Investment Allocation by Traditional and Shadow Banks *

Sebastiaan Pool†

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Abstract

Since the 1980's the banking sector has been characterized by three trends: i) a secular decline in interest rates, ii) a reallocation of bank investment from corporate loans towards mortgages and iii) the rise of shadow banking relative to traditional banking. This paper builds a framework to examine how traditional and shadow banks allocate investment and how this affects the growth of both sectors. In the model an exogenous drop in real interest rates – motivated by the saving glut hypothesis – increases the share of mortgage investment. Consequently, the market for mortgage securities becomes deeper which improves the competitive advantage of shadow banks over traditional banks with respect to mortgage supply and, thereby, it fosters relative growth of the shadow banking sector. Meanwhile, the economy's production capacity declines and the share of loans collateralized by houses rather than by a claim on production increases. Loan-to-value constraints attenuate the reallocation of investment to mortgages and shadow banking growth.

Keywords: Shadow Banking, Traditional Banking, Financial Stability

JEL Code: E44, G10, G21, G23

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†Correspondence to: Sebastiaan Pool, Westeinde 1, 1017 ZN Amsterdam, email: `s.pool@dnb.nl`

1 Introduction

Since the 1980's the banking sector has been characterized by three major trends. Perhaps the best documented trend is the continues decline in real interest rates in most developed economies.[1] In March 2005 former Fed chairman Bernanke emphasized the existence of a global savings glut, an increase in the global supply of savings, as the main source of this secular decline in interest rates, see Figure 1. An efficiently functioning banking sector would allocate these savings to their most productive use and depress real interest rates along the yield curve. However, starting in the 1980s and up to the recent financial crisis, banks increased the amount of loans secured by real estate – henceforth: mortgages – much faster than the amount of commercial and industrial loans – henceforth: corporate loans – see Figure 2. This reallocation of bank investment was accompanied by a third trend: a shift from traditional banking in which banks hold assets to maturity towards unregulated banking, i.e., the shadow banking sector, see Figure 3. There is a clear correlation between the growth rate of the shadow banking sector and the reallocation of bank investment from corporate loans towards mortgages, see Figure 4. However, no encompassing framework exists that explains a causal relationship in general equilibrium context.

The need for such a framework comes from recent concerns about productivity growth and financial stability. A reallocation of funds towards houses rather than physical capital might harm productivity growth in the long-run while a vastly growing shadow banking sector might undermine financial stability.[2] This paper builds a tractable model that shows how an exogenous inflow of funds depresses real interest rates, increases the share of mortgages on the aggregate bank balance sheet and fosters growth of in particular the shadow banking sector. The model distinguishes two assets that can serve as collateral for loans: residential houses for mortgages and physical capital for corporate loans. If consumers derive utility from consumption, leisure and owning a house, than a decline in interest rates induces them to consume more, work less and buy more housing. Inelastic housing supply causes house prices to rise which increases housing wealth. The fall in labor supply puts upward pressure on wages which decreases production and the value of physical capital. Collateral for mortgages improves while collateral for corporate loans deteriorates; consequently, banks increase mortgage lending and decrease corporate lending.

The fall in real interest rates fosters in particular growth of the shadow banking sector. The intuition behind this results can be understood as follows. Banks have the ability to create virtually safe, money-like claims which allows them to extract a rent from households, see Gorton and Pennacchi (1990); Stein (2012) and Krishnamurthy and Vissing-Jorgensen (2015). To keep claims liquid, deposit insurance and a liquidity backstop provided by the Central Bank are key

[1]See for example Caballero et al. (2008).

[2]For example Bernanke (2005) argues that in the long-run housing adds less to productivity growth than productive capital. Gennaioli et al. (2013) show how an exogenous increase in savings drives securitization, leverage and financial instability in the shadow banking sector. Moreira and Savov (2014) examine the interaction between shadow banks and the real economy and show how shadow banks can create liquidity via securitization but also additional instability.

to keep consumers calm (see e.g. Pozsar et al. (2010) and Adrian and Ashcraft (2012)). Shadow banks cannot participate in the deposit insurance scheme and offer their depositors therefore an early liquidation option before the asset pays off as in Stein (2012) and Hanson et al. (2015). As described by Diamond and Dybvig (1983), the liquid character of bank liabilities and the illiquid character of bank assets makes banks prone to runs.[3] Hence, in the model, shadow banks have lower marginal costs than traditional banks because they have no deposit insurance costs, but they are exposed to liquidity risk. Therefore they prefer liquid assets over illiquid assets (see Hanson et al. (2015)).[4] The exogenous inflow of funds increases the growth of mortgage loans and as a result, the interbank market for mortgage securities becomes deeper and the expected liquidation loss for shadow banks decreases. Shadow banks obtain a competitive advantage with respect to mortgage loans and grow in size following an inflow of funds while traditional banks obtain a competitive advantage with respect to corporate loans and shrink in size following.

The results have important policy implications. First, an inflow of funds might harm productivity growth when mortgage investment crowds out investment in corporate loans and corporate investment generates long-term productivity growth while investment in houses does not. Second, the reallocation of funds towards mortgages could be destabilizing as household debt is increasingly collateralized by the value of the underlying asset rather than a claim on production. Third, when the share of financial assets on the aggregate balance sheet grows, shadow banks grow. A large shadow banking sector can undermine financial stability because the deposit guarantee system is absent which makes shadow banks prone to liquidity risk. Specifically, a sudden reversal of inflows might trigger mortgages defaults and runs on shadow banks. Traditional banks provide a liquidity backstop to shadow banks, but this mechanism potentially crowds out corporate lending.[5] Loan-to-value ratios effectively attenuate macroeconomic fluctuations but are not sufficient to avert the re-allocation of bank investment towards mortgages.

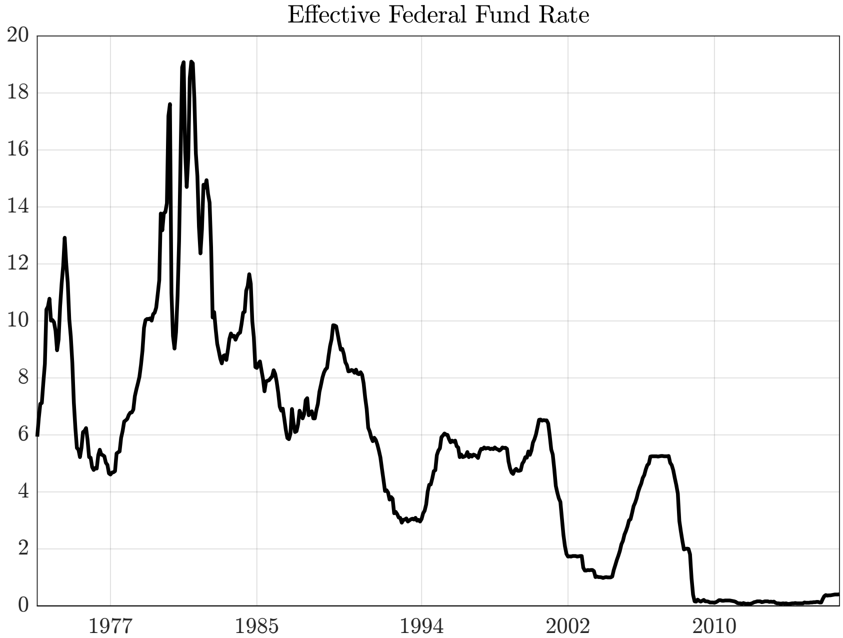
The rest of the paper is organized as follows. Section 2 presents the model. I look at the allocation of funds when the demand for liquid claims increases exogenously, say a savings glut. Section 3 describes the calibration results. Section 4 discusses the policy implications and concludes.

[3]Stein (2012) shows that when intermediaries do not internalize the costs of fire-sales, unregulated private money creation is typically sub-optimal. Mink (2016) and DeAngelo and Stulz (2015) show that banks having access to a very liquid interbank market in which systemic risk is insured by a lender of last resort leads to excessive liquidity creation and high bank leverage. Brunnermeier (2009); Brunnermeier and Pedersen (2009) and Brunnermeier and Sannikov (2014) show that banks that fund themselves with liquid deposits to finance illiquid investment are more vulnerable to liquidity risk. These risks could negatively effect lending to the real economy when asset prices fall and credit risk rises, see e.g. Ivashina and Scharfstein (2010).

[4]One manifestation of this liquidity difference is the existence of a deep and liquid interbank market for mortgage backed securities, stocks and government bonds, while the interbank market for corporate loans is less deep and liquid.

[5]Shleifer and Vishny (2010a,b) and Shleifer and Vishny (2011) show how financial assets hold by shadow banks might in this case crowd out loans to firms by traditional banks. In a fire sale, liquidity constrained shadow banks sell financial assets below their fundamental value. Non-constrained traditional banks are aware of this potential capital gain and buy these financial assets, thereby crowding out corporate lending.

Figure 1: Financial and real assets as % of aggregate balance sheet of financial sector U.S.

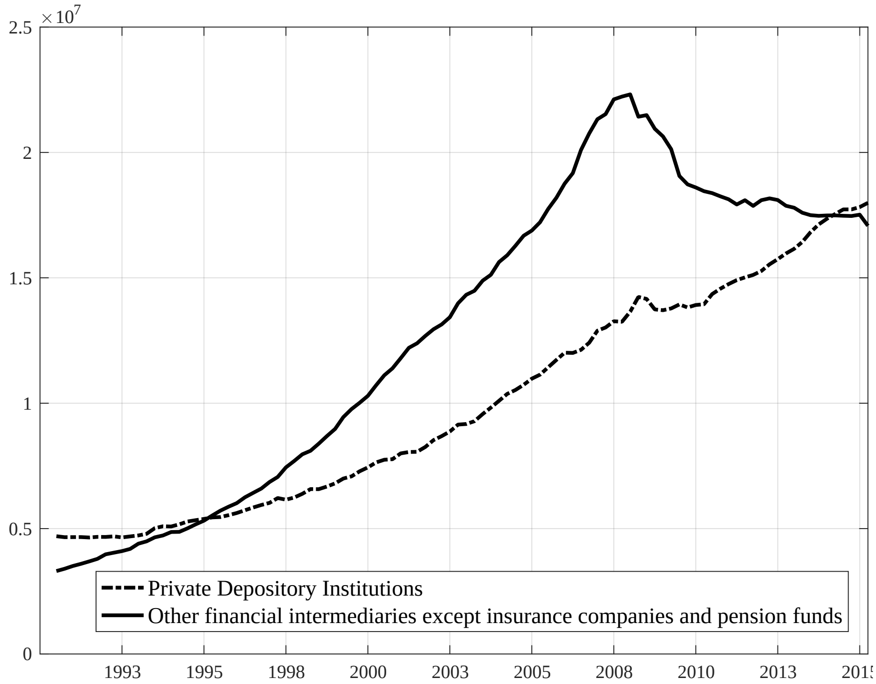


Source: Historical statistics on banking (Federal deposit insurance corporation)

Figure 2: Financial and real assets as % of aggregate balance sheet of financial sector U.S.

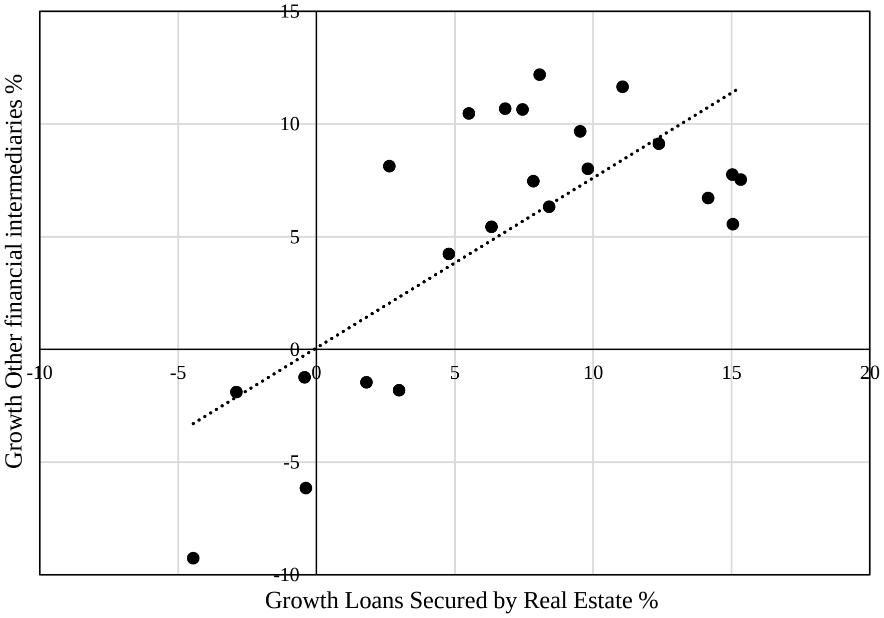
Source: Historical statistics on banking (Federal deposit insurance corporation)

Figure 3: Total liabilities traditional banks and shadow banks U.S.



Source: Flow of funds accounts of the United States (FRB).

Figure 4: Growth financial investment and shadow banks



2 Model

The model describes three sources of heterogeneity: patient and impatient consumers denoted by the superscript $j \in \{p, i\}$, traditional banks and shadow banks denoted by the superscript $b \in \{tb, sb\}$, and mortgages and corporate loans denoted by the superscript $\iota \in \{e, f\}$. Impatient consumers discount the future more heavily than patient consumers. As a consequence, patient consumers will prefer to save while impatient consumers will prefer to borrow. Traditional banks are regulated and forced by a Central Bank to insure their deposits while shadow banks are not. Consequently, shadow banks have lower marginal costs, but are subject to liquidity risk. Both banking types can fund mortgages and corporate loans. Corporate loans are used by firms to buy physical capital and mortgage are used by households to fund a residential house.

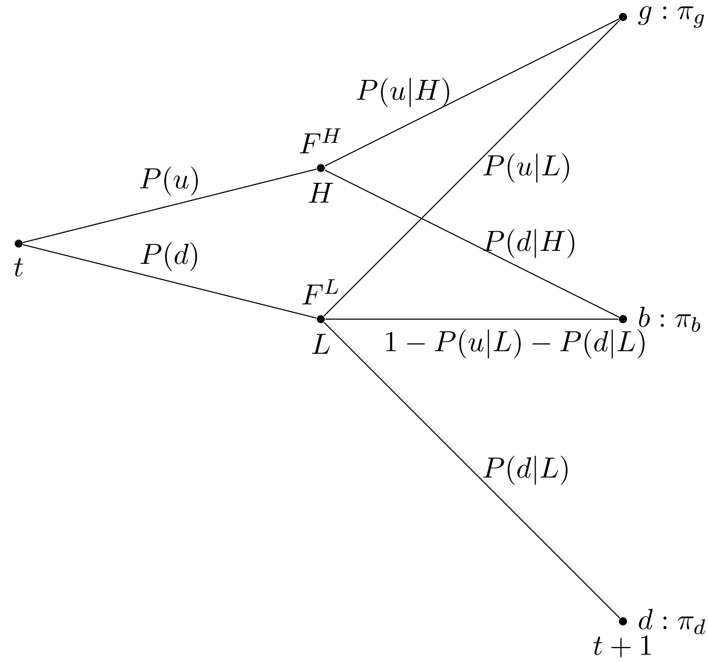
The model embeds elements of the financial structure developed in Stein (2012), Gennaioli et al. (2013) and Hanson et al. (2015) in a general equilibrium context. All households buy risk-free money-like claims (henceforth deposits) from risk neutral banks because deposits are needed to consume, i.e, as cash-in-advance constraint. Besides, patient households might buy risky equity of both banking types in order to save part of their income. Since households value deposits for their safety and liquidity, the deposits rate trades at a discount of the rate on bank equity. Consequently, both shadow banks and traditional banks prefer to finance their lending with deposits rather than equity which is more expensive.

Aggregate productivity risk is introduced to create scope for deposit insurance and liquidity risk, but never materializes. Aggregate risk cannot be diversified and poses a potential threat to the risk-free claim of depositors. The Central Bank requires traditional banks to insure all downside aggregate risk in the deposit guarantee scheme (DGS). Shadow banks are unregulated and have no access to the DGS. Shadow banks can create risk-free claims by offering depositors an early liquidation option (Stein, 2012; Hanson et al., 2015). If a pessimistic signal about the future state of the world would realize, shadow banks sell their assets in the interbank money market to traditional banks. The opportunity costs of traditional banks and the market depth of the underlying asset determines the liquidation price and therefore capital loss of liquidation. As aggregate risk does not materialize, liquidation never happens, but the threat introduces a friction that provides scope for two different banking business models.

2.1 Aggregate risk

The return on assets is dependent on the state of the world $s \in S$. At time t all agents assume that state $s \in S$ materializes with probability $\varrho_s > 0$ where $\sum_s^S \varrho_s = 1$. For reasons of tractability I assume that in each point in time banks expect only 3 different states. Specifically, in expectation there are 3 states of the world that can realize: $S = \{g, b, d\}$ referring to a *good*, *bad* and *disaster* state respectively. Accordingly, $\pi_g(\cdot) > \pi_b(\cdot) > \pi_d(\cdot)$ denote the probabilities of success in the respective states. Between time t and $t+1$ an interim news event $(S^{'})$ about the future economic state, which can be either optimistic H or pessimistic L, $(S^{'} = \{H, L\})$ could be observed. I denote the probability of an upturn $P(u)$ and the probability of a downturn

Figure 5: Probability tree



$P(d)$. If a optimistic signal is observed, agents know for sure that only a good or bad state will realize. If a pessimistic signal is observed, all three states can be realized.[6] The probability tree in Figure 5 formalizes the discussion.

2.2 Real economy

Households

The economy consist of two types of infinitely lived households, the only difference being that the latter group has a lower discount factor $\beta^i < \beta^p$. Of both types exists a continuum with total mass of one. In equilibrium patient households save, while impatient households borrow. Households derive utility from consumption C_t^j, risk-free monetary services M_t^j, i.e, deposits, leisure $(1 - L_t^j)$ and housing H_t^j.[7]. The corresponding household utility function takes the

[6]These assumptions can easily be generalized. In particular, S could include a continuous set of states s and a continuous set of signals might be observed that are consistent with the results presented below. Crucial, however, is that a optimistic set of signals can be observed such that the probability of a disaster state is negligibly small (or absent) to keep depositors calm while a pessimistic signals give rise to a significant probability of disaster states such that depositors respond by withdrawing their deposits.

[7]Money or deposits in the utility function can be motivated by a cash-in-advance constraint as households need money or deposits to pay for consumption. While money can be used directly for payment, equity must first be converted into a liquid asset like money before a household can use it for payment. This liquidity difference motivates why both types of households value money like claims over equity

following functional form:

$$U_t^j = E_t \left\{ \sum_{t=0}^{\infty} (\beta^j)^t \left(\frac{((C_t^j)^{\eta}(H_t^j)^{1-\eta})^{1+\sigma^c}}{1+\sigma^c} + \gamma^m \frac{(M_t^j)^{1+\sigma^m}}{1+\sigma^m} - \gamma^l \frac{(L_t^j)^{1+\sigma^l}}{1+\sigma^l} \right) \right\} \tag{1}$$

where deposits M_t^j can be supplied by both traditional banks $M_t^{j,tb}$ and shadow banks $M_t^{j,sb}$, E_t is an expectation operator, $1-\eta$ denotes the weight of housing, σ^c, σ^m and σ^l denote respectively the inverse of the elasticities with respect to consumption, deposits and work-effort, γ^m and γ^l denote the weights of deposits and labor in the utility function.

If a pessimistic signal is received, households liquidate their deposits in the shadow banks and store it in the traditional banks. If the signal is optimistic, households remain calm and leave their deposits in the shadow banks. The option to liquidate at the intermediate stage makes the shadow bank deposits ex-ante risk-free. Households never liquidate their traditional bank deposits because they are protected by the deposit guarantee system (DGS).

Households maximize their utility subject to their budget constraints. As patient household saving does not equal impatient household borrowing when some funds are reserved in the DGS, their budget constraints are slightly different. The patient household budget constraint is represented by:

$$\begin{aligned} M_t^p + Q_t + q_t^h(H_t^p - H_{t-1}^p) =& (1+i_{t-1}^m)M_{t-1}^p + (1+i_{t-1}^q)Q_{t-1} + r_t^h H_{t-1}^p - C_t^p + L_t W_t \\ &+ \theta(\Pi_t^b + \Pi_t^p) \end{aligned} \tag{2}$$

where $Q_t = Q_t^{tb} + Q_t^{sb}$ denotes the equity stakes of the patient households in the traditional and shadow banks respectively, i_t^m, either, $i_t^{m,tb}$ or $i_t^{m,sb}$ denote the rates on traditional and shadow bank deposits respectively, i_t^q, either, $i_t^{q,tb}$ or $i_t^{q,sb}$ denotes the risky interest rates on traditional and shadow banking equity respectively. The term W_t denotes the wage rate patient households receive for supplying labor to the firms and Π_t^p and Π_t^b denote firm profits and bank profits redistributed to households where θ denotes the share of patient households in the economy. Finally, q_t^h denotes the house price. Each period a household sells the house it has bought in the previous period for $q_t^h H_{t-1}^p$ and buys a new house for $q_t^h H_t^p$. The household owns the house a period and realizes a return on the house defined as: $r_t^h \equiv \frac{q_t^h}{q_{t-1}^h} - 1$.

The impatient households have the same utility function as the patient households, but own potentially different assets because they also represent the investors in the economy. Particularly, impatient households have two investment opportunities for which they have to borrow: they can invests in physical capital K_t or in housing H_t. Physical capital has a costs r_t^e and yields a return to capital r_t^k while housing has a cost r_t^f and yields a return r_t^h. The impatient household budget constraint is represented by:

$$\begin{aligned} B_t^f + B_t^e - M_t^i - q_t^h(H_t^i - H_{t-1}^i) =& (1+i_{t-1}^f)B_{t-1}^f + (1+i_{t-1}^e)B_{t-1}^e - (1+i_{t-1}^m)M_{t-1}^i - r_t^h H_{t-1}^i - \\ & W_t L_t^i - r_t^k K_{t-1} - (1-\theta)(\Pi_t^{tb} + \Pi_t^p) + C_t^i + I_t, \end{aligned} \tag{3}$$

where B_t^f denotes mortgages for the nominal value of the house $q_t^h H_t$ and B_t^e denotes corporate loans for the nominal value of physical capital $q_t^k K_{t-1}$, i_t^f denotes the gross lending rate for mortgages and i_t^e denotes the gross lending rate for physical capital (arbitrage ensures equality between these two rates). Impatient households rent out their capital stock to firms for a rental rate r_t^k. The physical capital stock accumulates according to:

$$K_{t+1} = K_t(1-\delta) + I_t\left(1 - \frac{\phi}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right), \tag{4}$$

where I_t denotes net investment in the physical capital stock. The second term in round brackets in (4) denotes capital stock adjustment costs. The ϕ parameter, denoting the degree of adjustment costs, determines to some degree shifts in demand between physical capital and housing.

The loans B_t^f and B_t^e cannot be larger than the value of the collateral. Without this constraint, impatient consumers borrow indefinitely to finance consumption. However, as the main purpose of this paper is to distinguish between investment in two types of assets, I restrict borrowing for consumption. For this reason, the following inequality constraint is postulated for impatient households (Appendix A.1 presents proof that (5) and (6) hold with equality):

$$q_t^h H_t^i \geq \zeta^f B_t^f, \tag{5}$$

$$q_t^k K_{t-1} \geq \zeta^e B_t^e. \tag{6}$$

where ζ^f is a loan-to-value constraint for mortgages and ζ^e is a loan-to-value constraint for corporate loans.

Household preferences determine both the return on banking equity and the deposit rate. Intermediation adds value as households are willing to pay a premium for a safe asset which can be made safe only by means of intermediation. Households have no access to the interbank money market and as such cannot construct a diversified portfolio to eliminate idiosyncratic risk. They therefore do not invest their endowment directly in corporate loans or mortgages. Hence, banks generate value on the liability side of their balance sheet by issuing risk-less claims collateralized by risky loans.

It is instructive to study (1)-(3) more closely. First, housing and consumption are substitutes: if consumption increases, housing demand increases because consumers equate the marginal rate of substitution to the price differential between house prices (P_t^h) and consumer prices (normalized to unity). Accordingly, consuming housing is costly. However, as houses do not perish each period like consumption goods, owning a house could also yield a return. If the increase in house prices is larger than the nominal lending rate, the real interest rate on housing becomes negative. Accordingly, a decrease in the lending rate or an expected increase in house prices increases housing demand and therefore house prices.

In contrast to Stein (2012), Gennaioli et al. (2013) and Hanson et al. (2015), depository funding via deposits, equity funding and household borrowing demand are all endogenously determined in the model. Patient households maximize (1) subject to (2) with respect to consumption, deposits, labor supply, housing and equity holdings. Impatient households maximize (1) subject to (3), (4), (5) and (6) by choosing consumption, deposits, labor supply, housing, mortgages, corporate loans, physical capital and investment, see Appendix A.1 for the details.

Firms rent their physical capital from the impatient household and hire labor from both types of households to minimize their production costs subject to the aggregate production technology:

$$Y_t = E_t(\pi_s) A_t (K_{t-1})^{1-\alpha} (L_t)^{\alpha}, \tag{7}$$

where Y_t denotes production, $E_t(\pi_s)$ is in expectation equal to unity and denotes the expected probability of success in state of the world s. A_t denotes an aggregate productivity index which follows a stochastic process $A_t = e^{\eta_t^a}$, where $\eta_t^a = \rho^a \eta_{t-1}^a + \varepsilon_t^a$ and ε_t^a is an i.i.d.$\sim (0, \sigma^a)$ productivity shock.

Traditional and shadow banks

Depository funding is less expansive than equity funding because consumers value deposits for their liquidity. Both banking types therefore prefer depository funding over equity funding. As traditional banks are obliged by the Central Bank to insure their deposits in the DGS, traditional banks can adhere to a hold-to-maturity investment approach. In order to create a risk-free claim in the disaster state, traditional banks buy actuarially fair priced deposit insurance that pays-off in the disaster state (Hanson et al., 2015). As only the disaster state is insured, the market forces traditional banks to hold sufficient equity such that the depositor also holds a risk-free claim in the good or bad state of the world.

Shadow banks are not obliged to participate in the deposit insurance scheme. Shadow banks therefore adopt a less costly approach to issues risk-free deposits, i.e. they include an early liquidation option. If, in the intermediate state between t and $t+1$, a pessimistic signal about the future state of the world realizes, depositors liquidate their deposits in shadow banks. To repay its depositors, the shadow banks must liquidate its assets pledged as collateral in the interbank market at a potential loss. This potential loss determines how much deposits a shadow bank can issue. The markets requires shadow banks, similar to traditional banks, to hold sufficient equity to remain solvent in the bad state. Consequently, liquidation only materializes after a pessimistic signal because the worst outcome after a optimistic signal is the bad state.

Both traditional and shadow banks, denoted by the superscript $i \in (sb, tb)$, have the same objective function except for the deposit insurance premium. Each period the banks issue M_t^i units of deposits and Q_t^i units of equity and promises to repay $(1 + i_t^{m,i}) M_t^i$ and $(1 + i_t^{q,i}) Q_t^i$ the succeeding period. These funds are used to fund mortgages $B_t^{f,i}$ and corporate loans $B_t^{e,i}$.[8] The

[8] No idiosyncratic risk is considered. In Appendix A.4 I show that both traditional banks and shadow banks will always completely diversify their portfolio if diversification costs are low. Accordingly, only fully diversified portfolio without idiosyncratic risk are considered here.

objective function for both banks can be described by:

$$\max\left\{(E_t\{\pi_s\}[(1+i_t^f)B_t^{f,i}+(1+i_t^e)B_t^{e,i}]-i_t^{m,sb}(M_t^i+M_t^{i,x})-i_t^{q,i}Q_t^i-B_t^{f,i}-B_t^{e,i}-\Xi_t^i-\xi D_t\right\}, \tag{8}$$

where i_t^f and i_t^e are the expected returns on investment in mortgages and corporate loans respectively, M_t^i is the sum of patient $M_t^{p,i}$ and impatient household deposits $M_t^{i,i}$ and $M_t^{i,x}$ denotes foreign deposits for which demand is specified below. The term Ξ_t^i denotes fixed costs and ensures that banks do not ear profits in equilibrium. Risk neutrality and no arbitrage ensure that in expectation all investments yield the same return: $E_t\{i_{t+1}^e\}=E_t\{i_{t+1}^f\}$. Hence, from the perspective of the risk neutral banks there is no difference between corporate loans. The latter term is the deposit guarantee premium D_t. For traditional banks $\xi=1$ and for shadow banks $\xi=0$. The actuarially fair priced deposit guarantee payment is expressed as:

$$D_t=\chi(B_t^f+B_t^e). \tag{9}$$

where $\chi=P(d)P(d|L)(\pi_b-\pi_d)$ is defined as the DGS cost per euro of investment in the risky assets. The deposit insurance needs to cover only the difference between the bad and disaster state as traditional banks holds enough equity to remain solvent in the bad state. Both banks satisfy to the same budget constraint:

$$B_t^{e,i}+B_t^{f,i}+\xi D_t\leq Q_t^i+M_t^i+M_t^{i,x}, \tag{10}$$

Equation (10) argues that the sum of investment in mortgages and corporate loans (and deposit insurance in case of traditional banks) cannot be larger than debt plus equity.

The market also requires banks to hold sufficient capital. The capital buffer constraint states that in the worst possible state the banks should be able to repay their risk-free debt. Since both banks adopt a different business model with respect to the creation of risk free claims, the traditional bank capital buffer constraint is different from the shadow bank capital buffer constraint. Specifically, the traditional bank capital buffer constraint is specified by:

$$\pi_b[(1+i_t^f)B_t^f+(1+i_t^e)B_t^e]\geq(1+i_t^{m,tb})(M_t^{tb}+M_t^{tb,x}), \tag{11}$$

The capital buffer constraint states that traditional banks should have sufficient equity to ensure that the return in the bad state of the world is sufficient to cover all risk-free deposits. Deposit insurance guarantees the disaster state and is therefore not of interest to the market.

The shadow bank capital buffer constraint is specified by[9]:

$$[P(d|H)\pi_g + (1 - P(d|H) - P(d|L))\pi_b + P(d|L)\pi_d][k_t^f(1 + i_t^f)B_t^f + k_t^e(1 + i_t^e)B_t^e] \geq \tag{12}$$
$$(1 + i_t^{m,s})(M_t^s + M_t^{tb,x}),$$

where $0 < k_t^f, k_t^e < 1$ specify the expected percentage of value that is retrieved when the shadow banks liquidate their assets in the interbank market to traditional banks. It is possible to read the participation constraint as a "worst case scenario outcome" which, for the shadow bank, is the realization of a pessimistic signal. In that case household liquidate their deposits. As, pessimistic, information about the future state of the world is available, the fundamental value of the assets is lower than the initial investment in the assets and must be discounted by k_t^f or k_t^e.

In the appendix I show for both banks the budget and capital constraints hold with equality. Hence, it is possible to substitute the constraints (10) and (11) in (8) to obtain the traditional bank maximization problem. Likewise, substituting the constraints (10) and (12) in (8) gives the shadow bank maximization problem. We learn form these problems that as long as the return on an asset is larger than the costs costs of equity plus the costs of DGS for a traditional banks or the expected liquidation costs for a shadow bank, both banks will increase asset holdings. Moreover, they will maximize the amount of depository funding and minimize the amount of equity funding.

Bank profits are represented by:

$$\Pi_t^{tb} = (1 + i_t^{f,tb})B_t^{f,tb} + (1 + i_t^{r.tb})B_t^{r,tb} - \Xi_t^{tb} - i_t^{q,tb}Q_t^{tb} - i_t^{m,tb}(M_t^{tb} + M_t^{tb,x}) = 0, \tag{13}$$
$$\Pi_t^{sb} = (1 + i_t^{f,sb})B_t^{f,sb} + (1 + i_t^{r,sb})B_t^{r,sb} - \Xi_t^{sb} - i_t^{q,sb}Q_t^{sb} - i_t^{m,sb}(M_t^{sb} + M_t^{sb,x}) = 0, \tag{14}$$

which we set equal to zero to ensure that all excess returns off-steady state accumulate to equity holders.

Closure

The real side of the model is closed by imposing goods market equilibrium. Total production is equal to consumption, investment and lump-sum Central Bank consumption equal to the deposit premium paid by traditional banks:

$$Y_t = C_t^p + C_t^i + I_t + D_t \tag{15}$$

Prices are perfectly flexible and accordingly there is no role for conventional monetary policy to attenuate macroeconomic fluctuations.

[9] I assume that $\pi_b > \left(\frac{k_t^{r/f}}{(1-(1-P(u|L)-P(d|L)))k_t^{r/f}}\right)(P(u|L)\pi_g + P(d|L)\pi_d)$ as the gain from the positive signal $S' = H$ must be larger than the liquidation outcome otherwise the bank would liquidate rather than wait for the outcome of the project, even if the signal of the world is positive.

Housing supply is fixed at an arbitrarily level $\bar{H}$:

$$H_t^s = \bar{H}\epsilon_t^h \tag{16}$$

where ϵ_t^h denotes a housing supply shock $\epsilon_t^h = e^{\eta_t^h}$, where $\eta_t^h = \rho^h \eta_{t-1}^h + \varepsilon_t^h$ and ε_t^h is an i.i.d.$\sim (0, \sigma^h)$.

Finally, I assume foreign money demand takes the same functional form as the domestic money demand equation, but without any of the endogenous variables. All endogenous variables, except for the domestic deposit rate, are set a constant level lumped in a fixed value $\bar{\vartheta}$. The domestic interest rate provides feedback as an increase in foreign money demand reduces the domestic interest rate which attenuates the increase in foreign money demand. Moreover, foreign money demand is equally spread over shadow banks and traditional banks:

$$M_t^{tb,x} = (1 - \epsilon_t^m)\bar{\vartheta}\log(1 + i_t^{m,i}), \tag{17}$$

where ϵ_t^m denotes a foreign money demand shock, i.e., a savings glut, $\epsilon_t^m = e^{\eta_t^m}$, where $\eta_t^m = \rho^m \eta_{t-1}^m + \varepsilon_t^m$ and ε_t^m is an i.i.d.$\sim (0, \sigma^m)$.

Which bank will do what investment?

The expected liquidations costs are determined by the opportunity costs of traditional banks conditional on a pessimistic signal of the world and on the depth of the interbank market for mortgages or corporate loans, see Stein (2012) and Hanson et al. (2015).

The opportunity costs of traditional banks conditional on the realization of a pessimistic signal are endogenously determined in the model. At time t the expected return on a loan is equal to $E_t\{i_{t+1}^e\} = E_t\{i_{t+1}^f\}$. In case a signal about the future state of the world is pessimistic ($S' = L$) the expected return falls to $E_t\{r_{t+1|S'=L}^f\} = E_t\{r_{t+1|S'=L}^e\}$. Since, $\pi_s > \pi_{s|S'=L}$, we know that $E_t\{r_{t+1}^f\} > E_t\{r_{t+1|S'=L}^f\}$ and $E_t\{r_{t+1}^e\} > E_t\{r_{t+1|S'=L}^e\}$. As the contract is predetermined at the beginning of period t, both traditional and shadow banks expect to make a loss on the loans (the reverse holds when a signal about the future state of the world is positive). However, only shadow banks need to liquidate these, in expectation, negative net present value assets. Traditional banks will buy these assets if the price of the loans falls sufficiently. Specifically, the price falls until traditional banks are indifferent between buying shadow bank assets and new lending which yields a zero return in expectation.

Also the depth of the interbank market determines the liquidation discount. In fact, market liquidity is dependent on the size of the individual bank's investment in the asset relative to the total market. However, in a representative bank setting the number of bank is indeterminate and therefore I use market depth as a proxy. The liquidation costs per unit of investment is therefore specified by:[10]

$$k_t^\iota = (1-\chi)\left(\frac{r^\iota_{t|S'=L}}{r^\iota_t}\right)\varphi^\iota(B^\iota_t), \tag{18}$$

where χ specifies the DGS costs for traditional banks and $\varphi^{\iota'}(\cdot) > 0$ and $\varphi^{\iota''}(\cdot) < 0$ are functions that specify market liquidity of corporate loans and mortgages which is dependent on the depth of the market. In the limit, i.e. the depth of the market goes to infinity, $\lim_{B_t^\iota \to \infty}\{\varphi^\iota(\cdot) = 1\}$, no liquidity discount is added and the expected price of the asset equals its fundamental value. Absent a market for the asset, $\lim_{B_t^\iota \to 0}\{\varphi^\iota(\cdot) = 0\}$, such that $k_t^\iota = 0$. The difference between the fundamental value of the asset and the price for which the asset is sold could be interpreted as the bid-ask spread of the asset.

Traditional banks pay for deposit insurance costs. Shadow banks circumvent the deposit insurance costs, but must include the potential loss after liquidations. Equating the weighted average costs of capital of traditional banks and shadow banks, see Appendix A.3, it is possible to distinguish three different scenarios:

Proposition 2.1.

If $\kappa_t^e, \kappa_t^f < \frac{1}{1+\chi}$ *liquidity in interbank market for both corporate loans and mortgages is too low for shadow banks to be able to compete with traditional banks. Traditional banks supply both mortgages and corporate loans.*

If $\kappa_t^e < \frac{1}{1+\chi} < \kappa_t^f$ *liquidity in the interbank market for mortgages is deep enough for shadow banks to overcome the liquidation costs disadvantage. Traditional banks supply corporate loans while shadow banks supply mortgages.*

If $\kappa_t^e > \frac{1}{1+\chi} > \kappa_t^f$ *liquidity in the interbank market for corporate loans is deep enough for shadow banks to overcome their liquidation costs disadvantage. Traditional banks supply mortgages while shadow banks supply corporate loans.*

Liquidity externalities

The liquidation price (19) gives rise to two externalities as shadow banks take the expected liquidation discount k_t^ι as given, i.e., a shadow bank does not take into account the incremental impact it has on the value of k_t^ι. This impact is twofold. First, in equilibrium the shadow bank capital constraint binds such that shadow bank deposit creation is at its maximum attainable level. If a shadow bank increases its deposit creation, it realizes a benefit in the form of lower financing costs. However, the shadow bank also reduces, absent the market liquidity term, the value of k_t^ι because more deposits are withdrawn when a pessimistic signal realizes. Consequently, the capital constraint for all other shadow banks tightens and the private outcome does no longer correspond to the social optimal value. This market externality is carefully described in Stein (2012).

[10]It is not possible to derive an analytical solution, so I resort to numerical methods by running a parallel model that determines return to capital in the bad state of the world.

Second, when shadow banks increase credit supply for mortgages or corporate loans and thereby deposits, the depth of the market for mortgages and corporate loans increases and the capital constraint for other shadow banks loosens. Consequently, there is a positive feedback loop as more financing by shadow banks causes liquidity in the inter bank market to increase, which increases the amount of deposits shadow banks can create and the amount of investment they can finance. As shadow banks do not take into account the incremental value they have on the liquidity of the interbank market, shadow bank deposit creation is below the optimal value.

However, if shadow banks concentrate on one investment class, say mortgages, while traditional banks concentrate in the other class, say corporate loans, a realization of a pessimistic signal causes the interbank market for mortgages to dry up completely because the shadow banks sell all mortgage loans. As such the growth of a particular asset class reduces shadow banks' idiosyncratic liquidity risk with respect to this asset class, but it is easy to see how the sectors' aggregate liquidity risk increases.

2.3 Calibration

I calibrate the model to take advantage of the general equilibrium structure of the model. Table 1 specifies the parameter setting. Patient and impatient consumers have a slightly different discount factor to ensure that impatient households borrow and that patient households save. The coefficient that determines the relative risk aversion of households is set equal to unity. The inverse of the elasticity of work effort with respect to the wage rate is set equal to 2. The substitution elasticity of deposits is set equal to 10, see Christiano et al. (2005). Moreover, I set the weight of housing in the consumption bundle $(1-\eta)$ equal to 0.25. The weights of labor and money γ^l and γ^m in the utility function are used to normalize labor supply in steady state of both representative households to 0.5 and an aggregate bank balance sheet in steady state of $Q/(Q+M) = 8\%$.

The capital adjustment cost parameter $\phi = 2.5$ is set close to the value estimated by Christiano et al. (2005). The capital depreciation rate and the share of labor in the production function take their standard values of $\delta = 0.025$ per quarter and $\alpha = 2/3$. The loan-to-value parameters ζ^f and ζ^e are set equal to unity in the benchmark case.

The probabilities that a state of the world realizes and the corresponding probability of success are set such that the ex-ante expected value of $E_t(\pi_s) = 1$. The probability of success after the bad signal is equal to approximately 90% and the DGS costs are set to approximately 1% of the bank balance sheet. Housing supply is fixed to unity $\bar{H}$. The supply elasticity of foreign money demand with respect to the domestic deposit rate $\bar{\vartheta}$ equals its domestic value in steady state.

Finally, we choose the following function for the liquidation value:

$$k_t^\iota = (1-\chi)\left(\frac{r^\iota_{t|S'=L}}{r_t^\iota}\right)\varphi^\iota\left(\frac{B_t^\iota}{B_t^\iota + B_t^{\iota'}}\right), \tag{19}$$

where ι' represents the other asset. Accordingly, φ^{ι} can be used to calibrate the steady state value of k_t^{ι} for which I pick different values. In the benchmark case I set φ^{ι} to consider the three different scenarios described in proposition 2.1.

Table 1: Calibrated parameters

Parameters	Description	Value
β^p	Discount factor patient households	0.99
β^i	Discount factor impatient households	0.98
θ	Share of patient households	0.5
η	Share of housing in the consumption bundle	1/3
γ_l	Weight leisure in utility function	1
γ_m	Weight money in utility function	0.04
α	Share of labor in the production function	2/3
δ	Capital depreciation rate	0.025
ϕ	Capital adjustment costs	2.5
σ_c	Substitution elasticity consumption	-1
σ_m	Substitution elasticity money holdings	10
σ_l	Substitution elasticity leisure	2
π_g	Probability success good state	0.99
π_b	Probability success bad state	0.80
π_d	Probability success disaster state	0.10
$P(s_1 = H) = P(u)$	Probability good signal	0.90
$P(S = \pi_g \vert S' = H) = p(u \vert H)$	Probability good state if good signal	0.95
$P(S = \pi_g \vert S' = L) = p(u \vert L)$	Probability good state if bad signal	0.80
$P(S = \pi_d \vert S' = L) = p(d \vert L)$	Probability disaster state if bad signal	0.10
ρ^a	persistence parameter productivity shock	0.90
ρ^g	persistence parameter savings glut shock	0.90
μ^a	mean productivity shock	0
μ^g	mean savings glut shock	0
σ^a	S.D. productivity shock	0.1
σ^g	S.D. savings glut shock	1.0

3 Results

3.1 An increase in foreign money demand

Figure 6 shows the effect of a foreign money demand increase for three different banking sector structures. The solid line shows, as a benchmark case, a banking sector with only traditional banks $\left(\frac{1}{1+\chi} > \kappa_t^e, \kappa_t^f\right)$. The barbed line shows a banking sector in which the shadow banks have a competitive advantage over traditional banks in mortgages $\left(\kappa_t^e < \frac{1}{1+\chi} < \kappa_t^f\right)$. The circled line shows the opposite scenario in which the shadow banks have a competitive advantage over traditional banks in corporate loans $\left(\kappa_t^f < \frac{1}{1+\chi} < \kappa_t^e\right)$.

The intuition behind the reallocation result can be understood as follows. Banks hold more deposits on their balance sheet; consequently, bank leverage increases and their capital constraint tightens. To relax the capital constraint banks invest the new deposits and/or reduce the amount of deposits. Banks increase investment in both assets and reduce domestic deposits by lowering the deposit and lending rates. In doing so, the residual claim on the bank's cash flow, bank equity, increases and leverage falls.

For savers, the patient households, two forces are at play. First, arbitrage ensures that all interest rates decline. Consequently, accumulating savings is less attractive and patient households increase consumption. Second, patient households save in multiple assets. The relative gains on these assets changes because banks generate more bank equity to satisfy their capital constraint. As the return of owning a house in terms of capital gains decreases after the first period by more than the costs of buying a house in terms of foregone bank equity savings, patient households prefer to sell their house and increase their holdings of bank equity. That is, patient households rebalance their portfolio because they feel richer as their banking equity has increased. Accordingly, they sell their house.

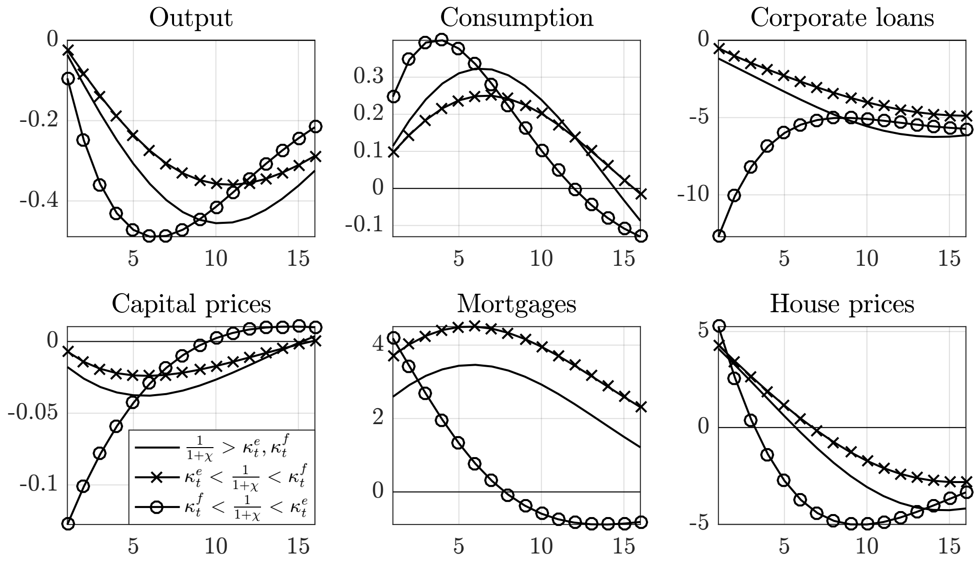
In contrast, impatient households do not own any bank equity. As lending rates decline, impatient households prefer to increase their indebtedness to buy more houses and physical capital. Also for impatient households, the net gain of holding a house decreases after the first period. However, the gain of owning a house decreases by less than the costs of buying a house: the mortgage rate. The same is not true for physical capital. As total consumption increases, labor supply falls and the wage rate rises. The increase in production costs decreases production and consequently the return on capital falls. As the return on capital falls more than the costs of corporate loans, impatient households decrease borrowing for physical capital.

In a conventional New Keynesian model, a fall in interest rate would induce more corporate lending to buy physical capital. Whereas the fall in interest rates also increases consumption and the wage rate in these models, the fall in lending rates causes lending to increase. As a result, production usually increase because the latter effect dominates. For housing demand, no direct offsetting effect is present because both the increase in consumption, as well as the fall in lending rates, increase demand for houses. As corporate funding competes directly with mortgage funding, and demand for mortgages (and therefore house prices) increases more than demand for physical capital, less funds are allocated to corporate loans. As less funds are allocated, production falls further, decreasing the return on capital which decreases production further.

3.2 Differences in financial structure

Although the economic structure of the three scenarios is similar, the impulse response functions show different results depending solely on the structure of the banking sector as specified in proposition 2.1. The solid line shows a consolidated traditional banking sector which supplies both corporate loans and mortgages. Consequently, an increase in mortgages could be allocated to both mortgages and corporate loans, but all deposits must be insured in the DGS. DGS insurance lowers the amount of funds available for investment compared to the uninsured and highly leveraged shadow banking sector.

Figure 6: Shadow banks versus traditional banks: foreign deposit demand increase



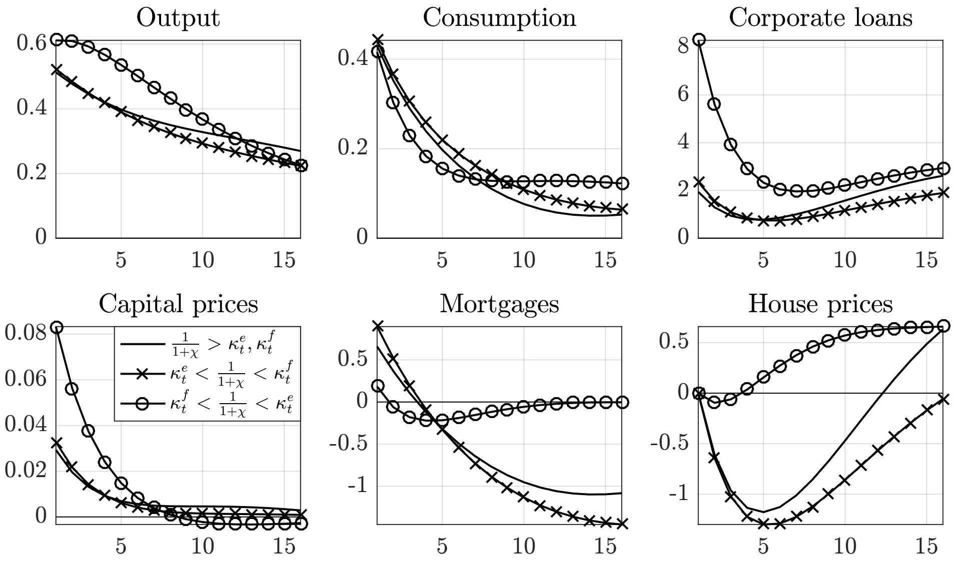
Impulse responses show an increase in foreign deposit demand of 1% of total deposits. Horizontal axis quarters.

Indeed, the barbed line shows a banking sector in which traditional banks have a competitive advantage in corporate loans while shadow banks have a competitive advantage in mortgages. When shadow banks are active, more funds are available because less deposit insurance is paid. These funds are allocated towards mortgages as shadow banks can only invest in mortgages. Consequently, the output and consumption fluctuations are attenuated. When shadow banks have a competitive advantage in corporate loans and traditional banks have a competitive advantage in mortgages, the circled line, funds available for mortgage loans decreases because traditional banks must insure their deposits in the DGS while funds for corporate loans increases as shadow banks do not insure their deposits. Consequently, the output and consumption fluctuations are amplified. Hence, the presence of shadow banks amplifies credit supply for investment in which they have a competitive advantage over traditional banks.

3.3 Productivity shock

Figure 7 shows the impulse response functions following a positive productivity shock. Productivity shocks are well understood and can be used to assess the validity of the model, while in this case the productivity shock also serves to contrast the effects of an increase in foreign money demand. Production goes up as both the marginal product of capital and labor increased. As firms would like to borrow more to buy more capital, the lending rate for corporate loans increases. The no-arbitrage condition ensures that also the rate on mortgages for impatient households increases. While the productivity shock increases the borrowing capacity of firms for corporate loans, it does not increase the borrowing capacity of households for mortgages. As a consequence, impatient household lending for mortgages decreases.

Figure 7



Impulse responses show an increase in productivity of 0.1%. Horizontal axis quarters.

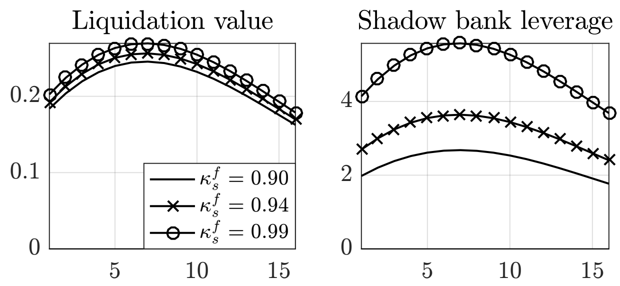
On impact the bank balance sheet expands as the drop in mortgage loans is smaller than the increase in corporate loans. Patient households are richer because the positive productivity shock has increased their income. Besides, the rise in the corporate loan rate and mortgage rate pushes the return on bank equity up. The rise in the return on bank equity increases the opportunity costs of patient household consumption. Patient households substitute consumption for housing and push house prices upwards. Patient households buy their houses one-for-one from the impatient households as housing supply is fixed. The cost of buying a house for the impatient households rises because patient households push house prices upwards and the mortgage rate has increased. As a result, a positive productivity shock increases savings and reallocates bank investment from mortgages towards corporate loans.

3.4 Market liquidity feedback

Market liquidity feedback has no real effects, but it does affect the financing structure of shadow banks. Yet, growth of the shadow banking sector relative to the traditional bank sector depends on shadow banks' competitive advantage over traditional banks. As shadow banks are prone to liquidity risk, traditional banks have a competitive advantage at holding illiquid assets while shadow banks hold relatively liquid assets. When the market for mortgage securities becomes deeper the expected liquidation loss for mortgages decreases. Shadow banks gain competitive advantage over traditional banks w.r.t. mortgage supply. As a result, shadow banks grow relative to traditional banks and increase their leverage.

Figure 8 plots the expected liquidation value κ_t^i and shadow bank leverage for three different liquidation values. When the liquidation value increases, because, shadow bank leverage

Figure 8: Foreign deposit demand increase and market liquidity feedback



Liquidity feedback such that steady state liquidation costs κ_s^f equals 0.90, 0.94 and 0.99 respectively. Horizontal axis quarters.

increases. The increase in leverage means that shadow banks can supply more credit and credit more deposits for a given amount of equity. Consequently, the market for mortgage securities becomes deeper which improves the competitive advantage of shadow banks over traditional banks with respect to mortgage supply and, thereby, it fosters relative growth of the shadow banking sector.

3.5 Loan-to-value constraints

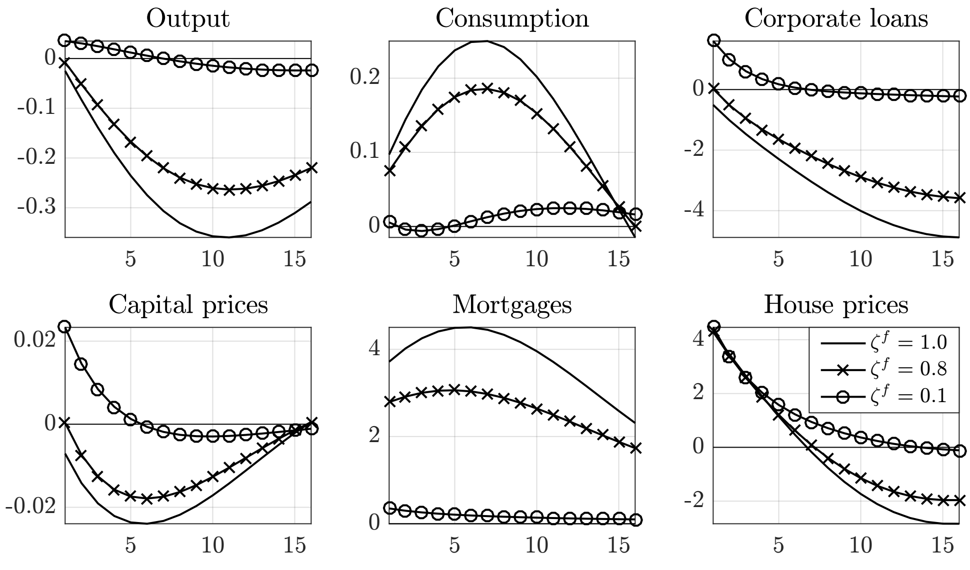
In section 3.1 I discussed which factors determine the reallocation of funds towards mortgages. As demand for houses increases by more than demand for capital, house prices increase by more than capital prices. Consequently, lending conditions for mortgage loans improve more than lending conditions for corporate loans and funds are reallocated towards the former. When funding for physical capital falls, the return to capital decreases and demand for physical capital declines further.

The economy's production capacity decreases while improvements in housing collateral support an increase in loan-to-income ratios. Recently, loan-to-value constraints have been discussed and implemented in various countries to reduce the amount of funds allocated towards mortgages. Figure 9 shows that in the model loan-to-value constraints for mortgages can attenuate and even prevent the reallocation of investment and thereby shadow banking growth. When loan-to-value ratios fall to very low levels, e.g. 10%, lending for physical capital also increases when foreign money demand increases. The intuition behind this results is as follows. When an inflow of funds cannot be allocated towards mortgages, households do not feel much richer and do not increase consumption as they would do otherwise. Hence, the loan-to-value constraint weakens the consumption boom. Consequently, wages are moderated and production does not slow down.

4 Policy implications and conclusion

The model showed that a secular decline in real interest rates could explain both the reallocation of assets from corporate loans to mortgages and growth of the shadow banking sector

Figure 9: Foreign deposit demand increase and loan-to-value constraints



Loan to value constraints at 100%, 80% and 10% respectively. Horizontal axis quarters.

relative to the traditional banking sector. Particular, positive feedback between the depth of the mortgage securities market and the shadow banks' liquidation costs fosters shadow bank growth. Consequently, shadow banks' competitive advantage over traditional banks in supplying mortgages increases such that both the share of mortgages on the aggregate bank balance sheet and the shadow banking sector grows.

The reallocation of funds towards mortgages could be destabilizing as collateral improvements support an increase in mortgage loans while total income and production fall. Moreover, a large shadow banking sector may generate financial instability because the DGS is absent which makes shadow banks prone to liquidity risk. Finally, an inflow of funds might harm long-term productivity growth when mortgage investment crowds out investment by firms in productive capital. Macroprudential regulation – like loan-to-value ratios – offer a first-line of defense for financial stability because they can attenuate the re-allocation of investment to mortgages and shadow banking growth.

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A Appendix

A.1 Appendix A

Patient Household problem Household utility function:

$$U_t^j = E_t \left\{ \sum_{t=0}^{\infty} (\beta^j)^t \varepsilon_t^j \left(\frac{((C_t^j)^\eta (H_t^j)^{1-\eta})^{1-\sigma^c}}{1-\sigma^c} + \gamma^m \frac{(M_t^j)^{1-\sigma^m}}{1-\sigma^m} - \gamma^l \frac{(L_t^j)^{1+\sigma^l}}{1+\sigma^l} \right) \right\} \tag{20}$$

Patient household budget constraint:

$$\begin{aligned} M_t^p + Q_t + q_t^h (H_t^p - H_{t-1}^p) =& (1 + i_{t-1}^m) M_{t-1}^p + (1 + i_{t-1}^q) Q_{t-1} + r_t^h H_{t-1}^p - C_t^p + L_t w_t + \\ & \theta(\Pi_t^{tb} + \Pi_t^p) \end{aligned} \tag{21}$$

Patient household Lagrangian:

$$\begin{aligned} \mathcal{L}^p =& E_0 \sum_{t=0}^{\infty} (\beta^p)^t \left\{ \varepsilon_t^p \left(\frac{((C_t^p)^\eta (H_t^p)^{1-\eta})^{1-\sigma^c}}{1-\sigma^c} + \gamma^m \frac{(M_t^p)^{1-\sigma^m}}{1-\sigma^m} - \gamma^l \frac{(L_t^p)^{1+\sigma^l}}{1+\sigma^l} \right) + \right. \\ & \lambda_t^p \Big[(1 + i_{t-1}^m) M_{t-1}^p + (1 + i_{t-1}^q) Q_{t-1} + r_t^h H_{t-1}^p + L_t w_t + \theta(\Pi_t^{tb} + \Pi_t^p) - C_t^p - I_t - M_t^p - \\ & Q_t - q_t^h (H_t^p - H_{t-1}^p) \Big] \end{aligned} \tag{22}$$

where λ_t^p is the Lagrangian multiplier associated with the patient household budget constraint. The FOC's conditions w.r.t. $C_t^p, L_t^p, H_t^p, M_t^p, Q_t$ are given by:

$$\eta C_t^{p(\eta-1)}(C_t^{p\eta}H_t^{p(1-\eta)})^{-\sigma^c} = \lambda_t^p \tag{23}$$

$$\varepsilon_t^p \gamma^l (L_t^p)^{\sigma^l} = \lambda_t^p w_t \tag{24}$$

$$\varepsilon_t^p(1-\eta)H_t^{p(-\eta)}(C_t^{p\eta}H_t^{p(1-\eta)})^{-\sigma^c} - \lambda_t^p q_t^h + \lambda_{t+1}^p \beta^p (q_{t+1}^h + r_{t+1}^h) = 0 \tag{25}$$

$$\varepsilon_t^p \gamma^m (M_t^{j,\iota})^{-\sigma^m} + \lambda_{t+1}^p \beta^p (1 + i_t^{m,\iota}) = \lambda_t^p \tag{26}$$

$$\lambda_{t+1}^p \beta^p (1 + i_t^q) = \lambda_t^p. \tag{27}$$

Rewriting the FOC's, substituting out the Lagrangian multiplier λ_t^p and setting σ^c gives the patient household Euler Equation:

$$C_t^p = E_t \left\{ \left(\frac{C_{t+1}^p}{\beta^p(1+i_t^q)} \right) \left(\frac{H_{t+1}^p}{H_t^p} \right)^{(1-\eta)} \right\}, \tag{28}$$

and patient household housing demand:

$$\frac{1}{H_t^p C_t^{j\eta}} = \left(\frac{\eta}{1-\eta} \right) \left(\frac{P_t^h}{C_t^p H_t^{p(1-\eta)}} - \frac{\beta^p (P_{t+1}^h + r_{t+1}^h)}{C_{t+1}^p H_{t+1}^{p(1-\eta)}} \right). \tag{29}$$

Impatient household Problem Impatient household Lagrangian:

$$\begin{aligned}
\mathcal{L}^i =& E_0 \sum_{t=0}^{\infty} (\beta^i)^t \Bigg\{ \left(\frac{((C_t^i)^\eta (H_t^i)^{1-\eta})^{1-\sigma^c}}{1-\sigma^c} + \gamma^m \frac{(M_t^i)^{1-\sigma^m}}{1-\sigma^m} - \gamma^l \frac{(L_t^i)^{1+\sigma^l}}{1+\sigma^l} \right) + \\
& \lambda_t^i \Big[(1+i_{t-1}^f) B_{t-1}^f + (1+i_{t-1}^e) B_{t-1}^e - (1+i_{t-1}^m) M_{t-1}^i - r_t^h H_{t-1}^i - w_t L_t^i - r_t^k K_t - \\
& (1-\theta)(\Pi_t^{tb} + \Pi_t^p) + C_t^i + I_t - B_t^f - B_t^e + M_t^i + q_t^h (H_t^i - H_{t-1}^i) \Big] - \\
& \lambda_t^i q_t^k \left[K_t(1-\delta) + I_t \left(1 - \frac{\kappa}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right) - K_{t+1} \right] + \\
& \mu_t^e \left(B_t^e - q_t^k K_t \right) + \\
& \mu_t^f \left(B_t^f - q_t^h H_t \right) \Bigg\}.
\end{aligned} \tag{30}$$

where λ_t^i is the Lagrangian multiplier associated with the impatient household budget constraint, q_t^k is the shadow value of capital associated with the capital accumulation identity and μ_t^e and μ_t^f denote the shadow value of the loan-to-value constraints. The FOC's w.r.t.

$K_{t+1}, I_t, B_t^f, B_t^e, C_t^i, H_t^i, L_t^p, M_t^p$:

$$\lambda_t^i q_t^k = \lambda_{t+1}^i r_{t+1}^k + \lambda_{t+1}^i q_{t+1}^k (1-\delta) + q_{t+1}^k \mu_{t+1}^e \tag{31}$$

$$\begin{aligned}\lambda_t^i =& \lambda_t^i q_t^k \left(1 - \frac{\kappa}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 - \kappa\left(\frac{I_t}{I_{t-1}} - 1\right)\left(\frac{I_t}{I_{t-1}}\right)\right) + \\ & \lambda_{t+1}^i q_{t+1}^k \beta^j \left(\kappa\left(\frac{I_{t+1}}{I_t} - 1\right)\left(\frac{I_{t+1}}{I_t}\right)^2\right)\end{aligned} \tag{32}$$

$$\lambda_t^i = \lambda_{t+1}^i \beta^i (1 + i_t^f) + \mu_t^f \tag{33}$$

$$\lambda_t^i = \lambda_{t+1}^i \beta^i (1 + i_t^e) + \mu_t^e \tag{34}$$

$$\lambda_t^i = \eta C_t^{i(\eta-1)} (C_t^{i\eta} H_t^{i(1-\eta)})^{-\sigma^c} \tag{35}$$

$$\lambda_t^i P_t^h = (1-\eta) H_t^{i(-\eta)} (C_t^{i\eta} H_t^{i(1-\eta)})^{-\sigma^c} + \lambda_{t+1}^i \beta^i (q_{t+1}^h + r_{t+1}^h) + \mu_t^f q_t^h = 0 \tag{36}$$

$$\frac{1}{(M_t^i)^{-\sigma^m}} = \frac{\lambda_t^i}{\gamma^m}\left(1 - \frac{1 + i_t^m}{1 + i_t^f}\right), \tag{37}$$

$$\gamma^l (L_t^i)^{\sigma^l} = \lambda_{t+1}^i W_t^i. \tag{38}$$

Rewriting the FOC's, substituting out the Lagrangian multiplier λ_t^i and setting σ^c gives the patient household Euler Equation:

$$\frac{1}{H_t^p C_t^{p\eta}} = \left(\frac{\eta}{1-\eta}\right)\left[\frac{P_t^h}{C_t^p H_t^{p(1-\eta)}} - \frac{\beta^p (P_{t+1}^h + r_t^h)}{C_{t+1}^p H_{t+1}^{p(1-\eta)}} + P_t^h \left(\frac{\beta^p (1 + i_t^f)}{C_{t+1}^p H_{t+1}^{p(1-\eta)}} - \frac{1}{C_t^p H_t^{p(1-\eta)}}\right)\right]. \tag{39}$$

Firm Problem Firm Lagrangian:

$$\mathcal{L}^f = r_t^k K_{t-1} + w_t L_t - \lambda_t^f \left(E_t(\pi_s) A_t (K_{t-1})^{1-\alpha} (L_t)^\alpha - Y_t\right) \tag{40}$$

where λ_t^f denotes firms' marginal costs which are in a competitive environment equal to the price level. As the model is real, we divide all variables by the price level and obtain the following FOC's w.r.t. K_{t-1} and L_t:

$$r_t^k = \frac{(1-\alpha) Y_t}{K_{t-1}} \tag{41}$$

$$w_t = \frac{\alpha Y_t}{L_t} \tag{42}$$

Assuming free-entry and exit, firms will enter until expected economic profits are zero. Accordingly, firm profits:

$$\Pi_t = E_t(\pi_s)(Y_t - W_t(L_t^p - L_t^i) - r_t^k K_t). \tag{43}$$

will be equal to zero.

A.2 Bank optimization problem

The bank maximizes its profits subject to its budget constraint and capital constraint:

$$\max\Bigg\{(E_t\{\pi_s\}[(1+i_t^f)B_t^{f,tb}+(1+i_t^e)B_t^{e,tb}]-i_t^{m,tb}M_t^{tb}-i_t^{q,tb}Q_t^{tb}-B_t^{f,tb}-B_t^{e,tb}-$$
$$\chi((1+i_t^f)B_t^f+(1+i_t^e)B_t^e)\Bigg\}-$$
$$\lambda_t^{tb}(B_t^{e,tb}+B_t^{f,tb}+\chi((1+i_t^f)B_t^f+(1+i_t^e)B_t^e)-Q_t^{tb}-M_t^{tb})$$
$$\mu_t^{tb}((1+i_t^{m,tb})M_t^{tb}-\pi_b[(1+i_t^f)B_t^f+(1+i_t^e)B_t^e]), \tag{44}$$

where λ_t^{tb} and μ_t^{tb} are the Lagrangian multipliers associated with the budget constraint and capital constraint respectively. The FOC w.r.t. $B_t^{f,tb}$, $B_t^{e,tb}$, M_t^{tb}, Q_t^{tb} are denoted by:

$$i_t^f=\chi(1+i_t^f)+\lambda_t^{tb}(1+\chi(1+i_t^f))+\mu_t^{tb}\pi_b(1+i_t^f), \tag{45}$$
$$i_t^e=\chi(1+i_t^f)+\lambda_t^{tb}(1+\chi(1+i_t^e))+\mu_t^{tb}\pi_b(1+i_t^e), \tag{46}$$
$$i_t^{m,sb}=\lambda_t^{tb}+\mu_t^{tb}(1+i_t^{m,tb}), \tag{47}$$
$$i_t^{q,sb}=\lambda_t^{tb}. \tag{48}$$

From the FOC's we get that the shadow value with respect to the budget constraint $\lambda_t^{tb}=i_t^{q,sb}>0$. Consequently, we know that the budget constraint holds with equality. Next we can combine the FOC w.r.t. M_t^{tb} and Q_t^{tb} to obtain: $\mu_t^{tb}=\left(\frac{i_t^{m,sb}-i_t^{q,sb}}{1+i_t^{m,tb}}\right)$. From the household problem we know that $i_t^{m,sb}<i_t^{q,sb}$ if $\gamma^m>0$, i.e., when households value money, the bank capital constraints holds with equality. Combining the FOC's we obtain:

$$i_t^f-\chi(1+i_t^f)=\lambda_t^{tb}(1+\chi(1+i_t^f))+\mu_t^{tb}\pi_b(1+i_t^f) \tag{49}$$
$$i_t^e-\chi(1+i_t^f)=\lambda_t^{tb}(1+\chi(1+i_t^e))+\mu_t^{tb}\pi_b(1+i_t^e) \tag{50}$$

We can interpreted these results as follows. Traditional banks will increase investment in either asset as long as the budget constraints and the capital constraints do not bind. It is possible to substitute the budget and capital constraints in the maximization problem to obtain:

$$\max\Bigg\{E_t\{\pi_s\}[(1+i_t^f)B_t^{f,tb}+(1+i_t^e)B_t^{e,tb}]-\pi_b[(1+i_t^f)B_t^f+(1+i_t^e)B_t^e]-(1+i_t^{q,tb})Q_t^{tb}\Bigg\}, \tag{51}$$

From this we know that as long as the return on a particular asset is larger than the costs of deposit insurance and equity, traditional banks increase investment. Hence, the capital constraint determines the amount of deposits, the credit supply curve is flat for lending rates larger than the costs of deposit insurance and equity, and bank equity is determined as the residual from the balance sheet identity.

For shadow banks the problem is similar:

$$\max \left\{ (E_t\{\pi_s\}[(1+i_t^f)B_t^{f,sb} + (1+i_t^e)B_t^{e,sb}] - i_t^{m,sb}M_t^{sb} - i_t^{q,sb}Q_t^{sb} - B_t^{f,sb} - B_t^{e,sb} \right\} -$$
$$\lambda_t^{sb}(B_t^{e,sb} + B_t^{f,sb} - Q_t^{sb} - M_t^{sb})$$
$$\mu_t^{sb}((1+i_t^{m,s})M_t^s - \nu[k_t^f(1+i_t^f)B_t^f + k_t^e(1+i_t^e)B_t^e]) \tag{52}$$

where $\nu \equiv [P(d|H)\pi_g + (1 - P(d|H) - P(d|L))\pi_b + P(d|L)\pi_d]$. The FOC w.r.t. $B_t^{f,sb}$, $B_t^{e,sb}$, M_t^{sb}, Q_t^{sb} are denoted by:

$$(1+i_t^f) = \lambda_t^{sb} + \mu_t^{sb}\nu k_t^f(1+i_t^f) \tag{53}$$
$$(1+i_t^e) = \lambda_t^{sb} + \mu_t^{sb}\nu k_t^e(1+i_t^e) \tag{54}$$
$$i_t^{m,sb} = \lambda_t^{sb} + \mu_t^{sb}(1+i_t^{m,sb}) \tag{55}$$
$$i_t^{q,sb} = \lambda_t^{tb}. \tag{56}$$

From the FOC's wrt M_t^{tb} and Q_t^{tb} we obtain again $\lambda_t^{sb} > 0$ and $\mu_t^{sb} > 0$ and so both constraints hold with equality. Substituting out the multipliers gives:

$$(1+i_t^f) = i_t^{q,sb} + \left(\frac{i_t^{m,sb} - i_t^{q,sb}}{1+i_t^{m,sb}} \right) \nu k_t^f(1+i_t^f) \tag{57}$$
$$(1+i_t^e) = i_t^{q,sb} + \left(\frac{i_t^{m,sb} - i_t^{q,sb}}{1+i_t^{m,sb}} \right) \nu k_t^e(1+i_t^e) \tag{58}$$

and similar to the traditional banking problem we obtain we can substitute the constraints in the profit function to obtain:

$$\max \left\{ (E_t\{\pi_s\}[(1+i_t^f)B_t^{f,sb} + (1+i_t^e)B_t^{e,sb}] - \nu[k_t^f(1+i_t^f)B_t^f + k_t^e(1+i_t^e)B_t^e] - (1+i_t^{q,sb})Q_t^{sb} \right\} \tag{59}$$

From this we know that as long as the return on a particular asset is larger than the expected liquidation costs and equity, traditional banks increase investment. Hence, similar to traditional banks the capital constraint determines the amount of deposits, the credit supply curve is flat for lending rates larger than the costs liquidation insurance and equity, and bank equity is determined as the residual from the balance sheet identity.

A.3 Competitive advantage

For shadow banks the weighted average costs of capital is denoted by:

$$i_t^{sb} = \frac{q_t^{sb}}{q_t^{sb} + m_t^{sb}} i_t^q + \frac{m_t^{sb}}{q_t^{sb} + m_t^{sb}} i_t^m \tag{60}$$

Using the balance sheet constraint and the capital constraint for asset ι:

$$i_t^{sb} = i_t^q + \frac{\pi_b[\kappa_t^\iota(1+i_t^\iota)b_t^\iota]}{b_t^\iota(1+i_t^m)}\left(i_t^m - i_t^q\right) \tag{61}$$

For traditional banks the weighted average costs of capital are:

$$i_t^{tb} = \frac{q_t^{tb}}{q_t^{tb}+m_t^{sb}} i_t^q + \frac{m_t^{tb}}{q_t + m_t^{tb}} i_t^m \tag{62}$$

Using the balance sheet constraint and the capital constraint:

$$i_t^{tb} = i_t^q + \frac{\pi_b[(1+i_t^\iota)b_t^\iota]}{(1+i_t^m)\,(1+\chi)\,b_t^\iota}\left(i_t^m - i_t^q\right) \tag{63}$$

Equating the shadow bank marginal costs with the traditional bank marginal costs to determine which banking sector has higher marginal costs we obtain that both banking sectors have the same marginal costs if:

$$\frac{1}{1+\chi} = \kappa_t^\iota \tag{64}$$

From this we can conclude that both banks invest in both assets if:

$$\frac{1}{1+\chi} = \kappa_t^e = \kappa_t^f \tag{65}$$

Traditional banks invest only in economic assets and shadow banks invest only in financial assets if:

$$\frac{1}{1+\chi} > \kappa_t^e \quad \text{and} \quad \frac{1}{1+\chi} < \kappa_t^f \tag{66}$$

Traditional banks invest only in financial assets and shadow banks invest only in economic assets if:

$$\frac{1}{1+\chi} < \kappa_t^e \quad \text{and} \quad \frac{1}{1+\chi} > \kappa_t^f \tag{67}$$

A.4 Idiosyncratic risk

In the main text I argued that both traditional and shadow banks will always completely diversify their portfolio if they have the opportunity. To diversify all idiosyncratic risk the intermediary must trade with other intermediaries as they are not able to completely diversify idiosyncratic risk by themselves because it is, for example, costly (see Hanson et al. (2015)). To diversify the risk of these projects, both banks trade in the interbank market. Specifically, they sell $S_t^{\iota,i}$ units of risky projects and they buy $B_t^{\iota,i}$ units of risky projects financed by other banks. Consequently, the actuarially fair priced deposit guarantee system is expressed as:

$$D_t = \Bigg[P(d)P(d|L)(1-\pi_d) + (P(d)(1-P(d|L)-P(u|L)) + P(u)P(u|H))(1-\pi_b) +$$
$$(P(u)P(u|H) + P(d)P(u|L)(1-\pi_g)]\pi_b + P(d)P(d|L)\pi_d(\pi_b - \pi_d)\Bigg] \times$$
$$\pi_b[(1+i_t^\iota)(I_t^\iota - S_t^\iota))] + P(d)P(d|L)[(1+i_t^\iota)B_t^\iota](\pi_b - \pi_d), \quad (68)$$

which says the deposit insurance premium consists of two parts. The first part calculates the probability of failure for the bank's own investment projects which are subject to both idiosyncratic and aggregate risk $(I_t^\iota - S_t^\iota)$, see Figure 5 for the probabilities of these projects defaulting. The bank also owns (potentially) diversified securities B_t^ι. These securities are not subject to idiosyncratic risk, but only aggregate. The deposit insurance in this case only needs to cover the difference between the bad and disaster state. Diversification lowers the premium paid for deposit insurance and therefore allows traditional banks to invest more in the risky asset. So, diversification allows banks to attract more deposits for a given amount of equity. Therefore traditional banks will always completely diversify their portfolio if diversification costs are sufficiently low.

Shadow banks do not gain directly from diversification. The shadow bank capital buffer constraint is specified by.

$$[P(u|L)\pi_g + (1-P(u|L)-P(d|L))\pi_b + P(d|L)\pi_d][k_t^\iota(1+i_t^\iota)(I_t^\iota + B_t^\iota - S_t^\iota)] \geq (1+i_t^{m,s})M_t^s, \quad (69)$$

from which we learn that shadow banks do not gain directly from diversification as it does not impact the fundamental value of the asset. It is best to read the participation constraint as a "worst case scenario outcome" which is the occurrence of a pessimistic signal. Diversification does not matter as it does not allow shadow banks to create additional risk-free debt claims. However, shadow banks liquidate all their assets in case a signal about the future state of the world is pessimistic. Traditional banks buy these assets, but only if the price of the securities falls until the marginal return on the loans sold by the shadow banks is equal to the marginal return on new investment in physical capital times the insurance costs:

$$k_t^\iota = (1-\chi)\left(\frac{r^\iota_{t|S'=L}}{r_t^\iota}\right)\varphi^\iota(B_t^\iota), \quad (70)$$

where χ is the DGS premium. It is evident from (69) that χ is larger if the shadow banks sell non-diversified assets. Consequently, the liquidation discount will in expectation be higher when shadow banks have a non-diversified portfolio. For this reason, also shadow banks diversify their portfolio completely when diversification costs are sufficiently low.

If we assume a symmetric equilibrium (all banks are alike), $S_t^{f,i} = B_t^{f,i}$ and $S_t^{e,i} = B_t^{e,i}$ so we can conclude that $I_t^{f,i} = S_t^{f,i} = B_t^{f,i}$ and $I_t^{e,i} = S_t^{e,i} = B_t^{e,i}$ and we obtain the completely diversified optimization problem stated in the main text.