Institutional Finance,

Princeton: Department-wide Seminar

Markus K. Brunnermeier
Represent. Agent “Euler Equation Finance”

- No (funding) friction
  - Starting with Lucas ...
  - Perfect aggregation

Financial sector is a veil

Pricing kernel = MRS of representative household
- Modeling: exotic preferences/utility functions + beliefs
- Data source: Consumption

Note: no causality
Funding frictions are at the center of institutional finance. Investors with expertise rely on funding without expertise due to:

- **No aggregation**
- **Market Failure**

Pricing Kernel = Shadow cost of funding (liquidity)

- **Modeling: institutional frictions**
- **Data source: Flow of funds**
Funding and Market Liquidity (with Lasse Pedersen)

- **Funding Liquidity**
  - Ease ... raise funds by using asset as collateral
  - $m^+ x^+ + m^- x^- \leq W$
  - Lagrange multiplier
  - Margins/haircuts can be changed every day
    - Short-term lending

- **Market Liquidity**
  - Ease with which one can raise funds by selling asset
  - Asset price
    - pricing kernel

• Margins
• Haircuts
• **Collateral**
**Liquidity spirals**

- **Loss spiral**
  - same leverage
  - mark-to-market

- **Margin/haircut spiral**
  - delever!
  - mark-to-model

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- Reduced Positions
- Higher Margins
- Losses on Existing Positions
- Funding Liquidity Problems
- Initial Losses e.g. credit
- Market Liquidity Prices Deviate

Brunnermeier-Pedersen (2009)
Margins/haircut spiral - *Procyclicality*

- Margins/haircut increase in times of crisis → delever margin = f(risk measure)

- Two Reasons
  1. Backward-looking estimation of risk measure
     - Use forward looking measures
     - Use long enough data series
  2. Adverse selection
     - Debt becomes more information sensitive (not so much out of the money anymore)

- Credit bubbles
  - whose bursting undermines financial system

- Countercyclical regulation
Margins/haircut spiral - Procyclicality

- Margins/haircut increase in times of crisis ➔ delever margin = f(risk measure)

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  ➔ Countercyclical regulation
Fire-sale externality

- Liquidity Spiral
  - Amplification
  - Fragility
  - Multiple Equilibria

Systemic risk is endogenous

- Precuniary externality + incomplete markets
  - Take on too much leverage/maturity mismatch
  - take fire-sale price as given
  - also in Stiglitz (1982), Geanakoplos-Polemarchakis (1986)

Fire-sales depress price also for others
Other Externalities/Financing Frictions

1. Hoarding
   - Micro-prudent
     - SIV might draw on credit line
     - At the same time interbank market is closed
   - Macro-prudent?

2. Runs – dynamic co-opetition

3. Network Externality
   - Hiding own’s commitment uncertainty for counterparties

See JEP article
Overview

- Institutional Finance
  - Liquidity Spiral: Amplification, Fragility, Multiplicity – with Lasse Pedersen
  - Procyclicality
  - Fire-sale Externality

- Implications for Financial Regulation
  - CoVaR – with Tobias Adrian

- Implications for Monetary Economics
  - Role of financial institutions
  - Maturity Rat Race – with Martin Oehmke
1. Risk of each bank in isolation → Value at Risk

2. Focus on asset side of the balance sheet matter
   - Asset side
     - Asset by asset – risk weighted diversify in off-balance SPV
     - Value at Risk (VaR)
   - Liability side – maturity mismatch gets little attention
Two challenges….

1. Focus on externalities – systemic risk contribution
   - What are the externalities?
   - How to measure contribution to systemic risk?
     - CoVaR influences
       - Who should be regulated? (AIG, …)
       - What is the optimal
         - capital charge (cap),
         - Pigouvian tax
         - Private insurance scheme?

2. Countercyclical regulation
   - How to avoid procyclicality?
     + incorporate liquidity risk – asset-liability interaction
1. **Externality:**
   - Measure contribution of institution to systemic risk: CoVaR
   - Response to current regulation
     “hang on to others and take positions that drag others down when you are in trouble” (maximize bailout probability)
     - become big
     - become interconnected

2. **Procyclicality:**
   - Lean against “credit bubbles” – laddered response
     - Bubble + maturity mismatch impair financial system (vs. NASDAQ bubble)
   - Impose Capital requirements/Pigouvian tax/Private insurance scheme
     - not directly on ΔCoVaR, but on
     - frequently observed factors, like maturity mismatch, leverage, B/M, *crowdedness* of trades/credit, ...
Overview

- Institutional Finance
- Implications for Financial Regulation
  - contribution vs. exposure CoVaR
  - Quantile Regressions
  - Addressing Procyclicality
  - Market variables
- Implications for Monetary Economics
  - Maturity Rat Race – with Martin Oehmke
CoVaR

- CoVaR = VaR conditional on institute $i$ (index) is in distress (at it’s VaR level)

- Exposure CoVaR
  - $Q_1$: Which institutions are most exposed if there is a systemic crisis?
    - $VaR^i | \text{system in distress}$

- Contribution CoVaR
  - $Q_2$: Which institutions contribute (in a non-causal sense)
    - $VaR^{\text{system}} | \text{institution } i \text{ in distress}$

<table>
<thead>
<tr>
<th>Cover both types</th>
<th>Institutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk spillovers</td>
<td>“individually systemic”</td>
</tr>
<tr>
<td>Tail risk correlations</td>
<td>“systemic as part of a herd”</td>
</tr>
</tbody>
</table>

- Non-causal, can be driven by common factor
### Quantile Regressions: A Refresher

- **OLS Regression:** min sum of squared residuals
  \[
  \beta^{OLS} = \arg \min_{\beta} \sum_{t} (y_t - \alpha - \beta x_t)^2
  \]

- **Quantile Regression:** min weighted absolute values
  \[
  \beta^q = \arg \min_{\beta} \sum_{t} \left\{ \begin{array}{ll}
  q |y_t - \alpha - \beta x_t| & \text{if } y_t - \alpha - \beta x_t \geq 0 \\
  1-q |y_t - \alpha - \beta x_t| & \text{if } y_t - \alpha - \beta x_t < 0
  \end{array} \right.
  \]
q-Sensitivities

CS/Tremont Hedge Fund Index
Fixed Income Arbitrage
50%-Sensitivity
5%-Sensitivity
1%-Sensitivity

Fixed Income Arbitrage
50%-Sensitivity
5%-Sensitivity
1%-Sensitivity
Quantiles = - Value-at-Risk

- Quantile regression:
  - Quantile $q$ of $y$ as a linear function of $x$

$$
\hat{y}_q \mid x = F_y^{-1} \quad q \mid x = \alpha_q + \beta_q x
$$

where $F^{-1}(q|x)$ is the inverse CDF conditional on $x$

- Hence, $F^{-1}(q|x) = q\%$ Value-at-Risk conditional on $x$.

  - Note out (non-traditional) sign convention!
CoVaR - using quantile regressions

\[ CoVaR_{ij}^{q} = VaR_{i}^{q} \mid VaR_{j}^{q} = \alpha_{q}^{ij} + \beta_{q}^{ij} VaR_{j}^{q} \]

\[ \Delta CoVaR_{ij}^{q} = CoVaR_{ij}^{q} - VaR_{i}^{q} \]

- **Illustration:**
  - Same individual VaR, but A’s CoVaR > B’s CoVaR
  - Analogy to Covariance in CAPM

- **Various conditionings?**
  1. **Exposure CoVaR:** Individual institution on financial index
     - Who is vulnerable/exposed to?
  2. **Contribution CoVaR:** Financial index on individual institution
     - Who contributes?
  3. **Risk Spillover:** Institution/strategy \( i \) on institution/strategy \( j \)
Data

- (Commercial bank and security broker dealer industry portfolios from Ken French 1926/07-2008/12)
- NYFed primary dealer (US) + GSE: CRSP returns 1986/01-2008/12 (weekly) [equity returns to also capture asset and liability]
  - Commercial banks
  - Investment banks
  - Portfolios sorted in quintiles based on
    - Maturity mismatch, liquidity, size, B/M, cash/asset, equity vol.
- CDS and option data of top 10 US banks, daily 2004-2008

- CSFB/Tremont hedge fund strategies 1994/1-2008/12 (monthly)
  - Long/Short Equity, Global Macro, Event Driven, Fixed Income Arbitrage, Multi-Strategy, Emerging Markets, Equity Market Neutral, Convertible Arbitrage, Managed Futures, Dedicated Short Bias
Overview

- Institutional Finance
- Implications for Financial Regulation
  - CoVaR contribution vs. exposure
  - Quantile Regressions
  - CoVaR versus VaR
  - Addressing Procyclicality
  - Market variables
- Implications for Monetary Economics
  - Maturity Rat Race – with Martin Oehmke
Q1: Who is in distress during systemic crisis?

- VaR and $\Delta \text{CoVaR}_{\text{exp}}$ relationship is very weak
- Data up to 12/07
- Most vulnerable
  - Lehman
  - Morgan Stanley
  - Countrywide
  - Bank of America
  - Bear Stearns
Q2: Who “contributes” to systemic risk?

- VaR does not capture systemic risk contribution \( \Delta \text{CoVaR}_{\text{contri}} \)
- Data up to 2007/12
Overview

- Institutional Finance
- Implications for Financial Regulation
  - contribution vs. exposure CoVaR
  - Quantile Regressions
  - Addressing Procyclicality
    - Time-varying CoVaRs
    - Link to characteristics
  - Market variables
- Implications for Monetary Economics
  - Maturity Rat Race – with Martin Oehmke
Time-varying CoVaR

- Relate to **macro factors**
  - VIX Level
  - 3 month yield
  - Repo – 3 month Treasury
  - Moody’s BAA – 10 year Treasury
  - 10Year – 3 month Treasury
  - (House prices)
  - (Aggregate Credit growth/spread)
  - (Haircut/margins (LTC ratios))
  - *... let’s figure out what matters!*

Interpretation:
- “Volatility”
- “Flight to Liquidity”
- “Credit indicator”
- “Business Cycle”

Obtain Panel data of CoVaR
- Next step: Relate to institution specific (panel) data
## Average factor exposure

<table>
<thead>
<tr>
<th>INSTITUTIONS</th>
<th>PORTFOLIOS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>VaR</strong>&lt;sup&gt;index&lt;/sup&gt;</td>
<td><strong>VaR</strong>&lt;sup&gt;i&lt;/sup&gt;</td>
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<tr>
<td><strong>VIX</strong></td>
<td></td>
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<tr>
<td>-0.20</td>
<td>-0.28</td>
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<tr>
<td>(-2.04)</td>
<td>(-4.93)</td>
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<tr>
<td>3 Month Yield</td>
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<tr>
<td>(1.41)</td>
<td>(-0.97)</td>
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<tr>
<td>Repo spread</td>
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<td>(1.80)</td>
<td>(0.31)</td>
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<tr>
<td>Credit spread</td>
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<tr>
<td>(-0.65)</td>
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<tr>
<td>Term spread</td>
<td>0.15</td>
</tr>
<tr>
<td>(0.40)</td>
<td>(0.21)</td>
</tr>
</tbody>
</table>

Average t-stats in parenthesis
Avoid Procyclicality

- Regulatory charges on $\Delta CoVaR_{contri}$ may introduce procyclicality
  - Like VaR does in Basel II framework
- Way out:
  - Link + predict $\Delta CoVaR_{contri}$ to frequently observed characteristics (use Panel data structure)
    - Maturity mismatch
    - Leverage
    - .... special data only bank supervisors have (e.g. crowdedness)
- Extra:
  - Show that these variable carry information beyond VaR
# Predictive (1 year lag)

## PANEL A: INSTITUTIONS

<table>
<thead>
<tr>
<th></th>
<th>CoVaR(^i)(_{\text{contri}})</th>
<th>CoVaR(^i)(_{\text{exp}})</th>
<th>CoVaR(^i)(_{\text{contri}})</th>
<th>CoVaR(^i)(_{\text{exp}})</th>
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<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
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<tr>
<td>VaR (lag)</td>
<td>0.02**</td>
<td>0.05***</td>
<td>-0.06**</td>
<td>0.03*</td>
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<tr>
<td>Mat-Mism(lag)</td>
<td>-0.30</td>
<td>-0.30</td>
<td>-1.84**</td>
<td>-1.79**</td>
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<tr>
<td>Leverage (lag)</td>
<td>-0.02***</td>
<td>-0.02***</td>
<td>-0.01</td>
<td>-0.02</td>
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<tr>
<td>B/M (lag)</td>
<td>-0.27**</td>
<td>-0.19**</td>
<td>-0.08</td>
<td>0.71***</td>
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<tr>
<td>Size (lag)</td>
<td>9.94</td>
<td>10.61</td>
<td>27.43*</td>
<td>-15.68</td>
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<tr>
<td>Constant</td>
<td>-0.35</td>
<td>-0.65**</td>
<td>-5.04***</td>
<td>-3.84***</td>
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<tr>
<td>Observations</td>
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<td>1657</td>
<td>1657</td>
<td>1657</td>
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<tr>
<td>R-squared</td>
<td>0.66</td>
<td>0.40</td>
<td>0.62</td>
<td>0.48</td>
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</table>
## Predicting with Market Variables

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<tr>
<th>COEFFICIENT</th>
<th>1 Quarter</th>
<th>1 Year</th>
<th>1 Quarter</th>
<th>1 Year</th>
<th>1 Quarter</th>
<th>1 Year</th>
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<th>1 Year</th>
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<th>1 Year</th>
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</thead>
<tbody>
<tr>
<td>CDS(_{\text{beta}}) (lag)</td>
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<td>-0.58**</td>
<td>-1.24***</td>
<td>-2.54***</td>
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<td></td>
<td>(0.05)</td>
<td>(0.23)</td>
<td>(0.39)</td>
<td>(0.85)</td>
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<tr>
<td>(\Delta\text{CDS}) (lag)</td>
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<td>0.06</td>
<td>1.39</td>
<td>-1.28</td>
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<tr>
<td></td>
<td>(0.17)</td>
<td>(0.68)</td>
<td>(1.10)</td>
<td>(2.20)</td>
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<tr>
<td>IV(_{\text{beta}}) (lag)</td>
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<td>-0.67***</td>
<td>-1.75***</td>
<td>-3.33**</td>
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<td>(0.18)</td>
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<tr>
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<td>-0.05</td>
<td>-0.77***</td>
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<td>(0.28)</td>
<td>(0.19)</td>
<td>(0.59)</td>
<td>(1.04)</td>
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<tr>
<td>Constant</td>
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<td>-1.28***</td>
<td>-1.13***</td>
<td>-1.15***</td>
<td>-4.65***</td>
<td>-4.82***</td>
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<td>4.20***</td>
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<tr>
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<td>(0.07)</td>
<td>(0.07)</td>
<td>(0.08)</td>
<td>(0.15)</td>
<td>(0.24)</td>
<td>(0.17)</td>
<td>(0.52)</td>
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<td>Observations</td>
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<td>178</td>
<td>148</td>
<td>178</td>
<td>148</td>
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<tr>
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<td>0.59</td>
<td>0.54</td>
<td>0.55</td>
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<td>0.71</td>
<td>0.68</td>
<td>0.72</td>
<td>0.65</td>
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</tbody>
</table>

1) beta w.r.t. first principal component on changes in CDS spreads within quarter
2) panel regression with FE – (no findings with FE+TE)
<table>
<thead>
<tr>
<th>COEFFICIENT</th>
<th>VaR_index</th>
<th>VaR_index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 Year</td>
<td>1.5 Years</td>
</tr>
<tr>
<td></td>
<td>1 Year</td>
<td>1.5 Years</td>
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<tr>
<td>Fitted CoVaR_contrib (lag)</td>
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<td>6.43***</td>
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<td></td>
<td>(1.91)</td>
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<td>Resid CoVaR_contrib (lag)</td>
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<td>0.52</td>
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<td></td>
<td>(0.40)</td>
<td>(0.41)</td>
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<tr>
<td>Fitted CoVaR_exp (lag)</td>
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<td></td>
<td>0.75</td>
<td>0.51</td>
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<td></td>
<td>(1.42)</td>
<td>(1.34)</td>
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<tr>
<td>Resid CoVaR_exp (lag)</td>
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<tr>
<td></td>
<td>2.94***</td>
<td>3.95***</td>
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<td>(0.57)</td>
<td>(0.54)</td>
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<tr>
<td>VaR_index (lag)</td>
<td>0.30**</td>
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<td>(0.12)</td>
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<td>(0.32)</td>
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</tbody>
</table>
Overview

- Institutional Finance
- Implications for Financial Regulation – CoVaR
  - Macro-prudential regulation
    - Focus on externalities
    - Measure for systemic risk is needed, e.g. CoVaR
    - Maturity mismatch (+ Leverage) – encourage long-term funding
  - Countercyclical regulation
    - Find variables that predict average future CoVaR
    - Forward-looking measures, spreads, ...
- Implications for Monetary Economics
  - Role of financial institutions
  - Maturity Rat Race
**Implications for Monetary Economics**

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price stability</td>
<td>Target rate (money supply)</td>
</tr>
<tr>
<td>Financial stability</td>
<td>Liquidity policy</td>
</tr>
</tbody>
</table>

- **Monetary Transmission**
  - Target rate (short-term)
  - Effective rate (short-term)
  - Corporate lending rate

- **Liquidity policy**
  - *Narrow*: Hold short-term rate close to target
    - Reduce term risk premium
  - *Broad*: financial stability to ensure transmission
    - Reduce term and credit risk premium

*Need to understand the role of financial institutions first*
Role of Financial Institutions

- **Project/asset selection**
  - Informational advantage (Sharpe, Rajan)

- **Create info-insensitive securities** (Gorton-Pennachi)
  - Pool and tranch in order to reduces lemon’s problem

- **Maturity transformation**
  Why short-term (debt) funding?
  - Liquidity shock insurance (Diamond-Dybvig)
    - maturity tranformation is *good*, but bank run caveat
  - Incentivize management (Calomiris-Kahn)
    - Maturity mismatch is *good*
  - **Maturity rat race** (with Martin-Oehmke)
    - Maturity mismatch is *bad*
The Maturity Rat Race

- Leads to a unraveling to short-term debt
- Friction with multiple creditors with differing maturities
- Mechanism:
  - Creditors with shorter maturity can adjust face value (reduce interest rate) since they can pull out in bad states
  - Part of cost in low state is borne not by borrower but by remaining long-term creditors (long-term debt holders are diluted)
Setup

- Financing can be
  - Long-term: two periods
  - Short-term: one period + rollover at $t=1$
- Borrower has to borrow from multiple lenders
  - Continuum of competitive lenders
  - Each has limited capital
- Priority in default
  - Proportional to face value of debt at time of default
Project Payoffs

- Long-term project costs 1 at t=0, pays out at t=2
- Expected payoff moves along binominal tree, $u = 1/d$
- Project can be liquidated prematurely at discount: fraction $(1-\delta)$ is lost
The Maturity Rat Race

- Hold everybody else’s financing fixed, can borrower and one lender profitably deviate by moving to rollover financing?
When is the Rat Race Inefficient?

1. Inefficient (early) unwinding in down state
   \[ dX < 1 \iff X < u \]

2. Project does not get off the ground (since long-term financing is not viable)
   \[ \pi u X + (1 - \pi) \delta dX < 1 \]

- When economy turns sour/risky
  problem becomes more severe
Inefficiencies

- Risk-free projects
- Rat Race causes no inefficiency
- Rat Race causes inefficient liquidation
- Rat Race prevents financing of project
Covenants limit Rat Race

- Since
  - E.g. covenant restrict raising face value of new short-term debt at time $t=1$
  - Short-term debt holders always pull out in down state

- Short-term financing trap (multiplicity)
  - If all lenders go short-term + pull out in down state at $t=1$, then borrower does not want to switch to “expensive” long-term financing
Covenants – Short-term Financing Trap

![Diagram showing different financing scenarios]

- **Risk-free**
- **No Rat Race No Trap**
- **ST Financing Trap**
- **Maturity Rat Race**

Not Efficient to Finance: NPV < 0
Conclusion

- Institutional Finance
  - Financial institutions are not a veil
  - Moving away from representative agent models

- Financial Regulation
  - Macro-prudential has to focus on measuring contribution to systemic risk
  - Countercyclicality (to overcome margin/haircut spiral)

- Monetary/Liquidity Policy
  - Role of financial institutions – why short-term funding?
  - Avoid “credit bubbles” since they impair financial system