I (Lagrange Multiplier)	$(\theta^c \omega - \mu_t^c)\, \lambda_t^c = \mu_t^c$
FOC II (Optimal Leverage)	$(\theta^c \omega - \mu_t^c)\, Q_t S_t^c = \left(v_{m,t}^c - \theta^c (1-\omega)\right) N_t^c + \left(v_{m,t}^c - v_{d,t}^c - \theta^c (1-\omega)\right) D_t$
FOC III (Optimal Portfolio)	$\left(v_{m,t}^c - v_{d,t}^c\right)(1 + \lambda_t^c) = \theta^c (1-\omega)\, \lambda_t^c$
Discount Factor	$\Omega_t^c = 1 - \sigma + \sigma\left[(1+\lambda_t^c)\, v_{m,t}^c - \theta^c (1-\omega)\, \lambda_t^c\right]$
Value Function Coefficient I	$v_{m,t}^c = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{t+1}^c R_{t+1}^M$
Value Function Coefficient II	$\mu_t^c = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{t+1}^c \left(R_{t+1}^K - R_{t+1}^M\right)$
Value Function Coefficient III	$v_{d,t}^c = \mathbb{E}_t \Lambda_{t,t+1} \Omega_{t+1}^c R_{t+1}$
Market Clearing	
Goods Market	$Y_t = C_t + \frac{\eta_i}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 I_t$
Loan Market	$K_t = S_t^b + S_t^c$
ABS Market	$M_t^b = M_t^c$

Table 4: DSGE Model Parameters

Parameter	Description	Value
β	Discount rate	0.990
h	Consumption habit parameter	0.700
φ	Inverse frisch elasticity of labour supply	0.300
θ^b	Fraction of capital that can be diverted by ABS-issuers	0.140
θ^c	Fraction of capital that can be diverted by commercial banks	0.235
ξ_b	Proportional transfer to entering ABS-issuers	0.001
ξ_c	Proportional transfer to entering commercial bankers	0.001
ω	Relative divertibility of ABS	0.750
σ	Survival rate of financiers	0.900
S^c/N^c	Leverage of commercial banks	4.500
S^b/N^b	Leverage of ABS-issuers	8.500
α	Capital share	0.300
δ	Depreciation rate	0.025
η_i	Inverse elasticity of net investment to the price of capital	1.726
ε	Elasticity of substitution between final goods	4.167
γ	Calvo parameter	0.779
ψ	Price indexation parameter	0.241
ρ_m	Interest rate smoothing parameter	0.800
ϕ^{Π}	Inflation coefficient in the monetary policy rule	1.500
ϕ^X	Mark-up coefficient in the monetary policy rule	-0.125