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 model, but key differences:
  - Runs on individual banks
  - Maturity critical for fragility

- Normative analysis
• Desirability of **credit easing** depends on source of the crisis

• Bad if driven by fundamentals. Good if driven by runs
Preview of Main Normative Results

- Desirability of **credit easing** depends on source of the crisis
  - Bad if driven by fundamentals. Good if driven by runs

- Repaying banks are **net buyers** during fundamental crisis, but are **net sellers** in the event of a run.
  - Increases in asset prices hurt repaying banks in a fundamental driven crisis, but benefit them in the case of runs
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 $\bar{K}$
- Competitive market for assets and deposits
All banks start at $t = 0$ with portfolio $(b_0, \bar{K})$

- 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
Banks’ Budget Constraints

- If default at time $t$:

$$c = (z + p_t)k - p_t k'$$

- Permanent financial exclusion $b' = 0$
  - Restriction on saving w/o loss
- Productivity loss $y = zk$
  - Evidence on losses of firms exposed to defaulting banks
Strategic Bank Default

\[ V_t^R(b, k) = \max_{k', b', c} \log(c) + \beta V_{t+1}(b', k') \]

s.t. \( c = (\bar{z} + p_t)k - Rb + q_t(b', k')b' - p_t k' \)

No-Ponzi

\[ V_t^D(k) = \max_{k', c} \log(c) + \beta V_{t+1}^D(k') \]

s.t. \( c = \bar{z}k + p_t(k - k') \)
Strategic Bank Default

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\[ V_t^D(k) = \max_{k', c} \log(c) + \beta V_{t+1}^D(k') \]

s.t. \( c = zk + p_t(k - k') \)

Repayment decision:

- If \( V_t^R(b, k) > V_t^D(k) \): repay
Strategic Bank Default

\[
V_t^R(b, k) = \max_{k', b', c} \log(c) + \beta V_{t+1}(b', k') \\
\text{s.t. } c = (\bar{z} + p_t)k - Rb + q_t(b', k')b' - p_t k'
\]

No-Ponzi

\[
V_t^D(k) = \max_{k', c} \log(c) + \beta V_{t+1}(k') \\
\text{s.t. } c = zk + p_t(k - k')
\]

Repayment decision:

- If \( V_t^R(b, k) < V_t^D(k) \): default
Strategic Bank Default

\[ V_t^R(b, k) = \max_{k', b', c} \log(c) + \beta V_{t+1}(b', k') \]

s.t. \( c = (\bar{z} + p_t)k - Rb + q_t(b', k')b' - p_t k' \)

No-Ponzi

\[ V_t^D(k) = \max_{k', c} \log(c) + \beta V_{t+1}(k') \]

s.t. \( c = z k + p_t(k - k') \)

Repayment decision:

- If \( V_t^R(b, k) = V_t^D(k) \): indifferent
Strategic Bank Default

\( V_t^R(b, k) = \max_{k', b', c} \log(c) + \beta V_{t+1}(b', k') \)

s.t. \( c = (\bar{z} + p_t)k - Rb + q_t(b', k')b' - p_t k' \)

No-Ponzi

\( V_t^D(k) = \max_{k', c} \log(c) + \beta V_{t+1}^D(k') \)

s.t. \( c = zk + p_t(k - k') \)

Repayment decision:

- If \( V_t^R(b, k) = V_t^D(k) \): indifferent
  - Repay for \( t > 0 \)
  - Default with probability \( \phi \) for \( t = 0 \)
• Equilibrium default only at $t = 0$
Equilibrium Consistent Borrowing Limit

- Equilibrium default only at $t = 0$

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

\[ V_{t+1}^R(b', k') \geq V_{t+1}^D(k') \]

Otherwise, $q = 0$. 
• Equilibrium default only at $t = 0$

• Bank at time $t$ faces $q_t = 1$ if

$$V_{t+1}(b', k') \geq V_{t+1}(k')$$

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 characterized analytically in the paper.
\[ \phi K_t^D + (1 - \phi) K_t^R = \bar{K} \]
General Equilibrium

Stationary values:

\[ p^R = \frac{\beta \bar{Z}}{1 - \beta - (1 - \beta R)\gamma^R} \]
\[ p^D = \frac{\beta \bar{Z}}{1 - \beta} \]
\[ \gamma^R = H(\gamma^R, p^R) \]
\[ \gamma^D = H(\gamma^D, p^D) \]
General Equilibrium

\[ \phi K_t + (1 - \phi) R_t = \gamma R p^R K \]

\[ \gamma^R p^R K \quad \text{Mixed eqm.} \quad \gamma^D p^D K \]

Stationary values:

\[ p^R = \frac{\beta \bar{z}}{1 - \beta - (1 - \beta R) \gamma^R} \]
\[ \gamma^R = H(\gamma^R, p^R) \]

\[ p^D = \frac{\beta}{1 - \beta} \bar{z} \]
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General Equilibrium

Stationary values:

\[ p^R = \frac{\beta z}{1 - \beta - (1 - \beta R)\gamma^R} \]

\[ \gamma^R = H(\gamma^R, p^R) \]

\[ p^D = \frac{\beta}{1 - \beta} z \]

\[ \gamma^D = H(\gamma^D, p^D) \]
General Equilibrium

### Stationary values:

\[
\begin{align*}
    p^R &= \frac{\beta \bar{z}}{1 - \beta - (1 - \beta R)\gamma^R} \\
    \gamma^R &= H(\gamma^R, p^R) \\
    p^D &= \frac{\beta}{1 - \beta} \bar{z} \\
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\end{align*}
\]
General Equilibrium

Stationary values:

\[ p^R = \frac{\beta \bar{z}}{1 - \beta - (1 - \beta R)\gamma^R} \]

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\[ p^D = \frac{\beta}{1 - \beta \bar{z}} \]

\[ \gamma^D = H(\gamma^D, p^D) \]

Result: \( \gamma^D p^D > \gamma^R p^R \rightarrow \text{Uniqueness} \)
Within thresholds, a degenerate equilibrium does not exist

- Fraction $\phi$ defaults and $1 - \phi$ repay
  - Generalize Kehoe-Levine, by allowing initial defaults
Within thresholds, a degenerate equilibrium does not exist

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

In the paper: Details

- Unique stationary eqm. and unique transition
- Repaying banks are net buyers of $k$ in the mixed eqm.
Equilibrium $\phi$ and $p_0$ as a function of $B_0$
Mixed Equilibrium Simulations

Price of Capital $p_t$

Leverage Threshold $\gamma_t$

Capital Holdings

- Repaying banks
- Defaulting banks
Outline of the Talk

1. Environment without runs

2. Model with bank runs

3. Policy analysis
We model bank runs following Cole-Kehoe:

- If creditors refuse to rollover ⇒ repayment more costly
- In turn, if optimal to default during a run ⇒ a bank run happens

Coordination problem between creditors give rise to multiplicity
Self-fulfilling Bank Runs

- Bank facing a run needs to de-lever:

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

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

- A bank that can borrow faces tighter constraint:

\[
\hat{V}_{\text{Safe}}^t(n) = \max_{b', k' \geq 0, c} \log(c) + \beta \hat{V}_{t+1}^\text{Safe} \left((\bar{z} + p_{t+1})k' - R b' \right)
\]

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

\[
\hat{V}_{t+1}^\text{Run}(n') \geq V_{t+1}^D(k') \quad \text{[If vulnerable, run happens]}
\]
Self-fulfilling Bank Runs

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\]

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

- A bank that can borrows faces tighter constraint:

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

\[
\hat{V}_{t+1}^{Run}(n') \geq V_{t+1}^{D}(k') \quad [\text{If vulnerable, run happens}]
\]

Three regions depending on \((b, k)\):

- **Safe:** \(\hat{V}_{t}^{Run}(n) > V_{t}^{D}(k)\): run does not happen
Self-fulfilling Bank Runs

- Bank facing a run needs to de-lever:

\[
\hat{V}_{t}^{\text{Run}}(n) = \max_{k' \geq 0, c} \log(c) + V_{t+1}((\bar{z} + p_{t+1})k') \\
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- A bank that can borrows faces tighter constraint:

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

\[
\hat{V}_{t+1}^{\text{Run}}(n') \geq V_{t+1}^{D}(k') \quad [\text{If vulnerable, run happens}]
\]

Three regions depending on \((b, k)\):

- Default: \(\hat{V}_{t}^{\text{Safe}}(n) < V_{t}^{D}(k)\): default due to fundamentals
Self-fulfilling Bank Runs

• Bank facing a run needs to de-lever:

\[
\hat{V}_{t}^{Run}(n) = \max_{k' \geq 0, c} \log(c) + V_{t+1}((\bar{z} + p_{t+1})k') \\
\text{s.t. } c = n + b' - p_{t}k'
\]

• A bank that can borrow faces tighter constraint:

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

\[
\hat{V}_{t+1}^{Run}(n') \geq V_{t+1}^{D}(k') \quad [\text{If vulnerable, run happens}]
\]

Three regions depending on \((b, k)\):

• Vulnerable: \(\hat{V}_{t}^{Run}(n) < V_{t}^{D}(k) < \hat{V}_{t}^{Safe}(n)\): default due to runs
Financial Fragility

\[ \gamma^R p^R K \quad \gamma^D p^D K \]

Repayment eqm. \quad Mixed eqm. \quad Default eqm

\[ B_0 \]
Repayment eqm.  Mixed eqm.  Default eqm

$γ^R p^{R\bar{K}}$  $γ^D p^{D\bar{K}}$

$B_0$
Financial Fragility

\[ \gamma^R p^R K \quad \text{Mixed eqm.} \quad \gamma^D p^D K \]

\[ B_0 \]
Outline of the Talk

1. Environment without runs

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3. Policy analysis
Credit Easing

- Government purchases assets $K^g$ at $t = 0$
  - Financed with lump sum taxes and bond issuances
  - Assets sold at $t = 1$

- Assume that govt. return $R^g = \frac{p_{1} + z^g}{p_0} < R$:
  \[\Rightarrow\] Investors don’t want to buy $k$ (if same return as gov.)
Credit Easing

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  - Financed with lump sum taxes and bond issuances
  - Assets sold at $t = 1$

- Assume that govt. return $R^g = \frac{p_1 + z^g}{p_0} < R$:
  \[ \Rightarrow \text{Investors don’t want to buy } k \text{ (if same return as gov.)} \]

**Q:** How does credit easing affect $\phi$ and welfare?
Welfare effects of Credit Easing  \( \phi > 0 \)

\[
\frac{dW}{dK_g} = \left[ \phi \frac{dV^D}{dK_g} - (1 - \phi) \frac{dV^R}{dK_g} \right] - \left( V^R - V^D \right) \frac{d\phi}{dK_g}
\]
Welfare effects of Credit Easing $\phi > 0$

\[
\frac{dW}{dK_g} = \left[ \phi \frac{dV^D}{dK_g} - (1 - \phi) \frac{dV^R}{dK_g} \right] - \left( V^R - V^D \right) \frac{d\phi}{dK_g} \rightarrow 0
\]

Without runs:

- $V^R = V^D \Rightarrow d\phi$ irrelevant
Welfare effects of Credit Easing $\phi > 0$

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

Without runs:

- $V^R = V^D \Rightarrow d\phi$ irrelevant
- Given $\{p_1, p_2\ldots\}$, $dV^R = dV^D = dW < 0$
Welfare effects of Credit Easing $\phi > 0$

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

Without runs:

- $V^R = V^D \Rightarrow d\phi$ irrelevant
- Given $\{p_1, p_2, \ldots\}$, $dV^R = dV^D = dW < 0$

With runs:

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

$\Rightarrow$ 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 $\uparrow p_0 \Rightarrow d\phi < 0$
Welfare effects of Credit Easing $\phi > 0$

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

Without runs:

- $V^R = V^D \Rightarrow d\phi$ irrelevant
- Given $\{ p_1, p_2, \ldots \}$, $dV^R = dV^D = dW < 0$

With runs:

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

  $\Rightarrow$ 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 $\uparrow p_0 \Rightarrow d\phi < 0$
Credit Easing: Self-Fulfilling vs. Fundamentals

**Self-Fulfilling Runs**

\[ \rho_0 \]

\[ \phi \]

![Graph of \( \rho_0 \) and \( \phi \) vs. \( K^g \)]
Credit Easing: Self-Fulfilling vs. Fundamentals

Self-Fulfilling Runs

\[ p_0 \]

\[ K^g \]

Fundamentals

\[ p_0 \]

\[ K^g \]

\[ \phi \]

\[ K^g \]
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 driven by fundamentals or self-fulfilling runs

• Agenda:
  • Anticipation effects of credit easing
  • Use framework for other policies, such as macroprudential
Government picks $\phi$ at $t = 0$

Banks’ welfare

$$W = (1 - \phi) V^R + \phi V^D$$
Government picks $\phi$ at $t = 0$

Banks’ welfare

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

- Assume only $p_0$ changes in response to policy:

$$\frac{dW}{d\phi} \bigg|_{\phi=\phi^E} = (V^D(p_0^E) - V^R(p_0^E)) + \left[ (1 - \phi) \frac{dV^R(p_0)}{dp_0} \bigg|_{p_0=p_0^E} + \phi \frac{dV^D(p_0)}{dp_0} \bigg|_{p_0=p_0^E} \right] \frac{dp_0}{d\phi}$$
Banks’ welfare

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

- Assume only \( p_0 \) changes in response to policy:

\[
\frac{dW}{d\phi} \bigg|_{\phi=\phi^E} = (V^D(p_0^E) - V^R(p_0^E)) + \\
\left[ (1 - \phi) \frac{dV^R(p_0)}{dp_0} \bigg|_{p_0=p_0^E} + \phi \frac{dV^D(p_0)}{dp_0} \bigg|_{p_0=p_0^E} \right] \frac{dp_0}{d\phi}
\]
Government picks $\phi$ at $t = 0$

Banks’ welfare

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

- Assume only $p_0$ changes in response to policy:

$$\left. \frac{dW}{d\phi} \right|_{\phi=\phi^E} = (V^D(p_0^E) - V^R(p_0^E)) + \left[ (1 - \phi) \left. \frac{dV^R(p_0)}{dp_0} \right|_{p_0=p_0^E} + \phi \left. \frac{dV^D(p_0)}{dp_0} \right|_{p_0=p_0^E} \right] \frac{dp_0}{d\phi}$$

$$\left. \frac{dV^R(p_0)}{dp_0} \right|_{\phi=\phi^E} = u'(c^R)(\bar{K} - k^R(p_0^E)), \quad \left. \frac{dV^D(p_0)}{dp_0} \right|_{\phi=\phi^E} = u'(c^D)(\bar{K} - k^D(p_0^E)).$$
Government picks $\phi$ at $t = 0$

Banks’ welfare

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

- Assume only $p_0$ changes in response to policy:

$$\frac{dW}{d\phi} \bigg|_{\phi=\phi^E} = \left[ V^D(p_0^E) - V^R(p_0^E) \right]$$

$$- (1 - \phi)\left[ u'(c^R(p_0^E)) - u'(c^D(p_0^E)) \right] \left( k^R(p_0^E) - \bar{K} \right) < 0$$

$\uparrow \phi$ reduces $p_0$ and helps repaying banks that have high $u'$
Government picks $\phi$ at $t = 0$

Banks’ welfare

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

- Assume only $p_0$ changes in response to policy:

$$\frac{dW}{d\phi} \bigg|_{\phi=\phi^E} = [V^D(p_0^E) - V^R(p_0^E)]$$

$$- (1 - \phi)[u'(c^R(p_0^E)) - u'(c^D(p_0^E))] (k^R(p_0^E) - \bar{K})$$

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

- Without runs: optimal to have more banks defaulting
Government picks $\phi$ at $t = 0$

Banks’ welfare

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

- Assume only $p_0$ changes in response to policy:

\[ \frac{dW}{d\phi} \bigg|_{\phi = \phi^E} = \left[ V^D(p_0^E) - V^R(p_0^E) \right] \]

\[ - (1 - \phi) \left[ u'(c^R(p_0^E)) - u'(c^D(p_0^E)) \right] \left( k^R(p_0^E) - \bar{K} \right) \]

↑ $\phi$ 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
**FUNDAMENTALS**

(a) Welfare

(b) $p_0$

(c) $\gamma_0 p_1$

**SELF-FULFILLING RUNS**

(d) Welfare

(e) $p_0$

(f) $\gamma_0 p_1$