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Monetary Policy Effects on Financial Intermediation via the Regulated and the Shadow Banking Systems

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Preliminary Draft

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Abstract

We extend the monetary DSGE model by Gertler and Karadi (2011) with a non-bank financial intermediary to investigate the impact of monetary policy shocks on aggregate loan supply. We distinguish between bank and non-bank intermediaries based on the liquidity of their credit claims. While banks can endogenously create deposits to fund firm loans, non-banks have to raise deposits on the funding market to function as intermediaries. The funding market is modeled via search and matching by non-banks for available deposits of households. Because deposit creation responds to economy-wide productivity automatically, bank reaction to shocks corresponds to the balance sheet channel. Non-banks are constrained by the available deposits and their behavior is better explained by the lending channel. The two credit channels are affected differently following a monetary policy shock. As a result of these counteracting effects, an increasing non-bank sector leads to a reduced reaction of aggregate loan supply following a monetary policy shock, which is consistent with the data. An extension to deposit like-issuance by the non-bank sector will allow further studies of re-regulating the non-bank sector.

Keywords: Shadow Banking, Monetary Transmission Mechanism, Credit Channel

JEL Classification: E32, E44, E51, G20

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1 Introduction

The credit channel of monetary policy transmission explains the effects of monetary policy on the real economy via the lending behavior of banks. 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 the non-bank financial sector has been rising in the last decades, even overtaking the traditional banking sector in several countries, see FSB (2013) [10]. Empirical studies indicate that banks and non-banks react differently to monetary policy shocks (see Altunbas, Gambacrota and Marques-Ibanez (2009) [1]; Den Haan and Sterk (2010) [13]; Igan et al. (2013) [15]): While banks reduce the amount of loans on their balance sheets following monetary policy tightening, non-banks increase lending. This suggests that the share of credit intermediation via the non-bank financial sector is an important determinant of the effectiveness of monetary policy on aggregate lending and the economy. We therefore ask, how does credit intermediation via non-banks affect the reaction of aggregate loan supply to monetary policy?

In light of the empirical evidence we develop a structural model that distinguishes between banks and non-banks based on the liquidity of their credit claims. This analysis allows the assessment of shocks to the real economy as well as optimal monetary policy. In our model banks create deposits endogeneously that serve as means of payment in the economy in the sense of "inside money" as in Kiyotaki and Moore (2004) [16] . We use the monetary DSGE model with financial intermediaries by Gertler and Karadi (2011) [11] to describe bank behavior and deposit creation and extend it with a non-bank, or shadow bank, sector. Non-banks cannot create deposits and instead need to raise funds from households to satisfy firm loan demand. We model fund raising by non-banks as a search for previously created deposits by banks on the funding market. Following Wasmer and Weil (2004) [27], we model funding market frictions analogously to those on the labor market because of their comparable characteristics of moral hazard, heterogeneity and specificity.

In the Gertler and Karadi model, an increase in nominal interest rates leads to an adjustment of deposit rates that banks pay to households. This lowers banks' net wealth and according to the balance sheet channel requires deleveraging, resulting in a credit squeeze for the real sector, disinvestment and a fall in output. Increased deposit rates discourage households from current consumption and instead encourage savings. In our paper, savings in the form of deposit holdings constitutes available funds for the non-bank sector. This increase in funds reduces funding market tightness for shadow banks and results in a higher share of savings in the shadow banking sector. Non-banks lend out these additional funds and thereby alleviate the credit squeeze, mitigating the fall in investments and any consequent recession. This is only possible because credit supply by banks is rationed in the original model. Bank deposits created in the process of lending to firms pass through the economy a second time in the form of funding for shadow bank credit. The change in supply of funds to the non-bank sector following monetary policy changes corresponds to the lending channel of monetary policy transmission.

We argue that banks are less constrained by the supply of loanable funds than non-banks since they can create deposits endogenously. Their reaction to monetary policy therefore corresponds more accurately to the balance sheet channel, see Disyatat (2011) [8]. Given their more limited ability to create credit claims, non-banks are rather constrained by the supply of loanable funds and their reaction is more accurately captured by the lending channel. By incorporating the quantitatively important non-bank sector using a basic search and matching framework, we are able to assess the effects of the lending channel for non-banks compared to the balance sheet channel for banks, see Mishkin (1995) [22]. The resulting impulse response functions correspond to empirical impulse responses to monetary policy shocks. Since the non-bank financial sectors have a different size in different jurisdictions, this model extension can help to better predict the impact of monetary policy on aggregate lending and the economy depending on the share of shadow banks in aggregate lending. In addition, our analysis suggests that a central bank that ignores the existence of a sizable non-bank financial sector may miss the appropriate monetary policy reaction to real shocks. The novelty behind our approach is found in the ideas to pin down household deposits by considering the source of deposit creation, which is the deposit-creating banking sector, instead of the household sector as well as using the concept of a hierarchy of money, which places credit claims by banks above those of non-banks (Pozsar, 2014 [24]). Furthermore, this model can be used to assess the change in regulation for the non-bank financial sector, although we will consider this in another exploration.

Existing macroeconomic models of shadow banking include Meeks, Nelson and Alessandri (2014) [20] and Verona, Martins and Drumont (2013) [26]. The former 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. (2012) [12] study different regulatory regimes to stop fire sales by shadow banks and take the opposite view to Verona et al., considering non-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.

In constrast to these efforts, we define shadow banking more broadly. As the name suggests, a rise in financial intermediation via these shadow banks has often been attributed to favorable or unfavorable regulatory circumstances or criminal conduct. Irrespective of the motivation for operating a shadow bank, we focus on the way that the sector interacts with the economy based on the nature of their credit claims compared to depository institutions, akin to Mehrling et al. (2013) [21]. Following the seminal work of Pozsar, Adrian, Ashcraft and Boesky (2010) [25] on the institutional characteristics of the sector, we focus on the different liquidity characteristics that liabilities of depository institutions compared to non-depository institutions have. Whereas banks offer borrowers newly created deposits in their own banks, see ECB (2011) [9] and Bank of England (McLeay, Radia and Thomas, 2014) [19], shadow banks for the most part have to raise funds first that they can then lend on, as is the case with non-bank financial institutions that "intermediate purchasing power that has to first be created by banks" as discussed in Benes, Kumhof and Laxton (2014) [2]. Shadow banks do create money albeit of a less liquid nature, not as acceptable in commercial transactions as bank deposits, see also Pozsar (2014) [24] 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." Importantly, our paper does not explain money itself with the existence of frictions in the tradition of Kiyotaki and Wright (1989) [17].

Search and matching in credit markets has been studied since Dell'Arricia and Garibaldi (1998) [6]. Den Haan, Ramey and Watson (2003) [7] analyze the business cycle effects of long-term lending relationships with frictions. Wasmer and Weil (2004) [27] 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 banks. We explicitly focus on this interaction.

In the next section, we will describe the basic model, which is a reduced version of Gertler and Karadi (2011), and the non-bank extension. Section 3 explains how deposit-like issuance by shadow banks can be incorporated into the analysis. Section 4 explains the deposit creation mechanism of banks and the intermediation by non-banks in detail. Section 5 contains the model analysis, including calibration, impulse response functions to monetary policy and technology shocks, and the behavior of aggregate lending depending on the share of credit intermediation via non-banks. Section 6 concludes.

2 The Model

This section lays out the basic model. It is the monetary DSGE model with financial intermediaries by Gertler and Karadi (2011) [11]. We add a second financial intermediation sector, called the non-bank financial or shadow banking sector, that issues loans to firms but can not create deposits and instead relies on the existing volume of savings in the economy. Regardless of the institutional details, these shadow banks have in common that they are not able to create deposits that are acceptable as means of payment.[1] Instead, they need to raise funds from households in the form of deposits created by the banking sector first to engage in firm lending. Irrespective of whether non-banks lend to the real sector directly, buy repurchase agreements or whether they buy securitized credit claims of previously originated loans, regulatory constraints on banks' balance sheets is freed up and non-banks are the effective intermediary.

In our model the economy is populated by six types of agents: households, deposit creating financial intermediaries (banks), non-deposit creating financial intermediaries (shadow banks), non-financial goods producers that demand loans, capital producers, and monopolistically competitive retailers. A central bank conducting monetary policy is the source of monetary disturbances and completes the model. The setup is equivalent to the Gertler and Karadi model with the exception of household savings and shadow banks.

2.1 Households

A continuum of households of measure one exists with each household constituting a family separated into a share $1 - f$ of "workers" and a share f of "bankers". Bankers manage the financial intermediaries called banks, accumulate profits over several periods, which we discuss below, and eventually redistribute them back to the households that they came from. Workers consume, save and supply labor. They maximize discounted lifetime utility

$$\max_{C_t, B_t, L_t} E_t \sum_{i=0}^{\infty} \beta^i [ln(C_{t+i} - hC_{t+i-1}) - \frac{\chi^{HH}}{1+\varphi} L_{t+i}^{1+\varphi}]$$

subject to the sequence of period budget constraints

$$C_t = W_t L_t + \Pi_t + R_t^w B_t - B_{t+1}.$$

Each unit of labor L_t earns the real wage W_t. B_t are savings in the form of government bonds, deposits held at banks, or fund shares with non-banks. Government bonds and deposits are both riskless and are treated as substitutes. We abstract from the government sector and bonds in this model, but the interest rate on deposits still equals that on bonds. Savings pay the weighted interest rate R_t^w based on the allocation of deposits in banks and fund shares in non-banks. Π_t are profits from ownership of capital producers, retailers and financial intermediaries, both banks and non-banks. β is the discount factor, h is the habit parameter, χ^{HH} is the relative utility weight of labor and φ is the inverse Frisch elasticity of labor supply.

With ϱ_t denoting marginal utility of consumption, the first order conditions for consumption and labor are given by, respectively,

$$\varrho_t = (C_t - hC_{t-1})^{-1} - \beta h E_t (C_{t+1} - hC_t)^{-1} \quad (1)$$

$$\varrho_t W_t = \chi^{HH} L_t^{\varphi} \quad (2)$$

[1] Some shadow banks do indeed create deposit-like securities that can be used as means of payment in some transactions, called "public shadow money" in Pozsar (2014). We will extend our model to deposit-like issuance of credit claims by shadow banks in Section 3.

with

$$E_t \beta \Lambda_{t,t+1} R^w_{t+1} = 1 \tag{3}$$

$$\Lambda_{t,t+1} = \frac{\varrho_{t+1}}{\varrho_t}. \tag{4}$$

2.2 Banks

Banks are deposit creating financial intermediaries that lend to goods producers. Their balance sheet is given by

$$Q_t S_t = D_{t+1} + N_t. \tag{5}$$

Banks fund their loan portfolio S_t priced at Q_t through their net worth N_t and deposits obtained from households D_{t+1} other than their family members. Because they pay interest on deposits of R_{t+1} and earn a return R_{kt+1} on their loans, their net worth evolves according to

$$\begin{aligned} N_{t+1} &= R_{kt+1} Q_t S_t - R_{t+1} D_{t+1} \\ &= (R_{kt+1} - R_{t+1}) Q_t S_t + R_{t+1} N_t. \end{aligned}$$

Banks want to maximize their expected terminal net wealth before they exit the industry with a probability θ per period and pay out all the accumulated profits to their respective households. Expected terminal net wealth is given by

$$\begin{aligned} V_t &= E_t \sum_{i=0}^{\infty} (1-\theta)\theta^i \beta^{i+1} \Lambda_{t,t+1+i} N_{t+1+i} \\ &= \nu_t Q_t S_t + \eta_t N_t \end{aligned}$$

with η_t being the marginal expected discounted value of net worth and ν_t being the marginal expected discounted value of expanding assets

$$\nu_t = E_t[(1-\theta)\beta \Lambda_{t,t+1}(R_{kt+1} - R_{t+1}) + \beta \Lambda_{t,t+1} \theta x_{t,t+1} \nu_{t+1}] \tag{6}$$

$$\eta_t = E_t[(1-\theta) + \beta \Lambda_{t,t+1} z_{t,t+1} \theta \eta_{t+1}] \tag{7}$$

and the growth rate in assets $z_{t,t+1}$ and the growth rate in net worth $x_{t,t+1}$ defined below.

Since it is profitable to increase their loan portfolio as long as the interest rate differential is positive, they are bound by an incentive constraint: every period a banker can divert a fraction of the loan portfolio λ that the depositors at the bank are not able to recover. As a consequence, the bank goes bankrupt. Accordingly, households will keep their deposits at individual banks only as long as the franchise value of the bank, V_t, is higher than or equal to the divertible amount,

$$V_t \geq \lambda Q_t S_t.$$

As in the original model, we will assume that the constraint always binds, and after substituting and rearranging, the size of a banker's loan portfolio then depends on the size of their net wealth according to

$$Q_t S_t = \frac{\eta_t}{\lambda - \nu_t} N_t \tag{8}$$

and we can define the leverage ratio as

$$\phi_t \equiv \frac{\eta_t}{\lambda - \nu_t}. \tag{9}$$

We can also define the growth rate in assets $z_{t,t+1}$ and the growth rate in net worth $x_{t,t+1}$ as

$$\begin{aligned}
z_{t,t+1} &= \frac{N_{t+1}}{N_t} \\
&= \frac{(R_{kt+1} - R_{t+1})Q_t S_t + R_{t+1} N_t}{N_t} \\
&= (R_{kt+1} - R_{t+1})\phi_t + R_{t+1} && (10) \\
x_{t,t+1} &= \frac{Q_{t+1} S_{t+1}}{Q_t S_t} \\
&= \frac{\phi_{t+1} N_{t+1}}{\phi_t N_t} \\
&= \frac{\phi_{t+1}}{\phi_t} z_{t,t+1}. && (11)
\end{aligned}$$

Since a constant share $1-\theta$ of bankers dies every period and distributes its retained earnings to their households, $f(1-\theta)$ workers become new bankers. They receive a start-up net worth N_{nt}. Net worth of existing bankers N_{et} and new bankers N_{nt} make up overall net worth N_t according to

$$\begin{aligned}
N_t &= N_{et} + N_{nt} && (12) \\
N_{et} &= \theta[(R_{kt} - R_t)\phi_{t-1} + R_t] N_{t-1} && (13) \\
N_{nt} &= \omega Q_t S_t. && (14)
\end{aligned}$$

Note that existing net worth is predetermined. The only way banks can react to changing loan demand within the period is via the adjustment of the leverage ratio and thereby deposit issuance, as well as via the inflow of start-up net worth, N_{nt}.

2.3 Shadow Banks

In our first analysis, non-bank financial intermediaries cannot create deposits, but instead sell their own fund shares, FS_t, to households in exchange for deposits. We will introduce deposit-like credit claims of non-banks in section 3. The amount of loans S_t^{SB} that non-banks can issue to the goods producers is therefore given by their balance sheet constraint:

$$Q_t S_t^{SB} = FS_t. \tag{15}$$

The shadow bank is a simple intermediary with no liquidity transformation on its balance sheet in line with the loanable funds model. To raise funds from households, non-banks post advertisements v_t for their fund shares FS_t that they exchange for households' holdings of bank deposits, which carries a cost κ and has a probability q_t of being successfully matched with a deposit. The idea behind this is to model investor-fund heterogeneity implicitly. Non-banks need to advertise their operations, which is costly. However, not every advertisement speaks to every household. Households may disagree with investment conditions, the targeted borrower base or the fund manager. Therefore every advertisement only has a certain probability of being matched with a given deposit by a household and has to keep searching otherwise.

Accordingly, non-banks maximize their discounted future profits by choosing fund advertisements and loan issuance S_t^{SB}:

$$\max_{v_t, S_t^{SB}} E_t \sum_{i=0}^{\infty} \beta^i \Lambda_{t,t+i} \Pi_{t+i}^{SB}.$$

non-banks' profits are made up of the interest rate differential times the volume of funds they intermediate net of advertisement expenses. The interest rates they pay on fund shares, R_t^{SB}, is negotiated below:

$$\Pi_t^{SB} = (R_{kt} - R_t^{SB})Q_{t-1}S_{t-1}^{SB} - \kappa v_t.$$

Once a non-bank has exchanged fund shares for deposits with households, the match will stay put until the household withdraws the initial bank deposit. As is common in the literature, we do not model fund redemption explicitly but instead assume a constant probability of separation χ^{SB}, which results in a law of motion for fund shares: Shadow banks' period t sources of funding consist of the fund shares that have not been redeemed plus the new matches from fund advertisement given by

$$FS_t = (1 - \chi^{SB})FS_{t-1} + q_t v_t. \tag{16}$$

The first order conditions for posting fund unit advertisements and loan issuance are, respectively,

$$\begin{aligned}
&\kappa = \mu_t q_t, \\
&\mu_t Q_t = \beta \Lambda_{t,t+1} \left\{ (R_{kt+1} - R_{t+1}^{SB})Q_t + \lambda_{t+1}(1 - \chi^{SB})Q_t \right\}
\end{aligned}$$

with μ_t the Lagrangian multiplier on the constraint (16). Combining these equations results in the Euler condition for fund advertisements:

$$\frac{\kappa}{q_t} = E_t \beta \Lambda_{t,t+1} \left\{ (R_{kt+1} - R_{t+1}^{SB}) + (1 - \chi^{SB}) \frac{\kappa}{q_{t+1}} \right\}. \tag{17}$$

New vacancies will be posted until the marginal cost of matching an additional fund unit is equal to the marginal benefit of having matched an additional fund unit, which is the combination of the interest rate differential and avoided future search costs by having established a match in the previous period.

Matching

To compute the probability of matching a non-bank looking for funds with a household we assume a funding market matching function $m(v_t, D_{t+1} - FS_t)$ that is increasing in its arguments, the number of fund unit advertisements v_t and the number of 'unemployed' funds $D_{t+1} - FS_t$ as seen from the non-banks' perspective. If a unit of deposits has been exchanged for a fund share, it is not available for the remaining searching non-banks anymore and hence 'employed'. We define unemployed funds as

$$D_{t+1}^u \equiv D_{t+1} - FS_t. \tag{18}$$

Assuming a constant returns to scale matching function, the probability that a non-bank will find suitable funding is then

$$q(\theta_t) = m(1, \theta_t^{-1}) = \frac{m(v_t, D_{t+1}^u)}{v_t} = \theta_t^{-\eta} \tag{19}$$

with matching elasticity η and funding market tightness θ_t given by

$$\theta_t \equiv \frac{v_t}{D_{t+1}^u}. \tag{20}$$

Interest Rate Bargaining

We assume that the interest rates non-banks pay on funds raised is determined via Nash bargaining over surpluses. ω^{HH} signifies the relative bargaining power of households, which we calibrate to match the steady state premium interest rate premium of fund shares compared to deposits. Interest rates R_{t+1}^{SB} are negotiated that maximize a convex combination of the surpluses,

$$R_{t+1}^{SB} = argmax \quad \omega^{HH} lnV_t^{HH} + (1-\omega^{HH}) lnV_t^{SB}.$$

The resulting interest rate that non-banks pay for funds raised is (see Appendix 7.1 for details)

$$R_{t+1}^{SB} = (1-\omega^{HH})R_{t+1} + \omega^{HH}\left\{R_{kt+1} + \theta_{t+1}\kappa\right\}. \tag{21}$$

If household bargaining power is low, non-banks can get away with paying only the interest rate R_{t+1} that banks pay on their deposits. With increasing bargaining power, non-banks need to share expected profits with investing households.

The interest rate that households receive on their savings is the weighted average of interests payments from holdings of deposits and holdings of fund shares

$$R_t^w = R_t \frac{D_t}{B_t} + R_t^{SB}\frac{FS_{t-1}}{B_t}. \tag{22}$$

2.4 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 can borrow from intermediaries 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 non-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}. Although non-banks alleviate this constraint, which results in downward pressure on the interest rate for borrowing, their lending is similarly limited since they need to find unemployed funds in the funding market, which is characterized by search and matching frictions. As long as the goods producer pays the required rate it can borrow without frictions. Except for the addition of another source of funding, capital producers are identical to the ones in the original Gertler and Karadi model.

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

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

with production given by

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{23}$$

where α is the capital share, Q_t is the real price of capital, δ is the depreciation rate and W_t are wages.

The first-order conditions are

$$R_{kt+1}Q_t = P_{mt+1}\alpha\frac{Y_{t+1}}{K_{t+1}} + (Q_{t+1} - \delta) \tag{24}$$

$$P_{mt}(1-\alpha)\frac{Y_t}{L_t} = W_t. \tag{25}$$

Since firms do not earn any profits, they 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 bankers and shadow bankers according to

$$K_{t+1} = S_t + S_t^{SB}. \tag{26}$$

2.5 Capital Producers

Following the original Gertler Karadi approach, 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

$$I_{nt} \equiv I_t - \delta K_t$$

where $f(1) = f'(1) = 0$ 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

$$Q_t = 1 + f(.) + \frac{I_{nt}+I_{SS}}{I_{nt-1}+I_{SS}}f'(.) - E_t\beta\Lambda_{t,t+1}\left(\frac{I_{nt+1}+I_{SS}}{I_{nt}+I_{SS}}\right)^2 f'(.). \tag{27}$$

2.6 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 ϵ, given by

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

Because users of final output minimize costs, we have

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

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

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

The evolution of the price level is given by

$$P_t = [(1-\gamma)(P_t^*)^{1-\epsilon} + \gamma(\Pi_{t-1}^{\gamma_p} P_{t-1}]^{1/(1-\epsilon)}.$$

2.7 Resources and Policy

The aggregate resource constraint is given by

$$Y_t = C_t + \kappa v_t + I_t + f\left(\frac{I_{nt}+I_{SS}}{I_{nt-1}+I_{SS}}\right)(I_{nt}+I_{SS}) \tag{28}$$

and capital evolves according to

$$K_{t+1} = K_t + I_{nt}. \tag{29}$$

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 ρ, the inflation coefficient κ_π and the output gap coefficient κ_y:

$$i_t = (1-\rho)\left[i_{SS} + \kappa_\pi \pi_t + \kappa_y(logY_t - logY_t^*)\right] + \rho i_{t-1} + \epsilon_t. \tag{30}$$

The exogeneous shock to monetary policy enters the nominal interest rate as ϵ_t. The nominal interest rate has an effect on the economy through the Fisher relation

$$1 + i_t = R_{t+1} E_t(1+\pi_{t+1}). \tag{31}$$

3 Extension: Deposit-like Issuance by Shadow Banks

IN PROGRESS

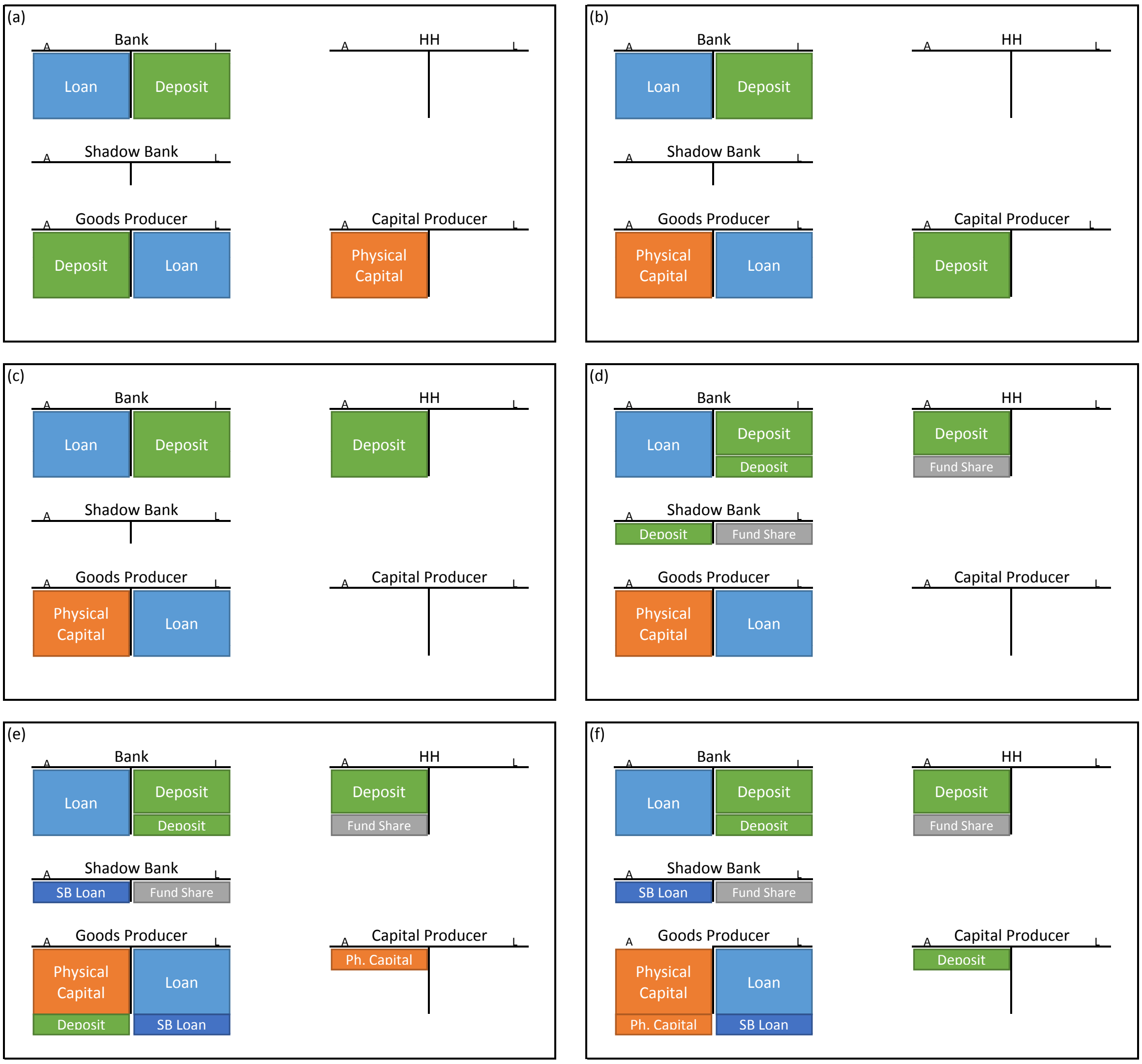

Figure 1: Change in balance sheets after lending increase

4 Intermediation Mechanism

In this section, we will look at the change in agents' balance sheets that is caused by additional lending by banks. We do not show the gross balance sheets but focus instead on the within-period adjustments starting out from the economy's steady state. Note that the following analysis is for the case without the extension of deposit-like issuance by shadow banks.

Households maximize their utility with respect to consumption and savings, which results in the Euler equation (3). This equation determines relative saving or dissaving by the household sector compared to the previous period but does not pin down the absolute amount of savings in the economy. Although each household can choose its level of savings, the household sector as a whole can not control the level of privately created money. Instead, banks choose the amount of deposits that maximizes their terminal value. This is in line with ECB (2011), who explain that "banks may also lend to borrowers, but thereby create deposits (initially held by the borrowers)" and McLeay, Radia and Thomas (2014), who show how money creation by the commercial banking sector is determined by the profitability of loans and not by new savings being deposited in banks. This is in contrast to non deposit creating intermediaries, such as "insurance corporations, as well as pension and investment funds" who "may intermediate between savers and borrowers by issuing securities and lending the receipts onward" (ECB, 2011). That is, non-banks need to find previously created deposits that they can lend on, consistent with the loanable funds model, e.g. Holmstrom and Tirole (1997) [14].

In the model this is embodied as follows. Banks finance loans through their liabilities, own net worth and issued deposits. Since bank net worth is partly predetermined according to (12), lending mostly adjust by varying the amount of deposits, see (5). The leverage ratio increases endogenously in the marginal expected discounted values of assets and net worth, signaling higher productivity in the economy. Therefore, banks are always able to create new deposits to fund lending if the loans are used productively, i.e. if expected profits allow goods producers to pay a borrowing rate above the deposit rate.

Contrast this to non-banks that perform a similar function to banks, channeling funds from households to firms. They are unable to create deposits and instead have to find previously created yet idle deposits to finance lending (we will later relax this assumption in an extension and make credit claims created by non-banks, the shadow counterpart to deposits, a less liquid but still acceptable form of payments in the economy, see Section 3). In this first approximation, shadow bankers do not have the ability to steal the assets the way that bankers do. However, shadow bankers do not have the ability to create deposits, either. The privilege of deposit creation is therefore attached to the responsibility of assuring one's depositors that their funds are safe.

To make the mechanism clear consider the changes in balance sheets within the period that an increase in lending implies. Depicted in figure 1, panel (a), are five of the agents in the model (retailers are not depicted since no transformation of balance sheets takes place). After a shock occurs at the beginning of the period, goods producers decide on how much physical capital they want to invest in. Assume for the moment that the shock causes increased productivity of the real sector and leads to additional lending (impulse response functions are analyzed in Sections 5.2 and 5.3). Goods producers need to finance physical capital with a loan of the same size from the banks. In return for the loan, the goods producers receive deposits from the banks to pay the capital producers, who create the physical capital in the amount demanded.

In panel (b) the capital producers sell their physical capital and receive deposits from the goods producers in return, who deposit them in their deposit accounts at their respective banks. Regardless of whether the capital producers selling the capital are at the same bank as the goods producers buying the capital, the total amount of newly created deposits can only reside within the banking system. Some banks will receive less deposits from capital producers than they lent out to goods producers and some will receive more. Any bank that received too few deposits will borrow deposits at the deposit rate R_{t+1} from other banks that received too many deposits to make up for any shortfall in funding and vice versa.

Since the capital producers belong to the households, any profits in the form of deposits are returned to them, as shown in panel (c). In the original Gertler and Karadi model, households will hold the deposits with the bank and receive interest on them in the next period.

In the baseline case, non-banks cannot offer internally created credit claims to borrowers that would serve as means of payment, like banks, because capital producers will not accept them in return for capital. Instead, non-banks need to raise funds in the form of previously created deposits. Since non-banks offer a higher return than banks, households will invest some of their deposits with them if there is a match, see panel (d). In return for the deposits, households receive fund shares on which the non-banks pay interest.

Since goods producers are loan constrained, non-banks offer these deposits to the goods producers in return for further interest payments, panel (e). Panel (f) shows the final configuration at the end of the period. At the beginning of the next period, households will receive interest on their deposits with banks and on their fund shares with non-banks, who each pay them with the proceeds of the interest payments they receive from goods producers.

5 Model Analysis

In this section, we will first pin down the model parameterization. Next we analyze how monetary policy and technology shocks propagate through the economy, both with and without non-banks. Finally we look at the effect of monetary policy on aggregate loan supply depending on the relative share of intermediation via the shadow banking system in the economy. Note that the following analysis is for the case without the extension of deposit-like issuance by shadow banks. The model is solved via first order perturbation around the deterministic steady state.

5.1 Calibration

Table 1 shows the chosen parameter values. All of the parameters present in the Gertler and Karadi original model are kept. The new parameters that follow the introduction of the shadow banking sector are the separation rate χ^{SB}, household bargaining power ω^{HH}, fund advertisement cost κ, and elasticity η of the matching function.

Since the shadow banking sector is heterogeneous it is often difficult to pin down a parameter value that is acceptable or even applicable for every part of the sector. For the separation rate, we choose a value of 5% to correspond with the quarterly redemption rates of mutual funds in the US. Household bargaining power is calibrated in such a way as to match the steady state interest rate premium households receive on their fund shares compared to deposits. Vacancy posting costs mostly influence the fund finding rate q, the probability that a vacancy will be turned into a match. The amount of vacancies posted will decrease with the cost, decreasing competition for funds and making it more likely that a vacancy will be turned into a match. We therefore assume a value of 0.05 for κ, which results in a 10% quarterly chance of a vacancy being turned into a match. Matching elasticity η indicates the share of vacancies and unemployed funds necessary for a match and can be used to regulate the size of the shadow banking system. Low values for elasticities require high amounts of unemployed funds for each match and vice versa. We assume a relatively large shadow banking system that intermediates about 40% of all credit in the economy. This is roughly in line with loan intermediation in the UK. The US has

Households		
β	.99	Discount rate
h	0 (0.815)	Habit
χ^{HH}	3.409	Relative utility weight of labor
φ	.276	Inverse Frisch elasticity of labor supply
Banks		
λ	.381	Fraction of capital that can be diverted
ω	.002	Proportional transfer to the incoming bankers
θ	.972	Survival rate of the bankers
Goods Producers		
α	.33	Effective capital share
δ	.025	Depreciation rate
Retail Firms		
ϵ	4.167	Elasticity of substitution
γ	.779	Probability of keeping prices fixed
γ_p	.241	Price indexation
Monetary Policy		
κ_π	1.5	Inflation coefficient of Taylor rule
κ_y	.125	Output gap coefficient of Taylor rule
ρ_i	.95	Smoothing parameter of the Taylor rule
Shocks		
ρ_a	.95	Autocorrelation of technology shock
σ_a	.01	Standard deviation of technology shock
σ_i	.005	Standard deviation of interest rate shock
Shadow Banks		
χ^{SB}	.05	Separation rate
ω^{HH}	.5	Household bargaining power
κ	.05	Vacancy posting cost
η	.9	Matching elasticity

Table 1: Parameter Values

a larger share of loans intermediated via the shadow banking system while the European Union has a lower share on average.

5.2 Response to a monetary policy shock

First, consider the case with no shadow banks present in the economy. After an unexpected monetary tightening of about 25 basis points, interest rates on government bonds increase. In order to encourage depositors to keep their savings with banks instead of shifting them into government bonds, banks need to raise interest on deposits. This increases bank funding costs and in order to keep their profit margin up, banks need to simultaneously raise the interest rate they demand from goods producers, which tightens credit standards and expels the least credit worthy borrowers. This reduces investments and therefore capital overall, as well as the price of capital. The unanticipated decrease in capital value weakens the ability of borrowers to repay their loans, resulting in an increased external finance premium (EFP), which further dampens investment. A negative financial accelerator as in Bernanke, Gertler and Gilchrist (1996) [3] ensues. In addition, higher deposit interest rates increase savings and reduce consumption. The drop in demand reduces prices and makes goods production even less profitable, putting further downward pressure on capital demand for production.

When non-banks are present, we see that the initial reaction is the same. Nominal and real rates rise, and to keep profit margins up, banks raise the borrowing rate. However, now the rise in interest rates on government bonds, bank deposits and bank loans has another effect. Non-banks negotiate the fund rate over their expected profits and households' alternative savings. Both the borrowing rate and deposit rates rise, which increases the fund rate. Since the borrowing rate increases more than the funds rate, the interest rate differential that non-banks earn increases and makes intermediation more profitable, raising vacancy postings. This increases new fund share sales and allows the non-banks to offer more credit, which is consistent with empirical studies of the shadow banking system (see Altunbas, Gambacrota and Marques-Ibanez (2009) [1]; Den Haan and Sterk (2010) [13]; Igan et al. (2013) [15]). Since many previously creditworthy borrowers were pushed out of the market, non-bank loans now replace some of the lost credit. This has a dampening effect on the fall in investment, which dramatically reduces capital decumulation to about half the case without non-banks. Because non-banks offer this high fund rate, initially more consumption is saved, increasing the fall in output. After this drop, output and consumption rebound more quickly than in the case without non-banks, since the external finance premium falls more quickly and the financial accelerator is weakened.

The reduction in non-bank loans after around eight quarters is due to the reduction in deposit holdings, which have not rebounded to their steady state levels because the economy is still in recession and demand for capital financing is below steady state levels. Increased funding market tightness in addition to a normalization of the interest rate differential non-banks earn on intermediation decrease the profitability and result in a reduction of loans below steady state levels. Because the shadow banking sector initially alleviated the financial accelerator, lending by the banking sector recovered more quickly than without non-banks and fills the missing non-bank loans after eight quarters.

5.3 Response to a technology shock

Next, we consider the effects of a positive technology shock of one standard deviation, which corresponds to a 1% increase of the goods producers' productivity, and first focus on the case without non-banks. The basic mechanism is standard as in Bernanke, Gertler and Gilchrist (1996) [4]. As the marginal productivity of capital and labor rises, increases in both capital and labor lead to increased investments and wages, respectively. Increased investments raise the price of capital, which increases net worth and decreases the external finance premium. Favorable credit conditions stimulate more investments, which affects the economy long after the technology shock has dissipated. Given the leverage constraint on deposit creation by banks, increased economic productivity increases bank net wealth, which results in higher deposits.

Non-banks do not change the picture dramatically. Since deposits rise and with them unemployed funds, funding market tightness is reduced and the fund finding rate increases. The increase in fund shares translates into increased non-bank credit intermediation. In constrast to a monetary policy shock, non-banks' reactions are comparable to that of banks, which is necessary to meet additional credit demand given that non-banks in this parameterization intermediate a sizable amount of credit. The overall effect of non-banks is a slightly reduced external finance premium.

The biggest difference in the responses is in the case of inflation, where the initial reaction without non-banks is mild deflation compared to mild inflation with non-banks. In both cases this is followed by a long deflationary period. Accordingly, the reaction of monetary policy is reversed. Whereas the monetary authority sets nominal interest rates lower when inflation is below the target as is the case without non-banks, nominal interest rates are increased in the presence of non-banks to counter inflation. Since they only converge after 8 quarters, this discrepancy suggests inoptimal reaction of monetary policy to technology shocks if the lending mechanism of non-banks is quantitatively important but neglected in the model. Given that the absolute difference is only a few basis points in this analysis, the practical difference this makes is most likely negligible. However, more research is warranted.

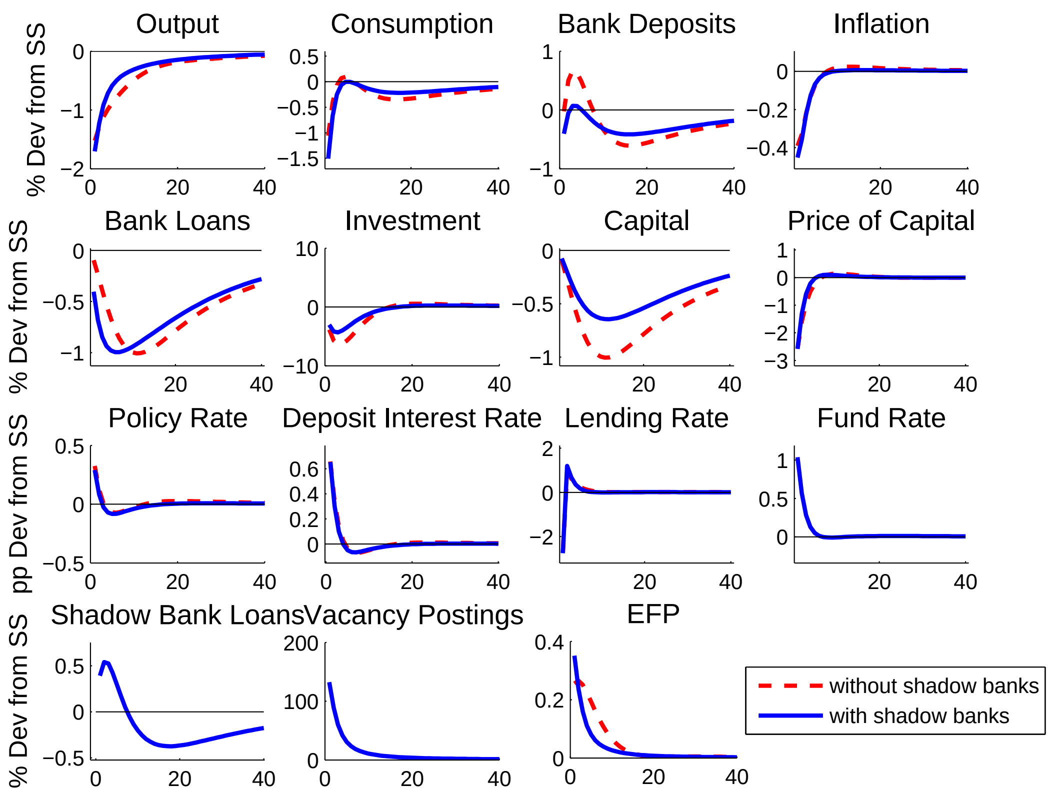

Figure 2: Impulse Response Functions to a Monetary Policy Tightening

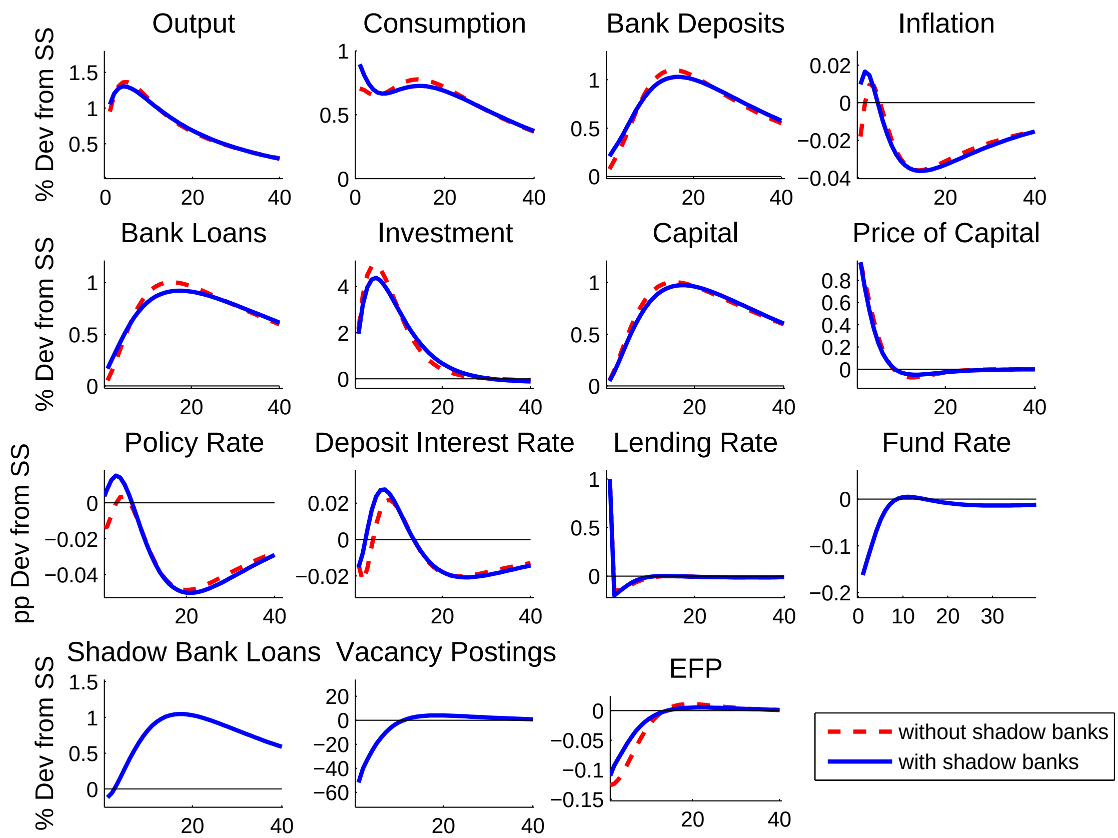

Figure 3: Impulse Response Functions to a Positive Technology Shock

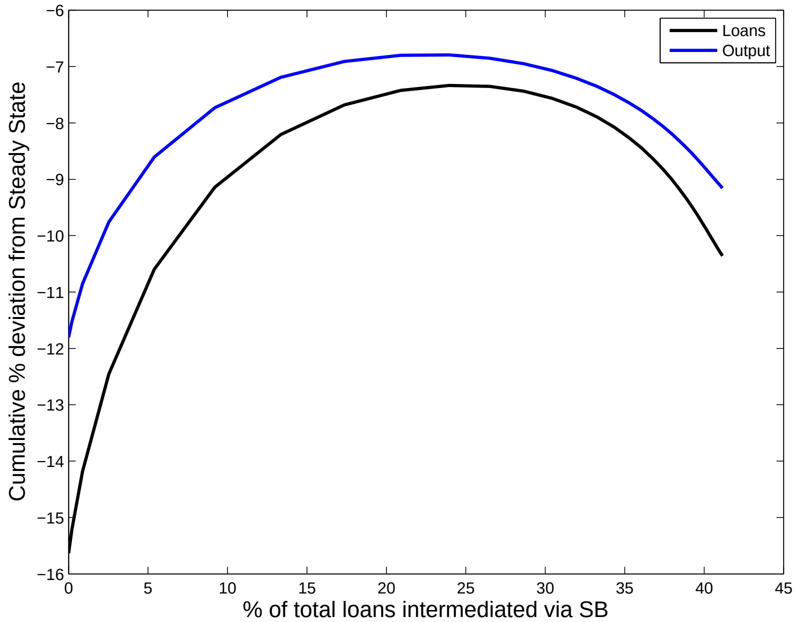

Figure 4: Size-dependent response of aggregate lending to a monetary policy shock

5.4 Shadow bank size-dependent response of aggregate lending to a monetary policy shock

Since the reaction of lending by banks and non-banks following a monetary policy shock is in opposite directions, we are interested in the aggregate effect of a monetary policy shock. The size of the non-bank loan volume will have an impact on the aggregate change in loans. We therefore vary the size of the shadow banking sector by changing matching elasticity η. Figure 4 shows the cumulative change in aggregate loan volume and output for the first 20 periods after a monetary tightening of 25 basis points for different relative sizes of the shadow banking sector.

The size of the shadow banking sector is capped at the amount of deposits in circulation, because non-banks are not able to create their own credit claims in this first analysis. Households may at most shift all of their deposits into fund shares, which results in a relative loan amount of less than 50%, because the amount of deposits is smaller than the amount of loans issued by the banking sector (some of the bank loans are financed by bank equity).

If matching elasticities are small enough, almost no deposits will be allocated to the shadow banking sector. The resulting relative intermediation is zero and aggregate lending is reduced by more than 15% over the next 20 quarters following a monetary tightening. Cumulative lost output, which depends on the amount of production and hence financing via loans, is around 11.5%. The figure shows that an increase of the shadow banking sector first decreases the cumulative reduction of aggregate loan issuance. Total loan reduction is halved when the shadow banking sector issues around 25% of all loans. Increasing matching elasticity further, and therefore the relative loan supply by non-banks, has a negative effect on total cumulative intermediation. A growing shadow banking sector beyond the 25% mark will result in fewer loans. At the limit of approximately 40% of loan intermediation via the shadow banking sector, cumulative loan reduction is around 10%.

There are three interacting factors that explain this outcome. First, increasing the matching

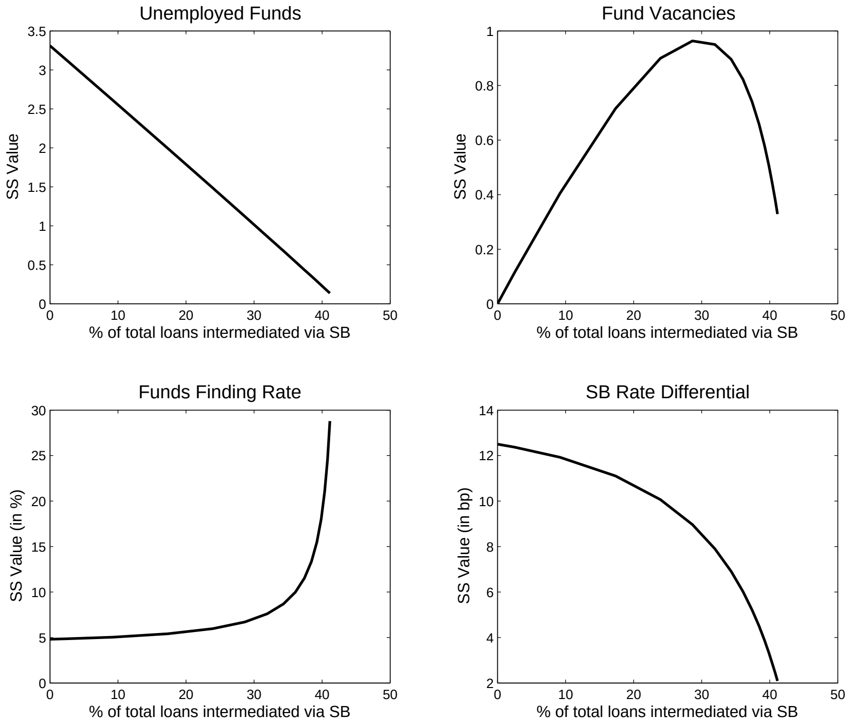

Figure 5: Steady State Levels with Different Matching Elasticities

elasticity η increases the number of matches for any set of matching inputs (v_t, B^u_{t+1}), which has an impact on the cost for finding matches and therefore on the absolute size of the shadow banking sector. Following Petrongolo and Pissarides (2001) [23], matching elasticity also determines the extent of externalities search participants impose on each other: Increasing η increases the congestion caused by each searching shadow bank on other searching shadow banks. At the same time, an increase in η increases the positive externality (thick-market effect) of unemployed funds on searching shadow banks. Second, the amount of unemployed funds B^u_{t+1} is decreasing in the size of the shadow banking sector, because non-bank credit is substituted for bank credit while households increase their relative savings in fund shares, lessening the need for deposits, see Figure 5. Third, the shadow banking system decreases credit rationing by banks and therefore increases economic activity.

In the case of a small shadow banking sector we have many unemployed funds and few searching non-banks. Without fierce competition on the funding market, shadow bank vacancies result in additional credit that competes with bank credit and results in increased economic activity. Increasing matching elasticity stimulates the economy further and initially makes job vacancy postings more profitable until the shadow banking system intermediates around 30% of total credit. At the same time a decreasing amount of unemployed funds and an increase in non-banks looking for funds coupled with increasing congestion effects results in more competition on the funding markets. This leads to competition for funds among non-banks to eventually become more pronounced, decreasing profitability of fund vacancies, see Figure 5. The increased competition drives non-banks out of the lending market and decreases the additional loans available through the shadow banking system.

Increasing the shadow banking size initially offsets some of the loan displacement because non-banks offer loans to companies that previously received funding from the banking sector. After a threshold of around 25% of aggregate loan intermediation by non-banks is reached, competition among non-banks reduces the profitability of intermediation, making non-bank credit less responsive to disturbances

6 Preliminary Conclusions

In this paper we have introduced non-bank financial intermediaries into a monetary financial DSGE model via the relatively parsimonious search and matching framework. In the simple case, only deposits are used as means of payment in the economy. Since banks create deposits endogenously to fund loans, funding supply is not a constraint on bank lending. Banks' response to shocks therefore represents the balance sheet channel of monetary policy transmission. Non-banks have to raise funds in the form of deposits to act as intermediaries. Their behavior is therefore dependent on the supply of deposits and corresponds more accurately to the lending channel. Modeling non-banks based on the differing nature of their credit claims compared to banks results in impulse response functions suggested by empirical studies of the sector: Following a monetary policy tightening, banks will decrease the amount of loans on their balance sheets while non-banks will increase loans. As a consequence, non-banks can significantly reduce the real effects of nominal shocks. Increasing the size of non-banks in the economy therefore results in a dampened response of aggregate lending to monetary policy shocks.

Another finding is that central bank policy may not react optimally to real shocks if it does not take the presence of non-bank intermediaries into account. Since banks and non-banks react to technology shocks in a comparable way, credit creation is amplified, which affects inflation. Monetary policy as modeled by a Taylor rule will not anticipate these effects if non-banks are not taken account of, and will therefore not react optimally. The recognition of non-bank intermediary behavior or a modified Taylor rule that includes data on money and credit as in Christiano, Motto and Rostagno (2007) [5] may solve this issue.

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) [18]. This analysis may shed light on the optimal size and regulation of non-banks in an economy. Given that non-banks alleviate the monopoly power of banks by channeling the bank created deposits through the economy a second time, steady state values of a non-bank based economy will differ from the exclusively bank based economy. Different steady state values will complicate the welfare analysis, which usually compares short term policies for equivalent long term positions.

In the model, non-banks fund themselves through fund shares that are sold to households only. In reality, non-banks are a huge debtor to banks. Additionally, non-banks are not able to create their own credit claims to be used as means of payment in the economy. These simplifications will be addressed in future versions of the paper and will then allow us to experiment with the re-regulation of the shadow banking sector, including the moneyness of shadow banking credit claims and optimal central bank policy.

In addition, household savings allocations are passively modeled in this version. The explicit microfoundation of savings decisions, together with the introduction of uncertain returns from the intermediary sector, will allow further realism and additional policy experiments.

7 Appendix

7.1 Interest Rate Bargaining

The marginal surplus non-banks stand to gain from lending out an additional loan is the difference between the value of an employed share $V^{SB,e}$ versus an unemployed share $V^{SB,u}$, with

$$\begin{aligned} V_t^{SB,e} &= \phi_t^{SB}(R_{kt} - R_t^{SB}) + \beta\Lambda_{t,t+1}[(1-\chi)V_{t+1}^{SB,e} + \chi V_{t+1}^{SB,u}] \\ V_t^{SB,u} &= -\kappa + \beta\Lambda_{t,t+1}[q_t V_{t+1}^{SB,e} + (1-q_t)V_{t+1}^{SB,u}]. \end{aligned}$$

(ϕ_t^{SB} is the leverage ratio of money creating shadow banks. In the simple case we assume no money creation by the central bank and set this value to 1.) If non-banks find a fund share buyer, they earn the difference on the interest rates and will keep this surplus if the match is not separated. If they do not find a match, they have to advertise, incurring advertisement costs κ, which has a probability q_t of finding a match next period. In accordance with the free entry condition in the labor search literature, we assume that non-banks advertise until the value of an unemployed share is zero, $V^{SB,u} = 0$. We can then express $\beta\Lambda_{t,t+1}V_{t+1}^{SB,e} = \kappa/q_t$. Inserting this above, the value of an employed share under free entry is then

$$V_t^{SB} = \phi_t^{SB}(R_{kt} - R_t^{SB}) + (1-\chi)\frac{\kappa}{q_t}.$$

For a household the value of savings at non-banks $V^{HH,e}$ versus savings at banks $V^{HH,u}$ are

$$\begin{aligned} V_t^{HH,e} &= R_t^{SB} + \beta\Lambda_{t,t+1}[(1-\chi)V_{t+1}^{HH,e} + \chi V_{t+1}^{HH,u}] \\ V_t^{HH,u} &= R_t + \beta\Lambda_{t,t+1}[f_t V_{t+1}^{HH,e} + (1-f_t)V_{t+1}^{HH,u}], \end{aligned}$$

where $f_t \equiv m(v_t, B_{t+1}^u)/B_{t+1}^u$ is the probability of an unemployed deposit being intermediated through a non-bank. The surplus from lending to a non-bank is the difference they receive in interest rates together with the value they have from keeping that savings relationship,

$$V_t^{HH} = R_t^{SB} - R_t + \beta\Lambda_{t,t+1}(1-\chi-f_t)V_{t+1}^{HH}.$$

From the first-order condition for interest rate bargaining we know that

$$\frac{\omega^{HH}}{V_t^{HH}} = \frac{\phi_t^{SB}(1-\omega^{HH})}{V_t^{SB}}.$$

Solving this forward one period and inserting above, as well as inserting V_{t+1}^{SB}, we get for the households surplus

$$\begin{aligned} V_t^{HH} &= R_t^{SB} - R_t + (1-\chi-f_t)\beta\Lambda_{t,t+1}V_{t+1}^{SB}\frac{\omega^{HH}}{1-\omega^{HH}}. \\ &= R_t^{SB} - R_t + (1-\chi-f_t)\frac{\kappa}{q_t}\frac{\omega^{HH}}{\phi_t^{SB}(1-\omega^{HH})}. \end{aligned}$$

Inserting the surpluses for non-banks and households into the first-order condition and solving forward one period results in

$$\frac{\omega^{HH}}{\left\{\phi_t^{SB}(R_{t+1}^{SB} - R_{t+1}) + (1 - \chi - f_{t+1})\frac{\kappa}{q_{t+1}}\frac{\omega^{HH}}{1-\omega^{HH}}\right\}} = \frac{(1 - \omega^{HH})}{\left\{\phi_t^{SB}(R_{kt+1} - R_{t+1}^{SB}) + \frac{(1-\chi)\kappa}{q_{t+1}}\right\}},$$

which can be solved for the interest rate non-banks have to pay on their fund shares

$$R_{t+1}^{SB} = (1 - \omega^{HH})R_{t+1} + \omega^{HH}\left\{R_{kt+1} + \theta_{t+1}\frac{\kappa}{\phi_t^{SB}}\right\}.$$

References

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

[2] J. Benes, M. Kumhof, and D. Laxton. Financial Crises in DSGE Models: A Prototype Model. IMF Working Papers 14/57, International Monetary Fund, Apr. 2014.

[3] B. Bernanke, M. Gertler, and S. Gilchrist. The Financial Accelerator and the Flight to Quality. *The Review of Economics and Statistics*, 78(1):1–15, February 1996.

[4] B. S. Bernanke, M. Gertler, and S. Gilchrist. The financial accelerator in a quantitative business cycle framework. In J. B. Taylor and M. Woodford, editors, *Handbook of Macroeconomics*, volume 1 of *Handbook of Macroeconomics*, chapter 21, pages 1341–1393. Elsevier, 1999.

[5] L. Christiano, R. Motto, and M. Rostagno. Two Reasons Why Money and Credit May be Useful in Monetary Policy. NBER Working Papers 13502, National Bureau of Economic Research, Inc, Oct. 2007.

[6] G. Dell'Ariccia and P. Garibaldi. Bank Lending and Interest Rate Changes in a Dynamic Matching Model. IMF Working Papers 98/93, International Monetary Fund, June 1998.

[7] W. J. den Haan, G. Ramey, and J. Watson. Liquidity flows and fragility of business enterprises. *Journal of Monetary Economics*, 50(6):1215–1241, September 2003.

[8] P. Disyatat. The Bank Lending Channel Revisited. *Journal of Money, Credit and Banking*, 43(4):711–734, 06 2011.

[9] European Central Bank. The supply of money - bank behavior and the implications for monetary analysis. Technical report, European Central Bank, 2011.

[10] Financial Stability Board. Global shadow banking monitoring report 2013. Technical report, Financial Stability Board, 2013.

[11] M. Gertler and P. Karadi. A model of unconventional monetary policy. *Journal of Monetary Economics*, 58(1):17–34, January 2011.

[12] C. A. Goodhart, A. K. Kashyap, D. P. Tsomocos, and A. P. Vardoulakis. Financial regulation in general equilibrium. Working Paper 17909, National Bureau of Economic Research, March 2012.

[13] W. J. D. Haan and V. Sterk. The Myth of Financial Innovation and the Great Moderation. *Economic Journal*, 121(553):707–739, 06 2011.

[14] B. Holmstrom and J. Tirole. Financial intermediation, loanable funds, and the real sector. *The Quarterly Journal of Economics*, 112(3):pp. 663–691, 1997.

[15] D. Igan, A. N. Kabundi, F. N.-D. Simone, and N. T. Tamirisa. Monetary Policy and Balance Sheets. IMF Working Papers 13/158, International Monetary Fund, July 2013.

[16] N. Kiyotaki and J. Moore. Evil is the root of all money. *American Economic Review*, 92(2):62–66, 2002.

[17] N. Kiyotaki and R. Wright. A search-theoretic approach to monetary economics. *The American Economic Review*, 83(1):pp. 63–77, 1993.

[18] J. Lucas, Robert E. Macroeconomic priorities. *American Economic Review*, 93(1):1–14, 2003.

[19] M. McLeay, A. Radia, and R. Thomas. Money creation in the modern economy. *Bank of England Quarterly Bulletin*, 2014.

[20] R. Meeks, B. Nelson, and P. Alessandri. Shadow banks and macroeconomic instability. Bank of England working papers 487, Bank of England, Mar. 2014.

[21] P. Mehrling, Z. Pozsar, J. Sweeney, and D. H. Neilson. Bagehot was a shadow banker: Shadow banking, central banking, and the future of global finance. Available at SSRN: http://ssrn.com/abstract=2232016 or http://dx.doi.org/10.2139/ssrn.2232016, 2013.

[22] F. S. Mishkin. Symposium on the monetary transmission mechanism. *Journal of Economic Perspectives*, 9(4):3–10, 1995.

[23] B. Petrongolo and C. A. Pissarides. Looking into the black box: A survey of the matching function. *Journal of Economic Literature*, 39(2):390–431, 2001.

[24] Z. Pozsar. Shadow banking: The money view. Ofr working paper, Office of Financial Research, 2014.

[25] Z. Pozsar, T. Adrian, A. Ashcraft, and H. Boesky. Shadow banking. Technical report, 2010.

[26] F. Verona, M. M. F. Martins, and I. Drumond. (Un)anticipated Monetary Policy in a DSGE Model with a Shadow Banking System. *International Journal of Central Banking*, 9(3):78–124, September 2013.

[27] E. Wasmer and P. Weil. The Macroeconomics of Labor and Credit Market Imperfections. *American Economic Review*, 94(4):944–963, September 2004.

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