Optimally Interconnected Banking Systems

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Positive Role for Interconnections

- Critics of the financial system have alleged that banks are *too interconnected to fail*
- Large interconnections imply that adverse shock to a bank is rapidly transmitted to entire system, with severe real consequences
- **Cynical View:** Interconnections have been created to induce govt. bailouts
- **This Paper:** *Renegotiations* between highly inteconnected banks facilitate mutual private sector bailouts to lower need for govt. bailouts

Examples of Renegotiations

- 1998: Consortium of banks renegotiate claims to avoid immediate liquidation of LTCM
- 2007: J.P. Morgan renegotiates claims with Bear Sterns and acquires most of remaining assets
- 2008: In the absence of govt. payouts to AIG, lower payments would have been made on written derivatives to Goldman, Societe Generale etc.

Renegotiated Interbank Loans

- We solve for optimal network of interbank loans and other derivatives for joint objective of incentive (to maintain asset quality) and hedging (lower dead weight costs)

- Optimal contract consists solely of large renegotiated interbank loans. Result robust to alternative bankruptcy and regulatory regimes

- Systemic risk spillovers and likelihood of financial crises is severely mismeasured if renegotiations not considered

OTCDs Versus Interbank Loans
Actual Usage

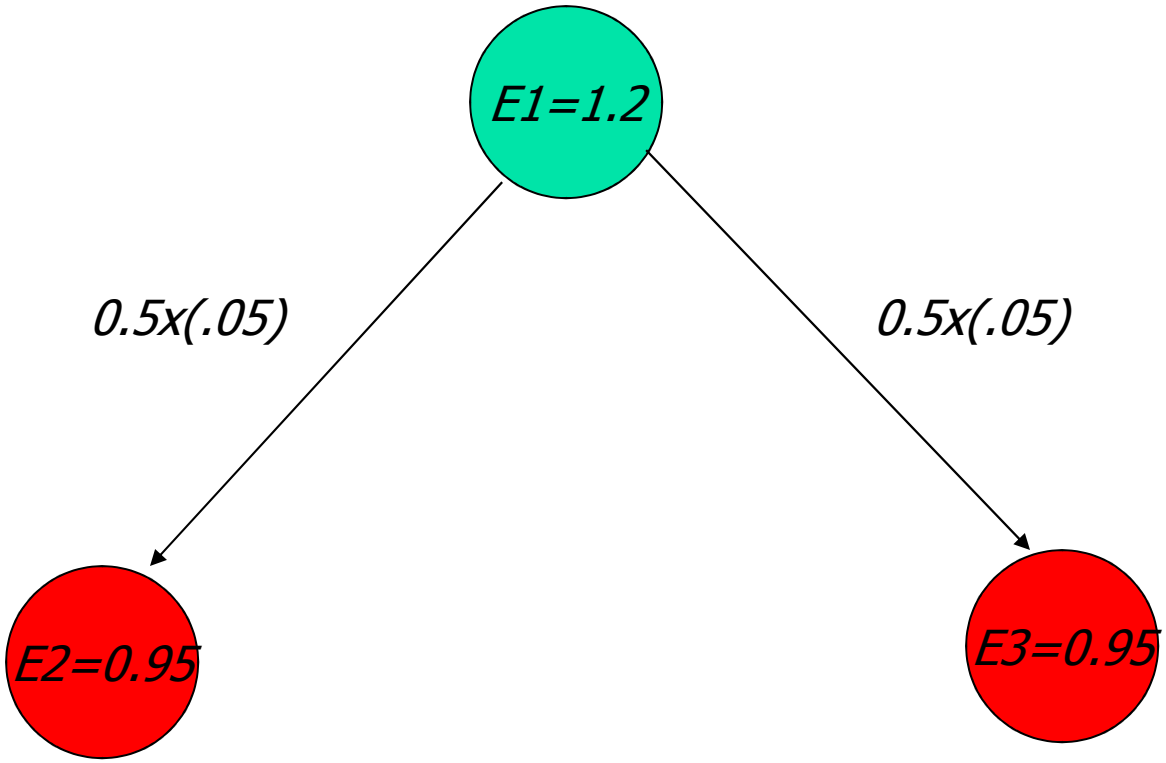
- Across countries, BIS estimates that gross credit exposure from derivatives is less than a third of interbank loans
- Differences across banking systems:

1. For large US banks, the two markets of equivalent size (Federal Reserve Board)
2. For EU countries, interbank exposure substantially larger (European Central Bank)
3. In Canada interbank loan exposure more than 20 times derivatives (Bank of Canada)

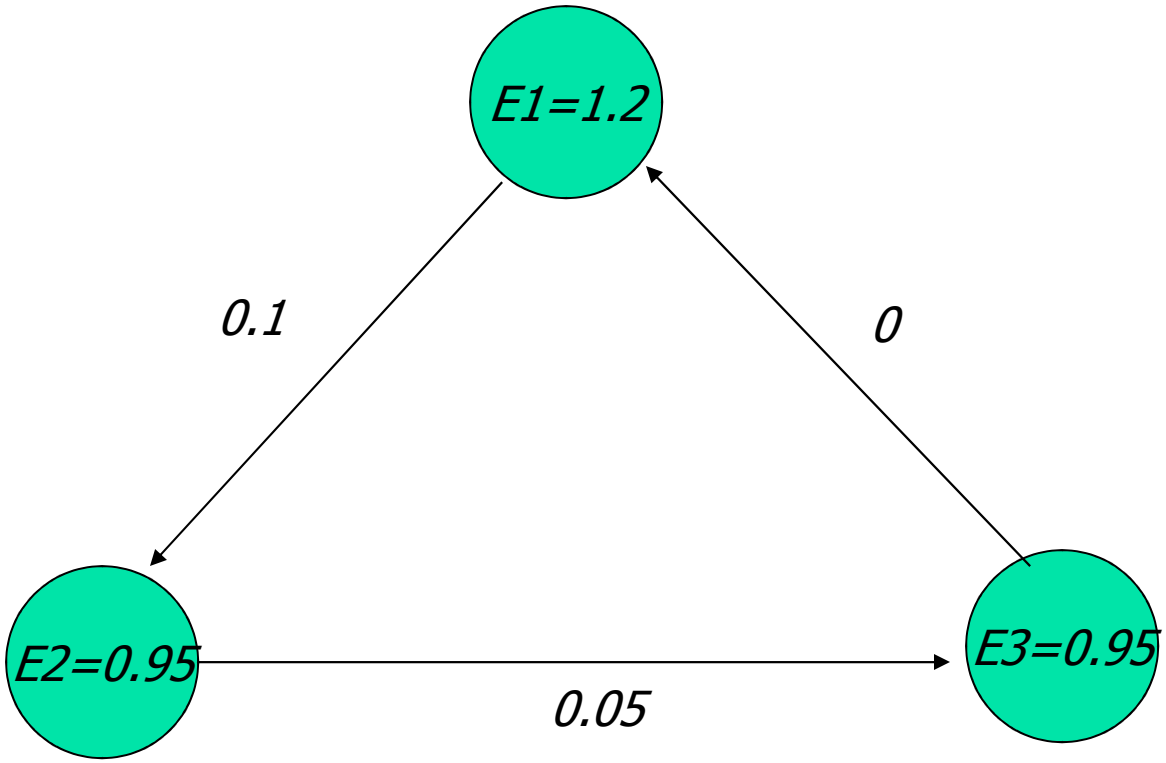
Renegotiations Example 1

- Three banks (1,2,3) in network
  - **Hedging Strategy 1 (CDS)**:
  - Each Bank receives $0.5 \cdot \max(1 - A_i, 0)$ from each other bank
  - **Hedging Strategy 2 (Interbank Loans)**: Each Bank owes 0.25 to each other bank
- In the event of liquidation, liquidation costs are 100%

Ex-Post Settlement with CDS



Ex-Post Settlement with I.Loans



Banks

- N banks in economy. Each bank has asset value

$$\tilde{A}_i = \tilde{B}_i \cdot \tilde{C}_i$$

$$\begin{aligned} B_i &\sim \mathrm{LN}(\mu_0 + \mu_1 h_i - 0.5\,\zeta\,\sigma^2, \zeta\,\sigma^2), \\ C_i &\sim \mathrm{LN}(-0.5\,(1-\zeta)\sigma^2, (1-\zeta)\,\sigma^2) \end{aligned}$$

- The two components are the *hedgeable* and *unhedgeable* components of asset value:

  Derivatives only on hedgeable part

- Mean of asset value depends on costly effort h_i
- Bank has deposits of L_i
- Bank equity: $e_i = A_i - L_i$

Interbank Hedging

Interbank claims junior to deposits

- *Interbank loans*, a, are circular
- *Asset Swaps*: bank i pays bank j $b\tilde{B}_i$ in return for $b\tilde{B}_j$
- *Credit Default Swaps*: bank i pays bank j $c\max(L_j - \tilde{B}_j, 0)$

in return for $c\max(L_i - \tilde{B}_i, 0)$

Netting agreements in place for all hedges

$$d_{ij} = \max(l_{ij} - l_{ji}, 0)$$

Deposit Insurance

- Deposit Insurance Premium:

$$\omega_i = E\left[\mathbf{1}_{\{D_i>0\}} M_n \max[L_i - (1-\Phi)\tilde{A}_i - y_i), 0]\right],$$

- $\mathbf{1}_{\{D_i>0\}}$ if bank i is liquidated. n is the number of banks in economy liquidated
- For large banking systems, an increase in liquidation correlation will increase the deposit insurance premium

The Bankruptcy Mechanism

Clearing Vector:

$$p_i = \min\left[d_i, \max\left(A_i - \Phi A_i \mathbf{1}_{p_i < d_i} + r_i - L_i, 0\right)\right]$$

Equity Holder's Payoff

$$w_i = \max(e_i + (\Pi)' \cdot p - d_i, 0)$$

Bargaining Protocol

- Game starts with nature choosing a bank to become the first proposer who makes take-it-or-leave-it offers to all its counterparties

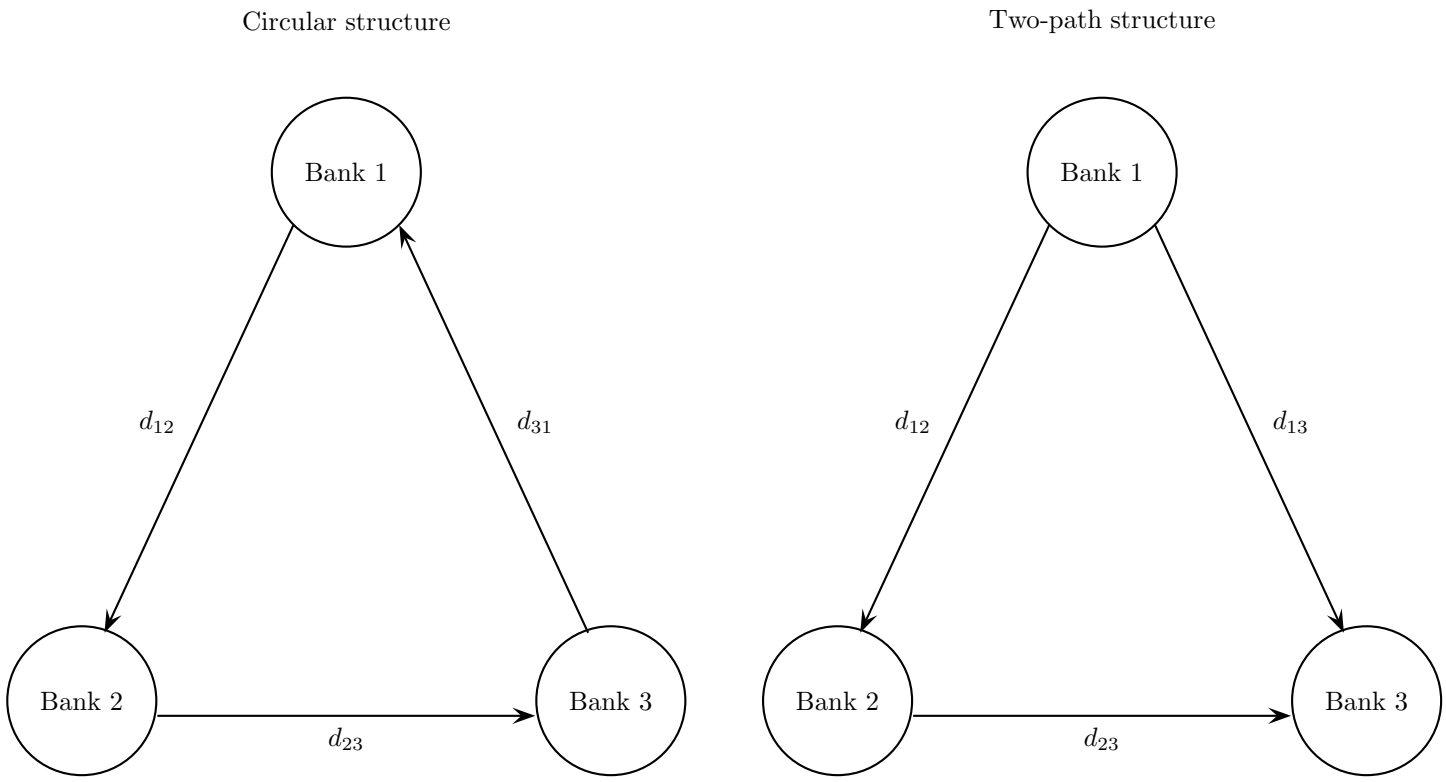
- If offers are accepted, then claims of proposer eliminated and the remaining players bargain over remaining claims

- If offers are rejected by any counterparty the bankruptcy mechanism is imposed

2 Player Bargaining

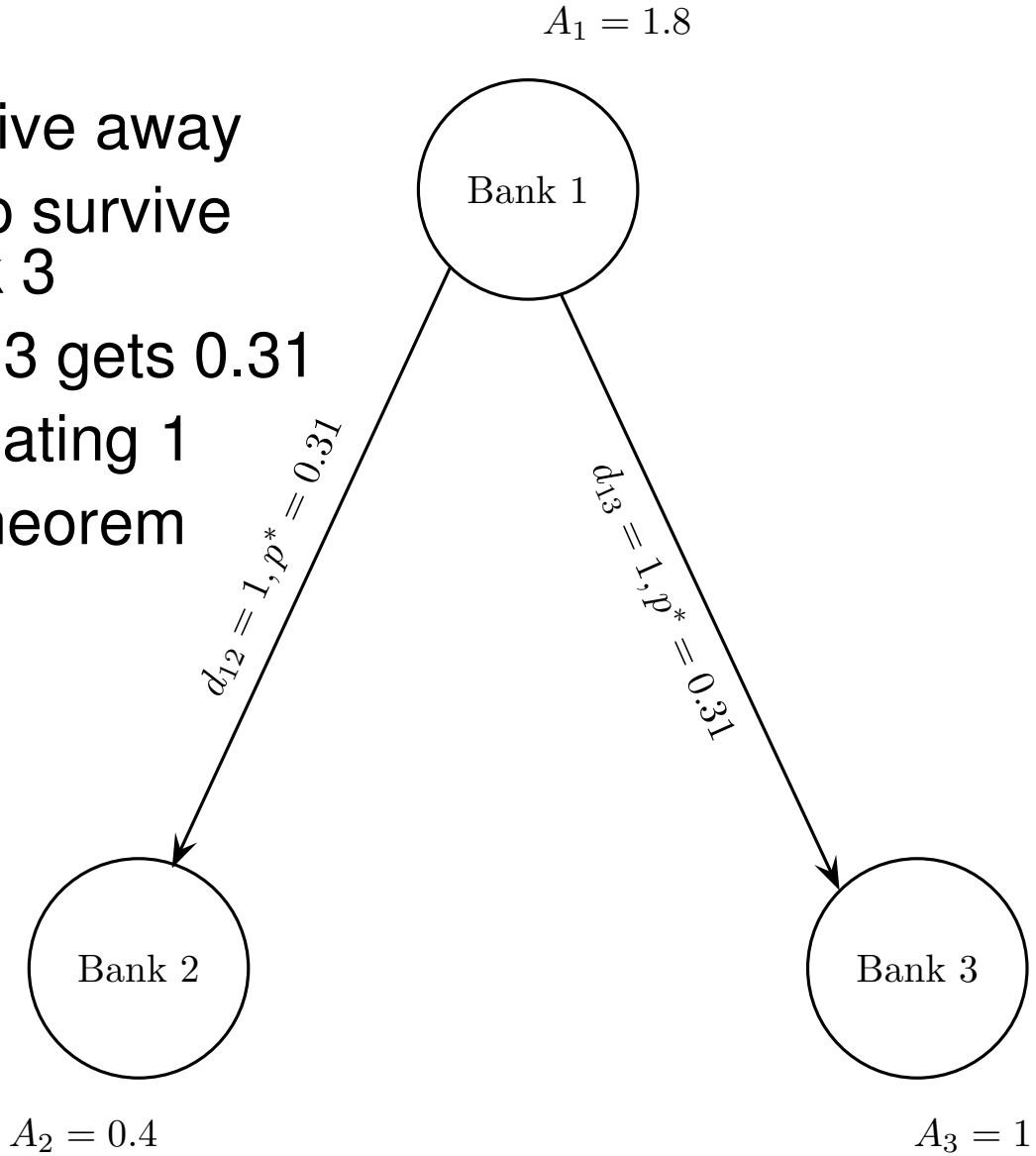
- Efficient liquidation policy for all contracts
- A bank is liquidated
  - full interbank payments insufficient
  - insufficient resources in system
- Coase Theorem holds

Ex-Post Possible Network Structures



Example of Inefficient Bargaining

- Bank 1 has 0.8 to give away
- Bank 2 needs 0.6 to survive leaving 0.2 for bank 3
- In bankruptcy bank 3 gets 0.31
- 3 better off by liquidating 1
- *Failure* of Coase Theorem



Renegotiation Breakdowns

- Renegotiation *successful*
  - all parties agree on a settlement
  - all banks survive
- Otherwise renegotiations *break down*

- *Proposition 2:* In the two-path structure a *necessary* condition for a breakdown
  - at least one bank has negative equity value
  - bankruptcy cost parameter is not too high

- Banks will choose hedging contracts to avoid breakdowns

Inoptimality of Interbank Loans without Renegotiation

- *Proposition 3*: Without renegotiations interbank loans not optimal

- *Intuition:*
  - Inflexible
  - Cannot condition payment on state of bank

- Most existing work on measuring systemic risk use interbank loans and study liquidations without renegotiations

Optimality of Interbank Loans with Renegotiation

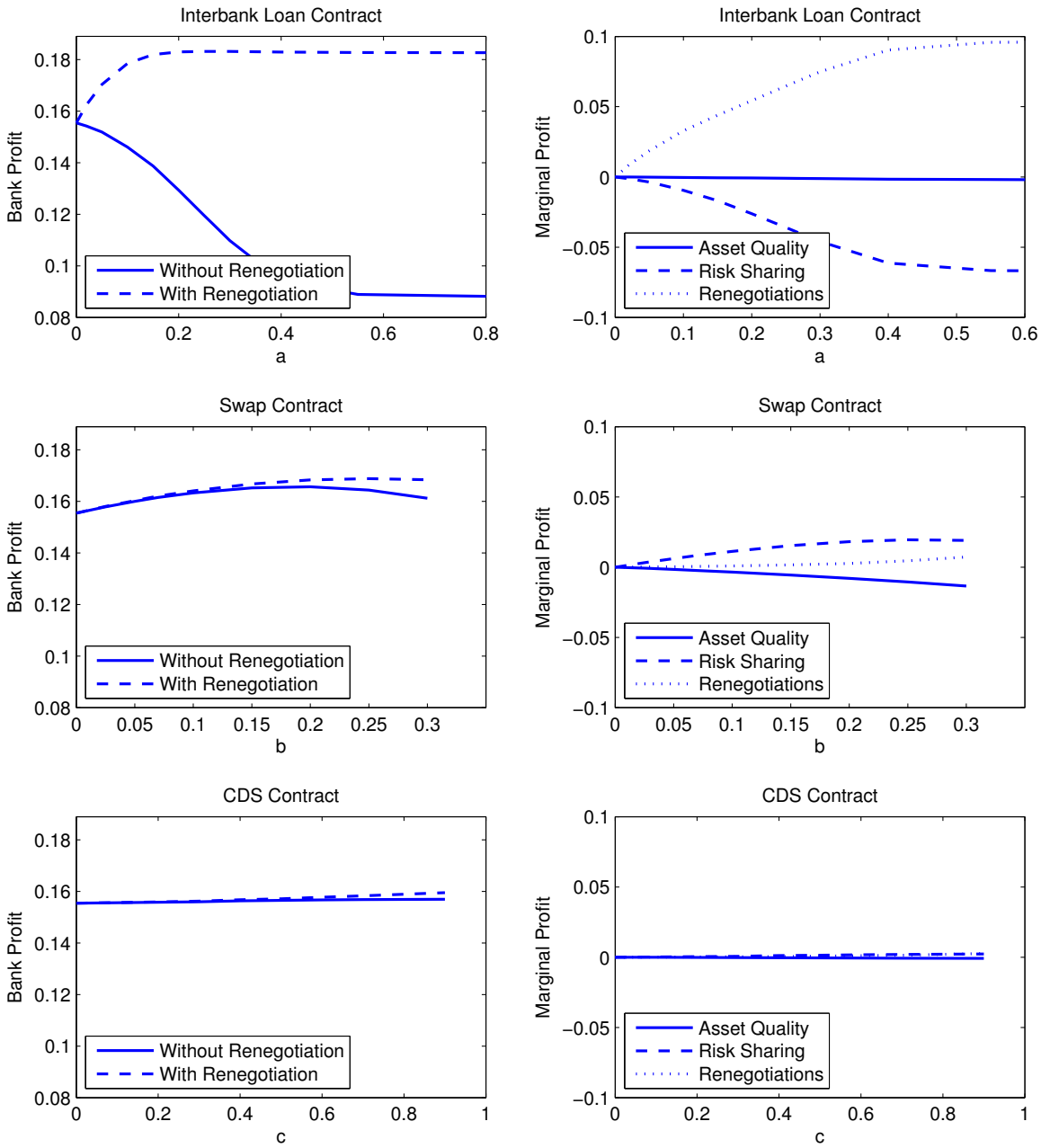
- *Proposition 4: With renegotiations and large interbank loans* $a \geq 2L$
  - *Liquidations only when aggregate resources insufficient*
  - ex-ante efficient

- Interbank connections as commitment device to bail out insolvent banks

Interbank Loans versus Swaps

- *Proposition 6: Only h*edgeable risk, positive effort costs $(\gamma > 0)$
  - Perfect hedging with Large interbank loans $a \geq 2L$ dominates asset swaps $b = 1/3$
  - Asset quality
  - Expected profit

- *Intuition*: With interbank loans, equity holders are still residual claimants


Interbank Loan Contract
Bank Profit
a
Without Renegotiation
With Renegotiation
Interbank Loan Contract
Marginal Profit
a
Asset Quality
Risk Sharing
Renegotiations
Swap Contract
Bank Profit
b
Without Renegotiation
With Renegotiation
Swap Contract
Marginal Profit
b
Asset Quality
Risk Sharing
Renegotiations
CDS Contract
Bank Profit
c
Without Renegotiation
With Renegotiation
CDS Contract
Marginal Profit
c
Asset Quality
Risk Sharing
Renegotiations

Optimality of Interbank Loans in Alternative Environments

Alternative environments

- *Hedgeable and ungedgeable risk*
- *Weak and strong bankruptcy regime*
  - *Lower and upper fixed point of the clearing vector*
  - *Strong and weak enforcement mechanisms*

- *Proposition 7*: Banks' ex-ante profits with large pure interbank loans $a \geq 2L$ do not depend on the fraction of unhedgeable risk or the bankruptcy regime

Conclusion

- To maintain incentives and minimize deadweight costs, large renegotiable interbank loans form the best interbank network
- Renegotiation is a way of ex-post customization of payoffs.
- Large interconnections are required for commitment to bailouts.
- Liquidation policy is efficient, but liquidations are highly correlated. Ignoring renegotiations will mis-estimate likelihood of financial crises.

Definitions of Efficiency

- Ex-post:
  - minimizes bankruptcy costs
  - Payments ≤ Contracted payments
- Ex-Ante
  - Minimize bankruptcy costs
- Ex-ante efficient will lead to perfectly correlated liquidations. Liquidations only when $\sum_i e_i < 0$

3-Player Bargaining

- Suppose the two-path structure is realized and bank 3 bids first

$$LP_3:$$

$$\begin{aligned} \sup_{x_{13},x_{23}} \quad & e_3 + x_{13} + x_{23} \\ 0 \quad & \leq x_{13} \leq \quad d_{13} \\ 0 \quad & \leq x_{23} \leq \quad d_{23} \\ e_1 - x_{13} \quad & > \quad 0 \\ e_2 - x_{23} + d_{12} \quad & > \quad 0 \\ e_1 - x_{13} + e_2 - x_{23} \quad & > \quad 0 \end{aligned}$$

$$\frac{1}{2}\left(e_2 - x_{23} + \min(d_{12}, e_1 - x_{13})\right) + \frac{1}{2}\left(e_2 - x_{23} + p_{12}^{-3}\right) > w_2$$

- Bank 3, then takes the max of the payoff from renegotiations LP_3

And its payoff in bankruptcy w_3