Bail-ins and Bailouts: Incentives, Connectivity, and Systemic Stability

Benjamin Bernard, **Agostino Capponi**, Joe Stiglitz

NTU, Columbia, Columbia

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Motivation

Interconnectedness and risk

- In an interconnected system, shocks to one unit of system may (are likely to) have effects on others
  - But in some cases, impacts can be spread throughout the system
  - Net effect is limited (approaches zero with sufficient diversification)
- Advocates of global financial integration talk about the advantages of risk sharing
- But in the context of crises, they worried about contagion, the spread of "disease" from one entity to another

  AIG Insurance was bailed out for $85 billion one day after Lehman Brothers defaults ($182 billion total). Troubled Asset Relief Program purchased assets in the size of $426 billion.

Is integration always desirable?

- The intuition behind why integration is desirable was based on "convexity"
  - With convex technologies and concave utility functions, risk sharing is always beneficial
  - If technologies are not convex, then risk sharing can lower expected utility
  - Plenty of non-convexities in the real world
    - Bankruptcy costs (**this paper**)
      Filing of Lehman Brothers wiped out $46 billion of its market value
    - Information (Radner-Stiglitz, Arnott-Stiglitz)
- Quarantines contain the spread of contagious diseases

Transmission of shocks

- Even without *direct* financial market interlinkages, there can be extensive interdependencies through which a shock in one part of the system can be transmitted to others.
  - Liquidity crises are associated with forced sales of assets, leading to price declines

    Bernanke estimated that Bear Stearns' rescue prevented a potential fire sale of nearly $210 billion of Bear Stearns' assets

- Financial linkages, while they may enhance risk sharing, may increase these adverse effects.

Main focus

- This paper focuses on the implications of interconnectedness on private and public intervention policies
- Without bail-outs
  - Structure and amount of linkages affect systemic risk (Allen and Gale, 2001, Greenwald and Stiglitz, 2003, Acemoglu, Ozdaglar, and Tahbaz Salehi, 2011)
- But there had long been a view that it would be better to have bail-ins
  - Few successes (LTCM)
  - Key question: how to induce banks to participate
    - Banks will be hurt if there is not a bail-out after failures of counterparties
    - But is the threat of government not to bail out credible?
    - Each bank has incentive to free ride on the bail-ins of other banks

Key results

- Show that there may exist an optimal bail-in strategy, which takes into account costs of government funds and losses of banks
- When such a bail-in strategy exists, it is preferable to a bail-out
- Dense networks with intermediate size shocks make the bail-in strategy less credible because systemic risk is increased
  - Reverse the desirability of dense vs. sparse networks for intermediate size shocks
  - Calibration to data from 2018 EBA stress test shows that welfare losses in the sparsest network are lower than in the most dense network by more than 13.96% in the presence of intervention
  - Emphasize key role of government policy as well as the nature of the shocks in assessing desirability of alternative network structures

Main result visualized

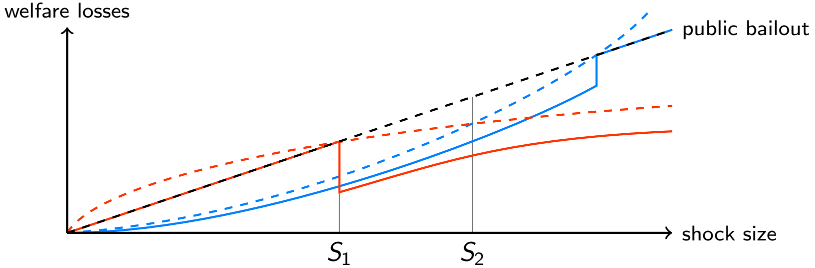


Figure: Welfare losses in a diversified (blue) and a concentrated network (red) in the presence (solid lines) and absence (dashed lines) of intervention.

- When no-intervention losses exceed costs of a public bailout (black dashed line), the government's threat to not intervene is not credible
- If the threat is credible, contributions are larger in the sparse network because free-riding incentives are weaker
- Without intervention or in a model with bailouts only, the diversified network is preferable unless the shock is too large

Methods of Intervention

Bailout: Government provides liquidity through taxpayer money.

Example: Citigroup, AIG Insurance, and UBS, among others.

Bail-in: Creditors voluntarily forgive part of the debt in exchange for equity in the reorganized company.

Example: Long Term Capital Management was bailed-in in 1998. Under the supervision of the Federal Reserve Bank of New York, a total of 14 banks agreed to participate in a recapitalization plan.

Assisted/subsidized bail-in: Contributions from regulator and banks.

Example: Bear Stearns was sold to JP Morgan Chase for $1.2 billion with a government protection of $30 billion.

Model of the Financial Network

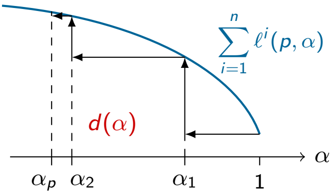
Model Primitives and Asset Liquidation

Balance sheet of bank $i = 1, \ldots, n$ is described by:

- Bilateral exposures L^{ji}, denoting i's liability to j.
- Financial commitments w^i by bank i with higher seniority than interbank liabilities (depositors' claims, wages, operating expenses).
- Bank i's cash holdings c^i.
- Bank i's investments of size e^i in projects/assets.

Each bank i can liquidate $\ell^i \in [0, e^i]$ to recover $\alpha\ell^i$ in cash, where

$$\alpha = d^{-1}(\ell) = \exp\left(-\gamma \sum_{i=1}^{n} \ell^i\right)$$



Network Structure and Bankruptcy Losses

Network topology captured by relative liability matrix

$$\pi^{ji} = \frac{L^{ji}}{L^i},$$

where $L^i = \sum_j L^{ji}$ are bank i's total liabilities.

A *clearing payment vector* $p = (p^1, \ldots, p^n)$ is a solution to

$$p^i = \begin{cases} L^i & \text{if } c^i + \alpha_p \ell_p^i + \sum_j \pi^{ij} p^j \geq L^i + w^i, \\ \left(\beta(c^i + \alpha_p \ell_p^i + \sum_j \pi^{ij} p^j) - w^i\right)^+ & \text{otherwise.} \end{cases} \quad (1)$$

For clearing payment vector p, we call (p, ℓ_p, α_p) a *clearing equilibrium*.

No-Intervention Outcome

Given (p, α), welfare losses are equal to

$$W(p, \alpha) = (1-\alpha)\sum_{i=1}^{n} e^i + (1-\beta)\sum_{i \in \mathcal{D}(p)} \left(c^i + \alpha e^i + \sum_{j=1}^{n} \pi^{ij} p^j \right),$$

where $\mathcal{D}(p) := \{ i \mid p^i < L^i \}$

Lemma

For any financial system $(L, \pi, e, c, w, \gamma, \beta)$, there exists a clearing equilibrium $(\bar{p}, \bar{\alpha}, \bar{\ell})$ that Pareto-dominates all other clearing equilibria.

Endogenous Intervention

Bail-ins and Bailouts

An assisted bail-in (b, s) consists of:

- Contribution $b^i \geq 0$ by every bank i,
- Subsidy $s^i \geq 0$ to bank i,
- Government's contribution is $\sum_i (s^i - b^i) \geq 0$.

Note: Includes bailouts and privately backed bail-ins as special cases.

After transfers:

- Liabilities are cleared with clearing equilibrium $\big(\bar{p}(b,s), \bar{\ell}(b,s), \bar{\alpha}(b,s)\big)$ of the financial system $(L, \pi, e, c+s, w+b, \gamma, \beta)$.
- Welfare losses are equal to

$$W_\lambda(b,s) := W\big(\bar{p}(b,s), \bar{\alpha}(b,s)\big) + \lambda \sum_{i=1}^{n} (s^i - b^i).$$

Strategic Intervention

Negotiation as a 3-stage process:

1. Regulator proposes an assisted bail-in (b, s).
2. Each bank i with $b^i > 0$ chooses $a^i \in \{0, 1\}$, indicating whether or not it agrees to participate.
3. Regulator chooses $r \in \{\text{bail-in, bailout, no intervention}\}$.

Goal: Characterize subgame Pareto efficient equilibia.

- Regulator moves last: lack of commitment power.
- For talk: restrict attention to complete rescues.

Credibility of No-Intervention Threat

Given proposal (b, s) and response a, regulator chooses between:

- *"bail-in"*: welfare losses $W_\lambda(ab, s)$.
- *"bailout"*: welfare losses W_P in an optimal bailout.
- *"no intervention"*: welfare losses $W_N = W_\lambda(0, 0)$.

Lack of commitment power:

- No-intervention threat is credible if and only if $W_N \leq W_P$.
- Banks are willing to participate only if the threat is credible.

Incentives & Equilibrium Bail-In

Equilibrium Response by Banks

Lemma

Let (b, s) be a bail-in proposal. In an equilibrium a, bank i with $b^i > 0$ accepts if and only if:

1. The no-intervention threat is credible,
2. $b^i - s^i \leq \sum_j \pi^{ij}(L^j - p_N^j) + \left(\bar{\alpha}(b, s, a) - \alpha_N\right)e^i$,
3. $W_\lambda(b, s, (0, a^{-i})) \geq W_N$.

Bank i is willing to contribute only if

- Its net contribution is smaller that its exposure to default cascade
- There is no bail-in coordinated without bank i (**no free-riding**)

Equilibrium Intervention

Let $\eta(\alpha(\ell), \ell)$ be the vector of largest incentive-compatible contributions for a given liquidation decision ℓ.

Theorem

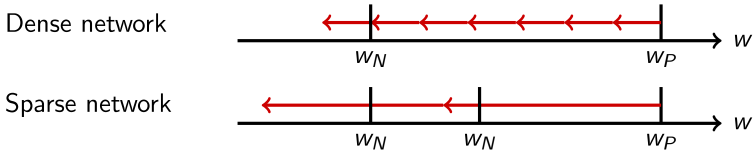
For any ℓ, let $i_1(\ell), i_2(\ell), \dots$ be a decreasing order of banks according to $\eta^i(\alpha(\ell), \ell)$. Let $\mathcal{C}(\ell) = \{i_1(\ell), \dots, i_{m(\ell)}(\ell)\}$, where $m(\ell)$ is smallest k with

$$W_P - g(\alpha_P) + g(\alpha(\ell)) - \lambda \sum_{j=1}^{k} \eta^{i_j(\ell)}(\alpha(\ell), 0) < W_N.$$

1. If $W_P < W_N$, the unique SPE equilibrium is a public bailout.
2. If $W_N \leq W_P$, there exists a set of liquidation decisions $\mathcal{L}_*$ such that in any SPE equilibrium, an assisted bail-in with $b^i = \eta^i(\alpha(\ell), \ell)$ for $i \in \mathcal{C}(\ell)$ and some $\ell \in \mathcal{L}_*$ is proposed and accepted by all banks.

- Clearing equilibrium (payments and liquidation value) and welfare losses are unique.

Size of Incentive-Compatible Contributions



Welfare losses of optimal bail-in are of the form

$$W_E^* \approx W_P - \sum_{i \in \mathcal{C}} \eta^i(\alpha_*, 0).$$

- Contributions are larger in sparser networks.
- Fewer banks can be included in bail-in due to free-riding condition.

Credibility of the Regulator's Threat

Amplification of the Shock

Lemma

Let $S_0 = \sum s_0^i$ be the aggregate shortfall of banks after the shock, and S_N the aggregate losses to all creditors after liabilities are cleared. The threat is credible if and only if

$$S_N - S_0 \leq \lambda S_0 + \sum_{i=1}^{n} (e^i - s_0^i) + g(\alpha_P),$$

where g is convex and trades-off taxpayer contributions with liquidation losses

- Larger weight λ to tax-dollars improves credibility of threat
- Enough illiquid assets to absorb the shock S_0 improves credibility
- Large shocks and dense interconnections reduce credibility

Throughput

- Total throughput of a bank i measures exposure of solvent junior creditors and senior creditors to a shock hitting i.
- Let $\mathcal{C}_N \subseteq \mathcal{D}_N$ denote the set of defaulting banks which repay their senior creditors in full. The *throughput* of a bank $i \in \mathcal{C}_N$ to a set of banks $\mathcal{S}$ is

$$\theta^i_{\mathcal{S}}(\beta,\pi) := \sum_{j \in \mathcal{S} \setminus \mathcal{D}_N} \pi^{\{j\}\mathcal{C}_N} \left(I - \beta \pi^{\mathcal{C}_N,\mathcal{C}_N}\right)^{-1} \rho_i^{\mathcal{C}_N} + \beta \sum_{j \in \mathcal{S} \cap \mathcal{D}_N \setminus \mathcal{C}_N} \pi^{\{j\}\mathcal{C}_N} \left(I - \beta \pi^{\mathcal{C}_N,\mathcal{C}_N}\right)^{-1} \rho_i^{\mathcal{C}_N} ,$$

  where $\rho_i^{\mathcal{C}_N}$ is a vector with entry 1 for bank i and 0 otherwise
- The *total throughput* of bank $i \in \mathcal{C}_N$ is then defined as $\theta^i(\beta,\pi) := \theta^i_{\{1,\dots,N\}}(\beta,\pi)$.

Total Throughput vs Network Structure

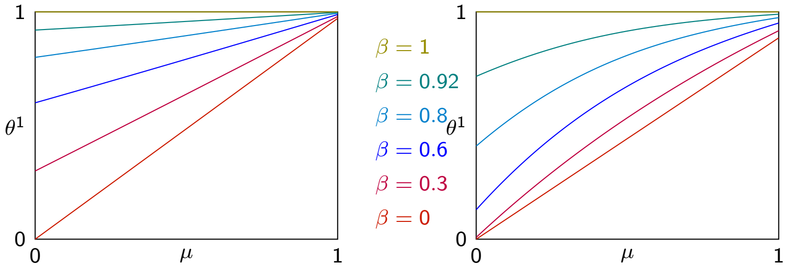


Figure: Let π_c and π_r denote the the complete and ring interbank networks, respectively. Let $\pi_\mu := \mu\pi_c + (1-\mu)\pi_r$. Left chart: total throughput $\theta^1(\beta, \pi_\mu)$ when $\mathcal{C}_N = \mathcal{D}_N = \{1, 2\}$. Right panel: total throughput $\theta^1(\beta, \pi_\mu)$ when $\mathcal{C}_N = \mathcal{D}_N = \{1, 2, 3, 4, 5\}$.

Credibility and Throughput

- We identify the *total throughput* as a sufficient statistic for the credibility $W_P - W_N$ of no-intervention threat

Lemma

Conditional on

(i) *The banks' levels of solvency under no-intervention (the sets $\mathcal{D}_N$, $\mathcal{C}_N$, and $\mathcal{I}_N$, where $\mathcal{I}_N$ is the set of illiquid but solvent banks),*

(ii) *The total value of banks' claims on solvent banks,*

$W_P - W_N$ depends on π only through $\sum_{i \in \mathcal{C}_N} \theta^i_{\mathcal{I}_N}(\beta, \pi)$ and $\sum_{i \in \mathcal{C}_N} \theta^i(\beta, \pi)$. Moreover, the total throughput of any bank is non-decreasing in β and takes values in $[0, 1]$.

Comparison Between Networks

	π_2 not credible	π_2 credible
π_1 not credible	equal	lower in π_2
π_1 credible	lower in π_1	

Lemma

Consider two financial networks (L, π_1, e, c, w) and (L, π_2, e, c, w). If the threat is credible in π_1 but not in π_2, then equilibrium welfare losses are lower in π_1 than in π_2.

Network Calibration and Welfare Comparison

- Analytical comparison not possible if threat is credible in both networks
- Analyze dependence of equilibrium welfare losses on network structure using data from 2018 EBA stress test
- Fit a sparse and a dense network π_s and π_d, respectively, to data
- Analyze welfare losses as a function of $\pi_\mu := \mu\pi_s + (1-\mu)\pi_d$ for $\mu \in [0, 1]$
- Shock to assets of HSBC, Barclays, and Deutsche Bank by an amount equal to their cash holdings
- No contagious defaults in the most dense network

Welfare Losses and Banks' Contributions

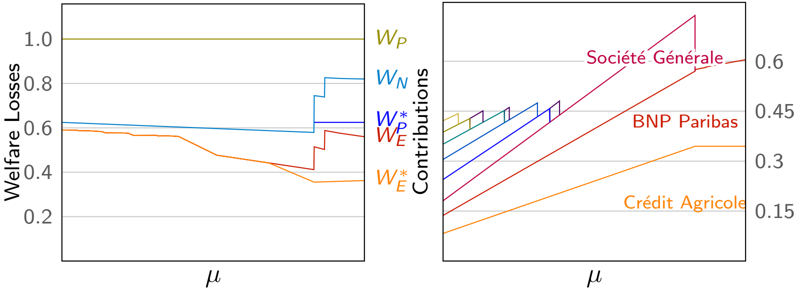


Figure: Welfare losses and welfare impacts of banks' contributions are shown relative to the welfare losses W_P in the complete bailout. Contributions of banks are shown cumulatively so that the contributed amount of a single bank corresponds to the distance between two consecutive lines.

- Equilibrium welfare losses in the sparsest network are 5.2% **lower** than in the most dense networks
- Without intervention, they would be 31.2% **larger**.

Policy Implications

Sparse connections may reduce equilibrium welfare losses:

- The threat is credible for a larger range of shock sizes.
- Bail-in contributions by banks are larger.

Policy implications:

- Sparsely connected networks may be socially preferable
  - Limiting exposures towards individual counterparties may lead to networks which are too diversified.
- Tax on interconnectedness to prevent banks from diversifying their exposures beyond a certain limit.

Conclusion

Conclusion

Network model for financial intervention, where:

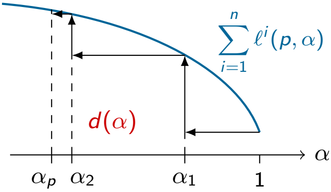
- There are two channels of contagion: counterparty and price-mediated contagion.
- The structure of intervention plan arises endogeneously as the result of strategic interactions between regulator and banks

Equilibrium intervention plan:

- Depends fundamentally on credibility of regulator's threat.
- Credibility depends on network structure only through total throughput of defaulting banks
- Sparse connections are conducive to a bail-in:
  - Reduced incentives for free-riding lead to larger contributions by banks.
  - For low recovery rates or large shocks: credibility is enhanced.

Thank you!

Price-Mediated Contagion



Given (p, α), bank i liquidates

$$\ell^i(p,\alpha) = \min\left(\frac{1}{\alpha}\left(L^i + w^i - c^i - \textstyle\sum_j \pi^{ij} p^j\right)^+,\ e^i\right). \tag{2}$$

Lemma

For any interbank repayments p, there exists (α_p, ℓ_p) satisfying (1) and $\alpha = d^{-1}(\ell)$ simultaneously such that $\alpha \leq \alpha_p$ for any other solution (α, ℓ).

Complete Bailouts

In a complete bailout:

- Minimal/maximal subsidies are

$$s_L = (L + w - c - \alpha_L \ell_L - \pi L)^+, \qquad s_0 = (L + w - c - \pi L)^+.$$

- s_L and s_0 support clearing equilibria (L, ℓ_L, α_L) and $(L, 0, 1)$, resp.
- In a bailout with subsidies $s_L \leq s \leq s_0$, welfare losses are equal to

$$W_\lambda(s) = \sum_{i=1}^{n} (e^i + \lambda s_0^i) + g(\bar{\alpha}(s)),$$

where $g(\alpha) = \alpha\left(\frac{\lambda}{\gamma} \ln(\alpha) - \sum_{i=1}^n e^i\right)$.

- Regulator is indifferent between bailing and not bailing out the banks at the critical value $\alpha_{\text{ind}} = \exp\left(\frac{\gamma}{\lambda} \sum_{i=1}^n e^i - 1\right)$.
- When α is very small, social losses from fire sales are very large, and a bailout is desirable.

Optimal Bailout

Lemma

The liquidation value in an optimal bailout is $\alpha_P := \max\left(\min\left(\alpha_{\text{ind}}, 1\right), \alpha_L\right)$. Subsidies s are such that $s_L^i \leq s^i \leq s_0^i$ and

$$\sum_{i=1}^{n} s^i = \sum_{i=1}^{n} s_0^i + \frac{\alpha_P \ln(\alpha_P)}{\gamma}.$$

Let W_P denote the resulting welfare losses.

Intuition behind Theorem

- Regulator wants to minimize free-riding incentives. Hence, he includes banks that are most exposed to contagion (for which η is largest).
- However, $\eta(\alpha, \ell)$ depends on which set C of banks that he includes.
- In equilibrium, contributing banks C^* are the most-exposed banks for liquidation value α^* and liquidation decision ℓ, such that contributions by banks in C^* induces liquidation value $\alpha*$ and vector of liquidation ℓ.
- C^* and α^* are generically unique, but ℓ is not (α^* only determines total liquidation, but not distribution of liquidation across banks).

Implications on Equilibrium Welfare

- There is a threshold $\eta(\alpha, 0)$, up to which contributions are incentive-compatible and do not require asset liquidation.
- Up to $\eta(\alpha, 0)$ each dollar contributed by banks reduced required taxpayer contributions by 1$
- Above $\eta(\alpha, 0)$ additional contributions require liquidation and those impact welfare through the trade-off $g(\alpha)$
- Whether liquidation of assets is welfare enhancing depends on liquidity of asset
- Finally, even if liquidation may first-order decrease welfare, it may lead to an overall increase in welfare if it reduces free-riding incentives.

Total Throughput

- Throughput increases as the connectivity of defaulting banks increases.
- In sparsely connected networks, the regulator's threat may not be credible for small shocks, but the credibility improves as the shock grows larger.
- Because the total throughput is small, the systemic threat does not increase much with the size of the shock.
- By contrast, in more diversified network structures, small losses can be well absorbed and the threat not to intervene is credible.
- However, because the total throughput is large, the threat becomes less credible as the shock size increases.

Total Throughput: Intuition

- For a bank $i \in \mathcal{C}_N$, the amplification of losses due to negative feedback loops between defaulting banks is captured through the Leontief matrix $\left(I - \beta\pi^{\mathcal{C}_N,\mathcal{C}_N}\right)^{-1} = \sum_{k=0}^{\infty}\left(\beta\pi^{\mathcal{C}_N,\mathcal{C}_N}\right)^k$
- Term k in the sum corresponds to the propagation of losses through liability chains in $\mathcal{C}_N$ of length k
- After accounting for feedback effects and bankruptcy losses, the exposure of a solvent creditor to a shock on bank i's assets is π^{ji} for a solvent bank j and $\beta\pi^{ji}$ for the senior creditors of a bank $j \in \mathcal{D}_N \setminus \mathcal{C}_N$.

Subgame Pareto Efficient Equilibria (SPEE)

Definition

A strategy profile (b, s, a, r) is *subgame Pareto efficient* if it is subgame perfect and after any proposal (b, s), there is no other continuation equilibrium $(\widetilde{a}, \widetilde{r})$ of the accepting/rejecting subgame that Pareto dominates (a, r) for the contributing (non-fundamentally defaulting) banks and the regulator

- Capture the interactions between the regulator and the contributing banks, aiming at finding a suitable resolution outcome.
- Bail-in of LTCM: Peter Fisher of the FRBNY sat down with representatives of LTCM's creditors to find an appropriate solution

Accepting/Rejecting Subgame

Lemma

For any (b, s), the accepting/rejecting subgame has an equilibrium.

For a given proposal (b, s), a continuation equilibrium a is called

- an *accepting equilibrium* if $r(b, s, a) =$ *"bail-in"*,
- a *rejecting equilibrium* otherwise.

Lemma

All accepting equilibria are subgame Pareto efficient (SPE). Rejecting equilibria are SPE if and only if there exists no accepting equilibrium.