Financial Business Cycles*

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PRELIMINARY AND INCOMPLETE DRAFT.

Abstract

I construct a dynamic general equilibrium model where a recession is initiated by losses suffered by financial institutions, and exacerbated by their inability to extend credit to the real economy. The event that triggers the recession is similar to a redistribution shock: a small sector of the economy – borrowers who use their home as collateral – defaults on their loans (that is, they pay back less than contractually agreed). When banks hold little equity in excess of regulatory requirements, their porfolio losses require them to react immediately, either by recapitalizing or by deleveraging. By deleveraging, banks transform the initial redistribution shock into a credit crunch, and amplify and propagate the financial shock to the real economy. In my benchmark experiment aimed at replicating key features of the Great Recession, credit losses (that is, a redistribution shock) of about 5 percent of GDP lead to a 3 percent drop in output, whereas they would have little effect on economic activity in a model where banks are just a veil.

KEYWORDS: Banks, DSGE Models, Collateral Constraints, Housing.

JEL CODES: E32, E44, E47.

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1. Introduction

I construct a dynamic stochastic general equilibrium model where leveraged banks amplify the effects on economic activity of given financial shocks. The main questions that I want to address are: (1) To what extent can arbitrary redistributions of wealth disrupt the credit intermediation process that channels funds from savers to borrowers? (2) To what extent can a disruption of the credit intermediation process cause business cycles?

The motivation for these questions comes from the empirical observation that at least two of the last three recessions in the United States (the 1990-91 recession and the 2007-2009 recession) can be ascribed to situations that involved non-repayment on part of some borrowers on the one hand, and loan losses affecting financial institutions on the other. Under this interpretation, it is hard to classify the impulse of these recessions as something that can be easily inserted or found in standard equilibrium macroeconomic models. These models either abstract from financial frictions or, when they address them, they abstract from financial intermediation. Even when financial intermediation is modeled,[1] the shock that hits the economy in these models often involves an exogenous decline in the net worth of financial intermediaries, thus being very similar to shocks that destroy the economy's capital stock.

This paper goes one step further and addresses this gap. My objective is to develop a tractable framework that studies how disruptions to the flow of resources between agents can act as an exogenous impulse to business fluctuations. To do so, I construct a simple DSGE model where financial intermediaries (banks, for short) amplify and propagate business cycles that are "financial" in nature; that is, they are originated not by changes in technology, but by disruptions in the flow of funds between different group of agents. When one group of agents pays banks back less than expected, the resulting effect is a loan loss for the bank which causes a reduction in bank capital. As a consequence, the bank can either raise new capital or restrict asset growth by cutting back on lending. If raising capital is difficult, banks reduce lending. To the extent that some sectors of the economy depend on credit, the reduction in bank credit propagates a recession.

2. The Model

The model features two household types, entrepreneurs, bankers and a representative firm. A summary of the model setup in in Figure 1.

Households work, consume and buy houses, and deposit resources into (or borrow from) a bank through one-period loans: to model heterogeneity and household credit within households in a tractable fashion, they are divided into patient savers and impatient borrowers. To fix ideas, I interpret the impatient borrowers as subprime people (subprimers from now on): the idea that I want to explore is that the original shock that hits the system starts from the decision of these agents not to repay their

[1] Notable examples in this literature are the recent papers by Gertler and Kiyotaki (2010), Curdia and Woodford (2009), and Angeloni and Faia (2009).

loans. As a whole, the household sector is a net supplier of savings to the rest of the economy.

Entrepreneurs accumulate physical capital (which they rent to a representative firm) and borrow from the bank, subject to a collateral constraint.

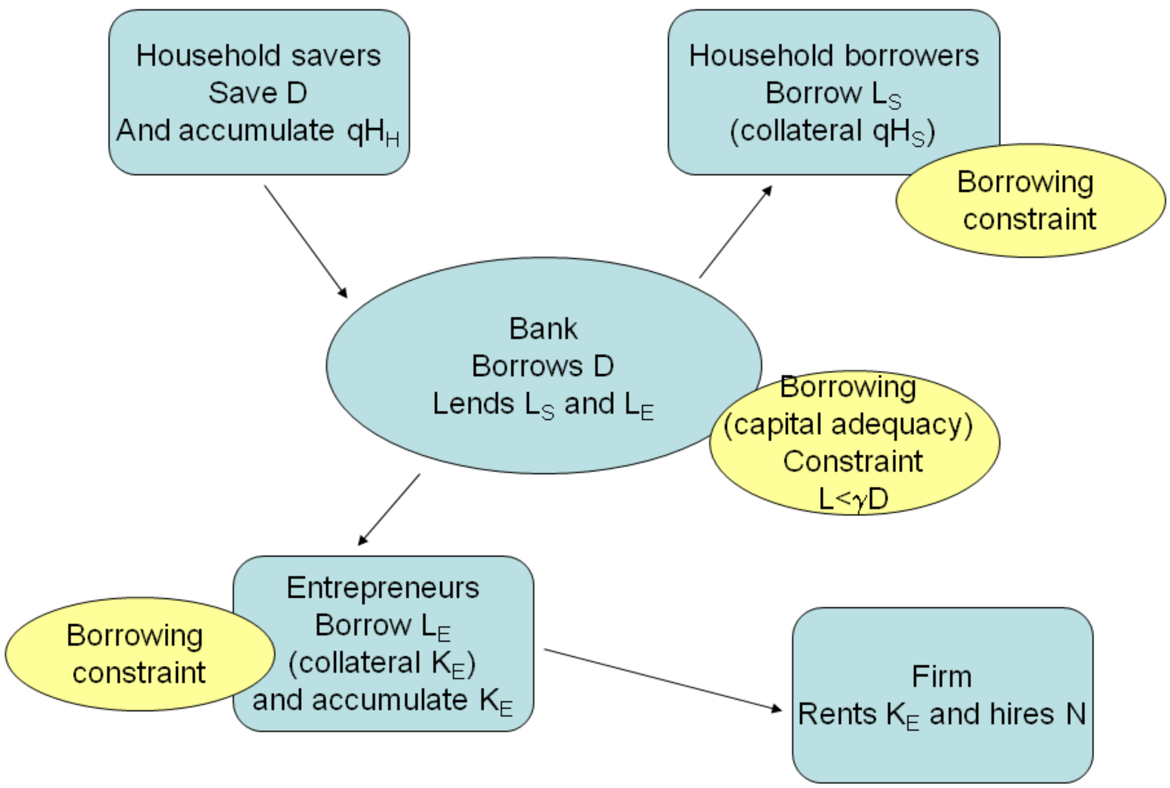

Figure 1: Summary of the Model Structure

Bankers intermediate funds between patient savers on the one hand, and entrepreneurs and subprimers on the other. The nature of the banking activity implies that bankers are borrowers when it comes to their relationship with households, and are lenders when it comes to their relationship with the credit-dependent sectors (entrepreneurs and subprimers) of the economy. I design preferences in a way that two frictions coexist and interact in the model's equilbrium: first, bankers' are credit constrained in how much they can borrow from the patient savers; second, entrepreneurs and subprimers are credit constrained in how much they can borrow from bankers. My interest is in understanding how these two frictions interact with and reinforce each other.

Finally, the representative firm converts entrepreneurial capital and household labor into the final good using a constant-returns-to-scale technology.

Patient Household Savers. There is a continuum of measure $1-\sigma$ of savers (indexed by H). They choose consumption C, housing H and time spent working N to solve the following intertemporal problem:

$$\max E_0 \sum_{t=0}^{\infty} \beta_H^t \left(\log C_{H,t} + j \log H_{H,t} + \tau \log \left(1 - N_{H,t}\right) \right)$$

where β_H is the discount factor, subject to the following flow-of-funds constraint:

$$C_{H,t} + D_t + \frac{\phi_H}{2} \left(D_t - D_{t-1}\right)^2 + q_t \left(H_{H,t} - H_{H,t-1}\right) = R_{H,t} D_{t-1} + W_{H,t} N_{H,t} \tag{2.1}$$

where D denotes bank deposits (earning a gross return R_H), q is the price of housing in units of consumption/final good, W_H is the wage rate. Housing does not depreciate, and adjustment of savings relative to the previous period requires paying a convex cost $\frac{\phi_H}{2} \left(D_t - D_{t-1}\right)^2$. This formulation implicitly assumes that households can only save through a bank (or by accumulating housing). The optimality conditions for the savers' problem yield (denoting with Δ the first difference operator) standard first-order conditions for consumption/deposits, housing demand, and labor supply.

$$\frac{1}{C_{H,t}} \left(1 + \phi_H \Delta D_t\right) = \beta_H E_t \left(\frac{1}{C_{H,t+1}} \left(R_{H,t+1} + \phi_H \Delta D_{t+1}\right) \right) \tag{2.2}$$

$$\frac{q_t}{C_{H,t}} = \frac{j}{H_{H,t}} + \beta_H E_t \left(\frac{q_{t+1}}{C_{H,t+1}} \right) \tag{2.3}$$

$$\frac{W_{H,t}}{C_{H,t}} = \frac{\tau}{1 - N_{H,t}}. \tag{2.4}$$

Subprimers (Impatient Households, Borrowers). Subprimers (measure σ, indexed by S) do not save and borrow up to a fraction of the value of their house. They solve:

$$\max \sum_{t=0}^{\infty} \beta_S^t \left(\log C_{S,t} + j \log H_{S,t} + \tau \log \left(1 - N_{S,t}\right) \right)$$

subject to the flow-of-funds constraint and the borrowing constraint:

$$C_{S,t} + q_t \left(H_{S,t} - H_{S,t-1}\right) + R_{S,t} L_{S,t-1} - \varepsilon_t = L_{S,t} + W_{S,t} N_{S,t} \tag{2.5}$$

$$L_{S,t} \leq E_t \left(\frac{1}{R_{S,t}} m_S q_{t+1} H_{S,t} \right). \tag{2.6}$$

The borrowing constraint limits borrowing to the present discounted value of their housing holdings. Below, I will show that the constraint binds in a neighborhood of the non-stochastic steady state if β_S is lower than a weighted average of the discount factors of patient households and bankers. The term L_S denotes (one-period) loans made to subprimers, paying a gross interest rate R_S. Finally the term ε_t in the budget constraint denotes an exogenous repayment shock: I assume that subprimers can pay back less (more) than agreed on their contractual obligations if ε is greater (smaller) than zero; from their point of view, this shock represents a positive shock to wealth, since it allows them to spend more than previously anticipated.

Assuming that the borrowing constraint binds, subprimers consumption will be determined off their budget constraint (since their consumption Euler equation does not hold with equality), and the optimality conditions for housing demand and labor supply can be written as:

$$\frac{1}{C_{S,t}} E_t \left(q_t - m_S \frac{q_{t+1}}{R_{S,t}} \right) = \frac{j}{H_{S,t}} + E_t \left(\frac{\beta_S}{C_{S,t+1}} q_{t+1} \left(1 - m_S \frac{R_{S,t+1}}{R_{S,t}} \right) \right) \tag{2.7}$$

$$\frac{W_{S,t}}{C_{S,t}} = \frac{\tau_S}{1 - N_{S,t}}. \tag{2.8}$$

In the housing demand equation above, $q_t - m_S E_t \left(\frac{q_{t+1}}{R_{S,t}} \right)$ represents the requirement downpayment to buy one unit of housing today, and $E_t \left(q_{t+1} \left(1 - m_S \frac{R_{S,t+1}}{R_{S,t}} \right) \right)$ denotes the expected capital gain in selling the house next period. Note that one could endogenize the repayment shock in other ways: for instance, one could assume that if house prices fall below some value, borrowers could find it optimal to default rather than roll their debt over: defaulting would be equivalent to choosing a value for $R_{S,t} L_{S,t-1}$ lower than previously agreed, which would generate the same effect as a positive shock to ε_t.

Entrepreneurs. A continuum of unit measure entrepreneurs solve the following problem:

$$\max \sum_{t=0}^{\infty} \beta_E^t \log C_{E,t}$$

subject to:

$$C_{E,t} + K_{E,t} + R_{E,t} L_{E,t-1} + \frac{\phi_K}{2} \left(K_{E,t} - K_{E,t-1} \right)^2 = L_{E,t} + \left(R_{K,t} + 1 - \delta \right) K_{E,t-1} \tag{2.9}$$

$$L_{E,t} \leq m_E K_{E,t}. \tag{2.10}$$

Here, L_E are loans that banks extend to entrepreneurs (yielding a gross return R_E), K_E is capital that entrepreneurs rent to a goods producing firm at the rate R_K, and δ is the capital depreciation rate. I assume that entrepreneurs cannot borrow more than a fraction $m_E < 1$ of their hard assets K_E. As for the case of impatient borrowers, this constraint will be binding near the non-stochastic steady state, provided that entrepreneurs are impatient enough. If the borrowing constraint is binding, the entrepreneur's first-order condition can be written as:

$$\frac{1}{C_{E,t}} \left(1 + \phi \left(K_{E,t} - K_{E,t-1} \right) \right) = \beta_E E_t \left(\frac{1}{C_{E,t+1}} \frac{R_{K,t} + 1 - \delta - R_{E,t} m + \phi \left(K_{E,t+1} - K_{E,t} \right)}{1 - m_E} \right). \tag{2.11}$$

Bankers. A continuum of unit measure bankers solve the following problem:

$$\max \sum_{t=0}^{\infty} \beta_B^t \log C_{B,t}$$

subject to:

$$C_{B,t} + (1-\sigma) R_{H,t} D_{t-1} + L_{E,t} + \sigma L_{S,t} = (1-\sigma) D_t + R_{E,t} L_{E,t-1} + \sigma R_{S,t} L_{S,t-1} \qquad (2.12)$$
$$-\sigma \varepsilon_t - \left(\frac{\phi_E}{2} \Delta L_{E,t}^2 + \frac{\phi_S}{2} (\sigma \Delta L_{S,t})^2 + \frac{\phi_D}{2} ((1-\sigma) \Delta D_t)^2 \right)$$

where the right-hand side measures the sources of funds for the bank (net of adjustment costs and loan losses): D are household deposits, and $R_E L_E$ and $\sigma R_S L_S$ are repayments from entrepreneurs and subprimers on previous period loans. The funds can be used by the bank to pay back depositors and to extend new loans, or can be used for banker's consumption. Note that this formulation is analogous to a formulation where bankers maximize a convex function of profits (discounted at rate β_B), once C_B is relabeled accordingly.

In a frictionless model, one implicitly assumes that deposits can be costlessly converted into loans. Here instead I assume that the bank is constrained in its ability to issue liabilities by the amount of equity capital (assets less liabilities) in its portfolio. This constraint can be motivated by regulatory concerns or by standard moral hazard problems: for instance, typical regulatory requirements (such as those agreed by the Basel Committee on Banking Supervision) posit that banks hold a capital to assets ratio greater than or equal to some predetermined ratio. Letting $E_t = \gamma_E L_{E,t} + \gamma_S \sigma L_{S,t} - (1-\sigma) D_t$ define bank capital at the end of the period, a capital requirement constraint can be reinterpreted as a standard borrowing constraint, such as

$$(1-\sigma) D_t \leq \gamma_E L_{E,t} + \gamma_S \sigma L_{S,t}. \qquad (2.13)$$

Above, the left-hand side denotes banks liabilities $(1-\sigma) D_t$, while the right-hand side denotes which fraction of each of the banks' assets can be used as collateral.[2]

Denote with $\lambda_{B,t}$ the multiplier on the bank's borrowing constraint (later, I will show the conditions that ensure that the constraint is binding). Let $m_{B,t} = \beta_B E_t \left(\frac{C_{B,t+1}}{C_{B,t}} \right)$ denote the banker's stochastic discount factor, The bank's optimality conditions for deposits, loans to entrepreneurs and loans to subprimers are respectively:

$$1 - \lambda_{B,t} = E_t (m_{B,t} R_{H,t+1}) \qquad (2.14)$$
$$1 - \gamma_E \lambda_{B,t} + \phi_E \Delta L_{E,t} = E_t (m_{B,t} (\phi_E \Delta L_{E,t+1} + R_{E,t+1})) \qquad (2.15)$$
$$1 - \gamma_S \lambda_{B,t} + \phi_S \sigma \Delta L_{S,t} = E_t (m_{B,t} (\phi_S \sigma \Delta L_{S,t+1} + R_{S,t+1})). \qquad (2.16)$$

The interpretation of these first-order condition is straightforward. It also illustrates why the different classes of assets pay different returns in equilibrium. Consider the ways a bank can increase its consumption by one extra unit today.

[2] In the simple case where $\gamma_E = \gamma_S = \gamma < 1$, the fraction $\frac{E}{L} = 1 - \gamma$ can be interpreted as the bank's capital-asset ratio, while $\frac{L}{E} = \frac{1}{1-\gamma}$ denotes the bank's leverage ratio (the ratio of bank's liabilties to its equity).

1. The banker can borrow from household, increasing $(1-\sigma) D$ by one unit today: in doing so, the bank reduces its equity by one unit too, thus tightening its borrowing constraint one–for–one and reducing the utility value of an extra deposit by λ_B. Next period, when the bank pays the deposit back, the cost is given by the stochastic discount factor times the interest rate R_H.

2. The banker can consume more today by decreasing loans to, say, entrepreneurs, by one unit. By lending less to the entrepreneurs, the bank tightens its borrowing constraint, (since it reduces its equity, loans minus deposits), thus incurring a utility cost equal to $\gamma_E \lambda_{B,t}$; hence the cost is larger the larger γ_E is: intuitively, the more loans are useful as collateral for the bank activity, the larger the utility cost of not making loans.

For the bank to be indifferent between collecting deposits (borrowing) and making loans (saving), the returns on all assets must be equalized. Given that R_H is determined from the household problem, the banker will be borrowing constrained, and λ_B will be positive, so long as $m_{B,t}$ is sufficiently lower than the inverse of R_H. In turn, if λ_B is positive, the returns on loans R_E and R_S will be lower, the lower γ_E and γ_S are. Intuitively, the larger γ is, the higher is the liquidity value of loans for bank in relaxing its borrowing constraint, and the smaller the compensation required for the bank to be indifferent between lending and borrowing. Moreover, loans will pay a return that is (near the steady state) higher than the cost of deposits, since, so long as γ is lower than one, they are intrinsically less liquid than the deposits.

Firms. The problem of final good firms is standard and purely static. I assume that these firms operate a standard constant-returns-to-scale technology, so they make no profit in equilibrium. They rent capital from entrepreneurs and labor from households to solve:

$$\begin{aligned} \max \Pi_t &= Y_t - R_{K,t} K_{E,t-1} - \left((1-\sigma) W_{H,t} N_{H,t} + \sigma W_{S,t} N_{S,t}\right) \\ Y_t &= K_{E,t-1}^{\alpha} \left((1-\sigma) N_{H,t} + \sigma N_{S,t}\right)^{1-\alpha}. \end{aligned} \tag{2.17}$$

The first–order conditions are standard. The assumption that households' hours are substitutes implies that in equilibrium $W_{H,t} = W_{S,t}$.

Equilibrium. I normalize the total supply of housing to unity. The market clearing conditions for goods and houses are:

$$Y_t = (1-\sigma) C_{H,t} + \sigma C_{S,t} + C_{B,t} + C_{E,t} + K_{E,t} - (1-\delta) K_{E,t-1} + adj_t \tag{2.18}$$

$$(1-\sigma) H_{H,t} + \sigma H_{S,t} = 1. \tag{2.19}$$

where adj_t denotes total adjustment costs. The set of equations summarizing the equilibrium of the model is summarized in Appendix A.

3. Discussion

3.1. Steady State Properties of the Model

In the non-stochastic steady state of the model, the interest rate on deposits equals the inverse of the household discount factor. This can be seen immediately from equation 2.3 evaluated at steady state. That is:

$$R_H = \frac{1}{\beta_H}.$$

In addition, when evaluated at their non-stochastic steady state, equations 2.14, 2.15 and 2.16 imply that: (1) so long as $\beta_B < \beta_H$ (bankers are impatient), the bankers will be credit constrained and; (2) so long as γ_E and γ_S are smaller than one, there will be a positive spread between the return on loans and the cost of deposits. The spread will be larger the tighter the capital requirement constraint for the bank. Formally:

$$\lambda_B = 1 - \beta_B R_H = 1 - \frac{\beta_B}{\beta_H} > 0 \tag{3.1}$$

$$R_E = \frac{1}{\beta_H} + \left(\frac{1}{\beta_B} - \frac{1}{\beta_H}\right)(1 - \gamma_E) > R_H \tag{3.2}$$

$$R_S = \frac{1}{\beta_H} + \left(\frac{1}{\beta_B} - \frac{1}{\beta_H}\right)(1 - \gamma_S) > R_H. \tag{3.3}$$

I turn now to entrepreneur and subprimers. Given the interest rates on loans R_E and R_S, a necessary condition for entrepreneur and subprimers to be constrained is that their discount factor is lower than the inverse of the return on loans above. When this condition is satisfied (that is $\beta_E R_E < 1$ and $\beta_S R_S < 1$), entrepreneurs and subprimers will be constrained in a neighborhood of the steady state. Alternatively, this condition requires that entrepreneurs' and subprimers' discount factors are lower than a weighted average (geometric mean) of the discount factors of households and banks.

$$\beta_E < \frac{1}{\gamma_E \frac{1}{\beta_H} + (1 - \gamma_E)\frac{1}{\beta_B}}$$

$$\beta_S < \frac{1}{\gamma_S \frac{1}{\beta_H} + (1 - \gamma_S)\frac{1}{\beta_S}}$$

It is also easy to show that both the bankers' credit constraint and the entrepreneurs' credit constraint create a positive wedge between the steady state output in absence of financial frictions and the output when financial frictions are present. The credit constraint on banks limits the amount of deposits (savings) that banks can transform into loans. Likewise, the credit constraint on entrepreneurs limits the amount of loans that can become physical capital. Both forces work to reduce the amount of savings that can be transformed into capital, thus lowering steady state output. The same forces are also at work for shocks that move the economy away from the steady state, to the extent that these shocks tighten or looser the severity of the borrowing constraints.

3.2. Dynamic Properties of the Model

To gain some intution into the workings of the model, it is useful to consider how time-variation in the tightness of the bankers' borrowing constraint can affect equilibrium dynamics. To do so, it is useful to focus both on the price and the quantity side of the story.

I begin with the price side. For the sake of argument, consider a perfect foresight version of the model, so that variables are equal to their expected values. In this case, in the limiting case of no adjustment costs, the expression for the spread between the return on loans and the cost of deposits can be written as:

$$R_{E.t} - R_{H,t} = \frac{\lambda_{B,t}}{m_{B,t}} (1 - \gamma_E).$$

According to this expression, the spread between the return on entrepreneurial loans and the cost of deposits gets larger whenever the banker's borrowing constraint gets tigher (an analogous expression holds for the spread between $R_{S,t}$ and $R_{H,t}$). Intuitively, when the capital constraint gets tighter (for instance because bank net worth is lower), the bank requires a larger compensation on its loans in order to be indifferent between making loans and issuing deposits. This occurs because loans are intrinsically more illiquid than deposits: when the constraint is binding, a reduction in deposits of 1 dollar requires cutting back on loans by $\frac{1}{\gamma_E}$ dollars. All else equal, a rise in the spread will act as a drag on economic activity during periods of lower bank net worth.

Now I move to the quantity side: whenever a shock causes a reduction in bank capital, the logic of the balance sheet requires for the bank to contract its asset side by a multiple of its capital, in order for the bank to restore its leverage ratio. The bank could avoid this by raising new capital (reducing bankers' consumption), but the bankers' impatience motive and the weak economy make this route impractical or, at best, insufficient. As a consequence, the bank reduceThs its lending. If a substantial part of the economy depends on bank credit to run its activities, the contraction in bank credit causes in turn a decrease in economic activity.

The obvious test of the model is: can bank losses of the magnitude occurred in the last couple of years justify a sharp, large and protracted drop in economic activity? Before I assess the quantitative significance of this mechanism, I need to calibrate the model.

3.3. The Model without Banks

As a reference point, it is useful to illustrate the key differences between the model above and a model without banks, or, alternatively, a model where banks are a pure veil and frictionlessy intermediate funds between borrowers and savers. In such a model, all savings are converted into loans, so that equation 2.13 is replaced by a simple definition

$$(1 - \sigma) D_t = L_{E,t} + \sigma L_{S,t}. \tag{3.4}$$

Moreover, bankers disappear from the model, so that $C_{B,t} = 0$ and $\lambda_{B,t} = 0$. In addition, the relevant discount factor to price loans is the patient household's stochastic discount factor $m_{H,t} = \beta_H E_t \left(\frac{C_{H,t+1}}{C_{H,t}} \right)$.

4. Calibration

There are thirteen parameters affecting the steady state for which I need to assign values, and five additional parameters control the size of the quadratic adjustment costs.

I begin with standard preference and technology parameters. The patient household discount factor is set at $\beta_H = 0.99$. The entrepreneurial discount factor is 0.925. The subprimers discount factors is set at 0.9. I set the capital share $\alpha = 1/3$ and its depreciation rate $\delta = 0.025$. The weight on housing in utility is set at $j = 0.125$. These parameters imply a steady state 4 percent return annualized on deposits, a capital-output ratio of 1.7 (annualized), a housing wealth to output ratio of 1.7 (annualized), and an investment to output ratio of 17 percent. The weight on leisure in the utility function of both households, τ, is set at 2. This number implies a Frisch labor supply elasticity around 3, in the range of macro estimates.

For the parameters controlling leverage, I choose $m_E = 0.9$, $m_S = 0.9$, $\gamma_S = 0.9$ and $\gamma_E = 0.9$. I also set the share of impatient households/subprimers to $\sigma = 0.3$.

I choose the discount factors for the bankers to match observations on average spreads. I set $\beta_B = 0.95$. Together with the bank leverage parameters, these values imply average excess returns of 2 percent on an annualized basis.

The capital adjustment cost parameter ϕ_K is set at 2. The other adjustment cost parameters are a bit harder to calibrate: I set them all equal to 0.25. The main qualitative and quantitative results of the next section were fairly robust to reasonable perturbations of these parameters around these values.

5. Properties of the Model

5.1. The Baseline Financial Shock

The thought experiment that I consider is the following. What are the consequences of a financial shock in this model? Of course, the experiment begs the question: what is a financial shock?

One possibility is that a financial shock is something that affects the ability of a bank to transform savings into loans. However, this shock is very similar to an investment-biased technology shock, and almost assumes the conclusions: moreover, we already know that this shock (see the discussion in Justiniano, Primiceri and Tambalotti, 2010) has a somewhat hard time (in absence of bells and whistles) in generating the joint comovement of consumption, investment and hours that is the essence of business cycles. Another possibility is that the financial shock captures an exogenous disturbance to the wedge between the cost of funds paid by borrowers and the return on funds received by lenders (see Hall, 2010, for such an interpretation): however, it is hard to give a general equilibrium interpretation of this shock, and one would like to believe that changes in spreads are the effect, not the cause, of financial shocks.

For my purposes, I want to give to the financial shock a different interpretation that starts by directly feeding into the model the losses that the shock causes. I want to think of this shock as purely redistributive in nature: for some unmodeled reason, the shock starts with one group of agents paying back less than initially agreed on their obligations. I assume these agents are the subprimers. Hence the shock I consider has a double nature: from the lender's (bank) point of view, it is equivalent to an exogenous destruction of the lender's assets (a negative wealth shock); however, from the borrowers' point of view, it is equivalent to a positive shock to wealth. Now, it is obvious that the financial shock was not exogenous: one could argue that the real trigger of the crisis was the decline in housing prices that led to defaults that led to non–repayments, but first–hand evidence suggests that the big fallout from the decline in housing prices did not occur until banks were forced by loan losses to take dramatic measures to reduce the size of their balance sheets.

The next question to ask is: how big is the shock? A nice thing is that I can use readily available data on quantities to get a sense of the size of my financial shock. Any unexpected non-repayment from the borrower causes a loss of the same amount for a lender. I use the estimates of bank losses following the financial crisis to gauge how big the shock is. In particular, I use estimated loan writedowns for the years between 2007 and 2010, as calculated by the IMF's Global Financial Stability Report (in April 2009).[3] The Global Financial Stability Report estimates loan losses over the 2007-2010 period of 1,068 billion dollars, that is, about 9 percent of private GDP (about 5 percent of private GDP if one looks at 2007 and 2008 only). Using this information, I calibrate the financial shock as a persistent repayment shock that results, over a four-year period, in total cumulative losses of around 10 percent of private GDP.[4]

How does the financial shock work? Figure 2 plots the impulse responses, comparing the model with banks with the reference model without banks.[5]

The negative repayment shock impairs the bank's balance sheet, by reducing the value of the banks' assets (in the model, it is total loans minus loan losses) relative to the liabilities (in the model, these are household deposits): at that point, the banker can restore its capital-asset ratio either by deleveraging (reducing its borrowing from households), or by reducing consumption in order to restore its equity cushion. In the baseline scenario, both forces kick in, and the bank simultaneously reduces both loans and deposits, thus propagating the credit crunch. In particular, the decline in all types of loans to the credit-dependent sectors of the economy (entrepreneurs and subprimers) acts a drag on both consumption and investment.

By contrary, in a model where banks are not forced to restore their capital–asset ratio, the losses are much smaller. The financial shock works like a pure redistribution shock that transfers wealth

[3] See `http://www.imf.org/external/pubs/ft/gfsr/2009/01/pdf/text.pdf`, Table 1.3.

[4] I compute private GDP using subtracting Government Consumption Expenditures & Gross Investment from total Gross Domestic Product. This gives me a figure of 11,325 billions of dollars for year 2009.

[5] The financial shock I consider has the nice property of being a pure wash, in absence of any financial frictions.

from agents from agents with a low marginal propensity to consume (the households who deposit their savings into the bank) to agents with a high marginal propensity to consume (the subprimers). The main effect of this shock works through labor supply. Subprimers work less (because their wealth is higher), savers work more (because their wealth is lower). Because subprimers have higher wealth, they can increase their borrowing and housing demand, thus crowding out some of the household savings away from the entrepreneurial sector. In the aggregate, the effects on economic activity are negative but very small, almost one order of magnitude smaller than those in the model with credit–constrained banks.

5.2. Some Robustness Analysis

Figure 3 compares the effects of a financial shock when I add nominal rigidities to the model in the form of Calvo-style staggered price adjustment. In general, the effects with nominal rigidities depend on how accommodative monetary policy is (or can be). With nominal rigidities, to the extent that the central bank lowers the interest rate (assumed to be the rate on deposits R_H) in a recession, that mitigates the effect on output.

Figure 4 compares the effects of a financial shock when I consider tighter capital constraints for banks. In my benchmark case, the bank's leverage ratio (deposits over net worth) is 10. When the leverage ratio is smaller – say 4 – because capital constraints are tighter, the effects of a financial shock on economic activity are larger.

6. Concluding Remarks

[TBA]

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Appendix A. The Complete Model

I summarize here the equations describing the equilibrium of the model.

$$C_{H,t} + D_t + ac + q_t \left(H_{H,t} - H_{H,t-1}\right) = R_{H,t-1} D_{t-1} + W_{H,t} N_{H,t} \tag{6.1}$$

$$\frac{1}{C_{H,t}} \left(1 + \phi_H \Delta D_t\right) = \beta_H E_t \left(\frac{1}{C_{H,t+1}} \left(R_{H,t} + \phi_H \Delta D_{t+1}\right) \right) \tag{6.2}$$

$$\frac{W_{H,t}}{C_{H,t}} = \frac{\tau_H}{1 - N_{H,t}} \tag{6.3}$$

$$C_{S,t} + q_t \left(H_{S,t} - H_{S,t-1}\right) + R_{S,t} L_{S,t-1} - \varepsilon_t = L_{S,t} + W_{S,t} N_{S,t} \tag{6.4}$$

$$L_{S,t} = E_t \left(\frac{1}{R_{S,t}} m_S q_{t+1} H_{S,t} \right) \tag{6.5}$$

$$\frac{W_{S,t}}{C_{S,t}} = \frac{\tau_S}{1 - N_{S,t}} \tag{6.6}$$

$$C_{B,t} + (1-\sigma) R_{H,t} D_{t-1} + L_{E,t} + \sigma L_{S,t} + ac = (1-\sigma) D_t + R_{E,t} L_{E,t-1} + \sigma R_{S,t} L_{S,t-1} - \sigma \varepsilon_t \tag{6.7}$$

$$(1-\sigma) D_t = \gamma_E L_{E,t} + \gamma_S \sigma L_{S,t} \tag{6.8}$$

$$\mu_t = 1/C_{B,t} \tag{6.9}$$

$$\mu_t \left(1 - \lambda_{B,t}\right) = \beta_B E_t \left(\mu_{t+1} R_{H,t+1}\right) \tag{6.10}$$

$$\mu_t \left(1 - \gamma_E \lambda_{B,t} + \phi \Delta L_{E,t}\right) = \beta_B E_t \left(\mu_{t+1} \left(\phi \Delta L_{t+1} + R_{E,t+1}\right)\right) \tag{6.11}$$

$$\mu_t \left(1 - \gamma_S \lambda_{B,t} + \phi \sigma \Delta L_{S,t}\right) = \beta_B E_t \left(\mu_{t+1} \left(\phi \sigma \Delta L_{S,t+1} + R_{S,t+1}\right)\right) \tag{6.12}$$

$$C_{E,t} + K_{E,t} + R_{E,t} L_{E,t-1} = L_{E,t} + \left(R_{K,t} + 1 - \delta\right) K_{E,t-1} \tag{6.13}$$

$$L_{E,t} = m_E K_{E,t} \tag{6.14}$$

$$\frac{1}{C_{E,t}} = \beta_E E_t \left(R_{E,t+1} \frac{1}{C_{E,t+1}} \right) + \frac{\lambda_{E,t}}{C_{E,t}} \tag{6.15}$$

$$\frac{1}{C_{E,t}} = \beta_E E_t \left(\frac{R_{K,t+1} + 1 - \delta}{C_{E,t+1}} \right) + \frac{\lambda_{E,t}}{C_{E,t}} m_E \tag{6.16}$$

$$Y_t = K_{E,t-1}^{\alpha} \left((1-\sigma) N_{H,t} + \sigma N_{S,t} \right)^{1-\alpha} \tag{6.17}$$

$$\alpha \frac{Y_t}{K_{E,t-1}} = R_{K,t} \tag{6.18}$$

$$(1-\alpha) \frac{Y_t}{(1-\sigma) N_{H,t} + \sigma N_{S,t}} = W_{H,t} \tag{6.19}$$

$$(1-\alpha) \frac{Y_t}{(1-\sigma) N_{H,t} + \sigma N_{S,t}} = W_{S,t} \tag{6.20}$$

$$\frac{q_t}{C_{H,t}} = \frac{j}{H_{H,t}} + \beta_H E_t \left(\frac{q_{t+1}}{C_{H,t+1}} \right) \tag{6.21}$$

$$\frac{1}{C_{S,t}} \left(q_t - m_S \frac{q_{t+1}}{R_{S,t}} \right) = \frac{j}{H_{S,t}} + E_t \left(\frac{\beta_S}{C_{S,t+1}} q_{t+1} \left(1 - m_S \frac{R_{S,t+1}}{R_{S,t}} \right) \right) \tag{6.22}$$

$$(1-\sigma) H_{H,t} + \sigma H_{S,t} = 1 \tag{6.23}$$

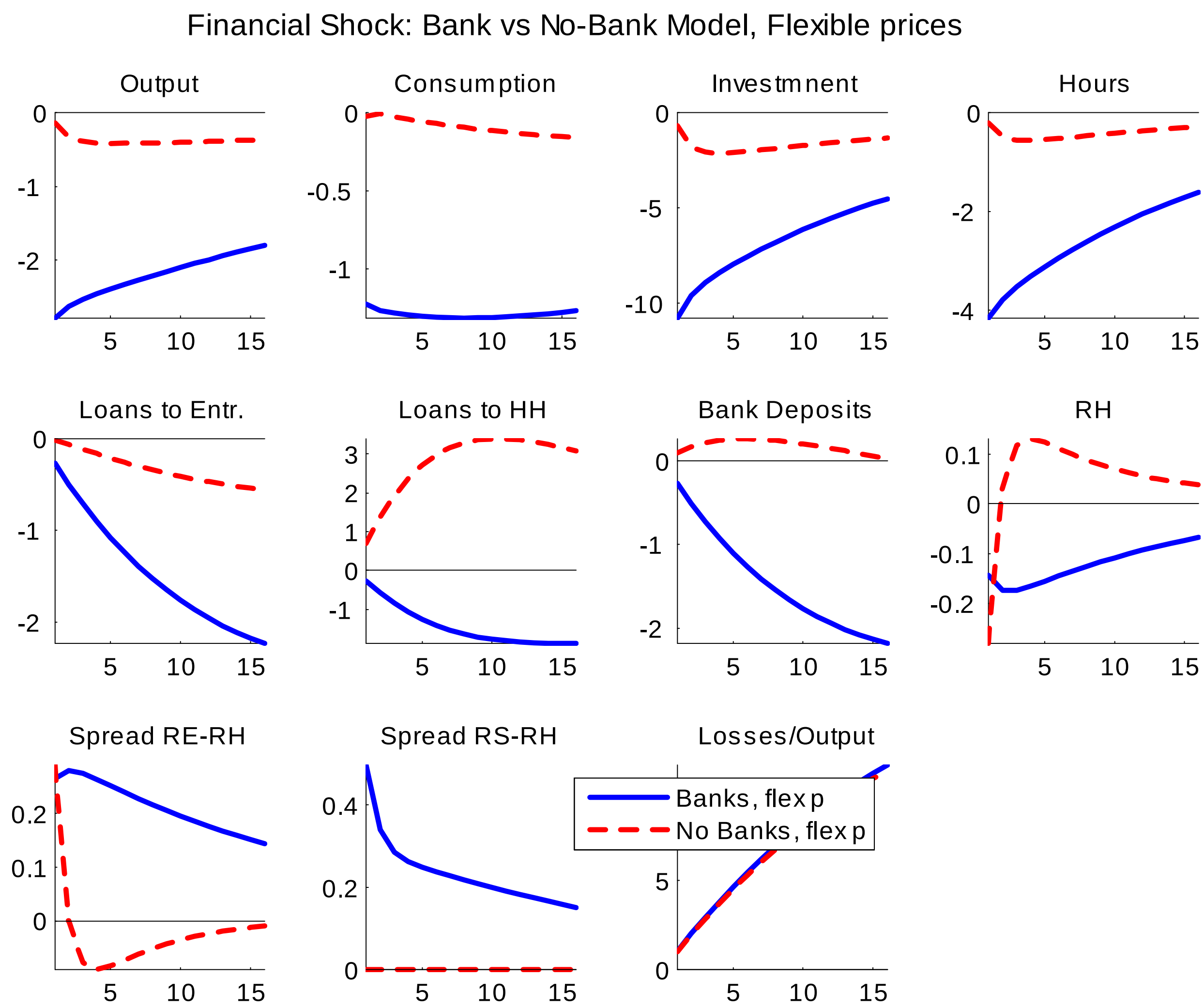

Figure 2: Impulse Responses to a Financial Shock: baseline banking model vs no-banking model. The shock is a (persistent) repayment shock that leads to credit losses (cumloss) for banks of 4% of GDP after one year (10% after four years). Variables are expressed in percent change from steady state; and losses over GDP, interest rates and spreads, in quarterly basis points.

Note: Each model period is a quarter. The y-axis measures percent deviation from the steady state.

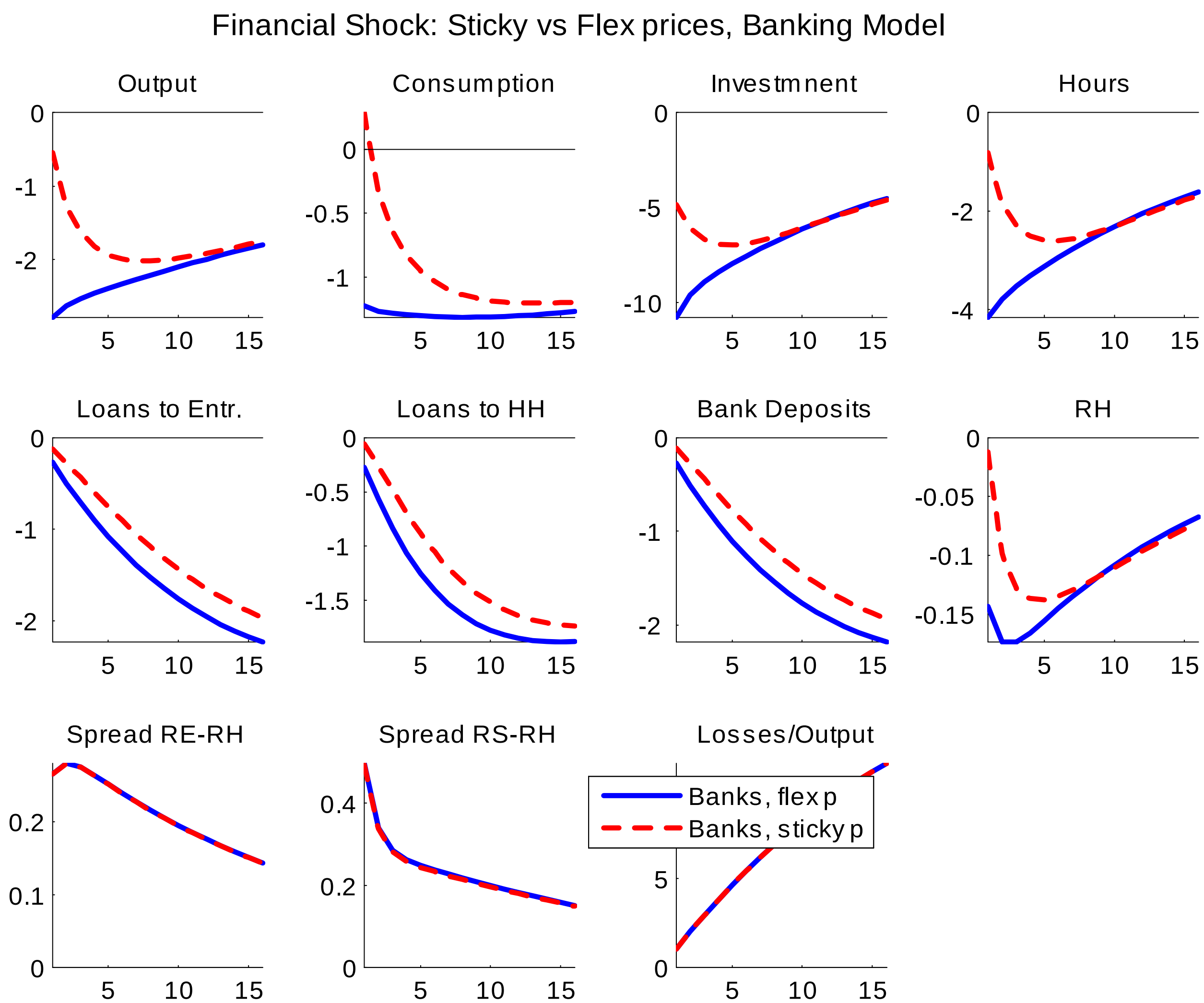

Figure 3: Impulse Responses to a Financial Shock: sensitivity to adding nominal rigidities.

Note: Each model period is a quarter. The y-axis measures percent deviation from the steady state.

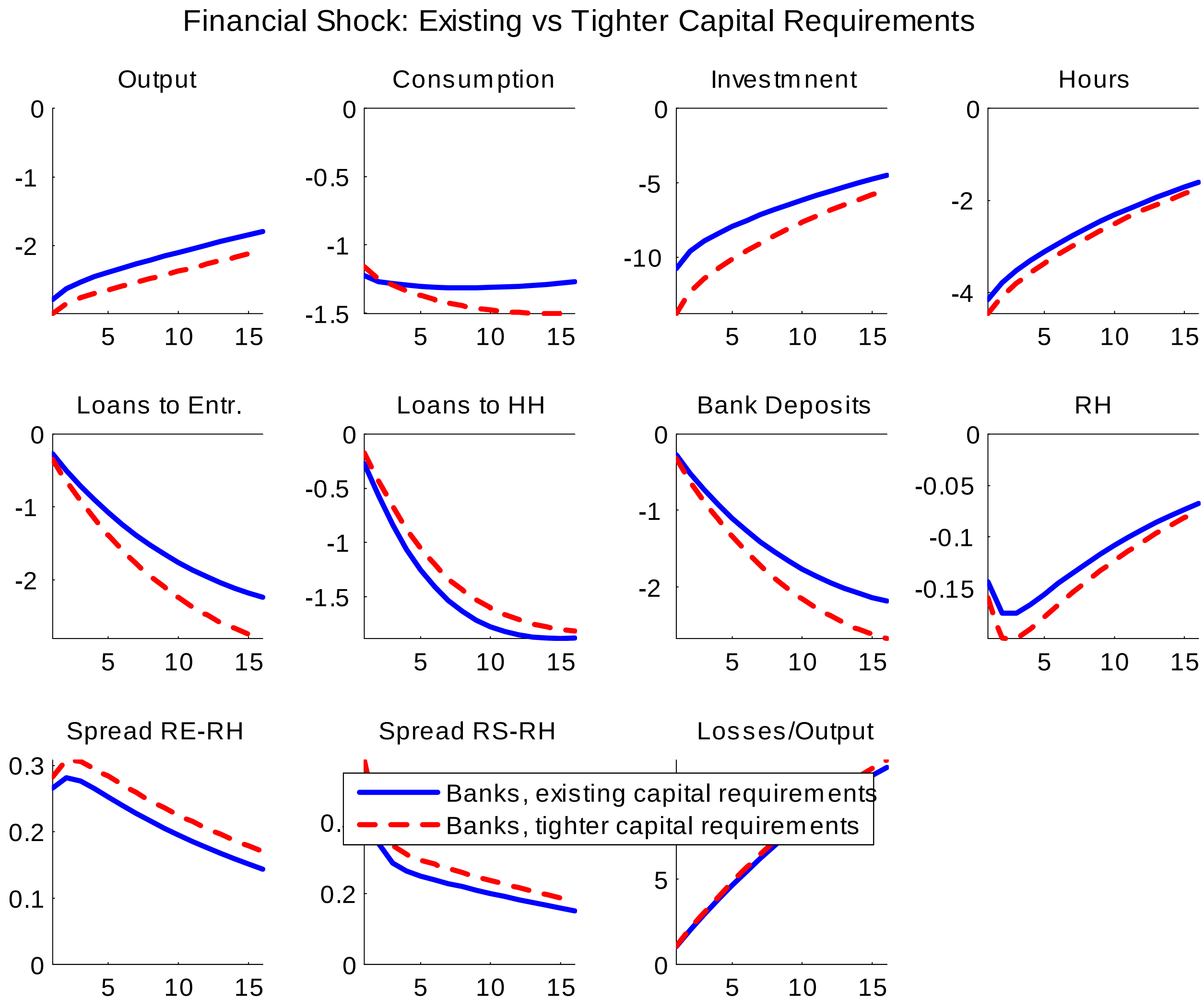

Figure 4: Impulse Responses to a Financial Shock: sensitivity to making capital constraints tighter.

Note: Each model period is a quarter. The y-axis measures percent deviation from the steady state.