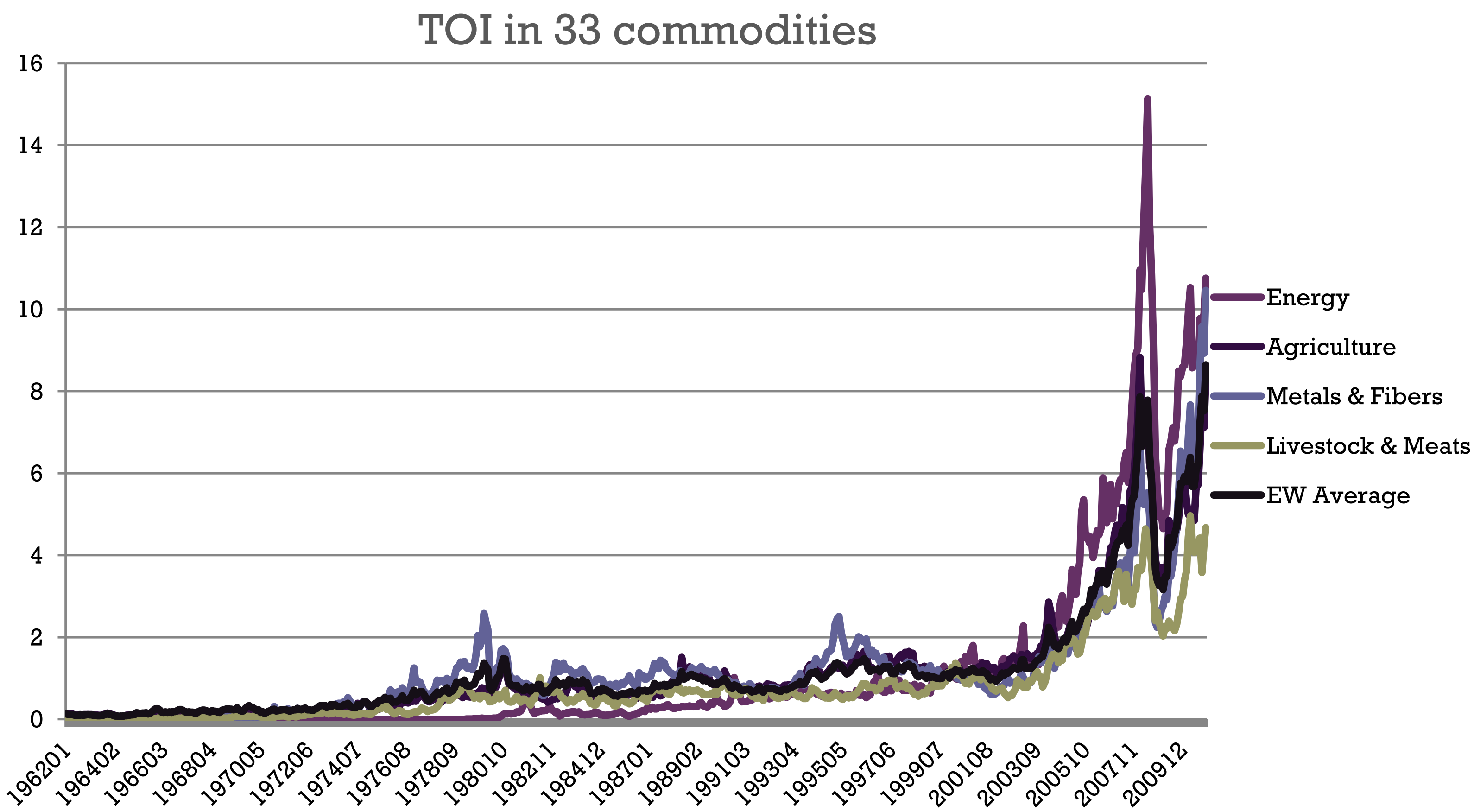
The Price of Commodity Risk in Stock and Futures Markets

EFMA – 27 June 2014

Martijn Boons, Nova School of Business and Economics
Frans de Roon, Tilburg University, Tias Business School
Marta Szymanowska, Rotterdam School of Management

+ Motivation

- Commodity Index Investing / Financialization
  - Dramatic change in size and composition of futures markets



+ Motivation

- Financialization of Commodities
  - Pre-Financialization commodity exposure
    - (Institutional) investors did not participate in commodity futures markets
    - commodity-related equity, physical commodities
  - Post-Financialization commodity exposure
    - commodity futures trading volume from 0.6 to 3.5 bln contracts p.a.
    - commodity index investment (CII) by institutions from 6% of total open interest (< 10$ billion) to 40% (> 200$ billion)
- Break point in the behavior of (institutional) investors / Financialization

+ Our goal

- We want to understand
  - commodity prices as a source of risk
  - price of this risk in the stock and commodity futures markets
  - impact of Financialization/commodity futures investing on commodity risk price
- This will allow us to shed light on
  - a link between stock and commodity futures markets (previously thought to be segmented)
  - "financialization" of commodities
  - stock market strategies to hedge or speculate on commodity prices

+ Our Approach

- A model with investors exposed to commodity price risk
  - in the spirit of Hirshleifer (1988,1989), Bessembinder and Lemmon (2002)
  - Study the effect of (non-)participation of investors
- Empirical approach
  - Sort stocks on commodity beta
  - Sort commodity futures on hedging pressure and market beta
- We find
  - Commodity risk is priced in the stock market in the opposite way before and after Financialization
  - Stock market risk is priced in the commodity futures market post-Financialization
  - Consistent with the structural change in investor behavior

+ The model

- Agents
  - Commodity Producers (trade futures)
  - Specialized Speculators (e.g. CTA's, trade futures)
  - Investors (trade stocks and possibly futures)
- (Non-)participating Investors
  - Before Financialization only invest in the stock market, no participation in futures market
  - Post Financialization participate in both stock and futures markets
- Standard, two-date, mean-variance framework
- Investors are exposed to commodity price risk
  - inflation
  - commodities as state-variable

Model: Stock market

- Investors maximize a mean-variance utility function:
  - No participation: over stocks only (w_r)

$$max_{w_r} R_{f,t} + w_r'\mu_r - \frac{\gamma_I}{2}\left\{w_r'\Sigma_{rr}w_r + 2w_r'\Sigma_{rS}\varphi + \varphi^2\sigma_{SS}\right\}$$

  - Participation: over stocks and futures (w_r, w_{Fut})

$$max_w R_{f,t} + w'\mu - \frac{\gamma_I}{2}\left\{w'\Sigma w + 2w'\Sigma_S\varphi + \varphi^2\sigma_{SS}\right\}$$

  - Optimal portfolios:

$$\begin{aligned}
\text{with limits: } w_r &= \frac{1}{\gamma_I}\Sigma_{rr}^{-1}\mu_r - \varphi\Sigma_{rr}^{-1}\Sigma_{rS}, \\
\text{without limits: } w_r &= \frac{1}{\gamma_I}\Sigma_{rr}^{-1}\mu_r - w_{Fut,spec}\Sigma_{rr}^{-1}\Sigma_{rF} \\
w_{Fut} &= w_{Fut,spec} - \varphi\frac{\sigma_{FS}}{\sigma_{FF}}, \text{ with} \\
w_{Fut,spec} &= \frac{1}{\gamma_I}\frac{a}{\sigma_{ee}}.
\end{aligned}$$

+ Model: Stock market

- Expected excess returns on stocks when Investors are exposed to commodity price risk
  - No participation

$$E\left[r_{i,t+1}\right] = \gamma_I \sigma_{im} + \gamma_I \varphi \sigma_{iS}$$

  - Participation

$$E\left[r_{i,t+1}\right] = \gamma_I \sigma_{im} + \frac{a}{\sigma_{ee}} \frac{\sigma_{SS}}{\sigma_{FF}} \sigma_{iS}$$

Model: Futures market

- No Participation: Producers and Speculators only

$$E\left[R_{Fut,t+1}\right] = \frac{\lambda_P}{\lambda_P + \lambda_S}\gamma_P \sigma_{FS}\left(1+\eta\right)$$
$$\lambda_i = N_i/\gamma_i, i = P, S.$$

- (Hedging Pressure effects)

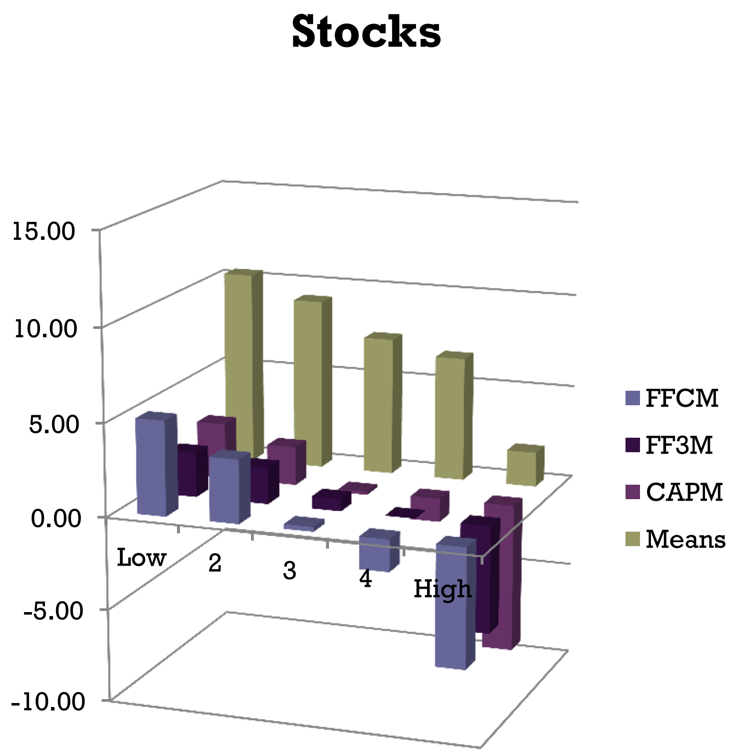
- Participation: Producers, Speculators and Investors

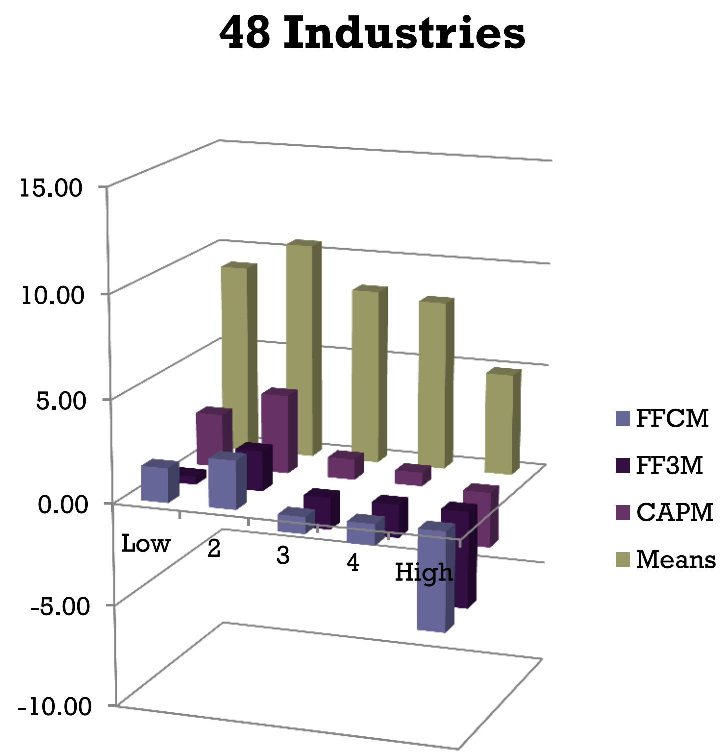
$$E\left[R_{Fut,t+1}\right] = \frac{\lambda_P\left(1+\eta\right)\gamma_P + \lambda_I \varphi \gamma_I}{\lambda_P + \lambda_S + \tilde{\lambda}_I}\sigma_{FS} + \frac{\tilde{\lambda}_I \gamma_I}{\lambda_P + \lambda_S + \tilde{\lambda}_I}\sigma_{Fut,tan}$$
$$with\ \lambda_i = N_i/\gamma_i, i = P, S, I$$
$$\tilde{\lambda}_I = \lambda_I \frac{\sigma_{FF}}{\sigma_{ee}},$$
$$\sigma_{Fut,tan} = Cov\left[R_{Fut,t+1}, r_{t+1}^{tan}\right].$$

+ Data and method

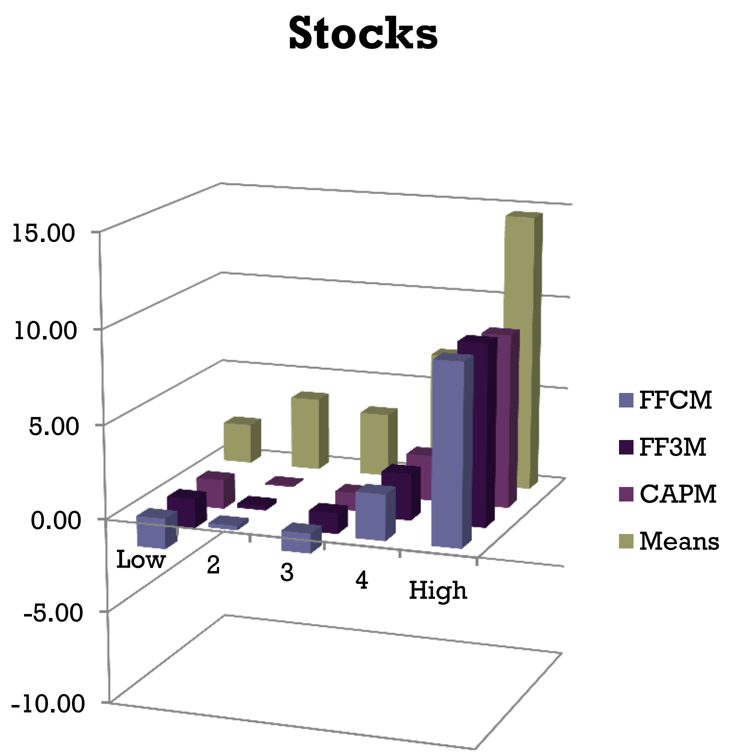
- All CRSP stocks, French's 48 industry portfolios
- OIW index of 33 commodities (from CRB and FII)
  - Robust: EW index, S&P-GSCI index
- Sorts on rolling 60 month commodity beta
  - High minus Low (HLCB) portfolios
  - Benchmark models: CAPM, FF3M and FFCM
- Robust
  - Different break points
  - Different rebalancing
  - Fama-MacBeth cross-sectional estimates
  - Between/within industry sort
  - Orthogonal to inflation

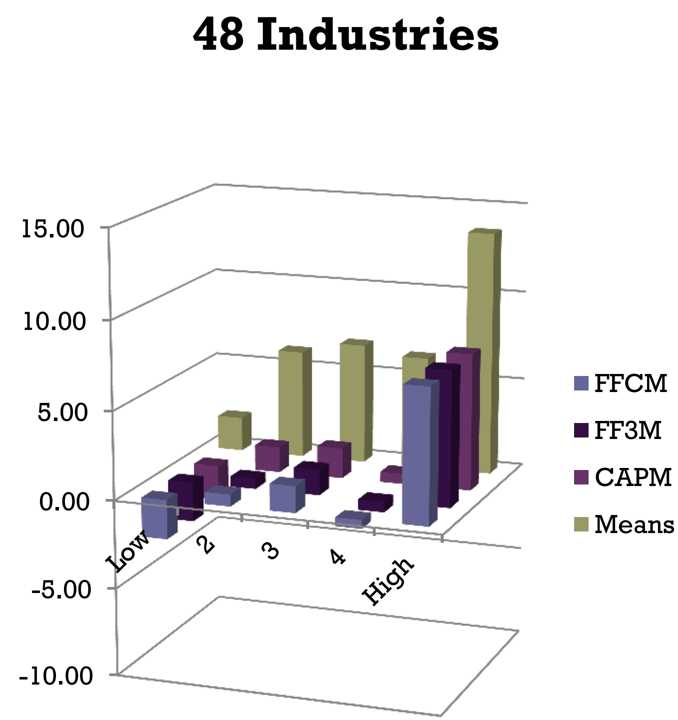
+ Stock market - pre-Financialization





+ Stock market – post-Financialization





Means and FFCM alphas

		Pre-Fin						Post-Fin					
		Size quintile			One-way			Size quintile			One-way		
		OIW S	OIW 3	OIW B	OIW Stocks	OIW 48 Ind.	EW Stocks	OIW S	OIW 3	OIW B	OIW Stocks	OIW 48 Ind.	EW Stocks
Means	H	5.88	3.55	2.33	**1.91**	5.00	4.45	12.13	15.29	15.10*	**14.85***	14.57	11.93
	4	8.88*	6.90*	7.04*	**6.58***	8.23*	5.77	12.02	9.97	4.78	**5.64**	5.97	7.33
	3	10.56*	9.44*	6.32*	**7.04***	7.84*	8.25*	11.07	8.58	2.08	**3.58**	6.62	5.16
	2	10.55*	11.32*	9.24*	**9.53***	10.07*	8.81*	9.25	7.91	3.08	**3.87**	6.47	5.07
	L	8.93*	13.03*	10.01*	**10.02***	9.72*	9.33*	1.88	1.98	3.25	**2.77**	2.35	3.24
	HLCB	-3.04	-9.47*	-7.68*	**-8.11***	-4.72*	-4.88	10.25*	13.31*	11.85*	**12.08***	12.22*	8.69
FFCM	H	-1.73	-6.12*	-5.52*	**-6.67***	-4.75*	-3.52	1.65	6.81	11.30*	**9.82***	8.60*	6.23
	4	0.69	-3.23*	-0.97	**-1.73**	-0.92	0.40	2.40	2.46	1.67	**1.33**	-0.82	1.76
	3	2.41	0.43	-0.61	**-0.13**	-1.99	0.76	1.60	1.66	-1.83	**-0.93**	1.08	1.16
	2	2.82	3.48*	3.22*	**3.33***	2.13	1.08	0.77	1.53	-0.47	**-0.19**	1.23	1.18
	L	2.75	5.59*	5.88*	**4.99***	2.12	2.77*	-6.66*	-4.67*	0.36	**-1.08**	-2.01	-0.09
	HLCB	-4.48*	-11.71*	-11.39*	**-11.66***	-6.87*	-6.30*	8.31*	11.48*	10.94*	**10.90***	10.60*	6.32

* Indicates significance at the 5%-level

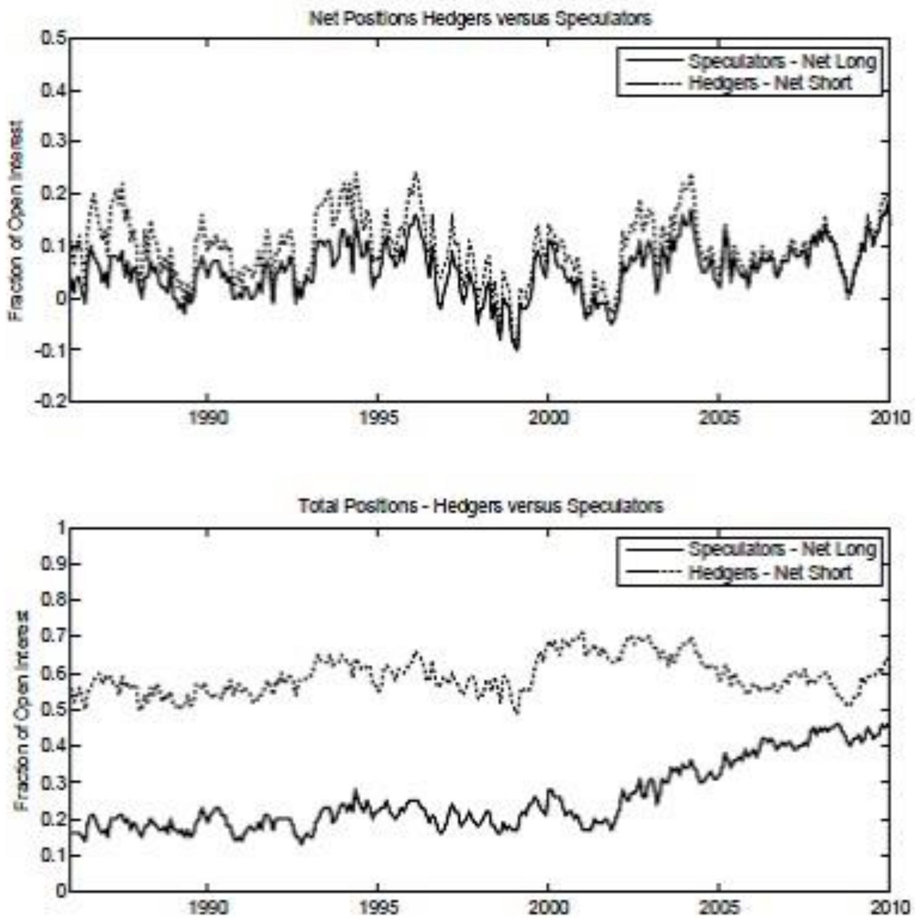
Commodity risk premium reverses if $\varphi < 0$ and $a/\sigma_{ee} > 0$

	(I) Pre-Fin	(II) Post-Fin
Setup	Investors seek commodity exposure in stock market	Commodity risk hedged with futures contract and speculative demand for commodity futures
Risk premium in stock markets	$E\left[r_{i,t+1}\right] = \gamma_I \sigma_{im} + \gamma_I \varphi \sigma_{iS}$ < 0 if $\varphi < 0$	$E\left[r_{i,t+1}\right] = \gamma_I \sigma_{im} + \frac{a}{\sigma_{ee}} \frac{\sigma_{SS}}{\sigma_{FF}} \sigma_{iS}$ > 0 if $a/\sigma_{ee} > 0$
Risk premium in futures markets	$E\left[R_{Fut,t+1}\right] = \frac{\lambda_P}{\lambda_P + \lambda_S} \gamma_P \sigma_{FS} \left(1+\eta\right)$	$E\left[R_{Fut,t+1}\right] = \frac{\lambda_P \left(1+\eta\right) \gamma_P + \lambda_I \varphi \gamma_I}{\lambda_P + \lambda_S + \tilde{\lambda}_I} \sigma_{FS} + \frac{\tilde{\lambda}_I \gamma_I}{\lambda_P + \lambda_S + \tilde{\lambda}_I} \sigma_{Fut,tan}$

+ Commodity risk premium reverses if $\varphi < 0$ and $a/\sigma_{ee} > 0$

- Investors are exposed to commodity price risk,
  - inflation
  - commodities as state-variable
- Hedging pressure from Producers sufficiently large, $a/\sigma_{ee}>0$
  - Producers are sufficiently risk averse (s.t. their speculative demand is small, and they have a strong need to hedge)
  - sufficiently many Producers
- Plausible given that traditional hedger's short positions are sufficient to cover speculator's long positions
  - (e.g., Stoll and Whaley (2009), Irwin and Sanders (2010) and Cheng et al. (2011))

Hedgers versus Speculators



Commodity risk premium reverses if $\varphi < 0$ and $a/\sigma_{ee} > 0$

	(I) Pre-Fin	(II) Post-Fin
Setup	Investors seek commodity exposure in stock market	Commodity risk hedged with futures contract and speculative demand for commodity futures
Risk premium in stock markets	$E\left[r_{i,t+1}\right] = \gamma_I \sigma_{im} + \gamma_I \varphi \sigma_{iS}$ < 0 if $\varphi < 0$	$E\left[r_{i,t+1}\right] = \gamma_I \sigma_{im} + \frac{a}{\sigma_{ee}} \frac{\sigma_{SS}}{\sigma_{FF}} \sigma_{iS}$ > 0 if $a/\sigma_{ee} > 0$
Risk premium in futures markets	$E\left[R_{Fut,t+1}\right] = \frac{\lambda_P}{\lambda_P + \lambda_S} \gamma_P \sigma_{FS} \left(1+\eta\right)$	$E\left[R_{Fut,t+1}\right] = \frac{\lambda_P \left(1+\eta\right) \gamma_P + \lambda_I \varphi \gamma_I}{\lambda_P + \lambda_S + \tilde{\lambda}_I} \sigma_{FS} + + \frac{\tilde{\lambda}_I \gamma_I}{\lambda_P + \lambda_S + \tilde{\lambda}_I} \sigma_{Fut,tan}$

+ Commodity futures markets

Sorting on Hedging Pressure						
	Full Sample		Pre-Fin		Post-Fin	
High	8.93	(2.67)	5.85	(1.73)	16.42	(2.06)
2	7.45	(2.22)	6.35	(1.96)	9.74	(1.19)
3	2.52	(0.74)	4.67	(1.40)	-2.72	(0.33)
Low	-0.59	(0.18)	-1.93	(0.63)	2.98	(0.50)
H-L	9.43	(2.59)	7.78	(1.92)	13.43	(1.75)

+ Commodity futures markets

Sorting on Stock market exposure (MKT + HLCB)						
			Pre-Fin		Post-Fin	
High			1.39	(0.31)	15.45	(1.72)
2			-0.63	(0.24)	6.99	(0.84)
3			0.57	(0.20)	4.29	(0.54)
Low			1.04	(0.40)	0.87	(0.18)
H-L			0.35	(0.07)	14.59	(1.85)

+ Conclusion

- Focus on the structural break in investors' behavior
  - Study a model with Investors exposed to commodity price risk
  - Analyze the effect of participation by Investors (related to Financialization)

- We find
  - Commodity risk is priced in stock market in the opposite way with and without position limits
  - Stock market risk is priced in the commodity futures market post-Financializaton
  - Consistent with Investors seeking commodity exposure in the stock market pre-Financialization and subsequently in the commodity futures markets
  - Stocks as a hedge or speculation on commodity prices

Conclusion (Ctd)

- We find
  - Results not sensitive to specific break-point
  - Stock market results not only an industry-effect
  - Energy and Metals & Fibers appear to be the most relevant commodity risks in the stock market
  - Commodity risk is not simply inflation risk

Stock market (further checks)

- Back to the stock market portfolios:
  - Is the timing (2003) crucial?
  - Is this an industry-effect?
  - Which commodities?
  - Is this simply inflation?

+ Timing of breakpoint

HLCB Post – Pre Breakpoint (mean returns)				
	Stocks		Indus	
2000	15.72	(2.33)	15.38	(2.63)
2001	19.00	(2.81)	15.29	(2.50)
2002	18.89	(2.95)	18.89	(2.92)
2003	16.95	(2.73)	16.95	(2.44)
2004	17.15	(2.52)	17.15	(2.20)
2005	13.60	(1.89)	13.60	(1.55)

Within-industry sort

- "Out-of-sample" test: spreads exist when using only within-industry variation in commodity beta
- Sort, while keeping industry exposure constant

		1980-2003 (Pre-Fin)						2004-2010 (Post-Fin)					
		Industries sorted on commodity beta						Industries sorted on commodity beta					
Within-industry		H	4	3	2	L	**Average**	H	4	3	2	L	**Average**
Means	HLCB	-3.39	-6.13*	-4.17	-3.34	-4.72	**-4.35***	13.64*	11.01*	5.38	19.05*	9.37	**11.69***
FFCM	HLCB	-6.92*	-7.58*	-4.37	-4.86*	-9.01*	**-6.55***	13.92*	9.76	2.17	14.58*	5.48	**9.18***

Which commodities?

Mean returns

	H	2	3	4	L	HL		Diff	
	Pre-Fin								
Energy	4.71	7.96	9.09	8.25	8.54	-3.82			
Agri	8.34	6.53	9.13	7.44	7.43	0.92			
Met/Fib	4.59	6.01	7.64	8.62	10.7	-6.13			
Live/Meat	6.79	9.48	7.65	7.23	5.93	0.86			
	Post-Fin								
Energy	14.8	6.40	3.54	3.81	1.26	12.8		17.4	(2.30)
Agri	4.91	6.59	5.41	8.17	3.80	-0.41		0.20	(0.03)
Met/Fib	8.67	5.76	6.61	4.95	2.83	3.81		12.0	(1.54)
Live/Meat	11.6	5.21	4.46	4.19	5.51	3.58		5.26	(0.87)

Which commodities?

FFCM-alphas

	H	2	3	4	L	HL		Diff	
	Pre-Fin								
Energy	-3.65	-0.01	1.50	1.32	1.05	-4.69			
Agri	0.77	-0.04	1.75	0.73	3.24	-2.46			
Met/Fib	-0.92	-0.90	1.26	1.88	3.46	-4.38			
Live/Meat	-1.75	1.14	-0.35	1.14	0.19	-1.94			
	Post-Fin								
Energy	9.82	2.32	-1.13	-0.01	-2.99	12.8		17.5	(2.36)
Agri	-1.03	1.75	1.72	4.00	-0.62	-0.41		2.05	(0.35)
Met/Fib	2.66	1.10	2.69	1.03	-1.15	3.81		8.18	(1.24)
Live/Meat	4.96	-0.05	0.35	1.08	1.38	3.58		5.52	(1.11)

Is it inflation (CPI)?

- Orthogonalize commodity returns w.r.t. inflation, and repeat
- FFCM-alphas:

	H	2	3	4	L	HL		Diff
	Pre-Fin							
Stocks	**-6.36**	-1.64	-0.18	**3.08**	**4.77**	**-11.1**		
Indu	**-5.19**	-1.27	-1.00	1.69	2.41	**-7.61**		
	Post-Fin							
Stocks	**7.85**	0.59	0.04	-1.17	-0.81	8.66		**19.8**
Indu	6.46	0.05	1.11	1.94	-1.70	8.16		**15.8**

+ Conclusion

- Focus on the structural break in investors' behavior
  - Study a model with Investors exposed to commodity price risk
  - Analyze the effect of participation by Investors (related to Financialization)
- We find
  - Commodity risk is priced in stock market in the opposite way with and without position limits
  - Stock market risk is priced in the commodity futures market post-Financializaton
  - Consistent with Investors seeking commodity exposure in the stock market pre-Financialization and subsequently in the commodity futures markets
  - Stocks as a hedge or speculation on commodity prices

Conclusion (Ctd)

- We find
  - Results not sensitive to specific break-point
  - Stock market results not only an industry-effect
  - Energy and Metals & Fibers appear to be the most relevant commodity risks in the stock market
  - Commodity risk is not simply inflation risk