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

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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.
This paper focuses on the implications of interconnectedness on private and public intervention policies.

Without bail-outs:

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 inter-bank 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

\[
p^i = \begin{cases} 
L^i & \text{if } c^i + \alpha_p \ell^i_p + \sum_j \pi^{ij} p^j \geq L^i + w^i, \\
(\beta(c^i + \alpha_p \ell^i_p + \sum_j \pi^{ij} p^j) - w^i)^+ & \text{otherwise}.
\end{cases}
\]  

For clearing payment vector \( p \), we call \( (p, \ell_p, \alpha_p) \) a clearing equilibrium.
Given \((p, \alpha)\), 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 \((\bar{p}(b, s), \bar{\ell}(b, s), \bar{\alpha}(b, s))\) of the financial system \((L, \pi, e, c + s, w + b, \gamma, \beta)\).
- Welfare losses are equal to

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

- Regulator moves last: lack of commitment power.
- For talk: restrict attention to complete rescues.
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. \(b^i - s^i \leq \sum_j \pi^{ij}(L^j - p^j_N) + (\bar{\alpha}(b, s, a) - \alpha_N)e^i\),
3. \(W_\lambda(b, s, (0, a^{-i})) \geq W_N\).

Bank \(i\) is willing to contribute only if

- Its net contribution is smaller than its exposure to default cascade
- There is no bail-in coordinated without bank \(i\) (**no free-riding**)
Let $\eta(\alpha(\ell), \ell)$ be the vector of largest incentive-compatible contributions for a given liquidation decision $\ell$.

**Theorem**

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

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

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 $i \in C(\ell)$ 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

\[ W^*_E \approx W_P - \sum_{i \in C} \eta^i(\alpha_*, 0). \]

- 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
**Lemma**

Let $S_0 = \sum s_i^0$ 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

$$S_N - S_0 \leq \lambda S_0 + \sum_{i=1}^{n} (e^i - s_i^0) + g(\alpha_P),$$

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

- Larger weight $\lambda$ 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.
Total throughput of a bank $i$ measures exposure of solvent junior creditors and senior creditors to a shock hitting $i$.

Let $C_N \subseteq D_N$ denote the set of defaulting banks which repay their senior creditors in full. The *throughput* of a bank $i \in C_N$ to a set of banks $S$ is

$$
\theta^i_S(\beta, \pi) := \sum_{j \in S \setminus D_N} \pi(j)^{C_N}(I - \beta\pi_{C_N,C_N})^{-1} \rho_{i}^{C_N} + \beta \sum_{j \in S \cap D_N \setminus C_N} \pi(j)^{C_N}(I - \beta\pi_{C_N,C_N})^{-1} \rho_{i}^{C_N},
$$

where $\rho_{i}^{C_N}$ is a vector with entry 1 for bank $i$ and 0 otherwise.

The total throughput of bank $i \in C_N$ is then defined as

$$
\theta^i(\beta, \pi) := \theta^i_{\{1, \ldots, N\}}(\beta, \pi).
$$
Figure: Let $\pi_c$ and $\pi_r$ denote 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 $C_N = D_N = \{1, 2\}$. Right panel: total throughput $\theta^1(\beta, \pi_\mu)$ when $C_N = D_N = \{1, 2, 3, 4, 5\}$. 

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 $\pi$ only through $\sum_{i \in \mathcal{C}_N} \theta_i^i (\beta, \pi)$ and $\sum_{i \in \mathcal{C}_N} \theta^i (\beta, \pi)$. Moreover, the total throughput of any bank is non-decreasing in $\beta$ and takes values in $[0, 1]$. 
### Comparison Between Networks

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### Lemma

Consider two financial networks \((L, \pi_1, e, c, w)\) and \((L, \pi_2, e, c, w)\). If the threat is credible in \(\pi_1\) but not in \(\pi_2\), then equilibrium welfare losses are lower in \(\pi_1\) than in \(\pi_2\).
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 \( \pi_s \) and \( \pi_d \), 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 endogenously 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!
Given \((p, \alpha)\), bank \(i\) liquidates

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

(2)

**Lemma**

For any interbank repayments \(p\), there exists \((\alpha_p, \ell_p)\) satisfying (1) and \(\alpha = d^{-1}(\ell)\) simultaneously such that \(\alpha \leq \alpha_p\) for any other solution \((\alpha, \ell)\).
Complete Bailouts

In a complete bailout:

- Minimal/maximal subsidies are
  \[ s_L = (L + w - c - \alpha_L \ell_L - \pi L)^+, \quad s_0 = (L + w - c - \pi L)^+. \]

- \( s_L \) and \( s_0 \) support clearing equilibria \((L, \ell_L, \alpha_L)\) and \((L, 0, 1)\), resp.

- In a bailout with subsidies \( s_L \leq s \leq s_0 \), welfare losses are equal to
  \[ W_\lambda(s) = \sum_{i=1}^{n} (e^i + \lambda s^i_0) + g(\bar{\alpha}(s)), \]
  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 \( \alpha \) is very small, social losses from fire sales are very large, and a bailout is desirable.
Lemma

The liquidation value in an optimal bailout is $\alpha_P := \max(\min(\alpha_{\text{ind}}, 1), \alpha_L)$. Subsidies $s$ are such that $s^i_L \leq s^i \leq s^i_0$ and

$$\sum_{i=1}^{n} s^i = \sum_{i=1}^{n} s^i_0 + \frac{\alpha_P \ln(\alpha_P)}{\gamma}.$$ 

Let $W_P$ denote the resulting welfare losses.
Regulator wants to minimize free-riding incentives. Hence, he includes banks that are most exposed to contagion (for which \( \eta \) 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 \( \alpha^* \) and liquidation decision \( \ell \), such that contributions by banks in \( C^* \) induces liquidation value \( \alpha^* \) and vector of liquidation \( \ell \).

\( C^* \) and \( \alpha^* \) are generically unique, but \( \ell \) is not (\( \alpha^* \) 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.
For a bank $i \in C_N$, the amplification of losses due to negative feedback loops between defaulting banks is captured through the Leontief matrix

$$\left(I - \beta \pi^{C_N,C_N}\right)^{-1} = \sum_{k=0}^{\infty} \left(\beta \pi^{C_N,C_N}\right)^k$$

Term $k$ in the sum corresponds to the propagation of losses through liability chains in $C_N$ 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 $\pi^{ji}$ for a solvent bank $j$ and $\beta \pi^{ji}$ for the senior creditors of a bank $j \in D_N \setminus C_N$. 
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 \((\tilde{a}, \tilde{r})\) 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.
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 \(r(b, s, a) = \text{“bail-in”}\),
- a *rejecting equilibrium* otherwise.

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