Risk Topography

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PRINCETON AND NBER, YALE AND NBER, NORTHWESTERN AND NBER
Objective

- Tools and data needed for assessing systemic risk
- Supervisory efforts currently underway
  - Fed stress tests (SCAP)
  - Proposed Office of Financial Research (OFR)
    - What data should be collected?
Defining Systemic Risk

- Systemic risk builds-up in a period of low volatility
- Materializes when negative shock hits susceptible financial sector balance sheets
- Spillovers
  - Direct contractual: domino effect (interconnectedness)
  - Indirect: price effect, credit crunch, liquidity hoarding, haircut/margin increases
  - System wide dislocations due to collection partial equilibrium responses
  - Unknown risk pockets/concentrations, crowded trades
  - Endogenous multiplier effects
    - Externalities, multiple equilibria, disequilibrium, ...

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Defining Systemic Risk

- Systemic risk describes a possible adverse general equilibrium response of the financial system to a shock

- What data do we need to diagnose when the financial system is susceptible to adverse feedback loops?
1. Two challenges for systemic risk measurement
   - Existing data offers poor proxies for risk and liquidity.
   - Systemic risk is about a general-equilibrium feedback. Need a model-based interpretation of data.
   - Motivating examples.

2. Risk topography

3. Uses of data to manage systemic risk
   - Regulatory use
   - Private sector use in risk management

4. Comparisons
Example 1: Liquidity Risk

- Firm with $20 of equity and $80 of debt
- Some of the debt is overnight repo financing at one percent and the other half is 5-year debt at 4.5 percent.
- The firm buys one Agency mortgage-backed security for $50 (which is financed via repo at a 0% haircut)
- Loans $50 to a firm for one year at an interest rate of 5 percent.

- Liquidity risk: What if the firm cannot renew financing?
- Leverage is a crude measure...
Example 2: More Liquidity Risk

- Firm with $20 of equity and $80 of debt
- Some of the debt is overnight repo financing at one percent and the other half is 5-year debt at 4.5 percent.
- The firm buys one Private-label mortgage-backed security for $50 (which is financed via repo at a 0% haircut)
- Loans $50 to a firm for one year at an interest rate of 5 percent.

- The asset-side is less liquid
- More liquidity mismatch in this example
Example 3: Derivatives

- Firm with $20 of equity and $80 of debt
- The firm buys $100 of U.S. Treasuries
- Writes protection on a diversified portfolio of 100 investment-grade U.S. corporates, each with a notional amount of $10; so there is a total notional of $1,000. The weighted-average premium received on the CDS is 5 percent.

- Risk measurement problem: Derivatives...
- Liquidity measurement problem: Dynamic collateral calls are a liquidity drain.
Example 4: Rehypothecation

- Dealer starts with $10 of equity, invested in $10 of Treasuries
  - Initially no leverage
- Dealer lends $90 to a hedge fund against $90 of ABS collateral in an overnight repo
- Dealer posts $90 of ABS collateral to money market fund, to borrow $90 in an overnight repo

- Leverage = 9X
- But, little asset risk; little liquidity risk
- What if hedge fund loan was 10 days? Liquidity falls...
Example 5: Crowded Trade

- Two identical banks: $20 equity, $80 debt
- Half the debt is overnight repo.
- Each bank owns $50 of private-MBS, $50 of Treasuries
- Risk management: Bank can withstand losses if MBS prices fall by 5%, but if they fall by more, the bank will sell MBS/hedge exposure in ABX.

**Issue:** Risk management in general equilibrium
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

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Financial Industry, Risk Managers

Regulators, Academics, Financial industry

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Risk Topography
Example

- Date 0: measurement date
- Date 1: Possible crisis. State $\omega \in \Omega$
- Firm i
  - (A)ssets: Securities/loans, derivatives, repo loans, cash
  - (L)iabilities: short-term debt, long-term debt, equity
- Measure value and liquidity of each firm in each possible state
  - Why? Most theoretical analyses of feedback mechanisms map value (e.g., capital) and/or liquidity into decisions.
Two-Factor Example

• Focus on “risk factors” and “liquidity factors”
  o N possible date 1 real estate prices (risk factor)
  o M possible date 1 repo haircuts (liquidity factor)
  o States s = M X N matrix
• Elicit information on value and liquidity for orthogonal movements in each factor
• *Ideally, this measurement is as close to current risk management practice as possible*
• Plus select cross-factors
Value

- Value = A(s)
- Equity value = A(s) – L(s)
- Suppose real estate prices decline by 5%, 10%, 15%,...; suppose margins double, triple, ...

- Non-linear effects in choice of scenarios
Liquidity Mismatch Index (LMI)

<table>
<thead>
<tr>
<th>A</th>
<th>L</th>
</tr>
</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 <strong>selling</strong> the asset</td>
<td>• Margin-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>
</tbody>
</table>

*Liquidity Mismatch Index* = liquidity of assets minus liquidity promised through liabilities

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Risk Topography
### Liquidity Mismatch Index (LMI)

<table>
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<tr>
<td><strong>Asset “liquidity weight”: ( \lambda )</strong></td>
<td><strong>Liability “liquidity weight”: ( \lambda )</strong></td>
</tr>
<tr>
<td>- Treasuries/cash: ( \lambda = 1 )</td>
<td>- Overnight debt: ( \lambda = 1 )</td>
</tr>
<tr>
<td>- Overnight repo: ( \lambda = 1 ) (or close to one)</td>
<td>- Long-term Debt: ( \lambda = 0.5 )</td>
</tr>
<tr>
<td>- Agency MBS: ( \lambda = 0.95 )</td>
<td>- Equity: ( \lambda = 0.20 )</td>
</tr>
<tr>
<td>- Private-label MBS: ( \lambda = 0.90 )</td>
<td></td>
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</table>

\[ LMI = \text{liquidity of assets} - \text{liquidity promised through liabilities} \]

**Basel 3:** Net Stable Funding Ratio, Liquidity Coverage Ratios implicitly assign some \( \lambda \) weights

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Risk Topography
Modeling 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

- Feedbacks when placed in general equilibrium
Data collected from firms

- Two pieces of information
  1. Capital and liquidity in each future stress scenario
  2. Measure of date 0 portfolio choice:
     - $\Delta(\text{value,liquidity})$ with respect to each factor
     - How much risk exposure is the firm taking?
     - How much liquidity exposure is the firm taking?
Calibrating Response Function

- Data presents a history of “date 0”s in varying conditions
  - Each date is a portfolio choice, $\Delta$, as a function of current firm value/liquidity and current state of economy
  - Panel data

- Key feature of our approach: entire history is useful.
General equilibrium modeling

- In each state we know **direct** responses to 5%, 10%, 15%,... drop in factor in terms
  - Value, Liquidity index
- Predict response function
  - Try to “fire” sell assets, hoard liquidity, credit crunch
- Derive likely **indirect** equilibrium response to
  - this stress factor
  - other factors

*Externalities, multiple equilibria, amplification, mutually inconsistent plans,...*

- **Competition among systemic risk models**
Choice of stress scenarios

- **Issue 1**: Need core data to form panel data set on which to calibrate response functions
  - Orthogonal stress scenarios on baseline set of factors
  - Repeated observations
- **Issue 2**: Much of the interest at any time \( t \) is on special cases
  - Correlated scenarios (cross-scenarios)
  - Tailored scenarios (e.g., Greek default)

- Need both ...
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,
  - Counterpart risk ...

- **Cross-scenarios**
  - Participants report on combination of factors that lead to worst outcome. Worst vector in ellipse.
  - Informs stress scenario in next round
Risk and Liquidity Pockets

- Risk measures aggregate across firms and sectors
  - What is sensitivity of a sector to a 10% fall in real estate prices?
  - Aggregate risk equals physical supply of risk

- Liquidity measures aggregate
  - Banking sector is net short liquidity
  - But, to whom, how much, etc.
  - Aggregated firm-level liquidity equals a “liquidity aggregate”

- Note: Measures designed to allow for some cross-checking, like Flow of Funds.
Data revelation – “financial stability report”

Transparency with delay

- Institutions react
  - Good..., but becomes more risk-taking
- **Data react** (form of Lucas critique)
  - Cross-checks are essential
- Idea:
  - Competition for best model among researchers in regulatory institutions, academia and financial industry
  - Improve models over time
    - e.g. call reports helped to understand commercial banks
Externality Regulation

- Externality regulation
- Described systemic risk-states are once subject to underinsurance
  - E.g. Caballero-Krishnamurthy
- How much is optimal insurance?
- How can we implement optimum?
Other issues

- Horizontal cross-check across institutions
  - Compare valuation models
- Complexity/simplicity
  - Standardization – more correlation
  - Hiding risks
- Snapshots versus average (quarter/year end spikes)
- Close cooperation with Fed
Different approaches to data collection

1. “Catch-all approach”
   - X terabytes in each second – insurmountable task(?)
     - IT firms (like Google/IBM) apply search/network algorithm
   - Complexity
   - Ownership of asset and hence investor reaction matters
     - deep pocket vs. leveraged investor

2. Our 2-Step approach – Risk Topography
   - Motivation:
     - Make use of 1000s of highly trained risk managers in financial industry
     - Risk managers are not trained to assess GE effects
     - Systemic risk is about GE effects
Data collection – existing data sets

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

• **Problems**
  o Not focused on systemic interactions (direct, price effects)
  o Old days: risky position was association w/ initial cash flow
    Nowadays: risky position is divorced from initial cash flow
  o Leverage is an outdated concept – risk sensitivities
**Difference to repeated SCAP**

### Risk topography
- “Core stress factors” that don’t change over time
- Effect from tailored scenario
- **Aim:** Describe GE feedback effects important in systemic risk
  - Create panel data to estimate GE effects
- All financial institutions (including hedge funds, insurance companies, ...)

### Repeated SCAP
- Single interlinked stress scenario
- Stress scenarios change over time
- **Aim:** Partial equilibrium stress analysis at each point in time
- Focus on main financial institutions
Summary

- Risk taking and initial cash flows are divorced
  - Flow of funds, Call Reports, outdated
- 2 step approach
  - Partial equilibrium response to risk factors (sensitivities – delta + nonlinear effects)
  - Build up panel data set to estimate response functions
  - General equilibrium modeling (competing models)