Risk Spillovers of Financial Institutions

Tobias Adrian and Markus K. Brunnermeier

Federal Reserve Bank of New York and Princeton University

Risk Transfer Mechanisms and Financial Stability
Basel, 29-30 May 2008

Motivation

- "Risk spillovers" across financial institutions
  - Hedge funds, dealers, commercial banks, insurance companies
  - Hedge fund strategies

- 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:
  - 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
5. Robustness
6. Related Literature

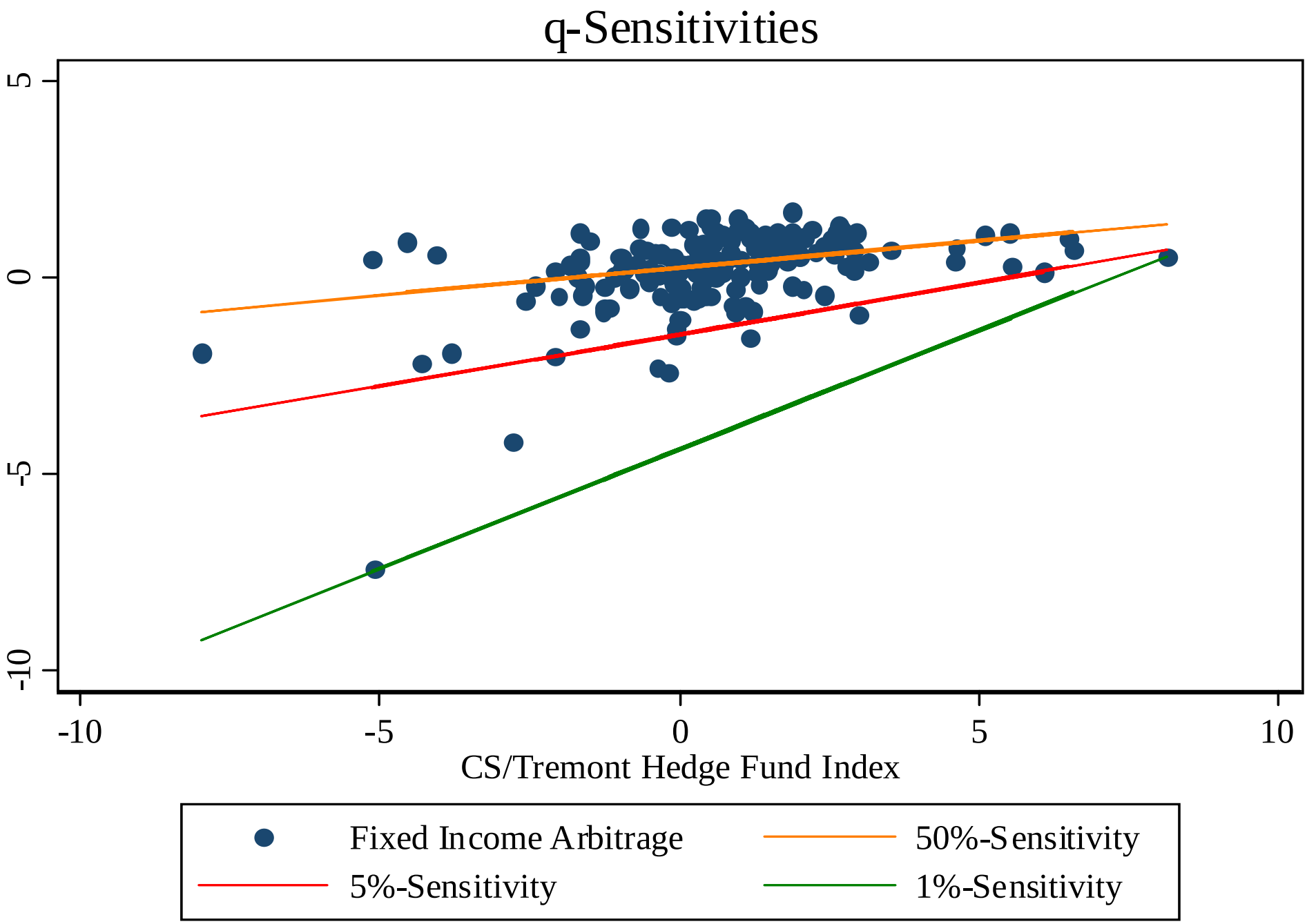
Quantile Regressions – A Refresher

- OLS regression: min sum of squared residuals:

$$\beta^{OLS} = \arg\min_{\beta} \Sigma_t \left(y_t - \alpha - \beta x_t \right)^2$$

- Quantile regression: min weighted absolute values:

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


q-Sensitivities
5
0
-5
-10
-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*:

$$\hat{y}_q \mid x = F_y^{-1}\left(q \mid x\right) = \alpha_q + \beta_q x$$

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!

q-Sensitivity and CoVaR

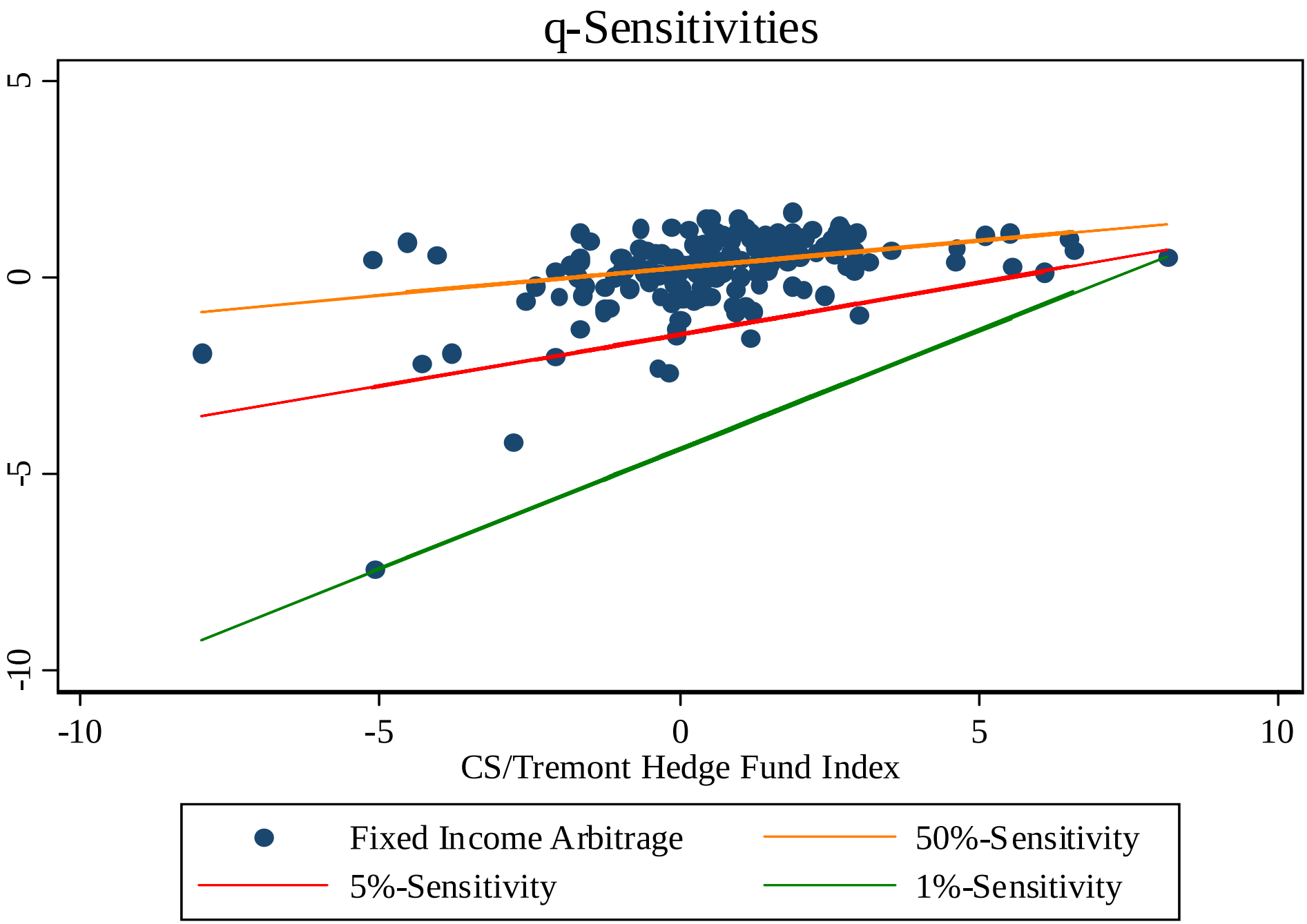
- Return R^i depends on return R^j for quantile q:

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

- Definition: The *q-sensitivity* is β_q which can be estimated using a quantile regression.
- Definition: We denote the $CoVaR^{ij}$, the *VaR* of style *i* conditional on the (unconditional) *VaR* of style *j* by:

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

Co since conditional measure captures contagion/comovement


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

Data

- Credit Swiss/Tremont Hedge Fund Strategies 1994/1-2008/03

- Returns of Investment Banks, Commercial Banks, and Insurance Companies (from CRSP)

Summary Statistics of Excess Returns

Panel A: Hedge Funds Strategies

	Sharpe	Mean	Std Dev	Skew	Kurt	Min	5%	Obs	Weight Dec-06
Long/Short Equity	0.22	0.63	2.83	0.12	6.89	-11.85	-3.52	171	29%
Event Driven	0.36	0.58	1.61	-3.16	24.84	-12.19	-1.83	171	24%
Global Macro	0.27	0.82	3.00	-0.06	6.20	-11.89	-3.58	171	11%
Multi-Strategy	0.33	0.42	1.26	-1.13	5.65	-5.10	-2.00	171	10%
Emerging Markets	0.12	0.53	4.48	-0.74	8.00	-23.45	-7.31	171	7%
Fixed Income Arbitrage	0.11	0.13	1.16	-3.14	18.19	-7.30	-1.88	171	6%
Equity Market Neutral	0.59	0.46	0.79	0.18	3.66	-1.59	-0.80	171	5%
Managed Futures	0.09	0.30	3.46	0.01	3.11	-9.80	-5.24	171	5%
Convertible Arbitrage	0.23	0.32	1.39	-1.58	7.22	-6.04	-1.86	171	3%
Dedicated Short Bias	-0.06	-0.31	4.83	0.80	4.89	-9.13	-7.48	171	1%

Panel B: Financial Institution Indices

	Sharpe	Mean	Std Dev	Skew	Kurt	Min	5%	Obs
Hedge Fund Index	0.25	0.54	2.15	0.00	5.40	-7.97	-2.61	171
Investment Banks	0.02	0.13	5.29	-0.27	3.25	-16.63	-9.31	168
Commercial Banks	0.15	0.78	5.20	-0.60	5.66	-24.45	-7.46	168
Insurance Companies	0.16	0.76	4.64	0.10	6.49	-16.23	-6.30	168
Market	0.13	0.56	4.17	-0.74	3.97	-16.20	-6.44	172

Result 1a: CoVaRs > VaR

	Unconditional VaR	CoVaR percent increase													
	↓	LSE	ED	GM	MS	EM	FIA	EMN	MF	CA	DSB	IB	CB	IC	M
Long/Short Equity (LSE)	**-7.95**	**0**	31	74	-69	11	209	52	-99	49	-52	37	19	43	31
Event Driven (ED)	**-3.36**	192	**0**	200	-11	113	785	272	-100	263	-110	209	144	238	181
Global Macro (GM)	**-7.48**	-2	103	**0**	44	73	53	-32	1	59	40	-1	-14	-23	-15
Multi-Strategy (MS)	**-3.83**	-40	50	21	**0**	3	95	-5	-46	129	33	6	-30	-62	-47
Emerging Markets (EM)	**-10.47**	85	34	146	-79	**0**	388	129	-72	124	-56	93	64	107	86
Fixed Income Arbitrage (FIA)	**-6.54**	40	32	-12	27	34	**0**	-74	42	12	12	-34	-56	-66	-52
Equity Market Neutral (EMN)	**-1.37**	39	56	53	106	-1	7	**0**	7	3	-3	18	22	38	28
Managed Futures (MF)	**-8.78**	-69	-35	59	-77	-22	-70	19	**0**	-79	12	-60	-18	-18	-19
Convertible Arbitrage (CA)	**-5.06**	70	55	23	46	60	110	0	-2	**0**	-1	-8	-13	-4	0
Dedicated Short Bias (DSB)	**-9.03**	-40	-40	-4	-2	-31	-1	-22	11	0	**0**	-38	1	1	-142
Investment Banks (IB)	**-12.72**	20	78	37	-57	29	96	32	-41	31	-15	**0**	13	25	21
Commercial Banks (CB)	**-11.79**	89	30	133	-43	53	346	112	-61	107	-18	79	**0**	85	76
Insurance Companies (IC)	**-13.57**	16	-6	32	-54	-2	93	21	-48	20	-37	12	40	**0**	**7**
Market (M)	**-10.76**	43	63	71	21	45	172	53	-69	51	-125	38	40	**69**	**0**
HF Average	**-6.14**					**54%**		**p-value**	**0.05**						
HF+IB+CB+IC Average	**-6.42**					**36%**		**p-value**	**0.00**						

Result 1b:

50%-sensitivities < 5 % sensitivities

	q-Sensitivities	
	50%	**5%**
HF Strategies	26%	42%
HF+IB+CB+IC	28%	43%

Result 1c:
HF-VaR predicts I-Bank's-VaR

Quantile Granger Causality

1994-2008	Hedge Funds Forecasting Banks			Banks Forecasting Hedge Funds		
	I-Banks	C-Banks	Insurance	I-Banks	C-Banks	Insurance
Hedge Fund Index	*					

2000-2008	Hedge Funds Forecasting Banks			Banks Forecasting Hedge Funds		
	I-Banks	C-Banks	Insurance	I-Banks	C-Banks	Insurance
Hedge Fund Index						

1994-2003	Hedge Funds Forecasting Banks			Banks Forecasting Hedge Funds		
	I-Banks	C-Banks	Insurance	I-Banks	C-Banks	Insurance
Hedge Fund Index	**			*		

Overview

1. Quantile regressions – refresher
2. Spillover risk – CoVaR
3. Offloading spillover risk with factors
4. Incentives to offload
5. Robustness
6. Related Literature

7-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"*
Carry Trade Excess Return:	*"FX Risk"*

Offloaded Returns

- All factors are excess returns
  - We can offload systematic risk
  - CoVaR and *q*-dependence of offloaded returns

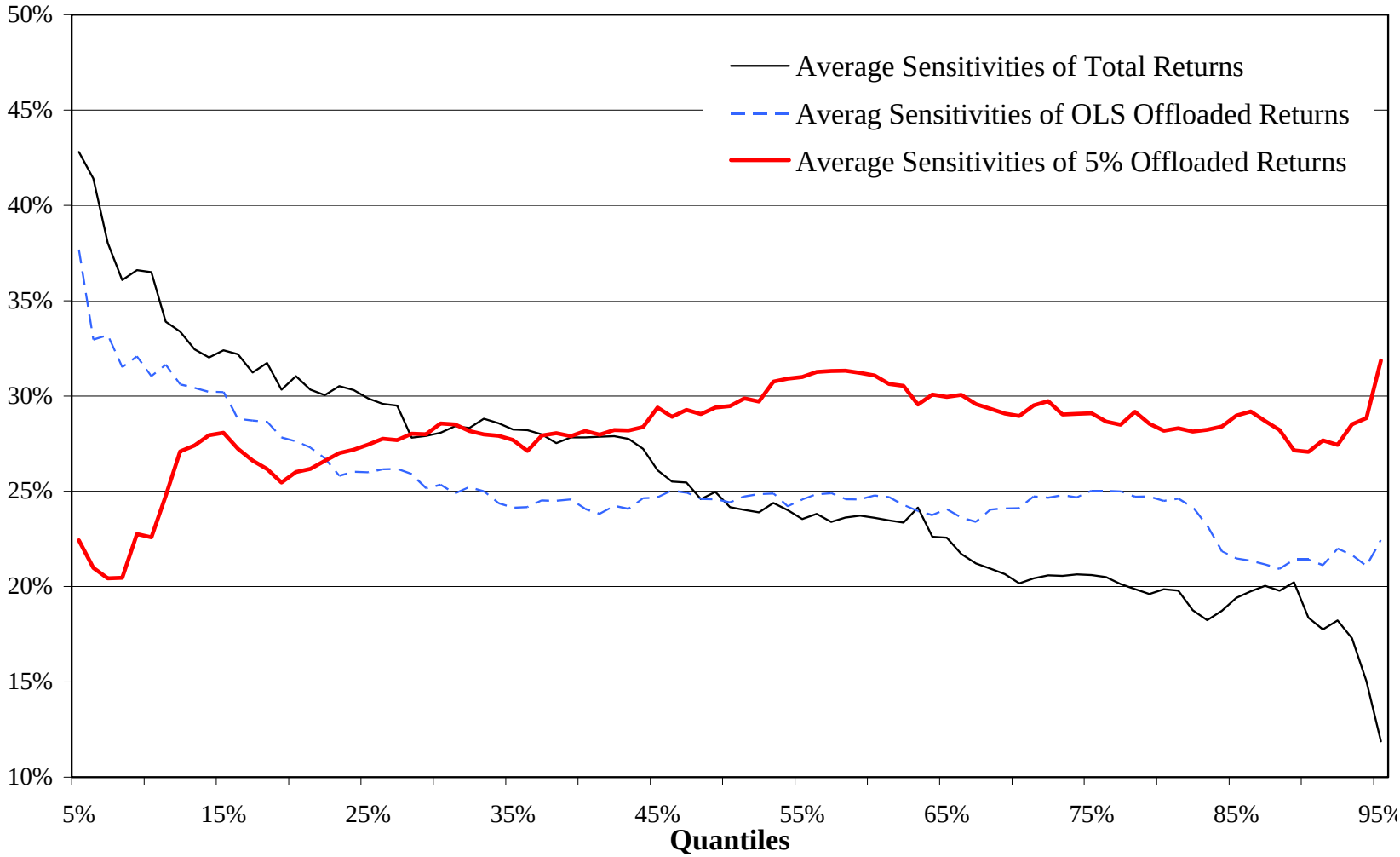
- Offloaded Return $i = R^i - \beta_q^i X = \alpha_q^i + res_q^i$

Result 2a: CoVaRs ~ VaRs for 5%-offloaded returns

	Unconditional VaR	**CoVaR percent increase**													
	↓	LSE	ED	GM	MS	EM	FIA	EMN	MF	CA	DSB	IB	CB	IC	M
Long/Short Equity (LSE)	**-6.65**	**0**	22	9	51	31	-2	31	-35	50	-74	-18	36	44	1
Event Driven (ED)	**-3.35**	61	**0**	46	89	60	3	1	-53	86	-67	-19	68	74	-14
Global Macro (GM)	**-6.66**	10	-9	**0**	-10	3	-3	1	-4	-9	-8	7	18	11	14
Multi-Strategy (MS)	**-4.34**	28	5	14	**0**	2	-26	12	-12	8	-26	-27	6	8	0
Emerging Markets (EM)	**-10.67**	42	48	15	72	**0**	-99	102	-8	72	-77	-57	57	68	15
Fixed Income Arbitrage (FIA)	**-3.72**	-9	64	4	9	-45	**0**	-38	-65	6	3	-28	-30	-30	-1
Equity Market Neutral (EMN)	**-1.30**	28	10	33	-8	-22	-22	**0**	0	-8	-35	25	22	15	48
Managed Futures (MF)	**-11.21**	-14	-6	-1	1	6	-22	5	**0**	-26	-2	8	-9	-17	2
Convertible Arbitrage (CA)	**-3.35**	19	63	-10	14	11	0	3	-36	**0**	-19	-31	7	10	1
Dedicated Short Bias (DSB)	**-10.28**	-55	-8	9	12	-22	8	-18	-5	9	**0**	-11	-20	-27	-67
Investment Banks (IB)	**-12.29**	2	-19	0	-39	-11	-22	-6	23	-21	-23	**0**	11	2	11
Commercial Banks (CB)	**-18.57**	25	16	23	37	23	4	53	-42	35	-53	-20	**0**	22	23
Insurance Companies (IC)	**-13.69**	19	12	40	31	25	5	48	-60	29	-62	-35	19	**0**	**7**
Market (M)	**-17.74**	13	-46	11	8	6	-14	6	1	-14	-56	24	-43	**-43**	**0**
HF Average	**-5.62**							**0.03**		**p-value**		**0.28**			
HF+IB+CB+IC Average	**-14.85**							**0.03**		**p-value**		**0.57**			

q-Sensitivities: Total and Offloaded Returns

Figure 2: Average q-Sensitivities by Quantiles



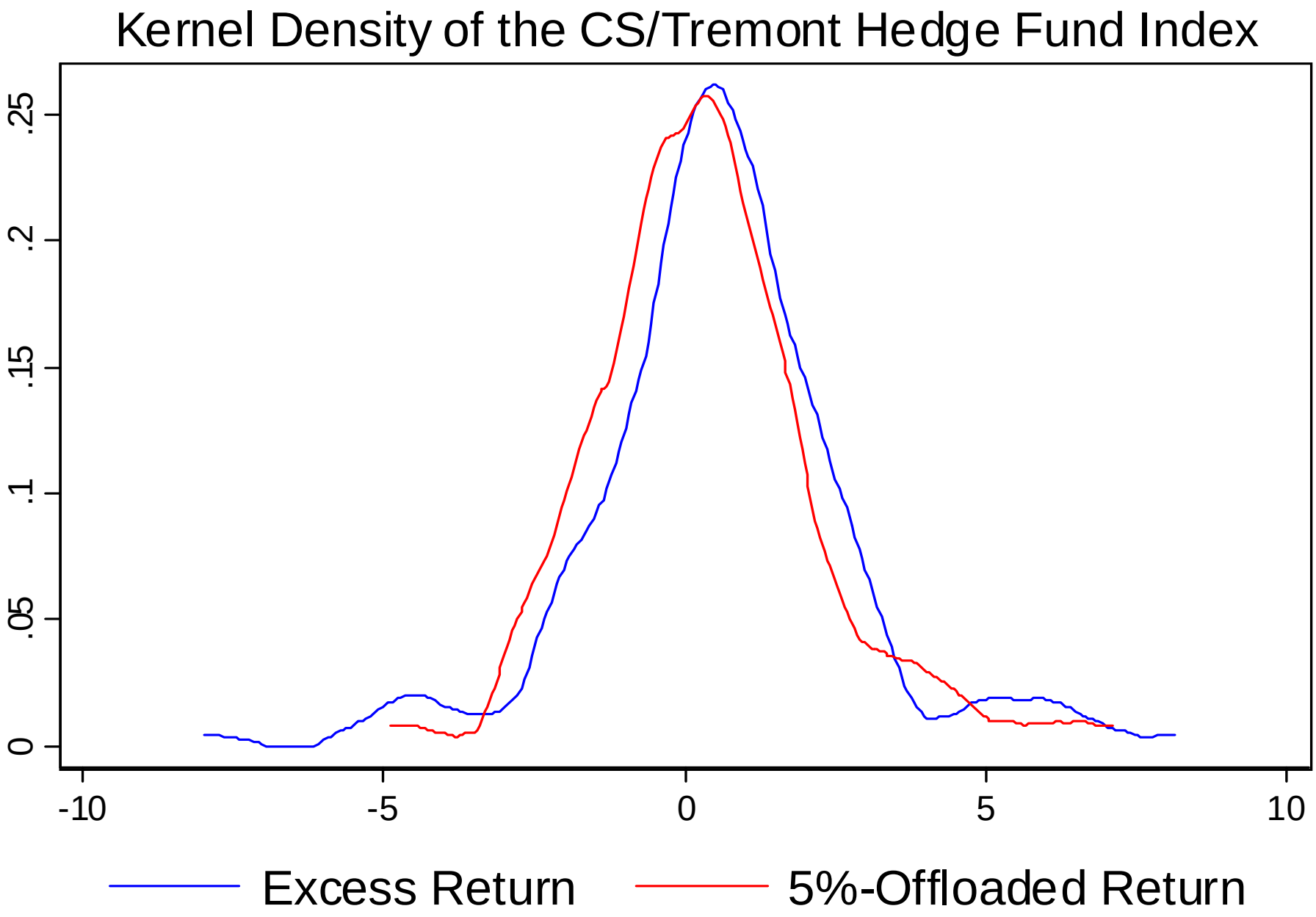
Incentives to hold Tail Risk

- Standard HF compensation (2 and 20)
  - 20 % of profit (return, **not** alpha)
  - 2 % from assets under management
- Tail risk offloading lowers returns
  - HF Sharpe ratio declines from 0.27 to -0.06
- Capital flows do not react to tail risk
  - React mostly to past returns, Sharpe ratio
  - **Not** much to alpha or information-ratio

Average OLS Alphas: Offloaded Returns

Excess Returns		5%-Offloaded Returns	
CAPM alpha	7-Factor alpha	CAPM alpha	7-Factor alpha
0.40 * **	**0.04**	**-0.15 ** **	**0.04**

- Offloading is alpha neutral with respect to 7-Factor model
- CAPM alpha becomes negative


Kernel Density of the CS/Tremont Hedge Fund Index
0
.05
.1
.15
.2
.25
-10
-5
0
5
10
Excess Return
5%-Offloaded Return

Overview

1. Quantile regressions – refresher
2. Spillover risk – CoVaR
3. Offloading spillover risk with factors
4. Incentives to offload
5. Robustness
6. Related Literature

Robustness Analysis

- Alternative measure of sensitivities:
  GARCH variances
- Alternative measure of tail risk:
  Expected Shortfall
- Other hedge fund indices:
  HFR

Expected Shortfall

- ES Measures the average return below the Value-at-Risk
- The main result holds for Expected Shortfall

Excess Returns	**Unconditional Expected Shortfall**	**Co-Expected Shortfall** Percent Increase
HF Average	-4.19	38.53
HF+IB+CB+IC Average	-9.68	23.49
ES offloaded risk factors		
HF Average	-3.88	6.26
HF+IB+CB+IC Average	-6.24	-0.49

Summary

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

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

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

Related Literature

- Dependence / contagion:
  Boyson, Stahel, Stulz (2006), Chan, Getmansky, Haas, Lo (2006), Patton (2007), Adrian (2007)

- 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)

Other Indices and Pricing Factors

- The main results go through with alternative hedge fund indices (HFR)

- The key risk factors for tail risk is the Repo – Treasury spread, and the Volatiliy Swap.

Result 2b: Factors explain Increase in q-Sensitivities

50%-q-Sensitivities	
HF Average Exposures	32%
HF Average Value Weighted	42%
IB+CB+IC Average Exposures	42%

5%-q-Sensitivities, excess returns	
HF Average Exposures	53%
HF Average Value Weighted	66%
IB+CB+IC Average Exposures	70%

5%-q-Sensitivities, OLS Risk Factor Offloaded	
HF Average Exposures	34%
HF Average Value Weighted	36%
IB+CB+IC Average Exposures	25%

5%-q-Sensitivities, 5%-Quantile Risk Factor Offloaded	
HF Average Exposures	20%
HF Average Value Weighted	26%
IB+CB+IC Average Exposures	14%

Result 3a:
Hedging Tail Risk Lowers Returns

	Excess Returns						5%-Risk Factor Offloaded Returns					
	Sharpe	Mean	SD	Skew	Kurt	5%	Sharpe	Mean	SD	Skew	Kurt	5%
Long/Short Equity	0.22	0.63	2.83	0.12	6.89	-3.52	-0.24	-0.46	1.93	1.14	7.06	-3.30
Event Driven	0.36	0.58	1.61	-3.16	24.84	-1.83	-0.08	-0.10	1.34	0.26	2.77	-2.03
Global Macro	0.27	0.82	3.00	-0.06	6.20	-3.58	-0.05	-0.18	3.29	0.71	3.56	-4.23
Multi-Strategy	0.33	0.42	1.26	-1.13	5.65	-2.00	0.31	0.44	1.44	-0.27	3.42	-1.95
Emerging Markets	0.12	0.53	4.48	-0.74	8.00	-7.31	0.32	1.27	3.94	0.01	3.54	-4.40
Fixed Income Arbitrage	0.11	0.13	1.16	-3.14	18.19	-1.88	-0.16	-0.21	1.34	0.30	3.38	-2.30
Equity Market Neutral	0.59	0.46	0.79	0.18	3.66	-0.80	0.15	0.13	0.89	0.74	3.75	-1.14
Managed Futures	0.09	0.30	3.46	0.01	3.11	-5.24	-0.56	-2.15	3.88	0.62	3.80	-7.61
Convertible Arbitrage	0.23	0.32	1.39	-1.58	7.22	-1.86	0.18	0.28	1.57	0.37	3.67	-2.23
Dedicated Short Bias	-0.06	-0.31	4.83	0.80	4.89	-7.48	0.09	0.25	2.85	0.30	2.60	-4.04
Weighted average	**0.27**	**0.54**					**-0.06**	**-0.15**				

Result 3b:
Flows do **Not** React to Tail Risk

Lagged		(i)	(ii)	(iii)	(iv)	(iv)	(vi)	(vii)	(viii)	(ix)	(x)
Monthly Return	coeff.	0.04	0.04	0.04	0.05	0.04	0.04	0.04	0.05	0.04	0.04
	p-value	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
Annual Return	coeff.	0.07	0.06	0.06			0.07	0.06		0.06	0.06
	p-value	0.00***	0.00***	0.00***			0.00***	0.00***		0.00***	0.00***
Alpha	coeff.	0.00							0.00	0.00	0.00
	p-value	0.73							0.55	0.60	0.64
Sharpe Ratio	coeff.	-0.02				0.06	-0.02	-0.01			
	p-value	0.66				0.02**	0.64	0.68			
Standard Deviation	coeff.	0.00	0.00	0.00				0.00			0.00
	p-value	0.87	0.76	0.76				0.81			0.82
6-factor VaR	coeff.	0.00		0.00	0.00			0.00			0.00
	p-value	0.43		0.42	0.45			0.43			0.42