Are there common factors in individual commodity futures returns?

Recent Advances in Commodity Markets (QMUL)

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Presentation Outline

- Motivation: This paper and related literature
- Dataset
- Macro and equity-motivated factor models
- Construction of commodity-specific factors
- Principal Components model
- Conclusions and implications

Motivation and Related Literature

- In search of a pricing model for **the cross-section** of commodity futures returns
- **Importance:** Investment performance evaluation and risk management imply or rely upon an asset pricing model
- **Challenge:** Commodities considered an "alternative" asset class but also constitute a rather heterogeneous market
- Established literature in a **time series setting** using commodity-specific factors: Carter et al. (1983), Hirshleifer (1988, 1989), Bessembinder (1992), de Roon et al. (2000), Gorton et al. (2012), Gospondinov and Ng (2013), Acharya et al. (2013)

Related Literature

- But these studies focus on **predictability** of commodity returns (**not** explaining their **cross-section**)
- Limited and inconclusive evidence for the **cross-section** of commodities returns:

1. Individual commodity futures: Jagannathan (1985), de Roon and Szymanowska (2010), Miffre et al. (2012), Basu and Miffre (2013)
2. Portfolios of commodity futures: Yang (2013), Szymanowska et al. (2013), Bakshi et al. (2013)
3. Extended universe of test assets (including other asset classes): Dhume (2011), Asness et al. (2013)

This paper

- We test whether there are common factors in the cross-section of (individual) commodity futures returns
- Use a cross-section of 22 contracts over the period 1989-2010
- Employ macro-based factor models and models that have proven successful for stock returns
- Construct theory-based commodity-specific factors
- Results show that none of the tested factors is economically/ statistically significant
- Provide a statistical and an economic interpretation of the results

Why individual contracts?

- Why not portfolios of commodity futures?
  1. Inference problem due to **low d.f.** when ∼5 portfolios are used
  2. **Tautology** criticism (see Ahn et al., 2009, Lewellen et al., 2010):
     - Inappropriate to form portfolios (test assets) using as sorting variable the **same** one used to construct the factor
     - Even more problematic when the **factor** is defined as the **spread return** of these portfolios
     - A successful factor should work for **any portfolio formation** approach, including alphabetical grouping! (Cochrane, AFA 2011)
  3. Masking **heterogeneity** in commodity returns → Potentially distorting factor risk premia estimates (see Ang et al., 2010)
- Why not an extended test assets universe?

  No guarantee that factor significance in the entire cross-section implies significance in its subsets →need to verify.
  Even more important if commodity market is **segmented**

Commodity futures dataset

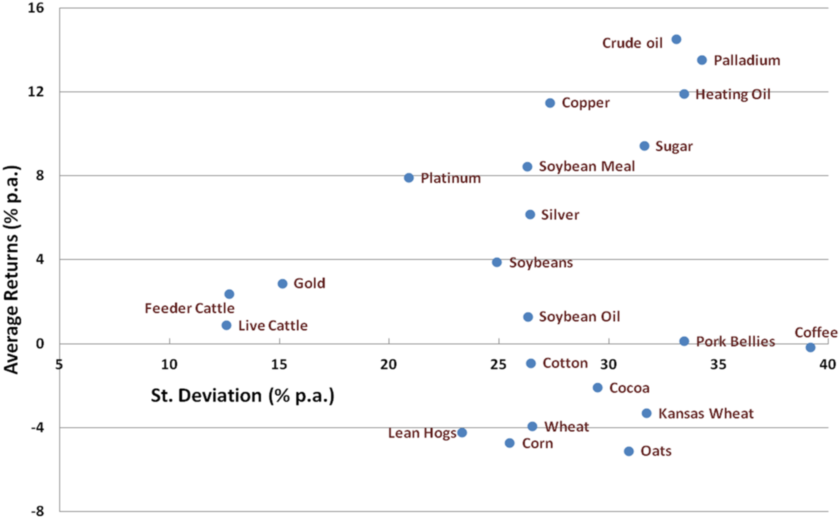
- 22 commodity futures contracts during January 1989- December 2010 obtained from Bloomberg (balanced panel)
- Rolling monthly excess returns for nearest-to-maturity contract that does not expire during next month (Gorton et al. 2012)

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

- Consumption growth from NIPA and a series of macro variables shocks from Fed/ Datastream
- M2 growth and primary dealers' repo growth from Fed
- Leverage factor of broker-dealers as in Adrian et al. (2013)
- Market, SMB, HML and MOM factors from French's library
- Alternative market indices: S&P GSCI and hybrid index
- Liquidity factor from Stambaugh and FX factor from Lustig
- Constructed commodity-specific factors using also:
  - # of long/ short hedgers from CFTC
  - open interest and trading volume for commodity contracts from Bloomberg

Risk and returns in commodity futures



Factor models

- Starting point: Consumption CAPM.
  SDF: $m = \frac{U'(c_{t+1})}{U'(c_t)}$ (or consumption growth under power utility)
- Empirical failure of CCAPM $\rightarrow$ 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. CCAPM: Consumption growth
2. CAPM: Stock/ Commodity market index returns
3. Money-CAPM (Balvers and Huang, 2009): Adds M2 growth
4. Money-CCAPM (Balver and Huang, 2009): Adds M2 growth
5. FX-CAPM (Dumas and Solnik, 1993): Adds FX returns factor
6. Leverage factor (Adrian et al., 2013): Innovations to broker-dealers' leverage as extra factor
7. Macro shocks model (ICAPM-type): IP (GDP), inflation, (real) rate

Equity-motivated tradable factor models

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

- Cochrane's Theorem: Under free portfolio formation+ LOP, if **SDF** belongs to the payoff space, it should be **unique**
- $\Rightarrow$ factor models explaining the cross-section of stock returns should also explain the cross-section of commodity futures returns
- 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

- Theory of storage: Low inventory commodities $\rightarrow$ high risk premia. Inventory data unavailable so proxies for inventory (Gorton et al. 2012):

1. **Basis** (low inventory $\rightarrow$ positive basis):

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

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

- **Hedging Pressure:**

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

Commodities with +ve HP should yield higher returns relative to commodities with -ve HP

- Benchmark approach (a): Long (Short) 5 commodities with most +ve (-ve) HP/ basis/ momentum and use post-formation spread returns
- Alternative (b): Use all commodities with +ve (-ve) HP/ basis/ momentum in the long (short) portfolio

- **Liquidity factor:** Average Amihud's RtoV across commodities
- **Open interest factor:** Shocks to the aggregate open interest across commodities

Commodity-specific factors

	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%
$\boldsymbol{HML_{HP}}$	**1.22%**	**14.91%**	$\boldsymbol{HML_{HP}}$	**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%
$\boldsymbol{HML_{B}}$	**11.44%**	**14.87%**	$\boldsymbol{HML_{B}}$	**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%
$\boldsymbol{HML_{M}}$	**13.30%**	**17.76%**	$\boldsymbol{HML_{M}}$	**14.78%**	**25.58%**
t-stat	***(3.505)***		***t-stat***	***(2.705)***	

Overview of results

- R^2 of time series regressions (1st pass of FM) for each commodity futures are typically **very low (~ 25%)**
- Factor **betas are highly time-varying** and often **insignificant** in the full sample
- Futures premia are not explained by factor exposures $\Rightarrow$ they remain as **alphas**
- **None of the factors risk premia** (λ's) is found to be significant in the cross-section (2nd pass regressions)
- Overall: **No factor is priced** in the cross-section of commodity futures returns (i.e. no common factor)

Fama-MacBeth results for macro models

	CAPM	CCAPM	MCAPM	MCCAPM	FXCAPM	Macro shocks
Constant	0.004	0.003	0.004	0.001	0.003	0.004
Shanken's t-stat	*(1.451)*	*(1.277)*	*(1.726)*	*(0.524)*	*(1.248)*	*(1.375)*
Market Return	0.000		-0.004		-0.002	
Shanken's t-stat	*(0.022)*		*(-0.538)*		*(-0.238)*	
Cons. growth		0.000		0.000		
Shanken's t-stat		*(0.211)*		*(-0.532)*		
Money growth			-0.001	-0.001		
Shanken's t-stat			*(-1.074)*	*(-0.969)*		
FX factor					-0.002	
Shanken's t-stat					*(-0.385)*	
Production shocks						-0.001
Shanken's t-stat						*(-1.009)*
Consumption shocks						-0.001
Shanken's t-stat						*(-0.896)*
Inflation shocks						-0.001
Shanken's t-stat						*(-0.779)*
Interest rate shocks						0.068
Shanken's t-stat						*(1.455)*
R-squared	11.25%	9.54%	19.15%	18.79%	18.36%	37.85%
Adj-R-squared	6.82%	5.01%	10.64%	10.24%	9.76%	23.23%

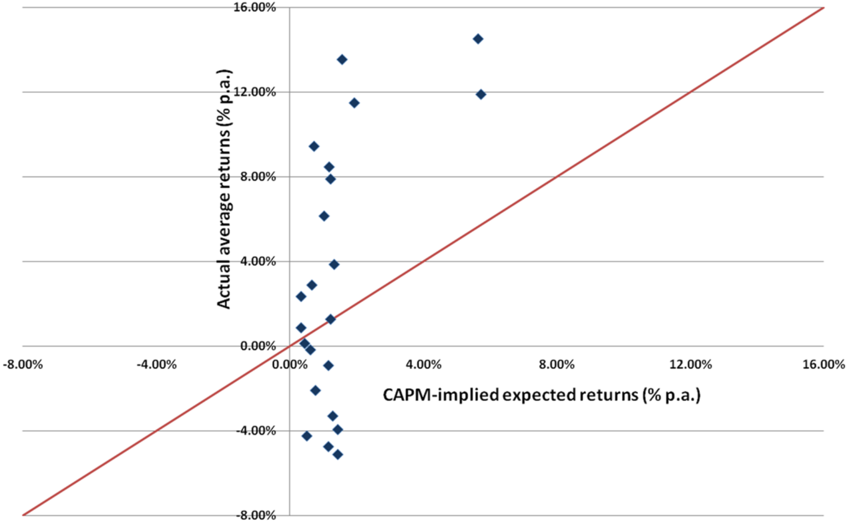
FM results for equity-motivated models

	Fama-French	Carhart	Liquidity+FF	Liq+Carhart
Constant	0.006	0.006	0.005	0.004
Shanken's t-stat	*(2.669)*	*(2.494)*	*(2.004)*	*(1.668)*
Market Factor	-0.002	-0.001	0.001	0.004
Shanken's t-stat	*(-0.301)*	*(-0.191)*	*(0.170)*	*(0.442)*
Size Factor	-0.002	-0.003	-0.003	-0.004
Shanken's t-stat	*(-0.391)*	*(-0.559)*	*(-0.518)*	*(-0.745)*
Value Factor	-0.002	-0.001	-0.003	-0.003
Shanken's t-stat	*(-0.228)*	*(-0.069)*	*(-0.435)*	*(-0.379)*
Momentum Factor		0.007		0.009
Shanken's t-stat		*(0.672)*		*(0.873)*
Liquidity Factor			0.005	0.004
Shanken's t-stat			*(0.628)*	*(0.514)*
R-squared	30.06%	39.14%	37.62%	45.68%
Adj-R-squared	18.41%	24.82%	22.94%	28.70%

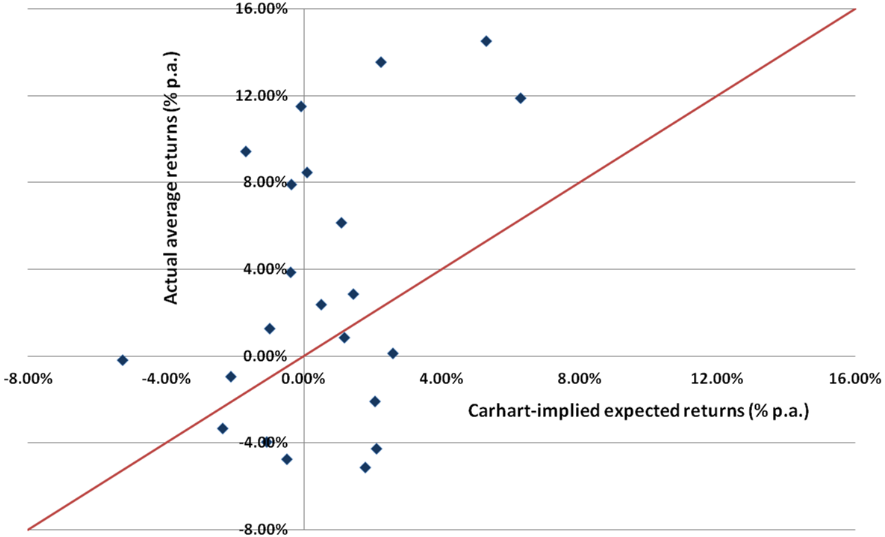
FM results for commodity-specific factor models

	HP(a)	HP(b)	Basis(a)	Basis(b)	Momentum(a)	Momentum(b)
Constant	0.003	0.004	0.003	0.003	0.004	0.004
Shanken's t-stat	*(1.311)*	*(1.575)*	*(1.540)*	*(1.172)*	*(2.037)*	*(2.049)*
Market Factor	0.001	0.000	-0.001	0.001	-0.004	-0.004
Shanken's t-stat	*(0.095)*	*(0.064)*	*(-0.171)*	*(0.118)*	*(-0.548)*	*(-0.468)*
HP Factor	0.001	0.000				
Shanken's t-stat	*(0.240)*	*(0.058)*				
Basis Factor			-0.005	0.011		
Shanken's t-stat			*(-0.832)*	*(1.309)*		
Momentum Factor					0.008	0.004
Shanken's t-stat					*(1.024)*	*(0.369)*
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%

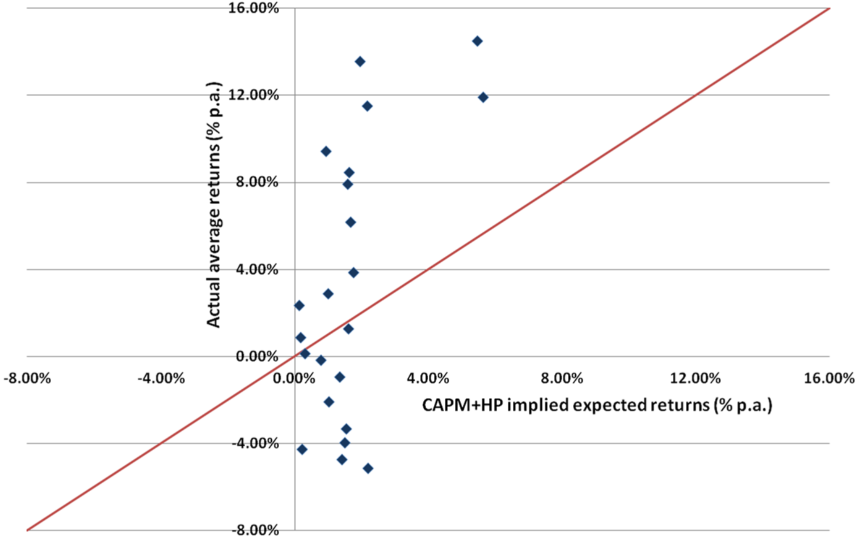
Full sample fit of CAPM (commodity market index)



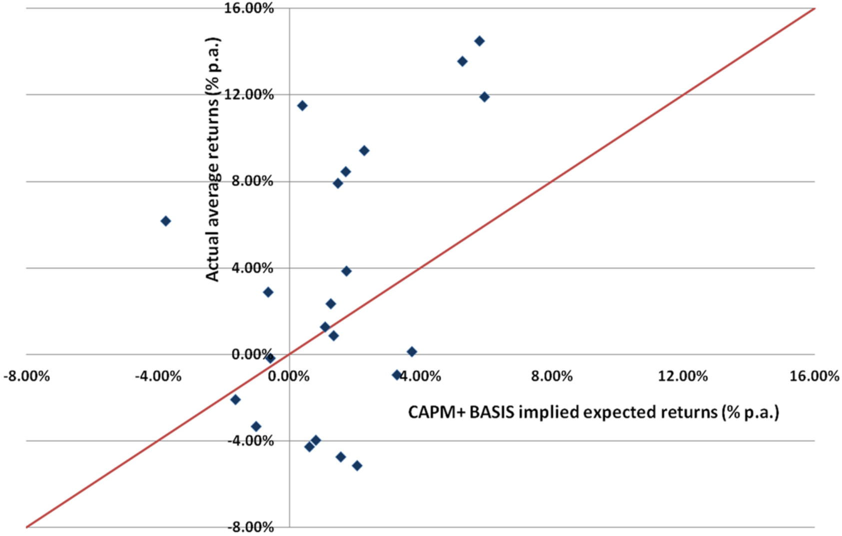
Full sample fit of Carhart model



Full sample fit of CAPM+ HP factor



Full sample fit of CAPM+ Basis factor



Full sample betas from single factor models

	Market	Commodity market	Consumption growth	Size	Value	M2 growth	FX factor	HP (a)	Basis (a)	Mom (a)
Energy										
Crude Oil	0.224	1.370***	-0.077	0.256	0.030	-4.097**	0.560*	-0.042	0.102	0.095
Heating Oil	0.216	1.392***	2.398	0.220	-0.034	-3.468*	0.480*	0.020	0.109	0.150
Grains & Oilseeds										
Corn	0.235*	0.276**	1.992	0.046	0.063	-0.459	-0.151	0.285**	0.055	-0.001
Kansas Wheat	0.190	0.308***	0.783	-0.047	-0.058	2.239	-0.104	0.267**	-0.182	-0.280
Oats	0.136	0.349**	1.961	-0.004	0.135	0.533	0.040	0.736***	0.077	0.224
Soybean Meal	0.163	0.285***	-0.323	0.100	0.082	-1.887	-0.040	0.436***	0.066	0.094
Soybean Oil	0.324**	0.292**	0.104	-0.017	0.167	-2.104	0.177	0.405**	0.009	0.084
Soybeans	0.246*	0.321***	-0.427	0.023	0.116	-2.061*	0.048	0.433***	0.056	0.097
Wheat	0.281**	0.345	1.291	0.135	0.027	-0.379	0.001	0.096	-0.032	-0.086
Livestock										
Feeder cattle	0.071	0.081*	0.440	0.085	0.027	-0.737	0.110	-0.189***	0.087	-0.134***
Lean Hogs	0.059	0.124*	1.774	0.089	0.168	-0.400	0.120	-0.265**	0.016	-0.270***
Livecattle	0.066	0.081*	1.212	0.100	0.029	-0.432	0.127	-0.157**	0.093	-0.115***
Pork Bellies	0.033	0.107	1.481	0.201	-0.076	3.043*	0.091	-0.134	0.296*	-0.108
Metals										
Copper	0.501***	0.465***	-0.061	0.152	0.242*	-4.319***	0.585**	0.271**	-0.105	0.133
Gold	-0.038	0.160***	-2.000**	0.091	-0.054	0.028	-0.033	0.315***	-0.106	0.141*
Palladium	0.397**	0.381	4.606*	0.589*	-0.246	-2.714	-0.019	0.394	0.349	0.201
Platinum	0.182	0.294***	-0.919	0.076	0.006	-1.526	0.161	0.370**	0.041	0.122
Silver	0.238**	0.250***	-2.285	0.180	0.022	-1.580	0.063	0.612***	-0.406***	0.294**
Softs										
Cocoa	-0.016	0.183*	-4.459*	0.075	0.138	-0.258	0.356*	0.260	-0.201*	0.062
Coffee	0.320**	0.148	-0.449	-0.150	0.113	-3.100*	0.364	0.166	-0.097	-0.121
Cotton	0.372**	0.278***	-1.308	-0.044	0.134	-3.725***	0.179	0.203	0.205*	0.109
Sugar	0.095	0.176**	-0.648	0.044	0.200	-1.265	0.144	0.199	0.147	0.161

PC Analysis of commodity futures returns

- Perform a Principal Components Analysis of these 22 futures 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. 5 factors required to explain 60%
2. Factor loadings (q's) cannot explain futures cross-sectional premia
3. PCs lack economic interpretation (no correlation with factors/ macro variables)

Fama-MacBeth results for main PCs

	1 factor	2 factors	3 factors	4 factors	5 factors
Constant	0.003	-0.002	0.002	0.002	-0.001
Shanken's t-stat	*(1.204)*	*(-0.818)*	*(0.790)*	*(0.706)*	*(-0.210)*
1st Factor	0.001	0.003	0.001	0.001	0.003
Shanken's t-stat	*(0.447)*	*(1.546)*	*(0.478)*	*(0.492)*	*(1.146)*
2nd Factor		0.003	0.002	0.002	0.003
Shanken's t-stat		*(2.312)*	*(1.250)*	*(1.291)*	*(1.806)*
3rd Factor			-0.003	-0.002	-0.001
Shanken's t-stat			*(-1.696)*	*(-1.553)*	*(-0.809)*
4th Factor				0.000	0.000
Shanken's t-stat				*(-0.305)*	*(-0.030)*
5th Factor					0.000
Shanken's t-stat					*(0.127)*
R-squared	13.56%	26.43%	38.59%	48.31%	55.79%
Adj-R-squared	9.24%	18.69%	28.35%	36.15%	41.98%

Robustness checks

- Results are very similar when:

1. Extending the sample period back to 1975 (unbalanced panel)
2. Using quarterly futures returns
3. Using **commodity portfolios grouped according to sector**
4. Expanding the cross-section with second nearest futures returns
5. Using one-step GMM estimation approach
6. Examining subsets of these contracts and post-2000 subsamples (financialization)
7. De-seasonalizing futures returns (seasonal dummies)

Conclusions and Implications

- Commonly used models for stocks do not explain the cross-section of commodity futures premia -> markets are segmented
- Theory-based commodity-specific factor models not successful either
- PCA confirms the lack of common factors in the cross-section of commodity futures
- No common risk factor structure $\Rightarrow$ risk/ return profiles are mainly idiosyncratic
- Commodity returns are exposed to different sets of factors $\Rightarrow$ large degree of heterogeneity
- Provide support for models on non-marketable risks (individual characteristics matter for risk premia)