**Definition of Systemic risk**

- **Systemic risk build-up** during (credit) bubble ... and materializes in a crisis
  - contemporaneous measures are inappropriate

- **Spillovers – externalities**
  - Direct contractual: domino effect (interconnectedness)
  - Indirect: price effect (fire-sale externalities)
    - credit crunch, liquidity spirals, haircut

- **Adverse GE response** amplification, persistence
Overview

- **Definition:** Systemic Risk
  - Risk build-up view
  - Spillovers – externalities – propagation

- **Data Collection** – “Risk Topography”
  - with Gary Gorton and Arvind Krishnamurthy

- **Systemic Risk Measurement** – “CoVaR”
  - with Tobias Adrian

- **Regulation:** Systemic Risk Charges
Data collection – “Risk topography”

- Existing data sets
  - Flow of funds – Copeland (1947, 1952), Fed
    - Characterizes money flows within economy
  - Call reports – National Bank Act (1863), FDIC
  - SEC filings

- Problems
  - Not focused on systemic interactions (direct, price effects)
  - Old days: risky position was association w/ initial cash flow
  - Nowadays: risky position is divorced from initial cash flow
  - Leverage is an outdated concept               risk sensitivities
Data collection - different approaches

1. “Catch-all approach”
   - X megabytes – insurmountable task(?)
     - IT firms (like Google/IBM) apply search/network algorithm
   - Complexity
   - Investor response is ignored
     - Owners: deep pocket vs. leveraged investor

2. Two-Step approach – Risk Topography
   - Brunnermeier-Gorton-Krishnamurthy (work in progress)
   - Motivation:
     - Make use of 1000s of highly trained risk managers in financial industry
     - Risk managers are not trained to assess GE effects
     - Reaction function of investors matter (depends on funding structure)
Two-step approach – the idea

- Split into two subtasks
  1. Partial equilibrium response to (orthogonal) stress factors
     a. In value (equity value, enterprise value)
     b. In liquidity index
  2. General equilibrium effects
     - Amplification, multiple equilibria

- Collect long-run panel data set!

Financial industry

Regulators, Academics, Financial industry
Step 1: a) Value + liquidity sensitivity

- Suppose real estate prices decline by 5%, 10%, 15%,

1. Direct “value sensitivity”
   - Risk sensitivity
   - Capture non-linear effects
     (not only delta – partial derivative)

2. Direct “liquidity sensitivity”
   - Helps to figure out reaction of various market participants

\[ \Delta(\text{value, liquidity}) \text{ w.r.t. factors} \]
Liquidity mismatch index (LMI)

Funding liquidity
- Can’t roll over short term debt
- Margin-funding is recalled
Liquidity mismatch index (LMI)

<table>
<thead>
<tr>
<th>A</th>
<th>L</th>
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</thead>
<tbody>
<tr>
<td><strong>Market liquidity</strong></td>
<td><strong>Funding liquidity</strong></td>
</tr>
<tr>
<td>▪ Can only sell assets at fire-sale prices</td>
<td>▪ Can’t <strong>roll over</strong> short term debt</td>
</tr>
<tr>
<td>Ease with which one can raise money by selling the asset</td>
<td>▪ <strong>Margin</strong>-funding is recalled</td>
</tr>
<tr>
<td></td>
<td>Ease with which one can raise money by <strong>borrowing</strong> using the asset as collateral</td>
</tr>
<tr>
<td></td>
<td>Each asset has two values/prices</td>
</tr>
<tr>
<td></td>
<td>1. price</td>
</tr>
<tr>
<td></td>
<td>2. collateral value</td>
</tr>
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**Market liquidity**
- Can only sell assets at **fire-sale prices**

**Measures**
- Not bid-ask spread/volatility
- Price impact in case of crisis (comovement with crisis)
  - “superliquid” gold/Treasuries appreciate in times of crisis

**Funding liquidity**
- Can’t **roll over** short term debt
- **Margin**-funding is recalled

**Measures:**
- Not Haircut/margin
- Haircut/margin increase in case of crisis

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**Liquidity mismatch index (LMI)**

**Maturity mismatch**
### Liquidity mismatch index (LMI)

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<td><strong>Measures</strong></td>
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</tr>
<tr>
<td>Not bid-ask spread/volatility</td>
<td>Not Haircut/margin</td>
</tr>
<tr>
<td><strong>Price impact</strong> in case of crisis (comovement with crisis)</td>
<td>Haircut/margin increase in case of crisis</td>
</tr>
<tr>
<td>“superliquid” gold/Treasuries appreciate in times of crisis</td>
<td>“Goldfield:” HF -&gt; I-banks levered up, but no maturity mismatch (only CPCR)</td>
</tr>
</tbody>
</table>
Calibrating Response function

- We want to know how a firm will respond to a shock that changes value and liquidity
  - Shed risk
  - Hoard liquidity
  - Raise financing
- To determine feedbacks, these responses need to be placed in a general equilibrium
Step 2: General equilibrium modeling

- **Direct** responses to 5%, 10%, 15%, ... drop in factor to
  - Value
  - Liquidity index
- Elicit/predict position response
  - Try to “fire” sell assets or hold out, credit crunch
- Derive likely **indirect** equilibrium response to
  - this stress factor
  - other factors
    - Externalities, multiple equilibria, amplification, mutually inconsistent planes, ...
- Role of cross-scenarios – for nonlinear “cross effect”
Choice of stress scenarios

- **Orthogonal scenarios**
  - Market risk scenarios: Interest rate, credit spread, exchange rate, stock price, VIX, commodity prices, commercial and residential real estate
  - Liquidity risk scenarios: Haircut/margin spikes, can’t issue debt/sell assets, ...
  - Counterparty risk, ...

- **Cross scenarios**
  - Participants report on combination of factors that lead to worst outcome. “Worst vector in ellipse”
  - Informs stress scenario in next round
Difference to repeated SCAP

- Risk topography
  - Response to a list of factors
  - Core stress factors
  - “Core stress factors” don’t change over time
  - **Aim:** create panel data
    - Future research for GE effects
  - All financial institutions (including hedge funds, insurance companies, ...)

- Repeated SCAP
  - Response to a single stress scenario
  - Interlinked stress scenario
  - Stress scenarios change over time
  - **Aim:** best stress analysis at each point in time
  - Focus on main financial institutions
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3. Systemic Risk Measurement

- **Issue 1: procyclicality** – “build-up view of risk”
  - Contemporaneous risk measures are not reliable
  - Rely on other variables

- **Issue 2: externalities** – spillover effects

- **CoVaR method**
  
  \[ \text{CoVaR} = f(\text{frequently observed } X_{t-\tau}) \]

  - Drivers: in cross section: maturity mismatch, leverage, credit
    in time-series: macrovariables, credit growth, VIX,
    risk sensitivities w.r.t. stress factors
  - What is the optimal mix weight one should put on each driver?
    e.g. tradeoff between size and leverage (capital ratio)

Predictive regressions

(1986-2009)
3. Definition: CoVaR

- VaR\(_q^i\) is implicitly defined as quantile
  \[ \Pr(X^i \leq \text{VaR}^i_q) = q \]

- CoVaR\(_q^i|_j\) is the VaR\(_q^j\) conditional on
  institute \(i\) (index) being in distress (i.e., at it’s VaR level)
  \[ \Pr(X^j \leq \text{CoVaR}^i_q|_j \mid X^i = \text{VaR}^i_q) = q \]

- \(\Delta\text{CoVaR}^q_{ji} = \text{CoVaR}^i_q|_j - \text{VaR}^i_q\) normal times

Various conditionings? (direction matters!)

\[ \Delta\text{CoVaR} \]
- **Q1**: Which institutions move system (in a non-causal sense)
  - VaR\(_{\text{system}}^i\) | institution \(i\) in distress

- **Q2**: Which institutions are most exposed if there is a systemic crisis?
  - VaR\(_i^j\) | system in distress

- **Network \(\Delta\text{CoVaR}\)**
  - VaR of institution \(j\) conditional on \(i\)

- **Asset by asset \(\Delta\text{CoVaR}\)**
3. Network CoVaR

- conditional on origin of arrow
3. $\Delta \text{CoVaR and VaR in cross-section}$

$\Delta \text{CoVaR vs. VaR - Returns}$

- VaR does not capture systemic risk contribution
  $\Delta \text{CoVaR}_\text{contri}$

Data up to 2006/12

- Commercial Banks
- Investment Banks
- Insurance Companies
- GSEs
## ΔCoVaR Forecasts: 1-Year Horizon (Table 3B)

<table>
<thead>
<tr>
<th>COEFFICIENT</th>
<th>1%</th>
<th>5%</th>
<th>10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>VaR (lagged)</td>
<td>0.041***</td>
<td>0.073***</td>
<td>0.073***</td>
</tr>
<tr>
<td>Leverage (lagged)</td>
<td>-0.132***</td>
<td>-0.141***</td>
<td>-0.077***</td>
</tr>
<tr>
<td>Maturity mismatch (lagged)</td>
<td>-13.319***</td>
<td>-7.921***</td>
<td>-5.281***</td>
</tr>
<tr>
<td>Relative size (lagged)</td>
<td>-5.961***</td>
<td>-2.800***</td>
<td>-2.079***</td>
</tr>
<tr>
<td>2-year asset growth (lagged)</td>
<td>-0.249</td>
<td>-0.285***</td>
<td>-0.198***</td>
</tr>
<tr>
<td>Foreign</td>
<td>-4.004**</td>
<td>-0.821</td>
<td>-0.530</td>
</tr>
<tr>
<td>Investment Bank FE</td>
<td>2.911***</td>
<td>7.982***</td>
<td>5.925***</td>
</tr>
<tr>
<td>Insurance Company FE</td>
<td>-14.081***</td>
<td>-1.548***</td>
<td>-0.109</td>
</tr>
<tr>
<td>Real Estate FE</td>
<td>11.454***</td>
<td>17.370***</td>
<td>14.345***</td>
</tr>
<tr>
<td>Constant</td>
<td>-25.262***</td>
<td>-23.999***</td>
<td>-19.666***</td>
</tr>
</tbody>
</table>

| Observations                       | 9787       | 9787       | 9787       |
| R²                                 | 0.540      | 0.739      | 0.755      |
4. Translation into systemic risk charges

- **Suppose**
  - 8% microprudential capital requirement = leverage \(< 12.5 : 1\)
  - Focus on 5% CoVaR, 1 year in the future

- **Size-leverage tradeoff**
  - Small bank with 5% market share has 8.0% capital requirement
  - Large bank with 10% market share has 8.7% capital requirement

- **Maturity mismatch-leverage tradeoff**
  - Bank with 50% MMM has 8.0% capital requirement
  - Bank with 55% MMM has 10.3% capital requirement,
    
    where MMM = (short-term debt – cash) / total assets

- **Tax-base for “bank levy”** can be based on same analysis
4. Macro- vs. micro-prudential regulation

- **Fallacy of the Composition:** what’s micro-prudent need not be macro-prudent

<table>
<thead>
<tr>
<th>Balance sheet</th>
<th>action</th>
<th>micro-prudent</th>
<th>macro-prudent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset side</td>
<td>(fire) sell assets</td>
<td>Yes</td>
<td>Not feasible in the aggregate</td>
</tr>
<tr>
<td></td>
<td>no new loans/assets</td>
<td>Yes</td>
<td>Forces others to fire-sell + credit crunch</td>
</tr>
<tr>
<td>Liability side</td>
<td>(raise long-term debt)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>raise equity</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- Micro: based on risk in isolation
- Macro: Classification on systemic risk contribution measure, e.g. CoVaR
- Ratios versus Dollars
Conclusion

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