Bank Runs, Fragility, and Credit Easing

Manuel Amador [1] Javier Bianchi[2]

[1]Federal Reserve Bank of Minneapolis University of Minnesota
[2]Federal Reserve Bank of Minneapolis

April 2022
UCLA

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
  - Runs because of coordination failures at individual banks
- General equilibrium characterization: fraction of banks defaulting and dynamics of asset prices

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
- **Key distinction:** Repaying banks are net buyers when crises are driven by fundamentals but net sellers when driven by runs
  - Increase in asset prices have very different effects

Related Literature

- **Bank Runs:** Diamond and Dybvig 1983; Bryant 1980; Allen and Gale 2000; Ennis and Keister 2009; Uhlig 2010; Gertler and Kiyotaki 2015; Gertler, Kiyotaki and Prestipino 2020; etc.
  - Runs on individual banks and normative analysis
- **Limited Commitment:** Thomas and Worrall 1994; Abuquerque and Hopenhayn 2004; Kehoe and Levine 1993, Alvarez and Jermann 2000; Cole and Kehoe 2000; etc.
  - Mixed equilibrium with runs and defaults
- **Credit Easing:** Gertler and Karadi 2011; Curdia and Woodford 2011; Kiyotaki and Moore 2019; etc
  - Desirability depends on source of the crisis

Related Literature

- **Bank Runs:** Diamond and Dybvig 1983; Bryant 1980; Allen and Gale 2000; Ennis and Keister 2009; Uhlig 2010; Gertler and Kiyotaki 2015; Gertler, Kiyotaki and Prestipino 2020; etc.
  - Runs on individual banks and normative analysis
- **Limited Commitment:** Thomas and Worrall 1994; Abuquerque and Hopenhayn 2004; Kehoe and Levine 1993, Alvarez and Jermann 2000; Cole and Kehoe 2000; etc.
  - Mixed equilibrium with runs and defaults
- **Credit Easing:** Gertler and Karadi 2011; Curdia and Woodford 2011; Kiyotaki and Moore 2019; etc
  - Desirability depends on source of the crisis

Related Literature

- **Bank Runs:** Diamond and Dybvig 1983; Bryant 1980; Allen and Gale 2000; Ennis and Keister 2009; Uhlig 2010; Gertler and Kiyotaki 2015; Gertler, Kiyotaki and Prestipino 2020; etc.
    - Runs on individual banks and normative analysis
- **Limited Commitment:** Thomas and Worrall 1994; Abuquerque and Hopenhayn 2004; Kehoe and Levine 1993, Alvarez and Jermann 2000; Cole and Kehoe 2000; etc.
    - Mixed equilibrium with runs and defaults
- **Credit Easing:** Gertler and Karadi 2011; Curdia and Woodford 2011; Kiyotaki and Moore 2019; etc
    - Desirability depends on source of the crisis

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 $\sum_{t=0}^{\infty} \beta^t \log(c_t)$.
- Risk-neutral creditors, 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

Environment

- Discrete time, infinite horizon, no aggregate risk
- Continuum of banks, preferences $\sum_{t=0}^{\infty} \beta^t \log(c_t)$.
- Risk-neutral creditors, 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

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 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

Banks' Optimization: Values of Repayment and Default

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

$$V_t^D(k) = \max_{k',c} \log(c) + \beta V_{t+1}^D(k')$$
$$\text{s.t.} \quad c = \underline{z}k + p_t(k - k')$$

Banks' Optimization: Values of Repayment and Default

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

$$
\begin{aligned}
V_t^D(k) \quad &= \quad \max_{k',c} \ \log(c) + \beta V_{t+1}^D(k') \\
&\quad \text{s.t.} \quad c = \underline{z}k + p_t(k - k')
\end{aligned}
$$

Repayment decision:

- If $V_t^R(b,k) > V_t^D(k)$: repay

Banks' Optimization: Values of Repayment and Default

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

$$
\begin{aligned}
V_t^D(k) &= \max_{k',c} \log(c) + \beta V_{t+1}^D(k') \\
& \quad \text{s.t.} \quad c = \underline{z}k + p_t(k - k')
\end{aligned}
$$

Repayment decision:

- If $V_t^R(b,k) < V_t^D(k)$: default

Banks' Optimization: Values of Repayment and Default

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

$$
\begin{aligned}
V_t^D(k) &= \max_{k',c} \log(c) + \beta V_{t+1}^D(k') \\
&\quad \text{s.t.} \quad c = \underline{z}k + p_t(k - k')
\end{aligned}
$$

Repayment decision:

- If $V_t^R(b,k) = V_t^D(k)$: indifferent

Banks' Optimization: Values of Repayment and Default

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

$$
\begin{aligned}
V_t^D(k) \quad &= \quad \max_{k',c} \; \log(c) + \beta V_{t+1}^D(k') \\
&\qquad \text{s.t.} \quad c = \underline{z}k + p_t(k - k')
\end{aligned}
$$

Repayment decision:

- If $V_t^R(b,k) = V_t^D(k)$: indifferent
  - Repay for $t > 0$ (w/o loss)
  - **Randomize at** $t = 0$

Equilibrium Consistent Borrowing Limit

- 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

$$V^R_{t+1}(b', k') \geq V^D_{t+1}(k')$$

Otherwise, $q = 0$.

Equilibrium Consistent Borrowing Limit

- Equilibrium default only at $t = 0$
- Bank at time t faces $q_t = 1$ if

$$V^R_{t+1}(b', k') \geq V^D_{t+1}(k')$$

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

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

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

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

where returns are

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

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

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

Policies:

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

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

Equilibrium Consistent Borrowing Limit

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

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

Equilibrium Consistent Borrowing Limit

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

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

- Potentially multiple solutions for $\{\gamma_t\}$

Equilibrium Consistent Borrowing Limit

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

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

- Potentially multiple solutions for $\{\gamma_t\}$
    - Will argue that No-Ponzi $\Rightarrow$ solution is unique

Solving for γ_t for Constant Price

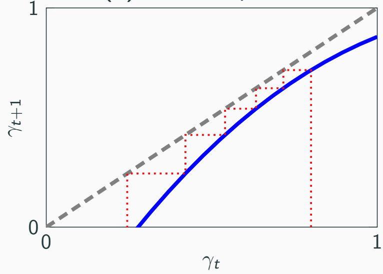
$$\gamma_{t+1} = 1 - \left(\frac{R^k(p)/R - \gamma_t}{R^D(p)/R} \right)^{\frac{1}{\beta}} \equiv H(\gamma_t)$$

Solving for γ_t for Constant Price

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

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

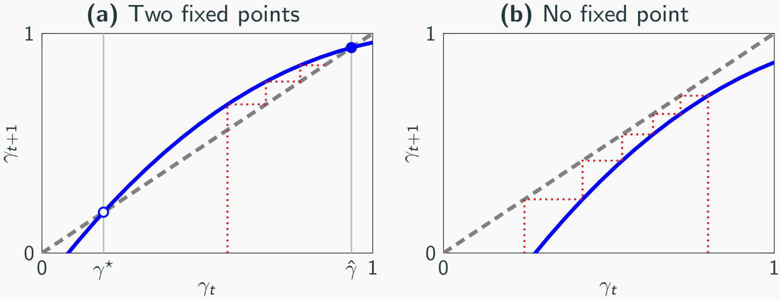
(b) No fixed point



Solving for γ_t for Constant Price

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

- If eqm ∃, two fixed points but only smallest satisfies No-Ponzi
  - First fixed point unstable ⇒ $\gamma_t = \gamma^\star$
  - $\gamma^\star$ 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

Consider possibility that $\phi \in [0,1]$ banks default at $t = 0$

- Market clearing for capital

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

General Equilibrium

Consider possibility that $\phi \in [0,1]$ banks default at $t = 0$

- Market clearing for capital

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

- Fraction ϕ must be consistent with optimal default decision

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

where

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

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

$$B_{t+1} = \mathcal{B}_{t+1}((\bar{z} + p_t)K_t^R - RB_t)$$

$$K_{t+1}^R = \mathcal{K}_{t+1}^R((\bar{z} + p_t)K_t^R - RB_t)$$

$$K_{t+1}^D = \mathcal{K}_{t+1}^D((\underline{z} + p_t)K_t^D)$$

(ii) Borrowing limits are equilibrium consistent

(iii) Market for capital clears

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

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

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

Type of equilibrium depends on B_0

Stationary values:

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

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

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

Type of equilibrium depends on B_0

Stationary values:

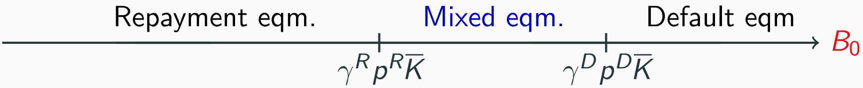
$$p^R = \frac{\beta \bar{z}}{1 - \beta - (1 - \beta R)\gamma^R} \qquad p^D = \frac{\beta}{1-\beta}\underline{z}$$

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

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

Mixed Equilibrium

Type of equilibrium depends on B_0

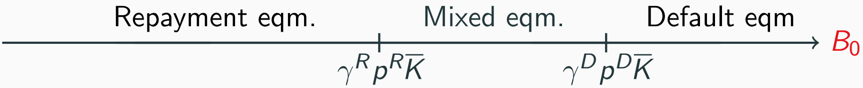


Within thresholds, a degenerate equilibrium does not exist

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

Mixed Equilibrium

Type of equilibrium depends on B_0



Within thresholds, a degenerate equilibrium does not exist

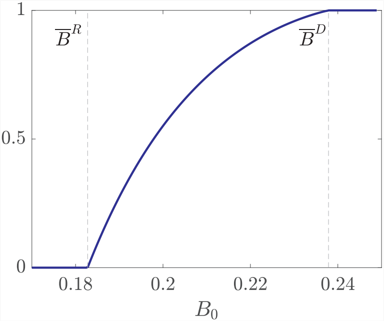
- Fraction ϕ defaults and $1 - \phi$ repay
  - Generalize Kehoe-Levine, by allowing initial defaults

In the paper: ▸ Details

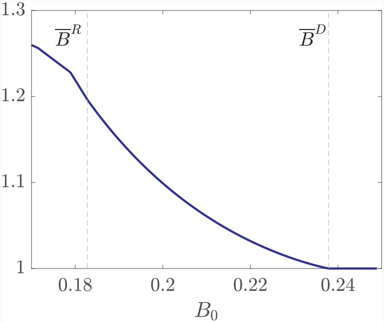
- Analytical characterization of thresholds
- Unique stationary eqm. and unique transition results
- Repaying banks are net buyers of k in the mixed eqm.

Equilibrium ϕ and p_0 as a function of B_0

Defaulting banks ϕ

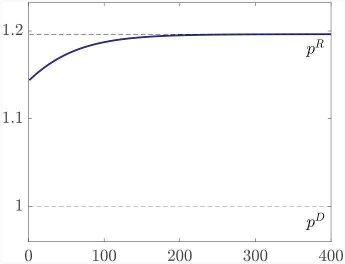


Price of Capital p_0

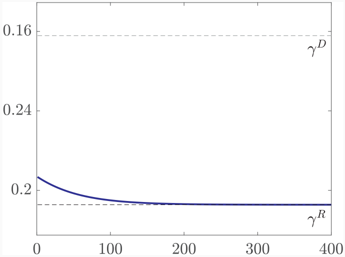


Mixed Equilibrium Simulations

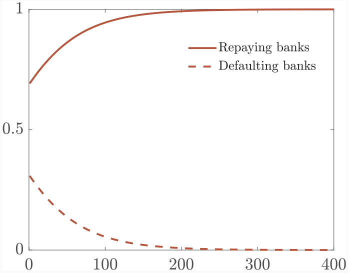
Price of Capital p_t



Leverage Threshold γ_t



Capital Holdings



Outline of the Talk

1. Environment without runs

2. Model with bank runs

3. Policy analysis

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”

Values of Repayment and Multiplicity

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

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

Values of Repayment and Multiplicity

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

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

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

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

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

Values of Repayment and Multiplicity

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

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

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

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

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

A bank facing a run more prone to default

- If $R_{t+1}^k > R_{t+1}$, we have $\hat{V}_t^{Safe}(n) > \hat{V}_t^{Run}(n)$

Values of Repayment and Multiplicity

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

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

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

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

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

A bank facing a run more prone to default

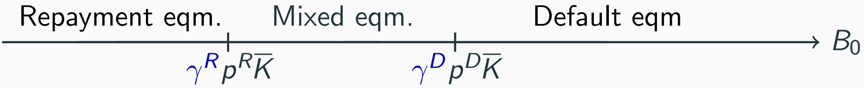
- Multiplicity: $\hat{V}_t^{Safe}(n) > \hat{V}_t^{D}(k) > \hat{V}_t^{Run}(n)$
    - Assume that if a bank is vulnerable for $t > 0$, a run happens

The Effects of Bank Runs

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

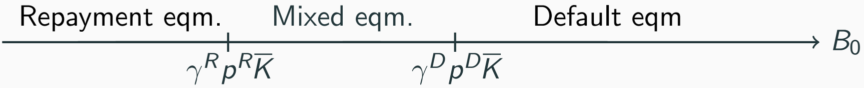
The Effects of Bank Runs

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



The Effects of Bank Runs

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



- 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

Government picks ϕ at $t = 0$

Banks' welfare

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

Government picks ϕ at $t = 0$

Banks' welfare

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

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

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

Government picks ϕ at $t = 0$

Banks' welfare

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

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

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

Government picks ϕ at $t = 0$

Banks' welfare

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

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

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

$$\left.\frac{dV^R(p_0)}{dp_0}\right|_{\phi=\phi^E} = u'(c^R)(\overline{K} - k^R(p_0^E)), \quad \left.\frac{dV^D(p_0)}{dp_0}\right|_{\phi=\phi^E} = u'(c^D)(\overline{K} - k^D(p_0^E)).$$

Government picks ϕ at $t = 0$

Banks' welfare

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

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

$$\left.\frac{dW}{d\phi}\right|_{\phi=\phi^E} = \underbrace{[V^D(p_0^E) - V^R(p_0^E)]}_{\to 0}$$

$$- \ (1-\phi)[\overbrace{u'(c^R(p_0^E)) - u'(c^D(p_0^E))}^{>0}]\overbrace{(k^R(p_0^E) - \bar{K})}^{>0}\overbrace{\frac{dp_0}{d\phi}}^{<0}$$

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

Government picks ϕ at $t = 0$

Banks' welfare

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

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

$$\left.\frac{dW}{d\phi}\right|_{\phi=\phi^E} = \underbrace{[V^D(p_0^E) - V^R(p_0^E)]}_{\to 0}$$

$$- \ (1-\phi)\overbrace{[u'(c^R(p_0^E)) - u'(c^D(p_0^E))]}^{>0}\overbrace{(k^R(p_0^E) - \bar{K})}^{>0}\overbrace{\frac{dp_0}{d\phi}}^{<0}$$

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

- Without runs: optimal to have more banks defaulting

Government picks ϕ at $t = 0$

Banks' welfare

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

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

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

$$- \ (1-\phi)\overbrace{[u'(c^R(p_0^E)) - u'(c^D(p_0^E))]}^{>0}\overbrace{(k^R(p_0^E) - \bar{K})}^{>0}\overbrace{\frac{dp_0}{d\phi}}^{<0}$$

$\uparrow \phi$ 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 ▸ Simulations

Credit Easing

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

Assume that government makes losses:

- Productivity $z^g < \underline{z}$ and return $(z^g + p_1)/p_0 < R$

$\Rightarrow$ Investors they do not purchase k if same productivity as govt.

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 $t = 0, 1$

$$\begin{aligned} p_0 K^g &= T_0 + B_1^g \\ R B_1^g &= (z^g + p_1) K^g \end{aligned}$$

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 $t = 0, 1$

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

Since $R > R^g$

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

Welfare Effects of Credit Easing

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

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

Welfare Effects of Credit Easing

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

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

$$\frac{dV^R}{dK^g} = u'(c_R)\left[(\overline{K} - k_1^R)\frac{dp_0}{dK^g} - \frac{dT_0}{dK^g}\right] + \left[u'(c_R) - \beta R \hat{V}_1^{R\prime}(n_1^R)\right] k_1^R \frac{d\gamma_0 \ldots}{dK \ldots}$$

$$+\beta \hat{V}_1^{R\prime}(n_1^R) k_1^R \frac{dp_1}{dK^g} + \beta \left.\frac{d\hat{V}_1^R(n)}{dK^g}\right|_{n= \ldots}$$

Welfare Effects of Credit Easing

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

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

$$\frac{dV^R}{dK^g} = u'(c_R)\left[(\overline{K} - k_1^R)\frac{dp_0}{dK^g} - \frac{dT_0}{dK^g}\right] + \left[u'(c_R) - \beta R \hat{V}_1^{R\prime}(n_1^R)\right] k_1^R \frac{d\gamma_0 \ldots}{dK \ldots}$$

$$+\beta \hat{V}_1^{R\prime}(n_1^R) k_1^R \frac{dp_1}{dK^g} + \beta \left.\frac{d\hat{V}_1^R(n)}{dK^g}\right|_{n= \ldots}$$

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

$$\frac{dV^R}{dK^g} = -u'(c_R)p_0\left(1 - \frac{R^g}{R}\right) < 0$$

Welfare $\Downarrow$ if defaults due to fundamentals

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

Welfare $\Downarrow$ if defaults due to fundamentals

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

Welfare $\Downarrow$ if defaults due to fundamentals

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

Welfare $\Downarrow$ if defaults due to fundamentals

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

Without runs:

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

Welfare $\Uparrow$ if defaults due to runs

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

Without runs:

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

Welfare $\Uparrow$ if defaults due to runs

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

0

Without runs:

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

With runs:

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

$\Rightarrow$ If $d\phi < 0$, possibility that $dW > 0$

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

$\Rightarrow$ benefits from intervention that raises asset prices

Welfare $\Uparrow$ if defaults due to runs

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

0

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 $dW > 0$

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

$\Rightarrow$ benefits from intervention that raises asset prices

Welfare $\Uparrow$ if defaults due to runs

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

0

Without runs:

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

With runs:

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

  $\Rightarrow$ If $d\phi < 0$, possibility that $dW > 0$

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

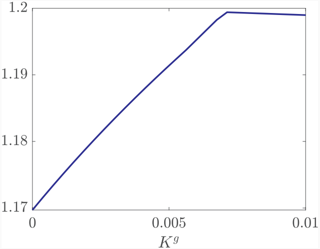
$\Rightarrow$ benefits from intervention that raises asset prices

In equilibrium, $d\phi < 0$

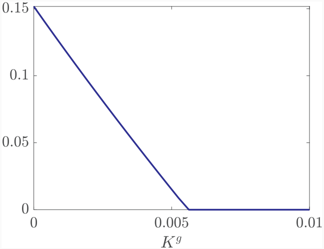
Credit Easing: Self-Fulfilling vs. Fundamentals

Self-Fulfilling Runs

p_0

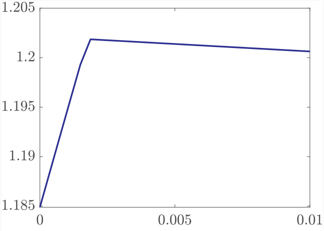


ϕ

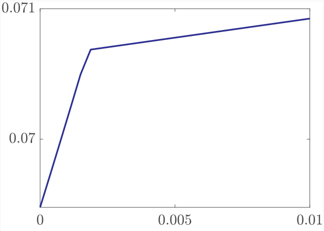


Fundamentals

p_0

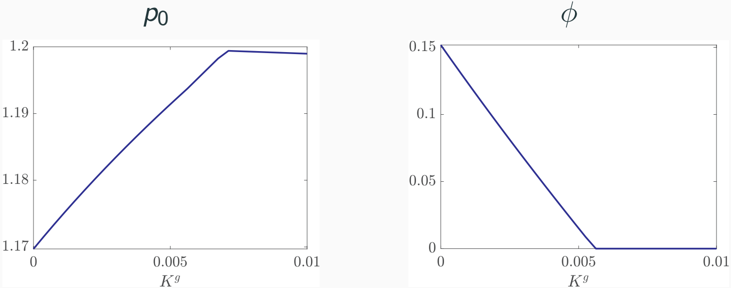


ϕ

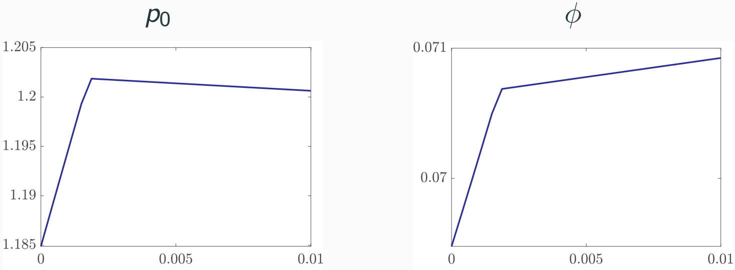


Credit Easing: Self-Fulfilling vs. Fundamentals

Self-Fulfilling Runs



Fundamentals



Other Policies

- 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

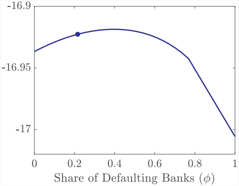
- A dynamic macroeconomic model of self-fulfilling bank runs
- General equilibrium effects crucial to assess govt. policies
- Desirability of credit easing depends on whether a crisis is diriven by fundamentals or self-fulfilling runs
- Agenda:
  - Anticipation effects of credit easing
  - Use framework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

Simulations: Socially Optimal Default

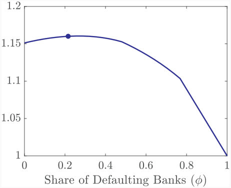
Back

Fundamentals

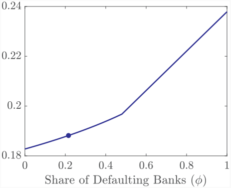
(a) Welfare



(b) p_0

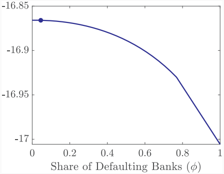


(c) $\gamma_0 p_1$

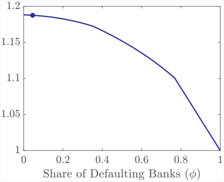


Self-Fulfilling Runs

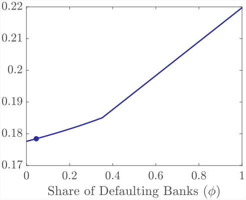
(d) Welfare



(e) p_0



(f) $\gamma_0 p_1$



Characterization of Dynamic System ▸ Back

Let $\tilde{k}_t = (1-\phi)K_t^R/\overline{K}$ *and* $\tilde{b}_t = (1-\phi)B_t/\overline{K}$*. Then,* $R\tilde{b}_t > (\bar{z} - \underline{z})\tilde{k}_t$ *and* $p_t > p^D$ *for all* $t \geq 0$*. The evolution of* $(\tilde{k}_t, \tilde{b}_t)$ *is* **uniquely determined** *by*

$$\tilde{k}_{t+1} = 1 - \beta\left(\frac{\underline{z} + p_t}{p_t}\right)(1 - k_t),$$

$$\tilde{b}_{t+1} = p_t k_{t+1} - \beta \tilde{n}_t,$$

where $\tilde{n}_t = (\bar{z} + p_t)\tilde{k}_t - R\tilde{b}_t$ and p_t is the unique solution to:

$$\frac{\left[(\bar{z} + p_t)\tilde{k}_t - Rb_t\right]^{1-\beta}\left[p_t - \beta(\underline{z} + p_t)(1 - \tilde{k}_t)\right]^{\beta}}{\beta^{\beta}(\underline{z} + p_t)\tilde{k}_t} = 1.$$

(i) Repaying bank are net buyers: $\tilde{k}_{t+1} > \tilde{k}_t$ for all $t \geq 0$.

(ii) Repaying banks pay less dividends at $t = 0$, $c_0^D > c_0^R$