The Stock Market Price of Commodity Risk

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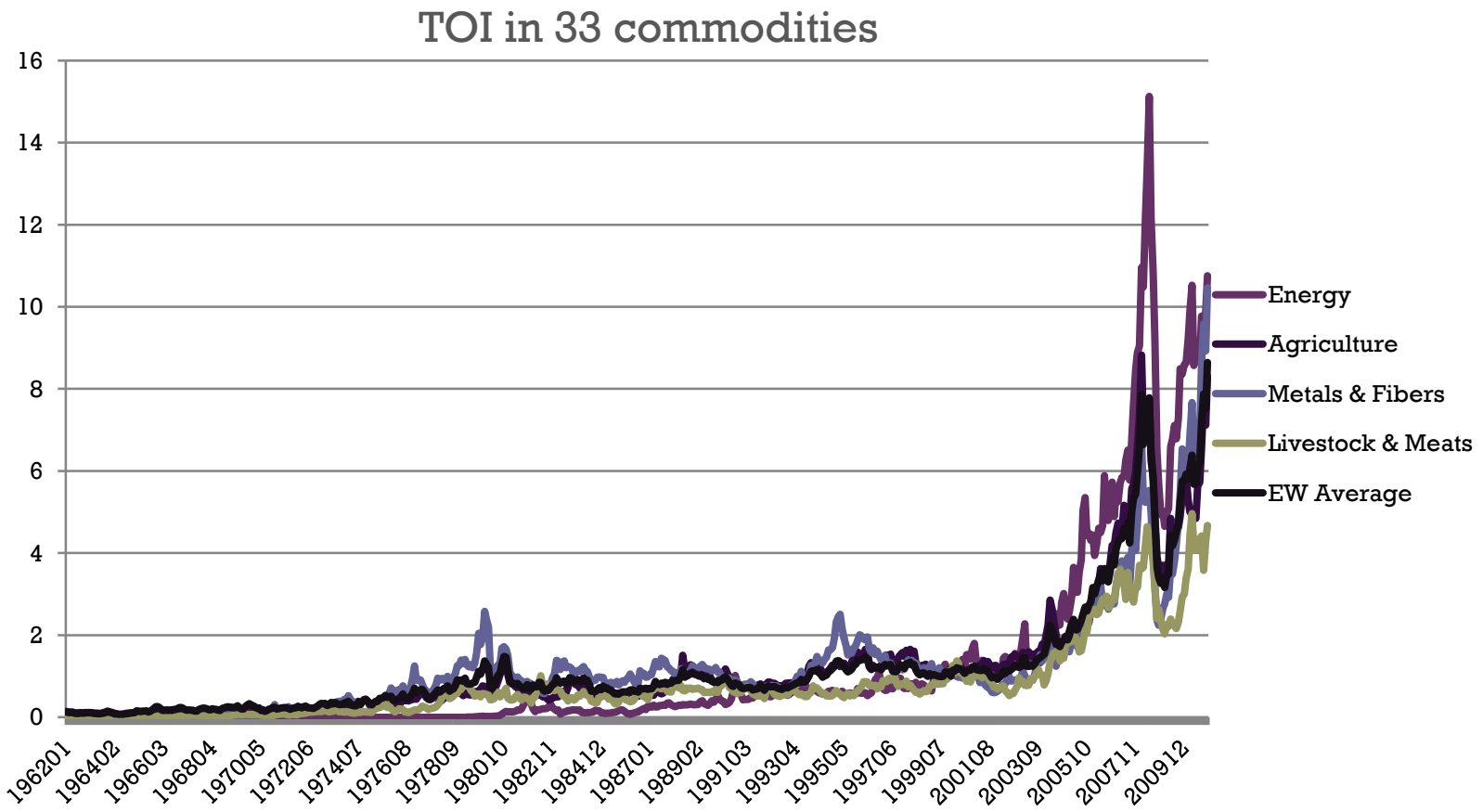
Motivation

- Commodity Index Investing / Commodity Futures Modernization Act (CFMA) / Financialization
  - Dramatic change in size and composition of futures markets



Motivation

- Commodity Futures Modernization Act (CFMA)
  - Pre-CFMA commodity exposure
    - position limits in futures markets
    - commodity-related equity, physical commodities
  - Post-CFMA 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)
- CFMA – 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 CFMA/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 position limits related to CFMA
- Testable implications
  - 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 CFMA
  - Stock market risk is priced in the commodity futures market post-CFMA
  - 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)
- Position limits for Investors
  - Before CFMA only invest in the stock market
  - Post CFMA invest 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:
  - With position limits: over stocks only (w_r)

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

  - Without position limits: 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
  - With limits

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

  - Without limits

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

Model: Futures market

- (Hedging Pressure effects)
- With position limits: Producers and Speculators only

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

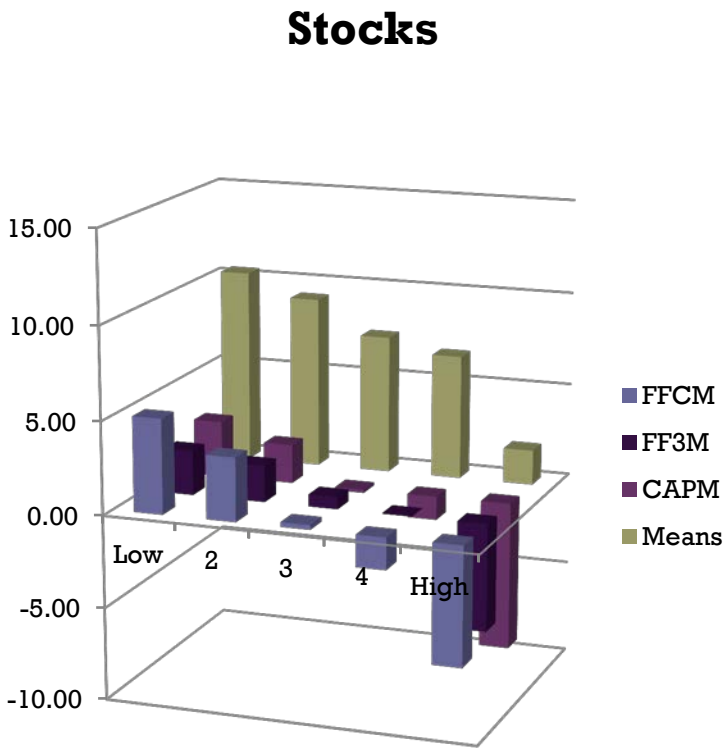
- Without position limits: Producers, Speculators and Investors

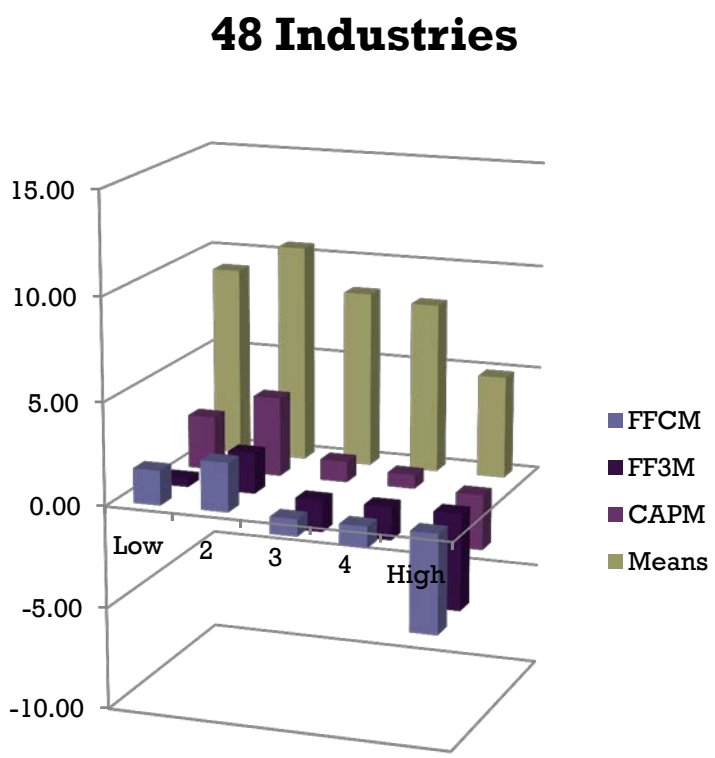
$$
\begin{aligned}
E\left[R_{Fut,t+1}\right] &= \frac{\lambda_P\left(1+\eta\right)\gamma_P+\lambda_I\varphi\gamma_I}{\lambda_P+\lambda_S+\tilde{\lambda}_I}\sigma_{FS}+\frac{\tilde{\lambda}_I\gamma_I}{\lambda_P+\lambda_S+\tilde{\lambda}_I}\sigma_{Fut,tan} \\
with\ \lambda_i &= N_i/\gamma_i, i=P,S,I \\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

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

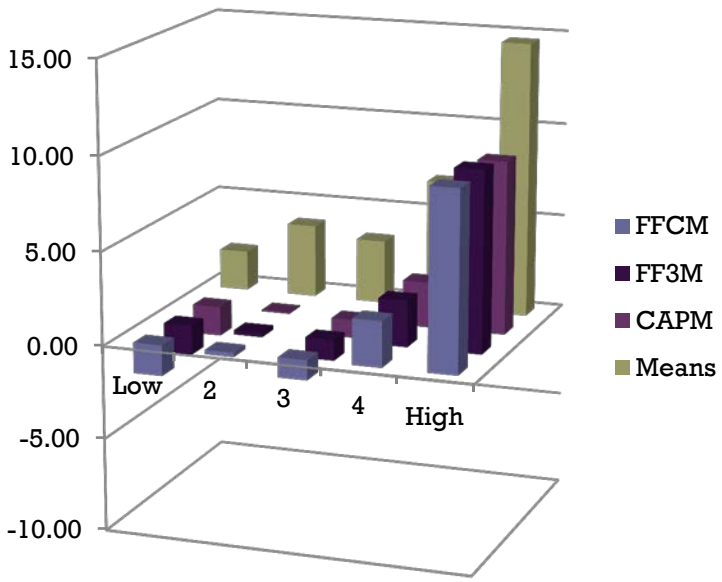
Stock market - pre-CFMA



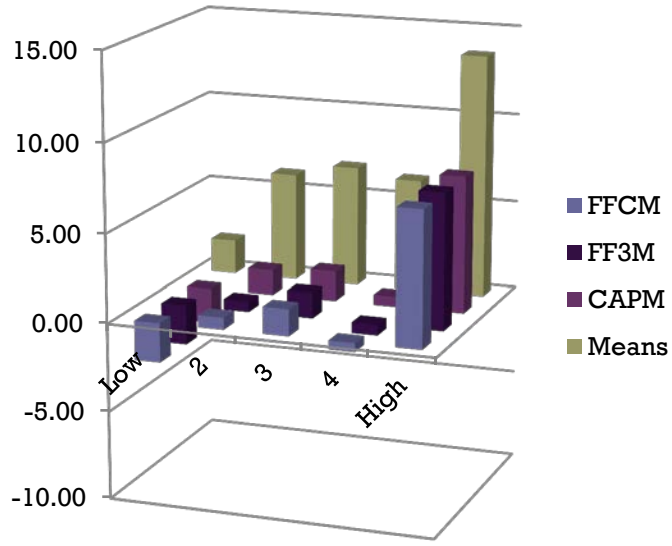


Stock market – post-CFMA

Stocks



48 Industries



Means and FFCM alphas

		Pre-CFMA						Post-CFMA					
		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

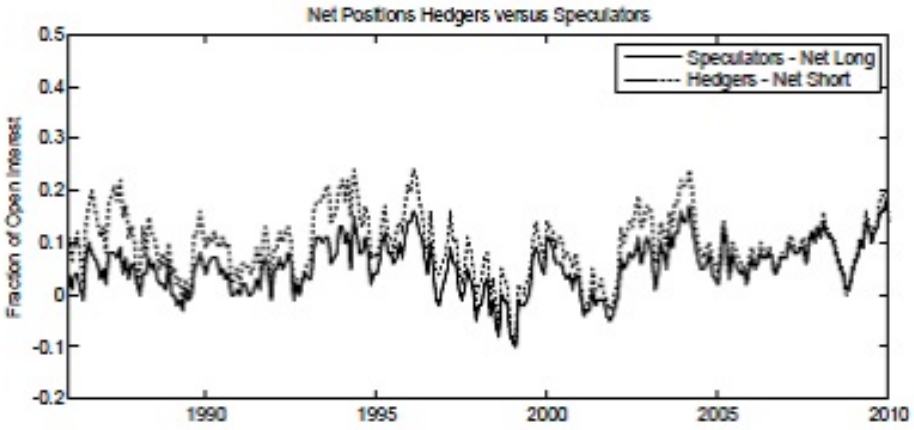
Commodity risk premium reverses if $\varphi < 0$ and $a/\sigma_{ee} > 0$

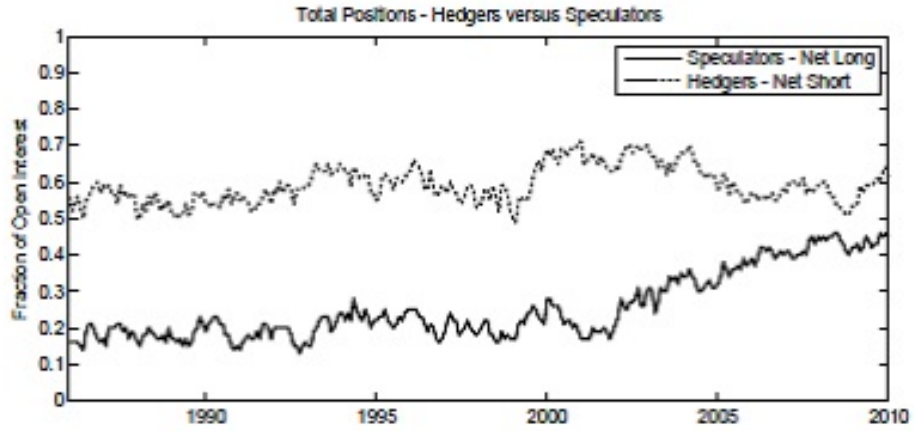
	(I) Pre-CFMA	(II) Post-CFMA
Setup	Investors seek commodity exposure in stock market	Commodity risk hedged with futures contract and speculative demand for commodity futures
Risk premium in stock markets	$E[r_{i,t+1}] = \gamma_I \sigma_{im} + \gamma_I \varphi \sigma_{iS}$ < 0 if $\varphi < 0$	$E[r_{i,t+1}]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

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))
- Also, historically, sizeable diversification benefits when commodities are added to portfolios of stocks and bonds

Hedgers versus Speculators





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

	(I) Pre-CFMA	(II) Post-CFMA
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	$E[r_{i,t+1}] = \gamma_I \sigma_{im} + \gamma_I \varphi \sigma_{iS}$ < 0 if $\varphi < 0$	$E[r_{i,t+1}] = \gamma_I \sigma_{im} + \frac{a}{\sigma_{ee}} \frac{\sigma_{SS}}{\sigma_{FF}} \sigma_{iS}$ > 0 if $a/\sigma_{ee} > 0$
Risk premium in futures markets	$E[R_{Fut,t+1}] = \frac{\lambda_P}{\lambda_P + \lambda_S} \gamma_P \sigma_{FS} (1 + \eta)$	$E[R_{Fut,t+1}] = \frac{\lambda_P (1+\eta) \gamma_P + \lambda_I \varphi \gamma_I}{\lambda_P + \lambda_S + \tilde{\lambda}_I} \sigma_{FS} + + \frac{\tilde{\lambda}_I \gamma_I}{\lambda_P + \lambda_S + \tilde{\lambda}_I} \sigma_{Fut,tan}$

Commodity futures markets

Sorting on Hedging Pressure						
	Full Sample		Pre-CFMA		Post-CFMA	
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-CFMA		Post-CFMA	
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)

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-CFMA)						2004-2010 (Post-CFMA)					
		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-CFMA								
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-CFMA								
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-CFMA								
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			
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-CFMA							
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-CFMA							
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 position limits related to CFMA
- 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-CFMA
  - Consistent with Investors seeking commodity exposure in the stock market pre-CFMA 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