Government Intervention and Financial Fragility

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Introduction

➢ Goal: study how government intervention distorts the interbank lending market and the consequences arising from that in terms of financial fragility;

➢ Question:

➢ Does government support create conditions for banks to become more interconnected?
➢ How the government affects the network structure of the interbank lending market?

➢ Object of study: network arising from banks’ interaction and it’s resiliency, or susceptibility to contagion, to liquidity and default shocks.
Related Literature

▶ Financial crises:
  ▶ Diamond and Dybvig (JPE, 83); Shleifer and Vishny (JF, 92); Allen and Gale (EJ, 00), Abreu and Brunnermeier (ECTA, 03); Geanakoplos (NER, 10); Brunnermeier and Pedersen (RFS, 09); Morris and Shin (AER, 98), He and Xiong (RFS, forth); Caballero and Krishnamurthy (JF, 08), Mendoza and Quadra (JME, 10), Mendoza (AER, 10);

▶ Financial networks:
  ▶ Rochet and Tirole (JMCB, 96), Kyotaki and Moore (97), Allen and Gale (JPE, 00), Freixas et al (JMCB, 00), Eisenberg and Noe (MS, 01), Lagunoff and Schreft (JET, 01), Cifuentes et al (JEEA, 05), Nier et al (JEDC, 07), Brusco and Castiglionesi (JF, 07), Caballero and Simsek (11), Zawadowski (11);

▶ Network formation:
  ▶ Leitner (JF, 05), Babus (09), Castiglionesi and Navarro (11), Cohen-Cole et al (11);

▶ Government intervention:
  ▶ Huang and Xu (EER, 99), Gorton and Huang (AER, 04), Schneider and Tornell (RES, 04), Corsetti et al (JME, 06), Morris and Shin (JIE, 06), Acharya and Yorulmazer (JFI, 07), Ennis and Keister (AER, 09), Diamond and Rajan (11), Farhi and Tirole (AER, forth).
Contributions of the Paper

- Framework where government intervention induces different network structures, each with a specific degree of financial fragility, or susceptibility to contagion;
- Consequences of a too-big-to-fail-type of policy addressed using networks;
- Flexibility to analyse different types of shocks, e.g. default and liquidity, within the same model;
- Model can be easily simulated to study the effects on the likelihood of contagion from changes in the key parameters.
Model

- 1-good ($), three-period economy, $t = 0, 1, 2$;
- Economy divided in $N$ regions, $N = \{1, \ldots, N\}$;
- Each region has a representative bank from $B^N = \{B^1, \ldots, B^N\}$, each of them initially endowed with equity $E^i$;
- Any bank has available two types of long-term, positive NPV projects:
  - A **large** project that pays $R^i_l$ and costs $2$;
  - A **small** project that pays $R^i_s$ and costs $1$.
  with the assumption that $2R^i_s < R^i_l$;
- Projects can be partially liquidated before maturity at a discount;
- Banks can borrow long-term from each other;
- Banks can transfer money from one period to another by investing in a short-term asset that pays zero interest rate;
- Each region is populated by a continuum of retail depositors, initially endowed with $1$ and with preferences given by:

\[
U^i (c_1, c_2) = \begin{cases} 
    c_1, & \text{with probability } \omega^i, \\
    c_2, & \text{with probability } 1 - \omega^i
\end{cases}
\]
Banks’ Interaction Process

- At the initial date, banks meet pairwise and at each round of interaction one bank is matched with another one. Assuming that there’s an even number $N$ of banks, at $t = 0$ there will be $N - 1$ rounds of interaction, so that, with four banks,

  Round 1: $(B^1 \leftrightarrow B^2, B^3 \leftrightarrow B^4)$
  Round 2: $(B^1 \leftrightarrow B^3, B^2 \leftrightarrow B^4)$
  Round 3: $(B^1 \leftrightarrow B^4, B^2 \leftrightarrow B^3)$

- At each round of interaction, banks collect $1$ from retail depositors and decide whether to:
  
  (i) Invest the $1$ received in the small project;
  (ii) Borrow $1$ more and invest the total in the large project;
  (iii) Lend $1$ to the other bank.
Network Structure

- With retail depositors having zero opportunity cost, banks pay zero interest rate on any $1 received from them;
- Since small projects have positive NPV and demand only $1 of initial investment, banks are always willing to accept deposits from retailers;
- By lending to another bank, the possibility of investing in the small project is foregone, so that a borrower has to pay an interest rate at least as high as the one the lender would obtain with the small project;
- A sufficiently high return on a large project allows a bank to:
  (i) Borrow at a rate that covers the opportunity cost of the lender;
  (ii) Make a profit higher with the large than with the small project (despite the higher interest rate it has to pay to the lender).
- Examples of networks at the end of the interaction process ($N = 4$):

\[
\begin{align*}
B^1 \rightarrow & B^2 \\
B^4 \rightarrow & B^3 \\
& B^1 \rightarrow B^2 \\
& B^4 \leftarrow B^3 \\
& B^1 \rightarrow B^2 \\
& B^4 \leftarrow B^3
\end{align*}
\]
Maturity Mismatch

- By accepting demand deposits from retailers and investing those in either projects or loans, banks finance long-term investments with short-term funds;

- Banks are assumed to be **wealth constrained**, in the sense that their initial endowment, $E^i$, is not sufficient to meet depositors’ withdrawals at $t = 1$ (recall there’s a fraction $\omega^i$ of them in each region $i \in N$), i.e., $E^i < \omega^i$. A fraction of the investment in the long project (or the loan made), therefore, has to be liquidated before maturity;

- There’s a cost (discount parameter) for the early liquidation of projects (or loans), such that:

  (i) Large projects have discount parameter $\lambda^l$: one unit in a large project paying $R^i_l$ at $t = 2$ is worth $\lambda^l R^i_l$ at $t = 1$;

  (ii) Small projects have discount parameter $\lambda^s$: one unit in a small project paying $R^i_s$ at $t = 2$ is worth $\lambda^s R^i_s$ at $t = 1$.

- Large projects are assumed to be more costly to liquidate early, i.e.,

  \[ 0 < \lambda^l < \lambda^s < 1. \]
Government Intervention

- Government alleviates the costs from the early liquidation of projects;
- With government support, the discount parameter turns to:
  
  (i) For large projects, $\lambda^l + g^l (1 - \lambda^l)$, i.e., one unit in a project paying $R^i_l$ at $t = 2$ is worth $[\lambda^l + g^l (1 - \lambda^l)] R^i_l$ at $t = 1$;
  
  (ii) For small projects, $\lambda^s + g^s (1 - \lambda^s)$, i.e., one unit in a project paying $R^i_s$ at $t = 2$ is worth $[\lambda^s + g^s (1 - \lambda^s)] R^i_s$ at $t = 1$.

- With no government intervention, i.e., $g^l = g^s = 0$, the original discount parameters apply, i.e., $\lambda^s$ and $\lambda^l$ for small and large projects, respectively;

- With full government intervention, i.e., $g^l = g^s = 1$, there’s no cost for banks to liquidate early projects;

- Too-big-to-fail policy: large projects command more support from the government than small projects, i.e., $g^l > g^s$, but overall it’s still more costly to liquidate large than small projects, i.e.,

  $\lambda^s + g^s (1 - \lambda^s) > \lambda^l + g^l (1 - \lambda^l)$. 
Illustration

Figure: Portfolio decision of banks at a particular round of interaction.
Timeline of Events

$\triangleright t = 0$:

1. Banks meet pairwise, giving rise to a network structure after the interaction process. At each round of meetings banks decide:
   (i) Whether or not to form a link (make a loan or borrow);
   (ii) How much to invest in the short-term asset;
   (iii) How much of the long-term asset (project or loan) to liquidate in order to meet early withdrawals.

$\triangleright t = 1$:

1. Banks execute the liquidation strategy;
2. Together with the investment in the short-term asset, proceeds are used to pay early depositors.

$\triangleright t = 2$:

1. Payoffs from long-term assets (projects and loans) are realized, with the fraction not previously liquidated accruing to banks;
2. Banks pay late depositors and clear positions with other banks, consuming the remainings as profits.
Investment in the Small Project

\[
\max(\alpha^i, y^i) \quad \Pi_s^i = \begin{cases}
\text{Small Proj} & (1 - \alpha^i) R_s^i + \alpha^i R_s^i \left[ \lambda^s + g^s (1 - \lambda^s) \right] + \\
\text{Early Liquidation} & y^i \\
\text{Short-term} & - \omega^i - \left(1 - \omega^i\right)
\end{cases}
\]

\[
s.t. \quad 1 + y^i \leq 1 + E^i \quad \text{(BC at } t = 0) \]

\[
y^i + \alpha^i R_s^i \left[ \lambda^s + g^s (1 - \lambda^s) \right] \geq \omega^i \quad \text{(BC at } t = 1) \]

\[
(1 - \alpha^i) R_s^i \geq 1 - \omega^i \quad \text{(BC at } t = 2) \]

\[
\Rightarrow \quad \Pi_s^i = R_s^i - \left\{ (1 - \omega^i) + \frac{\omega^i - E^i}{\lambda^s + g^s (1 - \lambda^s)} \right\}
\]
Investment in the Large Project

$$\max (\alpha^i, y^i, r^i) \quad \Pi^i_l = \frac{\text{Large Proj}}{(1 - \alpha^i) R^i_l + \alpha^i R^i_l \left[ \lambda^l + g^l (1 - \lambda^l) \right]} + \frac{\text{Early Liquidation}}{y^i}$$

$$- \frac{\text{Early Dep}}{\omega^i} - \frac{(1 - \omega^i)}{\text{Late Dep}} - \frac{\text{Lender}}{r^i}$$

s.t.  
$$2 + y^i \leq 2 + E^i \quad \text{(BC at } t = 0)$$

$$y^i + \alpha^i R^i_l \left[ \lambda^l + g^l (1 - \lambda^l) \right] \geq \omega^i \quad \text{(BC at } t = 1)$$

$$\left(1 - \alpha^i\right) R^i_l \geq \left(1 - \omega^i\right) + r^i \quad \text{(BC at } t = 2)$$

$$r^i \geq R^j_s \quad \text{(IR of the Lender)}$$

$$\Rightarrow \quad \Pi^i_l = R^i_l - \left\{ R^j_s + (1 - \omega^i) + \frac{(\omega^i - E^i)}{[\lambda^l + g^l (1 - \lambda^l)]} \right\}$$
Government Intervention and Network Structure

A bank $i \in N$ prefers to invest in the large rather than the small project whenever $\Pi_l^i > \Pi_s^i$, which is equivalent to:

$$R_l^i - \left( R_s^i + R_j^j \right) \frac{(\omega^i - E^i)}{[\lambda^s + g^s (1 - \lambda^s)] [\lambda^l + g^l (1 - \lambda^l)]} \geq \left[ \lambda^s + g^s (1 - \lambda^s) \right] - \left[ \lambda^l + g^l (1 - \lambda^l) \right];$$

With no government intervention, i.e., $g^l = g^s = 0$, this condition becomes:

$$R_l^i - \left( R_s^i + R_j^j \right) \frac{(\omega^i - E^i)}{[\lambda^s \lambda^l]} \geq \frac{\lambda^s - \lambda^l}{\lambda^s \lambda^l};$$

Therefore, if

$$\frac{\lambda^s - \lambda^l}{\lambda^s \lambda^l} > \frac{R_l^i - \left( R_s^i + R_j^j \right) ((\omega^i - E^i))}{[\lambda^s + g^s (1 - \lambda^s)] [\lambda^l + g^l (1 - \lambda^l)]},$$

with government intervention, a bank $i \in N$ that otherwise would prefer to invest in the small project is now better-off borrowing from another bank and investing in the large project;

**Government intervention, therefore, might lead banks to become more connected.**
Too-Big-To-Fail Policy and Network Structure

- The too-big-to-fail policy leads government participation to be higher in large rather than small projects, i.e., $g^l > g^s$;
- With no TBTF policy, the level of government intervention turns to be $g$ for both projects, with $g = g^s$, and the condition for investing in the large rather than the small project becomes

$$\frac{R^i_l - \left(R^i_s + R^j_s\right)}{(\omega^i - E^i)} \geq \frac{[\lambda^s + g^s (1 - \lambda^s)] - [\lambda^l + g^s (1 - \lambda^l)]}{[\lambda^s + g^s (1 - \lambda^s)] [\lambda^l + g^s (1 - \lambda^l)]};$$

- Since

$$\frac{[\lambda^s + g^s (1 - \lambda^s)] - [\lambda^l + g^s (1 - \lambda^l)]}{[\lambda^s + g^s (1 - \lambda^s)] [\lambda^l + g^s (1 - \lambda^l)]} > \frac{[\lambda^s + g^s (1 - \lambda^s)] - [\lambda^l + g^l (1 - \lambda^l)]}{[\lambda^s + g^s (1 - \lambda^s)] [\lambda^l + g^l (1 - \lambda^l)]},$$

the TBTF policy enlarges the set of parameters for which a bank would be better-off investing the in the large project - hence borrowing from another bank - relative to the option of just collecting money from households and investing in the small project;

- The TBTF policy, therefore, make stronger the incentives for banks to become more connected.
Welfare and Optimality of Government Intervention

Measuring **social welfare** by total output, if

\[ R^i_l > R^i_s + R^j_s, \]

i.e., if production with the large project is higher than what would result if banks were to invest separately in small projects, **government intervention is aligned with the maximization of social welfare**;

Otherwise, it wouldn’t be in the interest of the government to offer support but in that case bank \( i \) wouldn’t be interested in the large project anyway, implying that no distortion would be caused by the government absence.
Shocks

- There’s no uncertainty in the model, as banks face no risk regarding:
  1. The fraction of depositors withdrawing early;
  2. The payoff from either type of project;
  3. Debtors repaying their loans.

- Following Allen and Gale (JPE 2000), we consider two perturbations of the network obtained after the interaction process of banks:
  1. Default shock: from the original project’s payoff a bank $i \in I$ was to receive, only a fraction $\epsilon_D^i$ is obtained;
  2. Liquidity shock: in addition to the fraction of early depositors assumed by banks, an extra mass $\epsilon_L^i$ of retailers show up at the bank to withdraw their money.

- By assumption, at the initial date banks assign zero probability to either of these shocks and, upon the occurrence of one of them, the objective is to analyse the continuation equilibrium, i.e.:
  1. How banks adjust their portfolios;
  2. How a shock in one bank spreads to others and the possibility of contagion arising from that.
Default Shock

To focus on the possibility of contagion, we consider the case of bank $i \in N$ who borrowed from a bank $j$ to invest in the large project;

At the final date, bank $i$ realizes that the payoff of the large project is $\epsilon_D^i R_l^i$ rather than $R_l^i$, with $0 < \epsilon_D^i < 1$;

Upon the shock, bank $i$’s profit, $\tilde{\Pi}_l^i$, is given by:

$$
\tilde{\Pi}_l^i = \epsilon_D^i R_l^i - \left\{ R_s^j + \left( 1 - \omega^i \right) + \frac{(\omega - E^i)}{[\lambda^l + g^l (1 - \lambda^l)]} \right\};
$$

If $\tilde{\Pi}_l^i < 0$, i.e., for $\epsilon_D^i$ such that

$$
\epsilon_D^i < \frac{1}{R_l^i} \left\{ R_s^j + \left( 1 - \omega^i \right) + \frac{(\omega - E^i)}{[\lambda^l + g^l (1 - \lambda^l)]} \right\}
$$

bank $i$ is bankrupt, with its assets being liquidated and the proceeds used according to the following rule:

Retail depositors are paid first and whatever remains is distributed pro rata among creditors.
Default Shock and Contagion

- Bank $j$, creditor of bank $i$, who was supposed to be paid $R^i_j$, gets:

$$\tilde{R}^j_s \equiv \max \left\{ \epsilon^i_D R^i_l - (1 - \omega^i) - \frac{(\omega^i - E^i)}{[\lambda^l + g^l (1 - \lambda^l)]}, 0 \right\},$$

so that, if $\tilde{R}^j_s = 0$, i.e.,

$$\epsilon^i_D < \frac{1}{R^i_l} \left\{ (1 - \omega^i) + \frac{(\omega^i - E^i)}{[\lambda^l + g^l (1 - \lambda^l)]} \right\}$$

bank $j$ is automatically bankrupt;

- Otherwise, bank $j$’s profit, $\tilde{\Pi}^j_s$, is given by:

$$\tilde{\Pi}^j_s = \epsilon^i_D R^i_l - (1 - \omega^i) - \frac{(\omega^i - E^i)}{[\lambda^l + g^l (1 - \lambda^l)]} - \left\{ (1 - \omega^i) + \frac{(\omega^i - E^i)}{[\lambda^s + g^s (1 - \lambda^s)]} \right\},$$

- Even getting something, bank $j$ will fail, i.e., $\tilde{\Pi}^j_s < 0$, for $\epsilon^i_D$ such that

$$\epsilon^i_D < \frac{1}{R^i_l} \left\{ (1 - \omega^i) + (1 - \omega^j) + \frac{(\omega^i - E^i)}{[\lambda^l + g^l (1 - \lambda^l)]} + \frac{(\omega^j - E^j)}{[\lambda^s + g^s (1 - \lambda^s)]} \right\}.$$
Hierarchy of Default Shocks

\[ \epsilon _{D}^i < \frac{1}{R_l^i} \left\{ \left( 1 - \omega^i \right) + \left( 1 - \omega^j \right) + \frac{(\omega^i - E^i)}{[\lambda^l + g^l (1 - \lambda^l)]} + \frac{(\omega^j - E^j)}{[\lambda^s + g^s (1 - \lambda^s)]} \right\} \]

\[ \epsilon _{D}^i < \frac{1}{R_l^i} \left\{ R_s^j + (1 - \omega^i) + \frac{(\omega^i - E^i)}{[\lambda^l + g^l (1 - \lambda^l)]} \right\} \]

0 → Both Fail

... → Both Fail

... → Both Fail

... → Bi Fails

... → Both Scape
Default Shock in the Absence of Intervention

► In case of no government intervention \((g^l = g^s = 0)\) and banks being better-off investing in the small project, the profit upon receiving a default shock is

\[
\tilde{\Pi}_s^i = \epsilon_D^i R_s^i - \left[ \left( 1 - \omega_i^i \right) - \frac{\left( \omega_i^i - E_i^i \right)}{\lambda_s^i} \right];
\]

► A bank investing in small project will go bankrupt, \(\tilde{\Pi}_s^i < 0\), if the shock \(\epsilon_D^i\) is such that

\[
\epsilon_D^i < \frac{1}{R_s^i} \left[ \left( 1 - \omega_i^i \right) - \frac{\left( \omega_i^i - E_i^i \right)}{\lambda_s^i} \right];
\]

► Even if equivalent in terms of payoff, the option of lending to a bank (if there’s government support) and investing in the small project (in case there’s not) confer to a bank different degrees of fragility.
Liquidity Shock

- To focus on the possibility of contagion, we consider the case of bank $i \in N$ who borrowed from a bank $j$ to invest in the large project;
- The liquidity shock is such that a fraction $\epsilon^i_L$ of late depositors withdraw early instead so that, at $t = 1$, bank $i$ has to meet a demand for deposits of

$$\tilde{\omega}^i = \omega^i + \left(1 - \omega^i\right) \epsilon^i_L;$$

- There’s no cushion at $t = 1$ that bank $i$ can dispose of in order to meet the extra demand for funds. Instead, it has to liquidate a still higher fraction of its investment in the long-term project. If after that it’s still not able to pay early retailers, it’s declared bankrupt.
Liquidity Shock and Continuation Equilibrium

- Upon the liquidity shock, bank $i$ constraints become:

\[
E^i + \tilde{\alpha}_i R^i_l \left[ \lambda^l + g^l \left(1 - \lambda^l \right) \right] = \omega^i + \left(1 - \omega^i \right) \epsilon^i_L \quad \text{(BC at } t = 1),
\]

\[
\left(1 - \tilde{\alpha}_i \right) R^i_l \geq \left(1 - \omega^i \right) \left(1 - \epsilon^i_L \right) + R^j_s \quad \text{(BC at } t = 2).
\]

- With the updated fraction to be liquidated from the large project, $\tilde{\alpha}_i$, bank $i$ can absorb the liquidity shock, i.e., $\tilde{\Pi}_i \geq 0$, as long as

\[
\epsilon^i_L \leq \frac{\left[ \lambda^l + g^l \left(1 - \lambda^l \right) \right] \left[R^i_l - R^j_s - \left(1 - \omega^i \right) \right] - \left(\omega^i - E^i \right)}{(1 - \omega^i) \left[1 - \left[ \lambda^l + g^l \left(1 - \lambda^l \right) \right] \right]} \equiv \epsilon^i_L.
\]
Liquidity Shock and Contagion

- If bank $i$ is bankrupt, its assets are liquidated and used first to pay retail depositors and then creditors, if there’re any remaining proceeds, i.e., if

$$R_l^i \left[ \lambda^l + g^l \left( 1 - \lambda^l \right) \right] - 1 > 0;$$

- In this case, bank $j$ (creditor), upon receiving a haircut payment from bank $i$ (borrower), turns to have net-worth

$$\tilde{\Pi}_s^j = E^j + R_l^i \left[ \lambda^l + g^l \left( 1 - \lambda^l \right) \right] - 1 - 1,$$

so that, if

$$R_l^i \left[ \lambda^l + g^l \left( 1 - \lambda^l \right) \right] - 1 < 1 - E^j,$$

bank $j$ is bankrupt as well.
Liquidity Shock in the Absence of Intervention

- In case of no government intervention \((g^l = g^s = 0)\) and such that banks are better-off investing in the small project, constraints are:

\[
E^i + \tilde{\alpha}^i R^i_s \lambda^s = \omega^i + \left(1 - \omega^i\right) \epsilon^i_L \quad \text{(BC at } t = 1),
\]

\[
\left(1 - \tilde{\alpha}^i\right) R^i_s \geq \left(1 - \omega^i\right) \left(1 - \epsilon^i_L\right) \quad \text{(BC at } t = 2).
\]

- With the updated fraction to be liquidated from the small project, \(\tilde{\alpha}^i\), bank \(i\) can absorb the liquidity shock, i.e., \(\tilde{\Pi}^i \geq 0\), as long as

\[
\epsilon^i_L \leq \frac{\lambda^s \left[R^i_s - (1 - \omega^i)\right] - (\omega^i - E^i)}{(1 - \omega^i) (1 - \lambda^s)} \equiv \underline{\epsilon}^i_L;
\]

- If \(\epsilon^i_L > \underline{\epsilon}^i_L\), bank \(i\) is bankrupt but, since there’s no linkage (loan) with another bank, there’s no spillover from its demise.
Example I - Intervention and Reduced Fragility

<table>
<thead>
<tr>
<th>Discount</th>
<th>Bank $i$</th>
<th>Bank $j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda^l$</td>
<td>0.05</td>
<td>$R^i_l$</td>
</tr>
<tr>
<td>$\lambda^s$</td>
<td>0.60</td>
<td>$R^i_s$</td>
</tr>
<tr>
<td>$g^l$</td>
<td>0.40</td>
<td>$\omega^i$</td>
</tr>
<tr>
<td>$g^s$</td>
<td>0.30</td>
<td>$E^i$</td>
</tr>
</tbody>
</table>

**Table:** Discount and banks’ parameters.

Network Structure **with** Government Intervention

Network Structure **with no** Government Intervention

**Figure:** Network Structure and Government Intervention.
**Default Shock**

<table>
<thead>
<tr>
<th>Shock Level</th>
<th>Solvency Status $B^i$</th>
<th>Solvency Status $B^j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\epsilon^i_D \in (0.89, 1]$</td>
<td>Solvent</td>
<td>Solvent</td>
</tr>
<tr>
<td>$\epsilon^i_D \in (0.51, 0.89]$</td>
<td>Insolvent</td>
<td>Solvent</td>
</tr>
<tr>
<td>$\epsilon^i_D \in [0, 0.51]$</td>
<td>Insolvent</td>
<td>Insolvent</td>
</tr>
</tbody>
</table>

**Table:** Hierarchy of default shocks *with* intervention.

<table>
<thead>
<tr>
<th>Shock Level</th>
<th>Solvency Status $B^i$</th>
<th>Solvency Status $B^j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\epsilon^i_D \in (0.93, 1]$</td>
<td>Solvent</td>
<td>Solvent</td>
</tr>
<tr>
<td>$\epsilon^i_D \in [0, 0.93]$</td>
<td>Insolvent</td>
<td>Solvent</td>
</tr>
</tbody>
</table>

**Table:** Hierarchy of default shocks *with no* intervention.
### Liquidity Shock

<table>
<thead>
<tr>
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<th>Liquidity Status $B^j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\epsilon_L^i \in [0, 0.55)$</td>
<td>Liquid</td>
<td>Liquid</td>
</tr>
<tr>
<td>$\epsilon_L^i \in [0.55, 1]$</td>
<td>Illiquid</td>
<td>Illiquid</td>
</tr>
</tbody>
</table>

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<table>
<thead>
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<th>Liquidity Status $B^j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\epsilon_L^i \in [0, 0.17)$</td>
<td>Liquid</td>
<td>Liquid</td>
</tr>
<tr>
<td>$\epsilon_L^i \in [0.17, 1]$</td>
<td>Illiquid</td>
<td>Liquid</td>
</tr>
</tbody>
</table>

**Table:** Hierarchy of liquidity shocks **with no** intervention.
CDF of the Number of Failures After Shocks

Figure: CDF of failures, $Y$, after default and liquidity shocks.
Example II - Intervention and Increased Fragility

<table>
<thead>
<tr>
<th>Discount</th>
<th>Bank $i$</th>
<th>Bank $j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda^l$</td>
<td>$R^l_i$</td>
<td>$R^l_j$</td>
</tr>
<tr>
<td>$\lambda^s$</td>
<td>$R^s_i$</td>
<td>$R^s_j$</td>
</tr>
<tr>
<td>$g^l$</td>
<td>$\omega^i$</td>
<td>$\omega^j$</td>
</tr>
<tr>
<td>$g^s$</td>
<td>$E^i$</td>
<td>$E^j$</td>
</tr>
</tbody>
</table>

Table: Discount and banks’ parameters.

Network Structure **with** Government Intervention

Network Structure **with no** Government Intervention

![Network Structure with Government Intervention](image)

Figure: Network Structure and Government Intervention.
Default Shock

<table>
<thead>
<tr>
<th>Shock Level</th>
<th>Solvency Status $B^i$</th>
<th>Solvency Status $B^j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\epsilon_D^i \in (0.89, 1]$</td>
<td>Solvent</td>
<td>Solvent</td>
</tr>
<tr>
<td>$\epsilon_D^i \in (0.49, 0.89]$</td>
<td>Insolvent</td>
<td>Solvent</td>
</tr>
<tr>
<td>$\epsilon_D^i \in [0, 0.49]$</td>
<td>Insolvent</td>
<td>Insolvent</td>
</tr>
</tbody>
</table>

**Table:** Hierarchy of default shocks with intervention.

<table>
<thead>
<tr>
<th>Shock Level</th>
<th>Solvency Status $B^i$</th>
<th>Solvency Status $B^j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\epsilon_D^i \in (0.86, 1]$</td>
<td>Solvent</td>
<td>Solvent</td>
</tr>
<tr>
<td>$\epsilon_D^i \in [0, 0.86]$</td>
<td>Insolvent</td>
<td>Solvent</td>
</tr>
</tbody>
</table>

**Table:** Hierarchy of default shocks with no intervention.
Liquidity Shock

<table>
<thead>
<tr>
<th>Shock Level</th>
<th>Liquidity Status $B^i$</th>
<th>Liquidity Status $B^j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\epsilon^i_L \in [0, 0.59)$</td>
<td>Liquid</td>
<td>Liquid</td>
</tr>
<tr>
<td>$\epsilon^i_L \in [0.59, 1]$</td>
<td>Illiquid</td>
<td>Illiquid</td>
</tr>
</tbody>
</table>

**Table:** Hierarchy of liquidity shocks *with* intervention.

<table>
<thead>
<tr>
<th>Shock Level</th>
<th>Liquidity Status $B^i$</th>
<th>Liquidity Status $B^j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\epsilon^i_L \in [0, 0.85)$</td>
<td>Liquid</td>
<td>Liquid</td>
</tr>
<tr>
<td>$\epsilon^i_L \in [0.85, 1]$</td>
<td>Illiquid</td>
<td>Liquid</td>
</tr>
</tbody>
</table>

**Table:** Hierarchy of liquidity shocks *with no* intervention.
CDF of the Number of Failures After Shocks

Figure: CDF of failures, $Y$, after default and liquidity shocks.
Example III - Intervention and Shock Type-Dependent Fragility

<table>
<thead>
<tr>
<th>Discount</th>
<th>Bank $i$</th>
<th>Bank $j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\lambda^l$</td>
<td>0.25</td>
<td>$R^i_1$</td>
</tr>
<tr>
<td>$\lambda^s$</td>
<td>0.45</td>
<td>$R^i_s$</td>
</tr>
<tr>
<td>$g^l$</td>
<td>0.25</td>
<td>$\omega^i$</td>
</tr>
<tr>
<td>$g^s$</td>
<td>0.10</td>
<td>$E^i$</td>
</tr>
</tbody>
</table>

Table: Discount and banks’ parameters.

Network Structure **with** Government Intervention

Network Structure **with no** Government Intervention

Figure: Network Structure and Government Intervention.
Default Shock

Table: Hierarchy of default shocks \textbf{with} intervention.

<table>
<thead>
<tr>
<th>Shock Level</th>
<th>Solvency Status $B^i$</th>
<th>Solvency Status $B^j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\epsilon^i_D \in (0.94, 1]$</td>
<td>Solvent</td>
<td>Solvent</td>
</tr>
<tr>
<td>$\epsilon^i_D \in (0.57, 0.94]$</td>
<td>Insolvent</td>
<td>Solvent</td>
</tr>
<tr>
<td>$\epsilon^i_D \in [0, 0.57]$</td>
<td>Insolvent</td>
<td>Insolvent</td>
</tr>
</tbody>
</table>

Table: Hierarchy of default shocks \textbf{with no} intervention.

<table>
<thead>
<tr>
<th>Shock Level</th>
<th>Solvency Status $B^i$</th>
<th>Solvency Status $B^j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\epsilon^i_D \in (0.92, 1]$</td>
<td>Solvent</td>
<td>Solvent</td>
</tr>
<tr>
<td>$\epsilon^i_D \in [0, 0.92]$</td>
<td>Insolvent</td>
<td>Solvent</td>
</tr>
</tbody>
</table>
Liquidity Shock

<table>
<thead>
<tr>
<th>Shock Level</th>
<th>Liquidity Status $B^i$</th>
<th>Liquidity Status $B^j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\epsilon_L^i \in [0, 0.25)$</td>
<td>Liquid</td>
<td>Liquid</td>
</tr>
<tr>
<td>$\epsilon_L^i \in [0.25, 1]$</td>
<td>Illiquid</td>
<td>Illiquid</td>
</tr>
</tbody>
</table>

**Table:** Hierarchy of liquidity shocks *with* intervention.

<table>
<thead>
<tr>
<th>Shock Level</th>
<th>Liquidity Status $B^i$</th>
<th>Liquidity Status $B^j$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\epsilon_L^i \in [0, 0.09)$</td>
<td>Liquid</td>
<td>Liquid</td>
</tr>
<tr>
<td>$\epsilon_L^i \in [0.09, 1]$</td>
<td>Illiquid</td>
<td>Liquid</td>
</tr>
</tbody>
</table>

**Table:** Hierarchy of liquidity shocks *with no* intervention.
CDF of the Number of Failures After Shocks

Figure: CDF of failures, $Y$, after default and liquidity shocks.