Bank Heterogeneity and Financial Stability

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Motivation

Financial system is densely interconnected

- Technologies: securitization, interbank trading, syndicated loans...
- Problem: common risk exposures and systemic risk

Our focus: Bank runs in the interconnected financial system

- The literature mostly studies individual banks' fragility...
- ...or abstracts from fragility and focuses on interconnections

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- ...or abstracts from fragility and focuses on interconnections
- Our model emphasizes how cross-bank interactions amplify individual fragilities in a homogeneous financial system

Preview

Setting: Banking sector with fire-sale externalities

- Within-bank strategic complementarity a-la Diamond and Dybvig (1983)
- Cross-bank strategic complementarity due to fire sales
- *Two complementarities are mutually reinforcing*
  - When prices are low, depositors are more sensitive to runs within their banks

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Main result: Differentiating banks makes all banks less fragile

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- Asset portfolios are less correlated $\Rightarrow$ weaker complementarity amplification
- Increasing heterogeneity (to a certain extent) is Pareto improving
    - Policy debate: individual insolvencies vs systemic risk (Haldane, 2009)
    - Existing theory: optimal heterogeneity depends on the size of the shocks (e.g. Acemoglu et al., 2015; Cabrales et al., 2017)

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- Ring fencing, M&A regulation, crises resolution, bank disclosure...

Literature

Asset commonality and systemic risk

- Theories: Wagner (2010, 2011), Ibragimov, Jaffee and Walden (2011), Allen, Babus and Carletti (2012), Cabrales, Gottardi and Vega-Redondo (2017)
- Empirics: Adrian and Brunnermeier (2016), Acharya et al. (2017)

Panic runs

- Classics: Diamond and Dybvig (1983), Rochet and Vives (2004), Goldstein and Pauzner (2005)
- Panic runs with fire sales: Eisenbach (2017), Liu (2018), Luo and Yang (2019)

Global games with heterogeneous agents

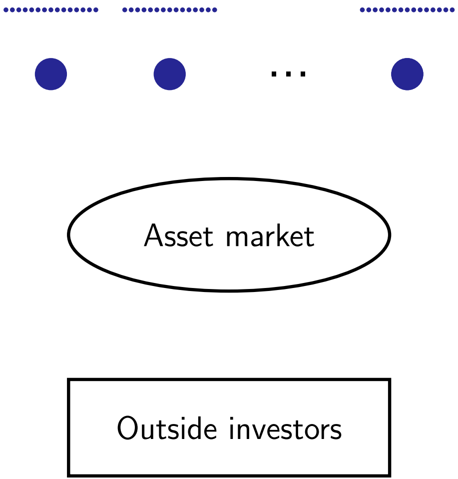
- Frankel, Morris and Pauzner (2003), Sakovics and Steiner (2012), Choi (2014)

Structure of the economy

t = 0
Investors finance banks

t = 1
Shocks are realized
Some investors choose to run
Fire sales; cross-bank spillovers

t = 2
Banks repay late withdrawers



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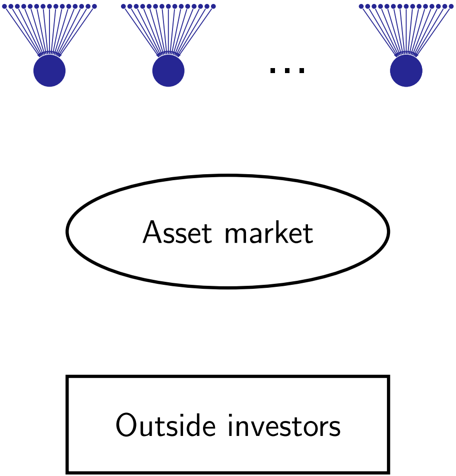

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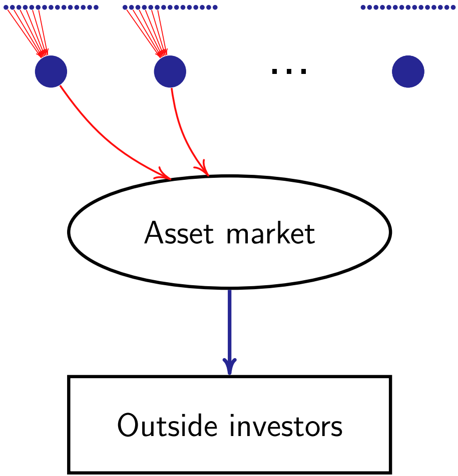

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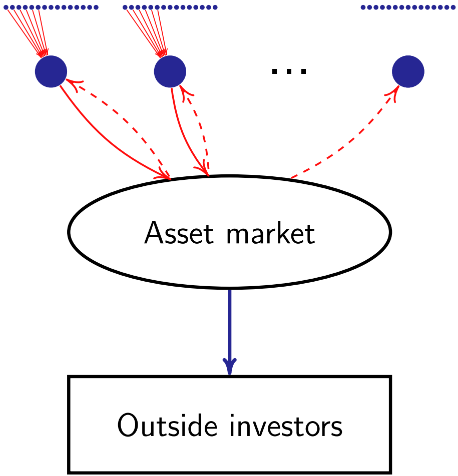

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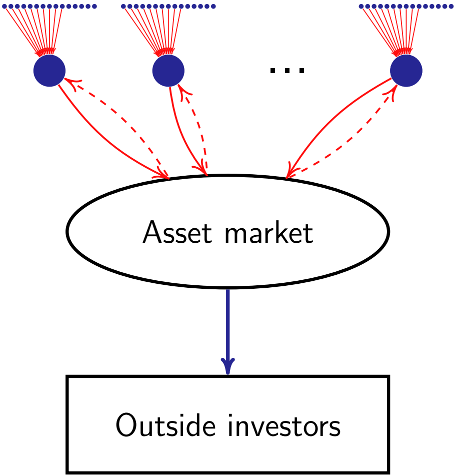

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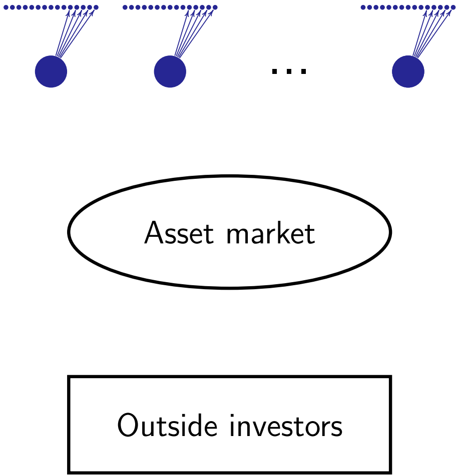

Model outline I

- Dates: $t \in \{0, 1, 2\}$. Three types of agents: banks, investors, outsiders

$\mathbf{t = 0}$

- A continuum of ex-ante identical banks $i \in [0, 1]$ with long-term asset return

$$z_i = \theta + \eta_i$$

- Aggregate productivity: $\theta \sim F(\cdot)$, $\mathbb{E}\theta > 1$
- Bank-specific productivities are i.i.d.: $\eta_i = \begin{cases} \Delta & \text{w.p. } 0.5 \\ -\Delta & \text{w.p. } 0.5 \end{cases}$
- Δ is the degree of heterogeneity between (ex post) strong and weak banks
- Bank i has no wealth but receives funding from a unit mass of investors

Model outline II

$\mathbf{t = 1}$

- Payoff from early withdrawal (run): $\pi_{run} = 1$
  - Fraction $\bar{m} < 1$ can withdraw funds early (e.g. due to limited attention)

- Given the mass of runners m_i, bank i sells $\frac{m_i}{p_i}$ units of assets to outsiders
  - $p_i < 1$ is determined by market-clearing condition
  - $\frac{\bar{m}}{p_i} \leq 1$: no bankruptcy

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t = 2

- Late withdrawers receive $\pi_{stay}(z_i, m_i, p_i) = \dfrac{z_i \left(1 - \frac{m_i}{p_i}\right)}{1 - m_i}$
- Within-bank strategic complementarity: $\dfrac{\partial(\pi_{stay} - \pi_{run})}{\partial m_i} < 0$ iff $p_i < 1$

Liquidation

Outsiders

- Deep-pocketed, competitive, less efficient than banks
- Purchase k_i unit of bank i's asset to maximize expected payoff

$$\max_{\{k_i\}_{i\in[0,1]}} f\left(\int z_i k_i di\right) - \int p_i k_i di$$

where $f(x) < x$, $f'(\cdot) > 0$, $f''(\cdot) < 0$, and $xf'(x)$ increases in x

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Liquidation prices

- Taking FOCs and imposing market-clearing conditions: $p_i = \dfrac{z_i}{\lambda(m)}$
- $m = \int m_i di$ is total mass of runners in the economy
- Cross-bank complementarity: $\lambda'(m) > 0$

Complementarities

Investors' incentive to stay

$$\pi_{stay} - \pi_{run} = \frac{z_i - \lambda(m)m_i}{1 - m_i} - 1$$

Two mutually reinforcing complementarities

- Within-bank complementarity: $\frac{\partial\left(\pi_{stay} - \pi_{run}\right)}{\partial m_i} < 0$
- Cross-bank complementarity: $\frac{\partial\left(\pi_{stay} - \pi_{run}\right)}{\partial m} < 0$
- Complementarities reinforce each other: $\frac{\partial^2\left(\pi_{stay} - \pi_{run}\right)}{\partial m \partial m_i} < 0$
  - When total amount of runs m is high, fire-sale discount $\lambda(m)$ is high
  - Investors of bank i are more sensitive to run decisions of each other

Bank runs

Information structure

- Investor j in bank i observes η_i (can be relaxed)
- Investor j in bank i receives a noisy signal s_{ij} about aggregate fundamental θ

$$s_{ij} = \theta + \sigma \epsilon_{ij}, \ \epsilon_{ij} \overset{\text{i.i.d.}}{\sim} \Phi(\cdot)$$

Run decision

- An investor j in bank i withdraws early if

$$\mathbb{E}\left[\pi_{stay}(z_i, m_i, p_i) \middle| s_{ij}\right] < \pi_{run} \Leftrightarrow \mathbb{E}\left[\frac{z_i - \lambda(m)m_i}{1 - m_i} \middle| s_{ij}\right] < 1$$

Global games

Equilibrium uniqueness

- Focus on the limit of negligible signal noise: $\sigma \to 0$
- Unique threshold equilibrium: investor j of bank i $\begin{cases} \text{runs if } s_{ij} \leq \theta_i^* \\ \text{stays if } s_{ij} > \theta_i^* \end{cases}$

Marginal investor in bank i: $s_{ij} = \theta_i^*$

- Indifference condition: $\displaystyle\int_0^1 \frac{\theta_i^* + \eta_i - \lambda\left(m(x)\right)\bar{m}x}{1 - \bar{m}x}dx = 1$
- Mass of runner on investor's own bank i: $\bar{m}x$
- Mass of runners in the economy: $m(x) = \bar{m}\displaystyle\int \Phi\left(\frac{\theta_k^* - \theta_i^*}{\sigma} + \Phi^{-1}(x)\right)dk$

Illustration

Heterogeneity: Run thresholds

Two groups of banks: strong and weak

$$\theta_i^* = \begin{cases} \theta_s^* & \text{if } \eta_i = \Delta, \\ \theta_w^* & \text{if } \eta_i = -\Delta \end{cases}$$

$$\int_0^1 \frac{\theta_s^* + \Delta - \lambda\left(0.5\bar{m}x + 0.5\bar{m}\Phi\left(t + \Phi^{-1}(x)\right)\right)\bar{m}x}{1 - \bar{m}x} dx = 1$$

$$\int_0^1 \frac{\theta_w^* - \Delta - \lambda\left(0.5\bar{m}x + 0.5\bar{m}\Phi\left(-t + \Phi^{-1}(x)\right)\right)\bar{m}x}{1 - \bar{m}x} dx = 1$$

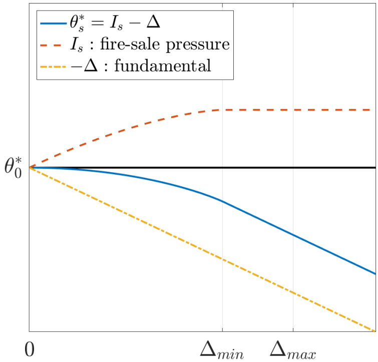
- $t = \lim_{\sigma \to 0} \frac{\theta_w^* - \theta_s^*}{\sigma}$ is a distance between run thresholds

Two effects of larger heterogeneity Δ

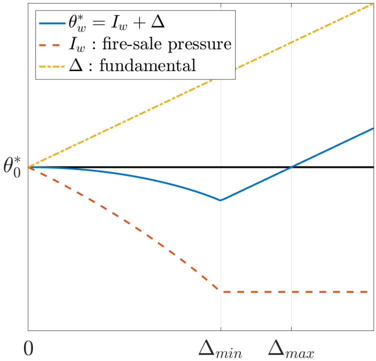
- *Fundamentals*: strong banks become stronger
- *Fire-sale pressure*: strong banks suffer from a higher fire-sale pressure

Heterogeneity and fragility I

Strong banks

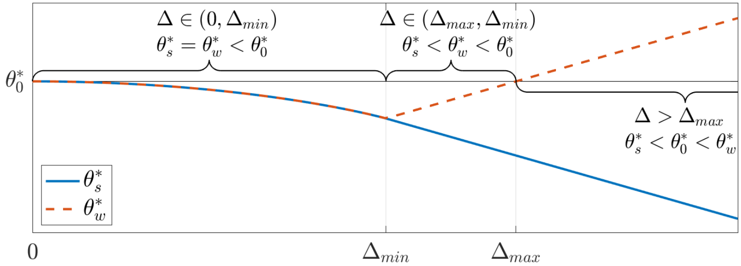


Weak banks



- $\Delta < \Delta_{min}$: strategic uncertainties across investors of different banks
  - Weak bank investors perceive runs on strong banks as possible
  - Strong bank investors believe that weak banks might avoid runs
- $\Delta > \Delta_{min}$: no more strategic uncertainties

Heterogeneity and fragility II



- Heterogeneity is Pareto-improving if $\Delta < \Delta_{min}$

Nonzero noise

Heterogeneity and fragility III

The effect of increasing heterogeneity Δ

	Weak banks	Strong banks
Fundamental	$\downarrow (-)$	$\uparrow (+)$
Fire-sale pressure	$\downarrow (+)$	$\uparrow (-)$

- Impact of Δ on run threshold θ^*:
  - Fundamental: zero net effect (by construction)
  - Fire-sale pressure: net benefit due to reinforcing complementarities Why
- $\Delta > \Delta_{min}$: fire-sale pressure is constant
  - Weak banks' investors are certain that strong banks are not liquidating
  - Strong banks' investors are certain that weak banks are liquidating

Robustness and extensions

- N types of banks Here
- Uncertain bank-specific productivities Here
- General payoff functions Here
- No aggregate uncertainty Here

Policies

Ring fencing

- Service divisions: commercial banks vs investment banks
  - United States: Volcker rule
  - United Kingdom: Banking Reform Act 2013
- Geographic divisions
  - Europe: legal restrictions on intragroup cross-border asset transfers and limitations on the distribution of profits by foreign-owned subsidiaries
- Heterogeneity is crucial: splitting banks into identical clones will not help
- M&A regulation: increase risk weights of merging banks

Bank support during crises

- U.S. Treasury forced all major banks to take the TARP money
- Avoid signaling and stigma
- Unintended (?) consequence: heterogeneity is preserved

Conclusion

Bank runs with common market for asset sales

- Two mutually reinforcing complementarities
- Aggregate uncertainty

Key results

- A homogeneous financial system is suboptimal
- Increasing heterogeneity is Pareto improving

Policy prescriptions

- Ring fencing, M&A regulation, support of banks in crises

Appendix

N types of banks

- Same setting but bank-specific productivity can take N values

$$\eta_i = \Delta_i \text{ with prob. } w_i, \text{ where } \sum_{i=1}^{N} w_i = 1, \; \sum_{i=1}^{N} w_i \Delta_i = 0$$

Proposition

Starting from a homogeneous financial system ($\Delta_i = 0 \; \forall i$), any sufficiently small heterogeneity reduces run thresholds for all banks.

Back

Uncertain bank-specific productivities

- Assume that bank i sends an imperfect signal $d_i \in \{G, B\}$ about its type at $t = 1$

$$\mathbb{P}(d_i = G|\eta_i = \Delta) = \mathbb{P}(d_i = B|\eta_i = -\Delta) = \alpha \in [0.5, 1]$$

Proposition

The model is equivalent to the benchmark one with

$$w^{eff}(\alpha) = w\alpha + (1-w)(1-\alpha),$$
$$\Delta^{eff}(\alpha) = \frac{2\alpha - 1}{w\alpha + (1-w)(1-\alpha)} w\Delta.$$

Effective heterogeneity $\Delta^{eff}(\alpha > 0)$, $\Delta^{eff}(0.5) = 0$, *and* $\Delta^{eff}(1) = \Delta$.

- Imperfect signals about bank-specific productivities reduce *effective* heterogeneity
- When $\alpha = 0.5$, banks are effectively homogeneous
- Main result holds as long as signals are informative, $\alpha > 0.5$

Back

General payoff function

- Consider a general (net) benefit from staying

$$g(z_i, m_i, m),\ \text{where } \frac{\partial g}{\partial z_i} > 0, \frac{\partial g}{\partial m_i} < 0, \frac{\partial g}{\partial m} < 0$$

Proposition

If $\frac{\partial^2 g}{\partial m_i \partial m} \leq 0$, $\frac{\partial^2 g}{\partial z_i \partial m} \geq 0$, $\frac{\partial^2 g}{\partial z_i^2} \geq 0$, a common run threshold θ^* is not increasing when heterogeneity Δ goes up (declines if any of the inequalities is strict).

- $\frac{\partial^2 g}{\partial m_i \partial m} \leq 0$ — mutually reinforcing complementarities
- $\frac{\partial^2 g}{\partial z_i \partial m} \geq 0$ — (mechanically) asymmetric fire-sale pressure
- $\frac{\partial^2 g}{\partial z_i^2} \geq 0$ — (mechanically) beneficial heterogeneity

Back

No aggregate uncertainty

- Bank i is characterized by its position $x_i \in [0,1]$: $\eta_i = \begin{cases} \Delta, & \text{if } x_i > 0.5, \\ -\Delta, & \text{if } i_x \leq 0.5 \end{cases}$
- Assume that agents perfectly observe θ but not x_i (i.e., η_i): $s_{ij} = x_i + \sigma\epsilon_{ij}$

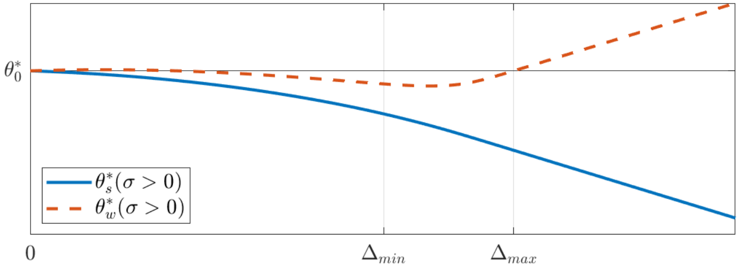
Proposition

- *$\theta > \theta_L$: there exists a 'low-run' equilibrium with the run threshold $x_L^* < 0.5$*
- *$\theta < \theta_H$: there exists a 'high-run' equilibrium with the run threshold $x_H^* > 0.5$*
- *$\theta_L(\Delta)$ is increasing and $\theta_H(\Delta)$ is decreasing in Δ*

- η_i is uncertain $\Rightarrow$ multiplicity due to within-bank complementarities is resolved
- Prices are certain $\Rightarrow$ multiplicity due to cross-bank complementarity is preserved
- Impact of heterogeneity depends on the type of equilibria being played

Back

Finite noise

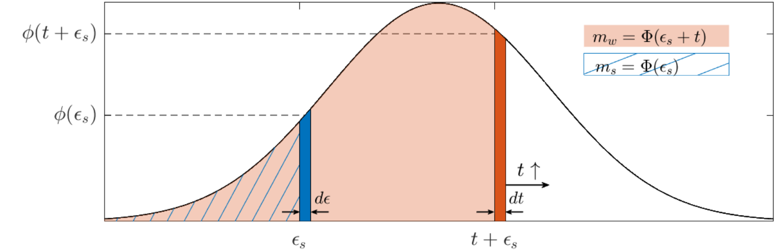


- Assume that signals are not infinitely precise
- Thresholds θ_s^* and θ_w^* are not infinitely close
- But overall pattern is preserved

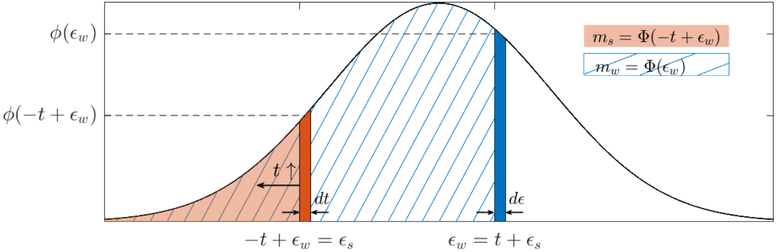
Back

Asymmetric fire-sale pressure

Fire-sale pressure on strong banks



Fire-sale pressure on weak banks



Back

Fragility of a homogeneous financial system

- Consider a homogeneous financial system, $\eta_i = 0 \; \forall i$

Benchmark case: Interacting complementarities

- Synchronized runs across different banks $\Rightarrow$ Threshold investor expects many runs on her bank when fire-sale discount is large
- Indifference condition: $\int_0^1 \frac{\theta_0^* - \lambda\left(\bar{m}x\right)\bar{m}x}{1 - \bar{m}x} dx = 1$

Fixed fire-sale discount: No complementarity interaction

- Fix fire-sale discount at its average level: $\bar{\lambda} = \int_0^1 \lambda\left(\bar{m}x\right) dx$
- Indifference condition: $\int_0^1 \frac{\hat{\theta}_0^* - \bar{\lambda}\bar{m}x}{1 - \bar{m}x} dx = 1$
- Banks are *less* fragile when complementarities do not interact: $\hat{\theta}_0^* < \theta_0^*$

Back