Risk Spillovers among Financial Institutions

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Federal Reserve Bank of New York and Princeton University

NBER Risk of Financial Institutions
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The views expressed in this paper are those of the authors and do not necessarily represent those of the Federal Reserve Bank of New York or the Federal Reserve System
Motivation

“Risk spillovers” across financial institutions
- Commercial banks, Investment banks, Hedge fund styles

Why do risk spillovers matter?
- Financial stability
- Counterparty credit risk management
- Portfolio management

Risk spillovers in crisis:
- 87 crash, Asian financial crisis, LTCM crisis, Bear Stearns crisis
Measuring Risk Spillovers

- **Our proposal:** CoVaR

- VaR conditional that others are in distress

- CoVaR is based on quantile regressions
  - Focus on tails
  - Data efficient
  - Simple
Overview

1. Quantile regressions – refresher
2. Spillover risk – CoVaR
3. Offloading spillover risk with factors
4. Incentives to offload
Quantile Regressions – A Refresher

- **OLS regression**: min sum of squared residuals:

\[
\beta^{OLS} = \arg \min_{\beta} \sum_t \left(y_t - \alpha - \beta x_t\right)^2
\]

- **Quantile regression**: min weighted absolute values:

\[
\beta^q = \arg \min_{\beta} \sum_t \begin{cases} 
q \left| y_t - \alpha - \beta x_t \right| & \text{if } y_t - \alpha - \beta x_t \geq 0 \\
1-q \left| y_t - \alpha - \beta x_t \right| & \text{if } y_t - \alpha - \beta x_t < 0 
\end{cases}
\]
q-Sensitivities

CS/Tremont Hedge Fund Index

-10 -5 0 5

-10 -5 0 5 10

CS/Tremont Hedge Fund Index

Fixed Income Arbitrage 50%-Sensitivity 5%-Sensitivity 1%-Sensitivity

q-Sensitivities
Quantiles and Value-at-Risk

Quantile regressions give an estimate of the quantile $q$ of $y$ as a linear function of $x$:

$$
\hat{y}_q \mid x = F^{-1}_y(q \mid x) = \alpha_q + \beta_q x
$$

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

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

Note our sign convention!
CoVaR – measure of risk spillover

- Return $R^i$ depends on return $R^j$ for quantile $q$:

$$\hat{R}_q^i = \hat{\alpha}_{q}^{ij} + \hat{\beta}_{q}^{ij} R^j$$

- **Definition:** We denote the $CoVaR_{ij}$, the $VaR$ of style $i$ conditional on the (unconditional) $VaR$ of style $j$ by:

$$CoVaR_{q}^{ij} = VaR_{q}^i \mid VaR_{q}^j = \hat{\alpha}_{q}^{ij} + \hat{\beta}_{q}^{ij} VaR^j$$

- **Conditioning shifts**
  - mean → contagion effect
  - variance
    - lower
    - increase due to heteroskedasticity + tail behavior
CS/Tremont Hedge Fund Index

Fixed Income Arbitrage

50%-Sensitivity

5%-Sensitivity

1%-Sensitivity

q-Sensitivities
Data

- CRSP equity returns 1986/4-2008/3
  - Five commercial banks
    - Bank of America, Citibank, J. P. Morgan Chase, Wachovia, Wells Fargo
  - Five investment banks
    - Bear Stearns, Goldman Sachs, Lehman Brothers, Merrill Lynch, Morgan Stanley

- CSFB/Tremont hedge fund strategies 1994/1-2008/05
  - Long/Short Equity, Global Macro, Event Driven, Fixed Income Arbitrage, Multi-Strategy, Emerging Markets, Equity Market Neutral, Convertible Arbitrage, Managed Futures, Dedicated Short Bias

- Commercial bank and security broker dealer industry portfolios from Ken French 1926/7-2007/3
**Result 1a: CoVaRs > VaR**

<table>
<thead>
<tr>
<th>Panel A: Institutions</th>
<th>5%-VaR</th>
<th>5%-CoVaR / 5%-VaR</th>
<th>t-stats</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>percent increase</td>
<td></td>
</tr>
<tr>
<td>CB</td>
<td>-12.23</td>
<td>43</td>
<td>29</td>
</tr>
<tr>
<td>IB</td>
<td>-13.69</td>
<td>45</td>
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<tr>
<td>HF</td>
<td>-2.40</td>
<td>27</td>
<td>23</td>
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</table>

<table>
<thead>
<tr>
<th>Panel B: Portfolios 1926-2008</th>
<th>5%-VaR</th>
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<td>IB</td>
<td>-11.83</td>
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### Result 1b: Quantile-CoVaRs > OLS-CoVaRs

#### Panel A: Institutions

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<th>HF</th>
<th>percent increase</th>
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<tbody>
<tr>
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#### Panel B: Portfolios 1926-2008

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<tr>
<td>Commercial Bank Portfolio (CB)</td>
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Result 2: HF-VaR predict I-Bank’s CoVaR

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<td>Commercial Banks (CB)</td>
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<td>IB</td>
<td></td>
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<tr>
<td>Commercial Bank Portfolio (CB)</td>
<td>-11.49</td>
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Overview

1. Quantile regressions – refresher
2. Spillover risk – CoVaR
3. Offloading spillover risk with factors
4. Incentives to offload
6-Risk Factor Pricing Model

Factors:
- Repo - 3 Month Treasury:
- 10 Year - 3 Month Treasury Return:
- Moody's BAA - 10 Year Treasury Return:
- CRSP Market Excess Return:
- VIX Straddle Excess Return:
- Variance Swap Return:

Interpretation:
- “Flight to Quality”
- “Business Cycle”
- “Credit Indicator”
- “Equity Market Risk”
- “Volatility Exposure”
- “Variation in Price of Risk”
Offloaded Returns

- All factors are excess returns
  - We can offload systematic risk
  - CoVaR of offloaded returns

Offloaded Return \( i = R^i - \beta^i_q X = \alpha^i_q + res^i_q \)
**Result 3a:** 5%-offloaded returns

CoVaRs $\sim$ VaRs

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<tr>
<td>Ten Hedge Fund Styles (HF)</td>
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**Result 3b: Offloaded Returns: Quantile CoVaRs ~ OLS VaRs**

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<td>CSFB/Tremont Hedge Fund</td>
<td>3</td>
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Percent increase
Figure 1: Kernel Densities of Total and 5%-Offloaded Returns

- Hedging reduces left tail
- But average returns decrease
- Incentives to hedge spillover risk
Figure 2: Average q-Sensitivities by Quantiles

- Average Sensitivities of Total Returns
- Average Sensitivities of OLS Offloaded Returns
- Average Sensitivities of 5% Offloaded Returns
Related Literature

- Dependence / contagion:

- Hedge fund tail risk:

- Pricing factors:

- Finance applications of quantile regressions:
  Bassett and Chen (2001), Chernozhukov and Umantsev (2001)
Summary

- Institutions have incentives to hold tail risk
  - Holding tail risk increases returns

- There is spillover of tail risk among hedge funds and among banks, as well as between hedge funds and banks (contemporaneous and lagged)

- The increase in CoVaR relative to VaR can be offloaded with liquid, tradable risk factors
Robustness Analysis

- Alternative measure of tail risk: 1%-CoVaR and Expected Shortfall
- Alternative measure of sensitivities: GARCH variances
Robustness check: 1%-CoVaR and Expected shortfall

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<tr>
<th>Panel B: 5%-Expected Shortfall</th>
<th>5%-ES</th>
<th>5%-CoES / 5%-ES</th>
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<td>Security Broker Dealer Portfolio (IB)</td>
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<td>37</td>
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Figure 3: Average GARCH Covariances over Time

- Total Returns
- 5% Offloaded Returns