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

- Limited commitment and endogenous default
    - Defaults triggered by fundamentals or runs
- Dynamic portfolio and equity payout decisions
- Asset prices endogenously determined in equilibrium
    - Fragility linked to individual and aggregate fundamentals
- Self-fulfilling runs occur despite assets being liquid
- Normative analysis of credit easing policies

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

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  - Bad if driven by fundamentals. Good if driven by runs

- Marginal banks are net buyers during fundamental crises, but net sellers during run driven crises

  ⇒ Increases in asset prices hurt repaying banks in a fundamental driven crisis, but benefit them in the case of runs

Contribution

Literature on bank runs: (Diamond and Dybvig 1983; Allen and Gale 2000; Ennis and Keister 2009; Uhlig 2010; Gertler and Kiyotaki 2015; Gertler, Kiyotaki and Prestipino 2020; etc).

- We embed runs in dynamic macro model
  - Key differences with bank panics in Gertler-Kiyotaki:
    - Coordination problem between depositors of individual banks
    - Fragility linked to short-term debt maturity
- Runs occur despite perfectly liquid assets
- Credit easing desirable if crisis driven by runs

Also build on literature on limited commitment and sovereign default: (Thomas and Worrall 1994; Abuquerque and Hopenhayn 2004; Kehoe and Levine 1993, Alvarez and Jermann 2000; Cole-Kehoe 2000)

Environment

- Discrete time, infinite horizon, no aggregate risk
- Technology
  - Production linear in capital
  - Capital in fixed supply $\overline{K}$
- Continuum of banks, preferences $\mathbb{E} \sum_{t=0}^{\infty} \beta^t \log(c_t)$.
- Continuum of creditors, linear utility and discount rate R
- Banks are ex-ante identical
  - Start at $t = 0$ with portfolio $(b_0 = B_0, k_0 = \overline{K})$
  - At $t = 0$, idiosyncratic shock and possibility of runs

Outline

1. Bank problem in partial equilibrium
2. General equilibrium: market clearing for capital
3. Credit policy analysis: government purchases of capital

Banks' Budget Constraints

- If repay at time t:

$$c_t = (z_t + p_t)k_t - Rb_t + q_t(b_{t+1}, k_{t+1})b_{t+1} - p_t k_{t+1}.$$

- q_t price of deposits
- p_t price of capital (liquid market)

  - Productivity
    - At $t = 0$, iid shock productivity z_0, drawn cdf F
    - $z_t = z$ for all $t \geq 1$

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Bank Optimization

$$V_t(b_t, k_t) = \max\left\{ \max_{k_{t+1}, b_{t+1}, c} \log(c_t) + \beta V_{t+1}(b_{t+1}, k_{t+1}), V_t^D(k_t) \right\}$$

$$\text{s.t.} \quad c_t = (z_t + p_t)k_t - Rb_t + q_t(b_{t+1}, k_{t+1})b_{t+1} - p_t k_{t+1}$$

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For default, assume

- Permanent financial exclusion $b' = 0$
- Productivity loss $y = z^D k$

$$V_t^D(k_t) = \max_{c_t, k_{t+1}} \log(c_t) + \beta V_{t+1}^D((p_{t+1} + z^D)k_{t+1})$$

$$\text{s.t.} \quad c_t = (p + z^D)k_t - p_t k_{t+1}$$

Equilibrium Consistent Borrowing Limit

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Otherwise, $q = 0$.

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- 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

Denote $n_t^D = (z^D + p_t)k_t$

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

where the return on capital under default

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

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

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

The Value of Repayment

Denote $n_t^R = (z + p_t)k_t - b_t R$

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

where returns are

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

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Policies:

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

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

Equilibrium Consistent Borrowing Limit

- Given a sequence of prices, a bank is indifferent between repaying and defaulting for if $V_{t+1}^R(n_{t+1}^R) = V_{t+1}^D(n_{t+1}^D)$

$$((z + p_t)k_t - R\gamma_{t-1}p_t k_t) \prod_{s=t+1}^{\infty} (R_s^e)^{\beta^{s-t}} = (z^D + p_t)k_t \prod_{s=t+1}^{\infty} (R_s^D)^{\beta^{s-t}}$$

for $t \geq 0$

$\Rightarrow$ Equilibrium consistent borrowing limit

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

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- Potentially many solutions for γ_t, but show that only one consistent with NPG

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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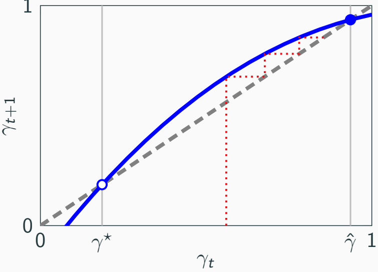
- If partial eqm $\exists$, two fixed points: only smallest satisfies NPG
  - First fixed point unstable $\Rightarrow$ pins down $\gamma_t = \gamma^\star$

(a) Two fixed points



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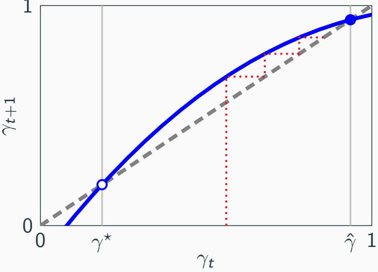

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  - $\gamma^\star$ is increasing in (β, z) and decreasing in (R, z^D, R^k)

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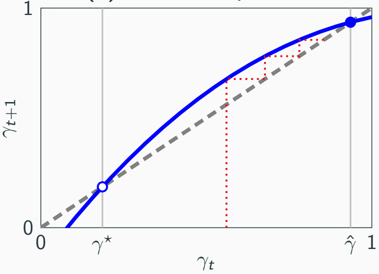

Time 0 default thresholds: with and without runs

Time 0 Default Thresholds: The Case of Fundamentals

- Indifference condition at $t = 0$ given by

$$((\hat{z}^F + p_0)k_0 - Rb_0)\prod_{t=1}^{\infty}(R_t^e)^{\beta^t} = (z^D + p_0)k_0\prod_{t=1}^{\infty}(R_t^D)^{\beta^t}.$$

- If $z_0 < \hat{z}^F$, a bank defaults at $t = 0$

Time 0 Default Thresholds: The Case of Fundamentals

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$$\hat{z}^F = (z^D + p_0) \prod_{t=1}^{\infty} \left(\frac{R_t^D}{R_t^e} \right)^{\beta^t} - p_0 \left(1 - R \frac{b_0}{p_0 k_0} \right)$$

- If $z_0 < \hat{z}^F$, a bank defaults at $t = 0$

Time 0 Default Thresholds: The Case of Runs

When a bank faces a run and repays, its value is:

$$V_0^{Run}(n_0) = \max_{k_1 \geq 0, c_0 > 0} \log(c_0) + \beta V_1^R \left((z + p_1)k_1\right),$$

subject to

$$c_0 = n_0 + \cancelto{0 \quad \text{Deleveraging}}{b'} - p_0 k_1.$$

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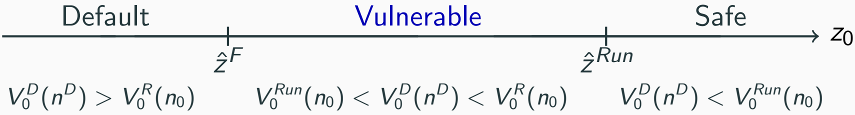
- Run & repayment is out-of-equilibrium



Default

Vulnerable

Safe

z_0

$\hat{z}^F$

$\hat{z}^{Run}$

$V_0^D(n^D) > V_0^R(n_0)$

$V_0^{Run}(n_0) < V_0^D(n^D) < V_0^R(n_0)$

$V_0^D(n^D) < V_0^{Run}(n_0)$

Run Thresholds, Spreads and Franchise Value

$$\hat{z}^{Run} = (z^D + p_0)\left(\frac{R_1^D}{R_1^k}\right)^{\beta} \times \prod_{t=2}^{\infty}\left(\frac{R_t^D}{R_t^e}\right)^{\beta^t} - p_0\left(1 - R\frac{b_0}{p_0 k_0}\right)$$

- Run threshold higher than fundamental one if $R_1^K > R$:
    - Inability to leverage reduces franchise value ⇒ Runs with liquid assets if $R^K > R$
- If $R_1^k = R$ (or $\gamma_0 = 0$), thresholds coincide
    - Access to spot market renders runs irrelevant

Run Thresholds, Spreads and Franchise Value

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    - Access to spot market renders runs irrelevant
- Marginal bank at run threshold: lower net purchases of capital than marginal bank at fundamental threshold
    - In particular, $\hat{k}_1^{Run} < k_1^D < \hat{k}_1^F$

General Equilibrium

- Market clearing for capital

$$K_t^D + K_t^R = \overline{K}$$

Consider two cases: (i) all banks subject to runs if vulnerable $\hat{z} = \hat{z}^{Run}$. (ii) only fundamental defaults $\hat{z} = \hat{z}^F$

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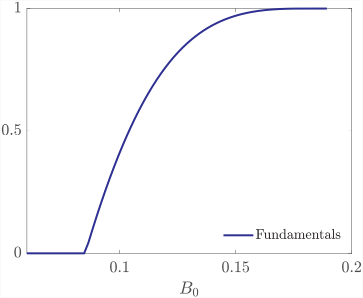
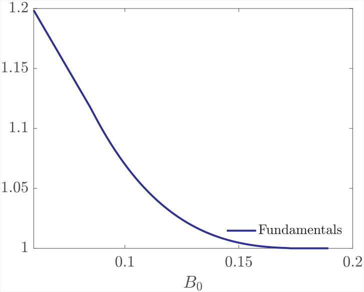
A competitive equilibrium is a sequence of prices of capital, $\{p_t\}_{t=0}^{\infty}$, a sequence of borrowing limits, $\{\gamma_t\}_{t=0}^{\infty}$, a sequence of net worths, debt and capital holdings, $\{N_t, N_t^D, B_t, K_t^R, K_t^D\}_{t=0}^{\infty}$, and a default threshold $\hat{z}$, such that

(i) Aggregates are consistent with banks' policies
(ii) The borrowing limits γ_t are equilibrium consistent
(iii) Markets clear for capital
(iv) The thresholds satisfy corresponding conditions

Equilibrium as a function of B_0

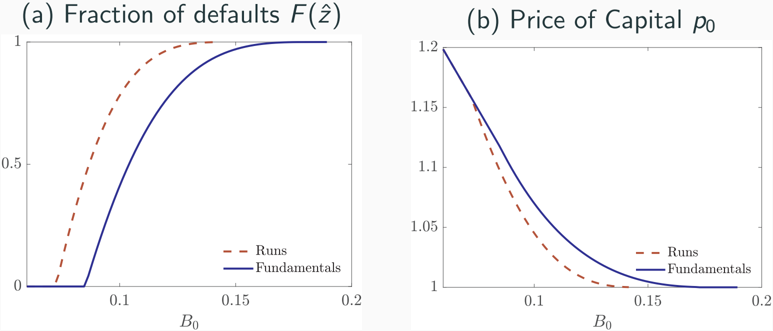


(a) Fraction of defaults $F(\hat{z})$



(b) Price of Capital p_0

Equilibrium as a function of B_0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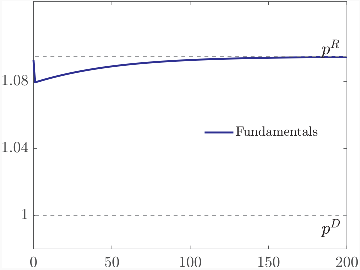
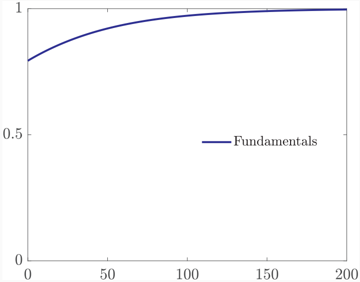
(b) Price of Capital p_0

Repaying banks increase capital over time



Price of Capital p_t



Capital Repaying Banks

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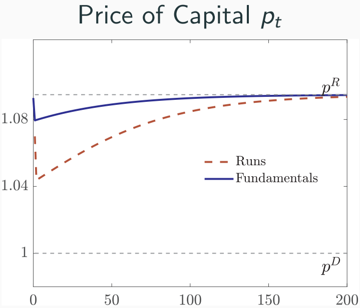

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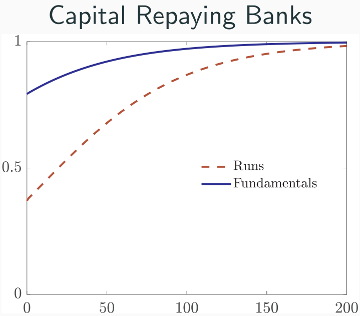

Capital Repaying Banks

Credit Easing

- Government purchases assets K^g at $t = 0$

$$K_t^D + K_t^R + K^g = \overline{K}$$

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- Govt. budget constraints at $t = 0, 1$

$$p_0 K^g = \tau(N_0 + N_0^D) + B_1^g, \qquad RB_1^g = (z^g + p_1)K^g$$

Credit Easing

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- Focus on govt. return $R^g = \frac{p_1 + z^g}{p_0} < R$:

$$\tau(N_0 + N_0^D) = \frac{p_0 K^g}{R} [R - R^g] > 0,$$

$\Rightarrow$ Government needs to tax to cover losses

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- If investors have same return as govt., they would not buy

Q: How do government purchases affect welfare?

Banks' Welfare

$$W(\hat{z}) \equiv \int_{\hat{z}}^{\overline{z}} V_0^R((z_0 + p_0)\overline{K} - RB_0)dF(z_0) + F(\hat{z})V_0^D((z^D + p_0)\overline{K})$$

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The effect of a change in the default threshold

$$W'(\hat{z}) = -f(\hat{z}) \underbrace{\left[V_0^R((\hat{z} + p_0)\overline{K} - RB_0) - V_0^D((z^D + p_0)\overline{K})\right]}_{>0 \text{ under runs}}$$

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- A reduction in default threshold improves welfare under runs

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- A reduction in default threshold improves welfare under runs
    - Crucial: how credit easing affects default thresholds?

The Effects on Run Threshold

$$\hat{V}((1-\tau_0)((\hat{z}+p_0)\overline{K}-RB_0)) = V_0^D((1-\tau_0)(z^D+p_0)\overline{K})$$

- With proportional tax to wealth, effects of K^g operate exclusively through $\{p_t\}$
- Assuming only p_0 changes, we can show that $\frac{d\hat{z}^{Run}}{dp_0} < 0$
  - Banks facing a run are net sellers of capital and thus benefit from a rise in asset prices
    - Defaulting banks may also benefit but to lower extent

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  - In the case of fundamentals, change in $\hat{z}$ is ambiguous
    - To the extent that marginal bank is a net buyer, $\frac{d\hat{z}^F}{dp_0} > 0$

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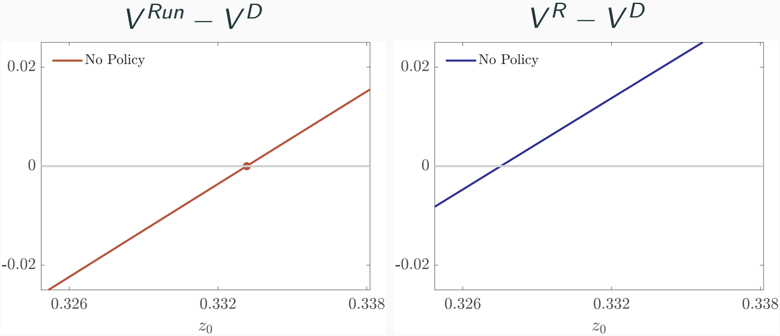
- If credit easing raises asset prices, positive effects on banks' welfare under runs

How credit easing affects default thresholds?


$V^{Run} - V^D$

$V^R - V^D$

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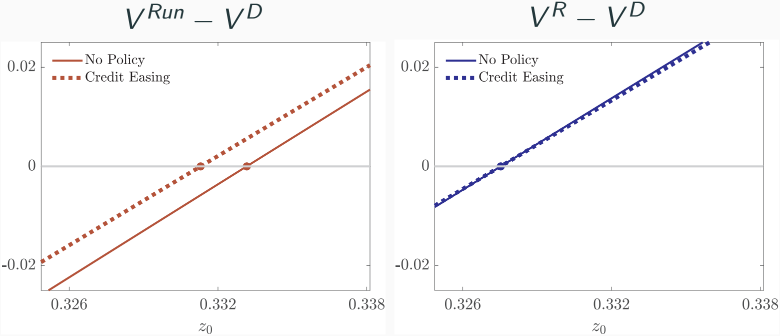
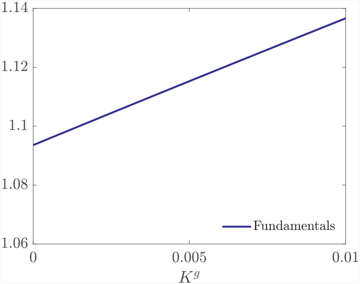
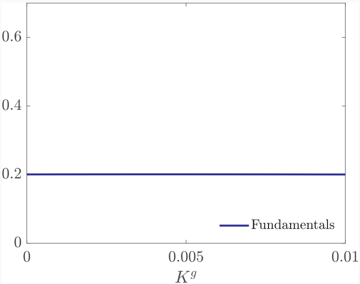


Credit easing under fundamentals

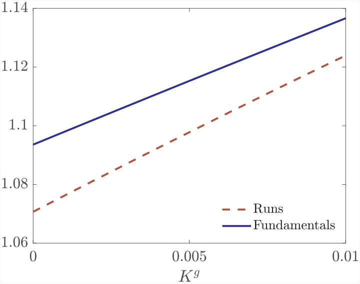
Price of Capital p_0



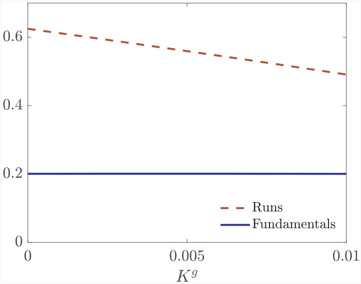
Share Defaulting Banks



Credit easing reduces defaults under runs

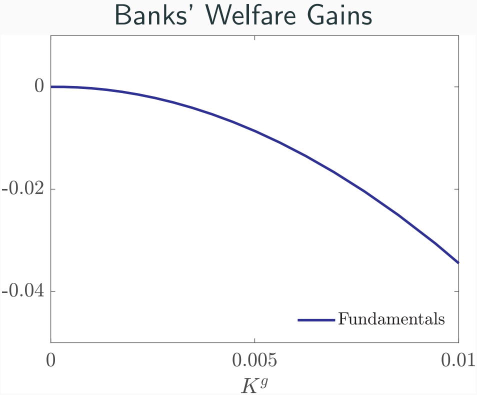


Price of Capital p_0

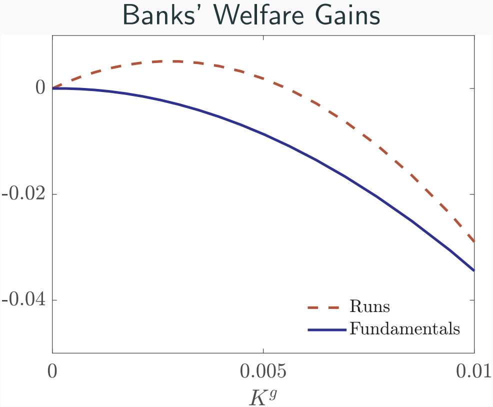


Share Defaulting Banks

Credit Easing desirable under Runs

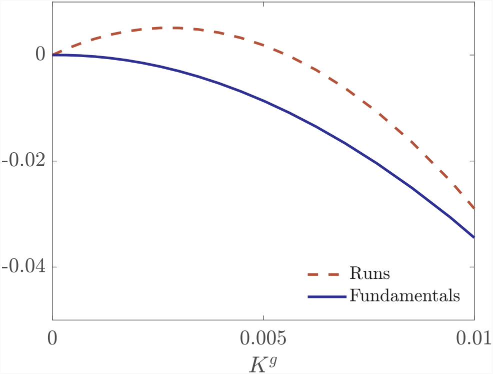


Credit Easing desirable under Runs



Credit Easing desirable under Runs

Banks' Welfare Gains



Note: Creditors' welfare goes up as long as fewer banks default

Extensions

- Sunspots
- Endogenous initial debt level B_0
- Alternative default values

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 monetary and macroprudential