The Role of Shadow Banking in the Monetary Transmission Mechanism

Falk Mazelis†

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Abstract

I show in a Bayesian Vector Autoregression that monetary policy tightening decreases bank lending but raises lending by non-bank financial institutions (NBFI, or shadow banks). To explain this finding, I develop a theoretical model that distinguishes between banks and NBFI based on their different abilities to raise debt and equity funding. The functional form for both intermediaries imposes no constraints ex ante, but a Bayesian estimation of key parameters results in banks having a comparative advantage at raising debt while NBFI are better at raising equity. Households, the savers in the economy, make a portfolio decision among different debt and equity instruments. Qualitatively and quantitatively comparable to my empirical observations, model shadow bank lending moves in the opposite direction to bank lending following monetary policy shocks, which mitigates aggregate credit responses. The recognition of a distinct shadow banking sector results in an amplified propagation of real shocks and a muted propagation of financial shocks.

Keywords: Shadow Banking, Monetary Policy, Portfolio Choice, Bayesian Methods, Search Frictions

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†Institute for Economic Theory II, Humboldt University Berlin and Collaborative Research Center 649: Economic Risk and Research Training Group "Interdependencies in the Regulation of Markets", currently on leave visiting Princeton University, NJ. Email: mazelisf@hu-berlin.de
1 Introduction

Loan issuance is traditionally understood as one of the core functions of the banking sector. However, the data show that the volume of financial intermediation via non-bank financial institutions (NBFI), i.e. the market based or shadow banking sector, has been rising in the last decades, even overtaking the traditional banking sector in several countries, see Financial Stability Board (2014). Reacting to this development, Woodford (2010) calls for "a framework for macroeconomic analysis in which intermediation plays a crucial role and [...] which also takes account of the fact that the U.S. financial sector is now largely market-based." Although the financial sector has been incorporated in recent models, it is still largely treated as a relatively homogeneous entity. However, empirical studies indicate that banks and shadow banks react to shocks in different ways.\(^1\) Consider monetary policy: I show that banks reduce the amount of loans on their balance sheets following monetary policy tightening, while shadow banks increase lending (Figure 1) during those episodes. This suggests that the share of credit intermediation via the shadow banking sector is an important determinant of the effectiveness of monetary policy on aggregate lending and the economy.

The merits of distinguishing among different financial intermediaries are as follows. Imagine a regulator that wants to assess the effects of the implementation of different regulatory frameworks in a model that only recognizes one type of intermediary. As long as the regulation is specific to a certain type of intermediary (e.g. deposit insurance, Basel, asset purchasing programs, access to liquidity facilities at a central bank), the model may misrepresent the reaction of aggregate credit supply and macroeconomic variables to the implementation. Likewise, consider a central bank that is ‘leaning against the wind’. If economic conditions warrant a change in the stance of monetary policy, ignoring the counter-intuitive reaction of a shadow banking sector (of considerable size) may lead to an inadequate adjustment in the policy rate. The present paper lays out a simple way to extend financial models by adding a shadow banking sector, as well as the ability to model a (bank) equity channel. Since the non-bank financial sectors have different sizes in different jurisdictions, this model extension can help to better assess the impact of monetary policy shocks on aggregate lending and the economy.

In this paper I will answer following questions: Why do shadow banks increase lending after monetary policy tightening, while banks decrease lending? How does the resulting credit intermediation of shadow banks affect the reaction of aggregate loan supply to monetary policy? In addition, if the inclusion of shadow banks changes the propagation of shocks, what has been its contribution to macroeconomic fluctuations in recent years?

The contributions of this paper are threefold: (i) I show empirically that contractionary monetary policy shocks induce an increase in lending by non-bank financial institutions, while banks decrease lending. (ii) I construct a model that incorporates an equity channel for two different types of intermediaries, allowing them to raise funding as well as allowing households to invest in a portfolio of assets. (iii) I explore the contributions of the different sectors in the run-up to the financial crisis, which suggest that ultra low monetary policy pre-2008 is not a main contributor.

To answer these questions I develop a structural model that distinguishes between banks and shadow banks based on their ability to raise funding. I use the monetary DSGE model with financial intermediaries by Gertler and Karadi (2011) (GK11 from here on) to describe intermediary behavior and extend it with a shadow banking sector. In addition to intermediaries being able to leverage, they are also able to raise equity and thereby substitute debt funding. I model equity fund raising by both intermediaries as a search in the funding market for deposits, which are held by the household

\(^1\)See e.g. Altunbas et al. (2009); Haan and Sterk (2011); Igan et al. (2013); Nelson et al. (2015).
sector. Following Wasmer and Weil (2004), I model funding market frictions analogously to those on the labor market because of their comparable characteristics of "moral hazard, heterogeneity and specificity". In contrast to Wasmer and Weil, in my model the amount of deposits changes endogenously.

In GK11, an increase in the monetary policy rate leads to an increase in the external finance premium for borrowers, prompting a decrease in the value of their collateral, thereby decreasing the willingness of banks to lend. The resulting deleveraging results in a credit squeeze for the real sector, disinvestment and a fall in output. Simultaneously, increased interest rates discourage households from current consumption and instead encourage savings, which take the form of intermediary equity or debt. Shadow banks lend out these additional funds and thereby alleviate the credit squeeze, mitigating the fall in investments and any consequent recession. Although intermediaries are modeled functionally equivalent, an estimation using Bayesian methods illuminates their different fund raising abilities: Shadow banks are better able to raise equity, which stems from the fact that they do not have to go through the lengthy process banks do (e.g. finding investors, printing marketing material, informing regulators, etc). The present model does not attempt to model these frictions explicitly, but incorporates them in a reduced form manner.

Existing macroeconomic models of shadow banking include Meeks et al. (2014); Verona et al. (2013); and Goodhart et al. (2012). The first is mainly concerned with financial stability and considers shadow banks as off balance sheet vehicles of commercial banks to unload risky loans. Verona et al. study adverse effects of excessively easy monetary policy and understand shadow banks as financial intermediaries specializing in less risky loans akin to bond issuance by investment banks. Goodhart et al. study different regulatory regimes to stop fire sales by shadow banks and take the opposite view to Verona et al., considering shadow banks to be less risk averse, but still funded by the regular banking sector, comparable to off balance sheet vehicles as in Meeks et al.

Models of endogenous equity issuance include Meh and Moran (2010) and Gertler et al. (2012). The former look at the role of bank equity in the propagation of a diverse number of shocks when banks are present. The latter allow outside equity to substitute for deposits in existing banks, but still assume an automatic creation of inside equity. In contrast, I endogenize the decision to create new banks based on the need for additional intermediaries and the value of funding operations for investors (households).

Search and matching in credit markets has been studied since Dell’Ariccia and Garibaldi (1998). den Haan et al. (2003) analyze the business cycle effects of long-term lending relationships with frictions. Wasmer and Weil (2004) study the effects of credit market frictions on labor market dynamics. What these models have in common is that the total amount of credit to be allocated is either fixed exogenously or is influenced endogenously but without any relation to credit creation by financial intermediaries. This paper explicitly focuses on this interaction.

In the next section, I empirically establish the opposing responses of bank and shadow bank lending to an increase in the monetary policy rate. In Section 3, I will describe the model with two types of intermediaries and the incorporation of equity issuance, as well as the portfolio choice by households. Section 4 contains the model analysis, including Bayesian estimation of newly introduced structural parameters and all shock parameters, impulse response functions to monetary policy shocks and a historical shock decomposition. Section 5 concludes.
2 Empirical Analysis of Intermediaries’ Responses to Monetary Policy Shocks

In the following, I study how credit intermediation by banks and NBFI react to an unanticipated tightening in monetary policy. To do so, I construct a quarterly Bayesian Vector Autoregression as in Banbura et al. (2010) with the following variables ranging from 1960Q1 to 2007Q4: Real GDP, Consumer Price Index, Index of Sensitive Materials Prices, the effective Federal Funds Rate (FFR), M2 Money Stock, and intermediated credit by banks and NBFI, respectively. The data for the first five series are from Stock and Watson (2012). Data for the latter two are from the Financial Accounts of the United States. Banks are US depository institutions and credit unions. NBFI are financial companies, funding corporations, money market mutual funds, other mutual funds, closed-end funds, real-estate investment trusts, and securities brokers and dealers. As a measure of credit I include loans, bonds, commercial paper, consumer credit and mortgages. Intermediaries typically fund substantial amounts of securities issued by the government and the various municipalities, as well as asset-backed securities (ABS) by government-sponsored entities (GSEs). I purposely exclude these items since government securities are often assumed for liquidity reasons and to counter the drop in lending to the real economy. Additionally, the following theoretical model only considers credit to the real economy.

Figure 1: Response of intermediaries to a contractionary monetary policy shock. Note: Empirical impulse responses of the effective fed funds rate, bank credit and non-bank financial institution credit to an unanticipated 100 basis point increase in the effective federal funds rate. The horizontal axis reports quarters since the shock. The vertical axis reports percentage deviations from the unshocked path. Shaded regions are 32nd-68th and 16th-84th percentiles confidence bands.
Identification of the monetary policy shock follows the recursiveness assumption of Christiano et al. (1999): output, CPI and commodity prices make up the first block and can only respond to monetary policy shocks with a lag of one period. The monetary authority observes these variables within the period. The last block consists of M2 and the credit variables, which can respond to monetary policy shocks within the period but are only observed by the monetary authority with a lag of one period. All variables except for the FFR have been transformed into logs. Intermediary credit has been deflated using the CPI. The lag order is four since the data are on a quarterly frequency.

After a 100bp increase in the monetary policy rate, banks react by gradually decreasing credit intermediation until eight quarters after the shock. After the maximum decrease in intermediation of 1%, credit intermediation reverts back to trend within several periods, but is statistically insignificant after about three years. During the quarter in which monetary policy tightens, a small increase in credit intermediation can be observed. This is usually attributed to companies drawing down on pre-established credit lines when other forms of funding become more expensive following tightening. NBFI credit intermediation reacts in the opposite direction. Three quarters after the shock, NBFI credit intermediation peaks at about 1% and then reverts back to the trend. Another increase several quarters later can be observed but is statistically insignificant from zero.

The results are robust with respect to assumptions regarding identification, lag order, NBFI inclusion and credit item selection. See Appendix A.2 for details.

3 The Model

The basic structure is the monetary DSGE model with financial intermediaries by GK11, to which I add endogenous equity formation. The traditional banking sector is mirrored by a second financial intermediary, called the non-bank financial or shadow banking sector, which also issues loans to firms. Irrespective of whether shadow banks lend to the real sector directly, or whether they buy securitized credit claims of previously originated loans, shadow banks become the effective intermediary, and banks’ balance sheets are freed up.

In this model the economy is populated by six types of agents: households, traditional banks, shadow banks, non-financial goods producers who demand loans, capital producers, and monopolistically competitive retailers. Intermediaries finance loans by issuing non-contingent debt, which takes the form of deposits at traditional banks and asset-backed commercial paper (ABCP) at shadow banks, and state-contingent equity to households. A central bank conducting monetary policy is the source of monetary disturbances and completes the model.\(^2\)

3.1 Financial Intermediaries

There are two types of financial intermediaries, traditional banks and shadow banks. Since their structure is almost identical, I will generally refer to both of them by the exponent \(j\), specifying \(j \in \{\text{Traditional Banks} = \text{TB}, \text{Shadow Banks} = \text{SB}\}\) when necessary. As in other models of the financial accelerator, intermediaries (both types) have a finite lifetime so that their lending operations will never become fully self-financed. The life cycle of a financial institution starts when a household member decides to enter as a potential intermediary looking for equity funding. If the potential intermediary finds funding, they are able to start their business and leverage their operations using

\(^2\)For the timing, see Figure 5 in Appendix A.1.
Intermediaries accumulate retained earnings until they die with a probability $\theta_j$ every period. They exit the intermediary market and pay out accumulated profits to the household that they came from.

Debt and equity financing are modeled using two different types of frictions. Debt financing via the moral hazard problem as in GK11 and Gertler and Kiyotaki (2010) guarantees that as long as the intermediary does not exceed a maximum amount of leverage per intermediary value, households are indifferent towards the absolute amount of debt that they hold with each intermediary or in total. Without explicitly modeling it, this can be understood as deposit insurance for traditional banks and secured debt for shadow banks. This indifference is reflected in the risk free interest rate that intermediaries pay.

Equity financing is risky. Since equity investors participate in the state-contingent returns of the intermediary, households are only willing to hold equity claims that have an underlying returns profile that fits into the individual household’s portfolio. Although this is not modeled explicitly, this heterogeneity on the micro level is captured via the search and matching mechanism: only a fraction of households agree to the terms of the potential intermediaries that they meet on the equity funding market. An equity dividend that is higher than the interest rate on debt signals this riskiness.

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Intermediary leverage is independent of individual characteristics as shown in GK11.
### 3.1.1 Existing Intermediaries

Existing intermediaries’ balance sheets are given by\(^4\)

\[ Q^j_t S^j_t = D^j_{t+1} + N^j_t. \]  

(1)

Intermediaries fund their loan portfolio \( S^j_t \) priced at \( Q_t \) through their net worth \( N^j_t \) and debt obtained from households \( D^j_{t+1} \). Because they pay interest on their debt of \( R^j_{t+1} \) and earn a return \( R^{kt}_{t+1} \) on their loans, an individual bank’s net worth evolves according to

\[ N^j_{t+1} = R^{kt}_{t+1} Q_t S^j_t - R^j_{t+1} D^j_{t+1} \]

\[ = (R^{kt}_{t+1} - R^j_{t+1}) Q_t S^j_t + R^j_{t+1} N^j_t. \]

Intermediaries want to maximize their expected terminal net wealth before they exit the industry with a probability \( \theta^j \) per period and pay out all the accumulated profits to the household that they came from. Expected terminal net wealth is given by

\[ V^j_t = E_t \sum_{i=0}^{\infty} (1 - \theta^j) (\theta^j)^i \beta^{i+1} \Lambda_{t,t+1+i} N^j_{t+1+i} \]

where the second line is the equivalent recursive formulation. The marginal expected discounted value of net worth is \( \eta^j_t \) and \( \nu^j_t \) is the marginal expected discounted value of expanding assets

\[ \nu^j_t = E_t[(1 - \theta^j)\beta \Lambda_{t,t+1}(R^{kt+1}_{t+1} - R^j_{t+1}) + \beta \Lambda_{t,t+1}\theta^j x^j_{t+1} \nu^j_{t+1}] \]  

(2)

\[ \eta_t = E_t[(1 - \theta^j)\beta \Lambda_{t,t+1} R^j_{t+1} + \beta \Lambda_{t,t+1} x^j_{t+1} \theta^j \eta^j_{t+1}] \]  

(3)

and the growth rate in net worth \( x^j_{t,t+1} \) and the growth rate in assets is \( x^j_{t,t+1} \) defined below.

It is profitable to increase the loan portfolio as long as the interest rate differential is positive. To motivate an endogenous constraint on intermediaries’ ability to leverage, a moral hazard problem is introduced: the intermediary can divert a fraction of the loan portfolio \( \lambda^j_t \) that the creditors are not able to recover. As a consequence, the intermediary goes bankrupt. Therefore, households will keep their debt claims\(^5\) at individual intermediaries only as long as the franchise value of the intermediary, \( V^j_t \), is higher than or equal to the divertible amount, which guarantees the intermediary’s interest in not diverting assets and declaring bankruptcy:

\[ V^j_t \geq \lambda^j_t Q_t S^j_t. \]

The divertible fraction \( \lambda^j_t \) is a time dependent AR(1) process with persistence \( \rho_{\lambda^j} \), which is included to analyze the role of trust in intermediaries and a corresponding ability to leverage. I will assume that the constraint always binds, and after substituting and rearranging, the size of an intermediary’s loan portfolio then depends on the size of their net wealth according to

\[ Q_t S^j_t = \frac{\eta^j_t}{\lambda^j_t - \nu^j_t} N^j_t \]  

(4)

\(^4\)For simplicity, I will abstract from equations of the individual agents and instead show their aggregate form directly, distinguishing between individual and aggregate forms as necessary. For more detail, GK11 show individual agents’ equations.

\(^5\)Deposits at traditional banks and ABCP at shadow banks.
and the leverage ratio can be defined as

$$\phi_t^j = \frac{\eta_t^j}{\lambda_t^j - \nu_t^j}. \quad \text{(5)}$$

The growth rate in net worth $z_{t,t+1}^j$ and the growth rate in assets $x_{t,t+1}^j$ are defined as

$$z_{t,t+1}^j = \frac{N_{t+1}^j}{N_t^j} = \frac{(R_{kt+1}^j - R_{kt}^j)Q_tS_t^j + R_{kt+1}^j N_t^j}{N_t^j} = (R_{kt+1}^j - R_{kt+1}^j)\phi_t^j + R_{kt+1}^j \quad \text{(6)}$$

$$x_{t,t+1}^j = \frac{Q_{t+1} S_{t+1}^j}{Q_t S_t^j} = \frac{\phi_{t+1}^j N_{t+1}^j}{\phi_t^j N_t^j} = \frac{\phi_{t+1}^j}{\phi_t^j} z_{t,t+1}^j. \quad \text{(7)}$$

### 3.1.2 New Intermediaries

A constant share $1 - \theta^j$ of intermediaries dies every period and distributes its retained earnings to their investors. New intermediaries enter in their place. To become a new intermediary, potential intermediaries have to receive equity funding from households. They do this by posting advertisements for their operations at a cost $\kappa^j$. Individual savers and individual potential intermediaries searching for equity funding randomly meet and evaluate the potential for a match in isolation. On the micro level, potential intermediaries differ with regard to their management style, loan applicants, investment policies, etc. Individual savers differ with regard to their preferences, their idiosyncratic risks and investment portfolios. I abstract from these differences on the macro level, where this behavior is approximated via search and matching in the market for equity funding. In aggregate, potential intermediaries will find a suitable investor with a probability $q_t^j$. The value of participation is

$$B_t^{j,S} = -\kappa^j + \beta \Lambda_{t,t+1} \left\{ q_t^j B_{t+1}^{j,M} + (1 - q_t^j) B_{t+1}^{j,S} \right\}. \quad \text{The value a potential intermediary has from establishing operations is}$$

$$B_t^{j,M} = \phi_{t-1}^j R_{kt} - (\phi_{t-1}^j - 1) R_t^j - R_t^{j,N} + \beta \Lambda_{t,t+1} \left\{ \theta^j B_{t+1}^{j,M} + (1 - \theta^j) B_{t+1}^{j,S} \right\}. \quad \text{Intermediaries stand to gain the borrowing rate times their leverage net of interest rates on deposits/ABCP and equity dividend payouts. There is generally future expected discounted value from continuing operations in the subsequent period with a probability } \theta^j. \text{ Potential intermediaries can assume leveraged operations since leverage is independent of firm-specific factors as shown in}$$

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6This is common practice in the labor literature, see e.g. Petrongolo and Pissarides (2001).
Assuming potential financiers will enter the market for equity funding until the expected value from participating in the search market $B_{j,S}$ is zero, a Euler condition for advertisements results:

$$\frac{\kappa_j}{q_j^t} = \beta \Lambda_{t+1} \left\{ \phi_j^t R_{kt+1} - (\phi_j^t - 1) R^N_{t+1} + \beta \frac{\kappa_j}{q_j^t} \right\}. \quad (8)$$

New advertisements will be posted until the marginal cost of establishing a match equals the marginal benefit of having established intermediary operations, which is the combination of the interest rate differential and avoided future search costs.

### 3.1.3 The Equity Matching Market

To compute the probability of matching a potential intermediary with a household I assume a funding market matching function $m(v_j^t, D_{TB_{t+1}}^j)$ that is increasing in its arguments, the number of advertisements $v_j^t$ and the number of deposits $D_{TB_{t+1}}^j$. Equity investments can only be made with bank deposits, which therefore enter the matching process of both traditional banks and shadow banks.\(^7\)

Assuming a constant returns to scale matching function, the probability that a potential intermediary will find suitable funding is then

$$q_j^t = m(1, (\Theta_j^t)^{-1}) = \frac{m(v_j^t, D_{TB_{t+1}}^j)}{v_j^t} = s_j^t (v_j^t)^{-\xi_j^t} (D_{TB_{t+1}}^j)^{\xi_j^t},$$

with matching elasticity $\xi_j^t$ and matching efficiency $s_j^t$.

The probability that a household will find equity in type $j$ intermediary is

$$f_j^t = m(\Theta_j^t, 1) = \frac{m(v_j^t, D_{TB_{t+1}}^j)}{D_{TB_{t+1}}^j} = s_j^t (v_j^t)^{1-\xi_j^t} (D_{TB_{t+1}}^j)^{\xi_j^t-1},$$

### 3.1.4 Equity Dividend Bargaining

Because of the existence of search frictions, intermediaries enjoy a rent on established matches. I assume that the dividend intermediaries pay on equity raised is determined via Nash bargaining over these surpluses. $\omega_j^t$ signifies the relative bargaining power of households. Dividends $R^N_{t+1}$ are negotiated that maximize a convex combination of the surpluses,

$$R^N_{t+1} = \arg \max \omega_j^t \ln V_{HH}^t + (1 - \omega_j^t) \ln V_j^t.$$ 

The resulting interest rate that traditional banks and shadow banks pay for equity raised is, respectively (see Appendix A.3 for details)

$$R^N_{t+1} = (1 - \omega^T) R^T_{t+1} + \omega^T \left\{ R^T_{t+1} + \phi^T_{t+1} (R^T_{kt+1} - R^T_{t+1}) + \kappa^T \frac{f_{TB_{t+1}}^T}{q_{TB_{t+1}}} \right\}$$

$$R^N_{t+1} = (1 - \omega^S) R^S_{t+1} + \omega^S \left\{ R^S_{t+1} + \phi^S_{t+1} (R^S_{kt+1} - R^S_{t+1}) + \kappa^S \frac{f_{SB_{t+1}}^S}{q_{SB_{t+1}}} \right\}$$

\(^7\)See Pozsar (2014) who writes that “banks and demand deposits are special [...] because of their unique role in forming the backbone of the payments system and facilitating the payments of all entities lower in the system-hierarchy.”
If household bargaining power is low, intermediaries can get away with paying only the interest rate \( r_{f,t} \) that banks pay on their deposits. With increasing bargaining power, intermediaries need to share expected profits with investing households.

### 3.2 Households

A continuum of households of measure one exists that consume, save in a portfolio of assets and supply labor. They maximize discounted lifetime utility

\[
\max_{C_t,L_t,D_{t+1}^j,N_{t+1}^j} E^\infty \sum_{i=0}^\infty \beta^i \left[ C_{t+1} - hC_{t+1} \right] - \frac{\chi}{1+\varphi} L_{t+1}^{1+\varphi}
\]

subject to the sequence of period budget constraints

\[
C_t + D_{t+1}^{TB,e} + N_{t+1}^{TB} + D_{t+1}^{SB} + N_{t+1}^{SB} = W_t L_t + \Pi_t + R_{t}^{f,SB} D_{t+1}^{f,SB} + R_{t}^{f,TB} N_{t+1}^{TB} + R_{t}^{f,SB} D_{t+1}^{SB} + R_{t}^{N,SB} N_{t+1}^{SB}.
\]

Each unit of labor \( L_t \) earns the real wage \( W_t \). \( \Pi_t \) are profits from ownership of capital producers, retailers and financial intermediaries, both traditional banks and shadow banks. \( \beta \) is the discount factor, \( h \) is the habit parameter, \( \chi \) is the relative utility weight of labor and \( \varphi \) is the inverse Frisch elasticity of labor supply. The asset portfolio consists of debt and equity in traditional banks and shadow banks. On the micro level, when a household wants to invest into equity, it enters the equity matching market and randomly meets a potential intermediary. If the equity investment is a good fit regarding individual portfolio characteristics, they will invest and form a match. On the macro level, this behavior is approximated by a search and matching mechanism: we only observe a fraction \( f_t^{j} \) searching households to establish a match. The amount of effective deposits that remain in the portfolio after investment into both forms of equity are then \( D_{t+1}^{TB,e} = D_{t+1}^{TB}(1 - f_t^{TB} - f_t^{SB}) \).

Since only a fraction of intermediaries ceases operations every period, a law of motion for equity by traditional banks and shadow banks emerges each

\[
N_{t+1}^{j} = \theta^j N_{t+1}^{j} z_{t+1} \zeta_{j} + f_t^{D_{t+1}^{TB}}.
\]

With \( q_t \) denoting marginal utility of consumption and \( \mu_t^{j} \) denoting the additional value of being invested in type \( j \) equity, the first order conditions are given by

- Consumption \( C_t \) : \( q_t = \frac{1}{C_t - hC_{t-1}} - \frac{\beta h}{C_{t+1} - hC_t} \)
- Labor \( L_t \) : \( \chi L_t^q = q_t W_t \)
- Deposits \( D_{t+1}^{TB} \) : \( q_t = (1 - f_t^{TB} - f_t^{SB}) E_t \beta R_{t+1}^{TB} q_{t+1} + f_t^{TB} (\mu_t^{TB} + q_t) + f_t^{SB} (\mu_t^{SB} + q_t) \)
- Equity \( N_{t+1}^{j} \) : \( \mu_t^{j} + q_t = E_t \beta \left\{ \theta^j R_{t+1}^{j,N} \mu_t^{j} + \mu_t^{j+1} \theta^{j+1} z_{t+1} \right\} \)
- ABCP \( D_{t+1}^{SB} \) : \( E_t \beta R_{t+1}^{SB} \frac{q_{t+1}}{q_t} = 1 \)

with the marginal rate of substitution between consumption today and tomorrow given by

\[
\Lambda_{t+1}^{j} = \frac{q_{t+1}}{q_t}.
\]

The first order conditions for consumption and labor are standard.
Equation (14) reduces to the commonly known Euler condition in the case that equity investments do not exist or have no additional value\(^8\), i.e. the household will increase savings until the marginal utility of consumption today equals the discounted expected marginal utility of consumption tomorrow. However, since the household’s investment in equity is constrained, i.e. \(f^j_t < 1\), being invested in equity is valuable, i.e. \(\mu^j_t > 0\). The household will therefore increase savings until the marginal utility of consumption today equals the probability of consuming tomorrow \((1-f^B_t - f^{SB}_t)\) times its value (the discounted expected marginal utility of consumption tomorrow) plus the probability of investing in one type of equity \(f^j_t\) times that value. The value of investing in equity type \(j\) is given by Equation (15), which shows that the marginal utility of investing in equity \(\mu^j_t + \gamma_t\) is tomorrow’s discounted dividend weighted by marginal utility of consumption, as well as the future value of staying matched. Since ABCP cannot be used for the purchase of equities, their holdings do not carry the potential for being invested in equity.\(^9\)

### 3.3 Goods Producers

Perfectly competitive goods producers manufacture intermediate goods and sell them to the retailer at the relative intermediate output price \(P_{mt}\). Goods producers need to finance their capital expenditures via loans from intermediaries, which they may borrow without frictions, i.e. intermediaries can enforce all of their claims. However, since banks are constrained in the amount of deposits they can issue and shadow banks are constrained in the amount of funds they can raise, lending by intermediaries is capital constrained, which affects the supply of funds to firms and therefore the required interest rate for borrowing, \(R_{kt+1}\). Except for the addition of another source of funding, capital producers are identical to those in GK11.

The firm maximizes its profits by choosing capital \(K_{t+1}\) and labor \(L_t\) optimally each period.

\[
\max_{K_{t+1}, L_t} E_t \sum_{i=0}^{\infty} \beta^i \Lambda_{t+i+1} \left[ P_{mt} Y_t + (Q_t - \delta) \xi_t K_t - W_t L_t - R_{kt+1} Q_{t+1} \right] 
\]

with production output given by

\[
Y_t = A_t (\xi_t K_t)^{\alpha} L_t^{1-\alpha} \quad (18)
\]

where \(\alpha\) is the capital share, \(Q_t\) is the real price of capital, \(\delta\) is the depreciation rate and \(W_t\) are wages.

The first-order conditions are

\[
R_{kt+1} Q_t = P_{mt+1} \alpha Y_{t+1} K_{t+1}^{-1} + (Q_{t+1} - \delta) \quad (19)
\]

\[
P_{mt}(1 - \alpha) \frac{Y_t}{L_t} = W_t. \quad (20)
\]

Firms do not earn any profits and pay out ex post returns to capital as interest payments, resulting in no profits state by state. They pay out all their profits to their creditors, who are a combination of banks and shadow banks according to

\[
K_{t+1} = S_t + S^{SB}_t. \quad (21)
\]

\(^8\)If \(\mu^B_t = \mu^{SB}_t = 0\), Equation (14) holds for all \(f^j_t\).

\(^9\)Interest rates on bank deposits have been below those on ABCP pre-2008, which the model explains by the additional utility from being able to use deposits for transactions.
3.4 Capital Producers

Following GK11, capital producers buy leftover capital from goods producers which they refurbish, for which the price is unity. Units of new capital are made using input of final output and are then sold to goods producers at $Q_t$, which capital producers set by solving

$$\max_{I_{nt}} E_t \sum_{\tau=t}^{\infty} \beta^{\tau-t} \lambda_{t,\tau} \left\{ (Q_{\tau} - 1)I_{n\tau} - f \left( \frac{I_{n\tau} + I_{SS}}{I_{n\tau-1} + I_{SS}} \right) (I_{n\tau} + I_{SS}) \right\}$$

with

$$I_{nt} = I_{tt} - \delta \xi_t. \quad (22)$$

Following the literature on the importance of marginal efficiency of investment (Justiniano et al., 2010), investment specific shocks $\iota_t$ affect the transformation of gross investment into net investment. The functional form of $f(.)$ obeys $f(1) = f'(1) = 0$ and $f''(1) > 0$. $f(.)$ determines capital adjustment costs with the steady state value for investments given by $I_{SS}$. The capital producer thus creates profits outside of the steady state. Households receive profits from sales of new capital at price $Q_t$, which is given by the first-order condition

$$Q_t = 1 + f(.) + \frac{I_{nt} + I_{SS}}{I_{nt-1} + I_{SS}} f'(.) - E_t \beta \Lambda_{t,t+1} \left( \frac{I_{nt+1} + I_{SS}}{I_{nt} + I_{SS}} \right)^2 f'(.) \quad (23)$$

3.5 Retailers

Retailers buy intermediate goods from goods producers at the relative intermediate output price $P_{mt}$. Final output is the CES composite of a continuum of output by each retailer $f$ with the elasticity of substitution $\epsilon$, given by

$$Y_t = \left[ \int_0^1 Y_{ft}^{\frac{1}{\epsilon-1}} df \right]^{\epsilon-1}.$$

Because users of final output minimize costs, we get

$$Y_{ft} = \left( \frac{P_{jt}}{P_t} \right)^{-\epsilon} Y_t$$

$$P_t = \left[ \int_0^1 P_{ft}^{1-\epsilon} df \right]^\frac{1}{1-\epsilon}.$$

Each retailer can reset prices with probability $1 - \gamma$ each period. Retailers will otherwise index their prices to lagged inflation. The retailers then choose their reset price $P_{t}^*$ optimally to solve

$$\max_{P_{t}^*} E_t \sum_{i=0}^{\infty} \gamma^i \beta^i \Lambda_{t,t+1} \left[ \frac{P_{t}^*}{P_{t+i}} \prod_{k=1}^{i} (1 + \pi_{t+k-1})^{\gamma_{p}} - P_{mt+i} \right] Y_{ft+i}.$$

The first-order condition is given by

$$E_t \sum_{i=0}^{\infty} \gamma^i \beta^i \Lambda_{t,t+1} \left[ \frac{P_{t}^*}{P_{t+i}} \prod_{k=1}^{i} (1 + \pi_{t+k-1})^{\gamma_{p}} - \frac{\epsilon}{\epsilon-1} P_{mt+i} \right] Y_{ft+i} = 0. \quad (24)$$

The evolution of the price level is given by

$$P_t = [(1 - \gamma)(P_{t}^*)^{1-\epsilon} + \gamma(\prod_{k=1}^{\infty} P_{t-k}^{1-\epsilon})^{1/(1-\epsilon)}]. \quad (25)$$
3.6 Resources and Policy

The aggregate resource constraint is given by

\[ Y_t = C_t + \kappa^{TB} v_t^{TB} + \kappa^{SB} v_t^{SB} + I_t + f \left( \frac{I_{nt} + I_{SS}}{I_{nt-1} + I_{SS}} \right) (I_{nt} + I_{SS}). \]  

Capital evolves according to

\[ K_{t+1} = \xi_t K_t + I_{nt}. \]  

Monetary policy is characterized by a Taylor rule. The nominal interest rate is given by \( i_t \), with a steady state interest rate of \( i_{SS} \), the natural rate of output given by \( Y_t^* \), an interest rate smoothing parameter \( \rho \), the inflation coefficient \( \kappa_\pi \) and the output gap coefficient \( \kappa_y \):

\[ i_t = \rho i_{t-1} \left[ i_{SS} (\pi_t)^{\kappa_\pi} \left( \frac{Y_t}{Y_{SS}} \right)^{\kappa_y} \right]^{1-\rho} \epsilon_t \]  

The exogenous shock to monetary policy enters the nominal interest rate as \( \epsilon_t \). The nominal interest rate has an effect on the economy through the Fisher relation

\[ 1 + i_t = R_{t+1} E_t (1 + \pi_{t+1}). \]  

To close the model, I assume that the deposit rate paid by traditional banks on household deposits is equal to the real risk-free interest rate

\[ R_{t+1}^{TB} = R_{t+1}. \]  

4 Model Analysis

In this section, I will first pin down the model parameterization using calibration and Bayesian estimation. Next, I analyze how monetary policy shocks propagate through the economy, both with and without shadow banks. I then conduct a historical shock decomposition. The differing reactions of both channels are explained and their practical relevance is examined. The model is solved via first order perturbation around the deterministic steady state using Dynare (Adjemian et al., 2011).

4.1 Parameterization

Most of the structural parameters are fixed and taken from GK11. The new parameters that follow the introduction of equity funding markets are the household bargaining power \( \omega^j \), search costs \( \kappa^j \), matching efficiency \( s^j \) and matching elasticity \( \xi^j \). Table 1 shows the fixed structural parameter values and their source. Household bargaining power targets the spread between dividends and the risk free rate pre-crisis. The search costs are set so that the rate at which intermediaries find equity funding is between zero and one. A robustness check shows that neither the steady state nor the dynamics of the model change much in the chosen values.
<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
<th>Description</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>β</td>
<td>0.99</td>
<td>Discount rate</td>
<td>GK (2011)</td>
</tr>
<tr>
<td>h</td>
<td>0.815</td>
<td>Habit</td>
<td>off</td>
</tr>
<tr>
<td>χ</td>
<td>3.409</td>
<td>Relative utility weight of labor</td>
<td>GK (2011)</td>
</tr>
<tr>
<td>ϕ</td>
<td>0.276</td>
<td>Inverse Frisch elasticity of labor supply</td>
<td>GK (2011)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>λᵢ</td>
<td>0.381</td>
<td>Fraction of bank assets that can be diverted</td>
<td>GK (2011)</td>
</tr>
<tr>
<td>θᵢ</td>
<td>0.972</td>
<td>Survival rate</td>
<td>GK (2011)</td>
</tr>
<tr>
<td>κᵢ</td>
<td>0.01</td>
<td>Search cost</td>
<td></td>
</tr>
<tr>
<td>ωᵢ</td>
<td>0.33</td>
<td>HH bargaining power re banks</td>
<td>pre-crisis spread</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>α</td>
<td>0.33</td>
<td>Effective capital share</td>
<td>GK (2011)</td>
</tr>
<tr>
<td>δ</td>
<td>0.025</td>
<td>Depreciation rate</td>
<td>GK (2011)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ε</td>
<td>4.167</td>
<td>Elasticity of substitution</td>
<td>GK (2011)</td>
</tr>
<tr>
<td>γ</td>
<td>0.779</td>
<td>Probability of keeping prices fixed</td>
<td>GK (2011)</td>
</tr>
<tr>
<td>γₚ</td>
<td>0.241</td>
<td>Price indexation</td>
<td>GK (2011)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>κₚ</td>
<td>1.5</td>
<td>Inflation coefficient of Taylor rule</td>
<td>GK (2011)</td>
</tr>
<tr>
<td>κᵧ</td>
<td>0.125</td>
<td>Output gap coefficient of Taylor rule</td>
<td>GK (2011)</td>
</tr>
<tr>
<td>ρᵰ</td>
<td>0.8</td>
<td>Smoothing parameter of the Taylor rule</td>
<td>GK (2011)</td>
</tr>
</tbody>
</table>

Table 1: Calibrated parameter values

The matching elasticities $\xi^j$, all parameters describing the shock processes, as well as the Taylor coefficients for output and inflation are estimated using Bayesian methods. Banks and NBFI are defined as in the empirical analysis in Section 2. The macroeconomic time series underlying the data for observables are: real GDP, Consumption, Investment (from the Bureau of Economic Analysis); Data on banks and shadow banks are taken from the Flows of Funds. For both sectors, we include time series on financial assets as well as the amount of fixed income liabilities convertible to currency on demand (Appendix 4). Since the model is expressed in log-deviations from steady state for estimation purposes, I take the log difference from the HP filtered trend (smoothing parameter is set to 1600). The data have a quarterly frequency and range from 1985:Q1 to 2008:Q4. Although earlier data are available, the shadow banking sector was a much smaller component of aggregate credit before 1985. I drop data after 2008 because the financial crisis and its aftermath had significant effects on the regulation and perception of the shadow banking sector. This is likely to have caused structural breaks and would change the parameters underlying the financial sector.

The priors for matching elasticities $\xi^j$ are relatively uninformative Beta distributions centered around 0.5 and allowing for values in the open interval between 0 and 1. Following Christiano et al. (2010), the priors for all persistence parameters are Beta distributions with a mean of 0.5 and a standard deviation of 0.2. The priors for the white noise processes on the innovations are Inverse Gamma distributions with means taken from GK11 and standard deviations of 0.05. The shock processes are a priori independent. I run 10 Monte Carlo Markov Chains with 20,000 draws each over the full sample period. Convergence is reached after about 10,000 draws (see Figure 15 in Appendix A.5) and I therefore drop the first 50% of estimated values. Table 2 shows the results.
Table 2: Priors and posteriors of estimated parameters

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Name</th>
<th>Prior Type</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Mean</th>
<th>Std. Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural</td>
<td>$\xi^{TB}$</td>
<td>Matching elasticity</td>
<td>Beta</td>
<td>0.5</td>
<td>0.2</td>
<td>0.62</td>
</tr>
<tr>
<td></td>
<td>$\xi^{SB}$</td>
<td>Matching elasticity</td>
<td>Beta</td>
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<td>0.2</td>
<td>0.40</td>
</tr>
<tr>
<td>Persistences</td>
<td>$\rho_A$</td>
<td>TFP</td>
<td>Beta</td>
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<td>0.2</td>
<td>0.87</td>
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<td>$\rho_i$</td>
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<td>0.2</td>
<td>0.48</td>
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<td></td>
<td>$\rho_\xi$</td>
<td>Capital Quality</td>
<td>Beta</td>
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<td>0.2</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>$\rho_{IS}$</td>
<td>Investment Efficiency</td>
<td>Beta</td>
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<td>0.2</td>
<td>0.71</td>
</tr>
<tr>
<td></td>
<td>$\rho_{N_{TB}}$</td>
<td>Bank Net Wealth</td>
<td>Beta</td>
<td>0.5</td>
<td>0.2</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>$\rho_{N_{SB}}$</td>
<td>Bank Net Wealth</td>
<td>Beta</td>
<td>0.5</td>
<td>0.2</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>$\rho_{TB}$</td>
<td>Traditional Bank divertible share</td>
<td>Beta</td>
<td>0.5</td>
<td>0.2</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>$\rho_{SB}$</td>
<td>Shadow Bank divertible share</td>
<td>Beta</td>
<td>0.5</td>
<td>0.2</td>
<td>0.86</td>
</tr>
<tr>
<td>Std dev.</td>
<td>$\epsilon_A$</td>
<td>TFP</td>
<td>Inverse Gamma</td>
<td>0.010</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>$\epsilon_i$</td>
<td>Monetary Policy</td>
<td>Inverse Gamma</td>
<td>0.010</td>
<td>0.05</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>$\epsilon_\xi$</td>
<td>Capital Quality</td>
<td>Inverse Gamma</td>
<td>0.010</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>$\epsilon_{IS}$</td>
<td>Investment Efficiency</td>
<td>Inverse Gamma</td>
<td>0.010</td>
<td>0.05</td>
<td>0.017</td>
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<td></td>
<td>$\epsilon_{N_{TB}}$</td>
<td>Traditional Bank Net Wealth</td>
<td>Inverse Gamma</td>
<td>0.010</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>$\epsilon_{N_{SB}}$</td>
<td>Shadow Bank Net Wealth</td>
<td>Inverse Gamma</td>
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<td>0.05</td>
<td>0.07</td>
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<tr>
<td></td>
<td>$\epsilon_{TB}$</td>
<td>Bank divertible share</td>
<td>Inverse Gamma</td>
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<td>0.05</td>
<td>0.04</td>
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<tr>
<td></td>
<td>$\epsilon_{SB}$</td>
<td>Shadow Bank divertible share</td>
<td>Inverse Gamma</td>
<td>0.010</td>
<td>0.05</td>
<td>0.07</td>
</tr>
</tbody>
</table>

The posteriors of the shock processes are informative (see Appendix A.5). Persistence is relatively high for all shock processes with the exception of capital quality and bank net wealth shocks. Traditional bank matching elasticity $\xi^{TB}$ is slightly higher than 0.5, while shadow bank matching elasticity $\xi^{SB}$ is slightly lower than 0.5. This means that advertisements for equity investments are a relatively higher input factor in shadow banks than in traditional banks, or alternatively that shadow banks are better able to influence the amount of equity issuance. This can be explained by the different ways in which banks and shadow banks raise equity funding. A bank has to raise equity in a relatively lengthy process, which includes finding investors, marketing the equity issuance, printing prospectuses, etc. Shadow banks don’t necessarily have this issue. Consider a money market mutual fund that is approached by a potential investor. A money market mutual fund would take the investment and wait until it finds a good opportunity to invest. It does not have to go through the whole process that banks (and for that matter any other public company) have to adhere to. This makes raising equity much easier for shadow banks, which is expressed in the different matching elasticities.

4.2 Response to a monetary policy shock

Figure 3 shows impulse response functions for key variables after unexpected monetary policy tightening for the case with i) only traditional banks, and ii) traditional banks and shadow banks.

First, consider the case with no shadow banks present in the economy (red, dashed line). After an unexpected monetary tightening of about 30 basis points in the first period, interest rates on bank deposits increase to encourage depositors to keep their savings with banks instead of shifting them into other assets. Because households shift their earnings into savings, consumption drops. The reduction in consumption demand translates into lower output and a reduction in the demand
for physical capital by firms, which also lowers the price for physical capital. Lower output and capital prices initially diminish the return on capital for the firm, see Equation (19). Since firms pass this return on as the borrowing cost to the intermediary, existing bank profits are hit. In the second period, the borrowing rate increases, because the price for physical capital slowly rises from its initial low. Since the monetary policy rate does not increase by as much, the EFP rises.

Consider the gains from expanding assets for a bank, Equation (2). The interest rate differential in the first term is the EFP. Since this differential rises, banks would like to raise assets. Similarly, the right hand side of the FOC for bank equity advertisement, Equation (8), includes the EFP. Since it rises, banks want to increase the amount of equity. Simultaneously, households stand to gain from the increase in equity dividends. New bank equity rises and the economy reverts slowly back to trend.

Figure 3: Model IRFs to monetary policy tightening. Note: The red, dashed line reports the IRFs from the model without NBFI, which is the basic GK model + endogenous search for equity. The blue, solid line reports IRFs from the full model including NBFI. The horizontal axis reports quarters since the shock. The vertical axis reports percentage deviations from the steady state (except for EFP, which is reported in percentage points).

With shadow banks present (blue, solid line) the initial reaction is the same. Risk free rates and borrowing rates rise and with them dividends of intermediary equity as lending for the remaining intermediaries becomes more profitable. This increases the amount of new equity issuance, especially by shadow banks as their issuance is relatively more dependent on advertisements than that of traditional banks, i.e. $\xi^{SB} > \xi^{TB}$ (see Equation (10)). Households will therefore invest more into new shadow bank equity rather than bank equity. This increases in equity insulates shadow banks’ source of funding and their ability to lend. Since many previously creditworthy borrowers
were pushed out of the market, shadow bank loans now replace some of the lost credit. This has a
dampening effect on the fall in investment, which reduces peak capital decumulation by about 33% compared to no shadow banks present. The effect is a less pronounced recession.

The behavior of shadow bank lending following a monetary policy tightening is qualitatively consistent with my empirical studies and those of other authors (see Figure 1 and Altunbas et al. (2009); Haan and Sterk (2011); Igan et al. (2013)). Igan et al show that some shadow banks increase lending after monetary policy tightening, while banks reduce lending. Den Haan and Sterk show that both mortgages and consumption credit increase following an increase in the monetary policy rate. Finally, Altunbas et al show that European banks with more securitization activities reduce their lending by less than non-securitizing banks after monetary tightening. European universal banks house both traditional banking and shadow banking activities within the same group structure. This finding is in line with understanding securitizing banks to be less affected by monetary shocks because their shadow banking operations are larger, which insulates aggregate group lending behavior by increasing shadow bank lending following monetary policy tightening.

4.3 The Role of Shadow Banks in the Business Cycle

Comparing variance decompositions of the economy with and without shadow banks shows that certain shocks are amplified while others are reduced, see Table 3. The contribution of technology shocks, both neutral and investment-specific, increases because shadow banks behave comparably to banks when real sector variables are affected. Shocks emanating from the banking sector are less pronounced, because the shadow banking sector offsets those developments, and vice versa. Monetary policy shocks are an in-between case, since they affect the real as well as the financial sectors simultaneously.

<table>
<thead>
<tr>
<th>Series \ shock</th>
<th>TFP</th>
<th>Mon Pol</th>
<th>Inv</th>
<th>Cap Quality</th>
<th>Bank NW</th>
<th>SB NW</th>
<th>Bank leverage</th>
<th>SB leverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>18% / 37%</td>
<td>2% / 2%</td>
<td>2% / 9%</td>
<td>13% / 14%</td>
<td>65% / 5%</td>
<td>- / 33%</td>
<td>1% / 0%</td>
<td>- / 0%</td>
</tr>
<tr>
<td>Hours</td>
<td>2% / 3%</td>
<td>5% / 6%</td>
<td>5% / 17%</td>
<td>8% / 12%</td>
<td>78% / 5%</td>
<td>- / 57%</td>
<td>3% / 0%</td>
<td>- / 1%</td>
</tr>
<tr>
<td>Investment</td>
<td>4% / 8%</td>
<td>2% / 1%</td>
<td>2% / 13%</td>
<td>5% / 7%</td>
<td>85% / 6%</td>
<td>- / 64%</td>
<td>2% / 0%</td>
<td>- / 1%</td>
</tr>
<tr>
<td>Consumption</td>
<td>17% / 29%</td>
<td>1% / 2%</td>
<td>1% / 4%</td>
<td>27% / 40%</td>
<td>53% / 5%</td>
<td>- / 19%</td>
<td>6% / 0%</td>
<td>- / 0%</td>
</tr>
<tr>
<td>Inflation</td>
<td>2% / 1%</td>
<td>10% / 7%</td>
<td>2% / 2%</td>
<td>8% / 3%</td>
<td>76% / 39%</td>
<td>- / 46%</td>
<td>2% / 0%</td>
<td>- / 1%</td>
</tr>
</tbody>
</table>

Table 3: Variance Decomposition without/with Shadow Banks

Given the changed nature of shock propagation, it follows that macroeconomic fluctuations may be attributed to different developments. To shed light on past business cycles, I perform a historical shock decomposition of the dynamics of key variables. Parameters are fixed at the posterior mean and the Kalman smoother is used to identify shock timelines that best explain the data. Figure 4 shows the log deviation of GDP, bank loans and shadow bank loans from the HP-filtered trend (data are Q1 1990 to Q4 2008).

Focusing on the lead up to the financial crisis, the model interprets the contribution of shadow banks from a rise in their leverage, as their equity has been decreasing and confidence had increased. This reverses in 2008 when shadow banks’ ability to leverage is negatively shocked.

In contrast to some voices (e.g. Taylor (2007)), the model does not interpret monetary policy to have been artificially low and thereby contributing to the housing boom. Monetary policy influences GDP growth positively in the second and third quarter of 2008, which were the time when the Federal Reserve Bank of the U.S. cut the monetary policy rate repeatedly. Monetary
policy hit the zero lower bound at the end of 2008 and the absence of aggressive further easing may – in the presence of conditions that elicit the Taylor rule to decrease rates further – be interpreted by the model as tightening.

Surprisingly, shadow bank equity receives positive shocks in the last three quarters of 2008. This may be attributed to the fact that equity in the model is measured by the difference in assets and liabilities. If shadow bank liabilities fell more quickly than their asset values, equity seems to have increased.

5 Conclusions

In this paper I have empirically studied the different lending reactions of banks and non-bank financial institutions to monetary policy shocks. In order to explain the opposing reaction to monetary policy shocks, I have introduced non-bank financial intermediaries into a monetary financial DSGE model via the relatively parsimonious search and matching framework. Since shadow banks can find equity funding more easily than traditional banks, they are better able to stem the outflow of funds from monetary policy shocks via new equity issuance. The shadow bank equity channel therefore insulates against some of the negative consequences of the other transmission channels.

In addition, I have introduced a portfolio choice over different assets into the household maximization problem. The portfolio choice results in a rebalancing of household portfolios following
shocks. Monetary policy shocks raise the attractiveness of shadow bank equity and traditional bank equity simultaneously. However, shadow banks can more quickly establish a match between equity seekers and household investors. This represents the real world feature of shadow banks not having to go through a lengthy equity raising process but instead issuing fund shares whenever investor demand arises. This allows shadow banks to substitute debt for equity after contractionary monetary policy shocks more readily than traditional banks are able to do.

Estimating the abilities of traditional banks and shadow banks to raise debt and equity results in impulse response functions suggested by empirical studies of the sector. Following monetary policy tightening, banks will decrease the amount of loans, while shadow banks will increase lending (Figure 1). As a consequence, shadow banks can reduce the real effects of monetary policy shocks. At the same time, they amplify the reaction of key variables to real and financial shocks.

A historical shock decomposition shows that leveraging of the shadow banking sector was an important contributing factor to the run up to the financial crisis. Expansionary monetary policy does not seem to have played a major role, mainly because credit developments by banks and shadow banks are affected in opposite directions. Deleveraging of shadow banks was a key contributor to the sharp drop in GDP in 2008.

The modification of impulse response functions in the face of different financial intermediaries suggests an impact on the welfare effects of business cycles in the tradition of Lucas (2003). A further reduction of volatility emanating from monetary policy shocks may be achieved with a change in key shadow bank parameter values. The recognition of additional effects shadow banks introduce may impact results on both the optimal size of the financial sector as a whole, and the relative shares of its components.

Another important question is whether central bank policy reacts optimally to real and financial shocks if it does not take the presence of shadow banks into account. Monetary policy as modeled by a Taylor rule may not anticipate dampened responses following the presence of shadow banks, and may therefore not react optimally. The recognition of shadow bank lending or a modified Taylor rule that includes data on money and credit as in Christiano et al. (2007) may generate further insights in another exploration.

In the model, shadow banks fund themselves through fund shares that are sold to households only. In reality, shadow banks are often debtors to banks. Additionally, before the 2008 financial crisis mostly US shadow banks contributed to the funding of mostly EU banks. These situations could be explored in both a national and international setting to understand the funding shocks more thoroughly. These analyses will also allow us to experiment with the appropriate re-regulation of the shadow banking sector.

The model generates several hypotheses that should be tested empirically in order to determine the strength of the model. The household portfolio choice among different savings and investment types is an important mechanism driving the model. Likewise, the reaction of different interest rates and dividends to the various shocks should be established empirically.
A Appendix

A.1 Figures

Figure 5: Timing of events

A.2 Robustness of VAR

TO BE UPDATED
A.3 Interest Rate Bargaining

Surplus for a potential banker

\[ R_{t+1}^N = \arg \max \omega \ln H_t + (1 - \omega) \ln E_t. \]

For a household the value of buying an equity stake in a bank \( V_{t}^{HH,e} \) versus savings at banks \( V_{t}^{HH,u} \) is

\[
\begin{align*}
V_{t}^{HH,e} &= R_{t}^N + \beta \Lambda_{t,t+1}[(1 - \chi)V_{t+1}^{HH,e} + \chi V_{t+1}^{HH,u}] \\
V_{t}^{HH,u} &= R_{t} + \beta \Lambda_{t,t+1}[f_{t}V_{t+1}^{HH,e} + (1 - f_{t})V_{t+1}^{HH,u}],
\end{align*}
\]

which can be combined to

\[
V_{t}^{HH} = R_{t}^N - R_{t} + \beta \Lambda_{t,t+1}(1 - \chi - f_{t})V_{t+1}^{HH}.
\]

From the first-order condition for dividend bargaining I know that

\[
\frac{\omega^{HH}}{V_{t}^{HH}} = \frac{(1 - \omega^{HH})}{B_{t}^{M}}.
\]

Solving this forward one period and inserting above, as well as inserting \( B_{t+1}^{M} \), I get for the dividend banks have to pay on their equity shares

\[
R_{t+1}^N = R_{t+1} + \omega^{HH} \left\{ \phi_{t}(R_{kt+1} - R_{t+1}) + \kappa \frac{f_{t+1}}{q_{t+1}} \right\}.
\]
### A.4 Data Sources

<table>
<thead>
<tr>
<th>Variables</th>
<th>Type</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate Output $Y_t$</td>
<td>Gross domestic product, USD, s.a.</td>
<td>BEA</td>
</tr>
<tr>
<td>Consumption $C_t$</td>
<td>Non-durable goods and services, USD, s.a.</td>
<td>BEA</td>
</tr>
<tr>
<td>Investment $I_t$</td>
<td>Gross private domestic fixed investment, USD, s.a.</td>
<td>BEA</td>
</tr>
<tr>
<td>Bank Loans $S_t$</td>
<td>Financial assets of U.S.-chartered depository institutions and credit unions, USD, not s.a.</td>
<td>U.S. FoF</td>
</tr>
<tr>
<td>Shadow Bank Loans $S^{SB}_t$</td>
<td>Financial assets of Money Market Mutual Funds,Funding corporations, finance companies, issuers of ABS, USD, not s.a.</td>
<td>U.S. FoF</td>
</tr>
<tr>
<td>Bank deposits $D_t$</td>
<td>Fixed income savings convertible to currency on demand of U.S.-chartered depository institutions and credit unions: checkable deposits, small time and savings deposits, large time deposits, open market paper, credit market instruments, USD, not s.a.</td>
<td>U.S. FoF</td>
</tr>
<tr>
<td>ABCP $B^{SB}_t$</td>
<td>Fixed income savings convertible to currency on demand of Money Market Mutual Funds, Funding corporations, finance companies, issuers of ABS: commercial paper, credit market instruments, USD, not s.a.</td>
<td>U.S. FoF</td>
</tr>
</tbody>
</table>

Table 4: Data sources and definitions

### A.5 Bayesian Estimation

Figure 6: Univariate Diagnostics
Figure 10: Univariate Diagnostics

Figure 11: Univariate Diagnostics
Figure 12: Univariate Diagnostics

Figure 13: Univariate Diagnostics
Figure 14: Univariate Diagnostics

Figure 15: Univariate Diagnostics
Figure 16: Multivariate Diagnostics
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