SYSTEMIC RISK MONITORING

Markus K. Brunnermeier

- Chicago Fed – IMF conference -
**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  - Leverage is an outdated concept  risk sensitivities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

- Collect long-run panel data set!

- ... reaction function

2. General equilibrium effects
   - Amplification, multiple equilibria

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</td>
<td>- Can’t <strong>roll over</strong> short term debt</td>
</tr>
<tr>
<td><strong>fire-sale prices</strong></td>
<td>- <strong>Margin</strong>-funding is recalled</td>
</tr>
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</table>

Ease with which one can raise money by **selling** the asset

Ease with which one can raise money by **borrowing** using the asset as collateral

Each asset has two values/prices

1. price
2. collateral value
Liquidity mismatch index (LMI)

**Market liquidity**
- Can only sell assets at fire-sale prices

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

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

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

Maturity mismatch
### 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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**“Goldfield:”** HF -> I-banks levered up, but no maturity mismatch (only CPCR)
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

- Future research for GE effects
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- **Regulation:** Systemic Risk Charges
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:
- Only indirect
- Not at high frequency

(1986-2009)
3. Definition: CoVaR

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

- CoVaR$_{q}^{j|i}$ is the VaR$_{q}^{j}$ conditional on institute $i$ (index) being in distress (i.e., at its VaR level)
  \[ \Pr(X^j \leq \text{CoVaR}^j_{q} | X^i = \text{VaR}^i_q) = q \]

- \( \Delta \text{CoVaR}^{j|i} = \text{CoVaR}^{j|i} - \text{VaR}^j_i \) normal times

Various conditionings? (direction matters!)

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

- Exposure \( \Delta \text{CoVaR} \)
  - Q2: Which institutions are most exposed if there is a systemic crisis?
  - VaR$^i |$ system in distress

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

- Asset by asset \( \Delta \text{CoVaR} \)
  - in non-causal sense!
3. Network CoVaR

- conditional on origin of arrow
3. \( \triangle \text{CoVaR and VaR in cross-section} \)

\[ \Delta \text{CoVaR vs. VaR - Returns} \]

VaR does not capture systemic risk contribution \( \triangle \text{CoVaR}_{\text{contri}} \)

Data up to 2006/12
**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>
<tr>
<td>Observations</td>
<td>9787</td>
<td>9787</td>
<td>9787</td>
</tr>
<tr>
<td>R²</td>
<td>0.540</td>
<td>0.739</td>
<td>0.755</td>
</tr>
</tbody>
</table>
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>
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- Micro: based on risk in isolation
- Macro: Classification on systemic risk contribution measure, e.g. CoVaR
- Ratios versus Dollars
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