Risk Spillovers among Financial Institutions

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Motivation

- “Risk spillovers” across financial institutions
  - Commercial banks, Investment banks, Hedge fund styles
- Why do risk spillovers matter?
  - Financial stability — Central banks
  - Counterparty credit risk management — Dealers and banks
  - Portfolio management — Fund-of-Funds
- 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

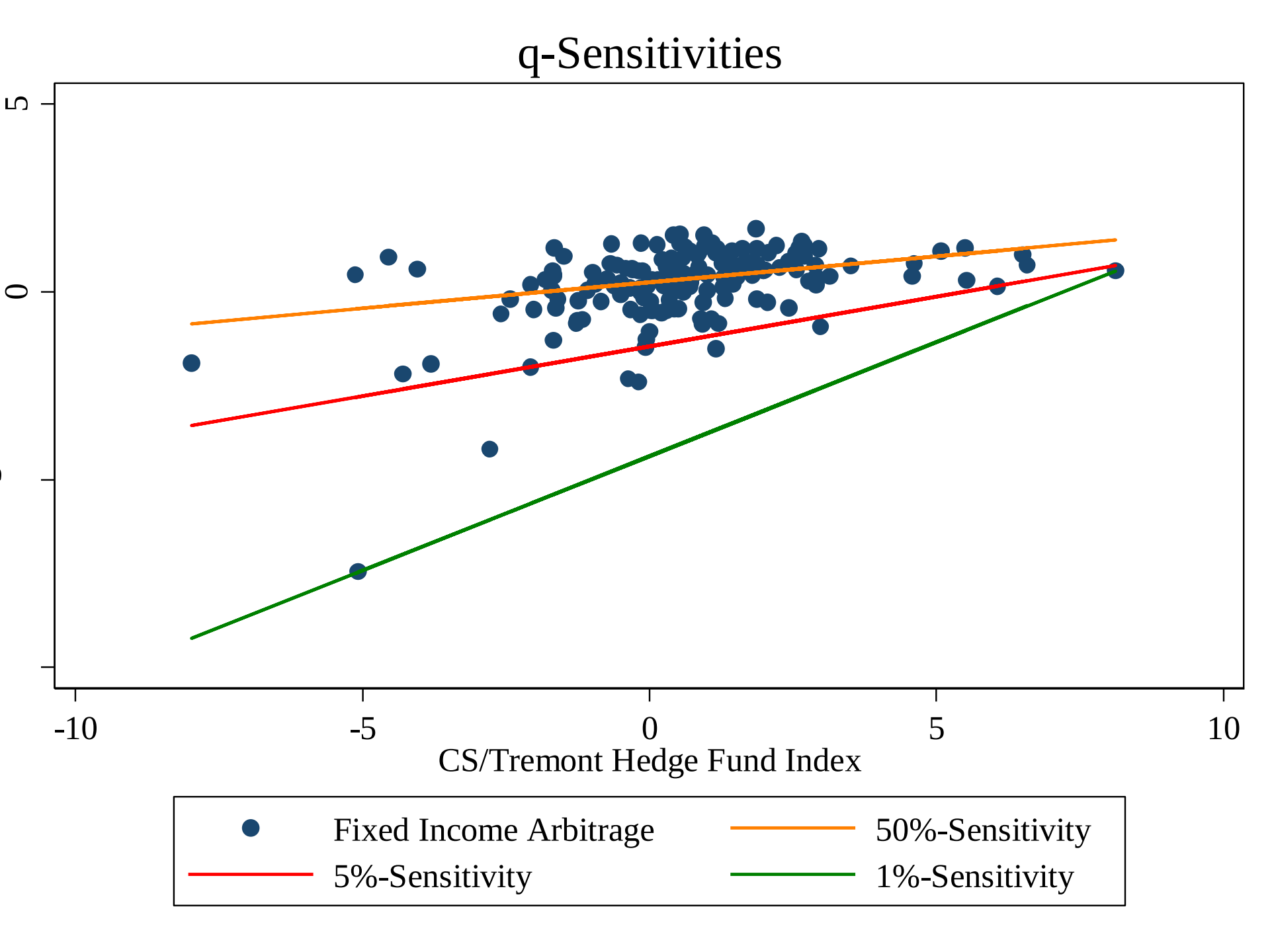
Quantile Regressions – A Refresher

- OLS regression: min sum of squared residuals:

$$\beta^{OLS} = \arg\min_{\beta} \Sigma_t \quad y_t - \alpha - \beta x_t \quad ^2$$

- Quantile regression: min weighted absolute values:

$$\beta^{q} = \arg\min_{\beta} \Sigma_t \begin{cases} q\left|y_t - \alpha - \beta x_t\right| & \text{if} \quad y_t - \alpha - \beta x_t \geq 0 \\ 1-q \ \left|y_t - \alpha - \beta x_t\right| & \text{if} \quad y_t - \alpha - \beta x_t < 0 \end{cases}$$


q-Sensitivities
5
0
-10
-5
0
5
10
CS/Tremont Hedge Fund Index
Fixed Income Arbitrage
50%-Sensitivity
5%-Sensitivity
1%-Sensitivity

Quantiles and Value-at-Risk

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

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

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

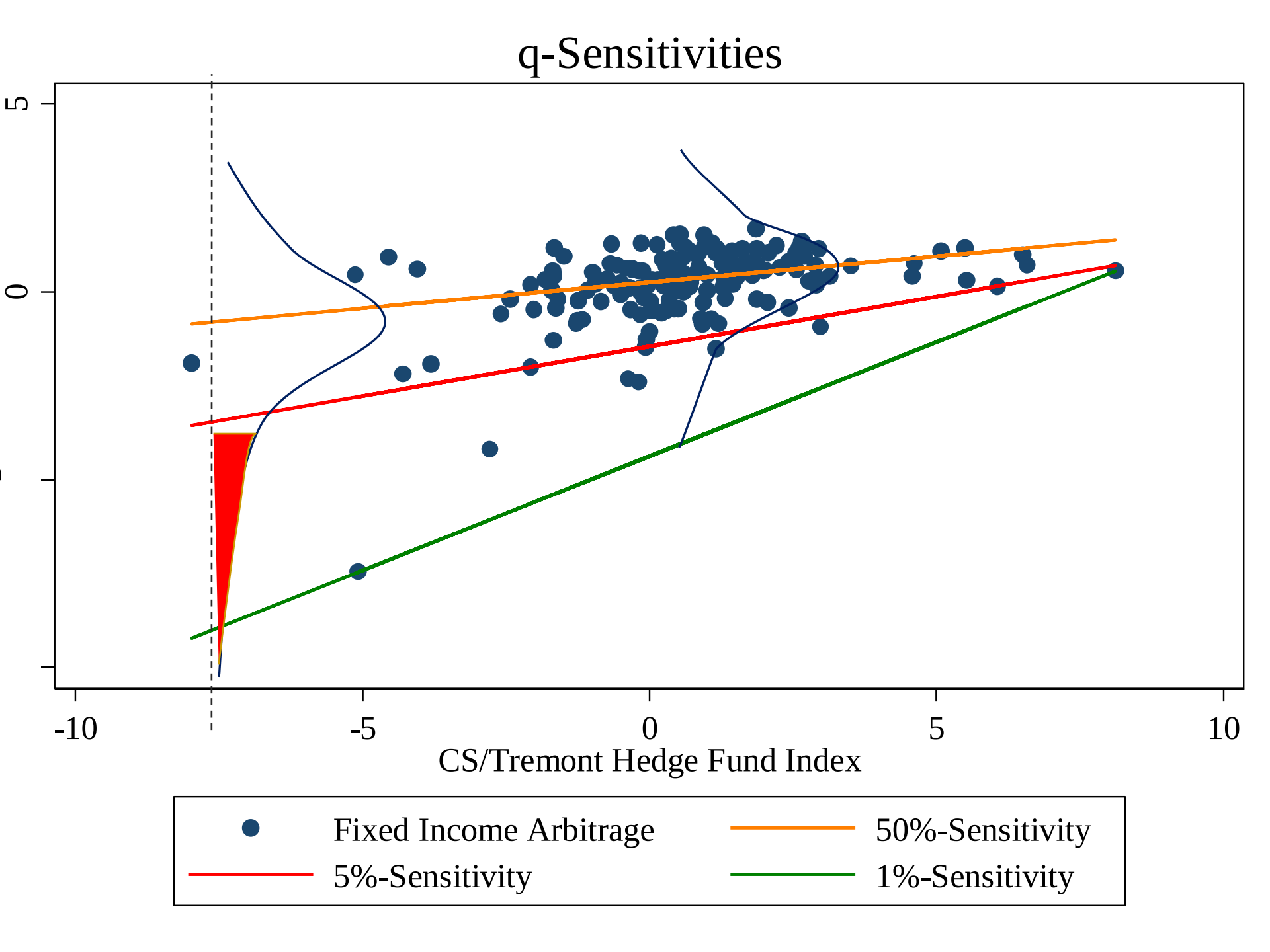
- Return R^i depends on return R^j for quantile q:

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

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

$$CoVaR_q^{ij} = VaR_q^i \,|\, VaR_q^j = \hat{\alpha}_q^{ij} + \hat{\beta}_q^{ij} VaR^j$$

- Conditioning shifts
  - mean ⇒ contagion effect
  - variance
    - lower
    - increase due to heteroskedasticity + tail behavior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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

	5%-VaR	5%-CoVaR / 5%-VaR percent icrease				t-stats		
Panel A: Institutions		CB	IB	HF		CB	IB	HF
Commercial Banks (CB)	**-12.23**	**43**	**29**	18	**-12.85**	**5.01**	**3.73**	0.94
Investment Banks (IB)	**-13.69**	**45**	**24**	**61**	**-7.86**	**5.03**	**3.14**	**4.13**
Ten Hedge Fund Styles (HF)	**-2.40**	27	23	**48**	**-9.24**	1.40	1.13	**2.84**

	5%-VaR	5%-CoVaR / 5%-VaR percent increase				t-stats		
Panel B: Portfolios 1926-2008		CB	IB	HF		CB	IB	HF
Commercial Bank Portfolio (CB)	-10.13	.	**42.64**	.	-17.84	.	**6.15**	.
Security Broker Dealer Portfolio (IB)	-11.83	**37.44**	.	.	-17.37	**5.06**	.	.

Result 1b:
Quantile-CoVaRs > OLS-CoVaRs

	5%-CoVaR / OLS-CoVaR percent increase			t-stats		
Panel A: Institutions	CB	IB	HF	CB	IB	HF
Commercial Banks (CB)	**18**	4	10	**2.64**	0.53	0.71
Investment Banks (IB)	**15**	**12**	**32**	**1.91**	**1.83**	**2.57**
CSFB/Tremont Hedge Fund Styles (HF)	21	17	**34**	1.22	0.99	**2.48**

	5%-CoVaR / OLS-CoVaR percent increase		t-stats	
Panel B: Portfolios 1926-2008	CB	IB	CB	IB
Commercial Bank Portfolio (CB)	.	**16**	.	**2.29**
Security Broker Dealer Portfolio (IB)	11	.	1.35	.

Result 2:
HF-VaR predict I-Bank's-CoVaR

	5%-VaR	5%-CoVaR / 5%-VaR percent increase			t-stats			
Panel A: Institutions		CB	IB	HF		CB	IB	HF
Commercial Banks (CB)	**-13.90**	-3	-2	-16	**-8.58**	-0.61	-0.17	-1.02
Investment Banks (IB)	**-15.09**	4	5	**32**	**-4.27**	0.49	0.68	**2.83**
Ten Hedge Fund Styles (HF)	**-3.30**	-2	2	3	**-6.57**	-0.28	0.23	0.41

	5%-VaR	5%-CoVaR / 5%-VaR percent increase		t-stats		
Panel B: Portfolios 1926-2008		CB	IB		CB	IB
Commercial Bank Portfolio (CB)	**-11.49**	.	4	**-11.00**	.	0.72
Security Broker Dealer Portfolio (IB)	**-13.78**	-7	.	**-12.16**	-1.61	.

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6-Risk Factor Pricing Model

Factors:	*Interpretation:*
Repo - 3 Month Treasury :	*“Flight to Quality”*
10 Year - 3 Month Treasury Return:	*“Business Cycle”*
Moody's BAA - 10 Year Treasury Return:	*“Credit Indicator”*
CRSP Market Excess Return:	*“Equity Market Risk”*
VIX Straddle Excess Return:	*“Volatility Exposure”*
Variance Swap Return:	*“Variation in Price of Risk”*

Offloaded Returns

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

- Offloaded Return $i = R^i - \beta_q^i X = \alpha_q^i + res_q^i$

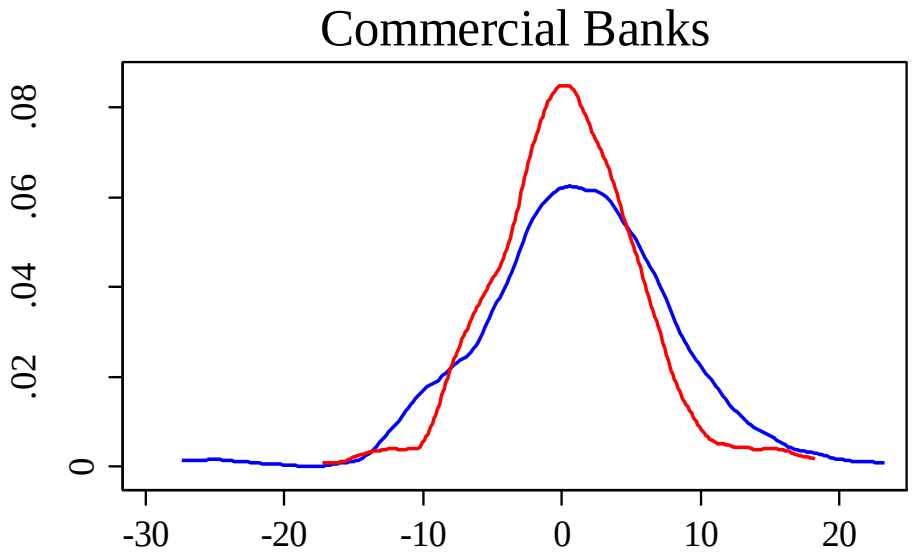
Result 3a: 5%-offloaded returns CoVaRs ~ VaRs

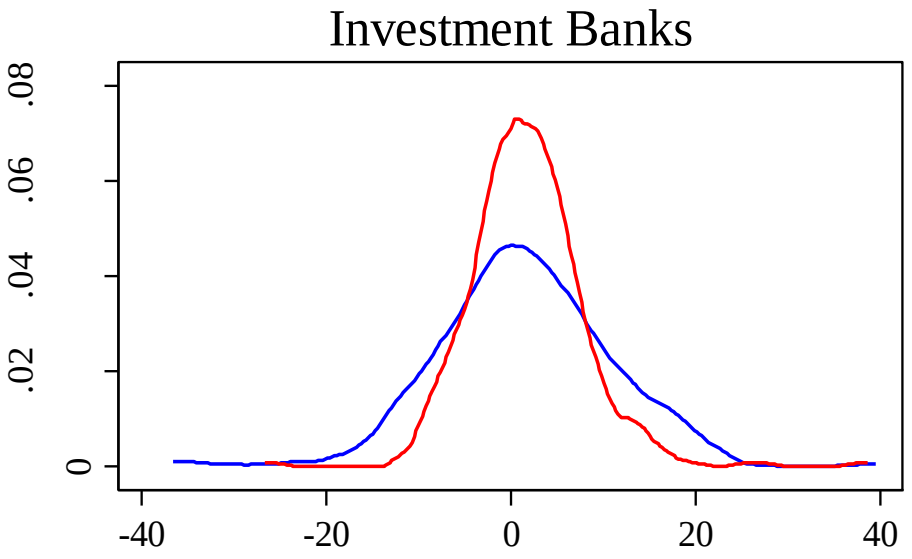
	5%-VaR	5%-CoVaR / 5%-VaR percent increase			t-stats			
		CB	IB	HF		CB	IB	HF
Commercial Banks (CB)	**-7.86**	**30**	3	-8	-33.45	3.54	0.31	-0.93
Investment Banks (IB)	**-10.28**	3	**14**	0	-60.95	0.39	1.76	-0.03
Ten Hedge Fund Styles (HF)	**-2.36**	1	1	10	-35.25	0.14	0.08	1.61

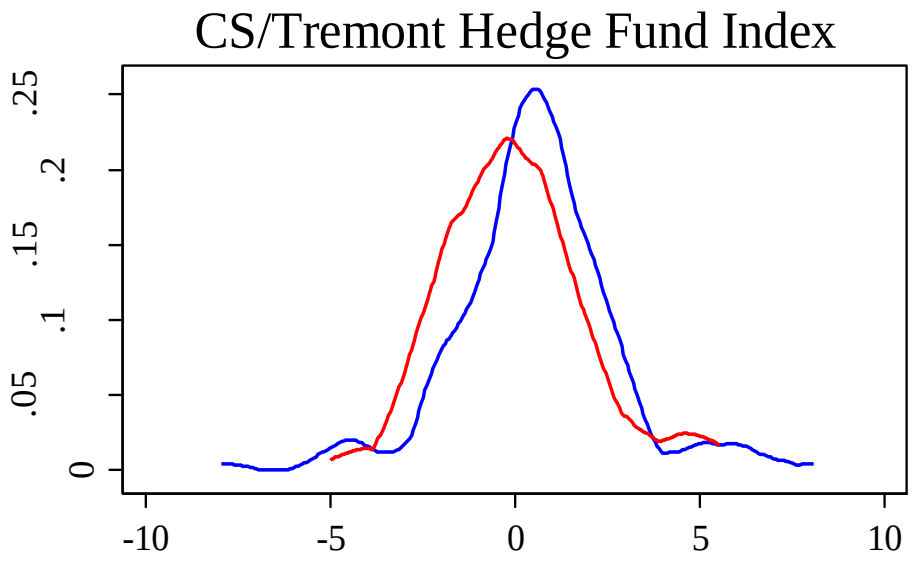
Result 3b: Offloaded Returns: Quantile CoVaRs ~ OLS VaRs

	5%-CoVaR / OLS-CoVaR percent increase			t-stats		
	CB	IB	HF	CB	IB	HF
Commercial Banks (CB)	-7	**-20**	-2	-0.92	**-2.80**	-0.11
Investment Banks (IB)	-14	1	-1	-1.14	0.10	-0.07
CSFB/Tremont Hedge Fund Styles (HF)	3	2	-2	0.33	0.20	-0.20

Figure 1: Kernel Densities of Total and 5%-Offloaded Returns



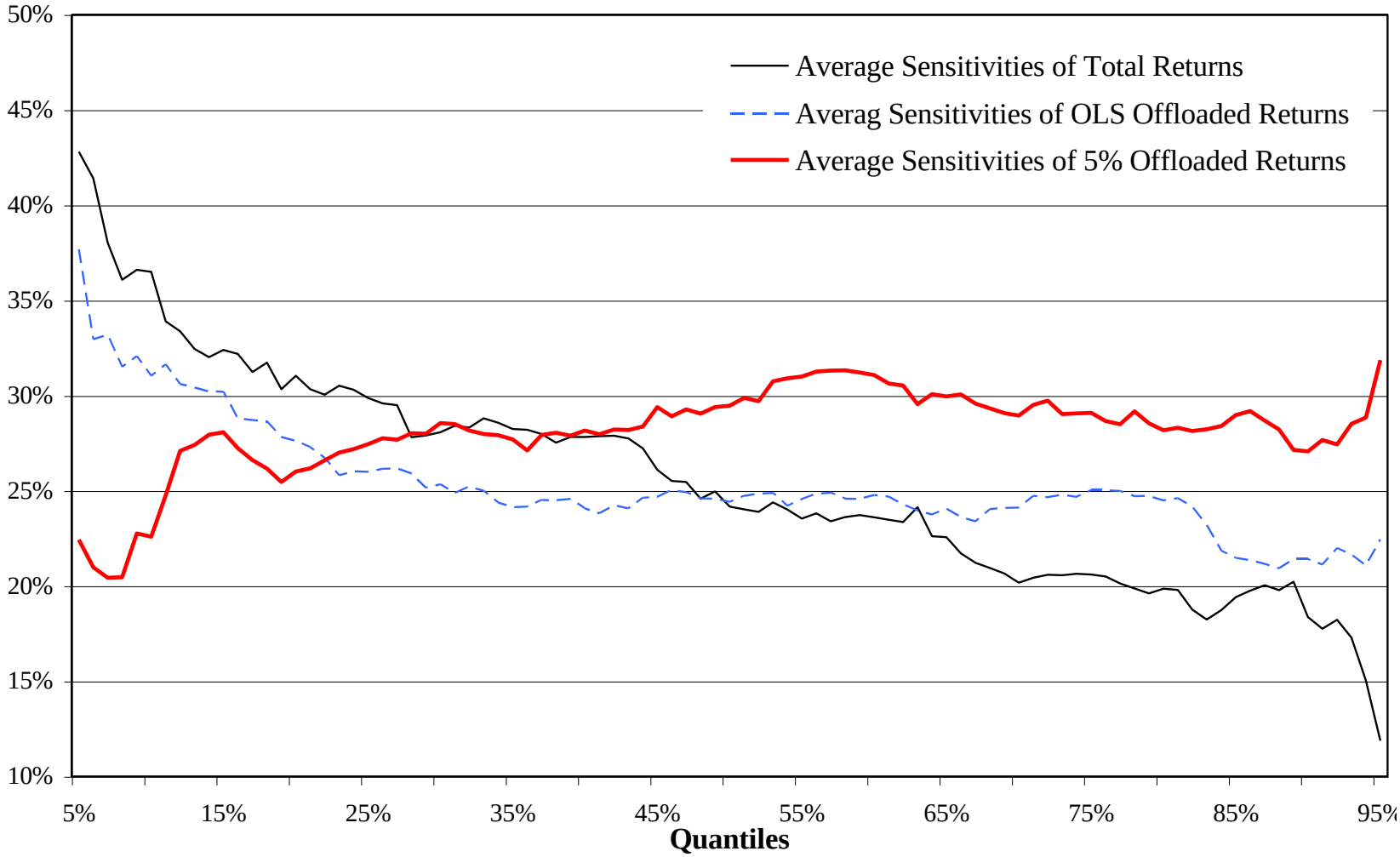




- Hedging reduces left tail
- But average returns decrease
- Incentives to hedge spillover risk

q-Sensitivities:
Total and Offloaded Returns

Figure 2: Average q-Sensitivities by Quantiles



Related Literature

- Dependence / contagion:
  Boyson, Stahel, Stulz (2008), Chan, Getmansky, Haas, Lo (2006), Adrian (2007), Forbes, Rigobon (2002)

- Hedge fund tail risk:
  Asness, Krail, Liew (2001), Agarwal & Naik (2004), Bali, Gokcan, Liang (2007), Liang & Park (2007), Bondarenko (2004)

- Pricing factors:
  Fung and Hsieh (2001, 2002, 2003), Hasanhodzic & Lo (2007)

- 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

	1%-VaR	1%-CoVaR / 1%-VaR percent icrease			t-stats	
Panel A: 1%-CoVaR		CB	IB		CB	IB
Commercial Bank Portfolio (CB)	**-21.46**	.	**23**	**-9.06**	.	**1.89**
Security Broker Dealer Portfolio (IB)	**-22.46**	**38**	.	**-9.30**	**3.44**	.

	5%-ES	5%-CoES / 5%-ES percent icrease			t-stats	
Panel B: 5%-Expected Shortfall		CB	IB		CB	IB
Commercial Bank Portfolio (CB)	**-13.67**	.	**40**	**-13.98**	.	**6.74**
Security Broker Dealer Portfolio (IB)	**-16.01**	**37**	.	**-14.63**	**5.95**	.

Figure 3: Average GARCH Covariances over Time