BDF Tutorials: Network based stress testing

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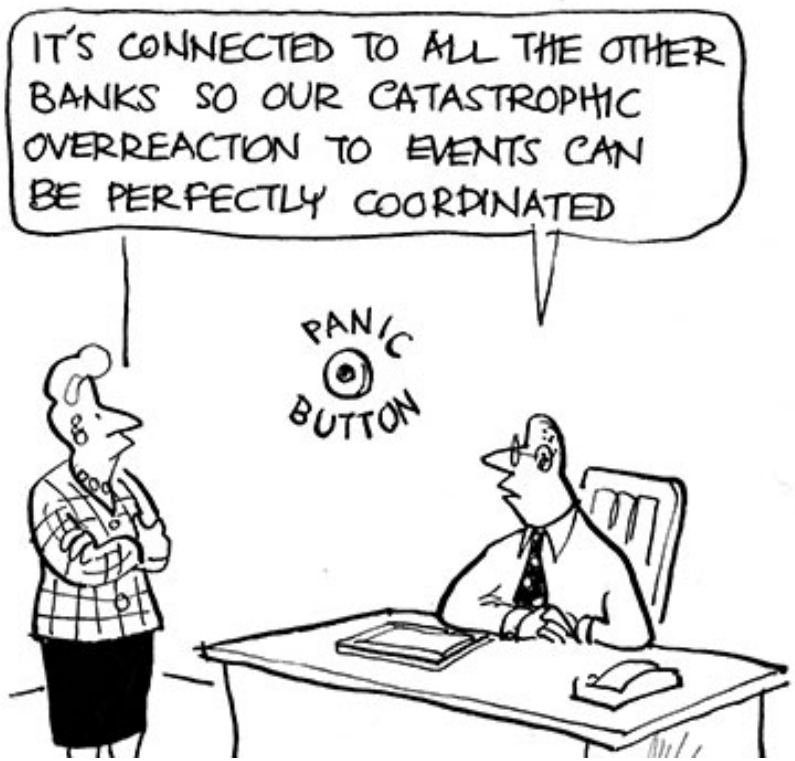
Avoiding coordinated overreaction



Outline

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- Systemic Risk
- Solvency contagion, liquidity contagion, and credit deterioration
- Mechanisms of solvency contagion
  - Ex-post clearing and partial exogenous recovery
  - Ex-post clearing and full endogenous recovery
  - Ex-post clearing and partial endogenous recovery
- Mechanisms of distress contagion
  - Ex-ante local uncertainty and no recovery
  - Ex-ante local uncertainty and endogenous recovery
- Exercises on financial contagion

Systemic risk

Systemic Risk. The risk of a loss involving a large fraction of the financial system and comparable with its total volume.

Financial contagion

Channels of financial contagion that cause systemic risk:

- **Solvency contagion.** The risk of being insolvent caused by a counterparty or by a market loss.
- **Distress contagion.** The risk of credit deterioration caused by a counterparty or by a market loss.
- **Liquidity contagion.** The risk of a lack of liquidity caused by a counterparty or by a market loss.

A general framework for financial contagion

We define a simple financial system composed by a set $\mathcal{B}$ of financial institutions with balance sheets consisting of:

- external assets, $\mathbf{A^{(e)}}$,
- external liabilities, $\mathbf{L^{(e)}}$,
- interbank liabilities. $(L_{ij})_{ij}^{|\mathcal{B}|}$.

Namely $\mathcal{F} = \{\mathcal{B}, \mathbf{A^{(e)}}, \mathbf{L^{(e)}}, (L_{ij})_{ij}^{|\mathcal{B}|}\}$.
Due to financial contagion, the net value of a financial institution, identified with a vector of equities $\mathbf{E}$, depends on the network of financial relations between the institutions.
In particular, for many relevant cases we can write the following:

$$E_i = A_i^{(e)} V^{(e)}(E_i) - L_i^{(e)} + \sum_j A_{ij} V(E_j) - \sum_j L_{ij} \qquad (1)$$

Mechanisms of solvency contagion

Furfine

- It accounts for **ex-post** clearing and **partial exogenous recovery**,
- An insolvent bank is defined by the condition $E_i < 0$
- An insolvent bank repays a fraction R of its liabilities.

$$E_i = A_i^{(e)} - L_i^{(e)} + \sum_j A_{ij} \left(\mathbb{1}_{E_j > 0} + R \mathbb{1}_{E_j \leq 0} \right) - \sum_j L_{ij} \qquad (2)$$

Mechanisms of solvency contagion

Eisenberg and Noe

- It accounts for **ex-post** clearing and **full endogenous recovery**,
- finds p_i, i.e. the payment vector resulting from the clearing procedure,
- defines $\bar{p}_i$ *total interbank liabilities*,
- *relative liabilities matrix*: i's liability to j as proportion of i's total $\Pi_{ij} = L_{ij}/\bar{p}_i$ if $\bar{p}_i > 0$ and $\Pi_{ij} = 0$ otherwise

$$p_i = min \left[\bar{p}_i, \sum_j \Pi_{ji} p_j + A_i^{(e)} - L_i^{(e)} \right] \tag{3}$$

Mechanisms of solvency contagion

Rogers and Veraart

- It accounts for **ex-post** clearing and **partial endogenous recovery**,
- includes, effectively, fire-sales of both external and interbank assets of insolvent banks,
- finds p_i, i.e. the payment vector resulting from the clearing procedure,
- defines $\bar{p}_i$ *total interbank liabilities*,
- *relative liabilities matrix*: i's liability to j as proportion of i's total $\Pi_{ij} = L_{ij}/\bar{p}_i$ if $\bar{p}_i > 0$ and $\Pi_{ij} = 0$ otherwise

$$p_i = min \left[\bar{p}_i, \beta(p_i) \sum_j \Pi_{ji} p_j + \alpha(p_i) A_i^e - L_i^{(e)} \right] \tag{4}$$

Mechanisms of distress contagion

DebtRank

- It accounts for **ex-ante** credit deterioration and effectively considers **no recovery**,
- considers the uncertainty due to solvency risk in the future,
- defines the leverage matrix Λ,
- finds h_i, i.e. the vulnerability vector $\mathbf{h}$, resulting from the DebtRank algorithm.

$$h_i(t+1) = \min \left[1, h_i(t) + \sum_j \Lambda_{ij}(t)[h_j(t) - h_j(t-1)] \right] \qquad (5)$$

Mechanisms of distress contagion

Endogenous DebtRank

- It accounts for **ex-ante** credit deterioration and considers **partial endogenous recovery**,
- considers the uncertainty due to solvency risk in the future,
- defines the stochastic process followed by a bank's counterparties external assets,
- finds a vector of equities which is consistent with a local Merton pricing of the interbank assets,
- converges to the corresponding ex-post model when time to maturity goes to zero.

$$E_i = A_i^{(e)} - L_i^{(e)} + \sum_j A_{ij} \mathbb{E}\left[\left(\mathbb{1}_{E_j^T>0} + \left(1 + \frac{E_j^T}{\bar{p}_j}\right)\mathbb{1}_{E_j^T\leq 0}\right)\middle| E_j\right] - \sum_j L_{ij} \tag{6}$$

Summary

Mechanisms of financial contagion

- Furfine, $V(E) = \mathbb{1}_{E_j>0} + R\mathbb{1}_{E_j\leq 0}$,
- Eisenberg-Noe, $V(E) = \mathbb{1}_{E>0} + (1 + E/\bar{p})\mathbb{1}_{E\leq 0}$,
- Rogers-Veraart,
  $V(E_i, E_j) = (\mathbb{1}_{E_i>0} + \beta\mathbb{1}_{E_i\leq 0})\left[\mathbb{1}_{E_j>0} + (1 + E/\bar{p})\mathbb{1}_{E_j\leq 0}\right]$,
- DebtRank, $V(E) = \frac{E}{E(0)}\mathbb{1}_{E>0} + R\mathbb{1}_{E\leq 0}$,
- Endogenous DebtRank,
  $V(E) = \mathbb{E}\left[\left(\mathbb{1}_{E^T>0} + \left(1 + \frac{E^T}{\bar{p}_j}\right)\mathbb{1}_{E^T\leq 0}\right)\middle| E\right]$,

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