

Endogenous Risk-Exposure and Systemic Instability



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Do highly connected financial networks contribute to systemic stability or systemic fragility?

Connected-Stability view:

- Provide a co-insurance mechanism against shocks.

- Allen and Gale (2000)

- Freixas, Parigi, and Rochet (2000)

Non-monotonicity view:

- Network also induces a propagation mechanism to spread the loss.

- Elliott, Golub, and Jackson (2014)

- Acemoglu, Ozdaglar, and Tahbaz-Salehi (2015)

Motivation

- ▷ The existing Literature assumed exogenous shocks.
- ▷ They studied how shocks are propagated.

However, banks' exposure to which particular shock is an endogenous choice variable.

Motivation

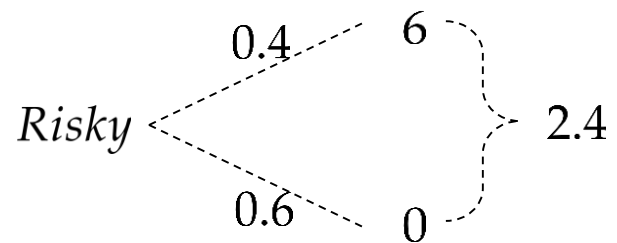
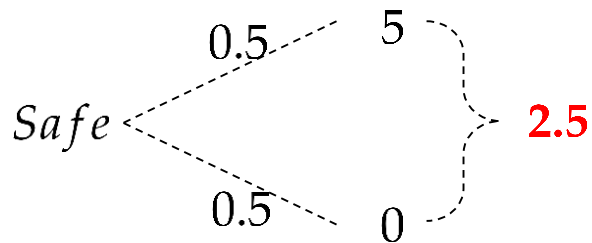
However, banks' exposure to which particular shock is an endogenous choice variable.

- ▷ safe borrowers vs subprime borrowers.
- ▷ exposure on asset-backed securities.

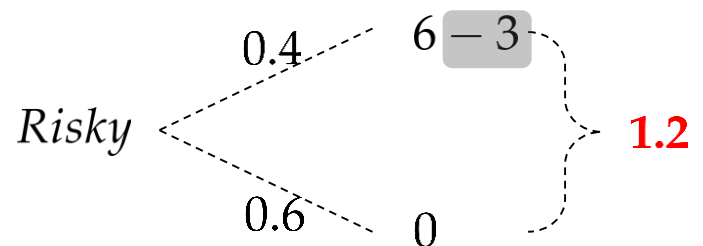
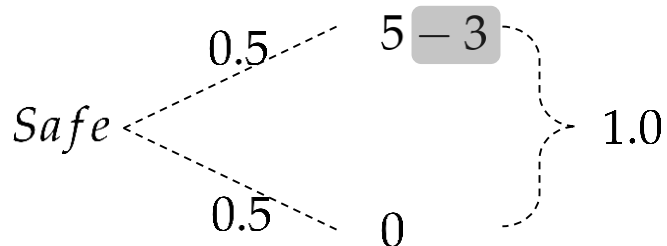
In this paper, I endogenize the banks' ex-ante choices of risk exposure.

Intuition

- ▷ Bank i needs to choose one project



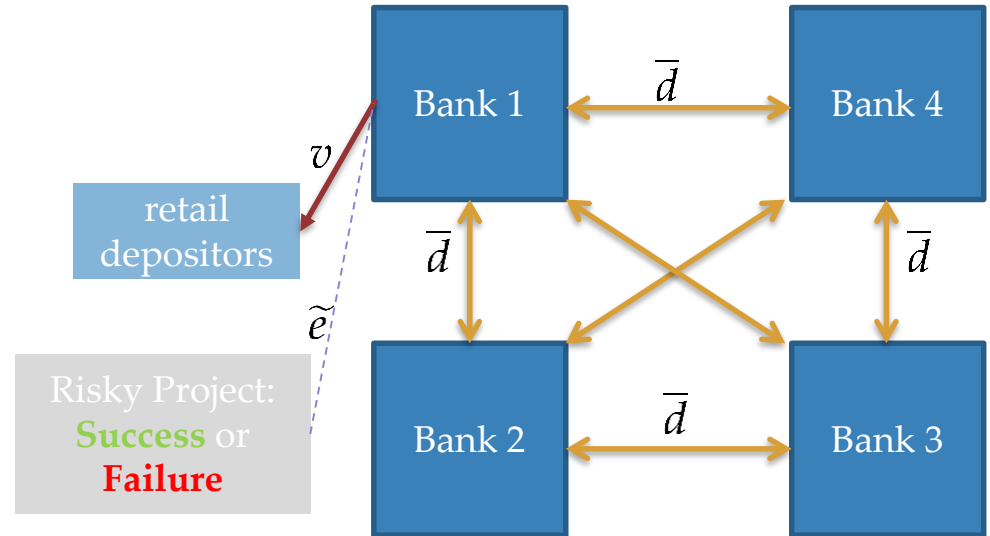
- ▷ Suppose its counterparty, bank j , fails:



Model & Equilibrium

Model

- N banks.
- \bar{d} : total interbank debt.
- v : deposits.
- choose one project, Z_i



$Z_i \in [\underline{Z}, \bar{Z}]$. The project Z_i will produce a random return of \tilde{e}_i

$$\tilde{e}_i = \begin{cases} Z_i & \text{w.p. } P(Z_i) \\ 0 & \text{w.p. } 1 - P(Z_i) \end{cases}$$

Model –continued

- For each state of nature $\omega = (\omega_1, \dots, \omega_N)$, the interbank payment $d^* = (d_1^*, \dots, d_N^*)$ will be determined as:

$$d_i^*(\omega; \mathbf{Z}) = \left\{ \min \left[\underbrace{\sum_j \theta_{ij} d_j^*(\omega; \mathbf{Z})}_{\text{payment inflow}} + \underbrace{e_i(\omega_i, Z_i)}_{\text{project}} - \underbrace{v, \bar{d}}_{\text{deposit}} \right] \right\}^+ \quad \forall i \in \mathcal{N} \quad \forall \omega \in \Omega$$

Limited liability: pay whatever it has or whatever it owes

Model –continued

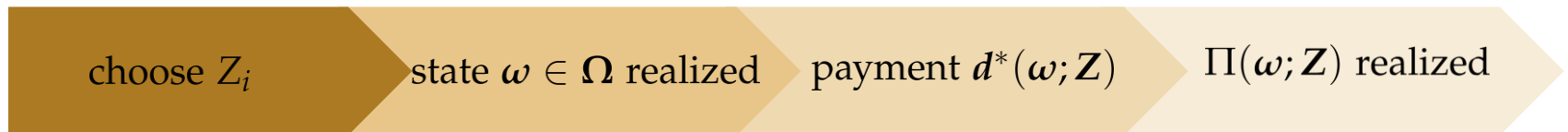
- After the interbank payment, bank i 's profit will be

$$\Pi_i(\omega; \mathbf{Z}) = \left(\underbrace{\sum_j \theta_{ij} d_j^*(\omega)}_{\text{payment inflow}} + \underbrace{e_i(\mathbf{Z}, \omega)}_{\text{project}} - \underbrace{v_i}_{\text{deposit}} - \underbrace{d_i^*(\omega; \mathbf{Z})}_{\text{payment outflow}} \right)^+$$

- From backward induction, each bank chooses its risk exposure Z_i to maximize its expected payoff

$$Z_i^* = \operatorname{argmax}_{Z_i} \mathbb{E} \left[\Pi_i(\omega; Z_i, \mathbf{Z}_{-i}^*) \right] \quad \forall i \in \mathcal{N}$$

Timeline



Choose risk
exposure

Project outcomes
revealed

Interbank
payment

Profit realized

$$Z_i^* = \operatorname{argmax}_{Z_i} \mathbb{E} \left[\Pi_i(\omega; Z_i, \mathbf{Z}_{-i}^*) \right]$$

$$\tilde{e}_i = \begin{cases} Z_i & \text{w.p. } P(Z_i) \\ 0 & \text{w.p. } 1 - P(Z_i) \end{cases}$$

$$d_i^*(\omega; \mathbf{Z}) = \left\{ \min \left[\sum_j \theta_{ij} d_j^*(\omega; \mathbf{Z}) + e_i(\omega_i, Z_i) - v, \bar{d}, \right] \right\}^+$$

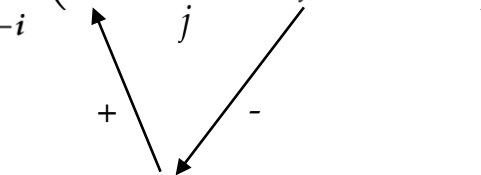
$$\Pi_i(\omega; \mathbf{Z}) = \left(\sum_j \theta_{ij} d_j^*(\omega) + e_i(\mathbf{Z}, \omega) - v_i - d_i^*(\omega; \mathbf{Z}) \right)^+$$

Network Distortion

- ▷ We can rewrite a connected bank's expected payoff into two parts

$$\mathbb{E}[\Pi_i(\omega; \mathbf{Z})] = \underbrace{P(Z_i)(Z_i - v)}_{\text{stand-alone } E(\Pi)} - \underbrace{P(Z_i)\mathcal{D}(\mathbf{Z}_{-i})}_{\text{network distortion}}$$

- ▷ The **network distortion** has a clear interpretation

$$\mathcal{D}(\mathbf{Z}_{-i}) \equiv \sum_{\omega_{-i}} \left(\bar{d} - \sum_j \theta_{ij} d_j^*(\omega^{i=s}) \right) \cdot \Pr(\omega_{-i}) > 0$$


Cross-subsidy to other banks

(-3 of the toy model)

Strategic Complementarity

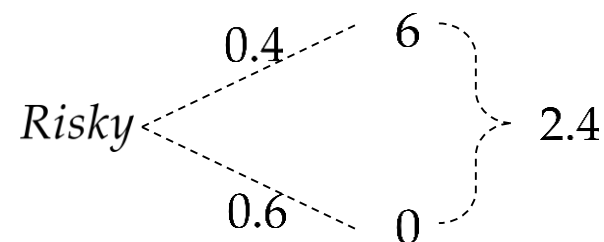
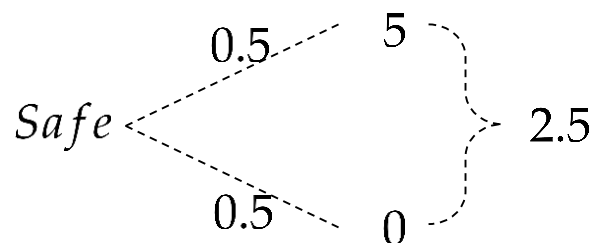
Proposition

The choices of risk exposure \mathbf{Z} are strategically complementary among all banks in the same financial network.

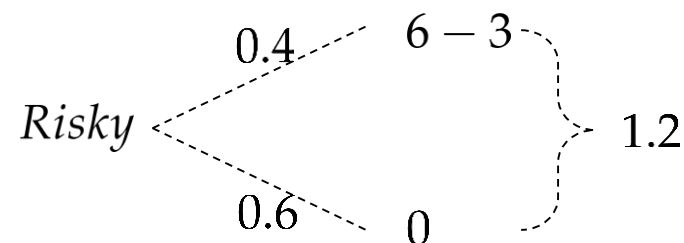
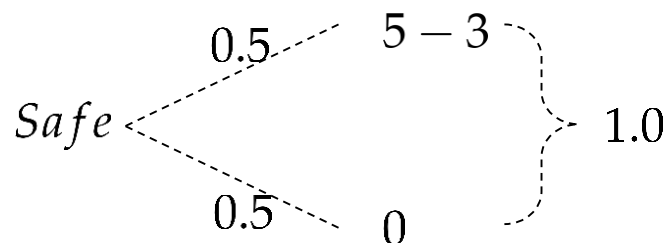
Intuition:

- ▷ If bank j chooses a greater risk, its project will be more likely to fail.
- ▷ When bank j 's project fails, bank i 's cross-subsidies to other banks will increase.
- ▷ Bank i will be less interested in the probability of success when trading off risk and return.

- ▷ When bank j **succeeds** (with probability p_j)



- ▷ When bank j **fails** (with probability $1 - p_j$)



- ▷ Bank i will choose the safe project if

$$2.5 \cdot p_j + 1.0 \cdot (1 - p_j) > 2.4 \cdot p_j + 1.2 \cdot (1 - p_j)$$

$$p_j > 2/3 \quad (\text{bank } j \text{ is safe})$$

Risk-taking Equilibrium

Proposition

*Banks in **any** financial networks will choose greater risks than stand-alone banks.*

- ▷ The only equilibrium is *(Risky, Risky)* in the toy model.
- ▷ “**too connected to fail**”: Besides an ex-post loss contagion (Acemoglu et al. 2015), the interbank network creates an ex-ante moral hazard problem for banks.

Network Structure

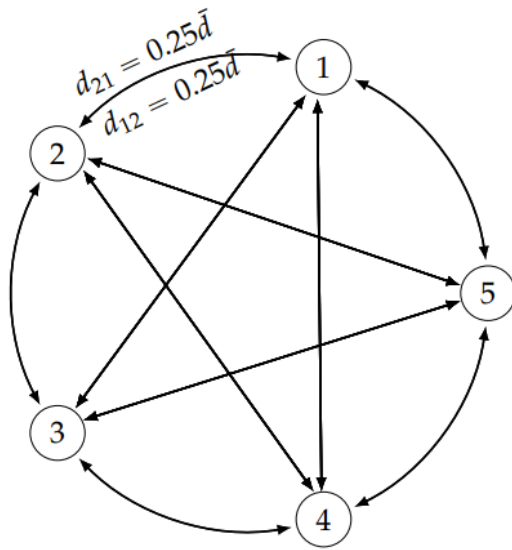
- network completeness

Network Structure

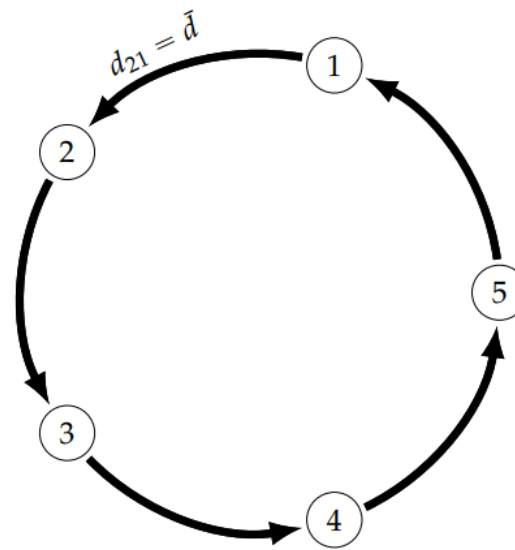
– network completeness

Proposition

Banks' choices of risk exposure Z_i^ are larger in a complete network than in a ring networks.*



(a) complete network



(b) ring network

Network Structure

– network completeness

Proposition

Banks' choices of risk exposure Z_i^ are larger in a complete network than in a ring networks.*

- ▷ In complete networks, each bank is exposed to the risk-taking externality of more other banks.
- ▷ The result stands in sharp contrast to the view of Allen and Gale (2000). They argue that a complete network is better at co-insurance and hence more resilient.
- ▷ But precisely due to this co-insurance, banks have greater risk-taking incentives.

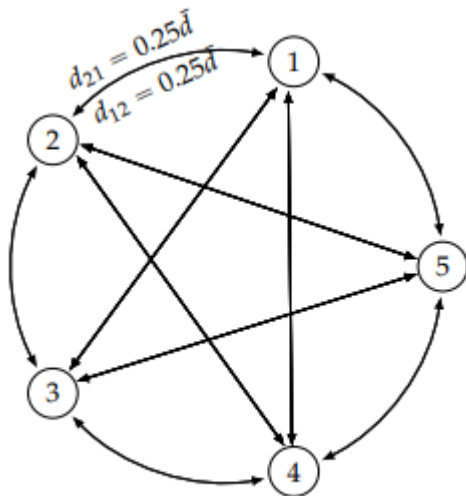
Policies

- Central Clearing Counterparties
- Equity Buffers

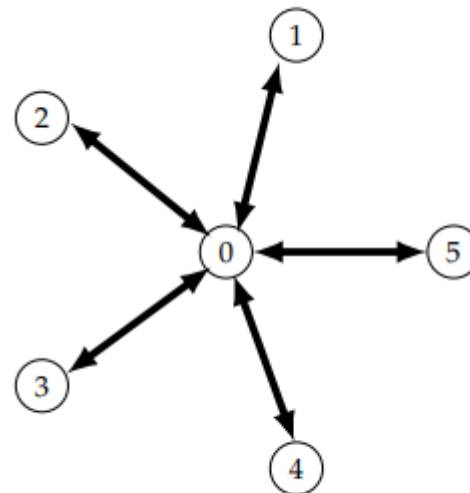
Central Clearing Counterparties

Proposition

In any network structure with a central clearing counterparty, the risk-taking equilibrium is equivalent to that of a complete network.



(a) complete network



(d) core-periphery network

Central Clearing Counterparties

Proposition

In any network structure with a central clearing counterparty, the risk-taking equilibrium is equivalent to that of a complete network.

- ▷ Through the CCP, each bank is forced to connect to every other bank.
- ▷ Banks with a CCP hence becomes exposed to greater risk-taking externalities.
- ▷ A CCP may increase originally loosely connected banks' risk-taking incentives.

Equity Buffer

Proposition

The network risk-taking externality is decreasing in the size of equity buffers.

There are two effects from a bank's equity buffer

$$\mathbb{E} \left[\Pi_i(\omega; \mathbf{Z}) \right] = P(Z_i)(Z_i + r_i - v) - P(Z_i)\mathcal{D}(\mathbf{Z}_{-i}; r_j)$$

Jensen-Meckling Network Effect

Direct effect: banks won't gamble their own equity.

Network effect: the risk taking externality gets reduced.

Equity Buffer

Proposition

The network risk-taking externality is decreasing in the size of equity buffers r .

Intuition:

- ▷ When bank j fails, his equity buffer will be withdrawn to pay his deposits before the co-insurance.
- ▷ The loss that may be otherwise propagated to other banks will now be first absorbed by this equity buffer.
- ▷ As a result, the network risk-taking distortion (-3) is reduced. Bank i will choose less risk exposure.

Summary

- ▷ There exists a network risk-taking externality.
- ▷ Connected banks' choices of risk exposure are higher than stand-alone banks.
- ▷ Particularly for banks in complete networks.

Policy Implications

- ▷ A CCP may increase banks' risk taking incentives.
- ▷ Equity buffer has a network effect and contributes to systemic stability.