Endogenous Financial Networks: Diversification and Intermediation

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November 6, 2018

NYU Micro Theory Student Lunch

Outline

Introduction

The Paper in a Nutshell

Why do OTC financial networks have core-periphery structure?

- **Contribution:** Endogenous weighted, directed networks
  - Links represent flows of funds, not just binary relationships
- **Method:**
  - Strongly stable equilibria of a network formation game
  - Intuitive structural interpretation of primitives
- **Answer:** Diversification and Intermediation
  - Banks want many counterparties $\rightarrow$ spread investment
  - Cost per link prevents high levels of diversification
  - Core banks offer peripheral banks a diversified portfolio ...
  - in exchange for intermediation rents.

Motivation

- Network approaches became popular after financial crisis
- Representative bank models ignore some problems
  - E.g. contagious defaults
- Network structure matters for financial stability
- We need a theory of how these networks form
  - Predict endogenous reaction to policy (e.g. bailouts)

Related Literature

Literature Gap

- Literature mostly takes network structure as given
- Resilience to shocks, risk-sharing properties, ...
  - Allen and Gale (2000), Eisenberg and Noe (2001), Gai and Kapadia (2010), Elliott et al. (2014), Acemoglu et al. (2015a), Cabrales et al. (2017) ...
- Endogenous networks: *Undirected/-weighted* graphs
  - Babus (2016), Di Maggio and Tahbaz-Salehi (2014), Erol (2018), Wang (2018), Babus and Hu (2017), Chang and Zhang (2016)
- Notable exceptions:
  - Farboodi (2017), Acemoglu et al. (2015b)
- This paper combines ...
  - intermediation à la Farboodi (2017) with a
  - diversification motive.

This paper vs. Farboodi (2017)

Additional Literature

- Robust empirical finding: Core-periphery networks
  - Bech and Atalay (2010), Hollifield et al. (2016), Craig and Von Peter (2014), in 't Veld and van Lelyveld (2014), ...
- Trading/Bargaining in (non-financial) networks
  - Choi et al. (2017), Condorelli et al. (2016), Goyal and Vega-Redondo (2007), Manea (2018) ...
- Endogenous (non-financial) core-periphery networks
  - Hojman and Szeidl (2008)
- Delegated monitoring
  - Diamond (1984)

Model

Environment

- Three periods $t = 0, 1, 2$
- Set of banks N, risk-neutral, profit-maximizing
- N partitioned into (ex ante known) subsets $\mathbb{I}$ and $\mathbb{D}$
- $\mathbb{I}$ banks have risky, proprietary investment projects in $t = 1$
- $\mathbb{D}$ banks raise d from depositors in $t = 0$ ($r_D = 0$ w.l.o.g.)
- In $t = 2$, projects (CRS) yield i.i.d. per-unit return

$$\begin{cases} R > 1 & \text{with probability} \quad p \\ 0 & \text{with probability} \quad 1 - p \end{cases}$$

Network Formation Game

- In $\mathbf{t = 0}$ banks open credit lines $b_{ij} \geq 0$
  - *Feasibility*: $\sum_{j \neq i} b_{ij} \leq \sum_{j \neq i} b_{ji} + d \times \mathbb{1}_{i \in \mathbb{D}} \quad \forall i \in N$
  - Lending banks pay fixed *management utility cost* κ per link
  - Outflowing funds are spread *equally* across lending links
- In $\mathbf{t = 1}$ counterparties bargain over interest rates r_{ij}
  - Symmetric Nash bargaining
  - Complete information about bank types and network
- In $\mathbf{t = 2}$ project returns realize, debt is repaid (if possible)
  - Pro-rata repayment of creditors
  - Bankruptcy (utility) cost δ per unit of defaulted *principle*

Timing

Credit lines are formed

Bargaining about interest rates

Lending/borrowing takes place

Investment in projects

Returns realize

Banks repay/default

Equilibrium Concept: Strong Stability

- Credit lines require consent of *both* contracting parties
  $\Longrightarrow$ Nash equilibria not appropriate

Definition

A deviation from network g to g' by a coalition $S \subseteq N$ is *feasible* if

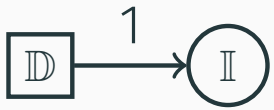
1. $b_{ij}^{g'} > 0$ and $b_{ij}^{g'} \neq b_{ij}^{g}$ implies $\{i, j\} \subseteq S$, and
2. $b_{ij}^{g} > 0$ and $b_{ij}^{g'} = 0$ implies $\{i, j\} \cap S \neq \emptyset$

A network g is *strongly stable* if no coalition of banks $S \subseteq N$ has a *feasible* deviation that makes all banks in S strictly better off.

- Dutta and Mutuswami (1997), Jackson and Van den Nouweland (2005)

Diversification

- Project returns are i.i.d. $\Longrightarrow$ Scope for diversification
- Example: Compare the following situations ($d = 1, \kappa = 0$)



- If *one* $\mathbb{I}$-bank's repayment is sufficient for $\mathbb{D}$'s survival ($\frac{1}{2}(1+r) \geq 1$):

$$\mathbb{E}\pi_{\mathbb{D}} = p^2 r + 2p(1-p)\left[\frac{1}{2}(1+r) - 1\right] - (1-p)^2\delta > pr - (1-p)\delta$$

  as long as $\delta > 1$
- Reduce probability of states in which lender defaults

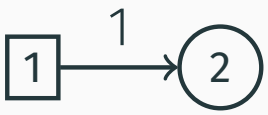
Diversification (ctd.)

- $\exists$ *optimal* degree of diversification, decreasing in κ
- Principle also applies to $\mathbb{I}$-banks
- A well-diversified bank is an attractive investment
  - Low default probability
  - Pay κ only once ("delegated diversification")
- Rationale for core-periphery networks in equilibrium
  - Core banks give peripheral banks access to diversification
  - They emerge *not* because of fundamental advantage

Unresolved Issues

Problem 1: When is κ paid?

- In simple bilateral relationship ($|\mathbb{D}| = |\mathbb{I}| = 1,\ d = 1$)



$$\mathbb{E}\pi_1 = pr - (1-p)\delta - \kappa$$
$$\mathbb{E}\pi_2 = p(R-1-r) - (1-p)\delta$$

- Without deal both earn zero, Nash bargaining yields

$$r = \frac{1}{2}\left(R - 1 + \frac{\kappa}{p}\right)$$

- Trade only happens if $p(R-1) \geq 2(1-p)\delta + \kappa$
- κ only enters bargaining outcome if paid upon agreement
  $\Longrightarrow$ Does not discipline link formation

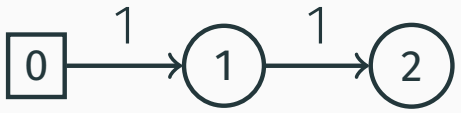
Problem 2: Competition and Market Power

Solution:

- Credit lines b_{ij} are earmarked (idle without agreement)
- Separation of prices and quantities simplifies analysis
- Shuts down $t = 1$ competition $\Rightarrow$ no market power

Problem 3: Interdependence of Interest Rates

- With an intermediary $\mathbb{I}$-bank



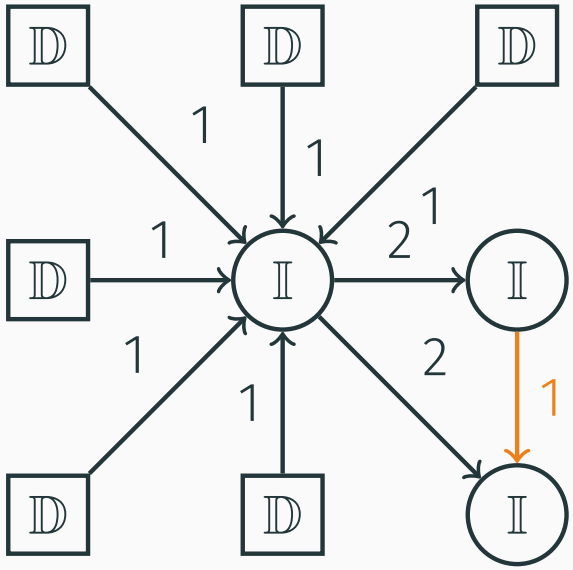
$$\mathbb{E}\pi_0 = pr_1 - (1-p)\delta - \kappa$$
$$\mathbb{E}\pi_1 = p(r_2 - r_1) - (1-p)\delta - \kappa$$
$$\mathbb{E}\pi_2 = p(R - 1 - r_2) - (1-p)\delta$$

- Nash bargaining: r_1 depends on r_2 (and vice versa)
- Simultaneous or sequential solution?
- If sequential $\Rightarrow$ restrict analysis to *acyclical* networks

$\Longrightarrow$ Need help from bargaining literature

Problem 4: Single Peripheral Borrower

Figure 1: The star as a special CP network



- Core $\mathbb{I}$-bank is optimally diversified
- No incentive to deviate for $\mathbb{D}$-banks
- Intermediation rent compensates for management cost 2κ
- How to prevent these deviations?

Conclusion

Summary and Outlook

- Key idea
  - Diversification motive + intermediation rents = CP network
  - Endogenous, weighted, directed network
  - Strongly stable equilibrium of network formation game
- Limitations
  - Integer/divisibility problems
  - Equilibrium will probably not be unique
  - Ex ante heterogeneous banks
- Next steps
  - Find a way to solve problems 1-4
  - Experiment with ex ante *identical* banks
  - Comparative statics (e.g. size of core/periphery)
  - What happens with anticipated bailouts?

Appendix

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This Paper vs. Farboodi (2017)

- Endogenous surplus sharing rule (bargaining)
- No random allocation of all funds along *just one link*
  - Links are not just *potential* lending relationships
  - Default probability may depend on multiple projects
- Diversification: No shortest path bargaining

Back