Bank Runs, Fragility, and Regulation

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The views expressed herein are those of the authors and not necessarily those of the Federal Reserve Bank of Minneapolis or the Federal Reserve System.

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Banking regulation proposals:

- Higher equity buffers to make banks less vulnerable to runs

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Today: risk of bank runs induce banks to over-leverage even absent bailouts

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- General equilibrium model of banks runs (Amador-Bianchi 2024)
  - Analyze efficiency of ex-ante leverage decisions

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Mechanism:

- Higher equity buffers induce higher asset prices
  $\Rightarrow$ banks more "liquid" $\Rightarrow$ less prone to (inefficient) runs

Environment

- Three periods $t = 0, 1, 2$
  - Idiosyncratic risk only – realized at $t = 1$
- Technology
  - Production linear in capital
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  - Idiosyncratic risk only – realized at $t = 1$
- Technology
  - Production linear in capital
  - Capital in fixed supply K
- Continuum of banks with concave utility
  - Identical initial deposits and capital $b_0 = B_0, k_0 = K$
  - Constant productivity z under repayment
  - Can default at $t = 1, 2$ – outside option shock at $t = 1$
- Creditors: linear utility and discount rate R

Individual Bank Problem

Preferences and budget constraints

- Preferences

$$u(c_0) + \beta \mathbb{E} u(c_1) + \beta^2 \mathbb{E} u(c_2),$$

where $u = \log$

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$$c_0 = (z + p_0)k_0 - Rb_0 + q_0(b_1, k_1)b_1 - p_0 k_1,$$

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Banks Outside Options: Default Values

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- Default triggers
  - Loss in productivity or capital
  - Exclusion from borrowing and capital markets

Banks Outside Options: Default Values

- Period 2 value

$$V_2^D(k_2) = u(z_2^D k_2)$$

  - z_2^D is predetermined and common across banks.

- Period 1 value

$$V_1^D(k_1, z_1^D) = u(z_1^D k_1) + \beta u(z_2^D k_1)$$

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V^D independent of prices (and increasing in k)

- Generates a standard endogenous borrowing limit

Period 2: Bank Problem

$$V_2(b_2, k_2) = \max_{d_2 \in \{0,1\}} \left\{ (1 - d_2) u(z k_2 - R b_2) + d_2 u(z_2^D k_2) \right\}$$

Default choice:

$$d_2(b_2, k_2) = \begin{cases} 1 & \text{if } \; R b_2 > \phi k_2, \text{where } \phi \equiv z - z_2^D \\ 0 & \text{otherwise}, \end{cases}$$

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$$V_1^R(n_1) = \sup_{c_1, k_2 \geq 0, b_2} \left\{ u(c_1) + \beta u(zk_2 - Rb_2) \right\}$$

Without a run

$$\text{s.t.} \quad c_1 = n_1 + b_2 - p_1 k_2$$

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can save but not borrow

Vulnerable to self-fulfilling runs when $V_1^{Run}(n_1) < V_1^D(k_1, z_1^D) \leq V_1^R(n_1)$

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- Given portfolio (k_1, n_1) and p_1
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Safe — Default — z_1^D

$\hat{z}^{Run}(k_1, n_1)$ — $\hat{z}^{F}(k_1, n_1)$

$V_1^{Run}(n_1) \geq V_1^D(k_1, z_1^D)$ — $V_1^D(k_1, z_1^D) > V_1^R(n_1)$

[Run & repay is off-equilibrium event]

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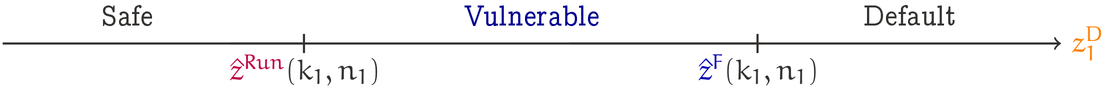

Runs occur despite assets being liquid (Amador-Bianchi 2024)

- When $R^K > R$, leverage raises expected profits
  - A run prevents bank from leveraging $\Rightarrow$ reduces profits and value of repayment $\Rightarrow$ run may become self-fulfilling, $\hat{z}^{Run} < \hat{z}^F$

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  - A run prevents bank from leveraging $\Rightarrow$ reduces profits and value of repayment $\Rightarrow$ run may become self-fulfilling, $\hat{z}^{Run} < \hat{z}^{F}$
- Instead, if $R^K = R$, defaults only occur due to fundamentals $\hat{z}^{Run} = \hat{z}^{F}$.

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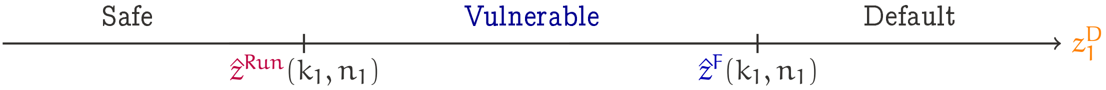

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$\Rightarrow$ Default probability for individual bank

$$d_1(n_1, k_1, z_1^D) = \begin{cases} 0 & \text{if } \; z_1^D \leq \hat{z}^{Run}(n_1, k_1) \\ \lambda & \text{if } \; \hat{z}^{Run}(n_1, k_1) < z_1^D \leq \hat{z}^{F}(n_1, k_1) \\ 1 & \text{if } \; z_1^D > \hat{z}^{F}(n_1, k_1) \end{cases}$$

Period 0: Value and Leverage Choice

$$V_0(n_0) = \max_{c_0 \geq 0, k_1 \geq 0, b_1} u(c_0)$$

$$+ \beta \int_{\underline{z}}^{\overline{z}} \left[d_1(n_1, k_1, \tilde{z}) V_1^D(k_1, \tilde{z}) + (1 - d_1(n_1, k_1, \tilde{z})) V_1^R(n_1) \right] dF(\tilde{z})$$

subject to

$$c_0 = n_0 + q_0(n_1, k_1) b_1 - p_0 k_1,$$

$$n_1 = (z + p_1) k_1 - R b_1.$$

where the bond price is given by

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Deposits allow for higher portfolio returns and c_0, but raises exposure to default

Competitive Equilibrium

Definition

Given B_0, and a run probability, λ, a *symmetric competitive equilibrium* consists of $\left\{p_0, p_1, q_0, \hat{z}^F, \hat{z}^{Run}, d_1, d_2, V_1^R, V_1^D, b_1, k_1, b_2, k_2\right\}$ such that:

(a) Banks optimize

(b) Investors break even

$$q_0(n_1, k_1) = (1-\lambda)F(\hat{z}^F(n_1, k_1)) + \lambda F(\hat{z}^{Run}(n_1, k_1))$$

(d) The market for capital clears

- Aggregate demand for capital equals K at $t = 0, 1$.

Equilibrium at $t = 1$

- Characterization in terms of **leverage** $l_1 = b_1/k_1$
  - Redefine thresholds as $\hat{z}^F(l_1|p_1)$, $\hat{z}^{Run}(l_1|p_1)$
  - In the aggregate $L_1 = b_1/K$
- Share of banks defaulting is increasing in L_1:

$$\underbrace{\left[1 - F(\hat{z}^F(L_1|p_1)\right]}_{\text{Fundamentals}} + \lambda \underbrace{\left[F(\hat{z}^F(L_1|p_1) - F(\hat{z}^{Run}(L_1|p_1)\right]}_{\text{Runs}}$$

- Price for capital p_1 decreasing in L_1 when banks are <u>constrained</u>

$$\mathcal{P}_1(L_1) \equiv \begin{cases} \frac{z}{R} & \text{if } L_1 \leq \hat{L}, \\ \beta z + (1+\beta)\frac{\phi}{R} - \beta R L_1 & \text{if } L_1 \in (\hat{L}, \overline{L}). \end{cases}$$

Roadmap for Normative Analysis

- Constrained-efficient planner problem
- Evaluate competitive equilibrium vs. constrained-efficient
  - Without runs $\lambda = 0$
  - With runs $\lambda > 0$

Constrained-Efficient Leverage

- Planner chooses L_1 and banks retain all other decisions
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$$\max_{c_0, L_1} \left\{ u(c_0) + \beta \int_{\underline{z}}^{\overline{z}} \left[d_1(L_1, \tilde{z}|p_1) V_1^D(K, \tilde{z}) + (1 - d_1(L_1, \tilde{z}|p_1)) V_1^R(n_1|p_1) \right] dF(\tilde{z}) \right\},$$

subject to:

$$c_0 = zK - RB_0 + q_0(L_1|p_1)L_1K,$$

and where:

$$n_1 = (z + p_1)K - RL_1K, \;\; p_1 = \mathcal{P}_1(L_1), \text{and } d_1 \text{ as defined above}$$

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Creditors remain indifferent

Analysis without Runs

Proposition (Constrained-efficiency)

Suppose $\lambda = 0$. *Any competitive equilibrium is constrained efficient.*

Prelude for the Proof

Lemma: Consider any aggregate leverage L_1 and its associated price $p_1 = \mathcal{P}_1(L_1)$

(i) $V_1^R((z+)K - RKL_1|p_1) \leq V_1^R((z+\hat{p}_1)K - RKL_1|\hat{p}_1)$;

(ii) $q_0(L_1|p_1) \leq q_0(L_1|\hat{p}_1)$,

with the first inequality is strict if $\hat{p}_1 \neq p_1$.

Key idea:

- In equilibrium, banks are neither net buyers nor net sellers
    - If price deviates from eqm. one, value of repayment goes up (for same leverage).

Proof of Constrained-Efficiency with $\lambda = 0$

Let L^E and L^P be the competitive eqm. and planner's leverage

Associated prices: $p_1^E = \mathcal{P}(L^E)$ and $p_1^P = \mathcal{P}(L^P)$

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Associated prices: $p_1^E = \mathcal{P}(L^E)$ and $p_1^P = \mathcal{P}(L^P)$

- In the competitive eqm., banks prefer (L^E, K) rather than (L^P, K) when facing p_1^E:

$$u\big(zK - RB_0 + q_0(L^E|p_1^E)L^E K\big) + \beta\mathbb{E}V_1(L^E, K|p_1^E)$$
$$\geq u\big(zK - RB_0 + q_0(L^P|p_1^E)L^P K\big) + \beta\mathbb{E}V_1(L^P, K|p_1^E).$$

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By prev. lemma: $\mathbb{E}V_1(L^P, K|p_1^E) \geq \mathbb{E}V_1(L^P, K|p_1^P)$

and $q_0(L^P|p_1^E) \geq q_0(L^P|p_1^P)$

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But planner can also choose L^E.

$\Rightarrow$ L^E must solve the planner's problem

Uniqueness and Existence

Proposition (Uniqueness)

Suppose that: (i) there is a unique solution to the planner problem, or (ii) there exists a competitive equilibrium with leverage $L_1 = B_1/K > \hat{L}$.

Then, there is at most one (symmetric pure-strategy) competitive equilibrium.

Proposition (Existence)

Suppose that Assumption 2 holds and

i) f *is continuous and such that* $f(\underline{z}) = f(\overline{z}) = 0$.

ii) $\left[\frac{1-F(z)}{1+\beta} + \frac{f(z)}{F(z)}z\right]$ *is decreasing in* z *for any* $z \in [\underline{z}, \overline{z}]$.

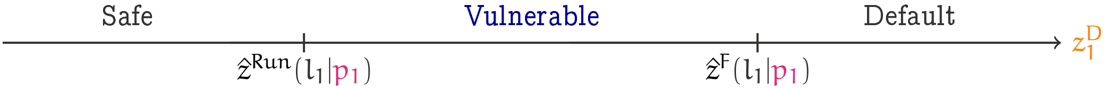
Then, there $\exists$ a competitive equilibrium.

Available theorems with default risk only in *partial equilibrium*

Economy with runs $\lambda > 0$

Preview: Thresholds as a Function of Aggregate Leverage

Start from $l_1 = L_1$ and consider a reduction in L_1



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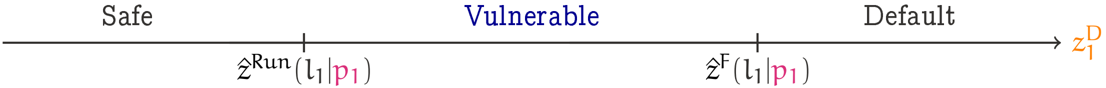
- Zero *first-order* effects on $\hat{z}^F$ (neither net buyer nor net seller)



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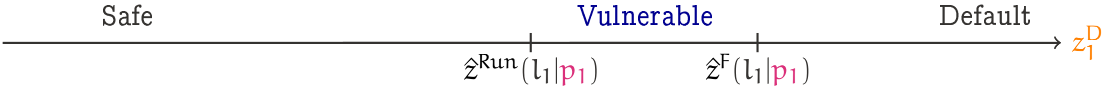

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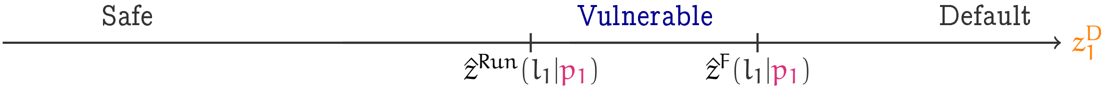
- Zero *first-order* effects on $\hat{z}^F$ (neither net buyer nor net seller)
- But $\uparrow \hat{z}^{Run}$ because banks are net sellers in a run
  - Not internalized by individual banks



Over-leverage with $\lambda > 0$

$$\frac{1}{c_0} - \frac{\beta R}{c_1} = -\frac{(1-\lambda) f(\hat{z}^F) \frac{\partial \hat{z}^F}{\partial L_1} + \lambda f(\hat{z}^{Run}) \frac{\partial \hat{z}^{Run}}{\partial L_1}}{q_0} \frac{L_1}{c_0}$$

$$-\frac{\lambda f(\hat{z}^{Run}) \frac{\partial \hat{z}^{Run}}{\partial L_1}}{q_0} \frac{\beta}{K} \left[V_1^R(n_1|p_1) - V_1^D(K, \hat{z}^{Run}) \right]$$

$$-\frac{\lambda f(\hat{z}^{Run})}{q_0} \underbrace{\frac{\partial \hat{z}^{Run}(L_1|p_1)}{\partial p_1} \mathcal{P}_1'(L_1)}_{\text{G.E.}} \left[\frac{L_1}{c_0} + \frac{\beta}{K} \left[V_1^R(n_1|p_1) - V_1^D(K, \hat{z}^{Run}) \right] \right]$$

Over-leverage with $\lambda > 0$

$$\frac{1}{c_0} - \frac{\beta R}{c_1} =$$

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Higher L_1 reduces q_0

Over-leverage with $\lambda > 0$

$$\frac{1}{c_0} - \frac{\beta R}{c_1} = -\frac{(1-\lambda) f(\hat{z}^F)\frac{\partial \hat{z}^F}{\partial L_1} + \lambda f(\hat{z}^{Run})\frac{\partial \hat{z}^{Run}}{\partial L_1}}{q_0}\frac{L_1}{c_0}$$

Higher L_1 reduces q_0

$$-\frac{\lambda f(\hat{z}^{Run})\frac{\partial \hat{z}^{Run}}{\partial L_1}}{q_0}\frac{\beta}{K}\left[V_1^R(n_1|p_1) - V_1^D(K, \hat{z}^{Run}))\right]$$

Higher L_1 raises run prob

Over-leverage with $\lambda > 0$

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Higher L_1 reduces q_0

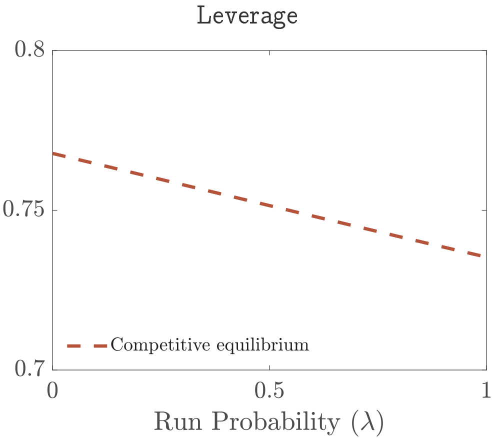
$$-\frac{\lambda f(\hat{z}^{Run})\frac{\partial \hat{z}^{Run}}{\partial L_1}}{q_0}\frac{\beta}{K}\left[V_1^R(n_1|p_1) - V_1^D(K, \hat{z}^{Run})\right]$$

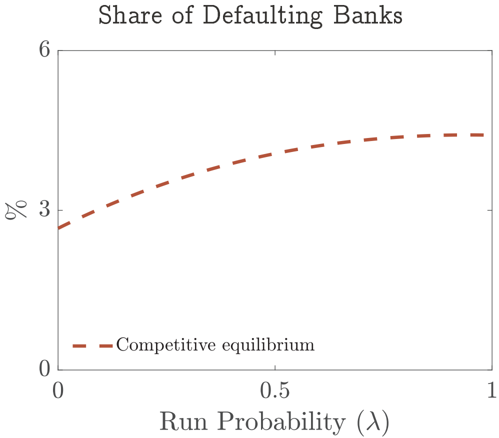
Higher L_1 raises run prob

$$-\frac{\lambda f(\hat{z}^{Run})}{q_0}\underbrace{\frac{\partial \hat{z}^{Run}(L_1|p_1)}{\partial p_1}\mathcal{P}_1'(L_1)}_{\text{G.E.}}\left[\frac{L_1}{c_0} + \frac{\beta}{K}\left[V_1^R(n_1|p_1) - V_1^D(K, \hat{z}^{Run})\right]\right]$$

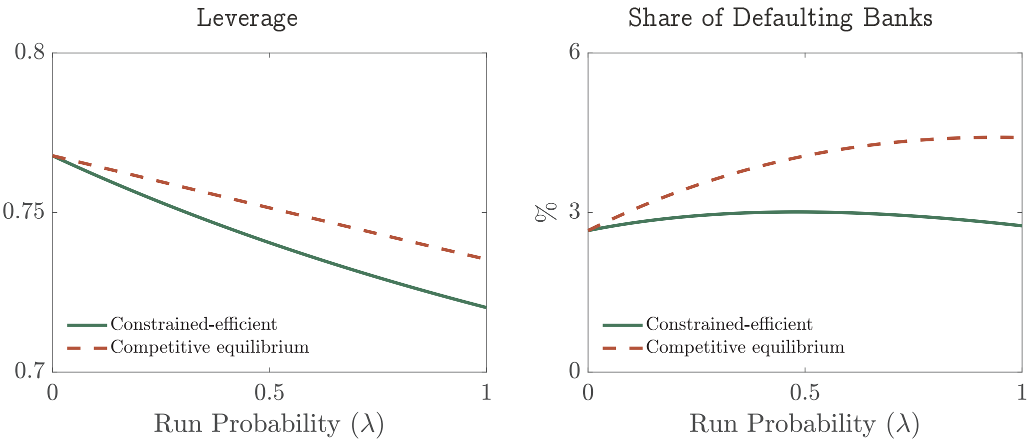
- An increase in p_1 helps $\uparrow V^{Run}$ because banks facing a run are net sellers $k_1^{Run} < K \Rightarrow$ fewer banks vulnerable
- Planner internalizes that $\downarrow L_1$ leads to $\uparrow p_1$ and fewer runs

Competitive Eqm. vs. Constrained Efficient





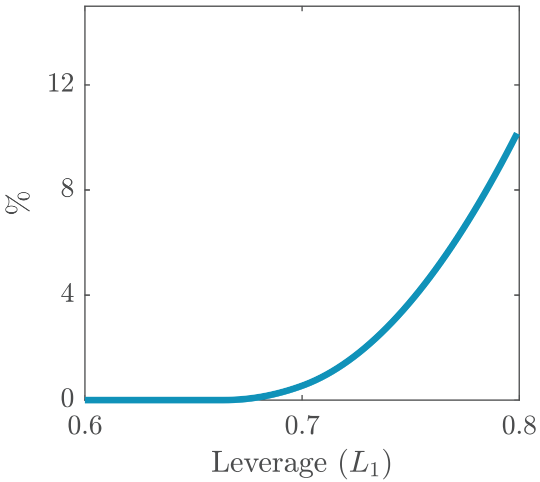
Competitive Eqm. vs. Constrained Efficient



Conclusions

- A macroprudential theory of banking regulation under self-fulfilling runs
- Banks do not internalize that by raising leverage
  - they contribute to lower asset prices
  - making other banks more vulnerable to runs
- Higher capital requirements can implement the constrained-efficient allocation

Share of Defaulting Banks



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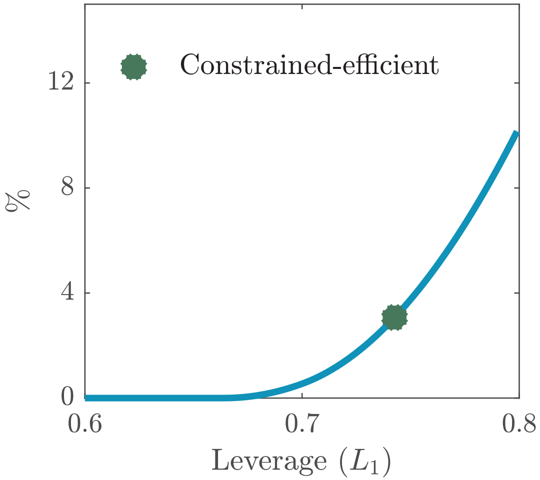
Share of Defaulting Banks



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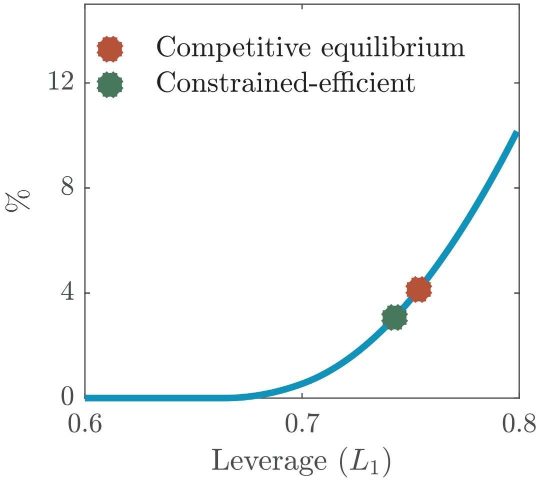
Share of Defaulting Banks



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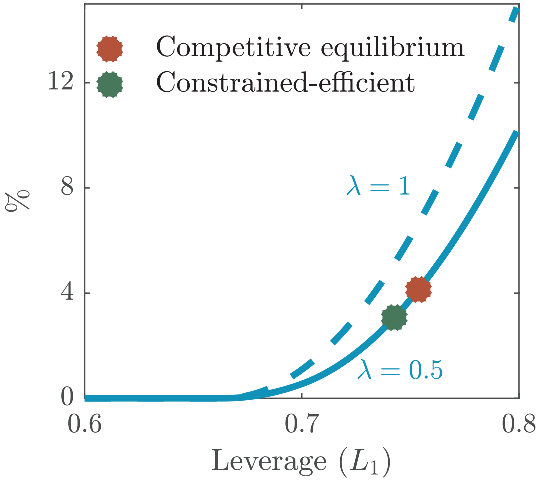
Share of Defaulting Banks



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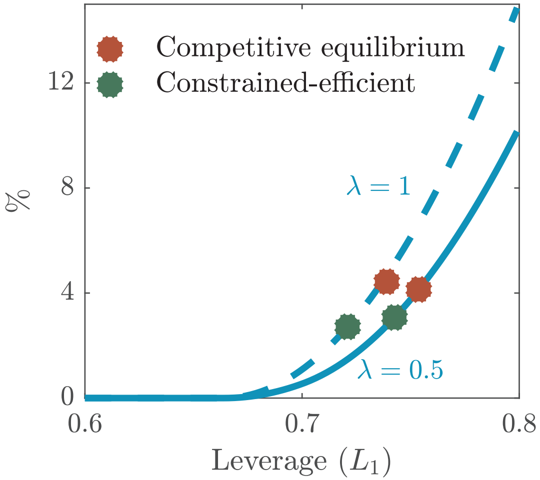
Share of Defaulting Banks



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