Investor Flows and the 2008 Boom/Bust in Oil Prices

Kenneth J. Singleton

Graduate School of Business
Stanford University

August, 2011

STANFORD UNIVERSITY

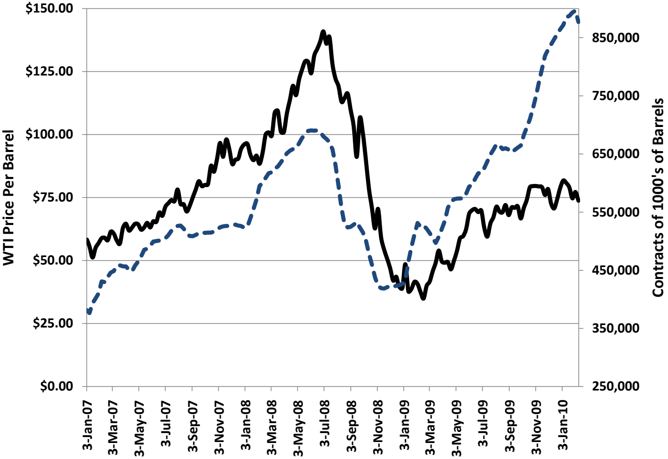
Investor Flows, Speculation, and Oil Prices

- The role of speculation (broadly construed) in the dramatic rise and subsequent sharp decline in oil prices during 2008?
- Many attribute these swings to changes in fundamentals of supply and demand, *within representative agent models.*
- At the same time there is mounting evidence of the "financialization" of commodity markets.
- Objective: investigate the impact of investor flows and financial market conditions on crude-oil futures prices.

Heterogeneity and Investor Flows

- The prototypical dynamic models referenced in discussions of the oil boom (e.g., Hamilton (2009), Pirrong (2009)) have representative agent-types (producer, storage operator, commercial consumer, etc.).
- Moreover, they do not allow for learning under imperfect information, heterogeneity of beliefs, and capital market and agency-related frictions that limit arbitrage activity.
- As such, they abstract entirely from the consequent rational motives for many categories of market participants to speculate in commodity markets based on their individual circumstances and views about fundamental economic factors.

Inferred Commodity Index Long Positions (Dash →) Against NYMEX WTI Futures (Solid ←)



STANFORD UNIVERSITY

Financialization of Commodities: What Do We Know?

- Tang and Xiong (2011) show that, after 2004, agricultural commodities that are part of the GSCI and DJ-AIG indices became much more responsive to shocks to a world equity index, changes in the U.S. dollar exchange rate, and oil prices.
- Using proprietary data from the CFTC, Buyuksahin and Robe (2011) link increased high-frequency correlations among equity and commodity returns to trading patterns of hedge funds.
- Less formally, Masters (2009) attributes price movements to flows into crude oil positions by index investors.
- Mou (2010) documents substantial impacts on prices of the “roll strategies” employed by index funds– index investors bear large implicit transactions costs.

Speculation and Booms/Busts in Commodity Prices

- Absent arbitrage opportunities and near stock-out conditions in a commodity market:

$$S_t = E_t^{\mathbb{Q}}\left[e^{-\int_t^T (r_s - \mathcal{C}_s)\,ds} S_T\right],$$

  - S_t denotes the price of crude oil S_t,
  - $\mathcal{C}_t$ denotes the convenience yield net of storage costs,
  - $E_t^{\mathbb{Q}}$ denotes the expectation of market participants under the risk-neutral pricing distribution.

- An implication of S_t drifting at the rate $(r_t - \mathcal{C}_t)S_t\,dt$.

- Additionally, the futures price for delivery of a commodity at date $T > t$ is related to S_T according to

$$F_t^T = E_t^{\mathbb{Q}}\left[S_T\right].$$

STANFORD UNIVERSITY

The Futures-Spot Basis

- Rearranging these expressions gives

$$\frac{F_t^T}{S_t} = \frac{1 - Cov_t^{\mathbb{Q}}\left(e^{\int_t^T \mathcal{C}_s\,ds}, e^{-\int_t^T r_s\,ds}\frac{S_T}{S_t}\right)}{B_t^T\, E_t^{\mathbb{Q}}\left[e^{\int_t^T \mathcal{C}_s\,ds}\right]} - \frac{1}{B_t^T} \times Cov_t^{\mathbb{Q}}\left(e^{-\int_t^T r_s\,ds}, \frac{S_T}{S_t}\right),$$

  where B_t^T denotes the price of a zero coupon bond.

- If the covariance terms are negligible, then (approximately)

$$\frac{F_t^T - S_t}{S_t} \approx y_t^T\,(T-t) - \ln E_t^{\mathbb{Q}}\left[e^{\int_t^T \mathcal{C}_s\,ds}\right],$$

  where y_t^T is the continuously compounded yield on a zero of maturity $(T-t)$ periods.

Representative Risk-Neutral Market Participants?

- Most of the extant model-based interpretations of the oil price boom focus on:
  - representative risk-neutral producers and refiners, and
  - they arrive at similar expressions, but with
  - the expectation $E_t^{\mathbb{Q}}$ replaced by $E_t^{\mathbb{P}}$, the expectation of market participants under the historical distribution.

Representative Risk-Neutral Market Participants?

- Most of the extant model-based interpretations of the oil price boom focus on:
  - representative risk-neutral producers and refiners, and
  - they arrive at similar expressions, but with
  - the expectation $E_t^{\mathbb{Q}}$ replaced by $E_t^{\mathbb{P}}$, the expectation of market participants under the historical distribution.
- If refiners and investors are heterogeneous and:
  - risk averse or
  - they face capital constraints that lead them to behave effectively as if they are risk averse, and
  - different classes of investors hold different views about future oil-market fundamentals,
- then risk-premiums and forecast errors will impact futures and, thereby, spot prices.

Accommodating Risk Premiums and Informational Heterogeneity

- Market risk premium: $RP_t^T \equiv \left(E_t^{\mathbb{Q}}[S_T] - E_t^{\mathbb{P}}[S_T] \right)$, $T > t$.
- For a short time interval $[t, \tau]$ over which r and $\mathcal{C}$ are approximately constant:

$$\frac{E_t^{\mathbb{P}}[S_\tau] - S_t}{S_t} - y_t^\tau (\tau - t) \approx \mathcal{C}_t (\tau - t) - RP_t^\tau .$$

- Thus, expected excess returns in the spot commodity market depend on both convenience yields and risk premiums.
- The same will in general be true of expected excess returns in the futures market, the percentage changes in the price of a future contract, adjusted for roll dates.

Heterogeneity Version I: Wealth-Weighted Futures Prices

- Suppose market participants hold different beliefs and have different purchasing powers.
- By analogy to Xiong and Yan (2010), if $\log S_t$ is an affine function of risk factors X_t that follow an affine process, then we expect futures prices to take a form similar to

$$F_t^T = \int_i \omega_i e^{a(T-t)+b_X(T-t)X_t+b_\theta(T-t)\theta_i},$$

  - ω_i is the wealth allocation of investor i,
  - θ_i summarizes investor i's beliefs about the state of the economy X_t.

- As beliefs and wealths change, so will the futures prices.

STANFORD UNIVERSITY

Heterogeneity Version II: Forecasting the Forecasts of Others

- Optimal when agents have different non-nested information sets. (Townsend (1983), Singleton (1987))
- Nimark (2009) abstracts from wealth distribution effects and focuses on agents' forecasting problem under log utility. In a bond market setting, the forward rate becomes:

$$f_t^n = \int_i E_{t,i} r_{t+n} \, di - \int_i E_{t,i} \left(r_{t+n} - \prod_{s=0}^{n-1} \int_i E_{t+s,i} r_{t+n} \right) + \nu_t .$$

- Note that the law-of-iterated expectations does *not* apply.
- Therefore, average expectations of investors' forecast errors effectively enter as a state variable.

Implications for Commodity Pricing

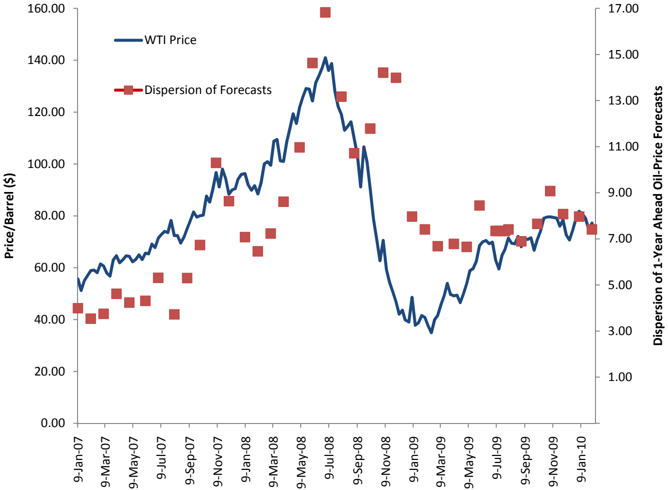
- Surely participants in oil market held different views about economic growth, global demand and supply of oil, inventory positions domestically and in emerging economies, etc.
- Consequently, averaging across investors will typically give

$$\frac{\int_i E_t^{i\mathbb{P}}[S_\tau] - S_t}{S_t} - y_t^\tau (T-t) \approx \tilde{\mathcal{C}}_t (T-t) - \tilde{RP}_t^\tau + \mathcal{E}_t^\tau,$$

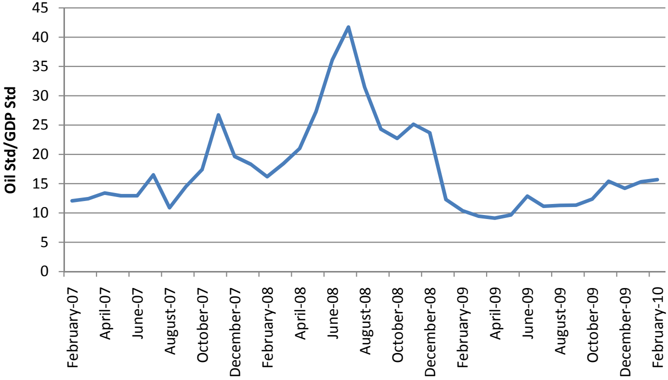
  where i indexes investors and $\mathcal{E}_t^\tau$ captures the effects of forecast errors and/or limits to arbitrage.

- Expect projections of realized "excess returns" to potentially capture aspects of all of these ingredients?

Disagreement and Prices in Oil Markets



Relative Disagreement about Oil Prices and Global (G7 + BRIC) GDP Growth



New Evidence on Investor Flows and Oil Prices

- **RSPn** and **REMn**: the n-week returns on the S&P500 and the MSCI Emerging Asia indices, respectively.
- **IIP13**: the thirteen-week change in the imputed positions of index investors in millions, computed using the same algorithm as in Masters (2009).
- **MMSPD13**: the thirteen-week change in managed-money spread positions in millions, as constructed by the CFTC.

STANFORD UNIVERSITY

More Conditioning Variables

- **REPOn**: the n-week change in overnight repo positions on Treasury bonds by primary dealers.
- **OI13**: the thirteen-week change in aggregate open interest.
- **AVBASn**: the n-week change in basis averaged across the maturities $\{1, 3, 6, 9, 12, 15, 18, 21, 24\}$ months.
  - The basis is a proxy for convenience yield– more later.

Linear Projections

$$ERmM_{t+n}(n) = \mu_{nm} + \Pi_{nm} X_t + \Psi_{nm} ERmM_t(n) + \varepsilon_{m,t+n}(n),$$

- $ERmM_t(n)$: realized excess return for an n-week investment horizon on a futures position that expires in m months.
- X_t is the set of predictor variables.
- Weekly data over the sample period September 12, 2006 through January 12, 2010.
- Robust standard errors allowing for heteroskedasticity and serial correlation.

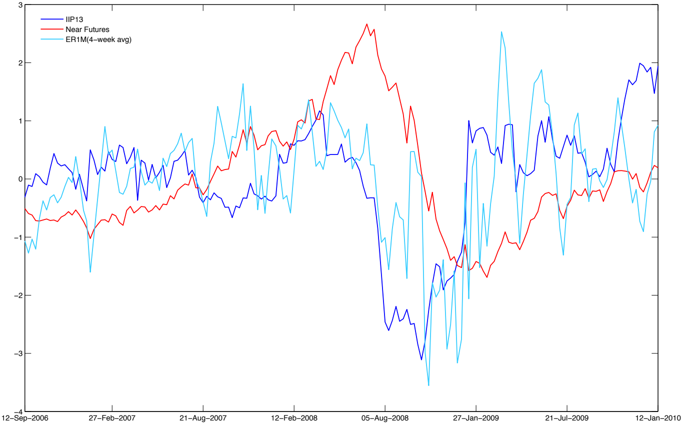
Projections of 1-Week Excess Returns

Contract	RSP1	REM1	REPO1	IIP13	MMSPD13	OI13	AVBAS1	R_{Lag}	Adj R^2
1	0.332	-0.342	-0.201	0.272	0.357	-0.103	-4.165	-0.219	0.27
	(1.44)	(-2.44)	(-2.89)	(3.51)	(4.36)	(-2.17)	(-6.26)	(-2.05)	
3	0.361	-0.242	-0.170	0.218	0.284	-0.082	-3.661	-0.152	0.27
	(1.99)	(-2.02)	(-2.76)	(3.71)	(4.43)	(-1.87)	(-6.48)	(-2.10)	
6	0.391	-0.261	-0.150	0.197	0.245	-0.072	-3.022	-0.105	0.25
	(2.35)	(-2.27)	(-2.64)	(3.49)	(4.14)	(-1.74)	(-5.59)	(-1.62)	
9	0.424	-0.275	-0.142	0.187	0.222	-0.067	-2.551	-0.090	0.24
	(2.67)	(-2.46)	(-2.58)	(3.45)	(3.95)	(-1.73)	(-4.72)	(-1.40)	
12	0.437	-0.283	-0.133	0.179	0.202	-0.064	-2.141	-0.075	0.22
	(2.84)	(-2.60)	(-2.49)	(3.42)	(3.83)	(-1.73)	(-3.97)	(-1.14)	
18	0.430	-0.286	-0.119	0.166	0.174	-0.058	-1.657	-0.054	0.20
	(2.99)	(-2.79)	(-2.35)	(3.42)	(3.61)	(-1.72)	(-3.13)	(-0.75)	
24	0.412	-0.287	-0.107	0.157	0.159	-0.053	-1.329	-0.046	0.18
	(2.98)	(-2.87)	(-2.21)	(3.46)	(3.40)	(-1.67)	(-2.60)	(-0.59)	
36	0.378	-0.294	-0.093	0.145	0.144	-0.048	-0.981	-0.033	0.16
	(2.85)	(-2.99)	(-2.05)	(3.52)	(3.02)	(-1.60)	(-2.10)	(-0.40)	

Projections of 4-Week Excess Returns

Contract	RSP4	REM4	REPO4	IIP13	MMSPD13	OI13	AVBAS4	R_{Lag}	Adj R^2
1	0.023	0.246	0.097	0.987	0.972	-0.447	-1.33	-0.229	0.38
	(.061)	(1.22)	(1.39)	(4.36)	(6.95)	(-3.91)	(-.688)	(-2.04)	
3	-0.137	0.342	0.038	0.927	0.934	-0.374	0.121	-0.279	0.41
	(-.521)	(2.36)	(.564)	(4.54)	(7.03)	(-3.36)	(.095)	(-2.59)	
6	-0.200	0.351	0.015	0.880	0.833	-0.338	0.539	-0.271	0.39
	(-.783)	(2.58)	(.237)	(4.32)	(6.71)	(-3.22)	(.452)	(-2.33)	
9	-0.216	0.330	0.015	0.846	0.756	-0.322	0.707	-0.254	0.37
	(-.854)	(2.52)	(.248)	(4.30)	(6.40)	(-3.21)	(.611)	(-2.10)	
12	-0.222	0.312	0.017	0.811	0.689	-0.306	0.782	-0.238	0.36
	(-.886)	(2.48)	(.295)	(4.25)	(6.11)	(-3.14)	(.693)	(-1.92)	
18	-0.219	0.276	0.023	0.744	0.588	-0.278	0.776	-0.211	0.33
	(-.902)	(2.36)	(.432)	(4.20)	(5.60)	(-2.97)	(.726)	(-1.68)	
24	-0.213	0.250	0.029	0.687	0.531	-0.255	0.706	-0.190	0.31
	(-.915)	(2.30)	(.571)	(4.15)	(5.34)	(-2.83)	(.701)	(-1.49)	
36	-0.212	0.237	0.036	0.613	0.480	-0.236	0.412	-0.175	0.28
	(-.993)	(2.43)	(.787)	(4.06)	(4.95)	(-2.78)	(.454)	(-1.37)	

Growth in Investor flows ($IIP13$) and the Four-week MA of the 1-week Futures Return ($ER1M$)



Risk Premiums/Expectational Factors or Convenience Yields?

- $ERmM$ depend in general on risk premiums, expectational factors, and convenience yields.
- Independent evidence on risk premiums: project $(S_\tau - F_t^\tau)$ $(\tau > t)$ onto information in investors' information set.
- The adjusted R^2 in the projection of $S_{t+4} - F_t^{t+4}$ onto the conditioning variables X_t (for the monthly horizon) is 0.39.

Risk Premiums/Expectational Factors or Convenience Yields?

- $ERmM$ depend in general on risk premiums, expectational factors, and convenience yields.
- Independent evidence on risk premiums: project $(S_\tau - F_t^\tau)$ $(\tau > t)$ onto information in investors' information set.
- The adjusted R^2 in the projection of $S_{t+4} - F_t^{t+4}$ onto the conditioning variables X_t (for the monthly horizon) is 0.39.
- Only $IIP13$ and $MMSPD13$ enter with statistically significant coefficients ⇒ impacting commodity prices through risk premiums or speculative expectational terms?
- Emerging market equity returns and open interest shaped the futures curve, but not so much spot market risk premiums.

STANFORD UNIVERSITY

Buyuksahin, B., and M. Robe, 2011, "Does "Paper Oil" Matter? Energy Markets' Financialization and Equity-Commodity Co-Movements," working paper, International Energy Agency.

Hamilton, J., 2009, "Causes and Consequences of the Oil Shock of 2007-08," *Brookings Papers on Economic Activity*.

Masters, M., 2009, "Testimony Before the Commodity Futures Trading Commission," working paper, Commodity Futures Trading Commission.

Mou, Y., 2010, "Limits to Arbitrage and Commodity Index Investments: Front-Running the Goldman Roll," working paper, Columbia Business School.

Nimark, K., 2009, "Speculative Dynamics in the Term Structure of Interest rates," working paper, Universitat Pompeu Fabra.

Pirrong, C., 2009, "Stochastic Fundamental Volatility, Speculation, and Commodity Storage," working paper, University of Houston.

Singleton, K., 1987, "Asset Prices in a Time Series Model with Disparately Informed, Competitive Traders," in *New Approaches to Monetary Economics*, ed. by W. Burnett, and K. Singleton, Cambridge University Press.

Tang, K., and W. Xiong, 2011, "Index Investing and the Financialization of Commodities," working paper, Princeton University.

Townsend, R., 1983, "Forecasting the Forecasts of Others," *Journal of Political Economy*, 91, 546–588.

Xiong, W., and H. Yan, 2010, "Heterogeneous Expectations and Bond Markets," *Review of Financial Studies*, 23, 1433–1466.

STANFORD UNIVERSITY