Bank Runs, Fragility, and Credit Easing

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Motivation

- Financial crises typically involve bank runs
- Short-term debt can make a bank vulnerable to a self-fulfilling run
- Empirically, runs more likely with weak aggregate fundamentals
  - General equilibrium feedbacks potentially important

★ Macroeconomic model essential to understand feedbacks

Q: What are the implications for government policy?

A Macroeconomic Model of Bank Runs

- Dynamic portfolio and equity decisions for banks
  - Depend on asset prices, determined in equilibrium
- Limited commitment and endogenous strategic default
  - Defaults triggered by fundamentals or runs
- Fragility linked to fundamentals, as in Gertler-Kiyotaki, but key differences:
  - Runs on individual banks
  - Maturity critical for fragility $\Rightarrow$ role for lender of last resort
- Normative analysis

Preview of Main Normative Results

- Desirability of **credit easing** depends on source of the crisis
  - Welfare *reducing* if driven by fundamentals, but welfare *improving* if driven by runs

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    - Welfare *reducing* if driven by fundamentals, but welfare *improving* if driven by runs

- Repaying banks are **net sellers** in a crisis driven by runs

$\Rightarrow$ Benefit from increase in asset prices

...but are net buyers if a crisis is driven by fundamentals

$\Rightarrow$ Lose from increase in asset prices

Outline of the Talk

1. Environment without runs

2. Model with bank runs

3. Policy analysis

Environment

- Discrete time, infinite horizon, no aggregate risk
- Continuum of banks, preferences $\sum_{t=0}^{\infty} \beta^t \log(c_t)$.
- Creditors have linear utility, discount rate R
- Technology
  - Production of consumption good: $y = zk$
  - Capital in fixed supply $\overline{K}$
- Competitive market for assets and deposits
- No commitment to repay deposits

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Banks' Budget Constraints

All banks start at $t = 0$ with portfolio $(b_0, \overline{K})$

- If repay at time t:

$$c = (\bar{z} + p_t)k - Rb + q_t(b', k')b' - p_t k'.$$

- q_t price schedule of deposits
- p_t price of capital

- Deposits are one-period non-state contingent claims
  - Without loss for now, but will matter with runs
- Capital is liquid
  - Price determined in equilibrium

Banks' Budget Constraints

All banks start at $t = 0$ with portfolio $(b_0, \overline{K})$

- If default at time t:

$$c = (\underline{z} + p_t)k - p_t k'$$

  - Permanent financial exclusion $b' = 0$
    - Restriction on saving w/o loss
  - Productivity loss $y = \underline{z}k$
    - Evidence on losses of firms exposed to defaulting banks

Strategic Bank Default

$$
\begin{aligned}
V_t^R(b,k) &= \max_{k',b',c} \log(c) + \beta V_{t+1}(b',k') \\
&\quad \text{s.t.} \quad c = (\bar{z} + p_t)k - Rb + q_t(b',k')b' - p_t k' \\
&\quad \qquad \text{No-Ponzi}
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Repayment decision:

- If $V_t^R(b,k) = V_t^D(k)$: indifferent
  - Repay for $t > 0$
  - **Default with probability** ϕ

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Otherwise, $q = 0$.

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- Bank at time t faces $q_t = 1$ if

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Otherwise, $q = 0$.

- Guess and verify borrowing constraint

$$b_{t+1} \leq \gamma_t p_{t+1} k_{t+1}$$

where $\{\gamma_t\}$ is an eqm. object to be determined

The Value of Default

$$V_t^D(k) = A + \frac{1}{1-\beta}\log(k(\underline{z} + p_t)) + \frac{\beta}{1-\beta}\sum_{\tau \geq t} \beta^{\tau - t} \log\left(R_{\tau+1}^D\right),$$

where the return on capital under default

$$R_{t+1}^D = \frac{\underline{z} + p_{t+1}}{p_t}$$

and $A \equiv \frac{1}{1-\beta}\left[\log(1-\beta) + \frac{\beta}{1-\beta}\log(\beta)\right]$

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Policies:

$$\mathcal{C}_t^D(k) = (1-\beta)\left(\underline{z}+p_t\right)k, \qquad \mathcal{K}_{t+1}^D(k) = \beta\frac{(\underline{z}+p_t)k}{p_t},$$

The Value of Repayment

Denote $n = k(\bar{z} + p) - bR$

$$V_t^R(n) = A + \frac{1}{1-\beta}\log(n) + \frac{\beta}{1-\beta}\sum_{\tau \geq t}^{\infty} \beta^{\tau - t}\log(R^e_{\tau+1}),$$

where returns are

$$R^e_{t+1} = R^k_{t+1} + (R^k_{t+1} - R)\frac{\gamma_t p_{t+1}}{p_t - \gamma_t p_{t+1}} \quad R^k_{t+1} \equiv \frac{\bar{z} + p_{t+1}}{p_t},$$

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Policies:

$$\mathcal{C}_t^R(n) = (1-\beta)n$$

$$\mathcal{B}_{t+1}^R(n) = \gamma_t p_{t+1}\mathcal{K}_{t+1}^R(n), \qquad \mathcal{K}_{t+1}^R(n) = \frac{\beta n}{p_t - \gamma_t p_{t+1}} \quad \text{if } R_{t+1}^k > R$$

Equilibrium Consistent Borrowing Limit

- Given a sequence of prices, a bank is indifferent between repaying and defaulting at $t+1$ if

$$\frac{\bar{z} + p_{t+1}(1 - \gamma_t R)}{\underline{z} + p_{t+1}} = \left(1 - \gamma_{t+1} \frac{p_{t+2}}{p_{t+1}}\right)^{\beta}$$

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- Potentially many solutions, but only one consistent with No-Ponzi

Solving for γ_t for Constant Price

$$\gamma_{t+1} = 1 - \left(\frac{R^k(p)/R - \gamma_t}{R^D(p)/R} \right)^{\frac{1}{\beta}} \equiv H(\gamma_t)$$

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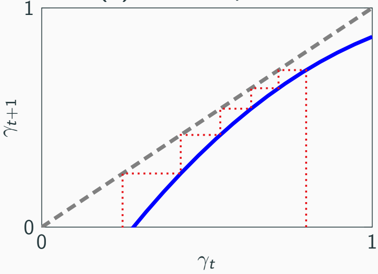
- Partial eqm. does not exist if return on capital is too high
  - No borrowing limit

(b) No fixed point



Solving for γ_t for Constant Price

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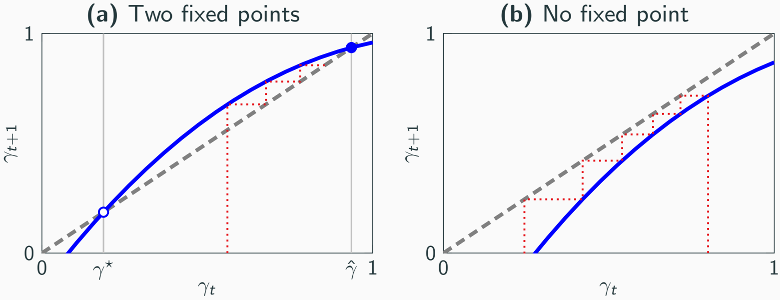
- If eqm ∃, two fixed points but only smallest satisfies No-Ponzi
  - First fixed point unstable $\Rightarrow \gamma_t = \gamma^\star$
  - $\gamma^\star$ is increasing in $(\beta, \bar{z})$ and decreasing in $(R, \underline{z}, p)$



Outline of the Talk

1. Environment without runs
    - Bank problem in partial equilibrium
    - General equilibrium
2. Model with bank runs
3. Policy analysis

General Equilibrium

- Market clearing for capital

$$\phi K_t^D + (1-\phi)K_t^R = \overline{K}$$

where $\phi \in [0,1]$ are the banks that default at $t=0$

$$\phi = \begin{cases} 1 & \text{if } B_0 > \gamma_{-1} p_0 \overline{K}, \\ 0 & \text{if } B_0 < \gamma_{-1} p_0 \overline{K}, \\ \in [0,1] & \text{if } B_0 = \gamma_{-1} p_0 \overline{K} \end{cases}$$

where

$$\frac{\bar{z} + p_0(1-\gamma_{-1}R)}{\underline{z} + p_0} = \left(1 - \gamma_0 \frac{p_1}{p_0}\right)^{\beta}$$

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Definition of Equilibrium

Given B_0, an equilibrium is a sequence of $\{p_t\}_{t=0}^{\infty}, \{\gamma_t\}_{t=-1}^{\infty}$, aggregate debt and capital, $\{B_t, K_t^R, K_t^D\}_{t=0}^{\infty}$, and an *initial share of defaulting banks*, ϕ, such that

(i) Evolution of aggregate B, K consistent with bank optimality

$$\begin{aligned} B_{t+1} =& \mathcal{B}_{t+1}((\bar{z} + p_t)K_t^R - RB_t) \\ K_{t+1}^R =& \mathcal{K}_{t+1}^R((\bar{z} + p_t)K_t^R - RB_t) \\ K_{t+1}^D =& \mathcal{K}_{t+1}^D((\underline{z} + p_t)K_t^D) \end{aligned}$$

(ii) Borrowing limits are equilibrium consistent

(iii) Market for capital clears

(iv) ϕ is consistent with banks' optimal default decision

General Equilibrium

Type of equilibrium depends on B_0

Stationary values:

$$p^R = \frac{\beta \bar{z}}{1 - \beta - (1 - \beta R)\gamma^R} \qquad p^D = \frac{\beta}{1-\beta}\underline{z}$$

$$\gamma^R = H(\gamma^R, p^R) \qquad \gamma^D = H(\gamma^D, p^D)$$

General Equilibrium

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Repayment eqm. Mixed eqm. Default eqm $\longrightarrow B_0$

$\gamma^R p^R \overline{K}$ $\gamma^D p^D \overline{K}$

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Repayment eqm. | Mixed ? eqm. | Default eqm $\longrightarrow B_0$

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Result: $\gamma^D p^D > \gamma^R p^R \rightarrow$ Uniqueness

Mixed Equilibrium

Type of equilibrium depends on B_0

Repayment eqm. | Mixed eqm. | Default eqm

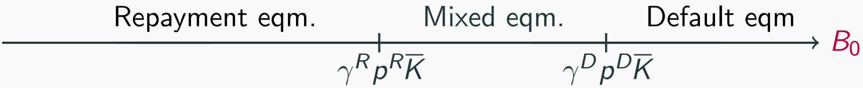
$\gamma^R p^R \overline{K}$ | $\gamma^D p^D \overline{K}$ | B_0

Within thresholds, a degenerate equilibrium does not exist

- Fraction ϕ defaults and $1 - \phi$ repay
    - Generalize Kehoe-Levine, by allowing initial defaults

Mixed Equilibrium

Type of equilibrium depends on B_0



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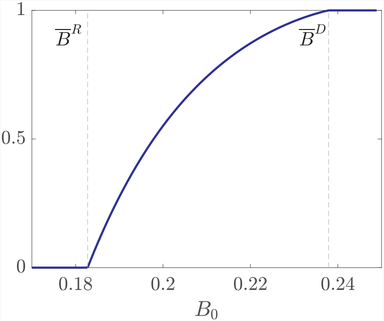
In the paper: ▸ Details

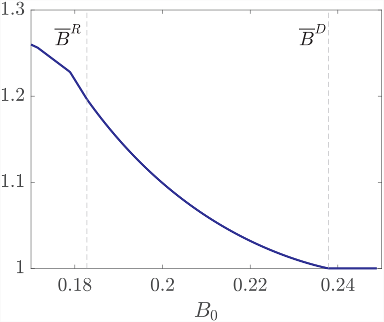
- Analytical characterization of thresholds
- Unique stationary eqm. and unique transition results
- Repaying banks are net buyers of k in the mixed eqm.

Equilibrium ϕ and p_0 as a function of B_0

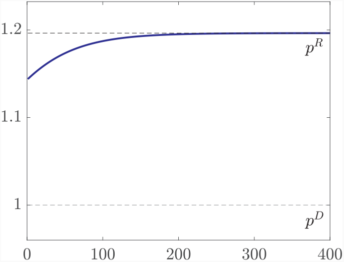
Defaulting banks ϕ



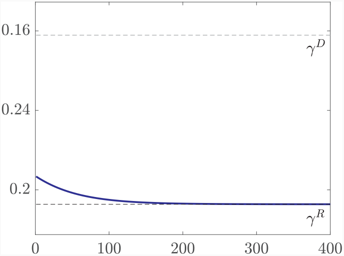
Price of Capital p_0



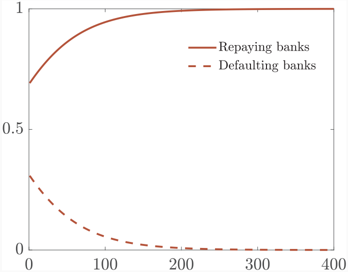
Price of Capital p_t



Leverage Threshold γ_t



Capital Holdings



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Self-Fulfilling Bank Runs

Coordination problem between creditors a la Cole-Kehoe

- Creditors may refuse to rollover $\Rightarrow$ repayment more costly
- If optimal to default during a run, a bank is "vulnerable"

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Coordination problem between creditors a la Cole-Kehoe

- Creditors may refuse to rollover $\Rightarrow$ repayment more costly
- If optimal to default during a run, a bank is "vulnerable"
  - Assume that if a bank is vulnerable for $t > 0$, a run happens

Multiplicity of Equilibria

- Bank facing a run needs to de-lever:

$$\hat{V}_t^{Run}(n) = \max_{k' \geq 0, c} \log(c) + V_{t+1}\left((\bar{z} + p_{t+1})k'\right)$$

$$s.t \quad c = n + \cancel{b'}^{\,0} - p_t k'$$

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- Safe bank faces tighter constraint:

$$\hat{V}_t^{Safe}(n) = \max_{b', k' \geq 0, c} \log(c) + \beta \hat{V}_{t+1}^{Safe}((\bar{z} + p_{t+1})k' - Rb')$$

$$s.t \quad c = n + b' - p_t k'$$

$$\hat{V}_{t+1}^{Run}(n') \geq V_{t+1}^{D}(k')$$

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- If $\hat{V}_t^{Safe}(n) < V_t^D(k)$: bank defaults

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$$\hat{V}_{t+1}^{Run}(n') \geq V_{t+1}^{D}(k')$$

- If $\hat{V}_t^{Safe}(n) > V_t^D(k) > \hat{V}_t^{Run}(n)$: bank is vulnerable

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The Effects of Bank Runs

- Financial fragility, default region expands $\downarrow \gamma^D$
  - Repayment region contracts $\gamma^R \downarrow$ if and only if $\beta R < 1$

Repayment eqm. | Mixed eqm. | Default eqm

$\gamma^R p^R \overline{K}$ $\quad$ $\gamma^D p^D \overline{K}$ $\quad$ B_0

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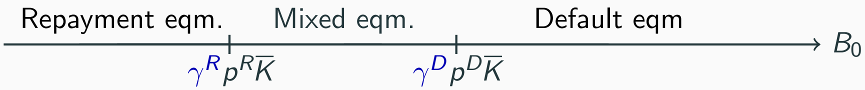

The Effects of Bank Runs

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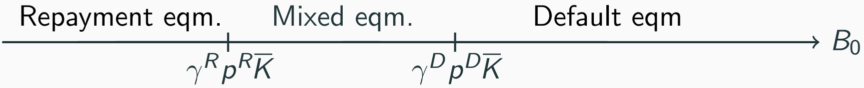

- Lower price of capital
  - Lower γ, implies lower demand by repaying banks
  - More defaulting banks, which have lower demand for capital

Outline of the Talk

1. Basic environment without bank runs
   - Bank problem in partial equilibrium
   - General equilibrium
2. Introduce bank runs
3. Policy analysis

Credit Easing

- Introduce government purchases of assets K^g at $t = 0$

$$\phi K_t^D + (1-\phi) K_t^R + K^g = \overline{K}$$

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$$\phi K_t^D + (1 - \phi) K_t^R + K^g = \overline{K}$$

- Assume that government makes losses:
  - Productivity $z^g < \underline{z}$ and return $(z^g + p_1)/p_0 < R$

$\Rightarrow$ If investors face same return as gov., they do not buy k

Q: How does credit easing affect ϕ and welfare?

Credit Easing (ctd)

Purchases financed with foreign debt and lump sum taxes at $t = 0$

- Govt. sells assets at $t = 1$ and repays debt
- No taxes/subsidies after $t > 0$

Government budget constraints for $t = 0, 1$

$$p_0 K^g = T_0 + B_1^g$$
$$R B_1^g = (z^g + p_1) K^g$$

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Since $R > R^g$

$$T_0 = \frac{p_0 K^g}{R} \left[R - R^g \right] > 0,$$

Welfare Effects of Credit Easing

$$W(K^g) = \phi V^D(K^g) + (1-\phi) V^R(K^g)$$

K^g affects banks' welfare through ϕ, T_0 and $\{p_t, \gamma_t\}$

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Ignoring effects on future prices and if $\phi = 0$

$$\frac{dV^R}{dK^g} = -u'(c_R)\underbrace{p_0\left(1 - \frac{R^g}{R}\right)}_{\left.\frac{dT_0}{dK^g}\right|_{K^g=0}} < 0$$

Welfare $\Downarrow$ if defaults due to fundamentals

$$\frac{dW}{dK_g} = \left[\phi \frac{dV^D}{dK_g} - (1-\phi)\frac{dV^R}{dK_g}\right] - \left(V^R - V^D\right)\frac{d\phi}{dK_g}$$

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Without runs:

- $V^R = V^D \;\Rightarrow\; d\phi$ irrelevant

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- $V^R = V^{Safe} > V^{Run} = V^D$

$\Rightarrow$ If $d\phi < 0$, possibility that $\Uparrow W$

A repaying banks facing a run is a net seller of assets

$\Rightarrow$ benefits from intervention that $\Uparrow p_0 \Rightarrow d\phi < 0$

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Other Policies

- Controlling default decisions: ▸ Details
  - Higher ϕ w/o runs and lower ϕ w/runs
- Tax on purchases of capital at $t = 0$ rebated lump sum
  - Irrelevant: after-tax price remains constant and has no effects
- Deposit insurance: deters runs, but requires borrowing limits
- Lender of last resort: must cover *all* banks to be effective

Conclusions

- A dynamic macroeconomic model of self-fulfilling bank runs
- General equilibrium effects crucial to assess govt. policies
- Desirability of credit easing depends on whether a crisis is diriven by fundamentals or self-fulfilling runs
- Agenda:
    - Anticipation effects of credit easing
    - Use framework for other policies, such as macroprudential

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Banks' welfare

$$W = (1 - \phi)V^R + \phi V^D$$

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$\uparrow \phi$ reduces p_0 and helps repaying banks that have high u'

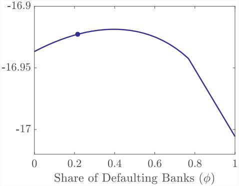
- Without runs: optimal to have more banks defaulting
- With runs: may be optimal to reduce defaults back

Simulations: Socially Optimal Default

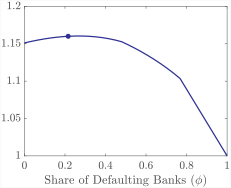
Back

Fundamentals

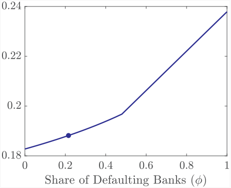
(a) Welfare



(b) p_0

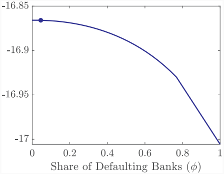


(c) $\gamma_0 p_1$

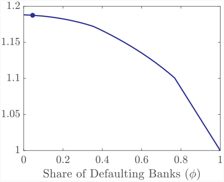


Self-Fulfilling Runs

(d) Welfare



(e) p_0



(f) $\gamma_0 p_1$