Financial Business Cycles

Matteo Iacoviello
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The views expressed here are my own and do not reflect the views of the Federal Reserve

Introduction

- Can financial frictions can explain of the quantitative effects of the financial crisis?
- Elements of the Financial crisis
  1. financial institutions suffer losses which impair their ability to extend credit to the real sector, causing a recession.
  2. borrowers balance sheets are impaired, causing a drop in spending
  3. credit supply is tight
- This paper: take to the data a model which embeds these elements
- Model elements: banks and heterogeneous agents
  Event triggering cycles: (1) redistribution shocks; (2) changes in asset values; (3) changes in credit supply.

Preview of the results

- Financial frictions and shocks in the financial sector account for more than half of the decline in GDP during the last recession
- Declines in asset values (2006-2007)
  Shocks hitting balance sheet of banks (2008-2009)
  Tightening of credit standards (2009-2010)

Related Papers

- GE models with financial intermediation
  Brunnermeier and Sannikov (2010), Angeloni and Faia (2009), Gerali, Neri, Sessa, and Signoretti (2010), Kiley and Sim (2011), Kollmann, Enders, and Muller (2011), Meh and Moran (2010), Williamson (2012), and Van den Heuvel (2008).
- As in Gertler and Karadi (2011) and Gertler and Kiyotaki (2010), I assume that intermediaries face a balance sheet constraint when obtaining deposits.
- In many of the models above: focus is different (normative), or event triggering the recession is a mysterious shock to the quality of bank capital.
- Here the goal is quantitative: I want to try to take the model as close as possible to the data, and estimate the contribution of the financial shocks to the recession (e.g. Jermann and Quadrini (2012) and Christiano, Motto, and Rostagno (2012))

Setup

1. **Households. Two types.**
   Savers: buy homes, supply deposits D to banks.
   Borrowers: borrow L_S against their homes, face credit constraint.
2. **Banks** collects deposits from savers and give loans to household borrowers and entrepreneurs.
3. **Entrepreneurs** borrow from bank, transform L into K, hire workers to produce Y, face credit constraint.
   Relative sizes of savers and borrowers controlled by wage share in production.
   HH Savers may also accumulate K directly, so as to nest RBC as a special case.
4. **Shocks**
   Borrowers subject to **repayment shocks**
   Changes in **asset values** and **loan-to-values** affect ability to borrow
   The usual suspects (TFP and preference)
5. **Bells and whistles**: convex portfolio adjustment costs, costvariable utilization, pay workers in advance, partial adjustment for borrowing constraint, habits.

Household Savers

Choose consumption, deposits and hours worked

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

s.t.

$$\begin{aligned} & C_{H,t} + \frac{K_{H,t}}{A_{K,t}} + D_t + q_t \Delta H_{H,t} \\ = \quad & \left(R_{M,t} + \frac{1 - \delta_{KH,t}}{A_{K,t}} \right) K_{H,t-1} + R_{H,t-1} D_{t-1} + W_{H,t} N_{H,t} + ac_H . \end{aligned}$$

Portfolio adjustment costs *ac* control interest elasticity of deposits.

Household Borrowers

Low discount factor, creates simple motive for borrowing $\beta_S < \beta_B$

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

s.t.

$$C_{S,t} + q_t \Delta H_{S,t} + R_{S,t-1} L_{S,t-1} - \varepsilon_{H,t} = L_{S,t} + W_{S,t} N_{S,t}$$

$$L_{S,t} \leq m_S A_{MH,t} E_t \frac{q_{t+1}}{R_{S,t}} H_{S,t} - \varepsilon_{H,t} + ac_S$$

If β_S is low enough, constraint on borrowing will hold in a neighborhood of the steady state.

ε_t is the repayment shock

Entrepreneurs

Borrow L_E, .hire N, combine them with K_E, K_H, H_E to produce Y.

$$\max E_0 \sum_{t=0}^{\infty} \beta_E^t \log C_{E,t}$$

s.t.:

$$\begin{aligned} C_{E,t} + K_{E,t}/A_{K,t} + q_t \Delta H_{E,t} + R_{E,t} L_{E,t-1} + R_{M,t} z_{KH,t} K_{H,t-1} + ac_E \\ = Y_t - W_t N_t + (1 - \delta_{KE,t}) K_{E,t-1}/A_{K,t} + L_{E,t} + \varepsilon_{E,t} \end{aligned}$$

and

$$L_{E,t} \leq A_{ME,t} \left(m_H \frac{q_{t+1}}{R_{E,t+1}} H_{E,t} + m_K K_{E,t} - m_N W_t N_t \right)$$

Borrowing constraint binds if, given R_E, β_E is sufficiently low.
The production function is

$$Y_t = A_{Z,t} \left(z_{KH,t} K_{H,t-1}\right)^{\alpha(1-\mu)} \left(z_{KE,t} K_{E,t-1}\right)^{\alpha\mu} H_{E,t-1}^{\nu} N_{H,t}^{(1-\alpha-\nu)(1-\sigma)} N_{S,t}^{(1-\alpha-\nu)\sigma}$$

Bankers

1. Bankers transform savings into loans. To do so, they are required to hold some equity (bank capital) in their business
2. Bankers are shortsighted: blinded by greed/impatience, they try and borrow as much as they can from household to increase the size of their balance sheet.

Bankers

The banker's problem

$$\max E_0 \sum_{t=0}^{\infty} \beta_B^t \log C_{B,t}$$

where $\beta_B < \beta_H$, subject to:

$$C_{B,t} + R_{H,t-1} D_{t-1} + L_{E,t} + L_{S,t} = R_{E,t} L_{E,t-1} + R_{S,t-1} L_{S,t-1} + D_t - \varepsilon_t + ac_B$$

ε_t : repayment shock
and additional constraint:

$$D_t \leq \gamma \left(L_{E,t} + L_{S,t} - \varepsilon_t \right) \leftarrow \text{capital adequacy constraint (CAC)}$$

CAC forces banker to hold equity if $\gamma < 1$.

Bank's optimality conditions for deposits and loans:

$$\begin{aligned} 1-\lambda_{B,t} &= E_t\left(m_{B,t}R_{H,t}\right) \\ 1-\gamma\lambda_{B,t} &= E_t\left(m_{B,t}R_{E,t+1}\right) \end{aligned}$$

- Expression for spread:

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

λ_B : multiplier of bank's capital constraint
m_B : banker's stochastic discount factor

- Spread is larger when banker's constraint gets tigher (λ_B rises)
- When constraint gets tighter, bank requires larger compensation on loans to be indifferent b/w making loans and issuing deposits. Loans are more illiquid than deposits: when constraint is binding, a reduction in deposits of 1\$ requires cutting back on loans by $\frac{1}{\gamma_E}$\$.
- Rise in spread depresses activity when bank net worth is low.

Remarks

Given the production function

$$Y_t = A_{Z,t} \left(z_{KH,t} K_{H,t-1}\right)^{\alpha(1-\mu)} \left(z_{KE,t} K_{E,t-1}\right)^{\alpha\mu} H_{E,t-1}^{\nu} N_{H,t}^{(1-\alpha-\nu)(1-\sigma)} N_{S,t}^{(1-\alpha-\nu)\sigma}$$

Models becomes an RBC model when

$$\begin{aligned} \mu, \nu &\rightarrow 0: \text{ all capital held by Household Savers} \\ \sigma &\rightarrow 0: \text{ wage share of Household Borrowers is zero} \end{aligned}$$

Alternatively, the model becomes a model without banks (or with frictionless ones) if Household Savers lend directly to Household Borrowers and Entrepreneurs.

Steady State

$$R_H = \frac{1}{\beta_H} \leftarrow \text{return on HH savings}$$

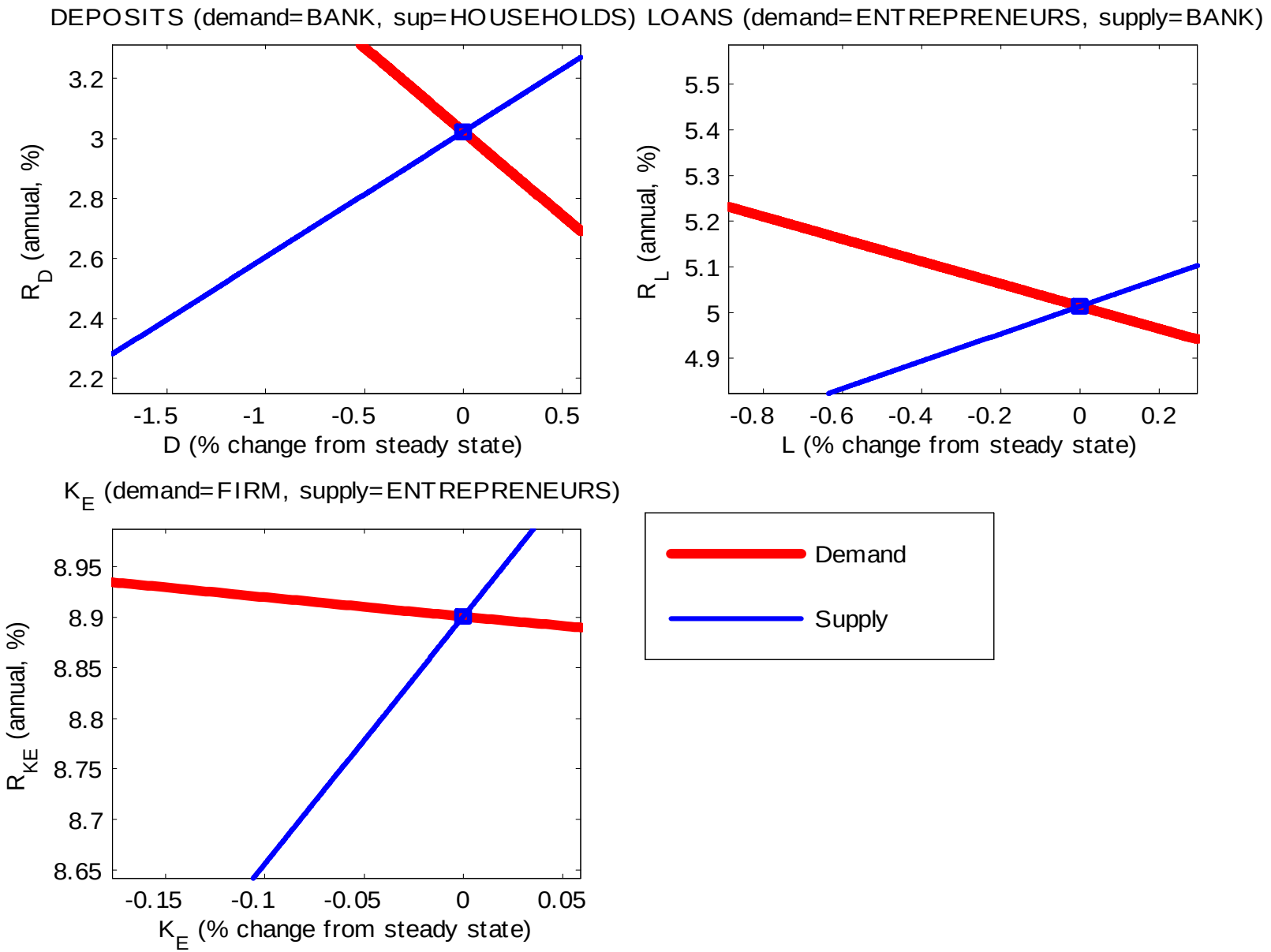
$$\lambda_B = 1 - \beta_B R_H = 1 - \frac{\beta_B}{\beta_H} > 0 \text{ banker is constrained}$$

$$R_E - R_H = (1-\gamma)\left(\frac{1}{\beta_B} - \frac{1}{\beta_H}\right) > 0 \leftarrow \text{spread}$$

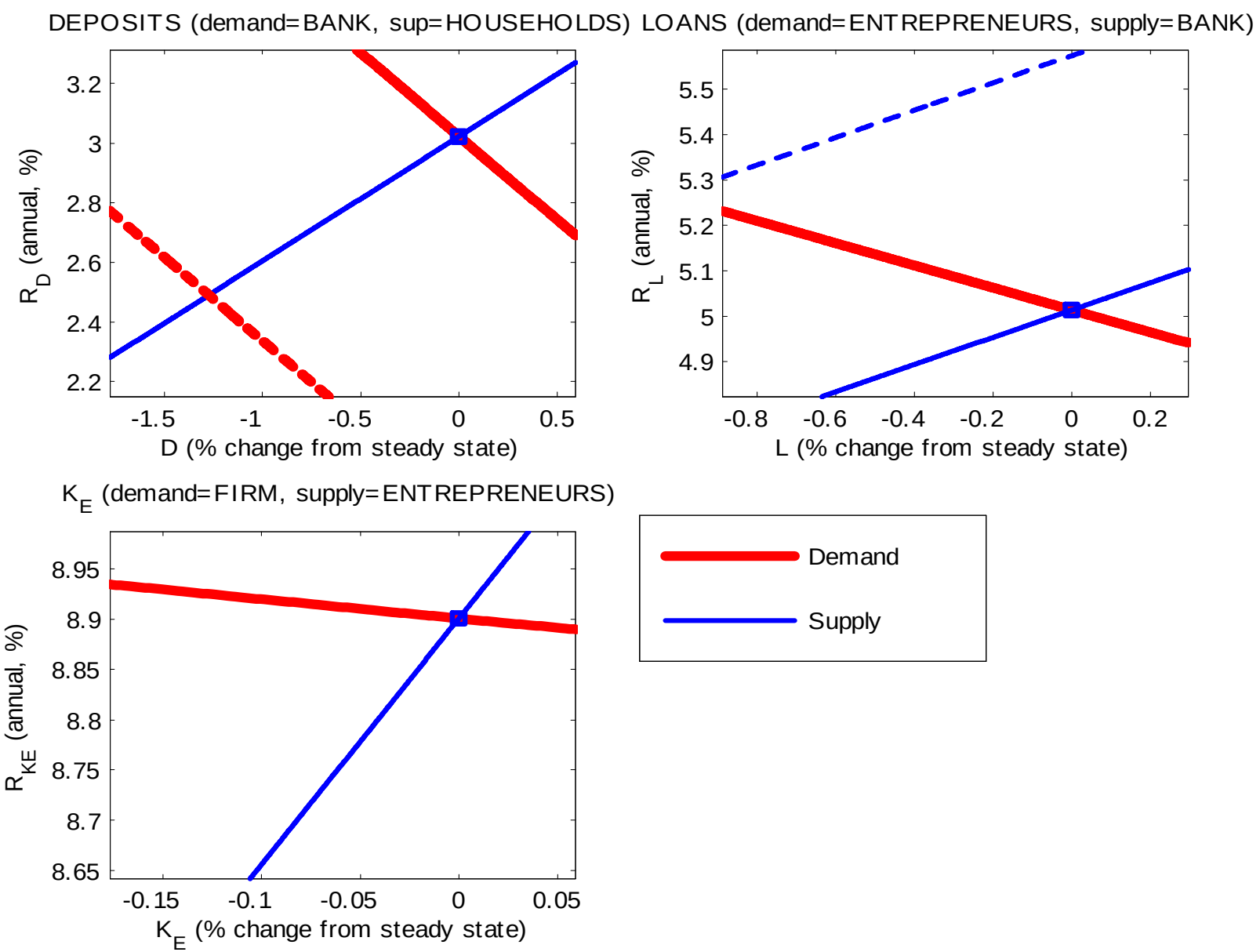
Hence $R_E > R_H$ (positive banking spreads):

1. Return on bank loans must compensate banker for higher impatience
2. ... must be higher than cost of deposits to make up for higher "liquidity" of loans relative to deposits
   The larger γ, the more loans become substitutes with deposits in the capital adequacy constraint, the lower the extra return on loans required for the bank to be indifferent between borrowing and lending.

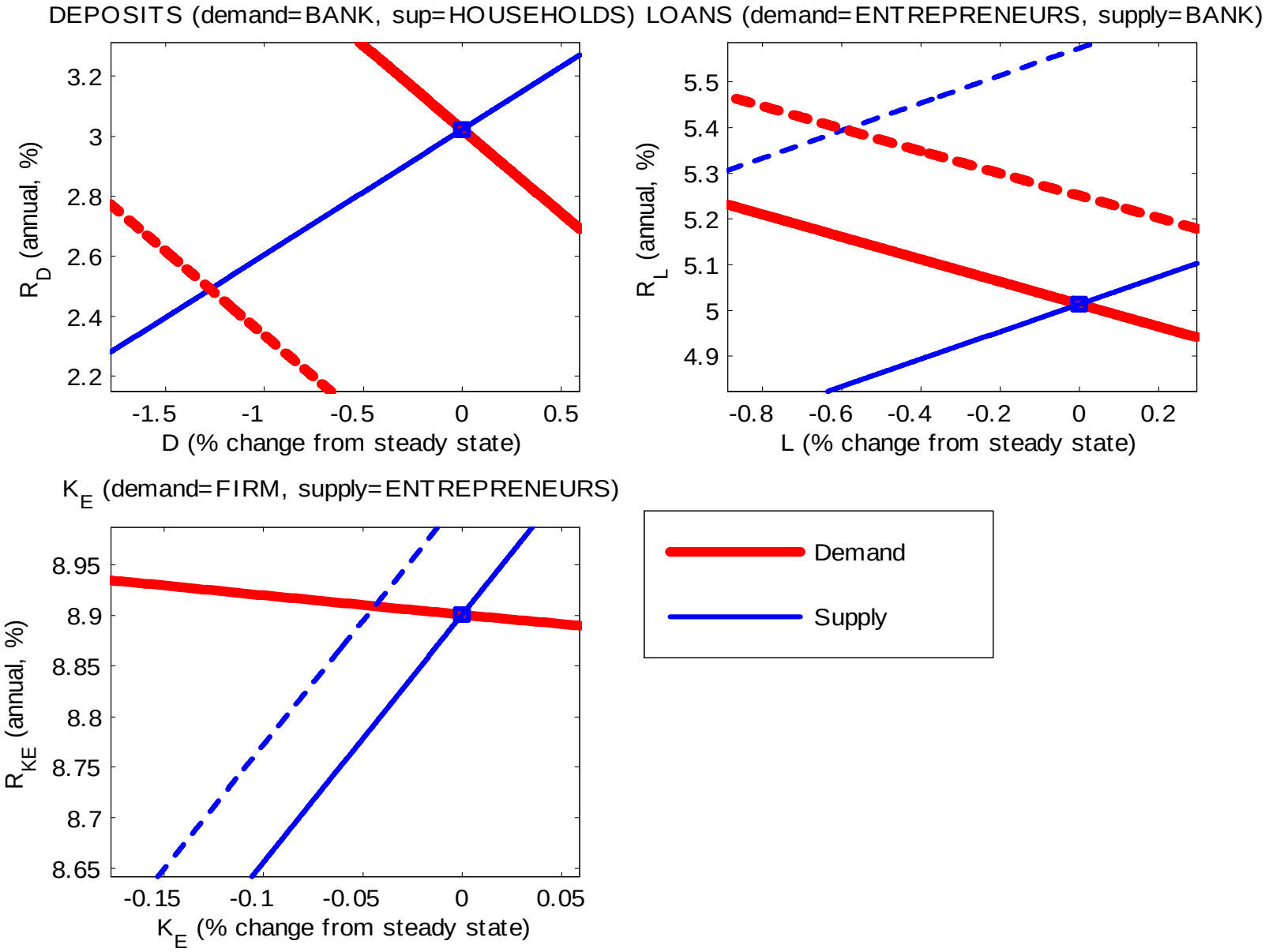
Demand and Supply



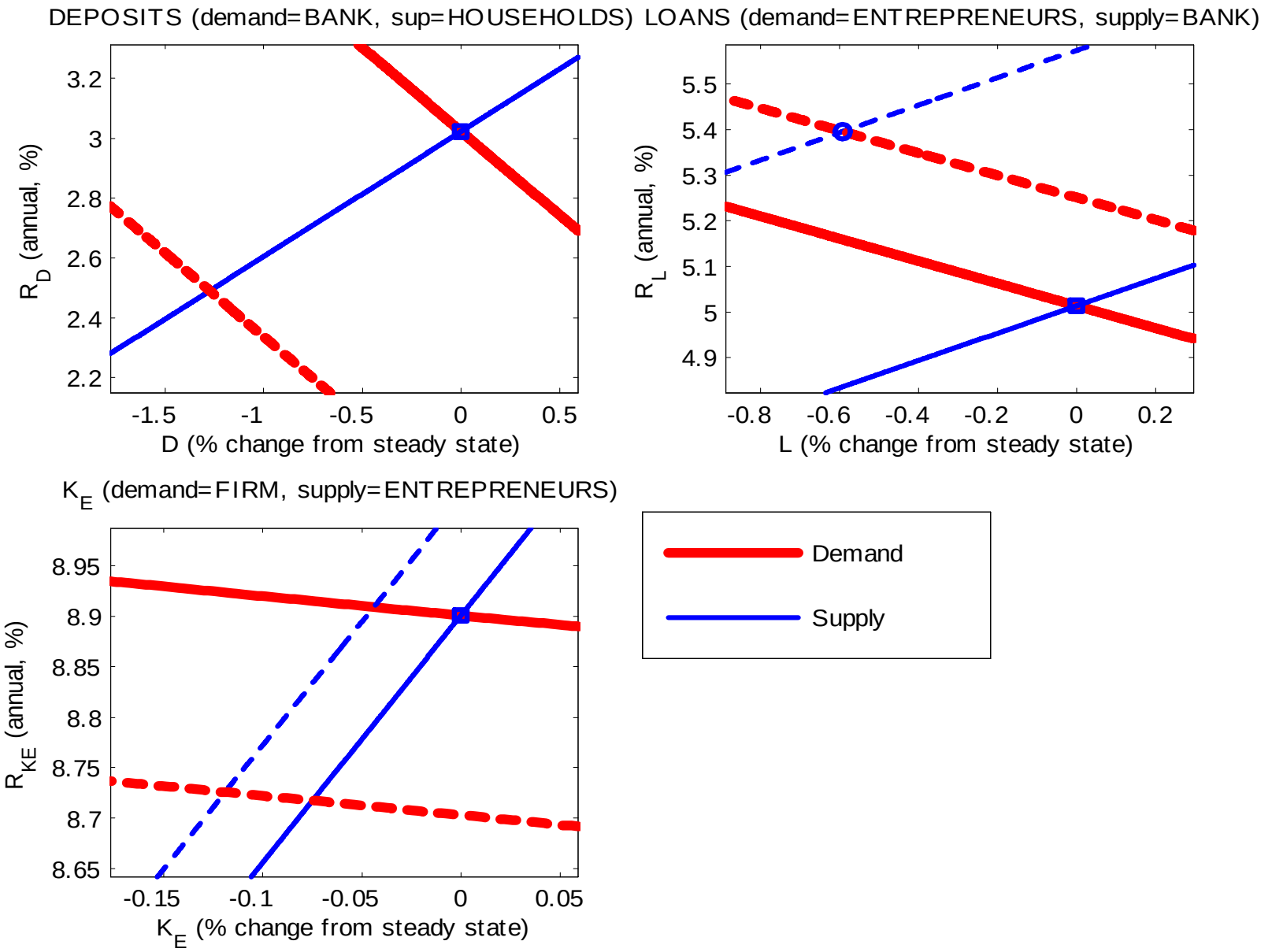
Demand and Supply: Bank Responses to Repayment Shock



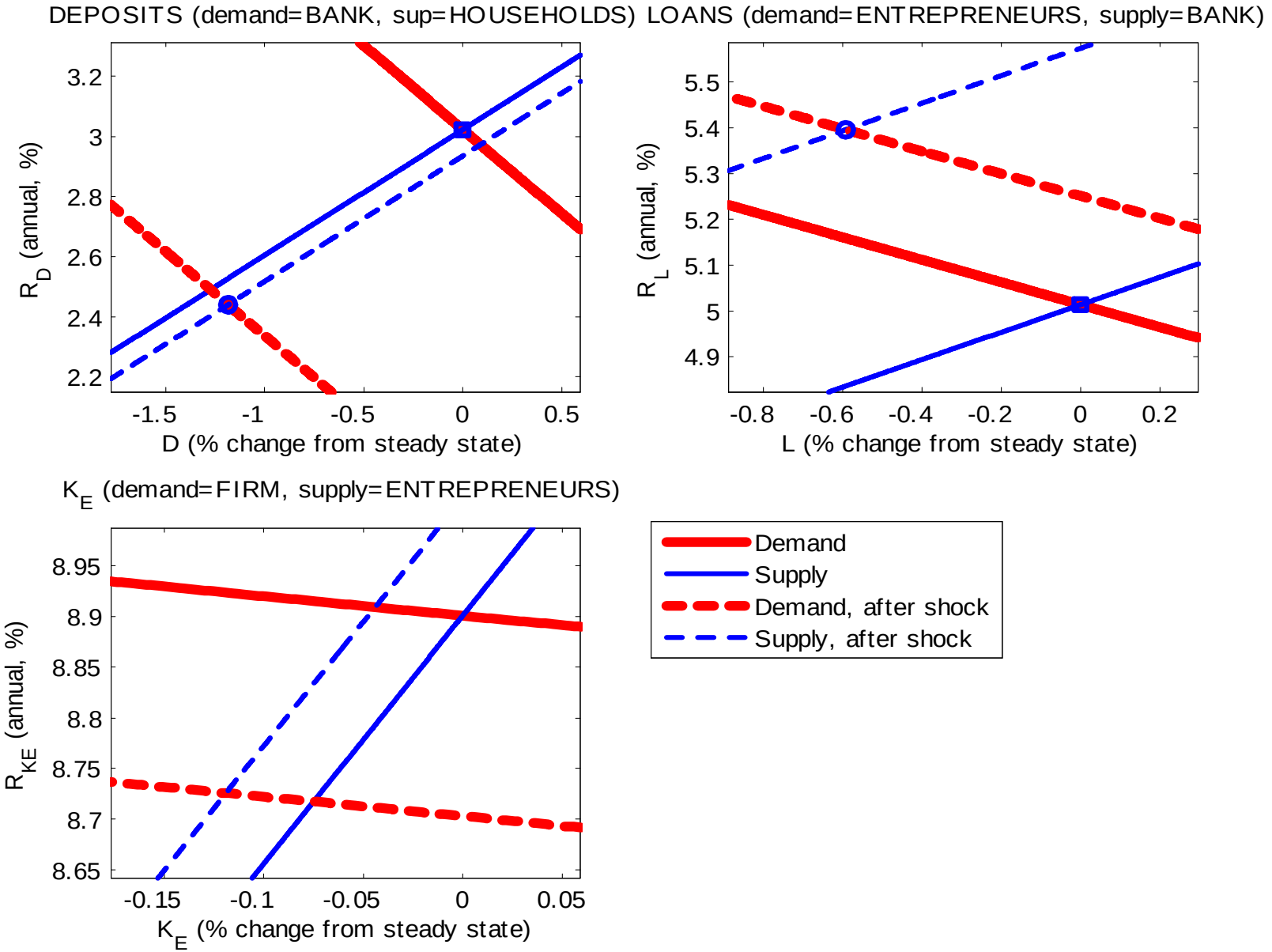
Demand and Supply: Entrepreneur Responses



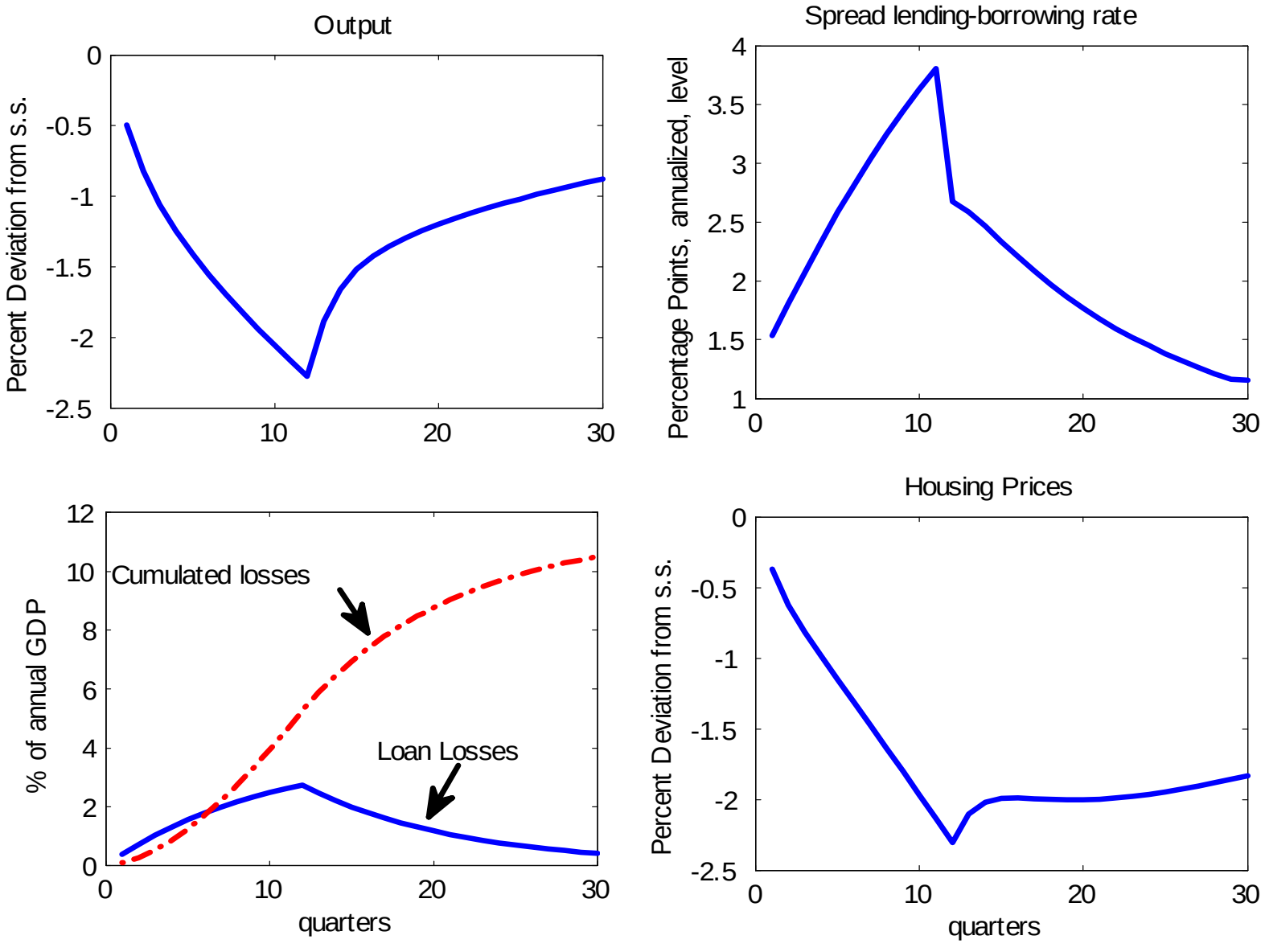
Demand and Supply: Entrepreneur Responses



Demand and Supply after Repayment Shock



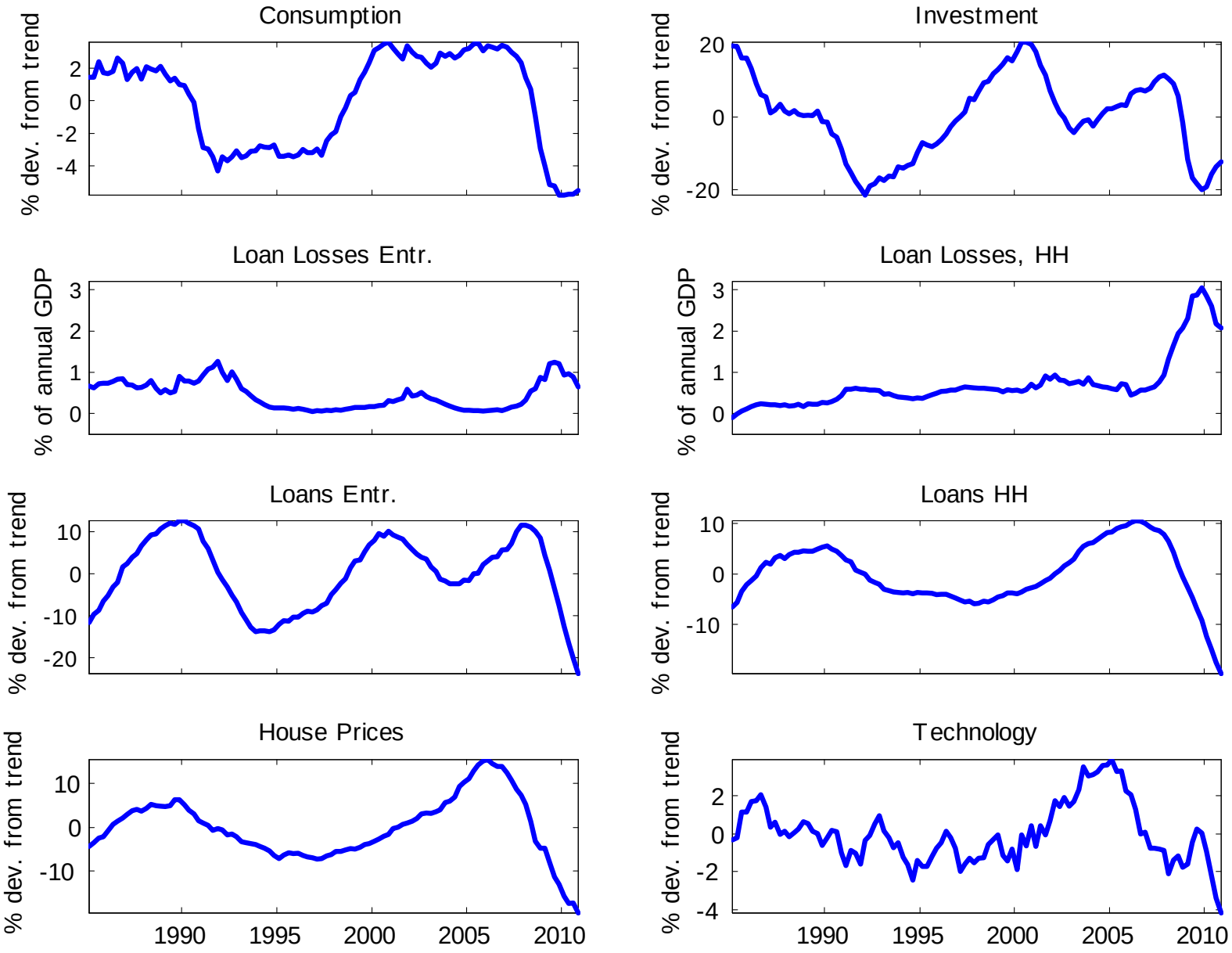
Responses to a Repayment Shock



Bayesian Estimation

1. Parameters measuring leverage are calibrated. m_E, m_S, m_H: 90%, m_K: 50%
   I estimate the model's structural parameters using standard Bayesian methods
2. For added quantitative realism the model features:
   – inertia in the borrowing and capital adequacy constraints ρ_D, ρ_E, ρ_S
   – quadratic deposit, loan and capital adjustment costs ϕ
   – habits in consumption for all agents η
   – variable utilization rate ζ
3. Besides the above, I estimate:
   – μ (capital share of entrepreneurs), ν (share of entrepreneurial real estate)
   – σ, (wage share of constrained HH).
4. 8 shocks (housing demand, repayment shocks for HH and E, LTV shocks for HH and E, preference, investment and TFP shock)

Time Series used in Estimation



Estimated Parameter Values

Table 2.a: Estimation, Structural Parameters

Parameter		Prior distribution			Posterior Distribution		
		Density	Mean	St.dev.	5%	Mean	95%
Habit in Consumption	η	beta	**0.5**	0.15	0.38	**0.47**	0.56
D adj cost, Banks	ϕ_{DB}	gamm	**0.25**	0.125	0.05	**0.13**	0.26
D adj cost, Household Saver (HS)	ϕ_{DH}	gamm	**0.25**	0.125	0.04	**0.11**	0.20
K adj. cost, Entrepreneurs (E)	ϕ_{KE}	gamm	**1**	0.5	0.22	**0.56**	1.12
K adj. cost, Household Saver (HS)	ϕ_{KH}	gamm	**1**	0.5	0.89	**1.74**	2.93
Loan to E adj cost, Banks	ϕ_{EB}	gamm	**0.25**	0.125	0.03	**0.07**	0.13
Loan to E adj cost, E	ϕ_{EE}	gamm	**0.25**	0.125	0.02	**0.06**	0.11
Loan to HB adj cost, Banks	ϕ_{SB}	gamm	**0.25**	0.125	0.27	**0.53**	0.80
Loan to HB adj cost, HH Borrower HB	ϕ_{SS}	gamm	**0.25**	0.125	0.14	**0.39**	0.75
Capital share of E	μ	beta	**0.5**	0.1	0.35	**0.47**	0.58
Housing share of E	ν	beta	**0.04**	0.01	0.03	**0.04**	0.05
Inertia in capital adequacy constraint	ρ_D	beta	**0.25**	0.1	0.10	**0.24**	0.40
Inertia in E borrowing constraint	ρ_E	beta	**0.25**	0.1	0.54	**0.65**	0.76
Inertia in HB borrowing constraint	ρ_S	beta	**0.25**	0.1	0.66	**0.72**	0.78
Wage share HB	σ	beta	**0.3**	0.1	0.23	**0.33**	0.45
Curvature for utilization function E	ζ_E	beta	**0.2**	0.1	0.19	**0.41**	0.61
Curvature for utilization function HS	ζ_H	beta	**0.2**	0.1	0.16	**0.37**	0.58

Estimated Shock Process Parameters

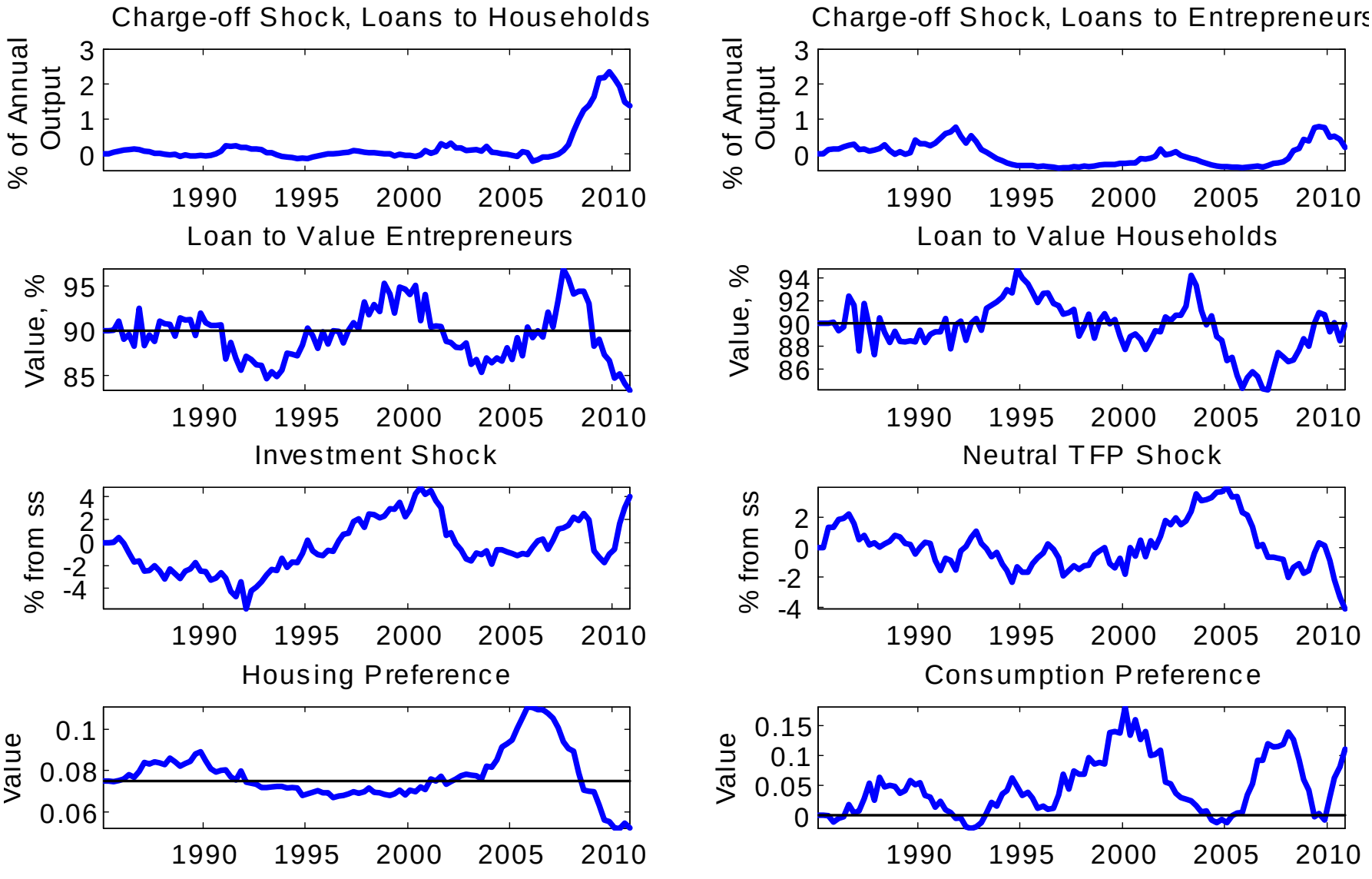
Table 2.b: Estimation, Shock Processes

Parameter		Prior distribution			Posterior Distribution		
		Density	Mean	St.dev.	5%	Mean	95%
Autocor. E default shock	ρ_{be}	beta	**0.8**	0.1	0.888	**0.931**	0.972
Autocor. HB default shock	ρ_{bh}	beta	**0.8**	0.1	0.942	**0.967**	0.987
Autocor. housing demand shock	ρ_j	beta	**0.8**	0.1	0.985	**0.991**	0.997
Autocor. investment shock	ρ_k	beta	**0.8**	0.1	0.848	**0.913**	0.971
Autocor. loan-to-value shock, E	ρ_{me}	beta	**0.8**	0.1	0.748	**0.831**	0.910
Autocor. loan-to-value shock, HB	ρ_{mh}	beta	**0.8**	0.1	0.748	**0.853**	0.938
Autocor. preference shock	ρ_p	beta	**0.8**	0.1	0.990	**0.994**	0.998
Autocor. technology shock	ρ_z	beta	**0.8**	0.1	0.975	**0.989**	0.997
St.dev., Default shock, E	σ_{be}	invg	**0.0025**	0.025	0.0009	**0.0011**	0.0012
St.dev., Default shock, HB	σ_{bh}	invg	**0.0025**	0.025	0.0012	**0.0013**	0.0015
St.dev., housing demand shock	σ_j	invg	**0.05**	0.05	0.0259	**0.0367**	0.0500
St.dev., investment shock	σ_k	invg	**0.005**	0.025	0.0048	**0.0076**	0.0125
St.dev., loan-to-value shock, E	σ_{me}	invg	**0.0025**	0.025	0.0131	**0.0201**	0.0316
St.dev., loan-to-value shock, HB	σ_{mh}	invg	**0.0025**	0.025	0.0099	**0.0126**	0.0163
St.dev., preference shock	σ_p	invg	**0.005**	0.025	0.0178	**0.0205**	0.0236
St.dev., technology shock	σ_z	invg	**0.005**	0.025	0.0061	**0.0070**	0.0079

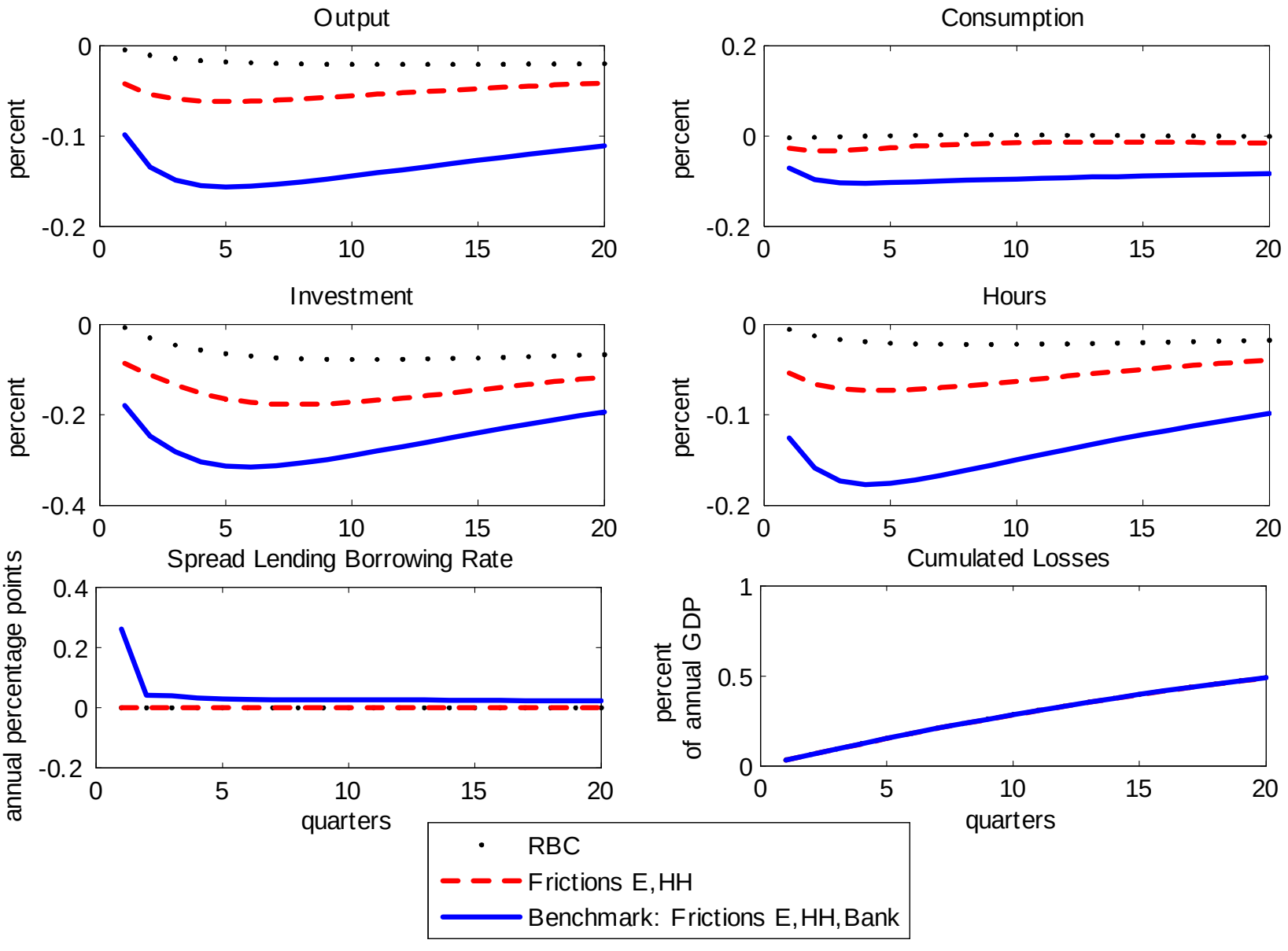
Remarks

1. I am using net charge-offs for banks from the data, and assuming that these charge-offs apply to the stock of mortgage and non–mortgage liabilities of HH and firms (which is larger than the stock of bank loans). Data: cumulative loan losses for comm. banks from 2007 to 2009 around $450bn. Banks "own" 1/3 of all debt instruments of households/firm: implied losses in the model are 3 times larger.
2. I am assuming that lenders cannot offset future expected charge–offs with higher interest rates

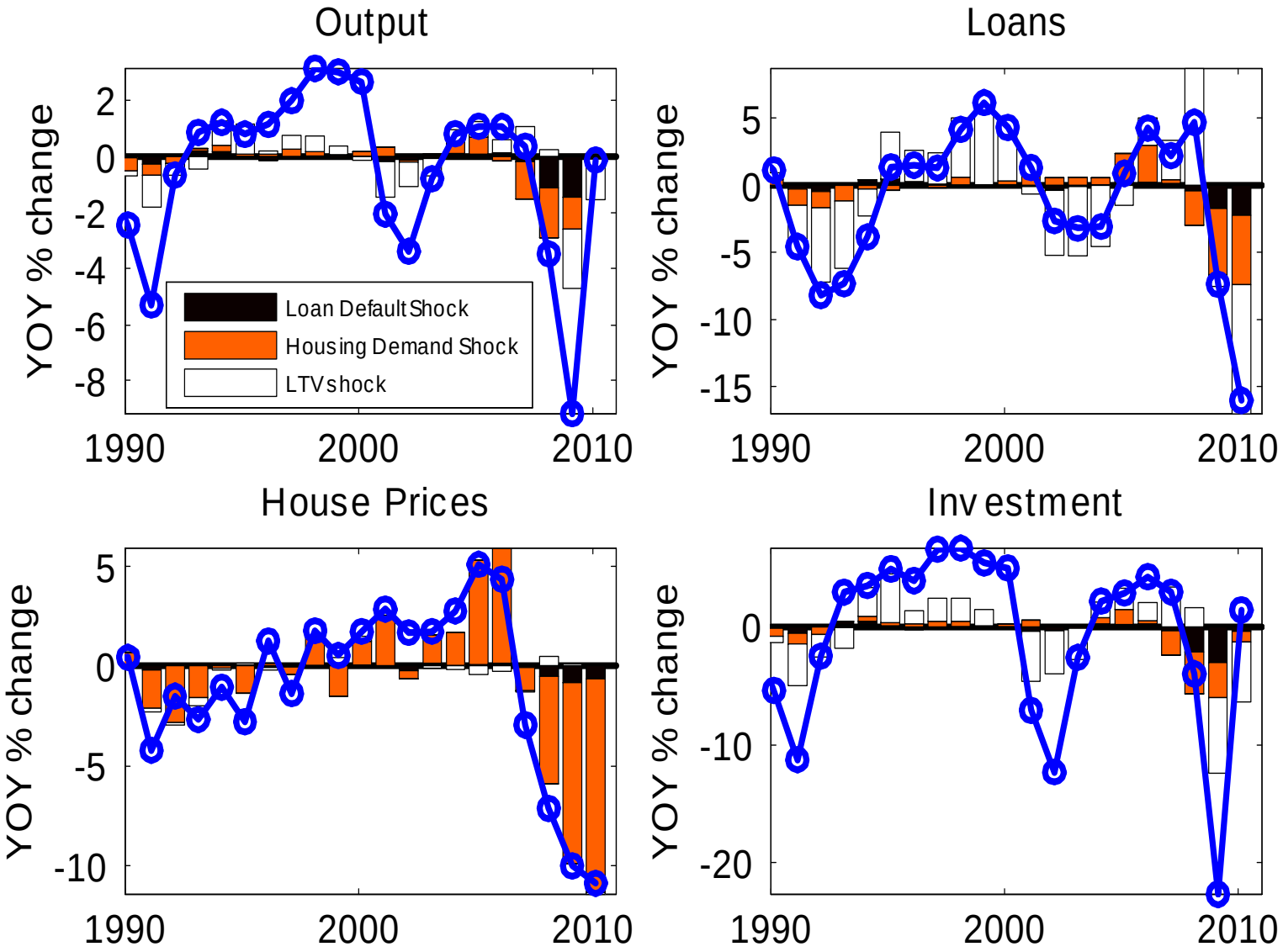
Estimated Shocks



Repayment Shock (blue: baseline, red: model without banks)



Historical Decomposition

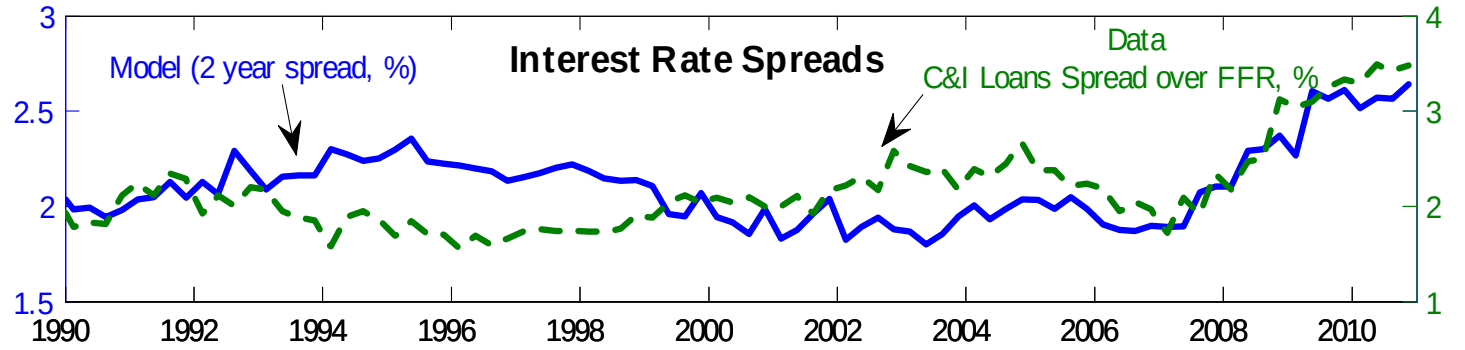


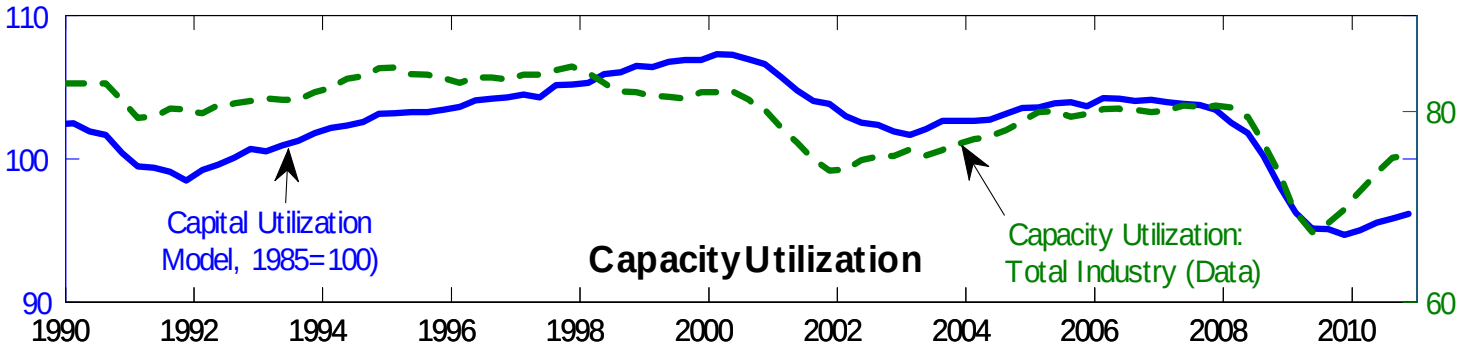
Historical Decomposition

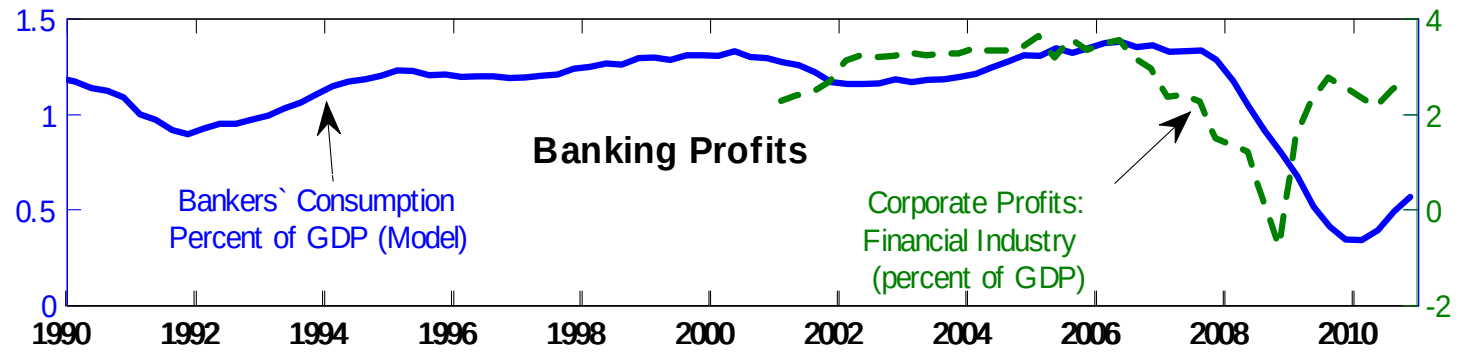
Table 3: Historical Decomposition

Contribution to Output growth of	**2007**	**2008**	**2009**	**2010**	**2007-2010**
Default shocks	*-0.2*	*-1.1*	*-1.4*	*-0.1*	*-2.8*
Housing Demand shock	*-1.3*	*-1.8*	*-1.2*	*0.0*	*-4.3*
LTV shocks	*1.1*	*0.2*	*-2.1*	*-1.4*	*-2.2*
Preference shock	2.9	-0.2	-4.8	2.5	0.4
TFP shocks	-2.2	-0.8	0.2	-1.2	-4.0
All shocks (data)	**0.3**	**-3.7**	**-9.4**	**-0.2**	**-12.9**
Contribution to Investment growth of	**2007**	**2008**	**2009**	**2010**	**2007-2010**
Default shocks	*-0.3*	*-2.2*	*-3.0*	*-0.4*	*-5.9*
Housing Demand shock	*-2.1*	*-3.5*	*-3.0*	*-0.9*	*-9.5*
LTV shocks	*3.4*	*1.6*	*-6.4*	*-5.1*	*-6.5*
Preference shock	2.4	-1.0	-5.6	5.1	0.8
TFP shocks	-0.5	0.8	-5.3	2.6	-2.4
All shocks (data)	**2.9**	**-4.3**	**-23.3**	**1.3**	**-23.4**

External Validation







The Timing of the Shocks

1. First stage of financial crisis 2007-2008: Housing Demand Shock drives drop in output
2. Second Stage 2008-2009: Redistribution Shock
3. Third Stage 2009-2010: LTV Shock
   Estimation tells a story in search of a unifying model (and perhaps one single shock): the decline in housing prices causes defaults which in turn cause tighter credit standard.

$$\left(1-\frac{\phi_{LE}}{L}\left(L_t-L_{t-1}\right)-\lambda_{E,t}\right)C_{E,t}^{-1} = \beta_E\left(R_{E,t+1}\right)C_{E,t+1}^{-1}$$

$$\left(1+\frac{\phi_{LB}}{L}\left(L_t-L_{t-1}\right)-\gamma_E\lambda_{B,t}\right)C_{B,t}^{-1} = \beta_B\left(R_{E,t+1}\right)C_{B,t+1}^{-1}$$