Are there common factors in commodity futures returns?

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Presentation Outline

- Motivation: In search of a model for the time-series *and the cross-section* of commodity future returns
- Do factor models that have been successful for stock returns work for commodities too?
- How about theory-based commodity-specific factor models?
- Empirical results and implications for *asset pricing* and *market segmentation*

Motivation: In search of a model

- Vast literature on factor models for equity asset pricing
- Limited and inconclusive evidence for the *cross-section* of commodities: Dusak (1973), Bodie and Rosanky (1980), Breeden (1980), Jagannathan (1985) and DeRoon and Szymanowska (2010)
- Most of the recent studies focus on predictability of *individual* commodity returns (*not* explaining the *cross-section* of returns): DeRoon et al. (2000), Acharya et al. (2011), Gorton et al. (2012)
- Very important issue for practitioners too: portfolio choice, investment performance evaluation and risk management

This paper

- We fill this gap by testing whether there are common factors in the cross-section of commodity futures returns
- Use a cross-section of 22 contracts over the period 1989-2010
- Employ macro-based factor models and models that have proved successful for stock returns
- Construct theory-based commodity-specific factors
- Results show that none of the tested models has sufficient explanatory power
- Provide a statistical and an economic interpretation of the results

Commodity futures dataset

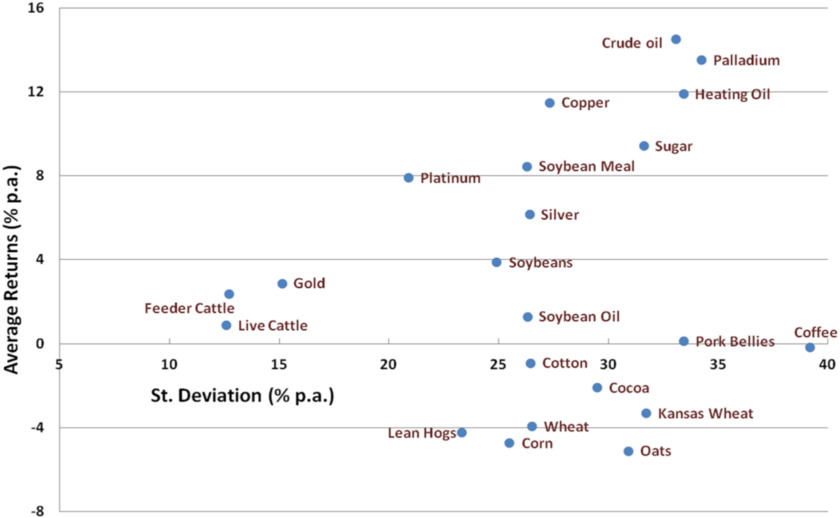
- 22 commodity futures contracts during January 1989- December 2010
- Monthly and quarterly returns for nearest futures contract using rollover strategy

Futures Contract	Exchange	Futures Contract	Exchange
Grains & Oilseeds		**Livestock**	
Corn	Chicago Board of Trade	Live Cattle	Chicago Mercantile Exchange
Wheat	Chicago Board of Trade	Lean Hogs	Chicago Mercantile Exchange
Kansas Wheat	Kansas City Board of Trade	Feeder Cattle	Chicago Mercantile Exchange
Soybeans	Chicago Board of Trade	Frozen Pork Bellies	Chicago Mercantile Exchange
Soybean Meal	Chicago Board of Trade		
Soybean Oil	Chicago Board of Trade	**Softs**	
Oats	Chicago Board of Trade	Cocoa	New York Board of Trade
		Coffee	New York Board of Trade
Metals		Cotton	New York Board of Trade
Gold	Commodity Exchange, Inc.	Sugar	New York Board of Trade
Silver	Commodity Exchange, Inc.		
Copper	Commodity Exchange, Inc.	**Energy**	
Platinum	New York Mercantile Exchange	Crude Oil	New York Mercantile Exchange
Palladium	New York Mercantile Exchange	Heating Oil	New York Mercantile Exchange

Factors dataset

- Kenneth French's online data library for market, size, value and momentum factors
- Alternative market indices: S&P GSCI, hybrid NYSE+GSCI index
- Real consumption per capita growth from NIPA tables
- M2 from St. Louis Fed and leverage of broker-dealers from Fed Flows of Funds
- Long and short hedging positions from CFTC
- Liquidity traded factor from Pastor and Stambaugh (2003), FX traded factor from Lustig et al. (2011)

Returns and Risk in commodity futures



Factor models

- Starting point: Consumption CAPM. Stochastic Discount Factor (SDF): $m = \frac{U'(c_{t+1})}{U'(c_t)}$ (or consumption growth under power utility)
- Empirical failure of CCAPM led to the introduction of factor models. Starting from a factor representation of the SDF

$$m = b^T f$$

we can derive the equivalent expected return-beta representation

$$E(r_i) = \beta_i^T \lambda$$

of the time-series regression

$$r_{i,t} = \alpha_i + \beta_i^T f_t + \varepsilon_{i,t}$$

- Use Fama-MacBeth two-pass regressions or GMM to estimate α_i, β_i (factor exposures) and λ (prices of risk)

Macro-based models

1. CAPM-type: Single factor, Market index returns
2. Money-CAPM (Balvers and Huang, 2009): Adds M2 growth to CAPM
3. Money-CCAPM (Balver and Huang, 2009): Adds M2 growth to consumption growth
4. FX-CAPM (Dumas and Solnik, 1993): Adds an FX returns factor to CAPM
5. Leverage factor (Adrian et al., 2011): Innovations to broker-dealers' leverage as extra factor

Equity-motivated tradable factors' models

1. Fama-French model: Market, Size (SMB) and Value (HML) factors
2. Carhart model: Market, SMB, HML and Momentum (MOM) factors
3. Pastor and Stambaugh (2003) model: Adds a Liquidity (LIQ) factor to FF or Carhart models

- Cochrane's Theorem: Under free portfolio formation+ the law of one price (LOP), if SDF belongs to the payoff space, it should be unique
- Therefore, factor models explaining the cross-section of equity returns should explain the cross-section of commodity futures returns too
- Otherwise, LOP does not hold and/ or commodity market is segmented from the equity market
- If markets are segmented, then commodity-specific factors may explain their premia (?)

Commodity-specific factors

- Hedging Pressure (Cootner 1960 hypothesis):

$$\text{HP} = \frac{\text{\# short hedge positions - \# long hedge}}{\text{\# Total positions}}$$

Com. with +ve HP should yield higher returns vs com. with -ve HP

- Theory of storage (Kaldor-Working-Brennan): Low inventory commodities command high risk premia. Proxies for inventory (Gorton et al., 2012):

1. Basis (positive basis-> low inventory):

$$\text{Basis} = \frac{F_1 - F_2}{F_1}$$

2. Momentum (reflects -ve shocks to inventory): prior 12-month return

- Commodities with +ve basis (+ve momentum) should yield higher returns relative to commodities with -ve basis (-ve momentum)

Commodity-specific factors

- Factors: post-formation spread returns of zero-cost portfolios: Long (Short) 5 commodities with most +ve (-ve) HP/ basis/ momentum
- Alternative: Use all commodities with +ve (-ve) HP/ basis/ momentum in the long (short) portfolio

	Mean	St. Deviation		Mean	St. Deviation
HP factor			**HP factor (alter.)**		
Long Portfolio (HP^+)	3.86%	14.05%	Long Portfolio (HP^+)	4.36%	17.23%
Short Portfolio (HP^-)	2.64%	14.48%	Short Portfolio (HP^-)	2.05%	15.21%
HML_{HP}	**1.22%**	**14.91%**	HML_{HP}	**2.31%**	**20.12%**
t-stat	***(0.383)***		***t-stat***	***(0.538)***	
Basis factor			**Basis factor (alter.)**		
Long Portfolio ($Basis^+$)	10.98%	16.90%	Long Portfolio ($Basis^+$)	7.63%	18.74%
Short Portfolio ($Basis^-$)	-0.46%	12.94%	Short Portfolio ($Basis^-$)	-3.97%	15.56%
HML_B	**11.44%**	**14.87%**	HML_B	**11.60%**	**18.89%**
t-stat	***(3.604)***		***t-stat***	***(2.874)***	
Momentum factor			**Momentum factor (alter.)**		
Long Portfolio (Mom^+)	8.71%	14.04%	Long Portfolio (Mom^+)	10.11%	20.42%
Short Portfolio (Mom^-)	-4.59%	16.27%	Short Portfolio (Mom^-)	-4.67%	18.84%
HML_M	**13.30%**	**17.76%**	HML_M	**14.78%**	**25.58%**
t-stat	***(3.505)***		***t-stat***	***(2.705)***	

Overview of results

- R^2 of time series regressions (1st pass of Fama-MacBeth) for each commodity futures are very low ($\sim$ 25%)
- Factor betas are highly time-varying and most of the times insignificant in the full sample
- Premia reported in futures returns are not explained by factor exposures- they appear as **alphas**
- None of the risk premia (λ's) is found to be significant in the cross-section (2nd pass regressions)
- Premia do not align with factor exposures (betas)
- Results remain the same at the quarterly frequency
- Overall: No common factor in the cross-section of commodity returns

Fama-MacBeth results for macro models (monthly)

	CAPM	CCAPM	MCAPM	MCCAPM	FXCAPM
Constant	0.004	0.003	0.004	0.001	0.003
t-stat	*(1.451)*	*(1.278)*	*(1.764)*	*(0.532)*	*(1.251)*
Market Return	0.000		-0.004		-0.002
t-stat	*(0.022)*		*(-0.548)*		*(-0.238)*
Cons. growth		0.000		0.000	
t-stat		*(0.211)*		*(0.539)*	
Money growth			-0.001	-0.001	
t-stat			*(-1.093)*	*(-0.981)*	
FX factor					-0.002
t-stat					*(-0.386)*
R-squared	11.25%	9.54%	19.15%	18.79%	18.36%
Adj-R-squared	6.82%	5.01%	10.64%	10.24%	9.76%

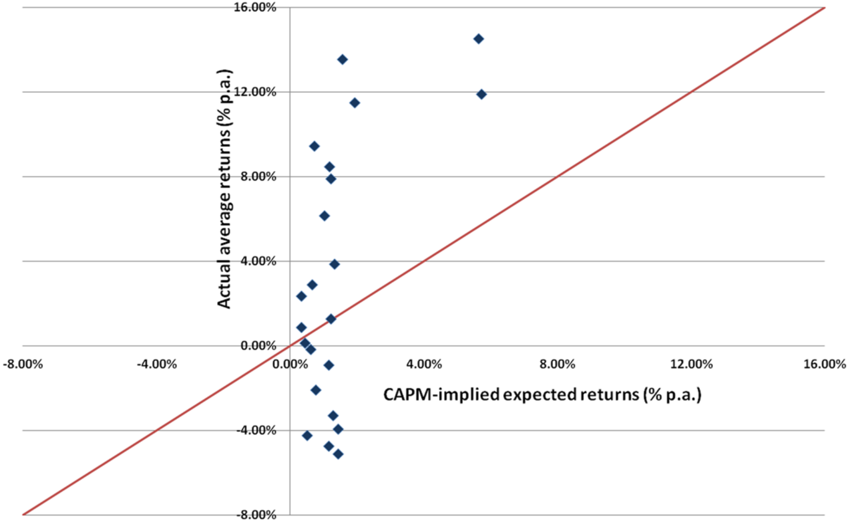
FM results for equity-motivated models (monthly)

	Fama-French	Carhart	Liquidity+FF	Liquidity+Carhart
Constant	0.006	0.006	0.005	0.004
t-stat	*(2.681)*	*(2.53)*	*(2.036)*	*(1.731)*
Market Factor	-0.002	-0.001	0.001	0.004
t-stat	*(-0.302)*	*(-0.193)*	*(0.172)*	*(0.456)*
Size Factor	-0.002	-0.003	-0.003	-0.004
t-stat	*(-0.393)*	*(-0.566)*	*(-0.525)*	*(-0.768)*
Value Factor	-0.002	-0.001	-0.003	-0.003
t-stat	*(-0.229)*	*(-0.070)*	*(-0.441)*	*(-0.391)*
Momentum Factor		0.007		0.009
t-stat		*(0.681)*		*(0.901)*
Liquidity Factor			0.005	0.004
t-stat			*(0.637)*	*(0.531)*
R-squared	30.06%	39.14%	37.62%	45.68%
Adj-R-squared	18.41%	24.82%	22.94%	28.70%

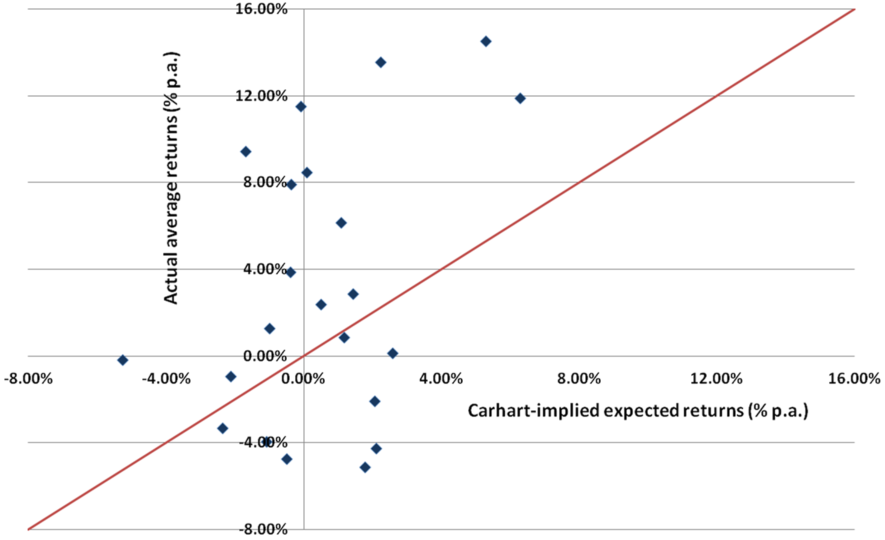
FM results for commodity-specific factor models

	HP+CAPM (a)	HP+CAPM (b)	Basis+CAPM (a)	Basis+CAPM (b)	Momentum (a)	Momentum (b)
Constant	0.003	0.004	0.003	0.003	0.004	0.004
t-stat	*(1.312)*	*(1.575)*	*(1.552)*	*(1.195)*	*(2.072)*	*(2.059)*
Market Factor	0.001	0.000	-0.001	0.001	-0.004	-0.004
t-stat	*(0.095)*	*(0.064)*	*(-0.172)*	*(0.12)*	*(-0.556)*	*(-0.470)*
HP Factor	0.001	0.000				
t-stat	*(0.241)*	*(0.058)*				
Basis Factor			-0.005	0.011		
t-stat			*(-0.837)*	*(1.33)*		
Momentum					0.008	0.004
t-stat					*(1.038)*	*(0.37)*
R-squared	21.54%	20.93%	21.27%	20.73%	22.93%	22.84%
Adj-R-squared	13.28%	12.61%	12.98%	12.38%	14.82%	14.72%

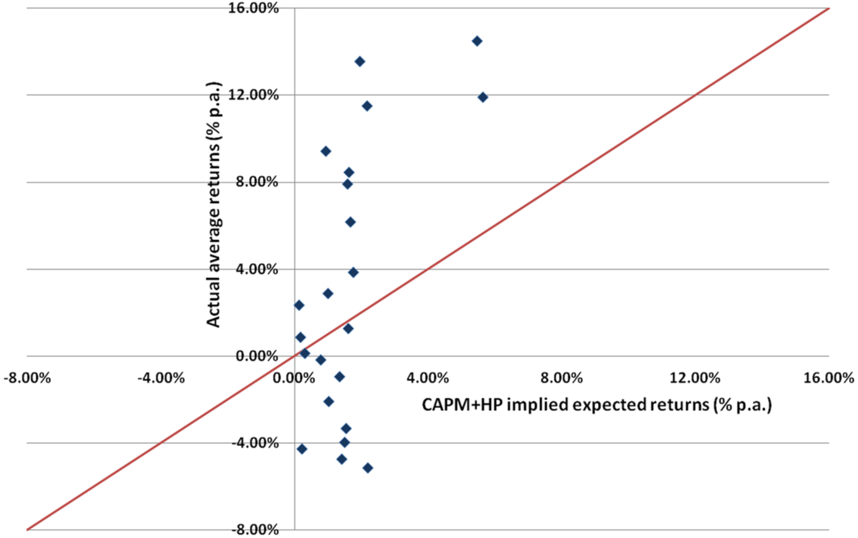
Full sample fit of CAPM (commodity market index)



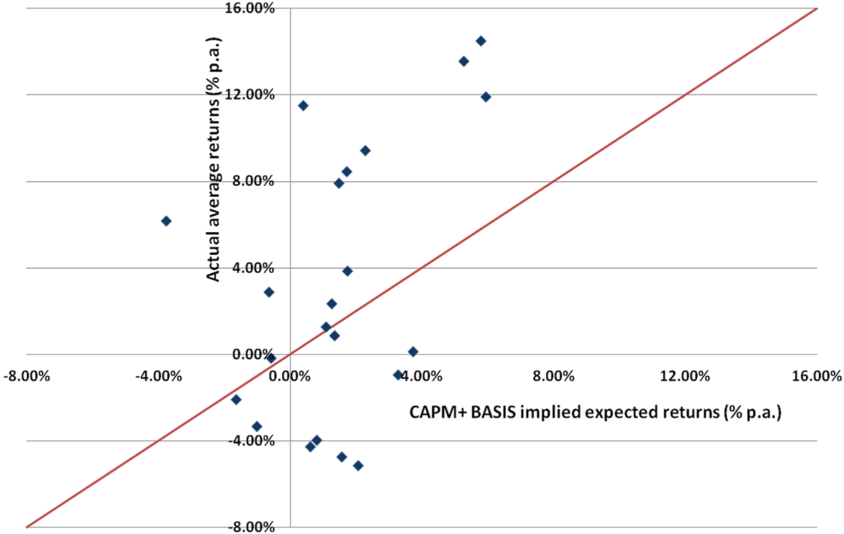
Full sample fit of Carhart model



Full sample fit of CAPM+ HP factor



Full sample fit of CAPM+ Basis factor



PC Analysis of commodity futures returns

- Perform a Principal Components Analysis of these 22 assets' returns to identify common factors in the cross-section (Cochrane, 2011)

$$r_{i,t} = q_{1i} f_{1,t} + q_{2i} f_{2,t} + \ldots + q_{22i} f_{22,t}$$

- q's (eigenvectors) are the factor loadings and f's are the a-theoretical orthogonal factors
- Confirming previous findings:

1. Lack of common factor structure: First factor explains only 25% of the returns' variation (eigenvalue). 5 factors required to explain 60%
2. Factor exposures q's cannot explain futures cross-sectional premia

Conclusions

- Commonly used, successful models for stocks do not explain the cross-section of commodity futures premia -> markets are segmented
- Theory-based commodity-specific factor models are not successful either
- PCA confirms the lack of common factors in the cross-section of commodity futures -> commodities market is segmented itself
- Each commodity futures contract is exposed to a different set of factors -> great degree of heterogeneity
- No common risk factor structure -> no systematic risk in these commodity returns -> risk/ return profiles are purely idiosyncratic
- Important implications for portfolio choice and investment performance evaluation