Why are Banks Highly Interconnected?

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Positive Role for Interconnections

- Critics of the financial system allege 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 interconnected banks facilitate mutual private sector bailouts to lower need for govt. bailouts
- Connectedness facilitates ex-post risk sharing
- Large interbank loans are optimal contracts

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

Allen and Gale (2000) model

- Builds on Diamond and Dybvig (1983) setup
- Banks can invest in short term or long term asset
- Banks face uncertainty about short term liquidity need of depositors.
- 2 regions have high short term demand whenever other 2 regions have low demand
- In aggregate: no uncertainty on liquidity demand.
- At $t = 0$ banks can insure each other by making reciprocal deposits.
- At $t = 1$ bank with high liquidity demand withdraws funds from banks with low liquidity demand.
- Each bank is either hit by a liquidity shock of its depositors or a withdrawal of IB deposits

Allen and Gale (2000) fragility

- "Pertubate model": Low probability state in which bank A has extra liquidity demand
- Not enough invested in the short asset in aggregate
- Bank A has to liquidate some long term assets
- Bank A has some buffer:
  - As long as long term depositors get at least as much as short term depositors they have no incentive to withdraw early
  - Bank is insolvent but not bankrupt
- If liquidity shortage in bank A exceeds buffer, then spillover to connected banks
- Connected banks can absorb loss if it is less than their buffer
- Fully connected structure: A's spillover gets spread out. system might survive
- Circular structure: Banks fall like dominoes

Leitner (2005) - network formation

- Each bank can invest in a project, need \$1 investment.
- Project succeeds only if the bank and all linked banks invest in their project
- Timing:
  - Financial network is chosen
  - Endowments of banks are realized, some banks might have less than \$1 needed.
  - Transfers are made (so that all banks can invest)
  - Investments are made
  - Cash flows are realized
- Transfers are private sector bailouts
- Look at optimal network formation
- Production function forces banks to bail each other out

This paper - Renegotiations

- Endogenize renegotiations
- Ex-ante identical banks with outside assets that require some effort to maintain them
- Timing:
  - Banks enter risk sharing agreements
  - Outside asset payoffs are realized
  - If banks cannot meet their obligations, they try to renegotiate
- Renegotiations can fail, even though the outcome is inefficient
- Renegotiation inefficiencies drive ex-ante network formation
- Create a situation of mutually assured destruction
- With renegotiations inflexible debt is preferred because it offers the most ex-post flexibility in renegotiations

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.

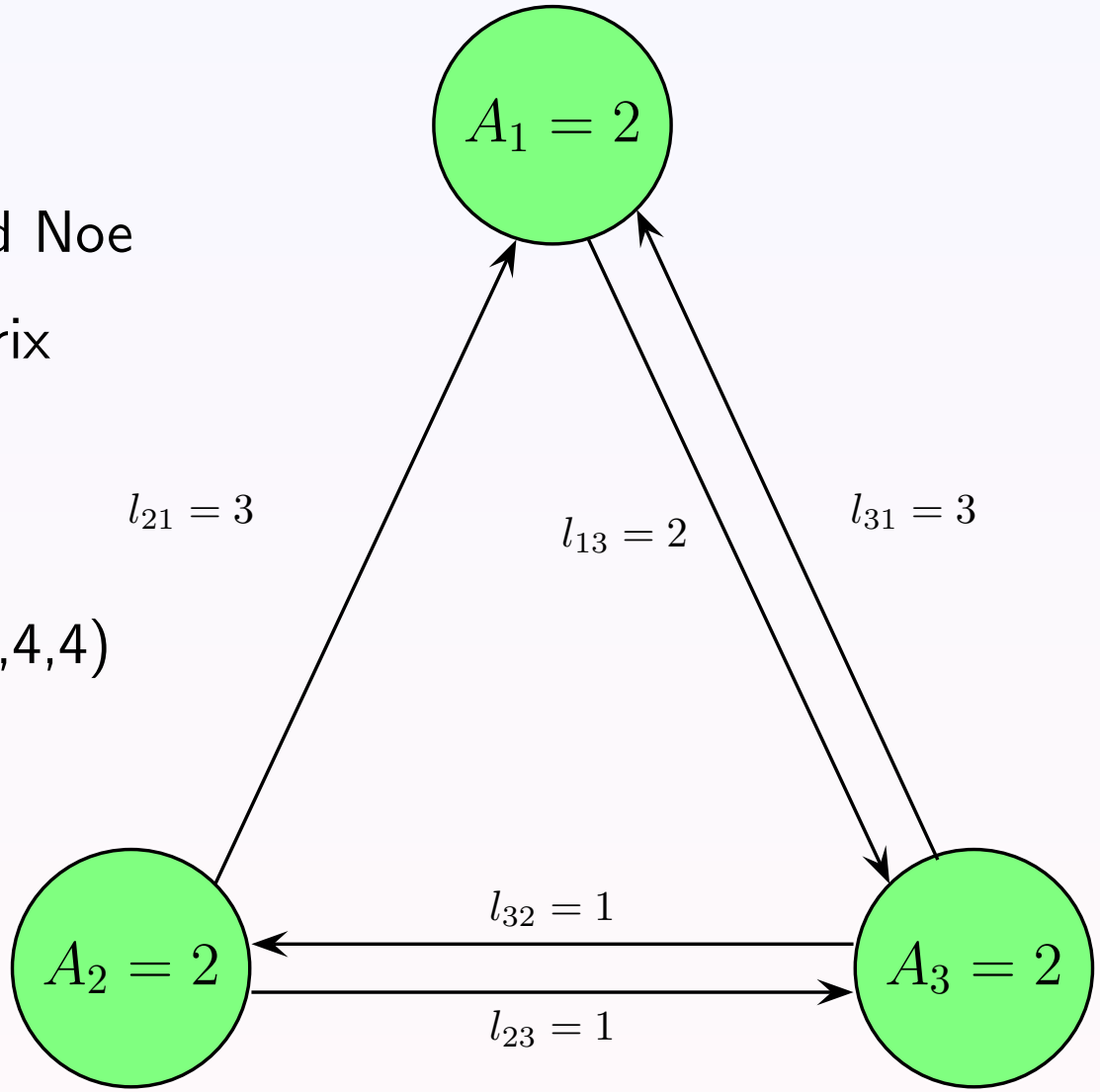
Banks

- N banks in economy. Bank i has asset value $\tilde{A}_i$
- Banks have senior deposits L_i
- 'outside equity' $e_i = A_i - L_i$
- Upfront payment for fair deposit insurance
- Netting agreements in place
- In Bankruptcy a fraction Φ of assets gets destroyed

The Network Model

Framework by Eisenberg and Noe

- Interbank Liability Matrix
$$\begin{pmatrix} 0 & 0 & 2 \\ 3 & 0 & 1 \\ 3 & 1 & 0 \end{pmatrix}$$
- Promised payments: (2,4,4)
- IB-matrix scaled:
$$\Pi = \begin{pmatrix} 0 & 0 & 1 \\ \frac{3}{4} & 0 & \frac{1}{4} \\ \frac{3}{4} & \frac{1}{4} & 0 \end{pmatrix}$$



The network model

net value without IB positions $A_i = 2, L = 1, \Phi = 0$.

$$\underbrace{\begin{pmatrix} 0 & \frac{3}{4} & \frac{3}{4} \\ 0 & 0 & \frac{1}{4} \\ 1 & \frac{1}{4} & 0 \end{pmatrix}}_{\text{Interbank Matrix}} \underbrace{\begin{pmatrix} 2 \\ 4 \\ 4 \end{pmatrix}}_{\text{promised payments}} + \underbrace{\begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}}_{\text{net value}} - \underbrace{\begin{pmatrix} 2 \\ 4 \\ 4 \end{pmatrix}}_{\text{promised payment}} = \underbrace{\begin{pmatrix} 5 \\ -2 \\ 0 \end{pmatrix}}_{\text{bank value}}$$

$$\underbrace{\qquad\qquad\qquad\qquad\qquad\qquad}_{\text{Payments from other banks}}$$

Bank 2 is in default (fundamental default)

$$\begin{pmatrix} 0 & \frac{3}{4} & \frac{3}{4} \\ 0 & 0 & \frac{1}{4} \\ 1 & \frac{1}{4} & 0 \end{pmatrix} \begin{pmatrix} 2 \\ \mathbf{2} \\ 4 \end{pmatrix} + \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} - \begin{pmatrix} 2 \\ \mathbf{2} \\ 4 \end{pmatrix} = \begin{pmatrix} \frac{7}{2} \\ 0 \\ -\frac{1}{2} \end{pmatrix}$$

Bank 3 is in default (contagious default)

The Bankruptcy Mechanism

Clearing Vector: payments under the bankruptcy mechanism (Eisenberg Noe)

- Find network settlement payments simultaneously
- Solution to a fixed point problem

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

- d_i . . . what bank i owes
- p_i . . . what bank i has to pay
- r_i . . . what bank i receives

Bargaining Protocol

- Nature chooses a bank to become the first proposer
- Makes take-it-or-leave-it offers to all its counterparties
- If offers are accepted:
  - claims of proposer eliminated
  - proposer gets paid and leaves the game
  - remaining players bargain over remaining claims
- offers that cannot be refused
  - as creditor: being paid in full
  - as debtor: get full debt forgiveness
- If offers are rejected by any counterparty the bankruptcy mechanism is imposed on remaining banks

Efficiency

- Ex-ante efficient
  - No bank gets liquidated as long as there are enough assets in the system
  - no liquidations as long as $\sum A_i > \sum L_i$
  - unrealistic as regulator cannot expropriate banks
- Ex post efficient
  - Payments are within contracted amounts
  - $0 \leq$ renegotiated payment $\leq$ promised payment
  - Banks can achieve this efficiency level through renegotiations

2 Player Bargaining

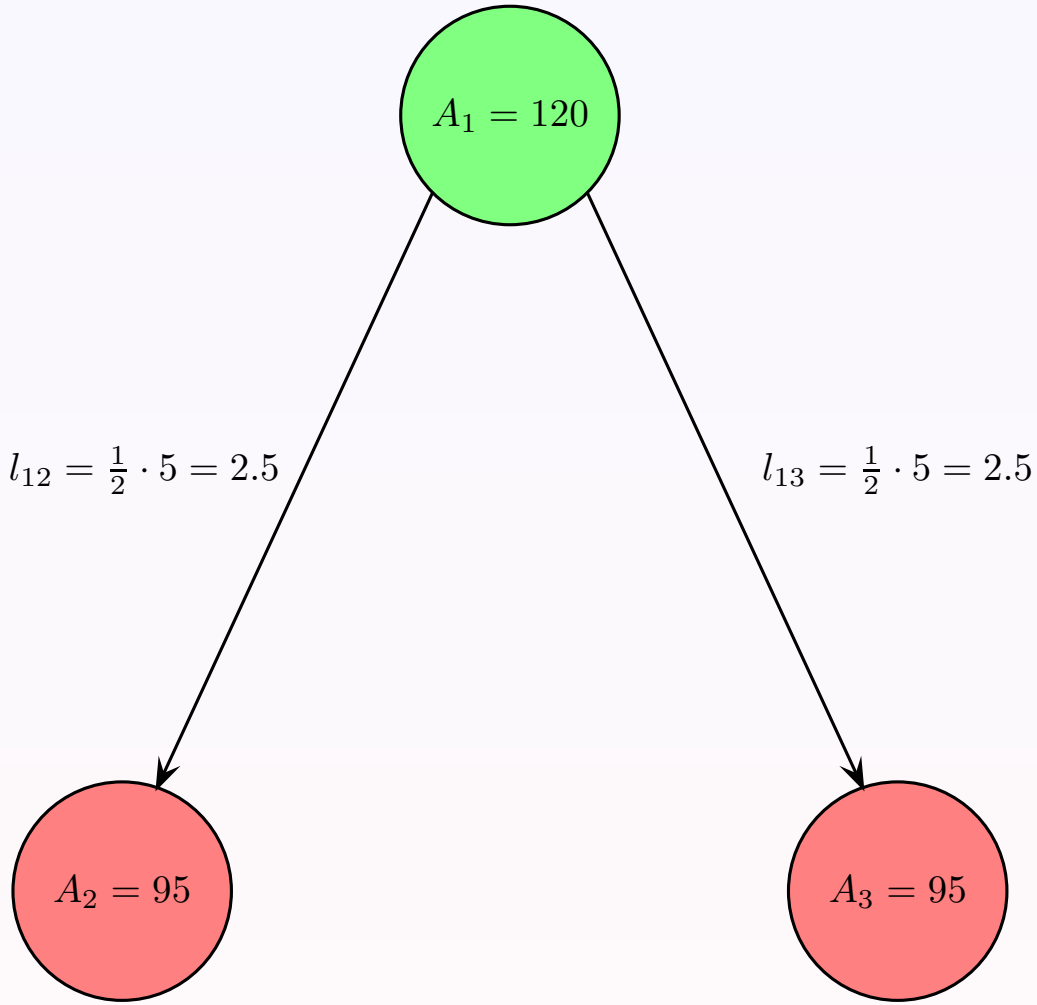
- For all contracts liquidation policy ex post efficient
- A bank is liquidated
  - Insolvent even after receiving full interbank payments
  - or insufficient resources in system
- Suppose bank 1 owes 2 a payment of d_{12}. Then the outcome is as follows:
  1. If $d_{12} \leq e_1$, bank 1 pays d_{12} and never gets liquidated. Bank 2 gets liquidated if $e_2 + d_{12} < 0$.
  2. If $0 \leq e_1 < d_{12}$, the bankruptcy payment vector is $p_{12} = \max(A_1(1-\Phi) - L, 0)$. A successful renegotiation (i.e. no liquidation) will only occur whenever $e_1 + e_2 \geq 0$. If bank 1 proposes first, the settlement $x_{12} = max(p_{12}, -e_2)$. If bank 2 proposes first, $x_{12} = e_1$.
  3. If $e_1 < 0$, bank 1 pays zero and gets liquidated. In this case, bank 2 gets liquidated if $e_2 < 0$.

Renegotiations Example 1

- Three banks (1,2,3) in network
  - Each Bank has assets A, and deposits of 100
- Hedging Strategy 1 (CDS):
  - Each Bank receives $\frac{1}{2}\max(100 - A_i, 0)$ from each other bank
  - Insure shortfall equally with counterparties
- Hedging Strategy 2 (Interbank Loans):
  - Each Bank owes 25 to each other bank
- Liquidation costs are 100%

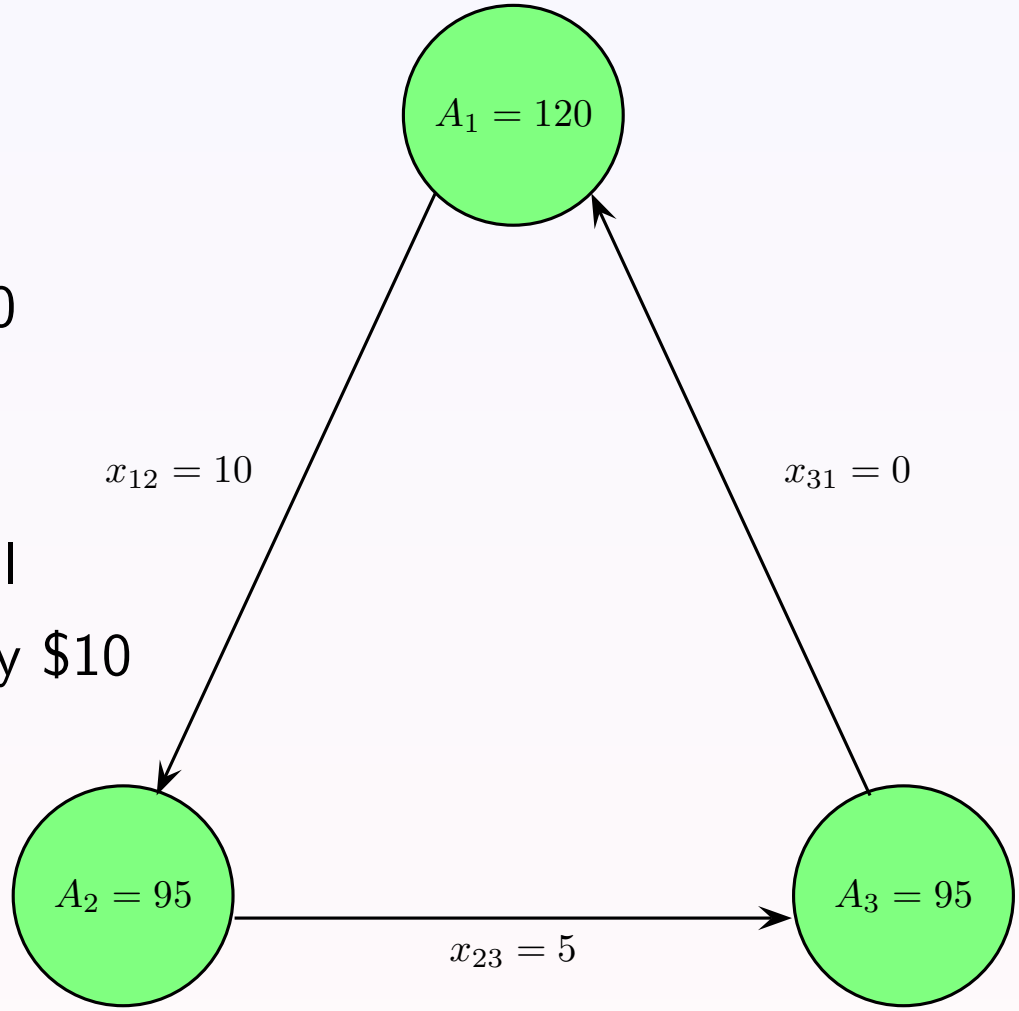
Ex-Post Settlement with CDS

- outside deposits \$100
- Banks 2 and 3 need \$5 to repay their depositors
- Bank 1 insures half of each banks' losses
- Default of the insurer



Ex-Post Settlement with I.Loans

- Liquidation cost 100%
- In bankruptcy all interbank payments =0
- Interbank loan: face value a=$25
- No bank can pay in full
- Bank 1 proposes to pay $10 to bank 2 and take 0 from bank 3
- All banks can survive



Takeaways from example

- High interconnection will span banks liquidation risk
- Interbank loans robust against the default of the insurer
- Liquidation decisions are endogenous: no bank in a highly connected system can stay out of a bailout
- Payment from the weak bank to the strong bank creates incentive for the strong bank to minimize dead weight losses

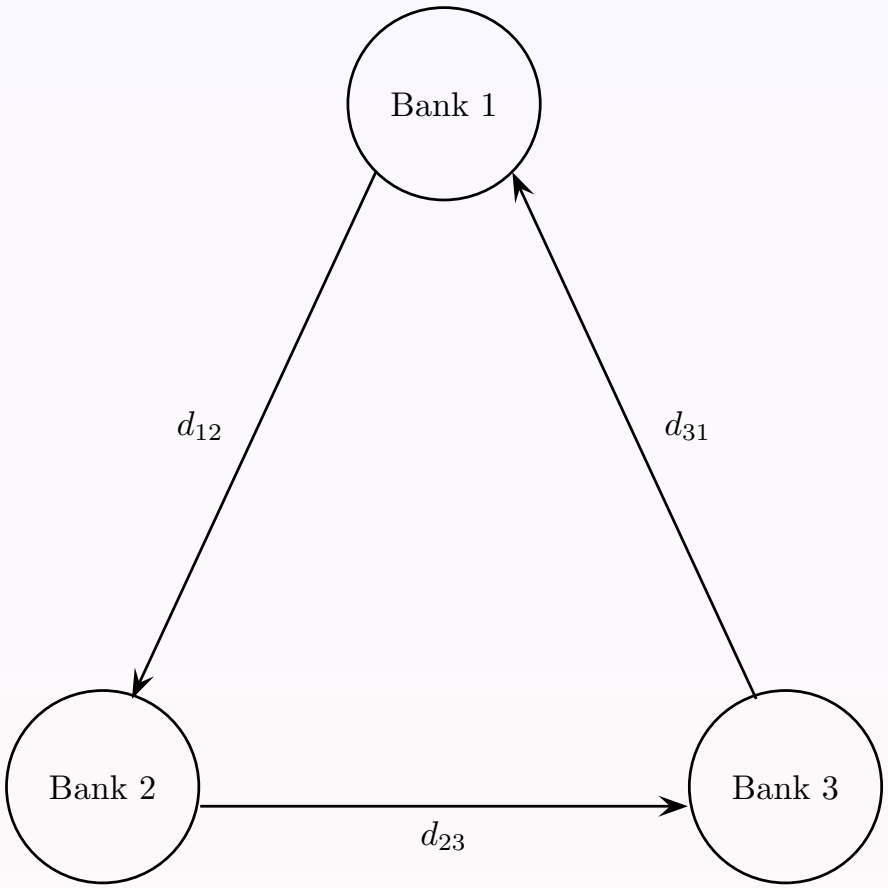
3 Player Bargaining

3 player bargaining is more complicated
Solve a linear program:

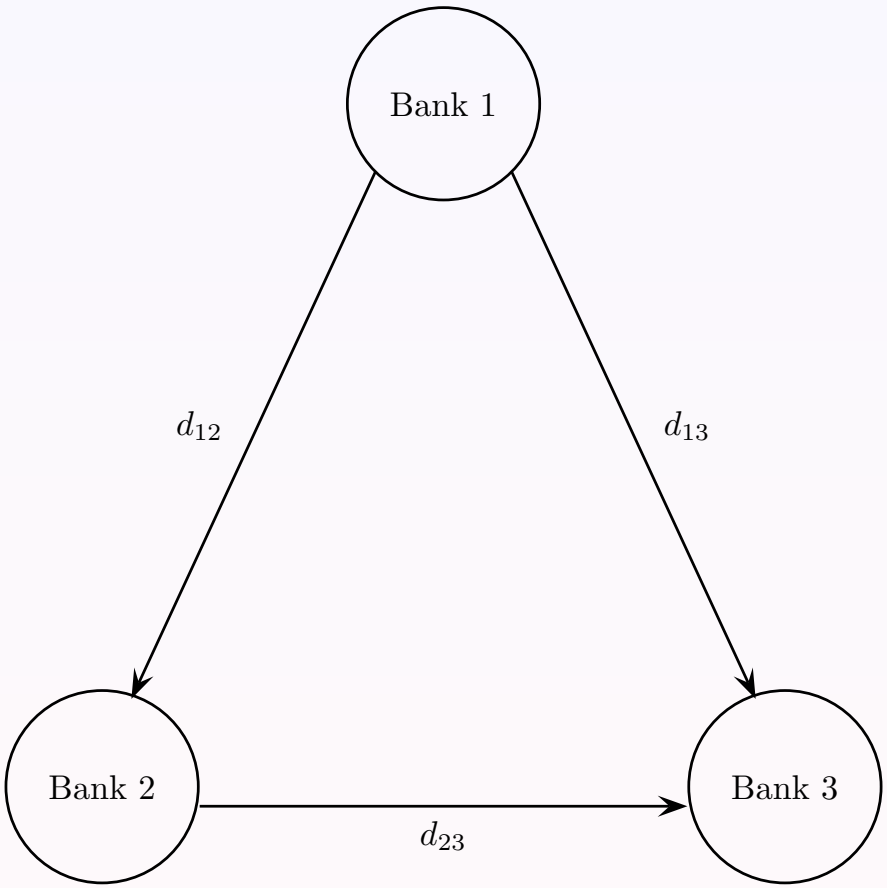
- Payoffs are between zero and contracted amounts
- Proposers counterparties only accept an offer that allows them to reach a bargaining solution in the subsequent bargaining round
- Each bank that can evoke bankruptcy must be at least as well off than under the bankruptcy mechanism
- Can lead to situation where one bank prefers liquidation

3 player bargaining - Possible network structures

Circular structure

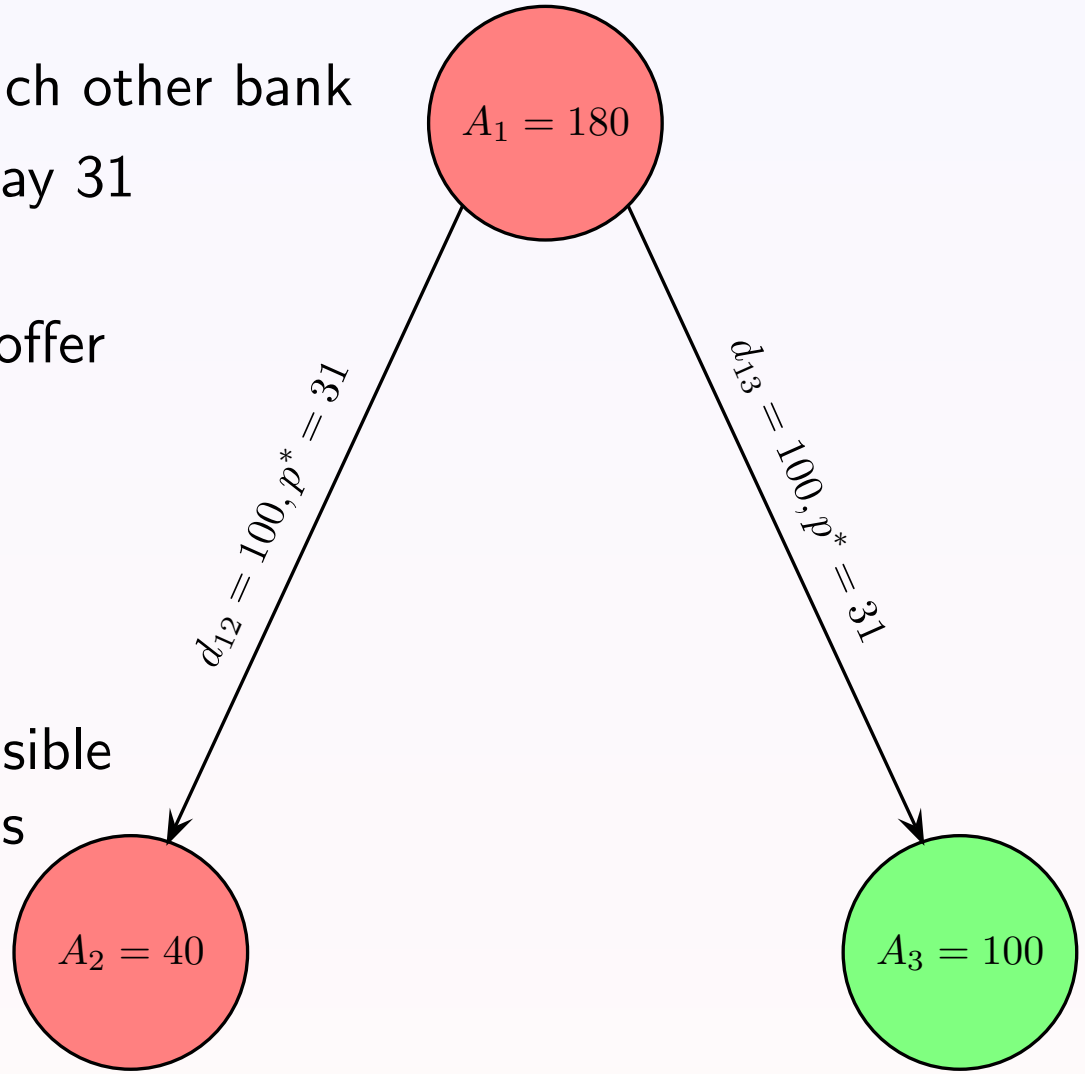


Two-path structure



Bargaining Breakdown

- Bank 1 promised 100 to each other bank
- In liquidation bank 1 will pay 31 to each creditor
- Bank 2 will not accept an offer less than 60.
- Leaves only 20 for bank 3, so its better off in bankruptcy with 31.
- Offers of 60 and 20 are feasible and result in no liquidations
- Efficient outcome when liquidations costs are high

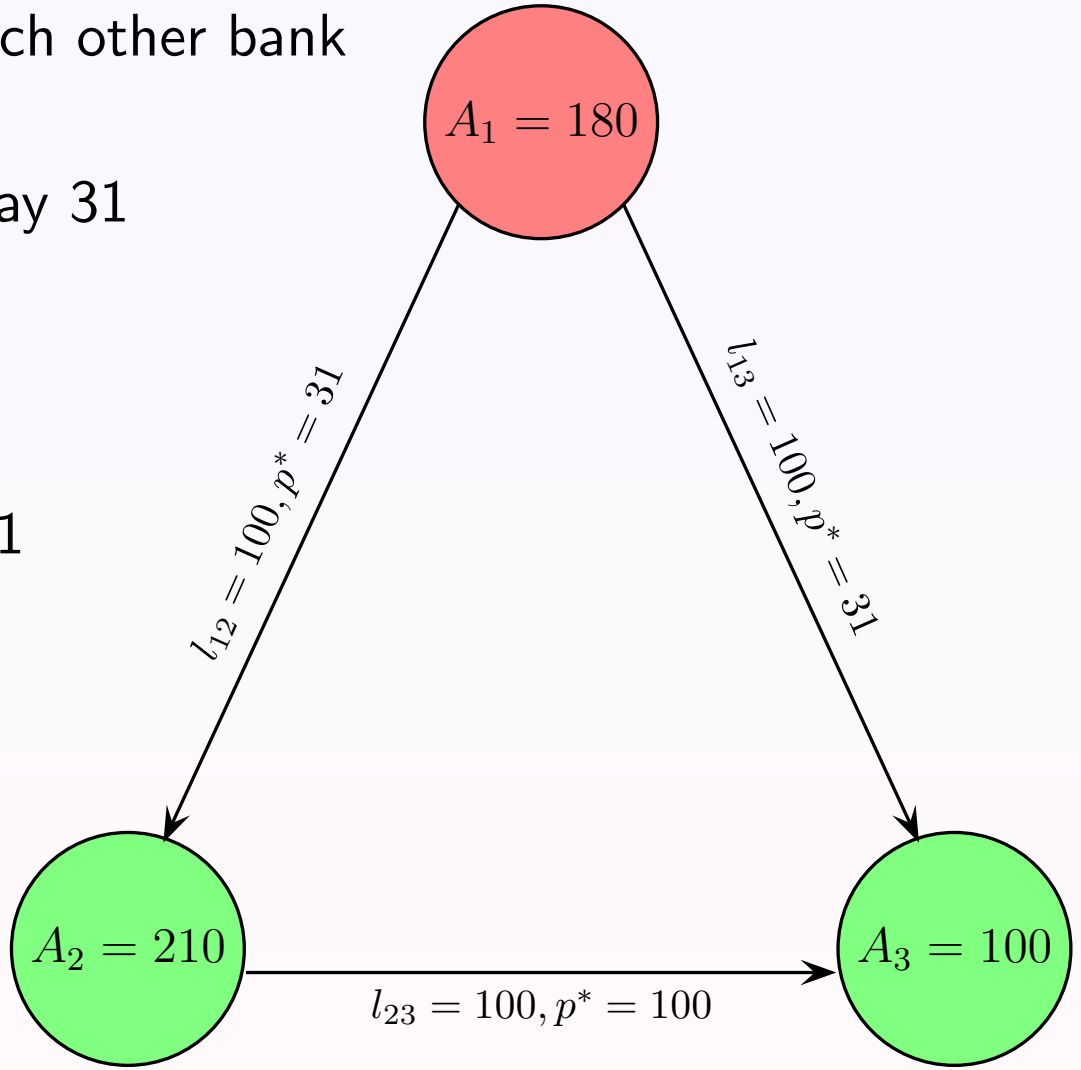


Renegotiation Breakdowns

- Renegotiation successful:
  - all parties agree on a settlement
  - all banks survive
  - Otherwise, we say renegotiations break down
- *Proposition 2*: In the two-path structure necessary condition for breakdown:
  - at least one bank has negative equity value
  - bankruptcy cost parameter is not too high
- As we will see, banks will choose hedging contracts to avoid breakdowns

Bargaining - Elimination of Bankruptcy Option

- Bank 1 promised 100 to each other bank Deposits of L=100
- In liquidation bank 1 will pay 31 to each creditor
- Bank 2 will always pay 100
- In bankruptcy bank 3 gets 100+100+31-Deposits=131
- Bank 2 proposes
- pay of 3 in full
- 3 cannot object
- 2 extracts 80 from 1
- 3 gets 100+100+**0** -Deposits=100



Banks - specific contracts

- Each bank has asset value

$$\tilde{A}_i = \zeta \tilde{B}_i + (1 - \zeta)\tilde{C}_i$$

- 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
- Convex effort cost

Interbank Hedging and Deposit Insurance

Interbank Claims

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

Deposit Insurance

- Bank pay a fair upfront deposit insurance premium to cover outside depositors

Ex-Ante Profits of Banks

Objective Function of Bank:

- Payoff assets
- +/- Interbank Payments under clearing/under renegotiations
- - effort costs
- - deposit insurance premium

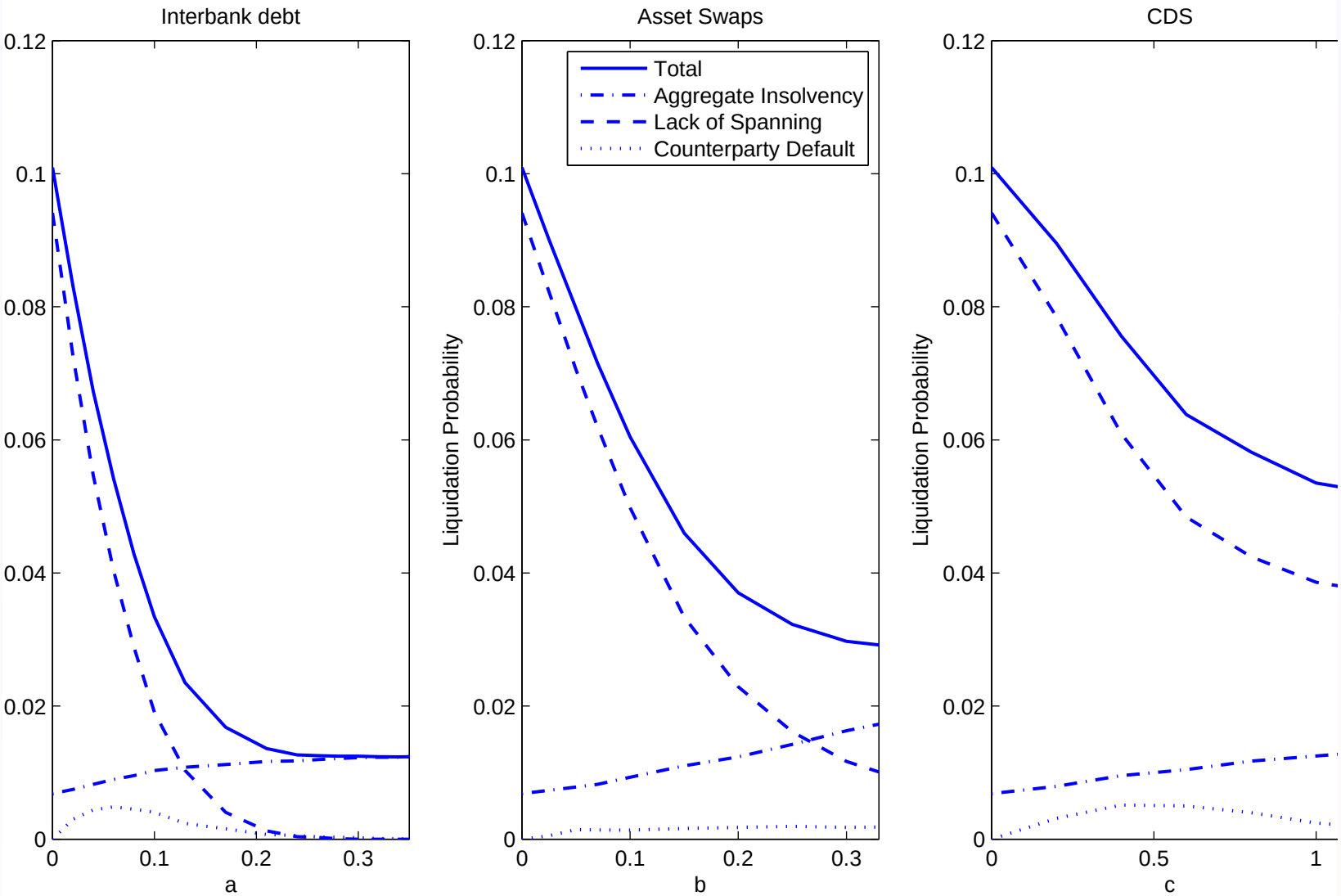
Inoptimality of Interbank Loans without Renegotiation

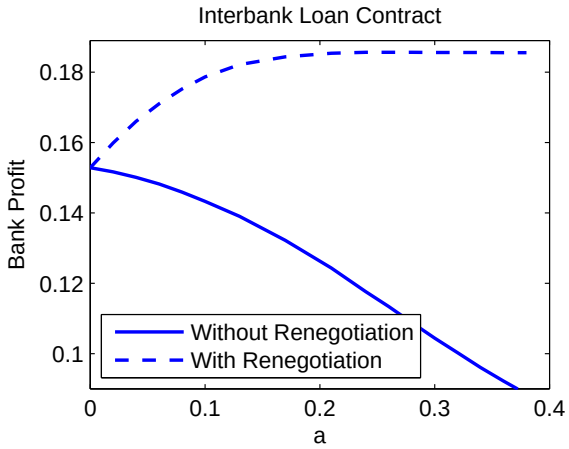
- *Proposition 3*: without renegotiation pure interbank loans will never be chosen
- Intuition: Inflexible payments without renegotiation cause a lot of financial distress.
- Much of the existing literature measures systemic risk from pure interbank loans and simulates defaults without renegotiation.

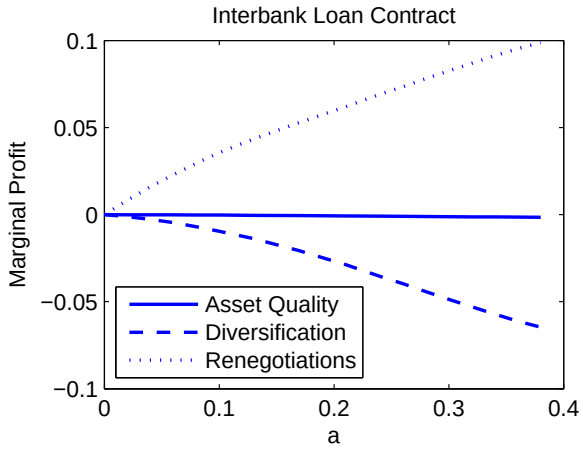
Optimality of Interbank Loans with Renegotiation

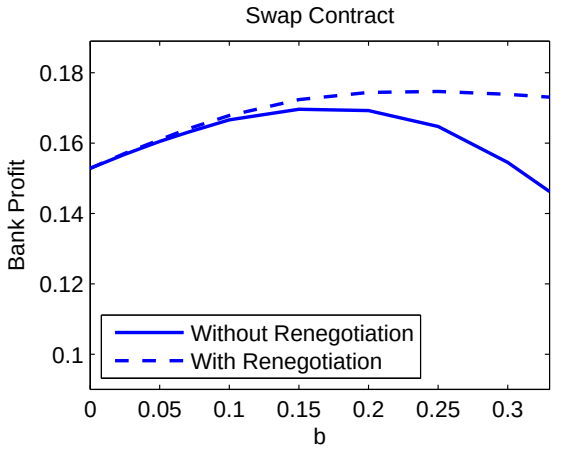
- *Proposition 4*: With renegotiations:
  - with pure interbank loans of $a \geq 2L$ bank liquidations are perfectly correlated.
  - Liquidations are ex-ante efficient
- Intuition: Large interbank loans imply that banks are tied together and forced to bail out insolvent banks to maximize their own value

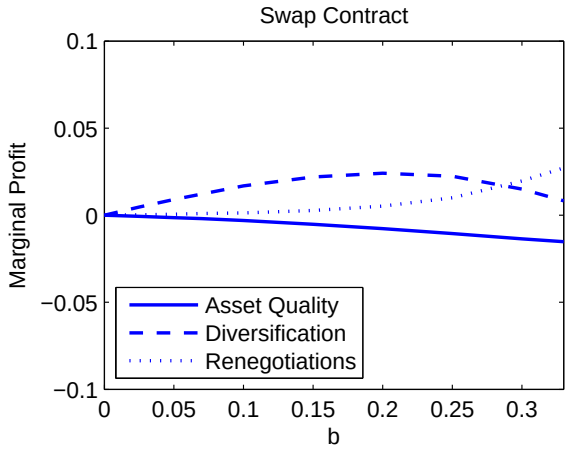
Bank Liquidation Prob. from Aggregate Insolvency, Lack of Spanning and Counterparty Default




Interbank Loan Contract
Bank Profit
a
Without Renegotiation
With Renegotiation


Interbank Loan Contract
Marginal Profit
a
Asset Quality
Diversification
Renegotiations


Swap Contract
Bank Profit
b
Without Renegotiation
With Renegotiation


Swap Contract
Marginal Profit
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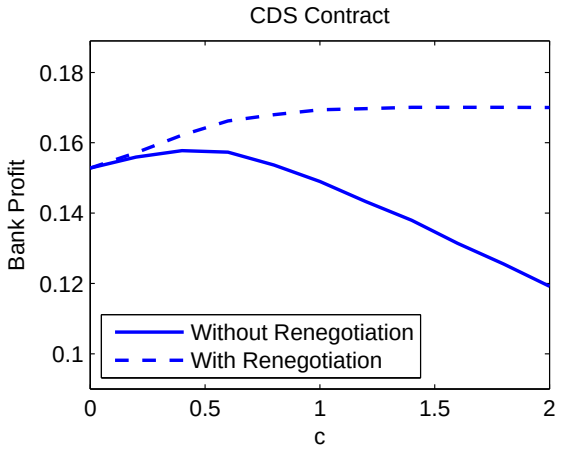
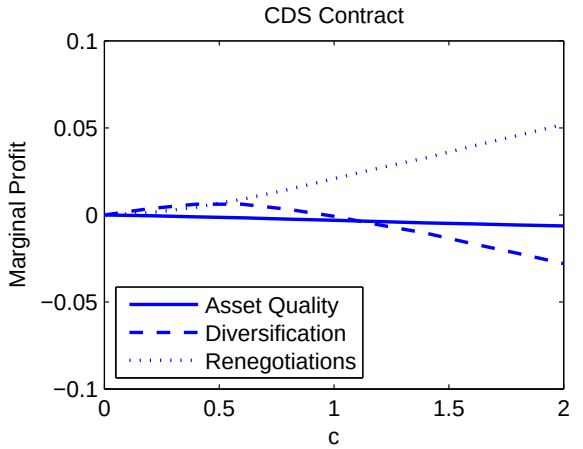

CDS Contract
Bank Profit
c
Without Renegotiation
With Renegotiation


CDS Contract
Marginal Profit
c
Asset Quality
Diversification
Renegotiations

Comparative Statics

Interbank loans

- preserve incentives to maintain asset quality
- span all risks
- only beneficial with renegotiations

Asset swaps

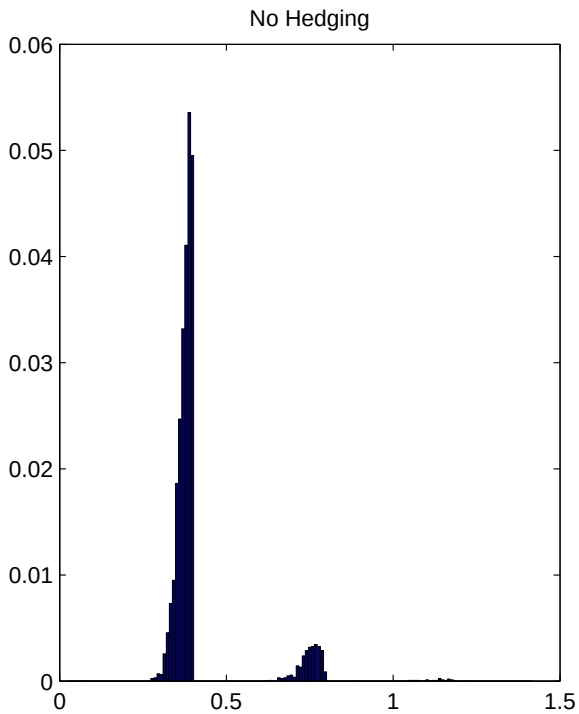
- destroy incentives to maintain asset quality
- do not suffer much from counterparty default
- do not benefit much from renegotiations

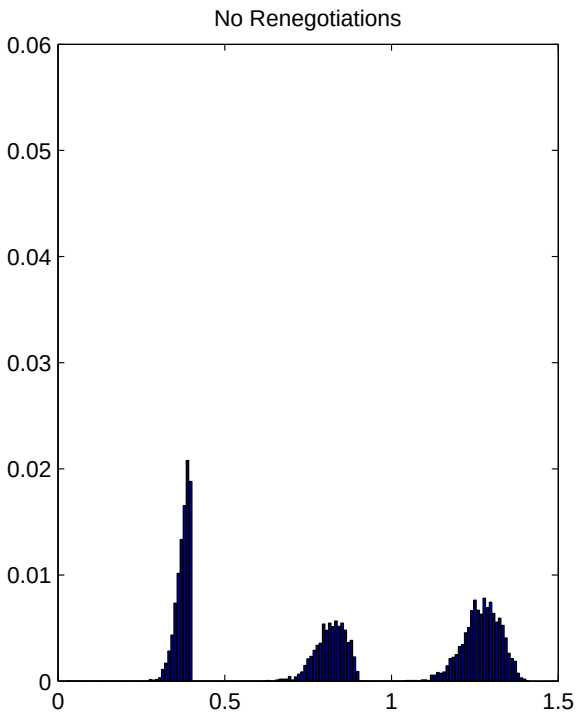
CDS

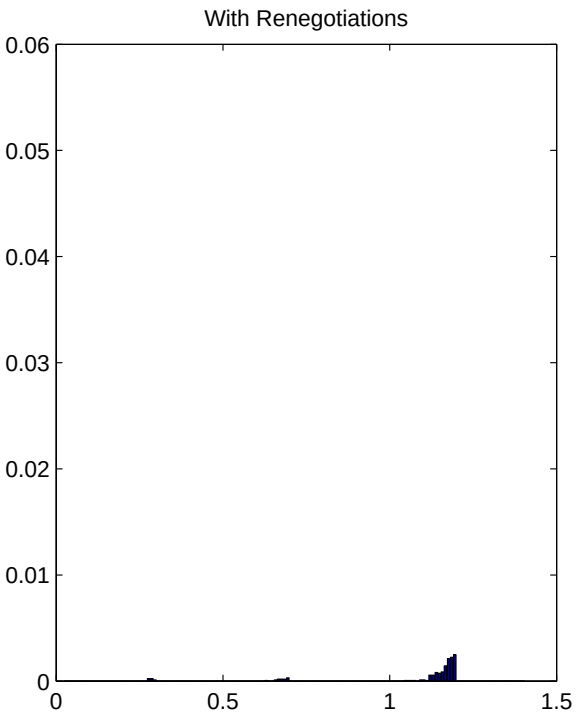
- preserve incentives to maintain asset quality
- poor spanning
- incentive to overinsure to replicate benefits of loans

Liquidation costs

- Large interbank loans with renegotiations ex-ante efficient
- Neglecting renegotiations overestimates systemic risk







Robustness

Large interbank loans are robust w.r.t.

- fraction of unhedgeable risk
- bankruptcy regime
- reserve requirements
- effort cost

Conclusion

- Large renegotiable interbank loans for the best network
  - Preserve incentives for asset quality
  - Allow spanning of bailout payments
  - Create commitment to participate in private sector bailout
- Banks form a highly interconnected network
- System seems fragile because systemic risk is overestimated when renegotiations are ignored.
- Introducing regulation to reduce default correlation reduces hedging possibilities.

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