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Shadow Bank run, Housing and Credit Market: The Story of a Recession

Hamed Ghiaie

UNIVERSITÉ de Cergy-Pontoise

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Abstract

This paper proposes a DSGE model with bank runs which improves Gertler and Kiyotaki (2015) to assess the impact of housing and credit markets in financial instability and shadow banking activities. This paper illustrates that a negative TFP shock is amplified by macro-financial and macro-housing channels through household's balance sheet, bank's balance sheet and liquidity channels. If the shock makes the shadow banking system insolvent, two equilibria, no-run and run equilibrium, coexist. In this view, run is a sunspot coordination failure; if households receive a negative signal from fundamentals and stop rolling over deposits to the financial sector, banks are not able to fund their losses by new deposits. So they are forced to liquidate their assets at an endogenous fire sale price. The main finding of this paper is that the model with housing comprehensively details the consequences of economic crises, namely home price double-dip, the output downward spiral and lengthy recovery period. In addition, the paper indicates that macroprudential policy tools in the form of capital adequacy buffers and loan-to-value ratios can be helpful for eliminating bank-run equilibrium. They safeguard the economy against extreme busts and help mitigate systemic risks by insulating asset prices.

JEL classification: E23, E32, E44, G21, G33 .

Keywords: Shadow banking, Bank run, Recession, Sunspot equilibrium, Double-dip.

1 Introduction

This paper outlines a DSGE model of financial instability for the purpose of assessing the impacts of housing on financial accelerator mechanisms and shadow financial institutions. The key questions addressed by this paper are: *i*) What is the role of the housing and credit markets in exacerbating financial distresses? *ii*) What are the significant channels through which shocks are amplified and propagated into the economy? and *iii*) does regulating shadow financial

*Department of Economics, Université de Cergy-Pontoise, Cergy-Pontoise, Ile de France, France.Email : hamed.ghiaie@u-cergy.fr

institutions provide mechanisms to mitigate the procyclicality and the amplitude of fluctuations? To answer these questions, this paper incorporates shadow financial intermediary agents, lender and borrower households, housing and credit markets, goods and capital producers. The model of this paper is calibrated using data pertaining to the US economy.

This paper is designed to improve Gertler and Kiyotaki (2015) (hereafter, GK). GK's model focuses on the liability side of bank's balance sheet and successfully identifies the sunspot phenomenon[1] of shadow bank runs. However, housing, mortgages and financial malfunctions, in the asset side of bank's balance sheet, were at the core of the recent recession[2]. This paper contributes to the literature by focusing on financial frictions between bankers and borrowers. This includes the role of housing frictions, house prices and the credit market. GK's model incorporates three agents: lender households, shadow banks and firms. These agents are connected through two types of goods: capital and non-durable goods. This paper improves GK's model by introducing a third asset, housing, and a fourth agent, borrower households, to the basic features of GK's shadow banking system[3]. In this manner, the financial agents' assets are composed of capital lent to the productive sectors, and credits demanded by households. Although simple models help to conceptualize the problem, they jeopardize the results by underestimating the impact of shocks and overlooking influential channels.

The main finding of this paper is that by introducing housing and credit market into the literature the model is able to capture the important features of crises such as the home price double-dip, output downward spiral[4], and lengthy recovery period. The explanation of these features are in following paragraphs.

This paper finds that the house price double-dip is an event which occur by banking recovery activities. Recession literature e.g. Giri et al. (2016), Koo (2014) and Marelli and Signorelli (2017) clarifies the concept of the economic double-dip, however the double-dip in house prices remains unexplored. The US data[5] shows the double-dip in the house price in 2010, two years after the crisis. This paper indicates that financial intermediary agents are primary in forming the house price double dip. The mechanism of double dip is as follows. The first shoot occurs during the crisis mainly due to a fall in mortgages and then a fall in borrowers housing demand. After the crisis, house prices are low so the demand by lender households is high. This increases the price i.e. the price start to recover. The higher house price relaxes collateral constraints and consequently, increases mortgage demands. Banks are in the recovery period so they need more deposits to answer the mortgage demands and accumulate more net worth. The high deposit demand by banks reduces lenders' housing demand and reduces the house prices one more time

[1]See Diamond and Dybvig (1983), Benhabib and Farmer (1999) and Farmer (2015) and self-fulfilling debt crisis literature: Cole and Kehoe (1996), Jeanne and Masson (2000) and Cole and Kehoe (2000).

[2]The asset side of bank's balance sheet is also the primary source of frictions in normal times, when marco-prudential in under control. See Christiano (2017).

[3]Market-based financing as some authorities prefer to call it.

[4]The continues decrease in output even after the shock. See Eichengreen (2004).

[5]See the S&P/Case-Shiller Home Price Index 2011, Harding (2011) and https://www.economist.com/blogs/dailychart/2010/12/house_prices

after the crisis.

This paper illustrates that the major factors in causing the shocks in output to persist (i.e. output downward spiral after the crisis) are financial frictions as well as frictions in capital investments. The mechanisms involved in this persistence are as follows. Two channels amplify a TFP shock into the economy: *i*) household balance sheets: a negative TFP shock shrinks the lender and borrower's wealth (firstly from a reduction in wage and the capital return, secondly from housing value). The contraction in the lender's wealth reduces deposit rollovers. This exacerbates banks' financing-ability and leads banks to distresses. In addition, the sagged borrower's wealth reduces the borrower's house demands, tightens collateral constraints and consequently reduces banks' assets. All theses affect capital investments and output. *ii*) bank balance sheets: a negative TFP shock affects the economy through both sides of bank's balance sheet and the asset liquidity. In the liability side, high leveraged banks cannot absorb more leverage due to financial constraints. This limits the ability of the bank to pay off its liabilities by new deposits. As a result, banks are forced to deleverage. In the asset side, by facing the deterioration of asset value, banks are obliged to decrease capital investment as well as credit. The cut back in investments causes a vicious circle in capital and output. This ignites an output downward spiral. The cut back in credit effects the borrower's house demand and has an adverse effect on house prices. This channel reinforces the the borrower balance sheet's impact which is explained above.

Finally, by comparing two equilibria i.e. no-bank run and bank run equilibrium, this paper finds that the financial collapse (or i.e. bank run) puts a major delay on recovery. The reasons are threefold. First, the financial collapse always comes with an asset fire sale. In other words, at the period of the run, banks liquidate all their assets. As a result, the excess capital supply remarkably reduces capital prices. The low asset prices, in addition, have impact on household wealth. All these effects put a delay on recovery. Second, the financial collapse negatively impacts the credit and housing markets. When the financial collapse occurs, the financial sector closes its door for one period. As a result, there is no credit market. This extremely impacts the housing market and delays recovery. Third, the financial collapse increases the cost of production. When the financial sector is shut down, households hold all capital. As they should pay management cost for holding capital, the production is more costly. This, in turn, affects output and recovery.

Considering the significance of the shadow banking system and its run-like behavior[6] during the recent recession, this paper models the financial agents in the form of market-based financing institutions. These shadow financial institutions do not adhere to formal banking regulations. There is only an incentive compatibility constraint which limits the bank's ability to raise liabilities. This constraint is created by the rationality of lenders. This agency problem markedly differentiates between traditional and shadow banking systems. The traditional banks are sup-

[6] See Christiano et al. (2017) and Adrian and Liang (2016).

posed to The regulatory constraints which are suggested in international regulatory frameworks by committees such as the Basel. These regulations are extensively studied in the literature e.g. Elenev et al. (2017), Rampini and Viswanathan (2017),He and Krishnamurthy (2013), Iacoviello (2015) , Brunnermeier et al. (2012) and Perri and Quadrini (2014). The financial sector adopted by this paper is standard and widely investigated in the literature, in particular, Gertler et al. (2010), Gertler and Karadi (2011), Gertler et al. (2012), Occhino and Pescatori (2014), Quadrini (2017) and Gertler et al. (2016a). The banking sector modeled here correspond best to the shadow banking sector which was at the core of the instability of the 2008 financial crisis. To do so, following Gertler and Kiyotaki (2015), the other types of financial intermediaries are excluded from this modeling because the nature and the possibility of their run is extremely different with the shadow banking sector. For instance, commercial banks, due to tight regulations and bank reserves at the central bank, are not supposed to the same type of run as that of shadow banks.

This paper finds that a proper marcoprudential policy tool is able to remove bank-run equilibrium. to do so, this paper assesses the supervision of both the bank and borrower balance sheets by introducing Capital Adequacy Ratio (CAR) à la Ghilardi and Peiris (2016) and caps on the Loan-To-Value (LTV) ratio à la Claessens et al. (2013) on financial stability. The share of shadow banking in the U.S. mortgage market as a whole increased to 38% in 2015, compared to 14% in 2007[7]. The debate on how to regulate these entities remains a controversial issue[8]. The impact of macroprudential policy tools in mitigating systemic distortions is wildly explored[9]. These policy tools control either bank balance sheets, borrower balance sheets or the liquidity of the banking sector[10].

This paper finds that the CAR increases the financial stability by insulating the bank's asset price. The CAR control carries out a countercyclical capital buffer. In this policy, shadow banks are obliged to withhold a certain ratio of their net worth over productive assets. This protects the economy by ensuring that the shadow banks have enough cushion to absorb temporary losses and pay off their obligations. This mitigates, as well, the insolvency risk. This helps banks facing a shock to modestly recapitalize without defaulting or causing panic[11]. Furthermore, the cap on the LTV reduces mortgage issuance and gives more leverage to banks for investing in capital. In

[7]See Buchak et al. (2017).

[8] To see the fragility of the shadow banking system before, during and after crisis please see https://www.federalreserve.gov/newsevents/speech/tarullo20120612a.htm at the conference on Challenges in Global Finance, Federal Reserve Bank of San Francisco. In addition, Collier (2017) describes the importance of shadow banking and the potential for systemic collapse in the current world economy especially in the biggest economies like the US and China.

[9]To have a comprehensive overview in theoretical and empirical researches on macroprudential policy tools, see Galati and Moessner (2017).

[10]See Laeven et al. (2016), Brown et al. (2016) and Brunnermeier and Sannikov (2014).

[11]Panics are one reason of bank runs. They act as an extrinsic random variable i.e. a sunspot which can firstly, make a bank run equilibrium feasible and secondly, shift the economy from the no-bank run equilibrium to the bank run equilibriumSee Diamond and Dybvig (1983) and Chen and Hasan (2008).

this regard, the cap on the LTV performs the same role as CARs. This is empirically confirmed in the literature e.g. Moreno (2011) and Cerutti et al. (2015).

This paper is organized as follows: Section 2 presents the model. Section 3 calibrates the parameters used as per the US data. Section 4 simulates the recession with and without a bank run. Section 5 outlines the effectiveness of countercyclical macroprudential policies and their protective mechanisms. Section 6 offers a conclusion on the findings of this paper.

2 Model

The model incorporates households, the financial and the production sector. There is a continuum of measure unity of each type. Households are either lenders or borrowers. The lender households consume, accumulate housing and capital. They, also, raise deposits in the financial sector.[12]. The borrowers consumes and accumulate housing by getting credits from the financial sector. Credits are subject to a collateral constraint. The financial sector is in the form of shadow banking. The financial sector issues credits and has its own capital. Finally, the firms use productive assets borrowed from the lender households and the bankers to produce non-durable goods.

2.1 Lender Households

The lender's problem[13] is

$$\begin{aligned}
\text{Max} \quad & E_t \sum_{\tau=t_0}^{\infty} \beta_P^{\tau-t_0} \{(1-\varphi_c)\log(C_\tau^P - \varphi_c C_{\tau-1}^P) + \varphi_h \log h_\tau^P + \varphi_l \log(1-l_t^P)\} \\
& s.t. \\
& C_t^P + D_t + p_t^h(h_t^P - h_{t-1}^P) + p_t^k(K_t^h - (1-\delta_k)K_{t-1}^h) + f(K_t^h) + (1-\sigma)N^n \leq \\
& w_t^P l_t^P + (1+r_{t-1})D_{t-1} + r_t^k K_{t-1}^h \qquad (2.1)
\end{aligned}$$

where t presents time. $\beta_P < 1$ is the discount factor , C_t^P is consumption, h_t^P is the housing asset of the lender household and l_t^P is the labor supply. φ_h and φ_l are the coefficients which represent the relative importance of housing and leisure in the utility function, respectively.

Every period, the lender engages in the following activities: consuming non-durable goods, depositing safe assets D_t to the banking sector, buying and selling housing at the house price p_t^h, investing in capital at the price p_t^k and working at the firms with wage w^P. r is the interest

[12] Cross sectional and over time analysis indicates the homogeneity of banks' liability structures: banks are almost financed by deposits. See Hanson et al. (2015). Shadow financial institutions are engaged with short-term debts and securitization.

[13] This type of utility function is known in literature. See Iacoviello (2015).

rate on the deposit and r^k is the one-period return on capital. K_t^h is capital held by the lender. The household bears a convex managing cost $f(K_t^h) = \frac{\alpha_k}{2}(K_t^h)^2$, $\alpha_k > 0$.

N^n is the donation of the household to perform new banks in the case of bank failure. The probability of a failure is $1 - \sigma$, i.i.d. This case will be explained in the bank section.

The Lagrange multiplier of lenders is the result of the first order condition with respect to consumption,

$$\lambda_t^P = \frac{1 - \varphi_c}{C_t^P - \varphi_c C_{t-1}^P} \tag{2.2}$$

The FOC with respect to the lenders' housing asset, deposit and capital, respectively, are

$$p_t^h = \frac{\varphi_h}{\lambda_t^P h_t^P} + \beta_P \mathbf{E}_t \frac{\lambda_{t+1}^P}{\lambda_t^P} p_{t+1}^h \tag{2.3}$$

$$1 = \beta_P \mathbf{E}_t \frac{\lambda_{t+1}^P}{\lambda_t^P}(1 + r_t) \tag{2.4}$$

$$p_t^k + f'(K_t^h) = \beta_P \mathbf{E}_t \frac{\lambda_{t+1}^P}{\lambda_t^P}[p_{t+1}^k(1 - \delta_k) + r_{t+1}^k] \tag{2.5}$$

2.2 Borrower Households

The borrower's problem is

$$\begin{aligned} \text{Max} \quad & E_t \sum_{\tau=t_0}^{\infty} \beta_I^{\tau-t_0}\{(1-\varphi_c)\log(C_\tau^I - \varphi_c C_{\tau-1}^I) + \varphi_h \log h_\tau^I + \varphi_l \log(1 - l_t^I)\} \\ & s.t. \\ & C_t^I + p_t^h(h_t^I - h_{t-1}^I) + (1 + r_t^b)M_{t-1} \le w_t^I l_t^I + M_t \\ & M_t \le \theta_m p_t^h h_t^I \end{aligned} \tag{2.6}$$

In order to make borrowing and lending possible for the agents, the borrower's discount factor is assumed to be less than that of the lender, $\beta_I < \beta_P$. At time t, the borrower consumes C_t^I, buys and sells housing assets h_t^I at the price p_t^h, receives mortgages M_t and pay the mortgage interest rate r_t^b. The borrower works for the firms at the wage, w_t^I and provides labor supply l_t^I. The borrower household does not accumulate physical capital nor hold any equity.

The collateral constraint restricts the mortgage to the fraction, θ_m, of the housing-asset value. θ_m is the loan-to-value (LTV) ratio. It is set by the regulatory as a macroprudential policy tool. The collateral constraint is one of the channels by which the financial sector is connected to the real economy. For instance, stricter regulation i.e. a smaller LTV lowers the consumption to income ratio[14].

[14] See Jappelli and Pagano (1994) and Chen et al. (2010).

The macroprudential constraint highlights the role of the house price in the borrower's portfolio decision. Higher house prices decrease house demands and affect consumption. On the other hand, the high house price relaxes the collateral constraint and increases available credit. This credit increase opens a new mechanism which increases spending capacity of constrained households[15]. In addition, higher house prices have a wealth effect on home owners which, again, increases the consumption capacity[16]. These contrary mechanisms impact the borrower at the same time, so the final effect is ambiguous prior to a calibration.
λ_t^I and λ_t^m are the Lagrange multipliers associated to the budget and collateral constraint, respectively. The FOC with respect to consumption is

$$\lambda_t^I = \frac{1-\varphi_c}{C_t^I - \varphi_c C_{t-1}^I} \tag{2.7}$$

the FOCs with respect to borrower's housing asset, mortgage and labor, respectively, are

$$(1 - \frac{\lambda_t^m}{\lambda_t^I}\theta_m)p_t^h = \frac{\varphi_h}{\lambda_t^I h_t^I} + \beta_I \mathbf{E}_t \frac{\lambda_{t+1}^I}{\lambda_t^I} p_{t+1}^h \tag{2.8}$$

$$1 - \frac{\lambda_t^m}{\lambda_t^I} = \beta_I \mathbf{E}_t \frac{\lambda_{t+1}^I}{\lambda_t^I}(1 + r_{t+1}^b) \tag{2.9}$$

$$\frac{\varphi_l}{1 - l_t^I} = \lambda_t^I w_t^I \tag{2.10}$$

2.3 Shadow Bankers

The bankers are responsible of shadow banking financial institutions[17]. The banker's problem is

$$\begin{aligned}
&\text{Max} \quad V_t = \mathbf{E}_t \sum_{\tau=t_0+1}^{\infty} \beta_B^{\tau-t_0}(1-\sigma)\sigma^{\tau-t_0-1} c_\tau^b \\
&\quad s.t \\
&\quad \text{Pro}\simeq \sigma \begin{cases} n_t = n_t^l = (r_t^k + (1-\delta_k)p_t^k)k_{t-1}^b + (1+r_t^b)m_{t-1} - (1+r_{t-1})d_{t-1} \\ c_t^b = 0 \end{cases} \\
&\quad \text{Pro}\simeq 1-\sigma \begin{cases} n_t = n^n \\ c_t^b = n_t^l \end{cases} \\
&\quad p_t^k k_t^b + m_t = d_t + n_t \\
&\quad \theta_b(p_t^k k_t^b + m_t) \leq V_t \quad \text{where } 0 < \theta_b < 1
\end{aligned} \tag{2.11}$$

[15]See Muellbauer and Lattimore (1995) and Cheng and Fung (2008). The housing wealth acts as buffer stock. Buffer stock is a supply of inputs held as a reserve to safeguard against unforeseen shortages or demands. See Carroll et al. (1992).
[16]See Christelis et al. (2015) and Cooper and Dynan (2016).
[17]The banking model here extends Gertler and Kiyotaki (2015)'s banking model to a bank granting mortgages.

where V_t is the bank's value function, β_B is the bankers' discount factor, c_t^b is the banker consumption and n_t is the total net worth of the shadow banker. There are two possibilities at the beginning of each period. First, the bank is still alive (with the probability σ). In this case, the banker pays off its liabilities and manages its net worth, $n_t = n_t^l$. Then the banker combines its net worth with new deposits d_t to operate new investments $p_t^k k_t^b + m_t$. Second, the banker fails and should leave the market (with the probability $1-\sigma$). In this case, the banker pays the liabilities and consumes all its net worth. Then, a new banker enters into the financial sector by receiving the start-up fund n^n, from lender households[18]. Thus, the banking utility function is defined as the present discounted value of banker's consumption. In both cases the bank balance sheet equates the liabilities to the assets.

The significant contrast between shadow and traditional banks arises from regulations. The last equation in problem 2.11 indicates an incentive compatibility constraint posed by the rationality of lenders restricts the liabilities of shadow banking sector. This constraint can be described by a simple agency problem.

Every period, the banker decides between operating normally or scamming. If the bank operates normally, it holds its assets and pays back the liabilities at the end of the period. If the bank chooses to scam, it sells the fraction, θ_b, of its assets in the open market, then leaves the economy. The banker is not able to sell the whole asset due to the asset illiquidity. In addition, this large financial transaction cannot be done without attracting attention. The capital constraint restricts the banker's ability to issue liabilities so that the banker's utility of the normal case is greater than the utility of the scamming case. One can see θ_b as the index of banker trustworthiness. The higher the value of θ_b, the greater the trust in the shadow banking system.

The value function is the expected present value of the next-period net worth. It is more informative to show this maximization recursively as a Bellman equation

$$V_t = \mathbf{E}_t \beta_B [(1-\sigma) n_{t+1}^l + \sigma V_{t+1}] \tag{2.12}$$

Equ. 2.12 drives the banker's *Tobin's Q*. It is the banker's value function over its net worth. Using the tobin's Q, the banker's problem can be rewritten as

$$\begin{aligned} \text{Max} \quad & v_t = \mathbf{E}_t \beta_B [(1-\sigma) + \sigma v_{t+1}] \frac{n_{t+1}^l}{n_t} \\ & \theta_b(\phi_t^d + 1) \leq v_t \end{aligned} \tag{2.13}$$

where $v_t = \frac{V_t}{n_t}$ is Tobin's Q and $\phi_t^d = \frac{d_t}{n_t}$ is the leverage ratio.

There is an arbitrage between the return on the mortgage and capital for the banker which

[18] This structure guarantees the existence of the steady state. Otherwise bankers accumulate their net worth every period, so the net worth is increasing and the aggregate net worth is not stationary. For more details on proof, see Gertler and Kiyotaki (2015) and Gertler et al. (2016a).

drives the relation between the prices,

$$\mathbf{E}_t(1+r^b_{t+1}) = \mathbf{E}_t(\frac{r^k_{t+1}+(1-\delta_k)p^k_{t+1}}{p^k_t}) \tag{2.14}$$

Considering the balance sheet and the arbitrage condition 2.14, the evaluation of net worth is

$$\frac{n^l_{t+1}}{n_t} = \frac{(r^k_{t+1}+(1-\delta_k)p^k_{t+1})k^b_t + (1+r^b_{t+1})m_t - (1+r_t)d_t}{n_t} \tag{2.15}$$

$$= s_{t+1}\phi^d_t + (1+r^b_{t+1}) \tag{2.16}$$

where $s_t = r^b_t - r_{t-1}$ is the spread between lending and borrowing rates. The first term of equ. 2.16 is the marginal profit gained by raising the deposit by one unit and the second term is the pure benefit from one unit of the net worth. From equations 2.4,2.5 and 2.14, the spread is a function of the lender management cost and the asset price

$$\beta_P \mathbf{E}_t \frac{\lambda^P_{t+1}}{\lambda^P_t} s_{t+1} = \frac{f'(K^h_t)}{p^k_t} \tag{2.17}$$

Assuming the capital constraint is binding, the Bellman equation 2.13 leads to

$$\theta_b(\phi^d_t+1) = \beta_B \mathbf{E}_t[(1-\sigma)+\sigma\theta_b(\phi^d_{t+1}+1)](s_{t+1}\phi^d_t + (1+r^b_{t+1})) \tag{2.18}$$

Equ. 2.18 describes the dynamic of the leverage ratio. The equation equates the minimum value of the marginal bank's value to the discounted marginal benefit of future operations. $s_{t+1}\phi^d_t + (1+r^b_{t+1})$ is the growth rate of the net worth.

Equ. 2.18 demonstrates the main difference between shadow financial institutions and regular banks. The leverage ratio of the regular banks is subject to regulations. The regular banks should set their activities in order to meet the regulations. The shadow financial institutions are not subject to the banking regulations. Their leverage ratio is set endogenously by the market. The equation 2.18 illustrates that the leverage ratio of a bank does not depend on its net worth or other individual characteristic. This property helps write the model in the aggregate form.

2.4 Firms

A perfectly competitive non-housing goods market is characterized by constant returns to scale. The identical firms of measure one are producing a homogeneous final good according to the Cobb-Douglas technology. The profit maximization determines factor prices. All households except bankers work for the firm with labor elasticity, ι_P, ι_I. It is assumed that $\iota_P + \iota_I = 1$.

The firm rents the capital from patient households and bankers in order to produce goods

$$Y_t = Z_t K_{t-1}^{\alpha_f}((l_t^P)^{\iota_P}(l_t^I)^{\iota_I})^{1-\alpha_f} \tag{2.19}$$

$$\Pi_t^f = Y_t - w_t^P l_t^P - w_t^I l_t^I - r_t^k K_{t-1} \tag{2.20}$$

Y is output, , $K = K^h + K^b$ is total capital in the economy, Z is total factor productivity and α_f is the output elasticity of capital. Π^f stands for the firms' profit. Factor markets are competitive. Factor prices are the result of the first order condition with respect to capital and labor, respectively

$$\alpha_f \frac{Y_t}{K_{t-1}} = r_t^k \tag{2.21}$$

$$(1-\alpha)\iota_i \frac{Y_t}{l_t^i} = w_t^i, \quad i = P, I \tag{2.22}$$

Total factor productivity Z has a stochastic nature. In the next sections, an adverse shock on this variable reduces productivity and starts a business cycle.

2.5 Capital Producers

In the economy there are perfectly competitive capital producers who produce capital subject to an adjustment cost. The capital investment by producers is i^k. The law of motion of capital is

$$[1 - \frac{\psi_k}{2}(\frac{i_t^k}{i_{t-1}^k} - 1)^2]i_t^k = K_t - (1-\delta_k)K_{t-1} \tag{2.23}$$

Capital producers buy the undepreciated part of the last-period capital from households and bankers to produce new capital. This capital is offered at price p^k to capital holders. Consequently, a producer maximizes[19] his gains as

$$E_t \sum_{\tau=t}^{\infty} \beta_P^{\tau-t} \frac{\lambda_\tau^P}{\lambda_t^P}[p_\tau^k(K_\tau - (1-\delta_k)K_{\tau-1}) - i_\tau^k] \tag{2.24}$$

the first order condition for capital production reveals the capital price,

$$p_t^k[1 - \psi_k(\frac{i_t^k}{i_{t-1}^k} - 1)\frac{i_t^k}{i_{t-1}^k} - \frac{\psi_k}{2}(\frac{i_t^k}{i_{t-1}^k} - 1)^2] + \beta_P \mathbf{E}_t p_{t+1}^k[\frac{\lambda_{t+1}^P}{\lambda_t^P}\psi_k(\frac{i_{t+1}^k}{i_t^k} - 1)(\frac{i_{t+1}^k}{i_t^k})^2] = 1 \tag{2.25}$$

[19]See Christiano et al. (2005) and Smets and Wouters (2007).

2.6 Market clearing

The leverage ratio of the bankers does not depend on individual bank specifics. So at time t, all the bankers behave in the same way. By using this feature, it is possible to describe the economy in the aggregate form. The capital letters state the aggregate variables. In the aggregate, the asset-to-net worth ratio ϕ is defined by

$$A_t \equiv p_t^k K_t^b + M_t = D_t + N_t \tag{2.26}$$

$$\phi_t \equiv A_t / N_t = \phi_t^d + 1 \tag{2.27}$$

where A is the total financial-sector asset. The aggregate net worth N is defined by

$$N_t^l = (1 + r_t^b) A_{t-1} - (1 + r_{t-1}) D_{t-1} \tag{2.28}$$

$$N^n = \varpi \overline{Y} \tag{2.29}$$

$$N_t = \sigma N_t^l + (1 - \sigma) N^n \tag{2.30}$$

where N^l is the aggregate net worth of the banking system at the beginning of period t and $(1 - \sigma)N^n$ is the aggregate household donation towards establishing new banks. To simplify the calibration and to fix the leverage ratio steady state to the target, it is supposed that the aggregate start up fund is equal to the small fraction, ϖ, of the output steady state.The aggregate bankers' consumption and the market clearing equations are

$$C_t^B = (1 - \sigma) N_t^l \tag{2.31}$$

$$H_t = h_t^P + h_t^I = 1 \tag{2.32}$$

$$K_t = K_t^b + K_t^h \tag{2.33}$$

$$Y_t = C_t + f(K_t^h) + i_t^k \tag{2.34}$$

where H_t is total housing which is normalized to one and $C_t = C_t^P + C_t^I + C_t^B$ is total consumption. Output is equal to total consumption, capital holding fees and capital investment.

A set of prices and allocations define an equilibrium so that households and banks maximize their utility functions subject to all constraints and all markets clears (markets for good, housing, labor, deposit, mortgage and capital).

3 Calibration

Table 1 presents the value of the parameters which are chosen from the US data to calculate the quarterly targets. In adherence to standard practices and maintain the comparability, a subset of parameters are taken from Gertler and Kiyotaki (2015). In the case of absence, parameters are calibrated from the very standard related literature or they are conventional and are calibrated

Table 1: Calibrated parameters (quarterly)

Parameters	Symbol	Value
Discount factors	$\beta_P, \beta_I, \beta_B$	$0.9901, 0.9877, 0.9876$
Consumption preference	φ_c	0.50
Housing preference	φ_h	0.08
Leisure parameter	φ_l	2.18
Capital depreciation rate	δ_k	0.035
Probability of survive	σ	0.96
loan-to-value ratio	θ_m	0.80
Truth index to bankers	θ_b	0.27
Coef. of start-up funds	ϖ	0.05
Coef. of capital cost function	α_k	0.0014
Elasticity of capital	α_f	0.37
Elasticity of labor	ι_P, ι_I	$0.51, 0.49$
Factor productivity SS	$\overline{Z}$	0.88
AR parameter of the shock	ρ_z	0.95
Capital investment adj. for Producer	ψ_k	2
Policy parameters	ρ_Ω, ϱ	$0.5, 3.5$

to match the long-run averages observed in the data. The calibration here is closely based on US data from 1985-2015. This information is sourced from the World Bank, the OECD, the Federal Reserve Bank, the Financial Flow Accounts and the 2011 American Housing Survey (Census Bureau).

In order to have a binding borrowing constraint in the steady state, the impatient discount factor should be set less than the weighted average of the two others. According to Gertler and Kiyotaki (2015), this setting of discount factors results in an annualized average real interest rate on deposits of 0.04 and an interest rate on loans of 0.05. The housing preference and loan-to-value ratio are calibrated to jointly match two long-run proportions: the total housing value over GDP equal to 1.3 on an annualized basis according to the Federal Reserve and the ratio of mortgage debt owed by households relative to their real estate holdings equal to 0.30 according to the 2011 American Housing Survey. The coefficient of leisure time in the utility function is calibrated to insure that the labor supply of households are approximately 30%. Consumption preference is set to 0.5 according to Iacoviello (2015). By the preference settings, the share of patient consumption on total consumption is $c^P/C = 56\%$, impatient $c^I/C = 41\%$ and banker $c^B/C = 3\%$. This is corroborated by the OECD data. In addition, consistent with the Financial Flow Accounts data and Roi et al. (2007), the ratio of quarterly consumption to housing is around 0.1. The coefficient of capital cost by lenders is set to 0.0014 in order to target the share of household capital over total capital which is equal to 30% based on Gertler and Kiyotaki (2015). The trustworthiness index to bankers, the coefficient of start-up funds to new bankers, and probability of survival are calibrated to jointly match the target of the asset-to-net worth ratio which equals 8.4 (and consequently the leverage ratio equals 7.4) according to the OECD data 1995-2015, and capital over GDP equal to 1.5 on an annualized basis according to the Federal Reserve Economic Data. The coefficient for adjustment cost for capital producers is set as per Justiniano et al. (2015). The capital depreciation rate is set to 3.5% according to Iacoviello (2015). Considering the target of capital, the interest rates and market clearings, elasticity of capital in Cobb–Douglas production function and total factor productivity are set to 0.37 and 0.88, respectively. The policy parameters come from Ghilardi and Peiris (2016).

4 Run and Recession

In this paper, the recession has a real origin. The shock to TFP exacerbates the deterioration of financial and real market conditions [20] by financial accelerator mechanisms which will be explained later in this section.

If the net worth of the shadow bank is positive, the economy has only one equilibrium. If the banking net worth gets negative, two equilibria coexist: bank run or no-bank run equilibrium. When the net worth is negative, paying off liabilities requires rolling over deposits by lenders. The decision of lender households between "still rolling over" or "stopping rolling over" deposits into the financial sector determines what equilibrium is chosen.

Rolling over deposits helps banking system pay off the liabilities by new deposits and accumulate net worth. This is the equilibrium without bank run. In the equilibrium with bank run, stopping rolling over forces the banking system to sell all its assets at the fire sale price to pay off the liabilities. In this case the run occurs because the value of the bank's assets at the fire sale price is less than the liabilities. The fire sale price might be well below the assets' intrinsic value. The price cutback depends on various elements such as the nature of the shock, bank's financial stance etc.

The equilibrium is selected by macroeconomic fundamentals and sunspots. By definition a sunspot is a non-payoff relevant signal that generates coordination on a particular equilibrium among many. While two equilibria coexist, at the same time, it is the sunspot which forms the bank run or no-bank run equilibrium[21].

The depositor recovery rate X depicts the sufficient condition for the existence of a bank-run equilibrium,

$$X_t = \frac{(r_t^k + (1-\delta_k)p_t^{k*})K_{t-1}^b + (1+r_t^b)M_{t-1}}{(1+r_{t-1})D_{t-1}} < 1 \tag{4.1}$$

where p^{k*} is the fire sale price. Expression 4.1 is equivalent to a negative net worth. As a result,

[20] See Bernanke et al. (1999) and Gertler et al. (2016b).

[21] Agents can coordinate based on the observation of the signal. Sunspots are extrinsic random variables which influence expectations. The extrinsic uncertainty caused by market psychology, self-fulfilling prophecies and panics etc can alter equilibrium outcomes.

the return on deposits is outlined by,

$$\text{The deposit interest rate} = \begin{cases} (1 + r_{t-1}) & \text{No-bank run equilibrium} \\ X_t(1 + r_{t-1}) & \text{Bank run equilibrium} \end{cases} \tag{4.2}$$

The timing of the model is as follows: the economy starts at the steady state at $t = 0$. At $t = 1$ an adverse technological shock hits the economy. This affects production, and consequently wages and the borrowing return rate. Total factor productivity Z follows $AR(1)$ process, a white noise process with zero mean and constant variance. If the shock satisfies $X_t < 1$, a bank run equilibrium exists. The bank run may occur in any period before X_t becomes greater than one. At any time t, to determine if a run occurs, as in GK's model, a sunspot can appear with a given probability: if the sunspot appears, then the run occurs and the economy follows then the "bank run" equilibrium; if the sunspot does not appear, then there is no run at t and the economy keeps following the "no bank run" equilibrium.

Figure 1 (left) presents the path for the depositor recovery rate X_t after the 5% adverse technological shock[22]. The run can happen when the depositor recovery rate is less than one.

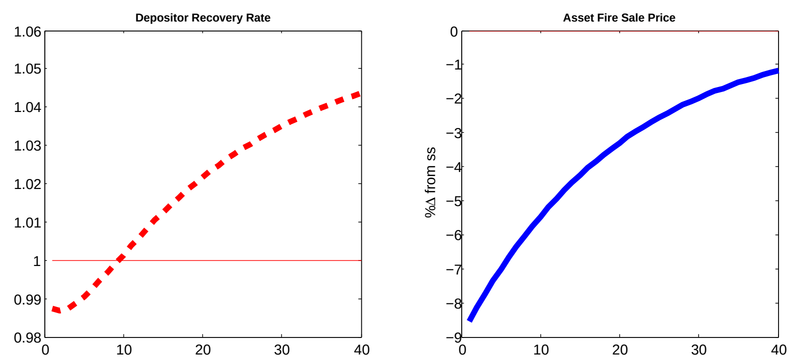

Figure 1: Bank run may happen in periods in which the depositor recovery rate (left) is less than one.

The asset fire sale price, using equ. 2.5, is

$$p_t^{k*} = \mathbf{E}_t \left[\sum_{i=1}^{\infty} \beta_P^i \frac{\lambda_{t+i}^P}{\lambda_t^P} (1 - \delta_k)^{i-1} [r_{t+i}^k - (1 - \delta_k) \alpha_k K_{t+i}^h] \right] - \alpha_k K_t^h \tag{4.3}$$

The asset fire sale price is the discounted sum of the returns minus the managing cost and taking into account the depreciation rate. Figure 1 (right) presents the fire sale price after the 5% adverse technological shock. This price is the capital price at the period of the run. So figure 1 (right) is only meaningful for the periods in which bank run is possible i.e. the depositor recovery

[22]The shock should be big-enough to make banks insolvent. Here I chose 5% adverse shock as well as Gertler and Kiyotaki (2015) to keep the comparability of the model with the model without housing. In addition, the same methodology as Gertler and Kiyotaki (2015) is used to solve and simulate the model. Starting from the end of the simulation and working backwards, the program compute the path of the economy after a run happens back to steady state.

rate is less than one. The later the run, the higher the fire sale price. Equ. 4.3 indicates three important points; first, the price depends on the household's capital holdings. The higher the volume of household's capital, the higher the marginal management cost and the lower the fire sale price. Second, it takes time until household's and bank's capital return to the steady state. The longer this process, the lower the fire sale price. Third, the price depends on the size of the shock: the more severe the adverse shock, the lower total factor productivity and the lower the expected yield. This means a lower return on capital and consequently, a lower fire sale price.

Figure 2 and 3 (dashed lines) present the paths of the aggregate variables after the 5% adverse technological shock for no-bank-run equilibrium.

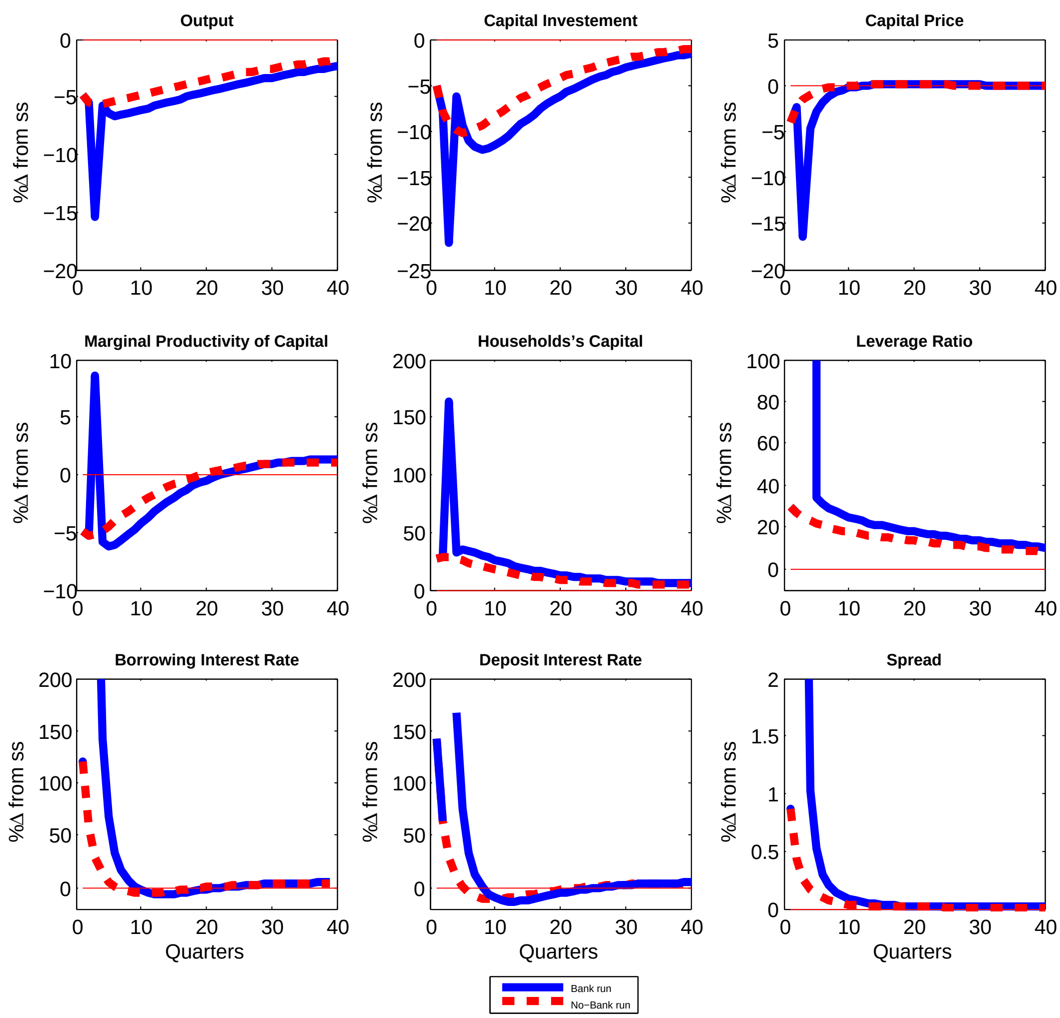

Figure 2: % change from the SS for the key variables, 5% technological shock at t=1, bank run at t=3

The explanation of the economy after the shock and before the bank run is as follows (the summary of mechanisms is depicted in figure 4). After the shock, banks suffer losses, so their net worth declines. This leads to a reduction in investment and capital prices. The drop in the capital price feeds back into lower net worth and leads to an increase in bank leverage. The reason why banks are allowed to take on more leverage is the credit spread. This financial amplification (same as in GK's model) rests on the countercyclical behavior of credit spreads. Figure 2 shows that after a negative realization of TFP, both the leverage ratio and spread increase.

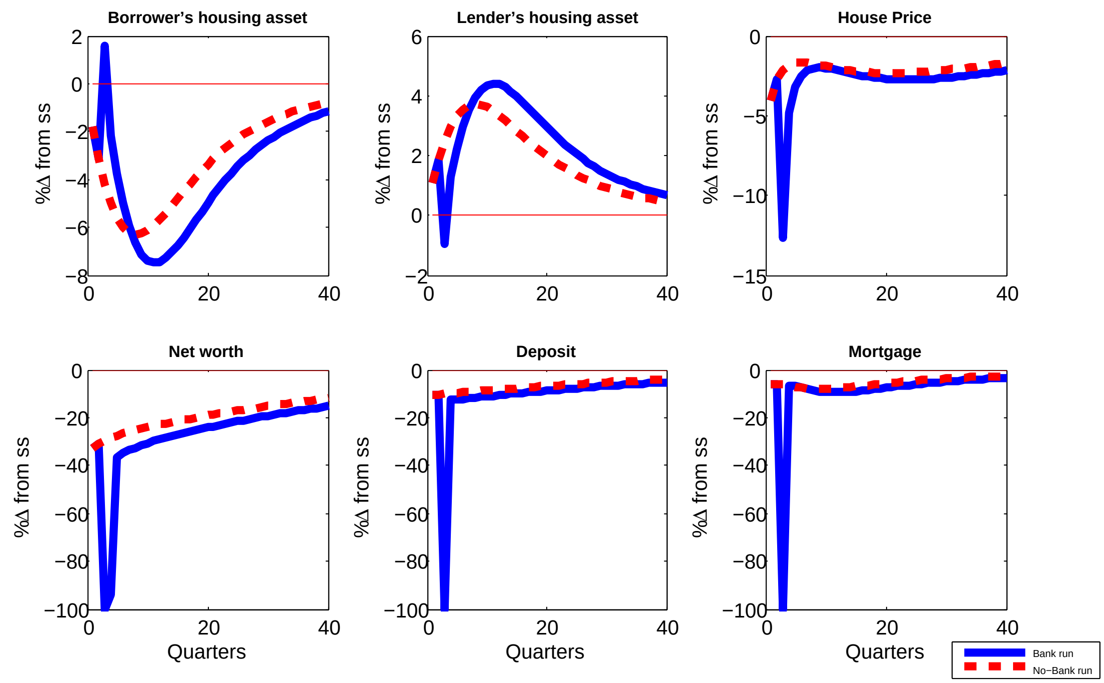

Figure 3: % change from the SS for the household and financial variables, 5% technological shock at t=1, bank run at t=3

In addition to credit spreads, before the bank run, the adverse real shock propagates into the economy of this model through two channels: *i*) The household balance sheet channel: The adverse shock reduces output as well as wages and the return on capital. This reduces the household wealth. As a result, lender households decrease their deposit and capital. In addition, borrower households reduce their housing and mortgage demand. So the house price drops. It is why lenders increase their housing. The low-price housing asset tightens the collateral constraint and therefore, again, adversely effects mortgages.

ii) the bank balance sheet channel: the shock affects both asset and liability sides. 1- the asset side: the TFP shocks reduces the marginal productivity of capital. As a result, net worth drops. In this situation, the bank has to reduce issuing credits. There is a reduction in resources available for borrowing, so there is less capital for production and less available resources for mortgages. The former caused a vicious circle between capital and output. In addition, the reduction in mortgages causes the borrowers' house demand to decline. This, consequently, decreases the house price. 2- the liability side: due to financial constraints, banks cannot pay off their liabilities by taking up more leverage. As a result, they are forced to deleverage. By deleveraging, banks sell their assets to pay off liabilities. This reduces bank's capital.

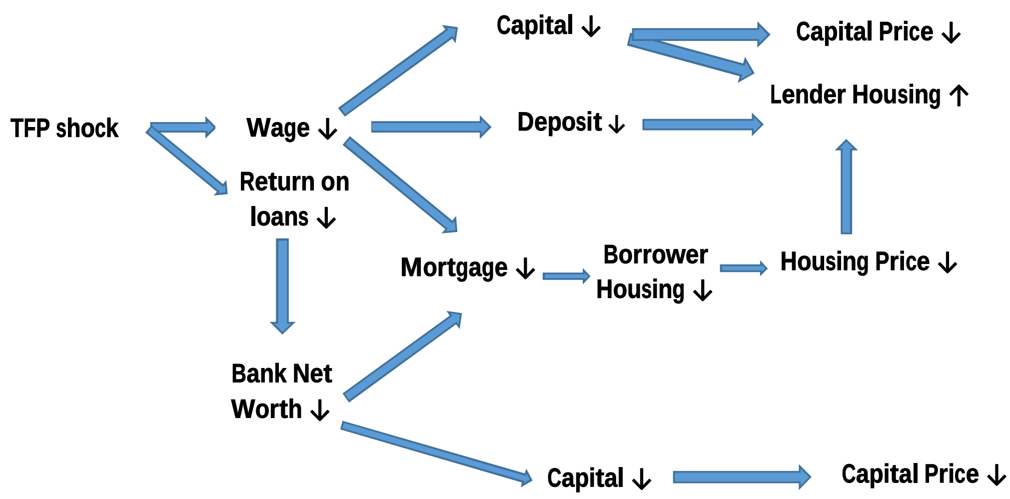

Figure 4: Mechanism of the model, after the shock before the bank run.

The bank run equilibrium is as follows. The bank run is unexpected. Hence, the behavior of the economy before the run is the same as the no-bank run equilibrium. If the sunspot determines the bank run equilibrium at t^*, banks are forced to liquidate all their assets at t^*. During the period of the systemic bank run, the intermediary sector becomes inactive. Households continue their activities without bankers. It is assumed that only one bank run occurs and there are no other bank runs after the first one. This circumstance leads to the zero balance sheet for banks at t^*: $N_{t^*} = A_{t^*} = M_{t^*} = K^b_{t^*} = D_{t^*} = 0$.

During the period of the run, lender households collect capital and invest directly. The lender's budget constraint becomes:

$$C^P_{t^*} + p^h_{t^*}(h^P_{t^*} - h^P_{t^*-1}) + p^k_{t^*}K^h_{t^*} + f(K^h_{t^*}) \leq w^P_{t^*}l^P_{t^*} + (1 + r^b_{t^*})(A_{t^*-1} + p^k_{t^*-1}K^h_{t^*-1}) \tag{4.4}$$

where $K_{t^*} = K^h_{t^*}$ indicates the total capital. At this period, borrowers do not have access to credit so they smoothen their consumption using their assets and income. The borrower's budget constraint is:

$$C^I_{t^*} + p^h_{t^*}(h^I_{t^*} - h^I_{t^*-1}) + (1 + r^b_{t^*})M_{t^*-1} \leq w^I_{t^*}l^I_{t^*} \tag{4.5}$$

At the period after the run, $t^* + 1$, the banking sector is revitalized. It uses the start-up fund provided by lender households to rebuild itself over time. In other words, the economy continues with the pre-run structure while all banks are newborn using start-up funds.

Figure 2 and 3 (solid lines) present the paths of the aggregate variables after the 5% adverse technological shock for bank run equilibrium. Here, it is assumed that the bank run occurs unexpectedly at $t^* = 3$ (the second period after the shock). No further bank runs occur after the first bank run.

The following is the interpretation of the time of bank run. When there is the run, households get all capital in the economy at the fire sale price. To do so, households reduce their housing. This, again, reduces housing prices. Note that there is no deposit for one period at t^*, because banks get inactive. Borrowers benefit the low house price and the excess supply of housing to increase their housing[23]. The summary of mechanisms at the bank run is depicted in figure 5.

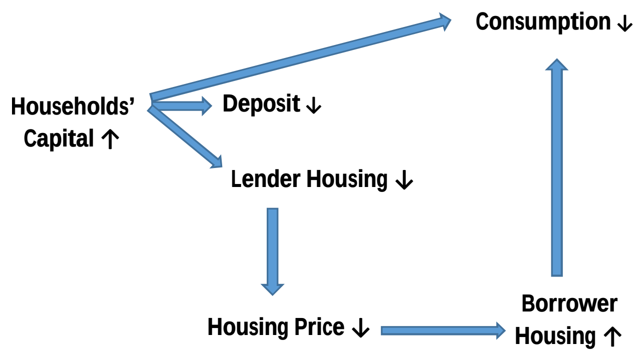

Figure 5: Mechanism of the model at the bank run.

After the run, the TFP shock monotonically retrieves to the steady state. This is not the case for the other variables in the model e.g. capital, housing and output. Due to the quick price increase after the bottom point (at the run), there is a short period of a high capital return. This leads to an *overshooting* in capital investment. This investment boom leads capital to go above the no-run case and make a peak for GDP. In addition, banks try to get back a part of their previous capital but given that the bank net worth remains depleted, the financial frictions slow down this recovery.

Figure 3 indicates an interesting point about the behavior of the house price: *the home price double-dip*. The figure shows that the home price has sagged to another low after rebounding from the shock. The US data shows the double-dip in the house price in 2010, two years after the crisis. Two mechanisms take the home price double-dip into account. First, lender's portfolio decision. The first drop in housing prices occurs during the run (explained in the previous paragraphs and figure 5). After the run, the banking system restarts its activities and retrieves capital. This gets lenders the opportunity to increase deposits and housing. As a result, the housing price increases. This relaxes collateral constraints and increases the mortgage demand.

[23]It is also the effect of the normalization of total housing supply to one, equ. 2.32.

Bank is in the recovery period, so needs to issue more loans and accumulates more net worth. To do so, bank needs more deposit. The bank's deposit demand is constrained, so bank can raise the desired amount of deposit with the low interest rate. As a result, lenders issue more deposit and reduces their housing. For this process to be the optimal decision of lenders, the return on the housing must be low. This low return is made by housing price decreased. So the housing price reduces one more time after the crisis. Lastly, the price goes back monotonically to its steady state value.

The ways in which financial collapses contribute slow recovery can be determined by comparing the run and no run equilibrium paths in figure 3. The output's path of the run equilibrium is always below that of the no run equilibrium. This means that the financial collapse poses damage on recovery. This damage is mostly made in three ways. First, the financial collapse severely reduces asset prices through the process of asset fire sale. Second, the financial collapse exacerbates housing and credit markets. Third, the financial collapse increase the production cost.

Figure 6 presents the response of aggregate variables of Gertler and Kiyotaki (2015) (the model which excludes the housing and credit markets) for the same size of TFP shock. There are four major differences between the results of this paper and GK. First, in this model, the economy exits faster from the bank runs-possible area than in the case of GK's economy. The period in which run can occur in GK's model is twice that of this paper. This is due to the absence of the credit market in the simple model. The borrowers' need to raise credit creates revenue for the banking sector which increases the bank's profitability. Second, GK's model is not able to capture the output downward spiral. This is due to its fixed total supply of capital and the fact that capital cannot depreciate. In addition, in GK's model there is no rigidity in the form of capital adjustment costs. The adjustment cost makes the shock persistence. Third, this paper simulates a lower asset fire sale price than GK's model. Indeed, housing reduces the asset fire sale price. This is because of the expansion in the lender household choices for saving. The availability of cheap houses increases lenders' housing demands. As a result, the household does not forced to only buy capital, but he can changes its portfolio depending on the trad-off between return and costs. Fourth, the output downfall in this model is more severe than GK's model. The reason for this is a contraction in borrower consumption which is due to tightening in the collateral constraint.

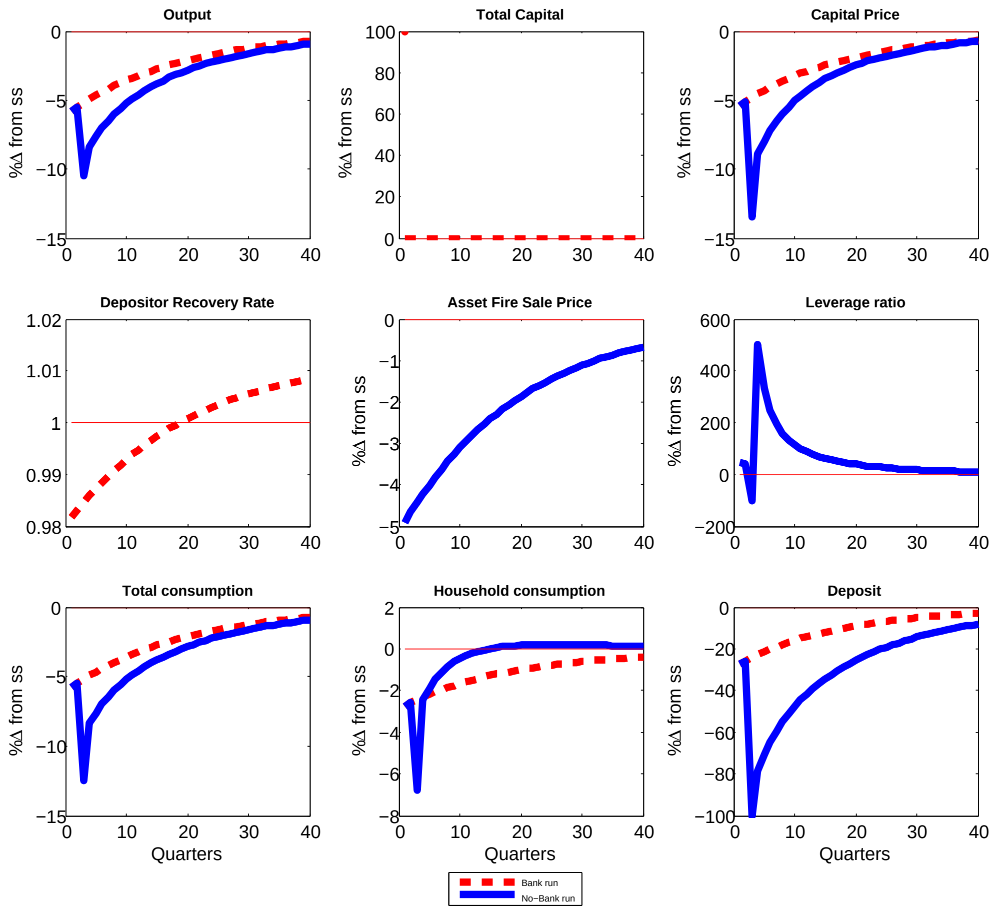

Figure 6: Aggragate changes for a 5% real shock in the model without housing and credit markets

5 Macroprudential Policy

This paper studies macroprudential policy on the bank balance sheet by introducing Capital Adequacy Ratio (CAR) and on the borrower balance sheet by the cap on the Loan-To-Value (LTV). Banks are obliged to pay a penalty if their CAR deviates from the regulatory target[24]. As a result, the bank aggregate net worth 2.30 changes to

$$N_t = \sigma N_t^l + (1-\sigma)N_t^n - \varrho(\frac{N_t}{p_t^k K_t^b} - \Omega_t)^2 \tag{5.1}$$

$$\Omega_t = (1-\rho_\Omega)\overline{\Omega} + \rho_\Omega \Omega_{t-1} + (1-\rho_\Omega)(\frac{Y_t - Y_{t-1}}{Y_{t-1}}) \tag{5.2}$$

where Ω_t is the macroprudential CAR target. This value considers only bank's capital asset and not other assets such as mortgages. This is in line with existing regulations. ϱ is the policy

[24] This modeling is standard and applied by Ghilardi and Peiris (2016).

parameter, $\overline{\Omega}$ is the steady state value of $\frac{N}{p^k K^b}$[25] and $0 < \rho_\Omega < 1$ is the parameter of the process. The growth value added to the CAR target corresponds to a countercyclical policy. It gives the flexibility to the policy to increase the target in booms and decrease it in recessions. This is in accordance with the current applied macroprudential policies recommended by Basel III.

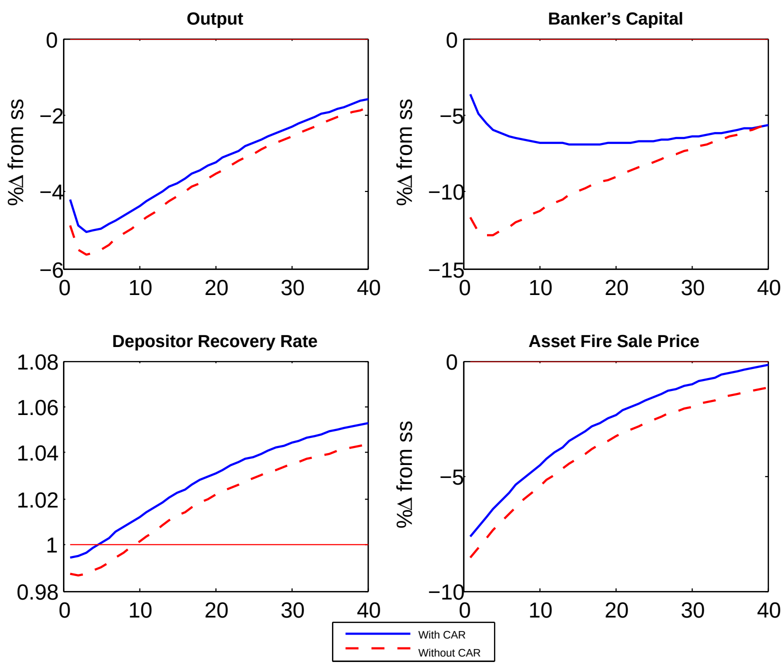

Figure 7: Impact of introducing the CAR

Figures 7 and 8 present the impact of the 5% adverse real shock in the presence and absence of the macroprudential policies. Introducing the CAR target and cutting down the LTV by 1% insulates the banks' capital assets against extreme drops. These policies increase the resilience of the financial sector and have three impacts on the economy: *i*) increasing asset fire sale prices, *ii*) regulating credits and *iii*) reducing the volatility of the real economy.

The CAR regulating policy imply that banks recover faster. This happens because the capital fire sale price is higher in this case than that of no-regulation case. The CAR insulates the capital fire sale price because it obliges the banking sector to always keep a certain amount of capital. From equation 4.3, the lower the bank's capital holding, the lower the capital fire sale price. Hence, the drop of net worth (equivalently, X) at the shock is smaller. This is of course in the price of limiting mortgages and dampening the housing market.

The LTV has the same impact as the CAR. By reducing the LTV, banks issue less mortgage, and keep more capital. This has the same as the CAR on the capital fire sale price. All these effects mitigate fluctuations in the real economy. This may impede boom-bust business cycles.

[25] $\overline{\Omega}$ is such that the steady state of the model is not modified by different value of $\overline{\varrho}$.

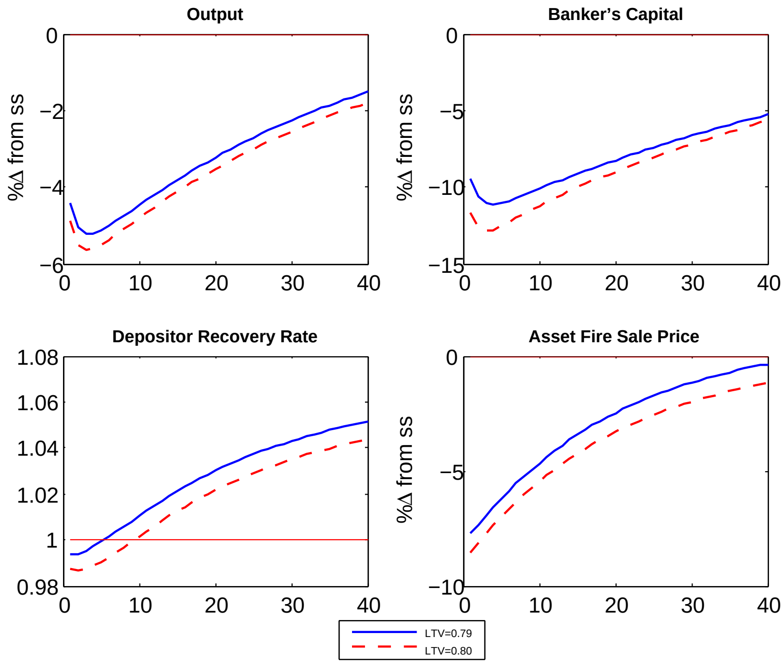

Figure 8: Impact of cutting down the LTV

The main result of this section is that given a TFP shock, there is a proper value of policy parameters (θ_m and ϱ) which eliminate the bank run equilibrium. In other words, the depositor recover rate does not get less than one after the shock. As a result, the economy passes only in the no-bank run equilibrium path. The value of these parameters are critical for 2 reasons. First, the higher the value, the lower the mortgage supply and the lower the borrowers' housing demand. Second, the proper value is highly depends on the size of the expected shock. If the shock is not close to the expectation, the proper value is not any more a good value. As a result, a policy maker, before setting a value, should pay attention to the trade-off between protecting the financial sector and the impacts on the housing and credit markets. Then the parameters should be set carefully based on the economic situation and economic targets.

6 Conclusion

This paper improves the DSGE model of Gertler and Kiyotaki (2015) to study the impact of the housing and credit markets on the stability of the economy. The model is made representative of the real economy through the introduction of two types of heterogeneous households: lender and borrower. In addition, the model incorporates the financial sector in the form of shadow banking system, goods and capital producers. The key elements of the model are stochastic financial frictions in the form of collateral constraint for the borrowers and incentive compatibility constraint for the banking sector. This paper indicates how direct linkages and associated financial channels lead to the transmission of shocks from one sector to another, and how this can be intensified by feedback loops. In addition, an assessment is made of the amendatory role of macroprudential policy tools, in particular the CAR and LTV, in safeguarding financial stability.

References

Adrian, T. and Liang, N. (2016). Monetary policy, financial conditions, and financial stability.

Benhabib, J. and Farmer, R. E. (1999). Indeterminacy and sunspots in macroeconomics. *Handbook of macroeconomics*, 1:387–448.

Bernanke, B. S., Gertler, M., and Gilchrist, S. (1999). The financial accelerator in a quantitative business cycle framework. *Handbook of macroeconomics*, 1:1341–1393.

Brown, M., Trautmann, S. T., and Vlahu, R. (2016). Understanding bank-run contagion. *Management Science*.

Brunnermeier, M. K., Eisenbach, T. M., and Sannikov, Y. (2012). Macroeconomics with financial frictions: A survey. Technical report, National Bureau of Economic Research.

Brunnermeier, M. K. and Sannikov, Y. (2014). A macroeconomic model with a financial sector. *The American Economic Review*, 104(2):379–421.

Buchak, G., Matvos, G., Piskorski, T., and Seru, A. (2017). Fintech, regulatory arbitrage, and the rise of shadow banks. Technical report, National Bureau of Economic Research.

Carroll, C. D., Hall, R. E., and Zeldes, S. P. (1992). The buffer-stock theory of saving: Some macroeconomic evidence. *Brookings papers on economic activity*, 1992(2):61–156.

Cerutti, E., Claessens, S., and Laeven, L. (2015). The use and effectiveness of macroprudential policies: new evidence. *Journal of Financial Stability*.

Chen, N.-K., Chen, S.-S., and Chou, Y.-H. (2010). House prices, collateral constraint, and the asymmetric effect on consumption. *Journal of Housing Economics*, 19(1):26–37.

Chen, Y. and Hasan, I. (2008). Why do bank runs look like panic? a new explanation. *Journal of Money, Credit and Banking*, 40(2-3):535–546.

Cheng, A. C. and Fung, M. K. (2008). Financial market and housing wealth effects on consumption: a permanent income approach. *Applied Economics*, 40(23):3029–3038.

Christelis, D., Georgarakos, D., and Jappelli, T. (2015). Wealth shocks, unemployment shocks and consumption in the wake of the great recession. *Journal of Monetary Economics*, 72:21–41.

Christiano, L. J. (2017). *Financial Frictions in Macroeconomics*, volume 0. Northwestern University.

Christiano, L. J., Eichenbaum, M., and Evans, C. L. (2005). Nominal rigidities and the dynamic effects of a shock to monetary policy. *Journal of political Economy*, 113(1):1–45.

Christiano, L. J. et al. (2017). The great recession: A macroeconomic earthquake. Technical report, Federal Reserve Bank of Minneapolis.

Claessens, S., Ghosh, S. R., and Mihet, R. (2013). Macro-prudential policies to mitigate financial system vulnerabilities. *Journal of International Money and Finance*, 39:153–185.

Cole, H. L. and Kehoe, T. J. (1996). A self-fulfilling model of mexico's 1994–1995 debt crisis. *Journal of international Economics*, 41(3-4):309–330.

Cole, H. L. and Kehoe, T. J. (2000). Self-fulfilling debt crises. *The Review of Economic Studies*, 67(1):91–116.

Collier, A. (2017). The risks of shadow banking. In *Shadow Banking and the Rise of Capitalism in China*, pages 145–169. Springer.

Cooper, D. and Dynan, K. (2016). Wealth effects and macroeconomic dynamics. *Journal of Economic Surveys*, 30(1):34–55.

Diamond, D. W. and Dybvig, P. H. (1983). Bank runs, deposit insurance, and liquidity. *Journal of political economy*, 91(3):401–419.

Eichengreen, B. (2004). understanding the great depression. *Canadian Journal of Economics/Revue canadienne d'économique*, 37(1):1–27.

Elenev, V., Landvoigt, T., and Van Nieuwerburgh, S. (2017). A macroeconomic model with financially constrained producers and intermediaries.

Farmer, R. E. (2015). Global sunspots and asset prices in a monetary economy. Technical report, National Bureau of Economic Research.

Galati, G. and Moessner, R. (2017). What do we know about the effects of macroprudential policy? *Economica*.

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

Gertler, M. and Kiyotaki, N. (2015). Banking, liquidity, and bank runs in an infinite horizon economy. *The American Economic Review*, 105(7):2011–2043.

Gertler, M., Kiyotaki, N., et al. (2010). Financial intermediation and credit policy in business cycle analysis. *Handbook of monetary economics*, 3(3):547–599.

Gertler, M., Kiyotaki, N., and Prestipino, A. (2016a). Anticipated banking panics. *The American Economic Review*, 106(5):554–559.

Gertler, M., Kiyotaki, N., and Prestipino, A. (2016b). Wholesale banking and bank runs in macroeconomic modeling of financial crises. *Handbook of Macroeconomics*, 2:1345–1425.

Gertler, M., Kiyotaki, N., and Queralto, A. (2012). Financial crises, bank risk exposure and government financial policy. *Journal of Monetary Economics*, 59:S17–S34.

Ghilardi, M. F. and Peiris, S. J. (2016). Capital flows, financial intermediation and macroprudential policies. *Open Economies Review*, 27(4):721–746.

Giri, F., Riccetti, L., Russo, A., and Gallegati, M. (2016). Monetary policy and large crises in a financial accelerator agent-based model.

Hanson, S. G., Shleifer, A., Stein, J. C., and Vishny, R. W. (2015). Banks as patient fixed-income investors. *Journal of Financial Economics*, 117(3):449–469.

Harding, R. (2011). Us home price double dip erases post-crisis gains. *Financial Times*, 31.

He, Z. and Krishnamurthy, A. (2013). Intermediary asset pricing. *The American Economic Review*, 103(2):732–770.

Iacoviello, M. (2015). Financial business cycles. *Review of Economic Dynamics*, 18(1):140–163.

Jappelli, T. and Pagano, M. (1994). Saving, growth, and liquidity constraints. *The Quarterly Journal of Economics*, 109(1):83–109.

Jeanne, O. and Masson, P. (2000). Currency crises, sunspots and markov-switching regimes. *Journal of international economics*, 50(2):327–350.

Justiniano, A., Primiceri, G. E., and Tambalotti, A. (2015). Household leveraging and deleveraging. *Review of Economic Dynamics*, 18(1):3–20.

Koo, R. C. (2014). Balance sheet recession is the reason for secular stagnation. *Secular Stagnation: Facts, Causes and Cures*, page 131.

Laeven, L., Ratnovski, L., and Tong, H. (2016). Bank size, capital, and systemic risk: Some international evidence. *Journal of Banking & Finance*, 69:S25–S34.

Marelli, E. and Signorelli, M. (2017). The double crisis in the eurozone: Recession, stagnation and high unemployment. In *Europe and the Euro*, pages 79–112. Springer.

Moreno, R. (2011). Policymaking from a'macroprudential'perspective in emerging market economies.

Muellbauer, J. and Lattimore, R. (1995). The consumption function: A theoretical and empirical overview. *Handbook of applied econometrics*, 1:221–311.

Occhino, F. and Pescatori, A. (2014). Leverage, investment, and optimal monetary policy. *The BE Journal of Macroeconomics*, 14(1):511–531.

Perri, F. and Quadrini, V. (2014). International recessions. Technical report, National Bureau of Economic Research.

Quadrini, V. (2017). Bank liabilities channel. *Journal of Monetary Economics*.

Rampini, A. A. and Viswanathan, S. (2017). Financial intermediary capital. Technical report, National Bureau of Economic Research.

Roi, M. B., Mendes, R. R., et al. (2007). *Should Central Banks Adjust Their Target Horizons in Response to House-Price Bubbles?* Bank of Canada.

Smets, F. and Wouters, R. (2007). Shocks and frictions in us business cycles: A bayesian dsge approach. *The American Economic Review*, 97(3):586–606.