# Banks, Capital Flows and Financial Crises

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Federal Reserve Board

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# Motivation

- Recent wave of financial crises has put financial stability at the forefront of policy discussions
- Need for models that can account for financial crises, and that can be used for analysis of financial stability policies
- A desirable feature of such models is that they be consistent with key stylized facts regarding financial crises
- Two salient facts:
  1. Characterized by strongly non-linear dynamics
  2. Often preceded by credit booms

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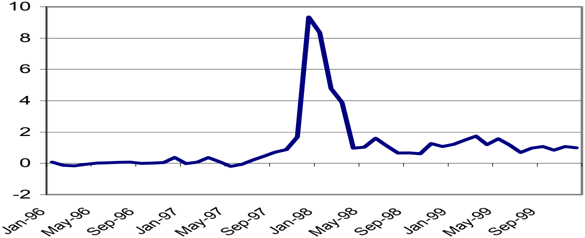
# Corporate Spread (%)

## Korea




## US and Euro Area

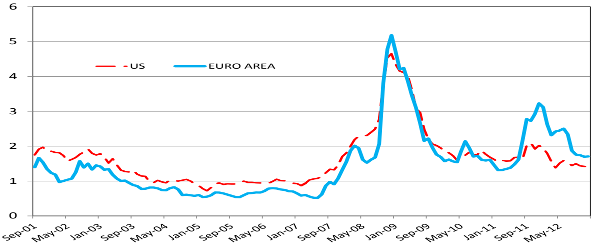
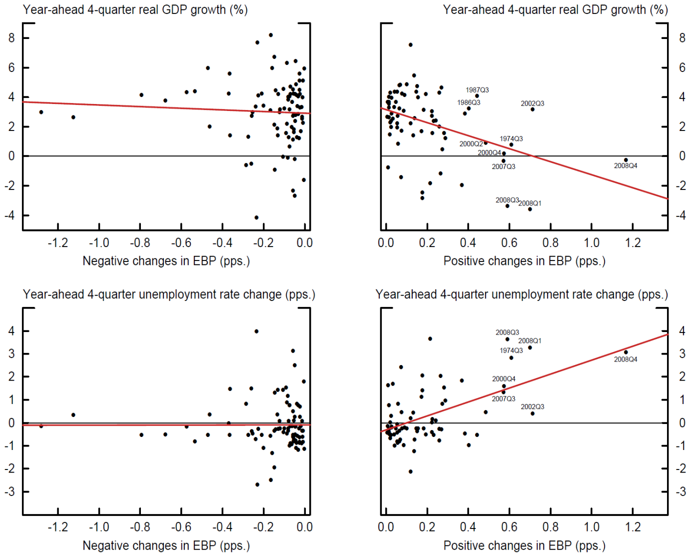


**Figure 2: Excess Bond Premium (EBP), Economic Growth, and the Labor Market**




Note: The left (right) chart in the middle panel depicts the relationship between year-ahead 4-quarter real GDP growth and negative (positive) quarterly changes in the EBP in quarter t. The left (right) chart in the bottom panel depicts the relationship between year-ahead 4-quarter change in the unemployment rate and negative (positive) quarterly changes in the EBP in quarter t.
Source: Gilchrist and Zakrajsek (2012) and author calculations based on data from the Bureau of Economic Analysis and the Bureau of Labor Statistics.

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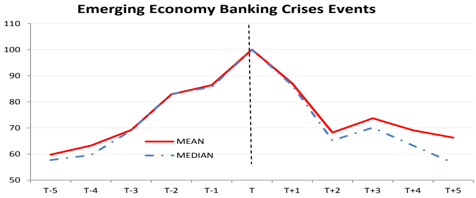
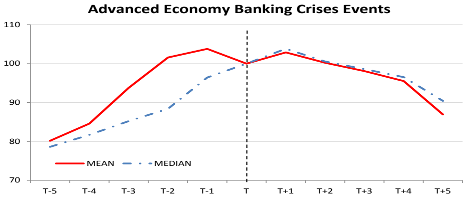
# Domestic Bank Credit (% of GDP)

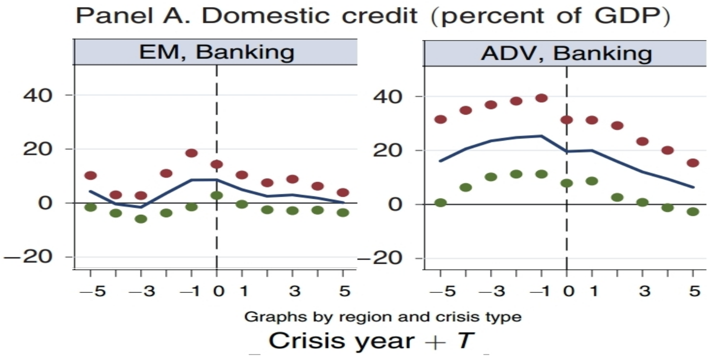



Events included: 1997 banking crises in Indonesia, Korea, Malaysia. Thailand. the Philiphines; and 1994 banking crises in Mexico. Event definition is from Laeven and Valencia (2010)



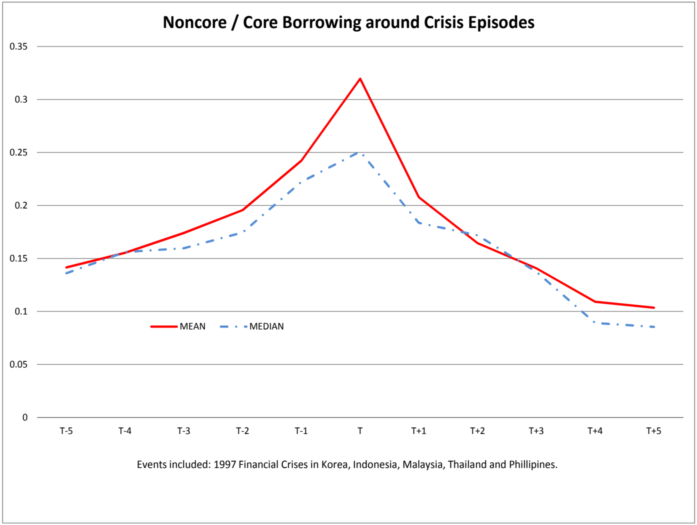

Events included: 2008 banking crises in Austria, Belgium, Denmark, France, Germany, Greece, Iceland, Ireland, Netherland, portugal, Spain, Switzerland ; 2007 banking crises in the UK and the US; and 1991 banking crises in Norway and Sweden). Event definition is from Laeven and Valencia (2010).

# Credit Boom-Bust Events




Source: Gourinchas and Obstfeld (2011)

# Foreign Borrowing and EME Financial Crises



# Objective

- Develop a macroeconomic model with financial intermediaries, consistent with these two facts
- Use the model for analysis of financial stability policies

# What We Do

- Develop a SOE model in which banks' balance sheet constraints are occasionally binding, and in which banks raise equity endogenously
  - Balance sheet constraints arise endogenously due to an agency problem, as in Gertler and Kiyotaki (2010).
- Unlike GK:
  - Banks may or may not be credit constrained
  - Strength of banks' balance sheets reflects not only the accumulation of retained earnings, but also banks' endogenous decision for equity issuance

# What We Do (cont'd)

- Illustrate quantitative properties of the model
  - Constraint induces nonlinearity and state-dependence in the economy's response to shocks
  - Model generates endogenous state-dependent probabilities of future financial crises
  - Low country interest rates lead to a credit boom and to increased probability of a financial crisis, consistent with the data
  - Model produces infrequent financial crises with features consistent with crises in the EMEs and AEs
- Use the model for analysis of macroprudential policy

# Related Literature

- Financial Accelerator models with or w/o financial intermediaries
  - Bernanke, Gertler and Gilchrist (1999), Kiyotaki and Moore (1997), Gertler and Kiyotaki (2010), Gertler and Karadi (2011), and others $\rightarrow$ constraint always binds.
- Non-linear macro models featuring systemic risk
  - Mendoza (2010), Bianchi (2011), Benigno et al. (2012) $\rightarrow$ no banking sector, no explicit agency friction.
  - Brunnermeier and Sannikov (2012), He and Krishnamurthy (2012), Boissay, et al. (2012) $\rightarrow$ not a full-blown macro model of the economy.

# Model

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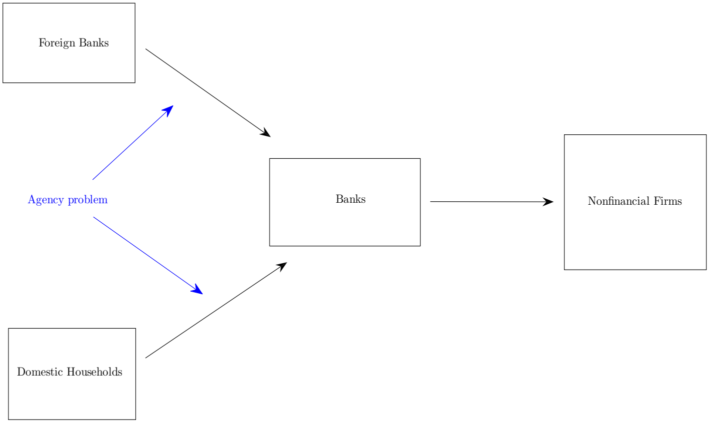


Foreign Banks
Agency problem
Banks
Nonfinancial Firms
Domestic Households

# Households

- Within each household, $1 - f$ "workers" and $f$ "bankers".
- Workers supply labor and return wages to the household.
- Each banker manages a financial intermediary and also transfers earnings back to the household.
- Perfect consumption insurance within the family.
- Bankers have finite survival probability $\sigma$ (average survival time $\frac{1}{1-\sigma}$). Starting bankers receive startup transfer equal to fraction $\xi$ of previous period assets.

# Households: Objective

$$Max \quad \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \frac{\left(C_t - \chi \frac{L_t^{1+\epsilon}}{1+\epsilon}\right)^{1-\gamma} - 1}{1-\gamma}$$

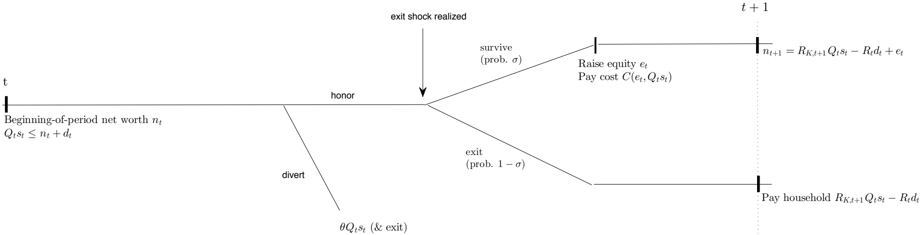
subject to

$$C_t + B_t \quad \leq \quad W_t L_t + R_{t-1} B_{t-1} + \Pi_t$$

where

- $B_t$ short term bonds (intermediary deposits and government debt)
- $\Pi_t$ payouts to the household from firm ownership net the transfer it gives to its new bankers

# Banks: Period-$t$ Timeline



# Banks: Balance Sheet and Net Worth

- Balance Sheet

$$Q_t s_t \leq n_t + d_t$$

where
$$d_t = b_t + b_t^*$$

- Evolution of Net worth
  - Surviving Banks: $n_t = R_{K,t} Q_{t-1} s_{t-1} - R_{t-1} d_{t-1} + e_{t-1}$
  - Exiting Banks: $n_t = R_{K,t} Q_{t-1} s_{t-1} - R_{t-1} d_{t-1}$

# Banks: Agency Problem

- After the banker/intermediary borrows funds at the end of period $t$, it may divert a fraction $\theta$ of assets back to its family.

- If the bank does not honor its debt, creditors can liquidate it and obtain the remaining of assets they initially funded.

- Banks' incentive constraint: $V_t \geq \theta Q_t s_t$

# Banks: Objective

$$V_t(n_t) = \max_{s_t, d_t, e_t} (1-\sigma)\mathbb{E}_t\left(\Lambda_{t,t+1}\overline{n}_{t+1}\right) + \sigma\left\{\mathbb{E}_t\Lambda_{t,t+1}\left[V_{t+1}(n_{t+1}) - e_t\right] - C(e_t, Q_t s_t)\right\}$$

subject to

$$\begin{aligned} Q_t s_t &\leq n_t + d_t \\ n_{t+1} &= R_{K,t+1} Q_t s_t - R_t d_t + e_t \\ V_t(n_t) &\geq \theta Q_t s_t \end{aligned}$$

where $\Lambda_{t,\tau} \equiv$ household's stochastic discount factor

and $\overline{n}_t = R_{K,t} Q_{t-1} s_{t-1} - R_{t-1} d_{t-1}$

# Bank: Value Function

One can show

$$V_t(n_t) = \mu_{K,t} Q_t s_t + \nu_t n_t + \sigma \left[\nu_{e,t} e_t - C(e_t, Q_t s_t)\right]$$

with

$$\begin{aligned} \mu_{K,t} &= \mathbb{E}_t[\Lambda_{t,t+1}\Omega_{t+1}(R_{K,t+1} - R_t)] \\ \nu_t &= \mathbb{E}_t[\Lambda_{t,t+1}\Omega_{t+1}]R_t \\ \nu_{e,t} &= \mathbb{E}_t\left[\Lambda_{t,t+1}\left(\alpha_{t+1} - 1\right)\right] \end{aligned}$$

where $\Omega_{t+1}$ is the shadow value of a unit of net worth at t + 1:

$$\begin{aligned} \Omega_{t+1} &= (1-\sigma) + \sigma \alpha_{t+1} \\ \alpha_{t+1} &= V'_{t+1}(n_{t+1}) \end{aligned}$$

# Banks: Optimality Condition for New Equity

- Define $x_t \equiv \frac{e_t}{Q_t s_t}$.
- The equity cost:

$$
\begin{aligned}
C(e_t, Q_t S_t) &= c(x_t) Q_t s_t \\
c(x_t) &= \frac{\kappa}{2} x_t^2
\end{aligned}
$$

- Optimality condition for new equity issuance:

$$
\nu_{e,t} = \kappa x_t
$$

# Banks: Credit Spreads

- The value function becomes

$$V_t(n_t) = \mu_t Q_t s_t + \nu_t n_t$$

where $\mu_t \equiv \mu_{K,t} + \sigma \frac{\kappa}{2} x_t^2$ is the "total" excess return on assets.

- When the constraint does not bind, $\mu_t = 0$.
- When the constraint binds, $\mu_t > 0$.

# Banks: Binding Incentive Constraint

- Re-writing Incentive Constraint:

$$\mu_t Q_t s_t + \nu_t n_t = \theta Q_t s_t$$

- Endogenous Leverage Constraint:

$$Q_t s_t = \phi_t n_t$$

with

$$\phi_t = \frac{\nu_t}{\theta - \mu_t}$$

- Maximum Leverage Ratio= $\phi_t$

# Banks: Normal Times vs Financial Crises

- In normal times,
  - $\mathbb{E}_t \left( R_{K,t+1} - R_t \right)$ small
  - Banks are unconstrained
  - New equity issuance is low
  - Behavior of the economy is similar to frictionless neoclassical environment
- In a financial crisis,
  - $\mathbb{E}_t \left( R_{K,t+1} - R_t \right) \uparrow\uparrow$
  - Banks' Incentive Constraints bind
  - Nonlinear financial accelerator effect: with constraint binding, $\downarrow N \rightarrow \downarrow I$ and $Q \rightarrow \downarrow N$

# International Capital Markets

- SOE pays a small debt-elastic interest rate premium, following SGU (2003).

$$R_t = \frac{1}{\beta} + \varphi(e^{\frac{B_t^*}{\overline{Y}} - \overline{b}} - 1) + e^{R_t^* - 1} - 1$$

where $R_t^*$ is the country interest rate such that:

$$\begin{aligned} \log(R_t^*) &= \rho_R \log(R_{t-1}^*) + \epsilon_{R,t} \\ \epsilon_{R,t} &\sim N(0, \sigma_R) \end{aligned}$$

# Nonfinancial Firms

**Capital firms**

- Purchase capital goods from capital producers (price $Q_t$) and rent it to final goods firms.

$$R_{K,t} = e^{\psi_t} \frac{\alpha \frac{Y_t}{e^{\psi_t} K_{t-1}} + (1-\delta) Q_t}{Q_{t-1}}$$

**Final goods firms**

- Production function:

$$Y_t = (e^{\psi_t} K_{t-1})^{\alpha} L_t^{1-\alpha}$$

- Optimality Condition for labor

$$(1-\alpha) \frac{Y_t}{L_t} = W_t$$

# Capital Producers

- Capital producers make new capital using input of final output and are subject to adjustment costs. They sell new capital to firms at the price $Q_t$.

- The price of capital goods is equal to the marginal cost of investment goods production:

$$Q_t = 1 + \psi_I \left( \frac{I_t}{e^{\psi_t} K_{t-1}} - \delta \right)$$

# Resource Constraint and Market Clearing

- Resource constraint:

$$Y_t = C_t + \left[1 + \frac{1}{2}\psi_I \left(\frac{I_t}{e^{\psi_t} K_{t-1}} - \delta\right)^2\right] I_t + \sigma \frac{\kappa}{2} x_t^2 Q_t K_t + NX_t$$

- Balance of payments:

$$R_{t-1} B_{t-1}^* - B_t^* = NX_t$$

# Computation

- Solve the model using the Parameterized Expectations method.
  - To take into account the precautionary savings behavior of risk averse banks.
  - To take into account strong nonlinearities, especially when the constraint binds.
- Method relies on approximating the expectations as a function of the state vector.

Table: Calibration

| Parameter | Symbol | Value | Source/Target |
|---|---|---|---|
| **Conventional** | | | |
| Discount factor | $\beta$ | 0.985 | Interest rate (6%, ann.) |
| Risk aversion | $\gamma$ | 2 | |
| Inverse Frisch elast. | $\epsilon$ | 1/3 | Frisch lab. sup. elast. (inv) |
| Labor disutility | $\chi$ | 2.8125 | Steady state labor (30%) |
| Capital share | $\alpha$ | 0.33 | Standard RBC value |
| Capital depreciation | $\delta$ | 0.025 | Mendoza (2010) |
| Investment adj. cost | $\Psi_I$ | 5 | BGG (2000) |
| Debt elast. of interest rate | $\varphi$ | 0.05 | |
| Reference debt/output ratio | $\bar{b}$ | 0.6 | Steady state $B/Y$ of 60% |
| **Financial Intermediaries** | | | |
| Survival rate | $\sigma$ | 0.95 | Expected horizon of 5 yrs, as in GK (2013) |
| fraction divertable | $\theta$ | 0.26 | Frequency of crises (2%) |
| Transfer rate | $\xi$ | 0.0001 | |
| Cost of raising equity | $\kappa$ | 5 | Steady State Leverage of 3.5 |
| **Shock Processes** | | | |
| Persistence of interest rate | $\rho_R$ | 0.9 | |
| SD of interest rate innov. | $\sigma_R$ | 0.008 | |
| SD of capital quality | $\sigma_\psi$ | 0.01 | |

Table: Stochastic Steady State

| Variables | No Policy | $\tau^s = 0.02$ | $\tau^s = 0.04$ |
|---|---|---|---|
| $Y$ | 0.8379 | 0.8387 | 0.8399 |
| $C$ | 0.6594 | 0.6597 | 0.6602 |
| $L$ | 0.2986 | 0.2989 | 0.2992 |
| $K$ | 6.8065 | 6.8163 | 6.8309 |
| $N$ | 1.9162 | 1.9809 | 2.0777 |
| $x$ | 0.0095 | 0.01 | 0.0108 |
| $QK/N$ | 3.55 | 3.44 | 3.29 |
| $B/Y$ | 0.58 | 0.58 | 0.59 |
| $U(C, L)$ | -3.1966 | -3.1973 | -3.1987 |
| **Moments** | | | |
| Time at the constr. (%) | 1.98 | 1.31 | 0.70 |
| 2-qtr-ahead crisis prob. (%) | 1.15 | 0.45 | 0.08 |
| 1-yr-ahead crisis prob. (%) | 5.77 | 3.76 | 1.84 |
| SD( annual $g_Y$ ) (%) | 1.82 | 1.80 | 1.78 |
| SD($Y$)/$\mathbb{E}$($Y$) (%) | 6.06 | 6.06 | 5.87 |
| SD($C$)/$\mathbb{E}$($C$) (%) | 5.89 | 5.89 | 5.71 |
| SD($I$)/$\mathbb{E}$($I$) (%) | 23.30 | 22.89 | 22.46 |
| SD($NX/Y$) (%) | 4.88 | 4.81 | 4.77 |
| **Welfare** | -213.705 | -213.4275 | -213.4302 |

# Figure: Responses to Decline in Country Interest Rate

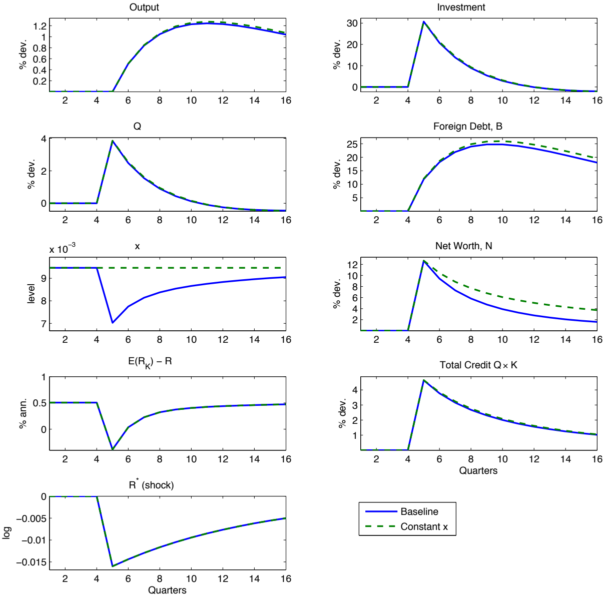
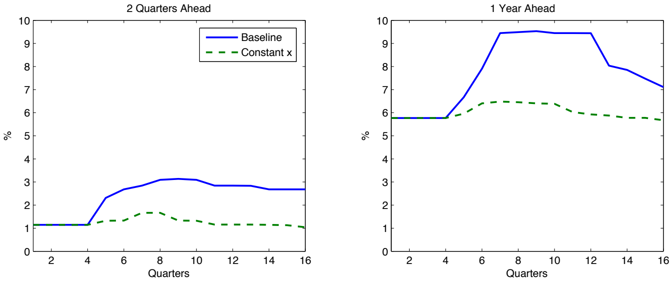
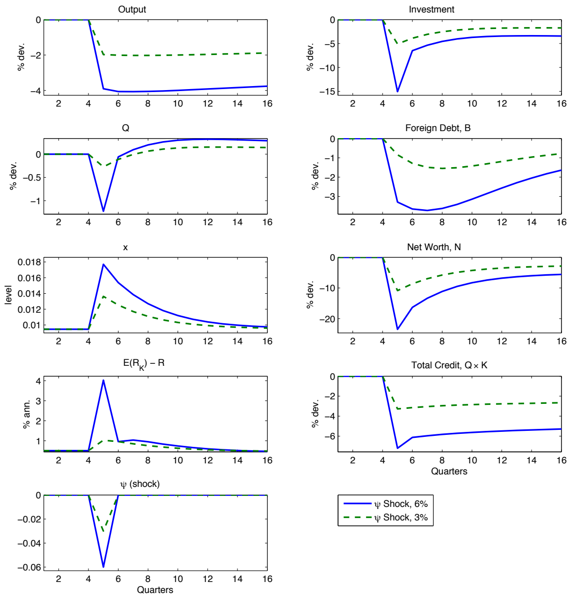


Figure: Responses to Decline in Country Interest Rate, Crisis Probabilities



# Figure: Responses to Capital Quality Shocks



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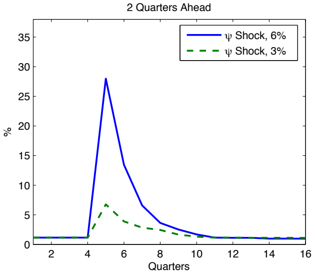
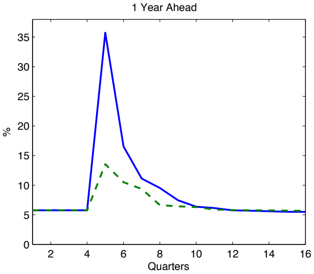
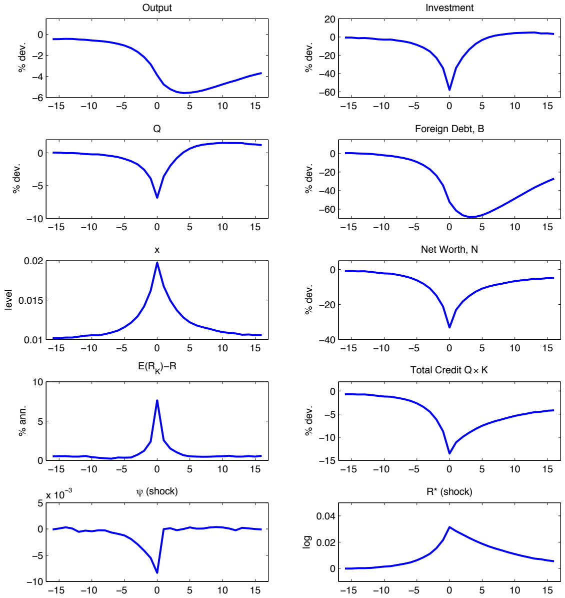


# Figure: Average Financial Crisis



# Policy Experiment

- Government sets a subsidy $\tau^s$ per unit of equity issued, financed by a tax $\tau_t$ on bank assets

- Bank's first order condition for equity issuance becomes

$$\nu_{e,t} + \tau^s = c'(x_t)$$

$\rightarrow$ the policy induces an increase in bank capital, similar to a capital requirement

- Balance sheet constraint is now

$$(1 + \tau_t) Q_t s_t \leq n_t + d_t$$

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# Next Steps

- Use the model to analyze time-varying capital requirements
- Study relative merits of capital controls *vis-á-vis* capital requirements
- Develop monetary version of the model and use it to study implications of conventional monetary policy for financial stability