

Intermediation and Voluntary Exposure to Counterparty Risk

Maryam Farboodi

Finance Seminar

October 15, 2013

Motivation

- Systemic risk and contagion
- Too-connected-to-fail

Motivation

- Systemic risk and contagion
- Too-connected-to-fail
- What is *too-connected*?
- Why do banks form connections in the first place?
 - Structure of endogenous equilibrium network
 - What is the optimal financial structure?

Motivation

- Treasury Undersecretary Robert Steel (Senate testimony, 3/2008)
 - *“The failure of a firm that was connected to so many corners of our markets would have caused financial disruptions beyond Wall Street”*

Motivation

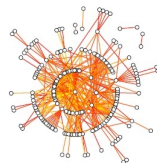
- Treasury Undersecretary Robert Steel (Senate testimony, 3/2008)
 - *“The failure of a firm that was connected to so many corners of our markets would have caused financial disruptions beyond Wall Street”*
- Vice Chairman FRB Donald Kohn (Senate testimony, 6/2008)
 - *“Supervisors need to enhance their understanding of the direct and indirect relationships among markets and market participants, and the associated impact on the banking system. Supervisors must also be even more keenly aware of the manner in which those relationships within and among markets and market participants can change over time and how those relationships behave in times of stress”*

This Paper

- Models banks and their bilateral exposures as a network
 - *Intermediation* needed to fund investment
 - Endogenous inter-bank network formation

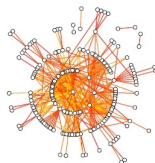
This Paper

- Models banks and their bilateral exposures as a network
 - *Intermediation* needed to fund investment
 - Endogenous inter-bank network formation
- Equilibrium network has *core-periphery* structure
 - Banks who invest at the core
 - High gross and low net exposure within the core



This Paper

- Models banks and their bilateral exposures as a network
 - *Intermediation* needed to fund investment
 - Endogenous inter-bank network formation
- Equilibrium network has *core-periphery* structure
 - Banks who invest at the core
 - High gross and low net exposure within the core
- Equilibrium network is inefficient
 - Intermediators exposed to excessive counterparty risk
 - Too many connections among banks who invest in risky asset
 - Too few connections among banks who provide funds



Evidence from Financial Crisis

- September 15: Lehman filed for bankruptcy
- First wave: holders of unsecured CP and lenders in tri-party repo
 - Wachovia (Evergreens Investment)
 - Reserve Management Company (Reserve Primary Fund)

Evidence from Financial Crisis

- September 15: Lehman filed for bankruptcy
- First wave: holders of unsecured CP and lenders in tri-party repo
 - Wachovia (Evergreens Investment)
 - Reserve Management Company (Reserve Primary Fund)
- Havenrock
 - IKB ABCP conduit (Rhineland): RMBS and CDO investment
 - CaLyon: liquidity backstop; FGIC: senior credit risk protection
- CDO crashed → FGIC unable to honor guarantee → CaLyon significant credit loss → capital injection by French government

► Stylized Facts

Related Literature

- Banking, intermediation and insolvency
 - Moore (2011), Diamond (1984), Rochet and Tirole (1996), Diamond and Rajan (2005)
- Networks
 - Acemoglu, Ozdaglar and Tahbaz-Salehi (2013), Babus (2012,13), Blume et al (2011), Zawadowski (2013)
 - Allen and Gale (2000), Eisenberg and Neo (2001), Elliott, Golub and Jackson (2011)
- Bargaining
 - Gale and Kariv (2007), Gofman (2011), Babus (2012), Manea (2013), Elliott (2013)

Outline

- 1 Model
- 2 Equilibrium Intermediation
- 3 Concluding Remarks

Environment

- I : banks who can invest
 - Potential to make risky investment
- NI : banks who can never invest
 - Have raised one unit on competitive market (debt)
- Value of other businesses for each bank: V_i
- Maximize expected return net of expected cost of failure
- Universal risk neutrality, no discounting

Risky Technology

- Date 1
 - Investment opportunity arrives with iid probability q at each I
- Date 2
 - iid return across investors \tilde{R}

$$\tilde{R} = \begin{cases} R & \text{with probability } p \\ 0 & \text{otherwise} \end{cases}$$

- Scalable

Frictions

- Contracting friction
 - Surplus allocation depends on network structure
 - Intermediators get positive share
 - Rents cannot be negotiated away
- Lending friction
 - Minimum size of lending contract
 - Intermediation required

Timing

- Date 0
 - Network formation: banks enter *potential* lending relationships
- Date 1
 - Risky investment opportunities arrive
 - Loans made
- Date 2
 - Return realized
 - Debt paid back
 - Bank fails and loses V_i if unable to pay back obligation

► Evidence

Frictions and Network Formation

- Contracting friction
 - Cannot negotiate rents down
 - Intermediation payoff only depends on endogenous network structure

Frictions and Network Formation

- Contracting friction
 - Cannot negotiate rents down
 - Intermediation payoff only depends on endogenous network structure
- Minimum size constraint
 - Limit on number of counterparties (endogenous)

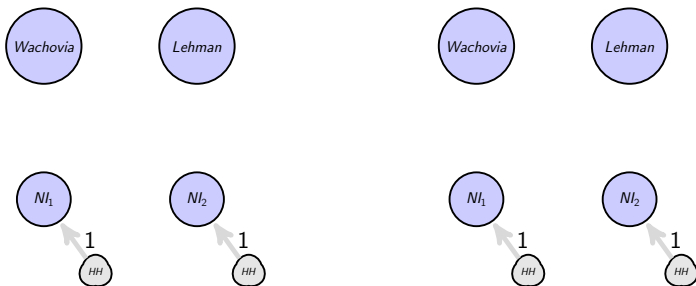
Frictions and Network Formation

- Contracting friction
 - Cannot negotiate rents down
 - Intermediation payoff only depends on endogenous network structure
- Minimum size constraint
 - Limit on number of counterparties (endogenous)
- Solution concept: Group Stability [▶ Detail](#)

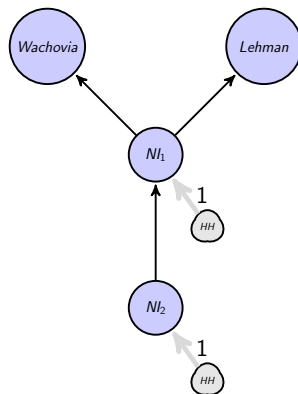
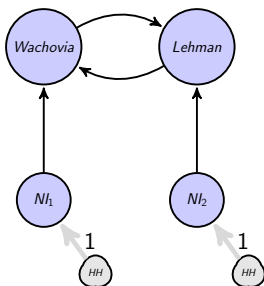
Outline

- 1 Model
- 2 Equilibrium Intermediation
- 3 Concluding Remarks

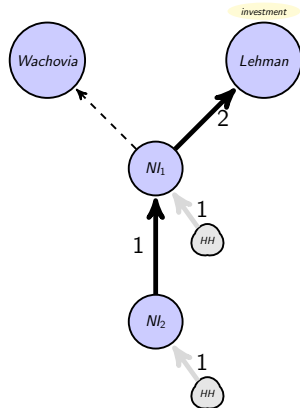
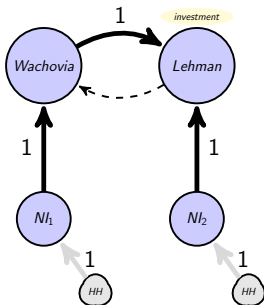
Evolution of Financial Network ($t = 0$)



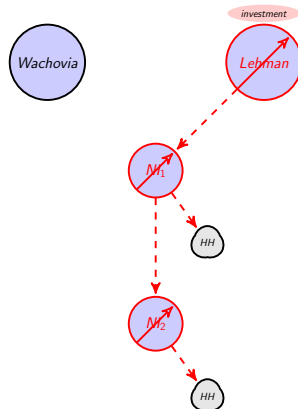
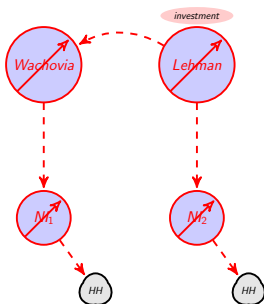
Evolution of Financial Network ($t = 0$)



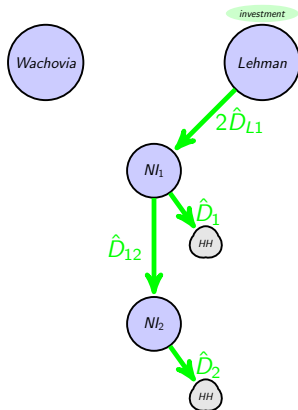
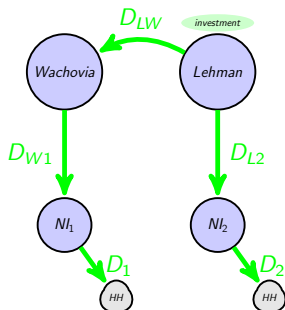
Evolution of Financial Network ($t = 1$)



Evolution of Financial Network ($t = 2$)



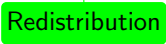

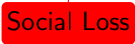

Evolution of Financial Network ($t = 2$)



- $D_{L2} > \hat{D}_{12}$: Return to lender
- $p(D_{LW} - D_{W1}) \leq (1 - p)V_I$: Intermediation spread versus cost of failure

► General

Misaligned Incentives

- Efficiency: scale of investment versus loss in the event of failure
 - *Efficient Intermediator*: impose minimal extra cost of failure
- Equilibrium: return versus loss of failure
 - **Intermediation spread** versus **cost of default**
 -  
 -  
 - *Equilibrium Intermediator*: offer highest rate of return
 - Does he minimize the cost?

Bank Problem

- Raise funds on the competitive market
- Invest
- Intermediate between other banks
- Maximize expected profit net of failure cost $\hat{V}_i(.)$
 - V_j lost if j fails

► Optimization

Lending Contracts

- All lending via debt contracts
- Banks
 - Divide the surplus with strictly positive shares
 - Realized lending chain $i \rightarrow \dots \rightarrow j$
 - Surplus share fall at rate α going from final borrower j to original lender i

[▶ Detail](#)
[▶ General](#)
- Efficient direct lending

[▶ Detail](#)

$$pR - 1 > (1 - p)(V_I + V_{NI})$$

Lending Contracts

- Contingent debt contract
- Not contractible
 - Project return
- Contractible
 - Lending network
 - Set of realized investment opportunities
- At date $t = 1$, each unit intermediated along the *shortest path* from bank who raise it to bank who invests

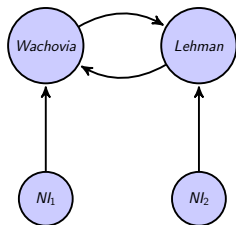
Equilibrium Concept: Stability

- k -Group Stable
 - *Intuition*: Not blocked by any coalition of size at most k

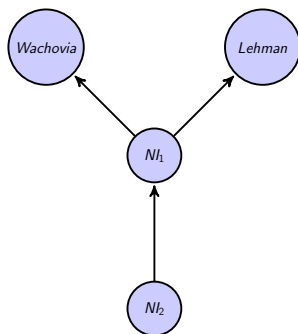
[▶ back](#)

Social Planner Problem

- Maximizes total surplus $TS = \sum_{i \in \mathbb{N}} \hat{v}_i$



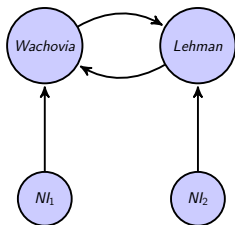
(a)



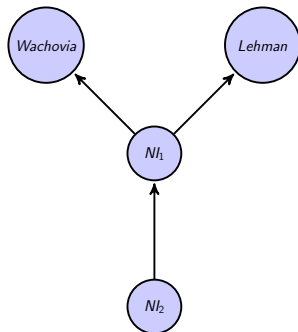
(b)

Social Planner Problem

- Maximizes total surplus $TS = \sum_{i \in \mathbb{N}} \hat{v}_i$

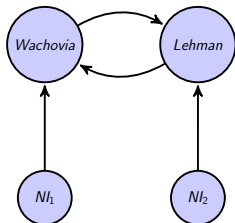


(a) Inefficient

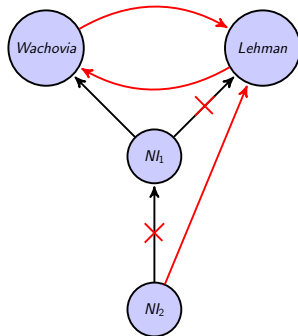


(b) Efficient

Stability (Equilibrium)



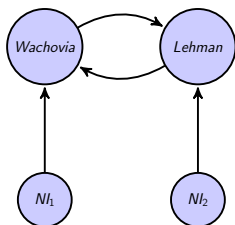
(a)



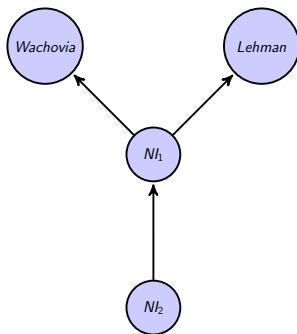
(b)

► Detail

Stability versus Efficiency



(a) Inefficient Stable



(b) Efficient Unstable

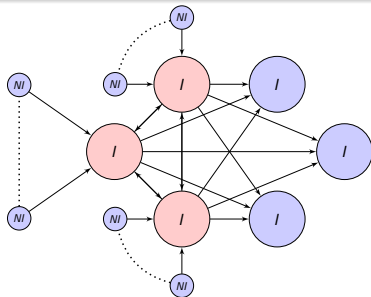
$$\bullet \quad \frac{\text{Intermediation Rent}}{\text{Cost of Failure}} > Z$$

► Detail

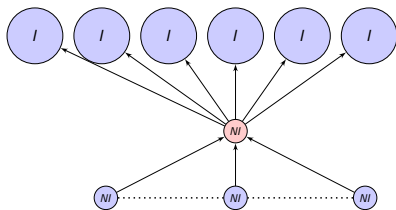
General Result

Theorem

When intermediation rents are sufficiently high, all the equilibria consist of a subset of I banks at the core, forming a digraph. Each I bank at the core borrows from a subset of NI banks, and lends to every I bank outside the core. These equilibria are all inefficient.



(a) Equilibrium



(b) Efficient

Outline

- 1 Model
- 2 Equilibrium Intermediation
- 3 Concluding Remarks

Policy Implications

- Cap on number of counterparties a bank can lend to
- Central Clearing Party (CCP)
- Dampening contagion: super-seniority of repo

Conclusion

- Core-periphery financial network
 - Banks who invest at the core
 - High gross and low net exposure at the core
- Inefficient intermediation (and dis-intermediation)
 - Voluntarily exposure to counterparty risk
- Policy implications

Stylized Facts

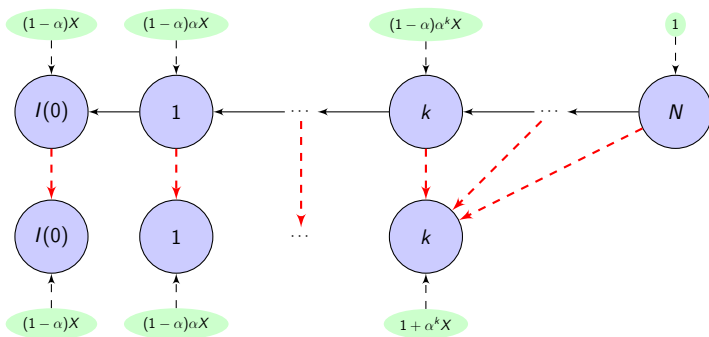
- Liability structure among banks looks like a core-periphery graph

Stylized Facts

- Liability structure among banks looks like a core-periphery graph
- OTC Interbank exposures
 - Dealer: High gross and small net positions
 - Aggregate trade quantity:
 - Dealer-to-dealer: $\sim 60\%$
 - Customer-to-dealer: $\sim 40\%$
 - Customer-to-customer: $< 1\%$

► back

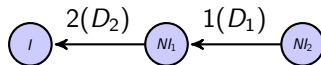
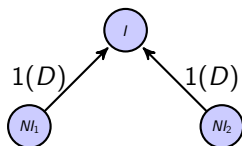
General Lending Structure



- $i < k$ gets $(1 - \alpha)\alpha^i X$
- k gets $1 + \alpha^k X$
- Shares only depend on distance from final borrower
- Face value of debt set to reflect shares

[▶ back](#)

Lending



$$pD - 1 = \alpha(pR - 1)$$

$$D = \frac{\alpha(pR-1)+1}{p}$$

$$D_1 = \frac{\alpha^2(pR-1)+1}{p} \leq D$$

$$D_2 = \frac{\alpha(pR-1)+1}{p} = D$$

$$D_2 - D_1 = \text{intermediation spread}$$

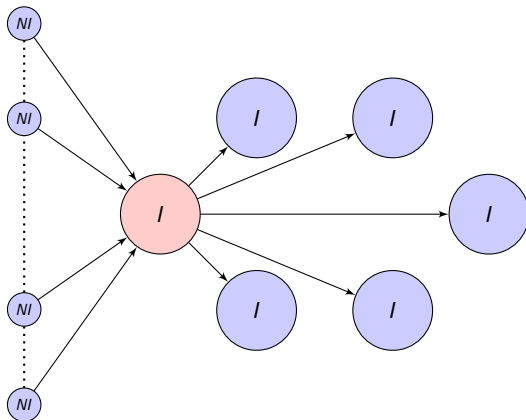
► back

General Rule for Division of Surplus

- Net surplus of each unit divided only among banks along corresponding chain
- Every member of intermediation chain gets strictly positive share
- Elimination of each intermediary
 - Weakly increase every other bank's share (along the chain)
 - Strictly increase lender's share

[▶ back](#)

Multiplicity of Equilibria

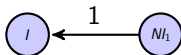


Bank i Maximization Problem

- e_{ij} : *potential* lending agreement from i to j
 - $E_i = \{e_{ij}, e_{ji}\}_{j \in \mathbb{N}}$
 - $E = \bigcup_{i \in \mathbb{N}} E_i$
- m_{ij} : amount lent from i to j
- D_{ji} : face value of debt

$$\begin{aligned}
 \max_{E_i} \quad & \hat{V}_i(E_i; E) = \\
 & \mathbb{E} \left[\mathbb{1}[i \in \mathbb{I}] \left(\tilde{R} \sum_{j \in \mathbb{N}} (m_{ji} - m_{ij}) \right) + \sum_{j \in \mathbb{N}} m_{ij} D_{ji} - \sum_{j \in \mathbb{N}} m_{ji} D_{ij} \right] + \\
 & P(i \text{ does not fail}) V_i \\
 \text{s.t.} \quad & m_{ij}, m_{ji} \geq 1 \quad \forall j
 \end{aligned}$$

Efficient Direct Lending



- Efficiency

$$pR - 1 > (1 - p)(V_I + V_{NI})$$

- Borrower and lender participation constraint

$$(1 - \alpha)(pR - 1) > (1 - p)V_I$$

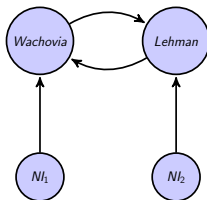
$$\alpha(pR - 1) > (1 - p)V_{NI}$$

Long Term Relationship Lending

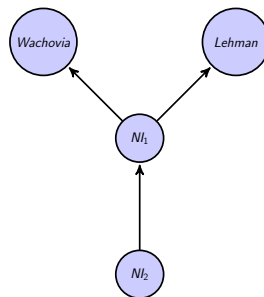
- Empirical evidence
 - Fed fund market: %60 of interbank borrowing persistent for one month
 - Hedge funds: maintain at most two prime brokers and rarely switch
- Theory
 - Switching costs
 - Monitoring costs: costly information acquisition

[▶ back](#)

Social Planner Solution



$$\begin{aligned}
 TS^a = & \\
 & 2[(1-q)^2(V_I + V_{NI}) + \\
 & q^2 p(V_I + V_{NI} + R) + \\
 & q(1-q)p(2V_I + 2V_{NI} + 2R)]
 \end{aligned}$$



$$\begin{aligned}
 TS^b = & \\
 & 2[(1-q)^2(V_I + V_{NI}) + \\
 & q^2(p(V_I + 2V_{NI} + 2R) + V_I) + \\
 & q(1-q)(V_I + p(V_I + 2V_{NI} + 2R))]
 \end{aligned}$$

NI Bank Profitable Deviation

$$\hat{V}_{NI_2}^a = (1 - q)^2 V_{NI} + q^2 [p(V_{NI} + D) - 1] +$$

$$q(1 - q)[p(V_{NI} + D) - 1] +$$

$$(1 - q)q[p(V_{NI} + D_1) - 1]$$

$$\hat{V}_{NI_2}^b = (1 - q)^2 V_{NI} + q^2 [p(V_{NI} + D_1)) - 1] +$$

$$2(1 - q)q[p(V_{NI} + D_1) - 1]$$

/ Bank Profitable Deviation

$$\hat{V}_I^a = (1 - q)^2 V_I + q^2 [p(V_I + R - D)] +$$

$$q(1 - q)[p(V_I + 2(R - D))] +$$

$$(1 - q)q[p(V_I + D - D_1)]$$

$$\hat{V}_I^b = (1 - q)^2 V_I + q^2 \left[\frac{1}{2} V_I + \frac{1}{2} [p(V_I + 2(R - D))] \right] +$$

$$q(1 - q)[p(V_I + 2(R - D))] +$$

$$(1 - q)q[V_I]$$

When is (a) an Equilibrium?

- N/I_2 always wants to deviate
- I wants to deviate if:

$$\hat{v}_I^a > \hat{v}_I^b$$

- Sufficient condition: $\frac{(pR-1)}{(1-p)V_I} > Z$

▶ back

Efficiency

- Pareto efficiency
 - **Neither** outcome is Pareto dominant

Efficiency

- Pareto efficiency
 - **Neither** outcome is Pareto dominant
- / bank funding
 - $\exists \bar{\epsilon} \mid s_i < \bar{\epsilon}$: inefficient equilibrium

[▶ back](#)

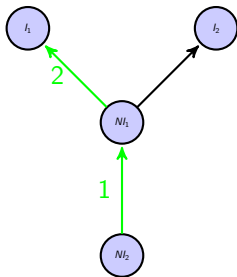
Quantifying the Inefficiency: Comparative Statistics

- When is the inefficiency large?
 - V_I large
 - V_{NI} small
 - $\frac{k_{NI}}{k_I}$ large

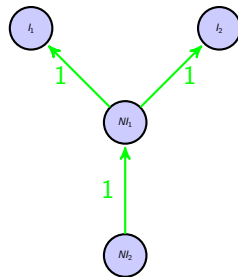
[▶ back](#)

Diversification

- Intermediator NI has a positive diversification effect
- Deviating NI incentive constraint not trivial anymore

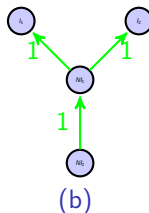
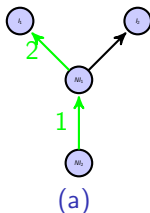


(a) No Diversification



(b) Diversification

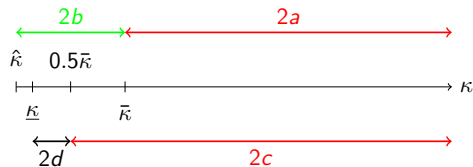
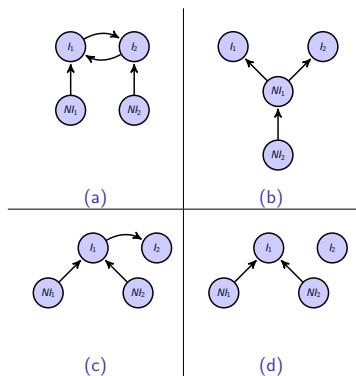
Diversification



$$\hat{V}_{NI_2}^{undiversified} = (1 - q)^2 V_{NI} + q^2 [p(V_{NI} + D) - 1] + \\ q(1 - q)[p(V_{NI} + D) - 1] + \\ (1 - q)q[p(V_{NI} + D_1) - 1]$$

$$\hat{V}_{NI_2}^{diversified} = (1 - q)^2 V_{NI} + q^2 [p(2 - p)(V_{NI} + \hat{D}_1)) - 1] + \\ 2(1 - q)q[p(V_{NI} + \hat{D}_1) - 1]$$

Possible Equilibria



$$\kappa = \frac{\alpha(1-\alpha)(pR-1)}{(1-p)V_I}$$

[▶ back](#)