Vulnerable Banks

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Hydraulic models: An ancient tradition in economics

Phillips with his analog computer. Each tank represented some aspect of the UK Economy and the flow of money around the economy was illustrated by coloured water. At the top of the board was a large tank called the treasury. Water flowed from the treasury to other tanks representing the various ways in which a country could spend its money.
Systemic Risk

- Goal: measuring systemic risk with a model that can be brought to the data.
  - Two kinds of linkages:
    - Inter-bank contracts → rare data (yet), lots of papers
    - Deleveraging externalities: → this paper

- What we do:
  - Quasi-structural, extremely stylized, model of liquidation spirals
  - Estimation on actual data:
    - European banks & sovereign risk
    - To measure systemic risk & make policy experiments

- Why focus on deleveraging externalities?
  - Less empirical studies
  - We have data
  - Rise of shadow banks
Intuition: 2 Banks & 2 Assets

**BANK 1**
- **Italian bonds** = 40 bn
- **Spanish bonds** = 10 bn
- **E = 10bn**
- **D = 90bn**

**BANK 2**
- **E = 10bn**
- **Spanish bonds** = 50 bn

**Leverage = D/E = 9**
**Intuition: 2 Banks & 2 Assets**

10% haircut on Italy

<table>
<thead>
<tr>
<th></th>
<th>E = 10-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italian</td>
<td>= 6bn</td>
</tr>
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BANK 1

- Italian bonds: $40 - 4 = 36$ bn
- Spanish bonds: $10$ bn
**Intuition: 2 Banks & 2 Assets**

10% haircut on Italy  →  Leverage of Bank 1 = $90/6 > 9$

### BANK 1

<table>
<thead>
<tr>
<th>Assets</th>
<th>Value</th>
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<tbody>
<tr>
<td><strong>Italian bonds</strong></td>
<td>$40bn - 40% = 36bn$</td>
</tr>
<tr>
<td><strong>Spanish bonds</strong></td>
<td>$10bn$</td>
</tr>
<tr>
<td><strong>Equity (E)</strong></td>
<td>$10bn - 4bn = 6bn$</td>
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<tr>
<td><strong>Debt (D)</strong></td>
<td>$90bn$</td>
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Intuition: 2 Banks & 2 Assets

10% haircut on Italy

➔ Leverage of Bank 1 = 90/6 > 9

➔ To keep same leverage (9), need to sell 9 x 4 = 36 bn of assets

**BANK 1**

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10% haircut on Italy

→ Leverage of Bank 1 = 90/6 > 9

→ To keep same leverage (9), need to sell 9 x 4 = **36 bn of assets**

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**What assets? E.g. Proportionally:**

→ Sell 36/96 = 37.5% of each asset
→ Sell 3.75 Bn of Spanish Bonds
Intuition: 2 Banks & 2 Assets

10% haircut on Italy

→ Leverage of Bank 1 = 90/6 > 9

→ To keep **same** leverage (9), need to **sell** $9 \times 4 = 36$ bn of assets

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• What assets? E.g. Proportionally:

→ Sell $36/96 = 37.5\%$ of each asset
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→ **Price impact on Spanish Bonds**:

$$\lambda \times 3.75$bn = 10e^{-13} \times 3.75$bn = 37.5bp$$
Intuition: 2 Banks & 2 Assets

10% loss on Italy

**BANK 1**

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3.75% loss on Spanish bonds (liquidation impact)

**BANK 2**

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<th>E  = 10bn</th>
<th>D  = 90bn</th>
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<tr>
<td>Spanish bonds</td>
<td>50 bn</td>
<td></td>
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Indirect contamination of Bank 2

Loss on Spain = 3.75% x 50bn = 1.9 Bn
= 19% of equity
Assumptions Needed

- What *amount* of assets do banks liquidate following shock?
  - We assume they liquidate some assets to keep leverage constant
    - No equity issuance

- In what *proportions* do they liquidate assets?
  - We assume they liquidate in proportion of existing holdings
    - Keep assets’ weighting unchanged

- Price impact of fire sales?
  - Assume exogenous Price-Impact ratios:
    - returns proportional to dollar sale (e.g. Amihud ratios)

- *(Model is flexible enough to accommodate more complex rules)*
Three steps

Step #1: From asset shocks to banks dollar losses

Step #2: From bank dollar losses to asset sales

Step #3: From asset sales to banks’ assets
Three steps

Step #1: From asset shocks to banks dollar losses

$ bank Losses_t = - A \times M \times F_t$

Step #2: From bank dollar losses to $ asset sales

$ Asset sales = M' \times B \times $ bank losses_t$

(B = Leverage)

Step #3: From asset sales to banks’ returns

Bank returns_{t+1} = - M \times L \times $ Asset sales

Portfolio weights

Diagonal matrix of liquidity factors (amihud)
What this framework delivers

Empirical measures of how much:

- 1 bank can be hurt by shock ("Direct Vulnerability")
- 1 bank can be hurt by others ("Indirect Vulnerability")
- 1 bank can hurt the others ("Systemicness")
- 2 banks are connected ("Cross vulnerability")
- Overall system is vulnerable ("Aggregate vulnerability")

Can perform policy counterfactuals:
- Systemic risk impact of Bank mergers?
- What happens if we cap size or leverage?
Literature and background: measuring structural risk

- Measuring bank default probability with CDS spreads
  - CDS spread contains counterparty risk $\rightarrow$ bank default probability
  - Ang and Longstaff (2010), Giglio (2011)
- Correlation of stock returns
  - When it is high, portfolios are very similar
    - Billio, Getmansky, Lo, Pelizzon (2010)
  - Bank return conditional on market crash
    - Acharya et al (2011) = vulnerability in our model
  - Market return conditional on bank crash
    - Adrian and Brunnermeier (2011) = systemicness in our model
- Fast growing literature on direct interconnectedness
- Our paper: Structural model
  - Focuses on deleveraging externalities
  - Uses simplified economic behavior
  - Uses data on these behaviors instead of market price movements
Combining the 3 steps

- From bank shock to each Bank

\[ R_{t+1} = -M \times L \times (M'B) \times (AxMxF_f) = (MLM'BAM) \times F_t \]

→ We focus only on 1-period dynamics:

Shock → deleveraging → bank returns
What we can measure

- \( R = (MLM'BAM) \times F \)

- “Indirect Vulnerability” of bank \( n \) = \( n^{th} \) element of \( (AMLM'BAM) \times F \)
  - Normalize by bank \( n \) equity
  - Careful: different from “direct vulnerability” AMF
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- "Systemicness" of bank \( n \) = \( 1' \times (MLM'BA\delta_nM) \times F \)
  - Normalize by aggregate bank equity
  - where \( 1 = \) vector of ones & \( \delta_n = \) matrix of zeros with only \((n,n)\) element=1
  - Different from indirect vulnerability
  - Big if \( n \) is levered, owns same assets as others, is big, is exposed
What we can measure

- $R = (MLM'BAM) \times F$

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- **“Aggregate systemicness”** = $1' \times (AMLM'BAM) \times F$
  - Sum of individual banks’ “systemicnesses”
Systemicness: decomposition

Connectedness x Size X Leverage X Direct Exposure

\[ S(n) = \gamma_n \times \left( \frac{a_n}{E_1} \right) \times b_n \times r_{n1}, \]

\[ \gamma_n = \sum_k \left( \sum_m a_m m_{mk} \right) l_k m_{nk}, \]

Bank holds illiquid assets that are held in large quantities by others
Some Intuition: Diversification can be bad

- Assume: 2 banks, identical leverage and 2 assets
- Which is best for “aggregate systemicness”?
  - Both banks have identical portfolios?
  - Or each bank owns 100% of one asset?

- Two opposing effects: Spreading volatile asset across banks
  - less average dollar liquidations of that asset
  ...But now some of the other asset will get liquidated

→ Diversification good when stable assets is the most liquid
Some Intuition: Too big to Fail?

- Cut a bank into 2 banks of **similar asset weights and leverage**: 

  ![Diagram showing a bank being cut into two smaller banks](image)

- **Effect of “slicing” bank on “Aggregate Systemicness”: NONE**
  - Two opposite forces: too big to fail vs too many to fail
  - Formally: the model is scale-free, a by-product of the price impact equation ($ \rightarrow \text{returns}$)
Some Intuition: Mergers

- Merge 2 banks:
  - Heterogeneous assets and leverage

- 2 effects:
  - Portfolio effect → stabilizing if most stable asset is liquid
  - Leverage effect → stabilizing if most levered bank holds more illiquid asset
European Banks

- **M** matrix (portfolio weights)
  - EBA stress tests data (90 largest banks in the EU27; July 2011)
    - Sovereigns, per country
    - Mortgages, commercial real estate, corporate loans, retail SMEs, consumer loans
    - **Sovereigns=13% total assets**

- **B** (leverages), **A** ($ sizes) from Datastream
  - Use book leverage (Can include private banks)

- Shock vector **F**
  - 50% write-down on the 5 GIIPS

- **L = (10e-13) I_d** : Identical liquidity of all assets
  - 10 bn dollar trading → 10 bp return impact
Policy Interventions

- Size cap (€ 500, € 900, € 1300 bn)
  - Bad: contaminates smaller banks
- Debt re-nationalization
  - Good: because GIIPS banks are less levered in our sample
- Merge banks most directly exposed to shock
  - Nothing: our model is scale-free (no ring-fencing effect)
- “Euro-Bond”: mix all euro sovereign debt and re-distribute according to initial total sovereign exposure
  - Bad: increases exposure to GIIPS debt of non GIIPS bank (contamination)
- Cap leverage
  - Good: but requires massive rebalancing: 480bn euros to cap leverage @ 15
Optimal Equity Injections

- Suppose we had \(X\) billion of euros to distribute in equity to banks, in an effort to stabilize system
  - Constraint: we can’t take equity from healthy banks
- How would we distribute this capital?

- Optimal injection in given bank strongly correlated with its systemicness
Conclusion

- **Simple framework**
  - Yields several measures and insights about fragility

- **Key contributions** (relative to other measures):
  - Quasi-structural but highly tractable
  - Isolating specific mechanism (fire sale contagion)
  - Able to perform policy experiments
  - Plasticity:
    - Can plug-in more complex liquidation rules
    - Possibility to estimate M matrix from stock returns

- **Limitations & areas for future work**
  - Build in bank optimization problem

- **Regulation**: through liquidation constraints?