Banking, Liquidity, and Bank Runs

in an

Infinite Horizon Economy

Mark Gertler and Nobuhiro Kiyotaki

NYU and Princeton

May 2012

Motivation

Banking distress and the real economy: Two complementary approaches:

1. "Macro" (e.g. Gertler and Kiyotaki, 2011)
   (a) Bank balance sheets affect the cost of bank credit.
   (b) Losses of bank capital in a downturn raises intermediation costs
2. "Micro" (e.g Diamond and Dybvig, 1983)
   (a) Maturity mismatch opens up the possibility of runs.
   (b) Runs lead to inefficient asset liquidation and loss of banking services.

Motivation (con't)

- During the crisis both "macro" and "micro" phenomena were at work.
  - (Gorton, 2010, Bernanke, 2010).
- Starting point: Losses on sub-prime related assets depleted bank capital
  - Forced a contraction of many financial institutions.
  - Bank credit costs sky-rocketed
  - Some of the major investment and money funds experienced runs

Motivation (con't)

- Macro models of banking distress:
  - Emphasize balance sheet/financial acceletorator effects
  - Bank runs are excluded.
- Micro models of banks
  - Highly stylized; e.g. two periods
  - Runs often unrelated to health of the macroeconomy.

What We Do

- Develop a simple macro model of banking instability that features both
  - Balance sheet financial/accelerator effects
  - Banks runs
- The model emphasizes the complementary nature of the mechanisms
  - Balance sheet conditions affect whether runs are feasible
  - Two key variables:
    * Bank leverage ratio (affects degree of maturity mismatch)
    * Liquidation prices
  - Both depend on macroeconomics conditions

Model Overview

- Baseline Model: Infinite horizon endowment economy with fixed capital
  - Households
  - Bankers
  - Assume bankers issue short term non-contingent debt
    - Leads to maturity mismatch

- Extended Model: adds idiosyncratic houshehold liquidity risks as in DD
  - Households face uncertain need to make extra expenditures.
  - A way motivate short term demandable bank debt (as in DD)

Intermediated vs. Directly Held Capital

- Capital Allocation

$$K_t^b + K_t^h = \overline{K} = 1$$

- – $K_t^b \equiv$ intermediated capital
  – $K_t^h \equiv$ capital directly held by households

Intermediated vs. Directly Held Capital (con't)

- Technology for intermediated capital

$$\begin{array}{ccc} \textit{date } t & & \textit{date } t+1 \\ K_t^b \text{ capital}\Big\} & \rightarrow & \begin{cases} K_t^b \text{ capital} \\ Z_{t+1}K_t^b \text{ output} \end{cases} \end{array}$$

- Rate of return on intermediated capital

$$R_{t+1}^b = \frac{Z_{t+1} + Q_{t+1}}{Q_t}$$

Intermediated vs. Directly Held Capital (con't)

- Technology for capital directly held by households

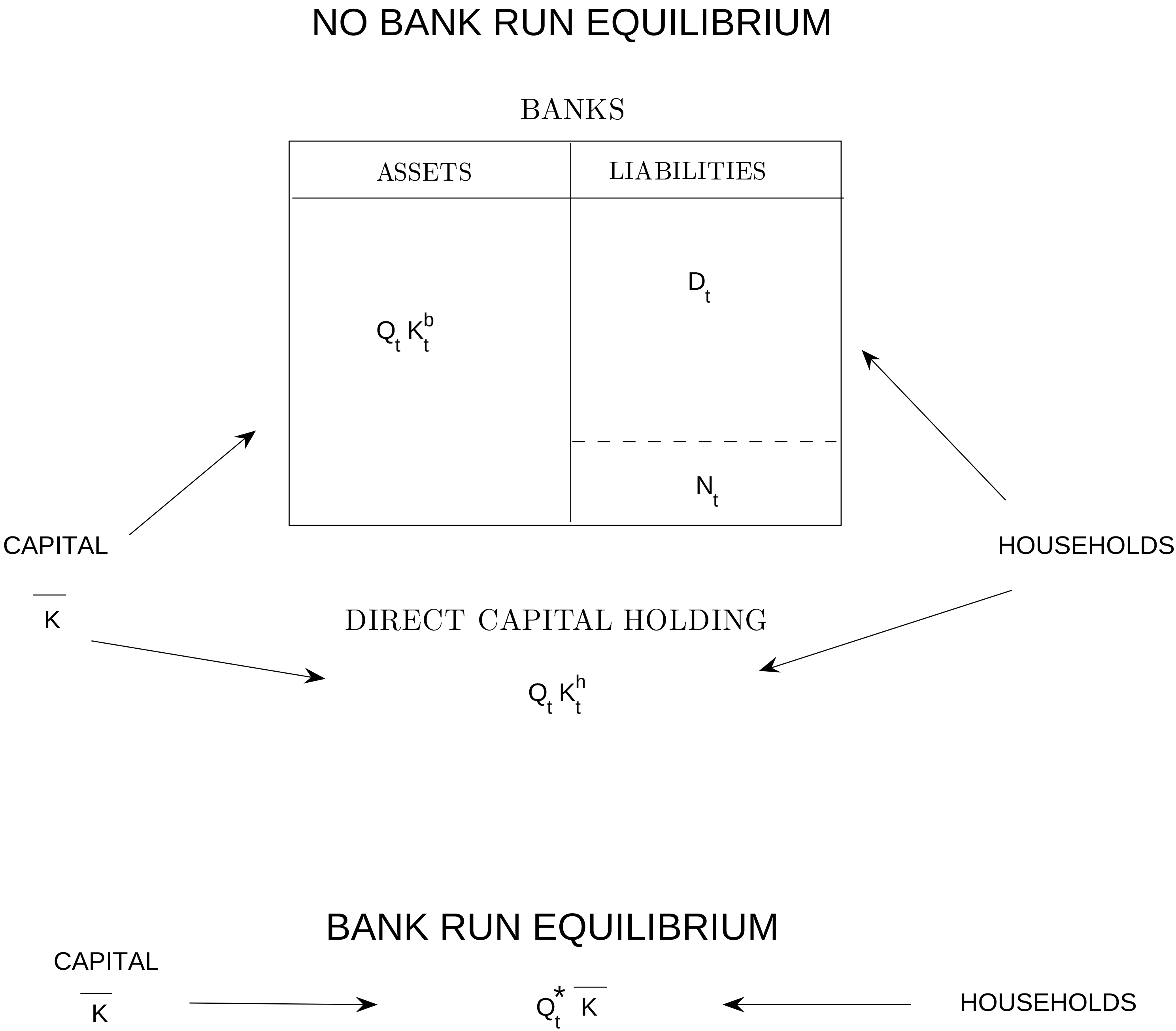
$$
\begin{array}{ccc}
\textit{date } t & & \textit{date } t\text{+1} \\
\left.\begin{array}{c} K_t^h \text{ capital} \\ f(K_t^h) \text{ goods} \end{array}\right\} & \rightarrow & \left\{\begin{array}{c} K_t^h \text{ capital} \\ Z_{t+1}K_t^h \text{ output} \end{array}\right.
\end{array}
$$

$f(K_t^h) \equiv$ management cost; $f' > 0$, $f'' \geq 0$.

- Rate of return on directly held capital

$$R_{t+1}^h = \frac{Z_{t+1} + Q_{t+1}}{Q_t + f'(K_t^h)}$$

- Households directly hold capital due to financial constraints on banks.


NO BANK RUN EQUILIBRIUM
BANKS
ASSETS
LIABILITIES
$Q_t K_t^b$
D_t
N_t
CAPITAL
$\overline{K}$
HOUSEHOLDS
DIRECT CAPITAL HOLDING
$Q_t K_t^h$
BANK RUN EQUILIBRIUM
CAPITAL
$\overline{K}$
$Q_t^* \overline{K}$
HOUSEHOLDS

Households

- Deposit contract:
  - Short term (one period)
  - Non-contingent return R_{t+1} (absent a bank run)
  - Sequential service constraint (as in Diamond/Dybvig)
    - In the event of a run, payoff either R_{t+1} or 0
    - Depends on place in line.
- Bank runs completely unanticipated.

Households (con't)

- choose $\{C_t^h, D_t, K_t^h\}$ to max:

$$U_t = E_t \left(\sum_{i=0}^{\infty} \beta^i \ln C_{t+i}^h \right)$$

- subject to:

$$C_t^h + D_t + Q_t K_t^h + f(K_t^h) = Z_t W^h + R_t D_{t-1} + R_{t+1}^h Q_{t-1} K_{t-1}^h$$

- fonc yield standard euler equations for D_t and K_t^h.

.

Bankers

- A measure unity of bankers

- Each has an i.i.d. survival probability of σ
  - $\Rightarrow$ expected horizon is $\frac{1}{1-\sigma}$

- Banker consumes wealth upon exit

- Preferences are linear in "terminal" consumption c^b_{t+i}

$$V_t = E_t \left[\sum_{i=1}^{\infty} \beta [(1-\sigma) c^b_{t+1} + \sigma \beta V_{t+1}] \right]$$

- Each exiting banker replaced by a new banker.
  - Starts with an endowment w^b.

Bankers (con't)

- Bank balance sheet

$$Q_t k_t^b = d_t + n_t$$

- Net worth n_t for surviving bankers

$$n_t = R_t^b Q_{t-1} k_{t-1}^b - R_t d_{t-1}.$$

- n_t for new bankers

$$n_t = w^b$$

- c_t^b for exiting bankers

$$c_t^b = n_t$$

Limits to Bank Arbitrage

- Agency Problem:
  - After the banker borrows funds at the end of period t, it may divert: a fraction of θ of loans
  - If the bank does not honor its debt, creditors can
    - recover the residual funds and
    - shut the bank down.

$\Rightarrow$

- Incentive constraint

$$\theta Q_t k_t^b \leq V_t$$

Solution

- "Leverage" constraint

$$\frac{Q_t k_t^b}{n_t} \leq \phi_t$$

- ϕ_t is
  - decreasing in θ
  - increasing in μ_t

$$\mu_t = \beta E_t[(R_{t+1}^b - R_{t+1})\Omega_{t+1}]$$

where $\Omega_{t+1} > 1$ is the banker's expected shadow value of n_{t+1}

- μ_t is countercyclical $\Rightarrow$ ϕ_t is countercyclical.

Aggregation

- Aggregate leverage constraint

$$Q_t K_t^b = \phi_t N_t$$

- Aggregate net worth

$$N_t = \sigma[(R_t^b - R_t)\phi_{t-1} + R_t]N_{t-1}] + W^b$$

- Volatility of N_t depends on ϕ_{t-1} and volatility of R_t^b.

Bank Runs

- Ex ante zero probability of a run.

- Consider the possibility of a run ex post:

- Ex post a "bank run" equilibrium" is possible if:

  – Individual depositors believe that if other households do not roll over their deposits, the bank may not be able to meet its obligations on the remaining deposits.

Conditions for a Bank Run Equilibrium (BRE)

- Timing of events:
  - At the beginning of period t, depositors decide whether to roll over their deposits with the bank.
  - If they choose to "run", the bank liquidates its capital and it sells it to households who hold it with their less efficient technology.

- A run is then possible if:

$$R_t^{b*} Q_{t-1} K_{t-1}^b < R_t D_{t-1}$$

$R_t^{b*} \equiv$ rate of return on bank assets conditional on liquidation:of bank assets

$$R_t^{b*} = \frac{(Z_t + Q_t^*)}{Q_{t-1}}$$

$Q_t^* \equiv$ the liquidation price of a unit of the bank's assets.

Conditions for a Bank Run Equilibrium (BREC) (con't)

- We can simplify the condition for a BRE:

$\Rightarrow$

$$R_t^{b*} < R_t \cdot \frac{D_{t-1}}{Q_{t-1}K_t^b} = R_t(1 - \frac{1}{\phi_{t-1}})$$

with

$$R_t^{b*} = \frac{(Z_t + Q_t^*)}{Q_{t-1}}$$

- Whether a BRE exists depends on (Q_t^*, ϕ_{t-1}, R_t).

- Q_t^* is procyclical and ϕ_t.is highly countercyclical $\Rightarrow$ the likliehood of a BRE is countercyclical.

Liquidation Price

- After a bank run at t :

$$K_{t+i}^{h} = \overline{K} = 1 \ \nabla i$$

- Household euler eqution for direct capital holding

$$E_t\{\Lambda_{t,t+1} R_{t+1}^{h*}\} = 1$$

with

$$R_{t+1}^{h*} = \frac{Z_{t+1} + Q_{t+1}^{*}}{Q_t^{*} + f'(1)}$$

where $f'(1)$ is the marginal management cost which as at a maximum at $K_t^h = 1$.

Household Liquidity Risks:

- Suppose the representative family has a continuum of members of measure unity.
- With probability π a member has a need for emergency expenditures.
- Let c_t^m be emergency expenditures by an individual, with $\pi c_t^m = C_t^m$ total expenditures by the family.
  - For an individual with emergency expenditures needs momentary utility is:
  $$\log C_t^h + \kappa \log c_t^m$$
  - For someone without:
  $$\log C_t^h$$

Household Liquidity Risk (con't)

Timing of Events:

- The family chooses C_t^h and its portfolio before learning of the realization of the liquidity risk.
- After choosing D_t, the household divides it evenly amongst it members.
- Emergency expenditures mus be financed by deposits:

$$c_t^m \leq D_t$$

- Those who do not use their deposits return them to the family
- The household also sells any unused endowment to other households for deposits
  - by l.l.n. outflows of D_t equal inflows during t.

Figure 1: A Recession in the Baseline Model: No Bank Run Case

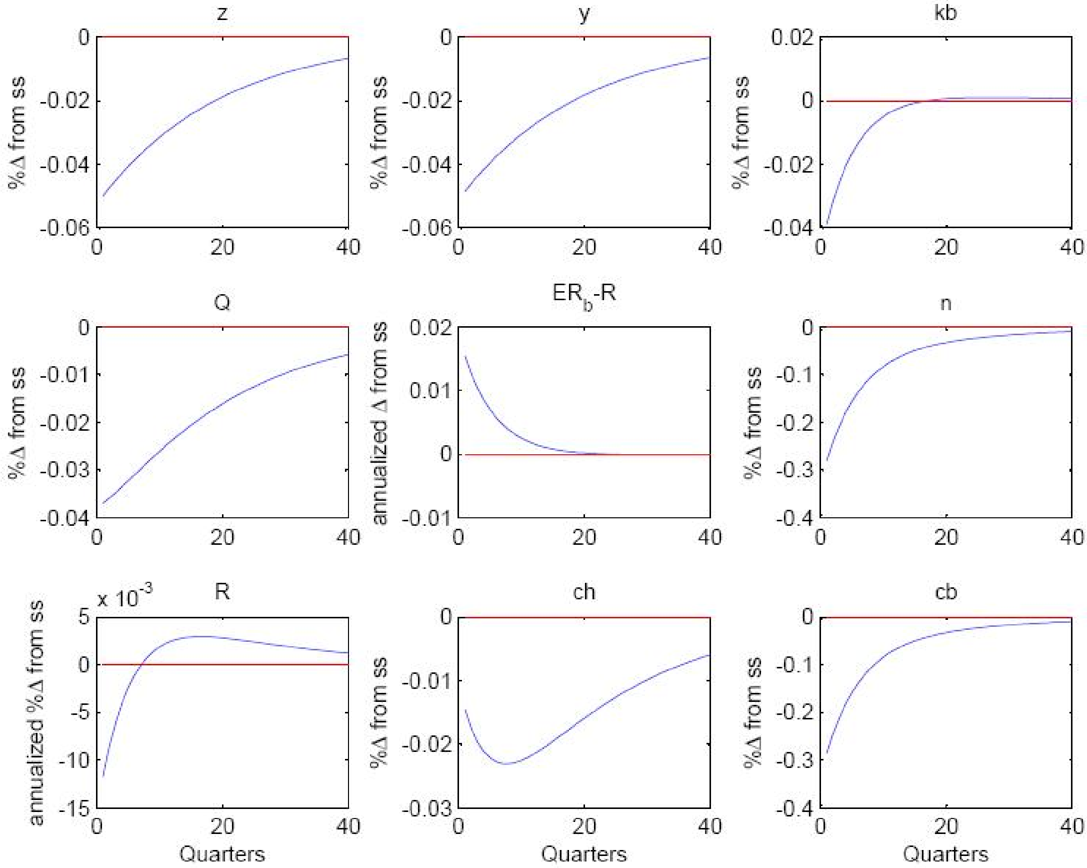


Figure 3: Ex Post Bank Run in the Baseline Model

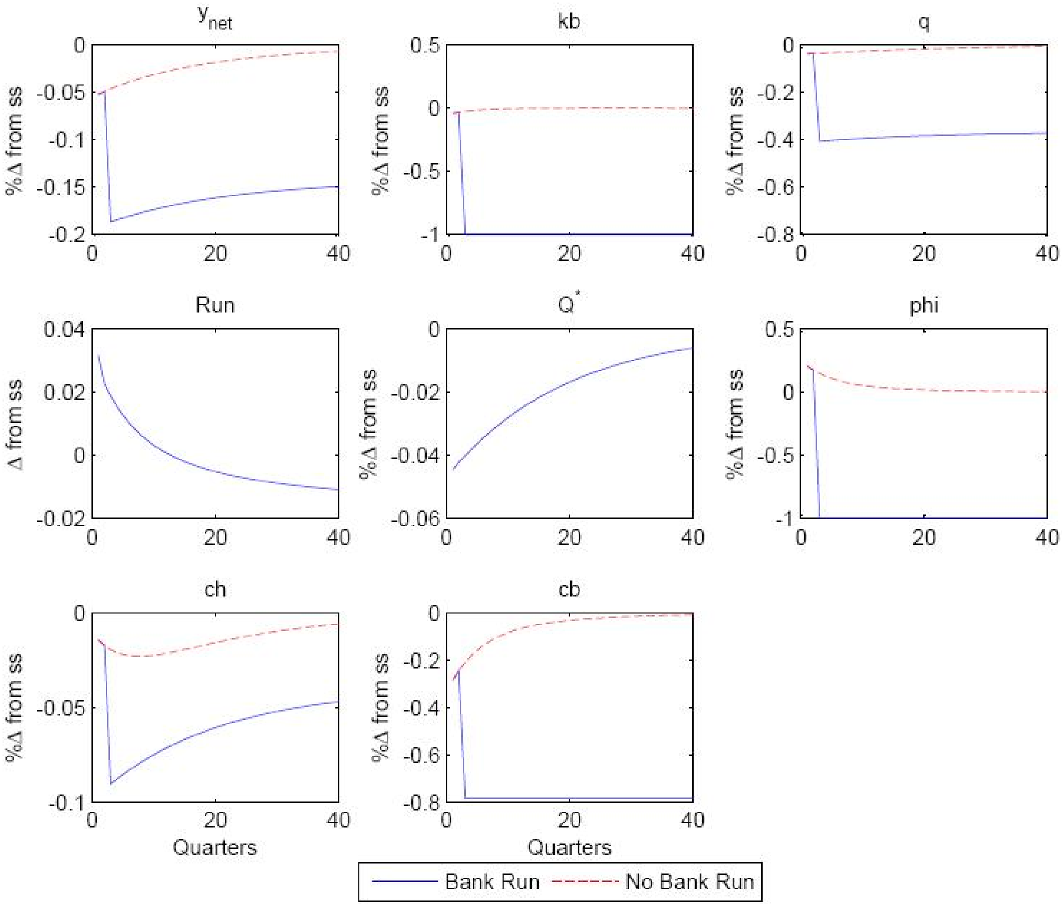


Figure 2: A Recession in the Liquidity Risk Model: No Bank Run Case

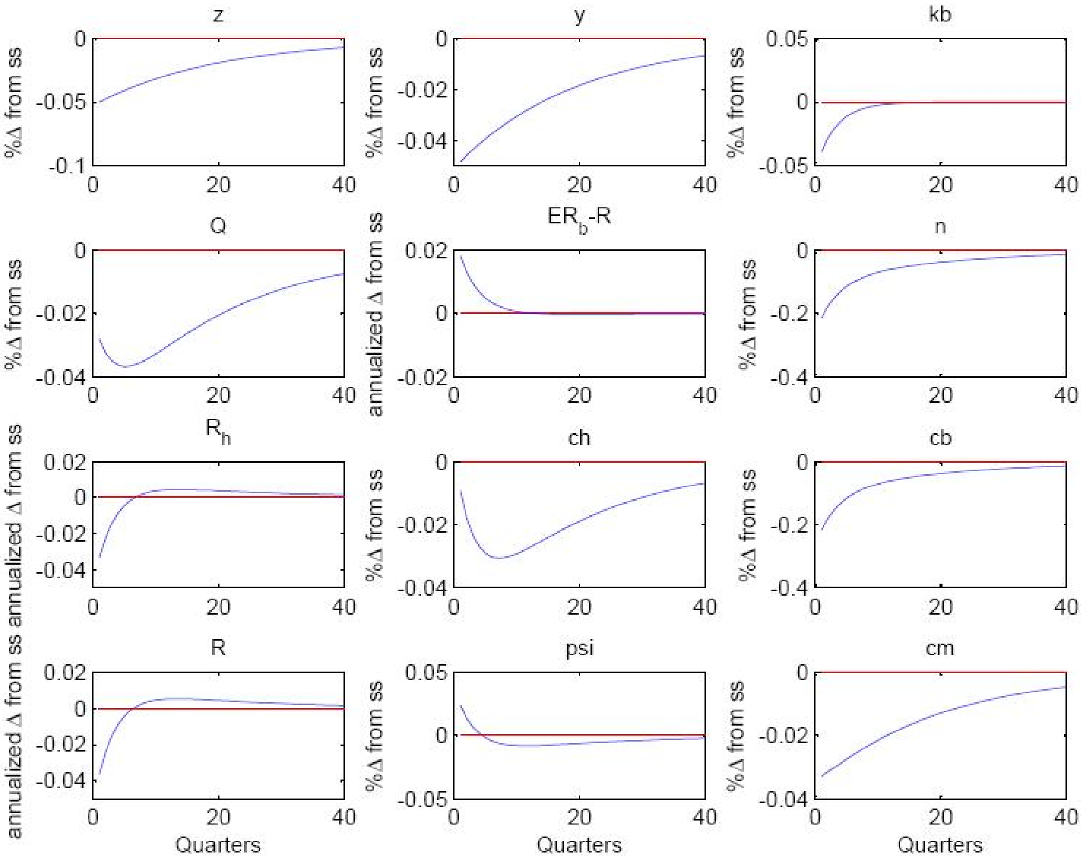
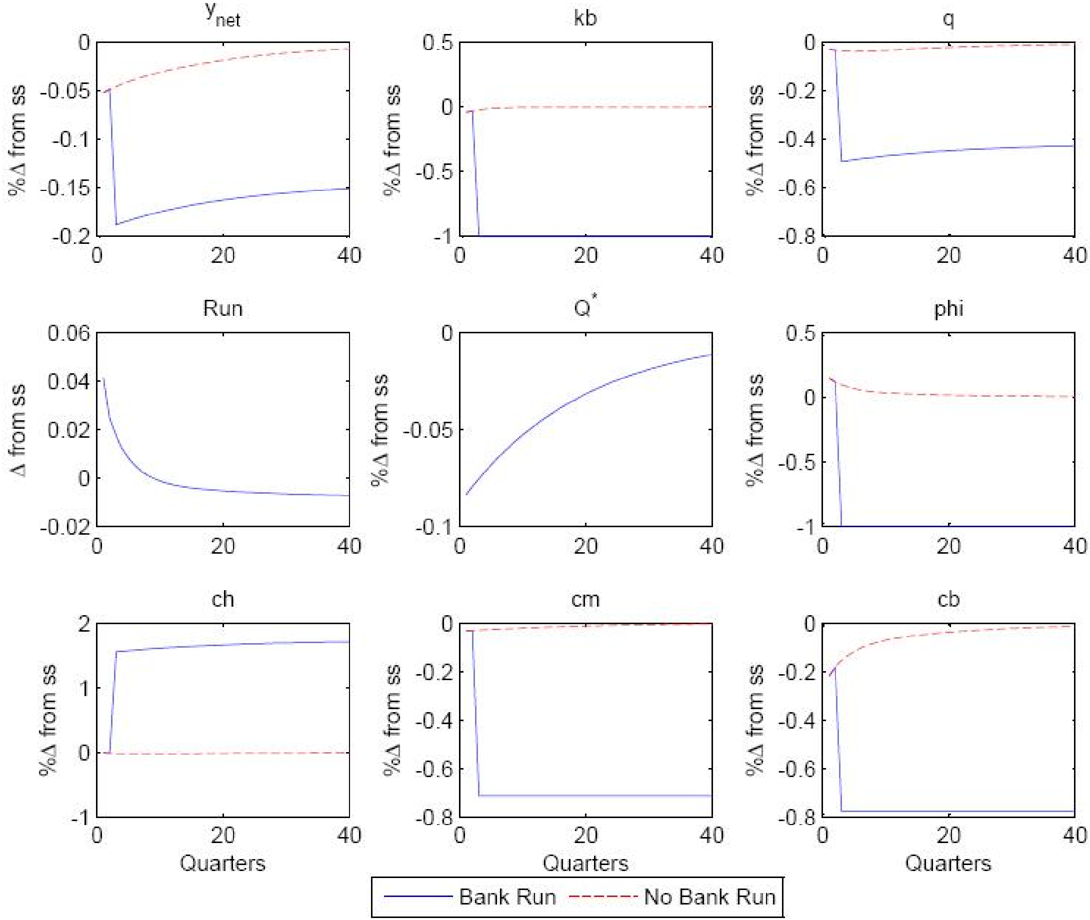


Figure 4: Ex Post Bank Run in the Liquidity Risk Model



Some Remarks About Policy

- As in Diamond/Dybivg a role for deposit insurance.
  - Eliminates bank run equilibrium
  - But may have moral hazard effects on risk-taking.
- Can offset with capital requirements
  - Reduces risk-taking
  - Reduces the liklelihood of a bank run equilibrium
  - But if bank equity capital costly to raise, can increase intermediation costs.
- Alernative: commitment to lender-of-last resort policies
  - Stabilizing liquidation prices reduces likliehood of bank runs
  - Examples: lending againt good collateral
  - Asset purchases a good quality securities (e.g. AMBS)

Table 1: Parameters

Baseline Model		
β	0.99	Discount rate
σ	0.95	Bankers survival probability
θ	0.35	Seizure rate
α	0.1	Household managerial cost
$\bar{K}^h$	0.096	Threshold capital for managerial cost
γ	0.72	Fraction of depositors that can run
ρ	0.95	Serial correlation of productivity shock
Z	0.0161	Steady state productivity
ω^b	0.0019	Bankers endowment
ω^h	0.045	Household endowment
Additional Parameters for Liquidity Model		
κ	62.67	Preference weight on c_m
$\bar{c}^m$	0.01	Threshold for c_m
π	0.03	Probability of a liquidity shock
γ_L	0.67	Fraction of depositors that can run

Table 2: Steady State Values

Steady State for No Bank-Run Equilibrium		
	Baseline	Liquidity
K	1	1
Q	1	1
C^h	0.0541	0.0184
C^m	0	0.0348
C^b	0.0087	0.0088
K^h	0.0594	0.0545
K^b	0.9406	0.9455
ϕ	8	8
R^b	1.0644	1.0624
R^h	1.0404	1.0404
R	1.0404	1.0384

Steady State for Bank-Run Equilibrium		
	Baseline	Liquidity
K	1	1
Q^*	0.6340	1
C^h	0.0520	0.0515
C^m	0	0.01
C^b	0.0019	0.0019
K^h	1	1
K^b	0	0
ϕ		
R^b	1.1016	1.1068
R^h	1.0404	1.0404
R		