Effects of index-fund investing on commodity futures prices

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Commodity futures contracts and financial investors

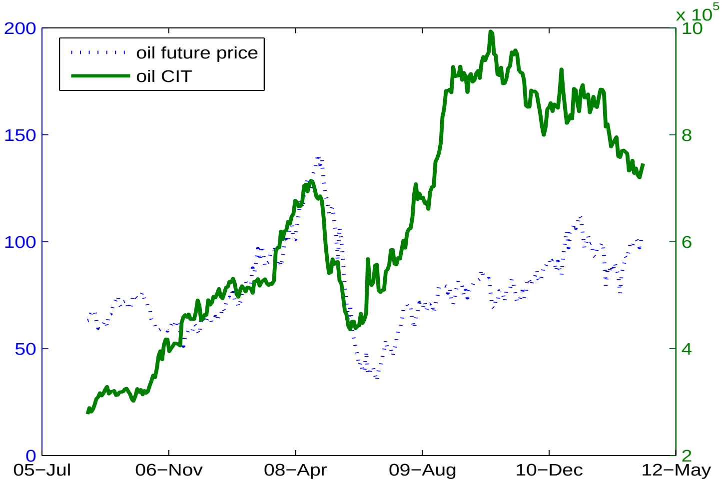
Huge growth in use of commodity futures contracts by financial investors

- Take long position in near futures contract
- Sell and take new long position in next contract before expiry
- Result: artificial asset that follows raw commodity price

Futures contracts used to create asset whose price follows popular commodity price indexes

- S&P Goldman Sachs Commodity Index (GSCI)
- Dow Jones UBS Commodity Index (formerly Dow Jones AIG)

Oil price and imputed holdings of commodity index traders



Price of near crude oil contract (left scale) and number of crude oil contracts held by index traders as imputed by Masters' method (right scale).

Previous literature

A few studies suggest a possible connection between CIT and higher commodity prices

- Tang and Xiong (2012)
- Singleton (2013)

Surveys of literature find little overall support

- Irwin and Sanders (2012)

  evidence "casts considerable doubt on the belief that index funds fueled a price bubble"

- Fattouh, Kilian, and Mahadeva (2013)

  "the existing evidence is not supportive of an important role of speculation in driving the spot price of oil after 2003."

Policy discussions

Why are policy-makers unpersuaded?

Masters (2009):

> *"Buying pressure from Index Speculators overwhelmed selling pressure from producers and the result was skyrocketing commodity prices."*

Claim involves two links:

1. increased volume on the buy side drives up the price of futures contract
2. higher futures prices produce increase in spot prices

Focus of paper

Our paper explores the first link

- By what mechanism would increased orders on long side drive up price of futures contract?
- What is the evidence for this effect?

Other papers have explored the second link (can higher futures prices drive up spot prices?)

- Hamilton (2009)
- Knittel and Pindyck (2013)
- Sockin and Xiong (2013)

What change in futures prices is necessary to persuade rational arbitrageur to be counterparty to index fund?

F_{nt} = price of n-period futures contract as of date t
z_{nt} = notional value of long position in contract

Cash flow at $t+1$:

$$z_{nt}\frac{F_{n-1,t+1}-F_{nt}}{F_{nt}}.$$

Wealth at $t+1$:

$$W_{t+1}=\sum_{j=0}^{J}q_{jt}\exp(r_{j,t+1})+\sum_{n=1}^{N}z_{nt}\frac{F_{n-1,t+1}-F_{nt}}{F_{nt}}.$$

Arbitrageur's decision

Optimization problem

$$\max_{\{q_{0t},q_{1t},\ldots,q_{Jt},z_{1t},\ldots,z_{nt}\}} E_t(W_{t+1}) - (\gamma/2)\mathrm{Var}_t(W_{t+1}).$$

subject to $\sum_{j=0}^{J} q_{jt} = W_t$.

Increase in z_{nt} may expose arbitrageur to additional risk for which must be compensated

Implications

If:

log commodity prices and asset returns are linear in factors x_t

$$f_{nt} = \log F_{nt} = \alpha_n + \beta_n' x_t.$$

$$r_{jt} = \xi_j + \psi_j' x_t \qquad j = 1, ..., J,$$

and factor dynamics are

$$x_{t+1} = c + \rho x_t + \Sigma u_{t+1} \quad u_{t+1} \sim \text{ i.i.d. } N(0, I_m)$$

Then: first order condition is:

$$\text{expected return} = \beta_{n-1}' \lambda_t$$

$$\lambda_t = \gamma \Sigma \Sigma' \left(\sum_{j=1}^{J} q_{jt} \psi_j + \sum_{\ell=1}^{N} z_{\ell t} \beta_{\ell-1} \right). \qquad (1)$$

Model implication

Return forecasting regression

$$r_t = f_{n-1,t+1} - f_{nt} = \kappa_{n-1} + \pi'_{n-1} x_t + \varepsilon_{n-1,t+1}$$

where the theory predicts

$$\pi'_{n-1} = \beta'_{n-1} \Lambda$$

Implication

$$\gamma = 0 \Leftrightarrow \pi_{n-1} = 0$$

CFTC Data

CFTC Supplemental Commitments of Traders Report

- 2006 - present
- Agricultural commodities: beans, wheat, corn, bean oil, cattle, cocoa, coffee, cotton, feeder cattle, hogs, Kansas city wheat, sugar
- composition of CIT: pension funds, managed funds taking a direct position; swap dealer offering their clients an over-the-counter product that mimics some futures-based index
- weekly positions for CIT, released on Fridays reflecting positions as of proceeding Tuesdays
- best weekly data publicly available

Return predicting regression

Notation

X_t: long positions (in number of contracts) held by CIT.
F_t: the price of the near contract.
CIT's notional exposure:

$$\tilde{x}_t = 100(\ln X_t + \ln F_t)$$

r_t: weekly return
Sample: April 11, 2006 to January 3, 2012.

Return predicting regression

$$r_t = \alpha_1 + \phi_1 r_{t-1} + \pi_1 \tilde{x}_{t-1} + \varepsilon_{1t}.$$

Regression results

Coefficient on $\tilde{x}_{t-1}$, standard error on coeff, and adjusted R^2

	coeff	(s.e.)	$\bar{R}^2$		coeff	(s.e.)	$\bar{R}^2$
Beans	-0.0056	(0.0051)	-0.0026	Wheat	-0.0166	(0.0094)	0.0036
Corn	-0.0033	(0.0071)	0.0005	BeanOil	-0.0058	(0.0051)	-0.0024
Cattle	-0.0024	(0.0042)	-0.0013	Cocoa	-0.0081	(0.0045)	0.0067
Coffee	-0.0024	(0.0059)	-0.0050	Cotton	-0.0014	(0.0075)	-0.0027
FedCattle	-0.0038	(0.0042)	-0.0032	Hogs	0.0069	(0.0061)	0.0018
KCWheat	-0.0053	(0.0071)	-0.0043	Sugar	0.0018	(0.0072)	-0.0050

Regression results

We find no predictability of commodity futures returns, consistent with a large number of previous studies.

- The coefficient estimates $\hat{\phi}_1$ and $\hat{\pi}_1$ are not statistically significantly different from zero for any of the 12 commodities
- Adjusted R^2 are usually negative.

Conclusion: although in principle index-fund investment could influence pricing of risk, we find no empirical evidence.

More regressions

Regression 1:

$$r_t = \alpha_1 + \phi_1 r_{t-1} + \pi_1 \tilde{x}_{t-1} + \varepsilon_{1t}.$$

Regression 2: weekly change in CIT positions for stationarity

$$r_t = \alpha_2 + \phi_2 r_{t-1} + \pi_2 (\tilde{x}_{t-1} - \tilde{x}_{t-2}) + \varepsilon_{2t}.$$

Regression 3: 13-week change in CIT positions to capture the longer run effect suggested by Singleton (2013)

$$r_t = \alpha_3 + \phi_3 r_{t-1} + \pi_3 (\tilde{x}_{t-1} - \tilde{x}_{t-14}) + \varepsilon_{3t}.$$

Regression 2 results

Coefficient on $\tilde{x}_{t-1} - \tilde{x}_{t-2}$, standard error, and adjusted R^2

	coeff	(s.e.)	$\bar{R}^2$		coeff	(s.e.)	$\bar{R}^2$
Beans	0.0321	(0.1012)	-0.0064	Wheat	-0.1738	(0.1583)	-0.0027
Corn	-0.1352	(0.1299)	0.0033	BeanOil	0.1034	(0.0701)	0.0006
Cattle	0.0717	(0.0640)	0.0017	Cocoa	-0.0373	(0.0439)	-0.0014
Coffee	-0.0293	(0.0955)	-0.0052	Cotton	**0.2530**	**(0.1013)**	0.0176
FedCattle	-0.0142	(0.0270)	-0.0050	Hogs	-0.0352	(0.0722)	-0.0017
KCWheat	0.0263	(0.0836)	-0.0059	Sugar	**-0.2466**	**(0.1249)**	0.0077

Results

Regression 2

- The coefficient on $\tilde{x}_{t-1} - \tilde{x}_{t-2}$ is statistically significant for cotton and sugar, but cotton has wrong sign.
- Coefficients on r_{t-1} and $\tilde{x}_{t-1} - \tilde{x}_{t-2}$ are not statistically significantly different from zero for any of the other 10 commodities

Regression 3

- None of the 24 estimated slope coefficients is statistically distinguishable from zero

Conclusion: we find no evidence that either the level, weekly change, or 13-week change in CIT position is related to the risk premium in agricultural commodities.

Simple robust regression

Goal: robust to any problems in measuring the CIT, and makes use of higher-frequency features of data.

Calendar schedule for rolling from the near to the next contract

- S&P Goldman Sachs Commodity Index: 5^{th} - 9^{th} business days
- Dow Jones UBS Commodity Index: 6^{th} - 10^{th} business days

Our finding: there is nothing special about the rolling window

Is crude oil different?

We found CIT does not predict returns on agricultural futures contracts, consistent with previous studies.

Singleton (2013) found CIT does help predict returns on crude oil futures contracts.

Imputing CIT holdings for oil

Motivation: CFTC does not report weekly CIT positions in crude oil.

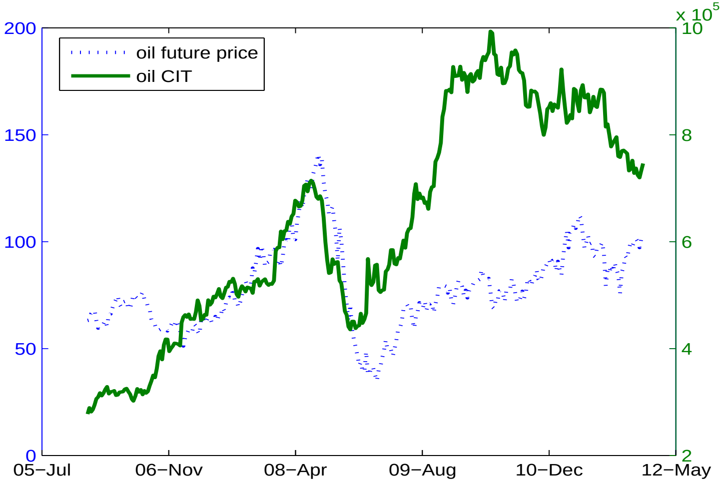
Masters (2008) imputed CIT for oil:

- CFTC reports CIT for soybean oil
- Masters assumed all reported CIT was either following Goldman Sachs index or Dow Jones index
- GSCI does not include soybean oil
- Given publicly known weights of DJ for crude oil and soybean oil, Masters inferred holdings of crude oil for funds trying to replicate Dow Jones index

Imputing CIT holdings for oil

- Likewise, GSCI includes KC wheat whereas DJ does not
- From CFTC reported CIT for KC wheat, Masters inferred total crude oil futures contracts held by GSCI-based funds
- GSCI also includes feeder cattle and DJ does not
- This gives second estimate of GSCI crude oil; Masters used average of two
- Masters' imputed CIT for crude oil is the sum of his estimates for DJ- and GSCI-based funds

Oil price and imputed holdings of commodity index traders



Price of near crude oil contract (left scale) and number of crude oil contracts held by index traders as imputed by Masters' method (right scale).

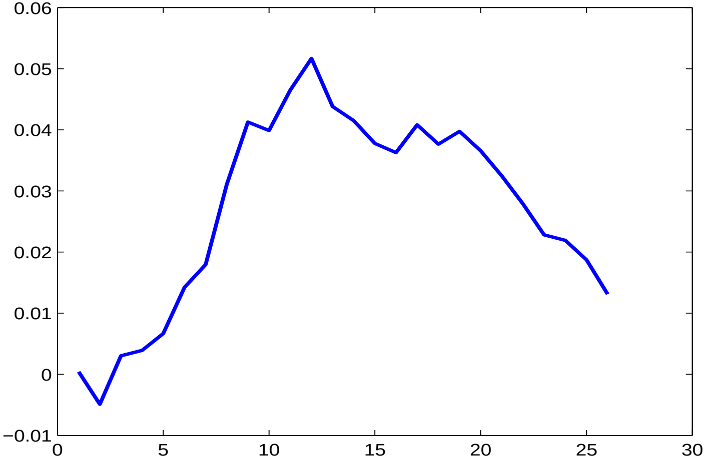
Results

Oil: CIT-Masters

	const	r_{t-1}	X_{t-1}	$\bar{R}^2$
level	-5.4784	-0.0314	0.0030	-0.0052
	(11.1081)	(0.0582)	(0.0063)	
1-wk diff	-0.0760	0.1006	-0.1340	-0.0004
	(0.3117)	(0.1151)	(0.1039)	
13-wk diff	-0.2298	-0.1171	**0.0440**	0.0438
	(0.3048)	(0.0606)	**(0.0111)**	

coeff on 13-week diff is statistically significant but has the wrong sign

Implication of using *n*-week differences



Adjusted R^2 as a function of n when n-week differences are used in oil regression

Alternative method: two equations and two unknowns

Key equation:

$$\tilde{X}_{it} = \delta_{it}^{G} \tilde{X}_{t}^{G} + \delta_{it}^{D} \tilde{X}_{t}^{D}$$

We observe:

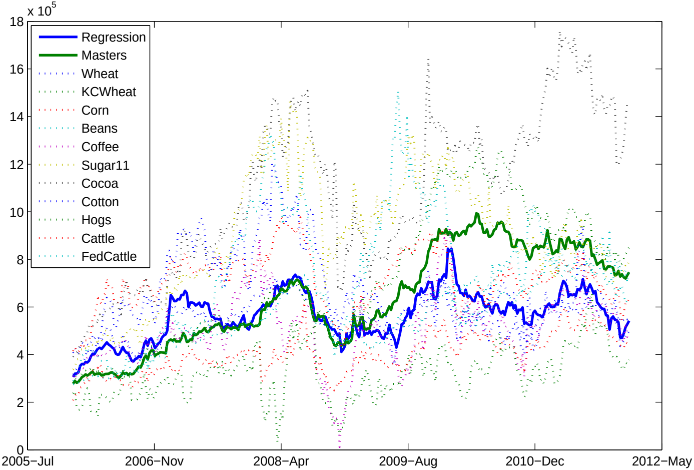
- $\tilde{X}_{it}$ = reported CIT for commodity i
- δ_{it}^{G} = GSCI weight for i
- δ_{it}^{G} = DJ weight for i

We can infer:

- total size of GSCI and DJ funds using any two commodities i and j
- total number of crude oil contracts held by GSCI and DJ funds

$$\tilde{X}_{\text{crude\_oil},t}^{[i,j]} = \begin{bmatrix} \delta_{\text{crude\_oil},t}^{G} & \delta_{\text{crude\_oil},t}^{D} \end{bmatrix} \begin{bmatrix} \delta_{it}^{G} & \delta_{it}^{D} \\ \delta_{jt}^{G} & \delta_{jt}^{D} \end{bmatrix}^{-1} \begin{bmatrix} \tilde{X}_{it} \\ \tilde{X}_{jt} \end{bmatrix}.$$

Variability of Masters-type imputed CIT



Holdings of crude oil contracts held by commodity index traders imputed by alternative methods

New method: regression-based

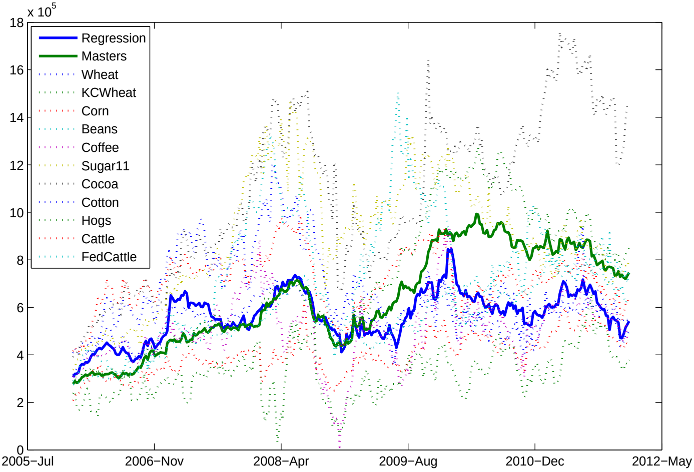
Solution: use information in all the 12 agricultural commodities

- choose $\tilde{X}_t^G$ and $\tilde{X}_t^D$ to minimize the sum of squared errors in predicting $\tilde{X}_{it}$ across the 12 commodities
$$\tilde{X}_{it} = \delta_{it}^G \tilde{X}_t^G + \delta_{it}^D \tilde{X}_t^D$$

Regression-based estimate

$$\tilde{X}_{\text{crude\_oil},t}^{[\text{all}]} = \begin{bmatrix} \delta_{\text{crude\_oil},t}^G & \delta_{\text{crude\_oil},t}^D \end{bmatrix} \begin{bmatrix} \sum_{i=1}^{12} (\delta_{it}^G)^2 & \sum_{i=1}^{12} \delta_{it}^G \delta_{it}^D \\ \sum_{i=1}^{12} \delta_{it}^D \delta_{it}^G & \sum_{i=1}^{12} (\delta_{it}^D)^2 \end{bmatrix}^{-1} \begin{bmatrix} \sum_{i=1}^{12} \delta_{it}^G \tilde{X}_{it} \\ \sum_{i=1}^{12} \delta_{it}^D \tilde{X}_{it} \end{bmatrix} .$$

Imputed oil CIT



Holdings of crude oil contracts held by commodity index traders imputed by alternative methods

Oil regressions using regression-based CIT

Oil: CIT-Masters				
	const	r_{t-1}	X_{t-1}	$\bar{R}^2$
level	-5.4784	-0.0314	0.0030	-0.0052
	(11.1081)	(0.0582)	(0.0063)	
1-wk diff	-0.0760	0.1006	-0.1340	-0.0004
	(0.3117)	(0.1151)	(0.1039)	
13-wk diff	-0.2298	-0.1171	0.0440*	0.0438
	(0.3048)	(0.0606)	(0.0111)	
Oil: CIT-regression				
	const	r_{t-1}	X_{t-1}	$\bar{R}^2$
level	-4.4562	-0.0306	0.0025	-0.0057
	(14.8859)	(0.0584)	(0.0085)	
1-wk diff	-0.1147	-0.0472	0.0191	-0.0057
	(0.3112)	(0.0964)	(0.0767)	
13-wk diff	-0.1337	**-0.1240**	**0.0448**	0.0499
	(0.3025)	**(0.0606)**	**(0.0107)**	

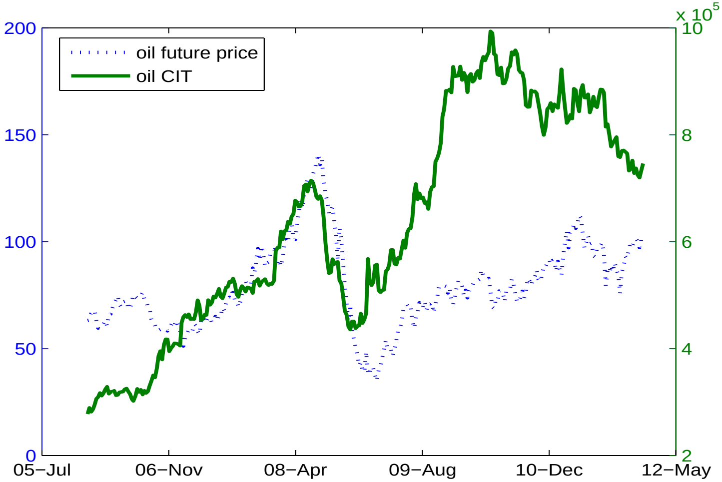
In-sample fit vs. post-sample prediction

In-sample: to January 12, 2010 (where Singleton's sample ended)
Out-of-sample: January 17, 2010 to January 3, 2012

	In-sample				Post-sample MSE	
	const	r_{t-1}	X_{t-1}	$\bar{R}^2$	regression	random walk
Oil	-0.4858	**-0.1507**	**0.0553**	0.0834	23.8206	21.9747
	(0.3937)	(0.0750)	(0.0123)			

- Good in-sample fit: $\bar{R}^2 = 0.0834$.
- Poor out-of-sample prediction: 22% bigger MSE than no-change forecast

High correlation breaks down out of sample



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Is this correlation driven by the Great Recession?

	In-sample				Post-sample MSE	
	const	r_{t-1}	X_{t-1}	$\bar{R}^2$	regression	random walk
Oil	-0.4858	-0.1507*	0.0553*	0.0834	23.8206	21.9747
	(0.3937)	(0.0750)	(0.0123)			
S&P500	-0.1332	-0.0637	**0.0125**	0.0130	6.5597	6.3688
	(0.2043)	(0.0718)	**(0.0059)**			

- For the 2006-2009 subsample, the Masters variable appears to predict S&P 500 return.
- This relation also breaks down out-of-sample.

Conclusion

- No relation between commodity futures contracts held by index-fund investors and expected returns for 12 agricultural commodities.
- Imputed CIT positions in crude oil appear to help predict crude oil returns over 2006-2009.
- This relation has no out-of-sample predictive power.

Our overall conclusion: we find little evidence that commodity index-fund investing is exerting a measurable effect on commodity futures prices.