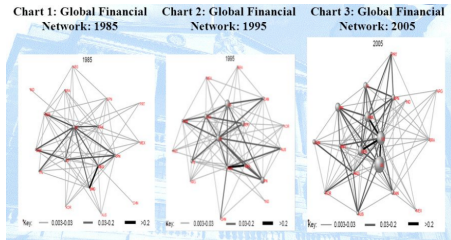# Systemic Credit Freezes in Financial Lending Networks

James Siderius joint with **Daron Acemoglu**, **Asu Ozdaglar**, and **Alireza Tahbaz-Salehi**

Motivation

- By the onset of the financial crisis of 2008, the US financial system had become increasingly more interconnected.

  - ▶ Complex lending relations: interbank and overnight lending, securitized lending such as repo market.
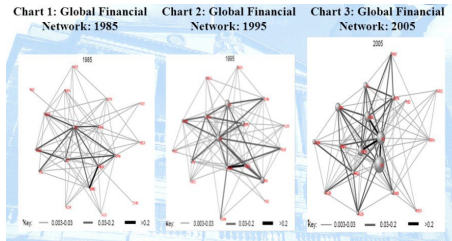
- Failure of an institution may trigger financial distress for its counterparties or those holding its shares.

- Lenders need to also assess creditworthiness of borrowers of the borrower, and so on.

Chart 1: Global Financial Network: 1985   Chart 2: Global Financial Network: 1995   Chart 3: Global Financial Network: 2005

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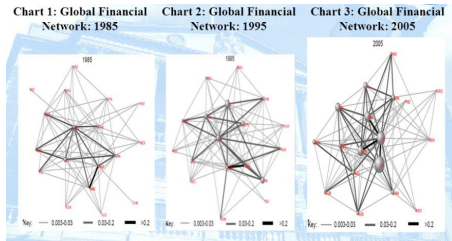
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Ex-Ante vs. Ex-Post

- **Ex-Post Contagion**: The failure of one institution can cause other institutions to fail.

- Ex-Ante Considerations: Credit freezes induced by the fear of future liquidity problems, ex-ante. Profitability of loans might be compromised because of additional perceived *systemic* risk.

"You have a neighbor, who smokes in bed. . .Suppose he sets fire to his house. You might say to yourself. . .'I'm not gonna call the fire department. Let his house burn down. It's fine with me.' But then, of course, what if your house is made of wood? And it's right next door to his house? What if the whole town is made of wood?"

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Chair of Federal Reserve Bank
during the 2008 financial crisis

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  - ex-ante incentives of the banks to make profitable loans
  - endogenous lending contracts and financial network
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Banks, Depositors, and Entrepreneurs

(a) Entrepreneurs ($\mathcal{E}$): Non-financial "bulky" project with return r^* for one unit of investment (\$1).

(b) Depositor ($\mathcal{D} = \{0\}$): Competitive market of depositors with access to outside risk-free technology with return r_0.

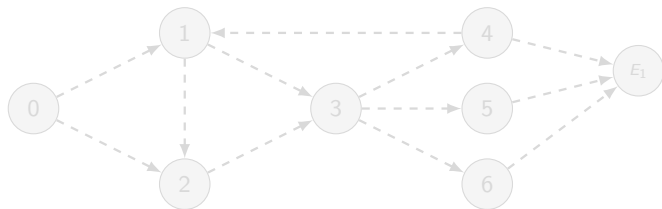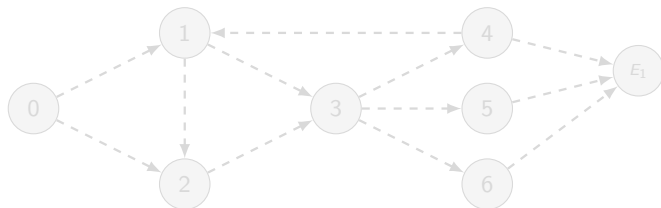(c) Banks ($\mathcal{B} = \{1, \ldots, n\}$): Intermediaries between depositors and entrepreneurs, and each other.

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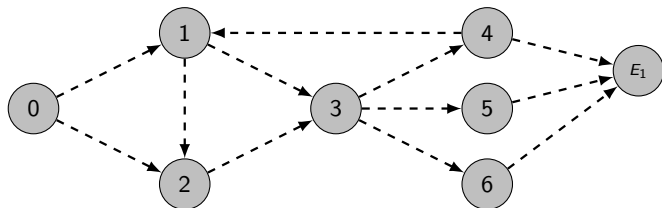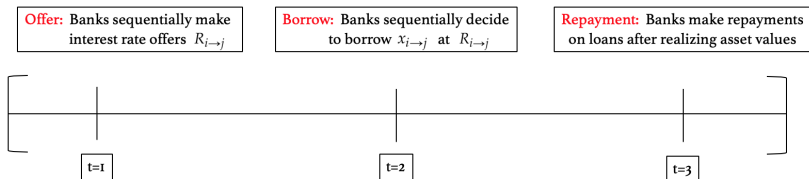(c) Banks ($\mathcal{B} = \{1, \ldots, n\}$): Intermediaries between depositors and entrepreneurs, and each other.

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Timing of Interbank Lending

- Take directed, opportunity network **G** as given. Let $\mathcal{N}_{in}(i)$ and $\mathcal{N}_{out}(i)$ denote the in and out-neighborhood of i, respectively.

- Lending model consists of three stages:

Offer: Banks sequentially make interest rate offers $R_{i \to j}$	**Borrow:** Banks sequentially decide to borrow $x_{i \to j}$ at $R_{i \to j}$	**Repayment:** Banks make repayments on loans after realizing asset values

t=1   t=2   t=3

Repayment Equilibrium

- Take financial network $\mathbf{G}_* = (\mathbf{R}, \mathbf{x})$ as given.

- The (realized) profit of bank j is

Balance Sheet Realization

Loans Owed

$$\pi_j = z_j + \sum_{k \in \mathcal{N}_{out}(j)} y_{k \to j} - \sum_{i \in \mathcal{N}_{in}(j)} R_{i \to j} x_{i \to j}$$

Profit

Repayments Received

- If $\pi_j \geq 0$, the bank is *solvent* and makes full repayment on all its loans, $y_{j \to i} = R_{i \to j} x_{i \to j}$.

- If a bank defaults, it repays nothing. This is known as the total failure model, where bankruptcy liquidation proceeds are zero.

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Lending Equilibrium

- Every bank j maximizes expected upside profit minus a default cost ($F \geq 0$) from bankruptcy, $\mathbb{E}[(\pi_j)_+ - F \cdot d_j]$, subject to the borrowing constraint:

$$\sum_{i \in \mathcal{N}_{in}(j)} x_{i \to j} \geq \sum_{k \in \mathcal{N}_{out}(j)} x_{j \to k}$$

- Weak solution concept: subgame perfect equilibria.

- Strong solution concept: refine subgame perfection to eliminate indifferences; trembling-hand perfect equilibrium for interest rate offers.

- Essential uniqueness: two financial networks $\mathbf{G}_*, \mathbf{G}'_*$ are equivalent if $\mathbf{x} = \mathbf{x}'$ and $R_{i \to j} = R'_{i \to j}$ agree wherever $x_{i \to j} > 0$.

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Strong Equilibrium Properties

Theorem

For any opportunity network **G**:

   (i) *There exists a strong lending equilibrium in* pure strategies.

  (ii) *For a generic probability distribution over* **z**, *the strong lending equilibrium is* essentially unique.

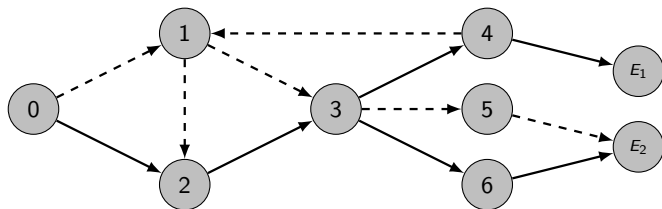 (iii) *Financial network* $\mathbf{G}_*$ *is a directed tree.*
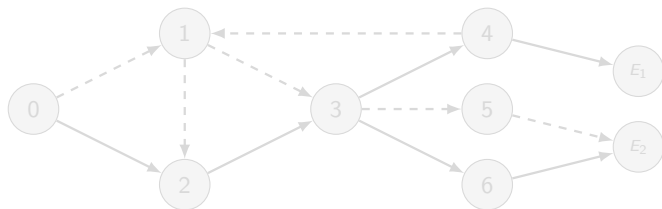
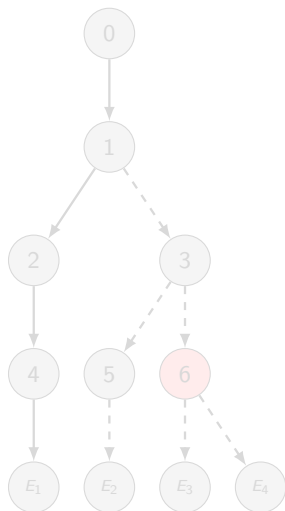Figure: Opportunity Network **G** (dashed) and Financial Network $\mathbf{G}_*$ (solid).

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Simple Freezes

- We say a freeze is simple if we increase the risk of bank i (i.e., decrease the distribution over z_i), and as a result:

  (i) if a bank $j \neq i$ experiences a credit freeze after the risk shift, then bank i does too;

  (ii) the set of banks that experience a credit freeze form a connected subcomponent of **G**.

Proposition

*In a single-entrepreneur economy, or if **G** is a directed tree and the default cost F is not too large, then any risk shift induces only simple freezes.*

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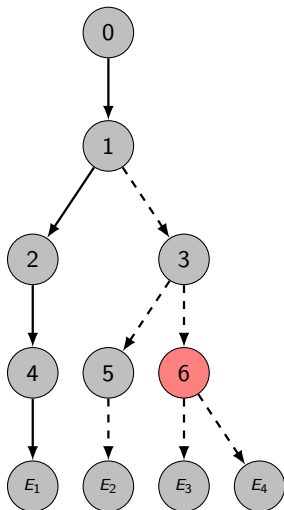
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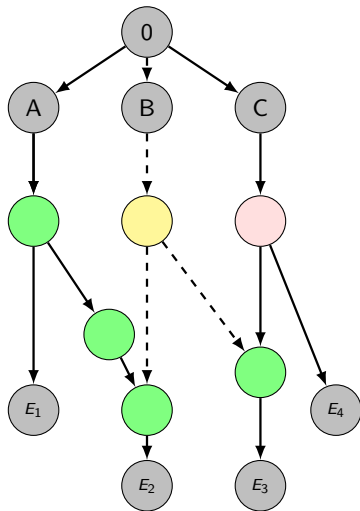
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- Green banks are always safe (realize state **G** with probability 1)
- Small chance yellow and pink banks get **B** return. Assume pink bank is slightly riskier.
- Branch A to E_2 is riskless so is more competitive than branch B.
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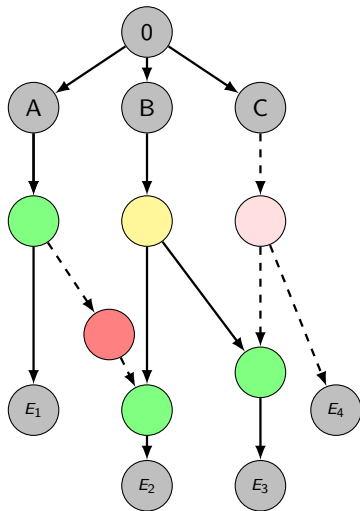
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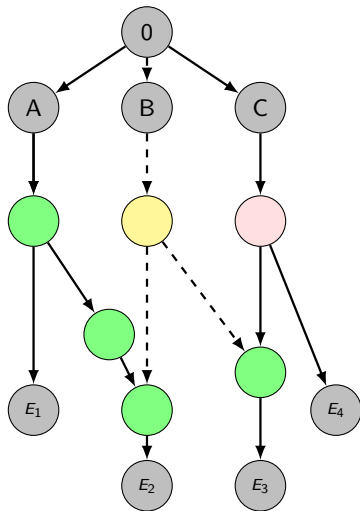
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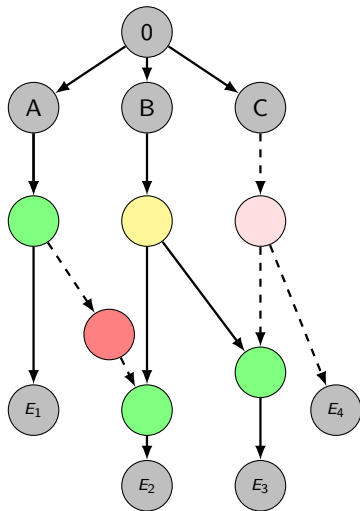
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- Shift risk of bank in branch A (red): realizes state **B** with probability 1 (for simplicity).

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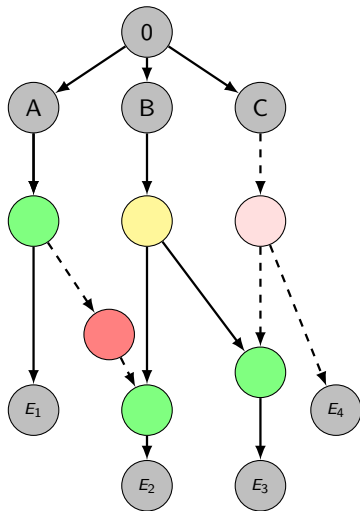
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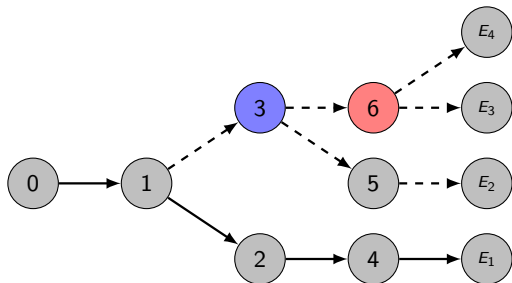 - Entrepreneur 4 loses access to credit, despite a shock to a separate part of the network.

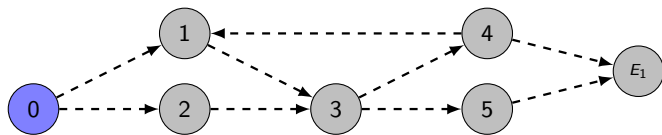# Main Central Bank Policy Findings

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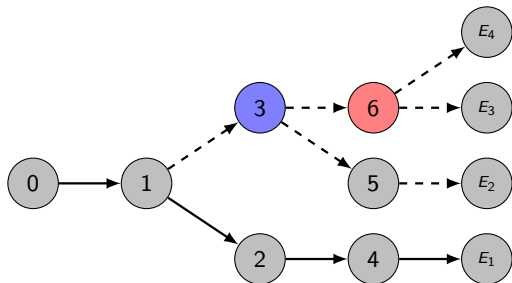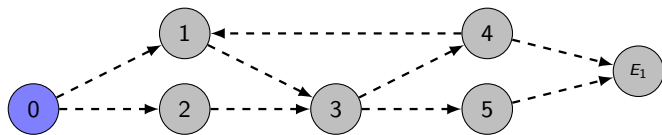
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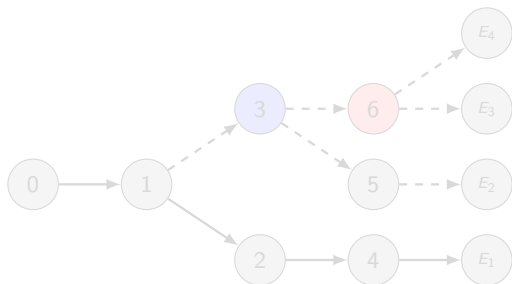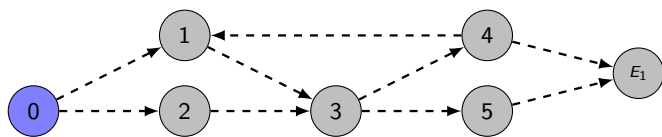
- When the freeze is complex, may be better to target banks unaffected by freezes.

Conclusion

- Extend current work on financial networks: link between ex-post defaults and ex-ante lending considerations.

- Lack of funding because of banks' uncertainty about future solvency:
  - Bear Stearns was in trouble (March 2008) months before the collapse of Lehman Brothers (September 2008).
  - Increasing interconnectedness of financial system caused tightening of credit, as early as August 2007 (Allen and Babus (2008)). Affected large financial institutions and small business alike.

- Extent of credit freeze is highly sensitive to the structure of lending. Ex-ante credit freeze "contagion" can affect remote parts of the network.

- Rescue policy can be effective if the cause of the freezes is well-understood. Policy becomes increasingly more complex as financial system becomes more complex.

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