Bail-in Bail-Outs: Incentives, Connectivity, and Systemic Stability

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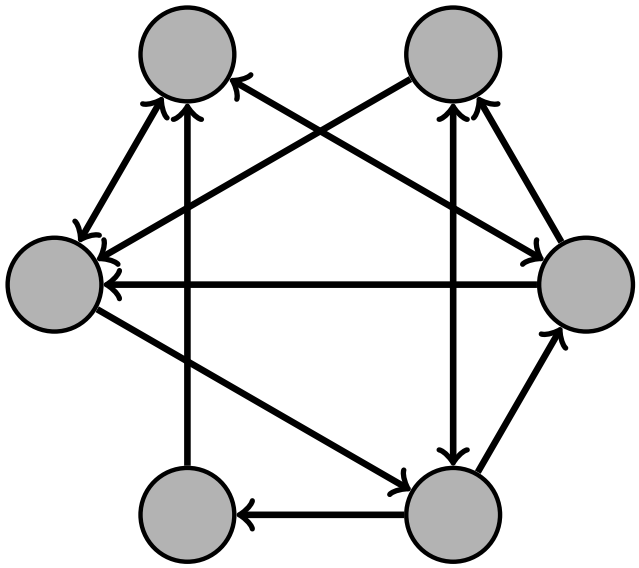
joint work with Benjamin Bernard and Joseph Stiglitz

Introduction

Contagion in an interbank network



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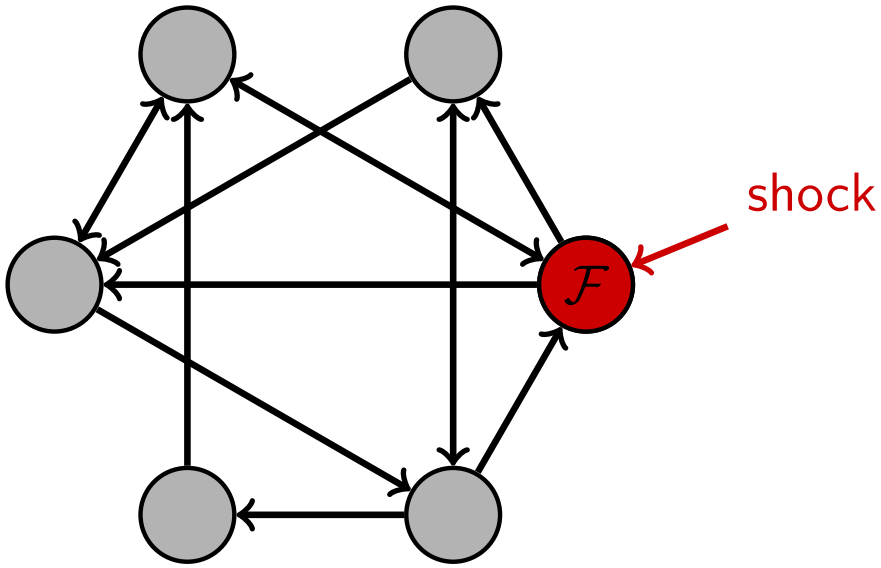

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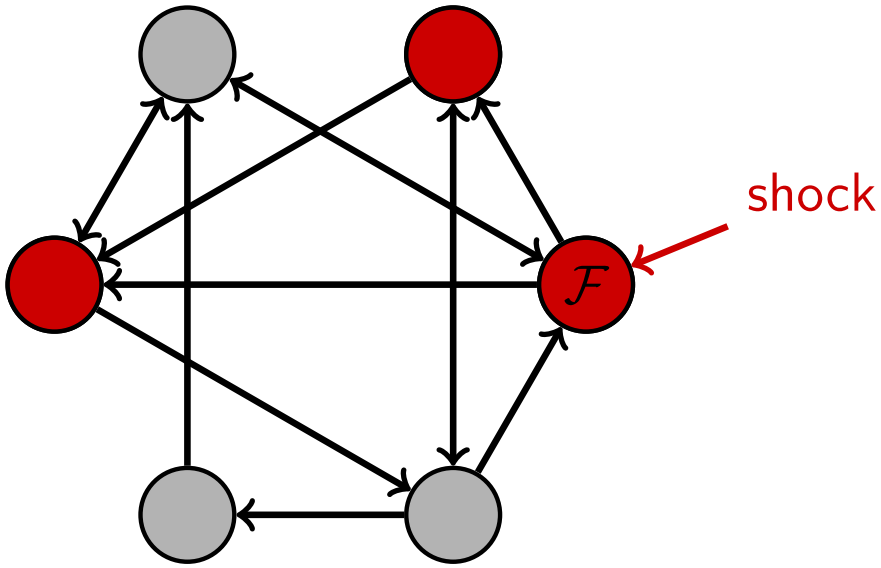

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- Shock propagates through network, leading to contagious defaults $\mathcal{C}$.

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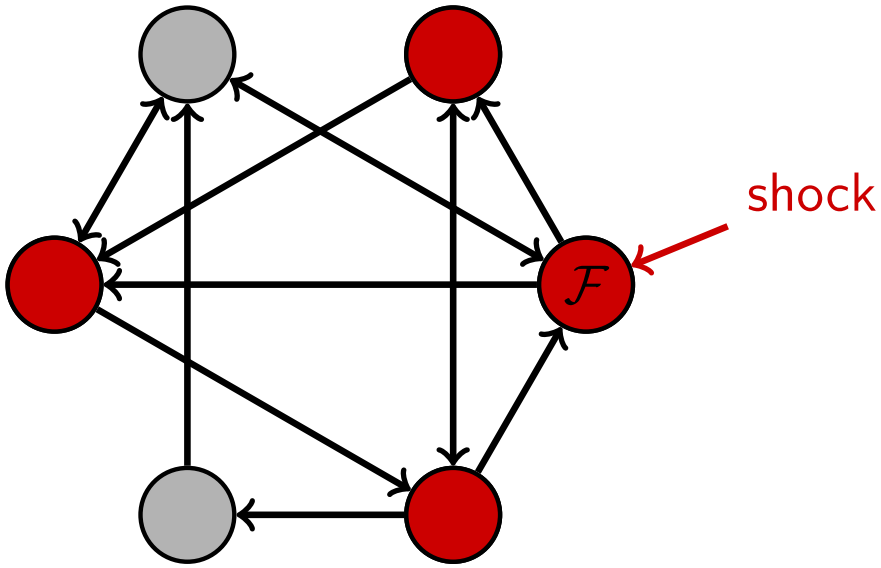

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Research Questions

- Is it possible to stop contagion by rescuing the set $\mathcal{F}$ of fundamentally defaulting banks?
- How should a subsidized bailout be structured so that banks do not walk away from it?
- Why is a subsidized bailout possible in some cases and not in others?
- What policies should a regulator put in place on interbank contracts to make a subsidized bailout possible?

Proposed Framework

- Investigate the role of a benevolent social planner when banks in the network are reactive
- The social planner's goal is to minimize welfare losses associated with defaults through provision of liquidity
- Banks can decide whether or not to participate in a rescue consortium coordinated by the social planner
  - (i) Bail-in
  - (ii) Subsidized bail-in
  - (iii) Bailout

Bail-in

- A bailed-in bank reduces its payment to creditors in exchange for equity in the reorganized company
- Alleviates the burden for taxpayers by forcing creditors of distressed banks to intervene
- Example:
  - Long-Term Capital Management: the hedge fund collapsed in the late 1990s. An agreement for a recapitalization plan of $3.6 billion was conducted on September 23, 1998, under the supervision of the Federal Reserve Bank of New York
  - The fourteen largest primary counterparties agreed to participate in the bail-in rescue consortium

Bailout

- The government injects liquidity to help distressed banks servicing their debt
- Mitigates the risk of fire sales losses generated by asset liquidation of defaulting banks
- Taxpayers provided capital to major banks during the great recession to help institutions remain in business (TARP):
  - Banks/Insurance: AIG insurance, Citigroup, and UBS.
  - Government sponsored entities: Fannie Mae, Freddie Mac

The takeaways

Credibility of no-intervention threat

- The credibility of the no-intervention threat is related to the amplification of the shock through the network
- If asset recovery rates are small, bankruptcy costs are high and defaulting banks are heavily interconnected, the shock will be heavily amplified
- Threat is credible if and only if the amplification of the shock is sufficiently small
- A non-credible threat leaves a public bailout as the only rescue option

Sparsely connected networks socially desirable?

- Without intervention, our analysis confirms the findings of [Allen and Gale (2001, JPE), Acemoglu et al. (2015, AER)]
  - Dense connections have a great potential for absorption of small shocks, but may lead to a large amplification of large shocks

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- Intuition:
  - Densely connected networks
    - Shock is spread among many banks
    - Each bank suffers a small loss, and is incentivized to contribute little to a bail-in.
  - Sparsely connected networks
    - Shock is spread among few banks
    - Creditors of defaulting banks suffer large losses and are willing to make higher contributions to a bail-in.

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    - Creditors of defaulting banks suffer large losses and are willing to make higher contributions to a bail-in.
- Key insight: Provided the no-intervention threat is credible, more sparsely connected networks may lead to lower welfare losses even under non-systemic shocks

Model of intervention

Methods of intervention

- In a *bail-in* allocation $b = (b^0, b^1, \ldots, b^n)$, each bank i buys up a part of the debt b^i and the social planner buys b^0.
- Bail-in has to be individually incentive compatible: banks can anticipate a bailout (threat is non-credible), and therefore they would not participate in the rescue consortium
- Social planner can incentivize banks by providing subsidies $(\lambda^1, \ldots, \lambda^n)$.

Stages of the game

The game has the following stages:

1. The social planner proposes a subsidized bail-in (b, λ).
2. Each bank $i \notin \mathcal{F}$ chooses $a^i \in \{0, 1\}$, i.e. whether or not to accept. If everyone accepts, the game ends with the proposed bail-in.

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3. If some set $\mathcal{B}$ of banks reject, social planner has three choices:
   (a) $a^0 = R$: proceed with the rescue, but make up for the contributions of defecting banks, i.e.

$$\widetilde{b}^0 = b^0 + \sum_{i \in \mathcal{B}} b^i.$$

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   (c) $a^0 = N$: abandon the rescue, which leads to cascading defaults.

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Goal: Characterize all subgame perfect equilibria.

Sketch of the outcome

Let w_N, w_P and w_R denote the welfare loss under the social planner's last-stage action $a^0 = \{N, P, R\}$. The social planner wishes to attain

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- $w_R < w_N \leq w_P$: subsidized bail-in possible.
- $w_N < \min\left(w_P, w_R\right)$: no intervention.

Clearing payments

Notation

Assets & liabilities:

- Let $L = (L^1, \ldots, L^n)$ denote banks' total liabilities $L^i = \sum_{j=1}^{N} L^{ji}$.
- Denote by π the relative liability matrix with $\pi^{ij} = \frac{L^{ij}}{L^j} 1_{\{L^j > 0\}}$ so that interbank assets of bank i are equal to $(\pi L)^i = \sum_{j \neq i} \pi^{ij} L^j$.
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- If $\left(L^i - c^i - \sum_j \pi^{ij} L^j\right)^+ > \alpha e^i$, bank i defaults.
- Upon default, bank i recalls its interbank assets and recovers a fraction $\beta \in [0, 1]$.

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This characterizes the set $\mathcal{F}$ of fundamental defaults.

Clearing equilibrium

A *clearing equilibrium* is a pair (ℓ, p) such that

$$\ell^i = \min\left(\frac{1}{\alpha}\left(L^i - c^i - \sum_j \pi^{ij} p^j\right)^+, e^i\right),$$

$$p^i = \begin{cases} L^i & \text{if } c^i + \alpha\ell^i + \sum_j \pi^{ij} p^j \geq L^i, \\ \left(c^i + \alpha\ell^i + \beta \sum_j \pi^{ij} p^j\right)^+ & \text{otherwise.} \end{cases}$$

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The value of bank i's equity in a clearing equilibrium (ℓ, p) equals

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The welfare losses are

$$w(\ell, p) = (1-\alpha)\sum_{i=1}^n \ell^i + (1-\beta)\sum_{i \in \mathcal{F} \cup \mathcal{C}} (\pi p)^i.$$

Subsidized bail-ins & incentive compatibility

Subsidized bail-ins

A bail-in allocation $b = (b^0, b^1, \ldots, b^n)$ is *feasible* if

- $\sum_{i=0}^{n} b^i \geq B$, where B is the total initial shortfall
- $b^i - \lambda^i \leq V_0^i - (1-\alpha)e^i$, where V_0^i is the value of bank i before liquidation

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A *subsidized bail-in* (b, λ) consists of a feasible bail-in allocation b and a vector of subsidies $\lambda = (\lambda^1, \ldots, \lambda^n)$.

Main result

Theorem

Let ν^i be the largest possible incentive compatible contribution of bank i to a bail-in. Let $K = |\mathcal{S} \cup \mathcal{C}|$ and let $i_1, \ldots, i_K$ be a non-increasing ordering of ν^i.

1. If $w_P < w_N$, the unique SPE outcome is a public bailout.
2. If $w_N \leq w_P$, then the unique SPE outcome is a subsidized bail-in with

$$w^* = \min\left(w_{\{i_1,\ldots,i_m\}}, w_N - \nu^{i_{m+1}}\right),$$

where $m := \min\left(k \mid w_{\{i_1,\ldots,i_k\}} < w_N\right)$.

Credibility of social planner's threat

Absolute Credibility

- Let:
  - B: shortfall, which measures the size of the initial shock
  - ℓ_*: liquidation amount
  - V_0^i: initial equity of bank i
  - V_N^i: equity of bank i under no-intervention

Proposition

The social planner's threat is credible and $w_N \leq w_P$ if and only if

$$\sum_{i=1}^{n}(V_0^i - V_N^i) - B \leq \min(\alpha, 1-\alpha)\sum_{i=1}^{n}\ell_*^i.$$

- The social planner's threat of inaction is credible only if the amplification of the shock is smaller than the unavoidable losses due to inefficient asset liquidation

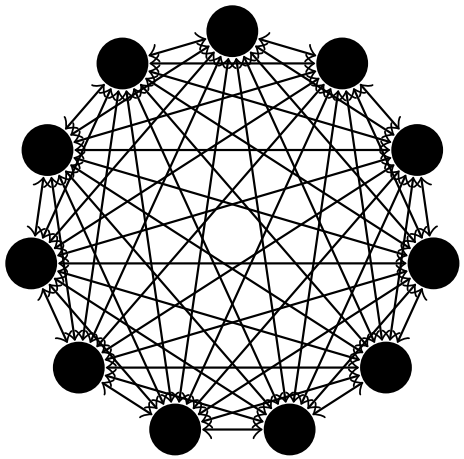
Relative Credibility

Let α^* be the credibility threshold, i.e. the social planner's threat is credible for all $\alpha \geq \alpha^*$.

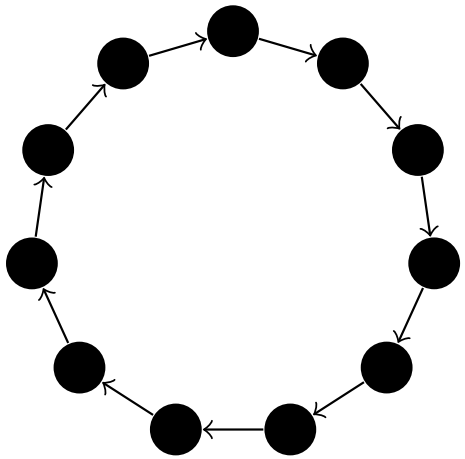
Defintion

1. Fix the initial shortfall B and the recovery rate β on interbanking claims. We say that the social planner's threat is *more credible* in network π_1 than in network π_2 if $\alpha_1^* < \alpha_2^*$.

The Network Topologies



(a) The complete network.



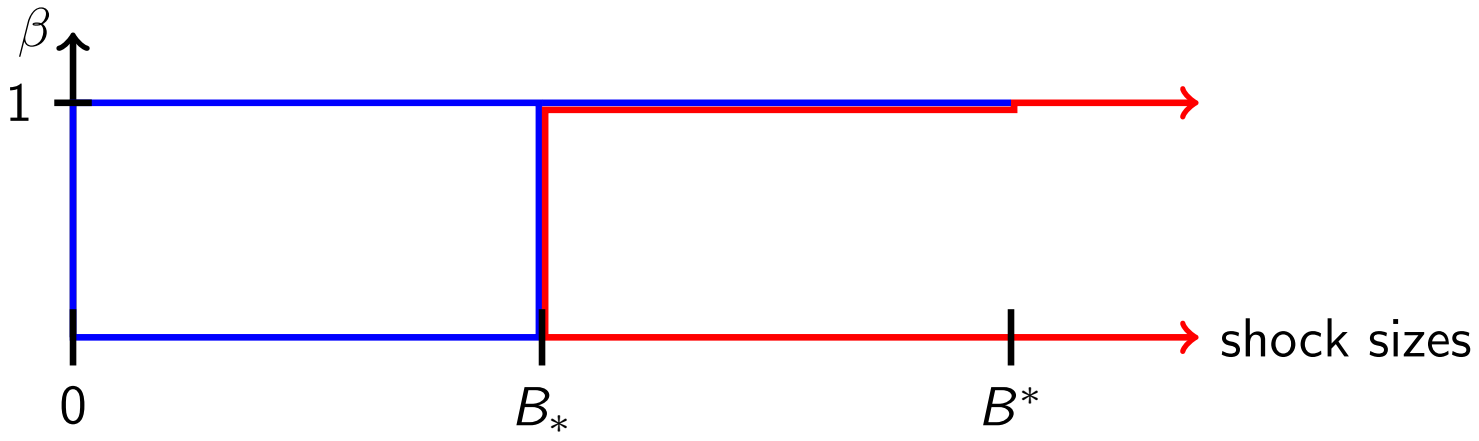
(b) The ring network.

We compare the credibility in the ring network π_R and the complete network π_C in a financial system with $L^i = L$ and $c^i = c$ for every bank i.

A shock hits the financial system such that

- there is 1 fundamentally defaulting bank,
- n_l banks are lowly capitalized with value of outside asset e_l,
- n_h banks are highly capitalized with $e_h > e_l$.

Phase Transition Effect on Bankruptcy Costs



Proposition

1. If $\beta = 1$, there exists L' such that for any $L \geq L'$, the social planner's threat is more credible in the complete network for any $B \in (B_*, B^*]$.
2. If $\beta < 1$, there exists L^* such that for any $L \geq L^*$, the social planner's threat is more credible in the ring network for any $B \in (B_*, B^*]$.

Conclusion

Conclusion

- Tractable framework for the analysis of socially desirable financial network infrastructures
- The credibility of the no-intervention threat of the social planner heavily depends on the network topology
- Without intervention, densely connected networks are more resilient for small shocks, but may amplify large shocks
- With intervention, sparsely connected networks may become socially desirable:
  - Creditors of fundamentally defaulting banks are willing to contribute a much larger amount to rescue insolvent banks

Related literature

- Models of financial networks: Allen and Gale (2001, JPE), Eisenberg and Noe (2001, MS), Greenwald and Stiglitz (2003)
- Impact of bankruptcy costs: Rogers and Veraart (2013, MS), Glasserman and Young (2014, JBF), Duffie and Wang (2017), Battiston et al. (2016, PNAS)
- Network stability, topology, and shocks: Acemoglu, Ozdaglar, and Tahbaz-Salehi (2015, AER), Elliott, Golub, and Jackson (2014, AER)

Literature

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- Daron Acemoglu, Asuman Ozdaglar, and Alireza Tahbaz-Salehi: Systemic risk and financial stability in financial networks, *American Economic Review*, **105** (2015), 564–608
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Greatest clearing equilibrium

Proposition

There exists a lowest and a greatest clearing equilibrium $(\underline{\ell}, \underline{p})$ and $(\widehat{\ell}, \widehat{p})$, respectively, such that for any clearing equilibrium (ℓ, p),

$$V(\underline{\ell}, \underline{p}) \leq V(\ell, p) \leq V(\widehat{\ell}, \widehat{p}), \qquad w(\widehat{\ell}, \widehat{p}) \leq w(\ell, p) \leq w(\underline{\ell}, \underline{p}).$$

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$\Rightarrow$ Everybody agrees on $(\widehat{\ell}, \widehat{p})$.

Amplification of shock

Lemma

Suppose that $I - \beta\pi^{\mathcal{D},\mathcal{D}}$ is invertible. Then, for any set S of banks, we have

$$\zeta^S := \pi^{S,\mathcal{D}}\left(I - \beta\pi^{\mathcal{D},\mathcal{D}}\right)^{-1}\left((1-\alpha)e^{\mathcal{D}} + (1-\beta)A^{\mathcal{D}} - V_0^{\mathcal{D}}\right).$$

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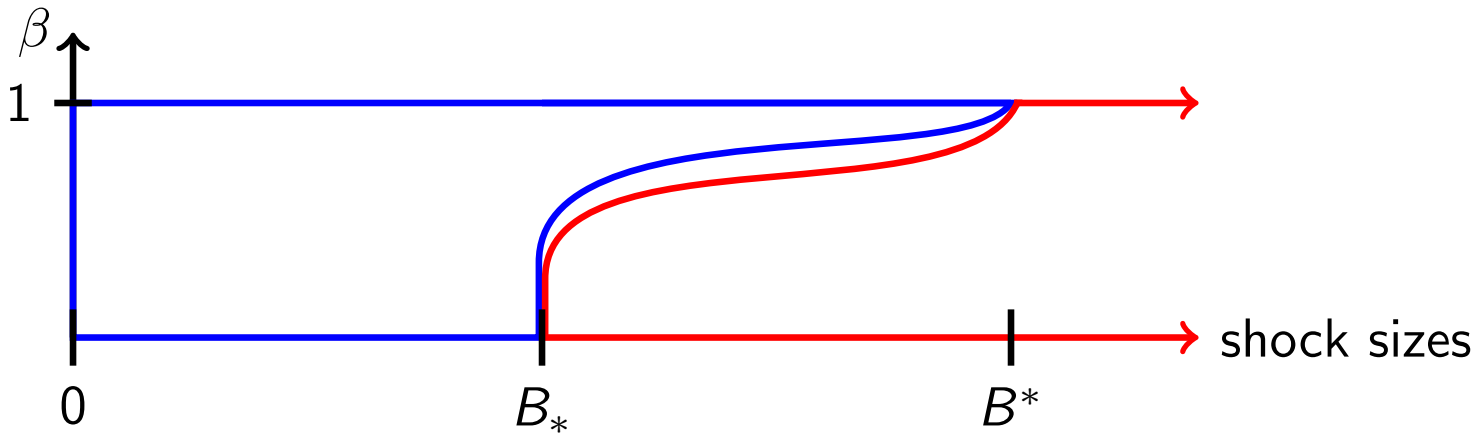
The initial shock B is

1. Increased by the bankruptcy costs $(1-\beta)\left\|A^{\mathcal{D}}\right\|_1$ and is dampened by the available equity $V_0^{\mathcal{D}} - (1-\alpha)e^{\mathcal{D}}$ that banks in $\mathcal{D}$ have.
2. Amplified by the Leontief matrix $(I - \beta\pi^{\mathcal{D},\mathcal{D}})^{-1}$ of the subnetwork of defaulting banks $\pi^{\mathcal{D},\mathcal{D}}$.
3. Dispersed among banks in S according to $\pi^{S,\mathcal{D}}$. A more diversified distribution of liabilities from defaulting to solvent banks reduces deadweight losses caused by inefficient liquidation

Theory vs Evidence

- Financial network was severely undercapitalized at the time when Citigroup collapsed
- Financial network was better capitalized at the time when Long Term Capital Management (LTCM) collapsed
- The amplification of the shock is high in a lowly capitalized network, and low in a highly capitalized network
- The differences in network capitalization may help explain why there was a bailout for Citigroup, while a bail-in was coordinated for LTCM

Phase Transition Effect on Shock Size



Proposition

Suppose that $L \geq \frac{1+\rho}{\beta} B^*$. Then there exist $B'(\beta)$ and $B''(\beta)$ with $B_* \leq B' \leq B'' \leq B^*$ such that

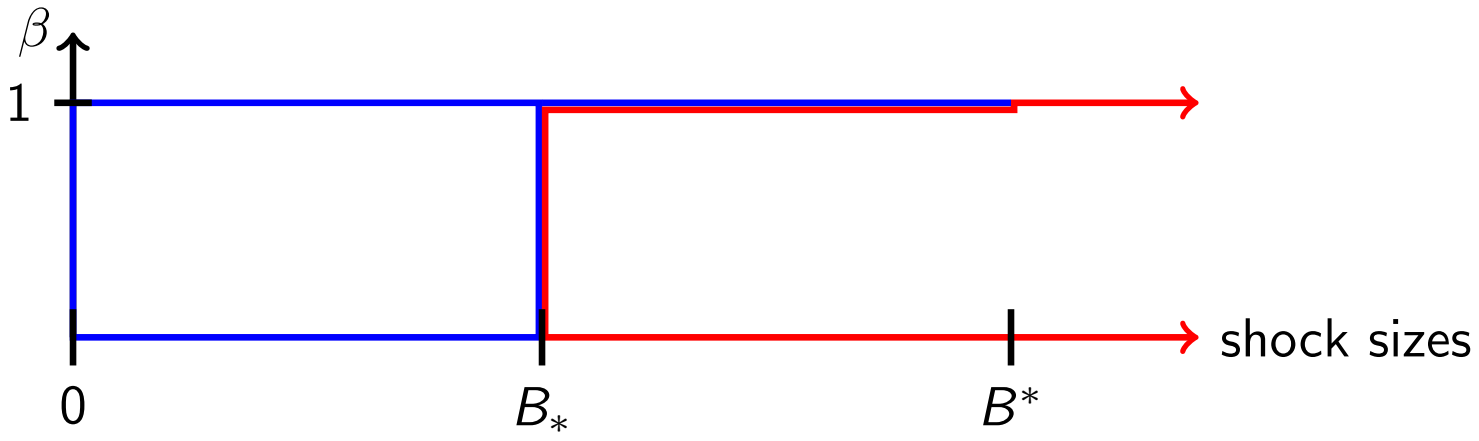
1. The threat is more credible in the complete network for any $B < B'$.
2. The threat is more credible in the ring network for any $B > B''$.
3. $B'(\beta)$ and $B''(\beta)$ are increasing in β with $B'(1) = B''(1) = B^*$.

Payoffs in a rescue

In a subsidized bail-in (b, λ),

- each bank i liquidates $\ell^i(b-\lambda) := \frac{1}{\alpha}(L^i + b^i - \lambda^i - c^i - A^i)^+$,
- the welfare loss equals $w(b) = b^0 + \sum_{i=1}^n \big(\lambda^i + (1-\alpha)\ell^i(b-\lambda)\big)$.

Intermediate shock sizes for large interbank liabilities



Proposition

1. If $\beta = 1$, there exists L' such that for any $L \geq L'$, the social planner's threat is more credible in the complete network for any $B \in (B_*, B^*]$.
2. If $\beta < 1$, there exists L^* such that for any $L \geq L^*$, the social planner's threat is more credible in the ring network for any $B \in (B_*, B^*]$.

Numerical example

Bank	L	c	e
1	1	-1	0.3
$2, \ldots, 6$	1	0	0.1
$7, \ldots, 11$	1	0	0.8

Network	$\lvert\mathcal{D}\rvert$	w_N	w_*
Complete	6	1.01	0.85
Ring	7	0.68	0.65

- Acemoglu et al. (2015, AER) find that, for small shocks, a complete network outperforms a ring network under no-intervention
- Deadweight losses are higher in complete than in ring network, even if a smaller number of defaults occur
- Ring network is socially preferable over complete network if intervention is allowed

Credibility thresholds

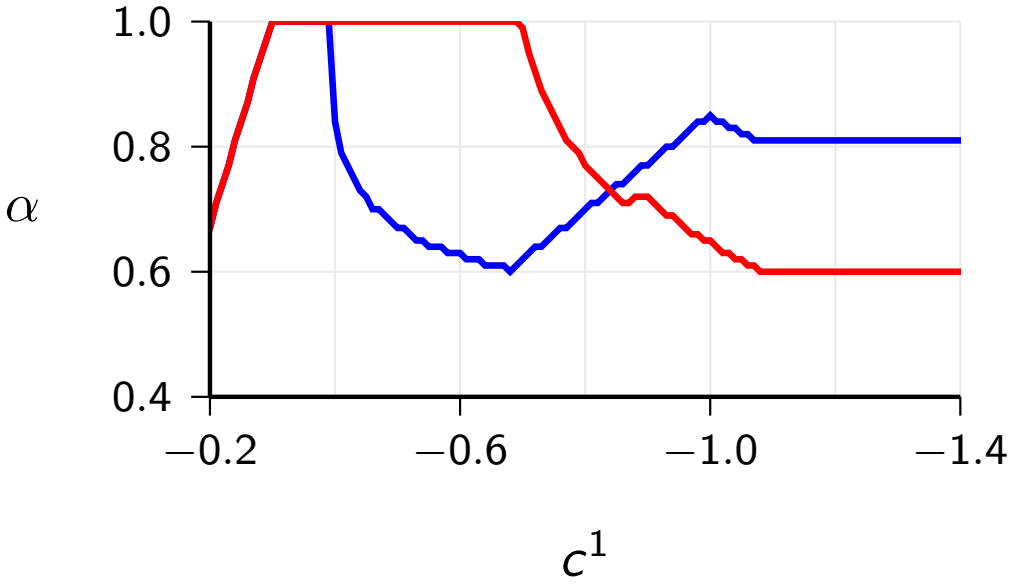


Figure: Red: ring. Blue: complete.

Equilibrium welfare losses

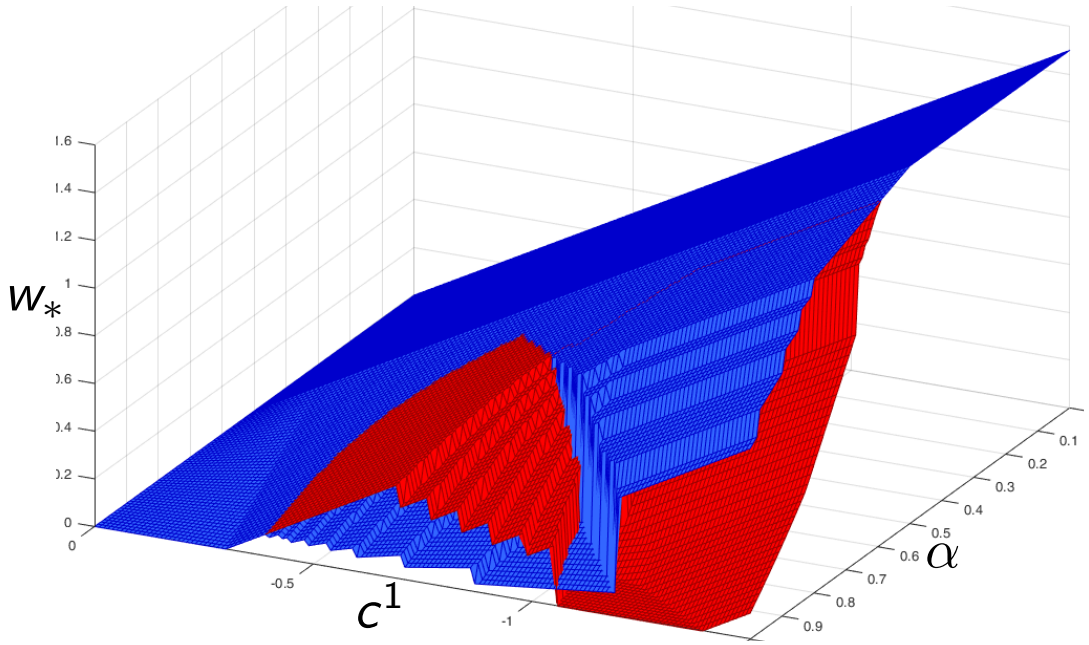


Figure: Red: ring. Blue: complete.

- Steps indicate the contributions of banks to a bail-in.
- Size of contributions are much larger in the ring network.
- For α sufficiently large, a private bail-in can be organized in the ring network, where $w_* = 0$.

When is the no-intervention threat credible?

- Long-Term Capital Management (LTCM):
  - Private bail-in, led by the New York Fed, coordinated to rescue Long-Term Capital Management in September 1998
  - Long-Term Capital Management was an important, yet, idiosyncratic event for the financial system
- Citigroup bailout:
  - US government rescued the largest bank in the world, Citigroup, through a public bailout in November 2008
  - Citigroup's bailout occurred in a period when the financial system was already lowly capitalized due to the many default events
- Amplification of the shock triggered by Citigroup's default likely to be higher than that caused by LTCM's default

Amplification of shock

Lemma

Suppose that $I - \beta\pi^{\mathcal{D},\mathcal{D}}$ is invertible. Then, for any set S of banks, we have

$$\zeta^S := \pi^{S,\mathcal{D}}\left(I - \beta\pi^{\mathcal{D},\mathcal{D}}\right)^{-1}\left((1-\alpha)e^{\mathcal{D}} + (1-\beta)A^{\mathcal{D}} - V_0^{\mathcal{D}}\right).$$

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$\sum_{i\in\mathcal{D}}(1-\alpha)e^i - V_0^i = B - \sum_{i\in\mathcal{C}}\xi^i$. The initial shock B is

1. Amplified by the bankruptcy costs $(1-\beta)\left\|A^{\mathcal{D}}\right\|_1$ and dampened by the available equity $\left\|\xi^{\mathcal{C}}\right\|_1$ of banks in $\mathcal{C}$.
2. Amplified by the Leontief matrix $(I - \beta\pi^{\mathcal{D},\mathcal{D}})^{-1}$ of the subnetwork of defaulting banks $\pi^{\mathcal{D},\mathcal{D}}$.
3. Dispersed among banks in S according to $\pi^{S,\mathcal{D}}$. A more diversified distribution of liabilities from defaulting to solvent banks reduces deadweight losses caused by inefficient liquidation

Sequential equilibrium response

Lemma

Set

- $\ell_*^i := \frac{1}{\alpha}(L^i - c^i - A^i)^+$ the minimal amount bank i needs to liquidate even if fundamentally defaulting banks are rescued
- ξ^i: loss in interbank assets that is absorbed by bank $i \in \mathcal{S} \cup \mathcal{C}$.

Let (b, λ) be a proposed bail-in with equilibrium response a.

- Incredible threat: If $w_P < w_N$, then $a^i = 1$ if and only if either
  (a) $\lambda^i - b^i \geq \alpha \ell_*^i 1_{\{\alpha < 0.5\}}$, or
  (b) $\lambda^i - b^i \geq 0$ and $w_R\big(b, \lambda, (0, a^{-i})\big) \leq w_P$
- Credible threat: If $w_P \geq w_N$, then $a^i = 1$ if and only if either
  (a) $\lambda^i - b^i \geq 0$, or
  (b) $b^i - \lambda^i \leq \xi^i$ and $w_R\big(b, \lambda, (0, a^{-i})\big) \geq w_N$.

- Social planner can anticipate banks' responses and thus only make proposals which will be accepted by all banks

Who does the social planner wants?

- The welfare loss if bank i walks away is

$$w_R\big(b, \lambda, (0, 1^{-i})\big) = w_R(b, \lambda, 1) + b^i - (1-\alpha)\big(\ell^i(b) - \ell^i_*\big),$$

- If the threat is credible and everybody accepts, deadweight losses $w_R(b, \lambda, 1)$ are bounded from below by

$$w_R(b, \lambda, 1) \geq w_N - \min_i \big(b^i - (1-\alpha)\big(\ell^i(b) - \ell^i_*\big)\big).$$

- Social planner includes banks in the bail-in which
  - offer a high contribution to the rescue consortium
  - generate small deadweight losses when they liquidate assets
  - high recovery rate ($\alpha \geq 0.5$): he prefers that banks liquidate their outside assets to buy up a larger amount of debt
  - low recovery rates ($\alpha < 0.5$): he prefers to buy more debt himself so as to avoid the liquidation of banks' outside assets