Fire Sales in a Model of Complexity

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Introduction

- **Fire sales:** Collapse in asset prices during crises increases financial distress at the worst time. Downward spiral.
- **Uncertainty** and **precautionary response:** Might be a key ingredient.

Recent subprime financial crisis:

- A "small" subprime shock generated massive **counterparty risk** and the worst flight-to-quality episode since the Great Depression.
- Why so many unconstrained agents refuse to "arbitrage"?
- Policy: Attempts to break the perverse feedback loop (bailouts, asset price supports).

Need to understand the sources of uncertainty.

Our contribution: A model

- A model of the sudden rise in uncertainty and its interaction with asset fire sales.
- Normal times: Financial institutions (banks) need to only know the financial health of their direct counterparties.
- Distress shock hits the financial system: Need to learn about the health of the counterparties of the counterparties...
- At some point, it becomes too complex (i.e., complicated):
  $\Longrightarrow$ Increase in banks' perceived uncertainty.
  $\Longrightarrow$ Fire sales and credit crunch.

Preview of setup and results

- Financial system is a network of **cross-exposures** (as in Allen and Gale, 2000).

Complexity: Banks are uncertain about cross-exposures (only local knowledge).

- A surprise liquidity shock hits the network.
- This leads to a **partial cascade**.
- When shock is small, cascade short and prices are "fair."
- When shock is larger, cascade longer, perceived uncertainty rises, potential buyers withdraw, prices plummet....
- **Amplification:** Low prices further lengthen the cascade.

- **Policy:** New source of inefficiency: **complexity externality**.

Our contribution: Literature "review"

- Relative to network failures and contagion in financial markets:
  - They focus on workings of cascades. We take these as the reason for the rise in uncertainty. Overcome "limited-size" critique.
- Relative to uncertainty and flight to quality:
  - They focus on the effect of the rise in uncertainty on financial markets. We generate the rise in uncertainty endogenously from the structure of the financial network.
- Relative to fire sales:
  - Panic (due to uncertainty) as the main reason for absence of buyers (as opposed to binding constraints or predatory reasons). Works for large number of potential buyers.

The model: banks face a liquidity-return trade-off

- Dates: $0, 1, 2$ with single good (dollar).

Players: n banks denoted by $\left(b^j\right)_{j=1}^n$.

- Start with a given balance sheet at date 0 (coming up), and care about net worth at date 2.

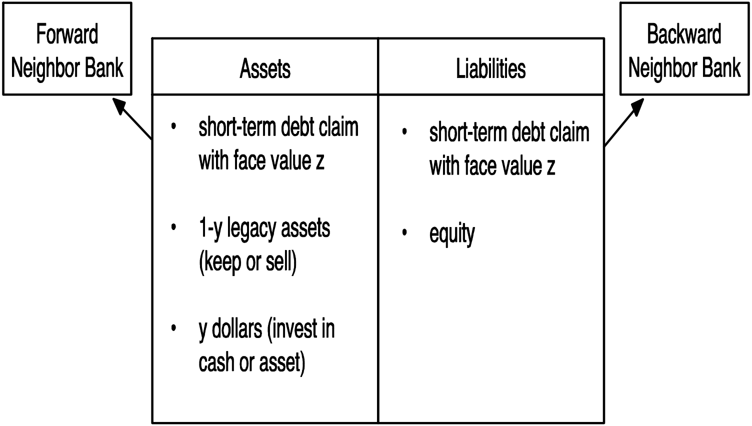
Investment technology:

- Cash: One dollar yields one dollar at the next date.
- **Asset:** Price 1 at primary market at date 0, yields $R > 1$ dollars at date 2. **Asset is illiquid at date** 1.

Secondary market for legacy assets at date 0:

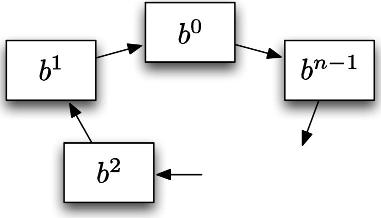
- Natural buyers are other banks.
- Price $p \in [p_{scrap}, 1]$ determined in equilibrium.

Banks' initial balance sheet: Cross-exposures



Cross debt claims capture cross-exposures.

A financial network is an ordering of banks around a circle



(1)

- **Main ingredient (later):** Uncertainty about the ordering. Captures uncertainty about cross-exposures.
- **Benchmark (next):** Banks know the ordering.

The shock: one bank needs additional liquidity

Date 0:

- Banks learn that one bank, b^0, will need θ dollars **at date** 1.
- Each bank takes an action $A_0^j = \{S, B\}$.

Date 1:

- Bank pays $q_1^j \leq z$ on its short term debt.

Date 2:

- Bank pays out net worth, q_2^j.

Bank's objective: Maximize q_2^j subject to meeting debt payment.

Equilibrium definition is standard

Equilibrium: collection $\left\{A_0^j, q_1^j, q_2^j\right\}_j$ and $p \in [p_{scrap}, 1]$, such that banks' actions are optimal and legacy asset market clears.

Useful notation:

- **Distance** from the distressed bank, d.
- **Liquidity need** of a bank with distance d:

$$z - q_1^{d-1} + \theta \left[d = 0\right].$$

- **Available liquidity** of a bank that chooses $A_j = S$:

$$l\left(p\right) = y + \left(1 - y\right) p.$$

Characterization: (i) Partial eq for given p, (ii) General eq.

Partial equilibrium features a partial domino effect

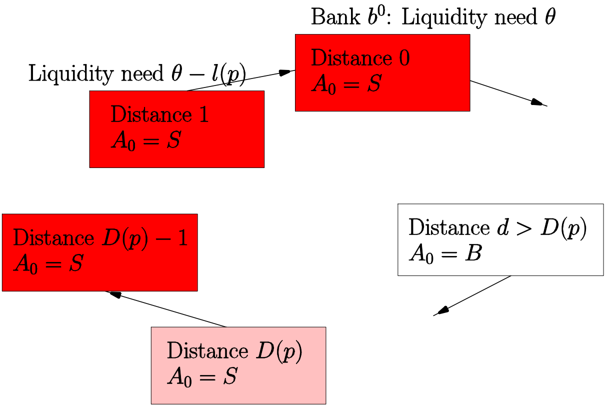
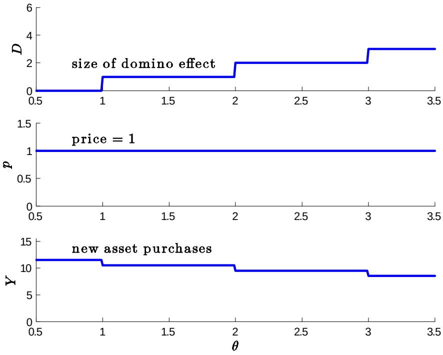


Figure:

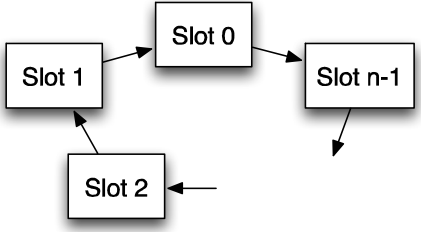
- There is a domino effect of size $D(p) = \left\lceil \frac{\theta}{l(p)} \right\rceil - 1.$

General equilibrium: (i) No fire sales (for ny>theta), (ii) Equilibrium changes "smoothly"



With complexity, these results will dramatically change.

Complexity: Uncertainty about cross-exposures



- Permutation, $\sigma : \{0, 1, .., n-1\} \rightarrow \{0, 1, .., n-1\}$, assigns bank j to slot $i = \sigma(j)$.
- The set of ex-ante possible financial networks:

$$\mathcal{N} = \{\sigma \mid \sigma : \{0, 1, .., n-1\} \rightarrow \{0, 1, .., n-1\} \text{ is a permutation}\}$$

Complexity: Uncertainty about cross-exposures

The set of networks bank j finds possible: $\mathcal{N}^j(\sigma) \subset \mathcal{N}$.

- **No-uncertainty benchmark:** $\mathcal{N}^j(\sigma) = \left\{\sigma^{identity}\right\}$ for all j, σ.

- **Local information (next):**

$$\mathcal{N}^j(\sigma) = \left\{ \tilde{\sigma} \;\middle|\; \begin{array}{c} b^j \text{ is in slot } i \text{ and } b^{forward-neighbor} \text{ is in slot } i-1, \\ \text{where } i = \sigma(j). \end{array} \right\}.$$

Banks know only their forward neighbor.

Knightian over network uncertainty: Bank's action solves:

$$\max_{A_0^j(\sigma)\in\{S,B\}} \min_{\tilde{\sigma}\in\mathcal{N}^j(\sigma)} q_2^j\left(\tilde{\sigma}\right).$$

Not necessary, but appropriate for context.

Equilibrium: collection $\left\{A_0^j\left(\sigma\right), q_1^j\left(\sigma\right), q_2^j\left(\sigma\right)\right\}_{j,\sigma\in\mathcal{N}}$ and $p \in [p_{scrap}, 1]$, such that banks' actions are optimal and legacy asset market clears.

Banks act as if they are closer to the distressed bank than they actually are

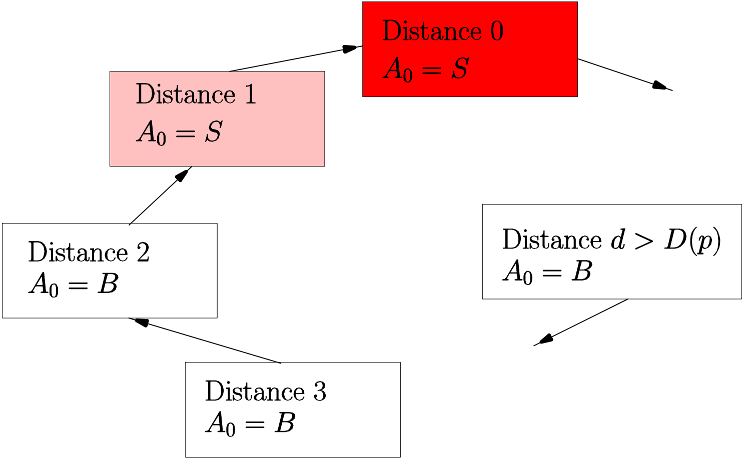
Key observation: A bank does not (necessarily) know its distance.

Max-min: Worst case scenario.

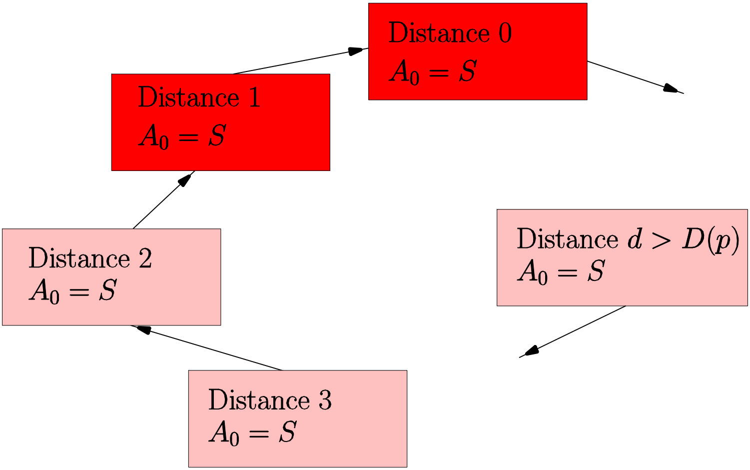
- Banks with $d \leq 1$ know d. Same action as before.
- Banks with $d \geq 2$ find possible all distances $\tilde{d} \in \{2, 3, .., n-1\}$.They act as if $\tilde{d} = 2$**..**

Partial equilibrium: Two cases depending on size of the shock, θ.

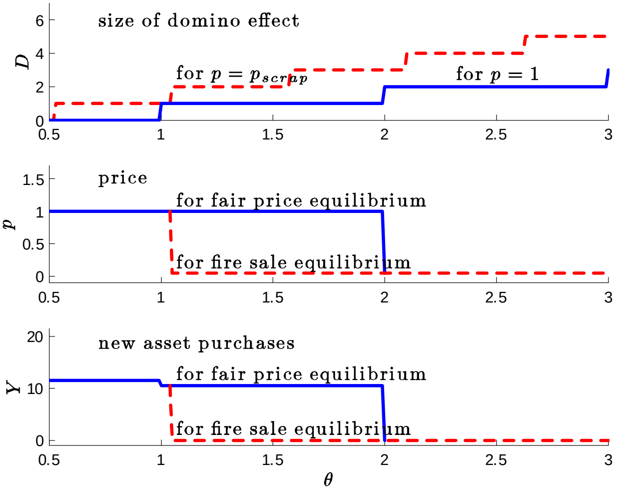
With small shocks, the partial equilibrium is identical to the no-uncertainty benchmark



With slightly larger shocks, there is a complete collapse of the financial system



General equilibrium with complexity: (i) Fire sales, (ii) Equilibrium changes "discontinuously"



The model features a novel "complexity externality"

Complexity externality: Actions that increase D increase payoff uncertainty and lower welfare.

Two versions: Non-pecuniary and pecuniary.

Next: A related externality in a simple example, followed by the two versions of complexity externality.

Non-pecuniary externality in an alternative model

Consider a simple alternative model:

- Agents $i \in I$ (measure one) choose a costly action, $a^i \in \{0, 1\}$.
- Preferences given by $u\left(x^i - ca^i\right)$.
- Variance of each x^i given by $1 - \int_I a^i di$.

Equilibrium: all agents choose $a^i = 0$.

Pareto improvement: For sufficiently small c, all agents choose $a^i = 1$.

Inefficiency: A non-pecuniary (technological) externality.

Nonprice complexity externality and bank bailouts

- Consider the setup with fixed price, p, and domino effect size $D(p) = 2$.
- **Bailout policy:** Suppose each bank can contribute $\left\{0, \frac{\theta}{n}\right\}$ to a bailout fund.

Equilibrium: All banks contribute 0.

Pareto improvement: All banks contribute $\frac{\theta}{n}$. Domino effect is lowered to $D(p) = 0$.

Inefficiency: Nonprice complexity externality. Public good of stability.

Price complexity externality and asset purchases

- Consider the setup with endogenous p and multiple equilibria.
- Suppose the economy is at the fire-sale equilibrium.

Pareto improvement: Floor on asset prices. Coordinates on fair-price equilibrium.

Inefficiency: Price complexity externality.

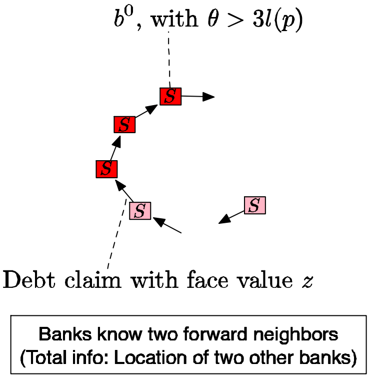
- A bank that sells an asset increases $D(p)$ and raises payoff uncertainty.
- Different than the usual fire-sale externality.

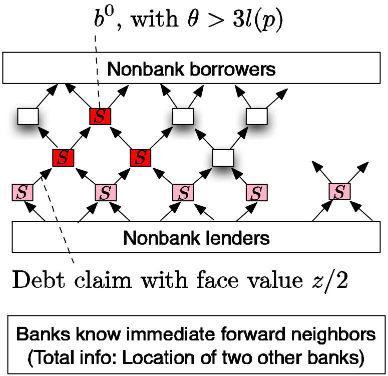
Role of assumptions

Strong assumptions: Zero probability, Knightian uncertainty, circle network (highly incomplete). Are they necessary?

1. **Zero probability:** Stand-in for lack of insurance.
   - Specific insurance: Difficult to obtain, also because of complexity.
   - Blanket insurance (CDS on neighbor): Too expensive. Possibly ineffective due to counterparty risk of the CDS seller.
2. **Knightian uncertainty:** Not necessary (risk aversion also works).
3. **Circle network:** The structure (e.g., completeness) of network is not important role **as long as we control for amount of info**.

Role of network structure: Not important





More complete networks reduce the size of domino effect, but also create greater informational burden on banks.

Taking stock: Cross-exposures and uncertainty

- During severe financial crises the **complexity of the environment** rises dramatically, and this in itself causes **uncertainty** and financial retrenchment.
- We capture the complexity of the environment with cross-exposures and the length of the partial domino effects.
- We also show that complexity and fire sales reinforce each other.
- **Complexity externality** provides plenty of scope for policy.