

# Investor Flows and the 2008 Boom/Bust in Oil Prices

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August 10, 2011

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## **Abstract**

This paper explores the impact of investor flows and financial market conditions on returns in crude-oil futures markets. I begin by arguing that informational frictions and the associated speculative activity may induce prices to drift away from “fundamental” values and show increased volatility. This is followed by a discussion of the interplay between imperfect information about real economic activity, including supply, demand, and inventory accumulation, and speculative activity. Then, I present new evidence that there was an economically and statistically significant effect of investor flows on futures prices, after controlling for returns in US and emerging-economy stock markets, a measure of the balance-sheet flexibility of large financial institutions, open interest, the futures/spot basis, and lagged returns on oil futures. The intermediate-term growth rates of index positions and managed-money spread positions had the largest impacts on futures prices. Moreover, my findings suggest that these effects were through risk or informational channels distinct from changes in convenience yield.

# 1 Introduction

The dramatic rise and subsequent sharp decline in crude oil prices during 2008 has been a catalyst for extensive debate about the roles of speculative trading activity in price determination in energy markets.<sup>1</sup> Many attribute these swings to changes in fundamentals of supply and demand with the price effects and volatility actually moderated by the participation of non-user speculators and passive investors in oil futures markets and other energy-related derivatives.<sup>2</sup> At the same time there is mounting evidence that the “financialization” of commodity markets and the associated flows of funds into these markets from various categories of investors have had substantial impacts on the drifts and volatilities of commodity prices.<sup>3</sup> This paper builds upon the latter literature and undertakes an in depth analysis of the impact of investor flows and financial market conditions on returns in crude-oil futures markets.

The prototypical dynamic models referenced in discussions of the oil boom (e.g., [Hamilton \(2009a\)](#), [Pirrong \(2009\)](#)) have representative agent-types (producer, storage operator, commercial consumer, etc.) and simplified forms of demand/supply uncertainty. Moreover, these models, as well as the price-setting environment underlying [Irwin and Sanders \(2010\)](#)’s case against a role for speculative trading, 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.

Detailed information about the origins of most of the open interest in OTC commodity derivatives that could in principle shed light on the historical contributions of information- and learning-based speculative activity is not publicly available. However, indirect inferences suggest that traders’ investment strategies did impact prices. [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. These trends are stronger for those commodities that are part of a major index than for other commodities. Tang and Xiong attribute their findings to “spillover effects brought on by the increasing presence of index investors to individual commodities (page 17).” Using proprietary data from the Commodity Futures Trading

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<sup>1</sup>This debate is surely stimulated in part by the large costs that oil price booms and busts potentially impose on the real economy. See, for example, [Hooker \(1996\)](#), [Rotemberg and Woodford \(1996\)](#), [Hamilton \(2003\)](#), and the survey by [Sauter and Awerbuch \(2003\)](#).

<sup>2</sup>The conceptual arguments and empirical evidence favoring this view are summarized in a recent Organization of Economic Cooperation and Development report by [Irwin and Sanders \(2010\)](#).

<sup>3</sup>See, for example, [Tang and Xiong \(2011\)](#), [Masters \(2009\)](#), and [Mou \(2010\)](#).

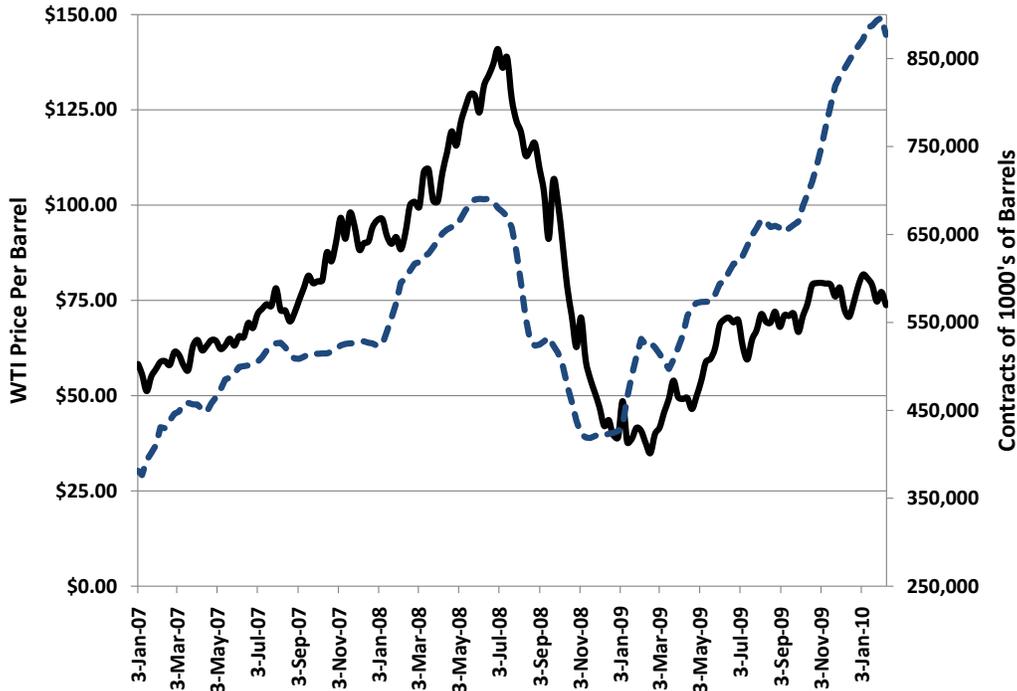


Figure 1: Commodity index long positions inferred from the CIT reports (dashed line, right sale) plotted against the front-month NYMEX WTI futures price (solid line, left scale).

Commission (CFTC), [Buyuksahin and Robe \(2011\)](#) link increased high-frequency correlations among equity and commodity returns to trading patterns of hedge funds. Less formally, [Masters \(2009\)](#) imputes flows into crude oil positions by index investors using the *CFTC*'s commodity index trader (*CIT*) reports. The imputed index long positions based on his methodology ([Figure 1](#)), displayed against the near-contract forward price of WTI crude oil, shows a strikingly high degree of comovement. Additionally, [Mou \(2010\)](#) documents substantial impacts on futures prices of the “roll strategies” employed by index funds, and finds a link between the implicit transactions costs born by index investors and the level of speculative capital deployed to “front run” these rolls.

To interpret these as well as my own empirical findings, I argue in [Section 2](#) that informational frictions (and the associated speculative activity) that can lead prices to drift away from “fundamental” values, were likely to have been present in commodity markets. [Section 3](#) discusses the interplay between imperfect information about real economic activity, including supply, demand, and inventory accumulation, and speculative activity. [Section 4](#) presents new evidence that, even after controlling for many of the other conditioning variables

in recent studies of price behavior and risk premiums in oil futures markets, there were economically and statistically significant effects of investor flows on futures prices. Concluding remarks are presented in Section 5.

## 2 Speculation and Booms/Busts in Commodity Prices

Virtually all classes of participants in commodity markets are, at one time or another, taking speculative positions.<sup>4</sup> Certainly in this category are the large financial institutions that make markets in commodity-related instruments; those who hold sizable inventories; hedge funds and investment management companies; and commodity index investors.

Absent near stock-out conditions in a commodity market, equilibrium in the market for storing oil implies the cost-of-carry relation:<sup>5</sup>

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

where  $S_t$  is the spot price of the commodity,  $\mathcal{C}_t$  denotes the instantaneous convenience yield net of storage costs,  $r_t$  is the instantaneous, continuously compounded short rate, and  $E_t^{\mathbb{Q}}$  denotes the expectation under the risk-neutral pricing distribution conditional on date  $t$  information. This expression is a consequence 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

$$F_t^T = E_t^{\mathbb{Q}} [S_T]. \quad (2)$$

Rearranging these expressions, it follows that

$$\frac{F_t^T}{S_t} = \frac{1 - Cov_t^{\mathbb{Q}} \left( e^{\int_t^T \mathcal{C}_s ds}, e^{-\int_t^T r_s ds} \frac{S_T}{S_t} \right)}{B_t^T E_t^{\mathbb{Q}} \left[ e^{\int_t^T \mathcal{C}_s ds} \right]} - \frac{1}{B_t^T} \times Cov_t^{\mathbb{Q}} \left( e^{-\int_t^T r_s ds}, \frac{S_T}{S_t} \right), \quad (3)$$

where  $B_t^T$  denotes the price of a zero coupon bond issued at date  $t$  that matures at date  $T$ . If the covariance terms are negligible, then (3) can be rewritten approximately as

$$\frac{F_t^T - S_t}{S_t} \approx y_t^T (T - t) - \ln E_t^{\mathbb{Q}} \left[ e^{\int_t^T \mathcal{C}_s ds} \right], \quad (4)$$

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<sup>4</sup>The primary exception would be participants that hold futures or options positions that precisely offset their current spot exposures and who adjust their derivative positions frequently enough to rebalance as new exposures arrive and old exposures dissipate.

<sup>5</sup>See, for examples, equation (1) of [Miltersen and Schwartz \(1998\)](#) or equation (4) of [Casassus and Collin-Dufresne \(2005\)](#), and related discussions in [Hamilton \(2009b\)](#) and [Alquist and Kilian \(2010\)](#).

where  $y_t^T$  is the continuously compounded yield on a zero of maturity  $(T - t)$  periods. This is the multi-period counterpart to the standard expression of the futures basis in terms of foregone interest and convenience yield. In the presence of stochastic interest rates and convenience yields, the multiperiod covariances between  $r$  and  $\mathcal{C}$  impact the relationship between  $F_t^T$  and  $S_t$  according to (3).

Most of the extant model-based interpretations of the oil price boom focus on representative risk-neutral producers and refiners and arrive at a similar expression with the expectation  $E_t^{\mathbb{Q}}$  replaced by  $E_t^{\mathbb{P}}$ , the expectation of market participants under the historical distribution. The perfect-foresight model of Hamilton (2009a), for instance, leads to a special case of a discrete-time counterpart of (1) without the expectation operator (since there is no uncertainty about future oil prices, inventory accumulations, or supply). If refiners and investors are risk averse, or if they face capital constraints that lead them to behave effectively as if they are risk averse, then (1) is the appropriate starting point for discussing speculation.

Implicit in (1) and (2) are the risk premiums that market participants demand when trading commodities in futures and spot markets. Define the market risk premium as  $RP_t^T \equiv (E_t^{\mathbb{Q}}[S_T] - E_t^{\mathbb{P}}[S_T])$ , for  $T > t$ . Further, consider a short time interval  $[t, \tau]$  over which  $r$  and  $\mathcal{C}$  are approximately constant. Then (3) implies that

$$\frac{E_t^{\mathbb{P}}[S_\tau] - S_t}{S_t} - y_t^\tau \approx \mathcal{C}_t - RP_t^\tau. \quad (5)$$

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, which are percentage changes in the price of a future contract, adjusted for roll dates (see the Appendix for details).

To sustain the pricing relation (3) and its approximate simplification (5) in equilibrium, it is not necessary that participants in the spot and futures markets, or those refining or holding inventories of crude oil, be one and the same individual.<sup>6</sup> It follows that: (i) Spot prices are influenced not only by current oil market and macroeconomic conditions, but also by investors' expectations about future economic activity. (ii) Supply and demand pressures in the futures and commodity swap markets will in general affect prices in the spot market. Indeed, these relationships are fully consistent with price discovery taking place in either the futures, the cash, or the commodity swap markets, or in all three. (iii) Risk premiums

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<sup>6</sup>In particular, the claim that “index fund investors ... only participated in futures markets... In order to impact the equilibrium price of commodities in the cash market, index investors would have to take delivery and/or buy quantities in the cash market and hold these inventories off of the market. (*ISOECD*, page 8)” is not true in the economic environment considered here.

will typically change over time as investors' willingness to bear risk changes. As I discuss in more depth below, the capacity of financial institutions to bear risk also changes over time, and this also may affect equilibrium futures and spot prices. (iv) Higher-order moments of prices and yields in financial markets also affect spot, futures, and swap prices through risk premiums and precautionary demands.

In addition these pricing relationships accommodate the possibility that investors hold different beliefs about the future course of economic events that impinge on commodity prices, and hence that there is not a representative investor in commodity markets. With the introduction of heterogeneity in beliefs, and absent risk aversion, one might naturally focus on the cross-investor average expectation of future spot prices in expressions like (5). However, when agents find it optimal to forecast the forecasts of others, the law of iterated expectations no longer applies, and forward prices are the average of investors expected future spot price *plus* an average across the forecast errors of the heterogeneously informed agents. That is, averaging across investors will typically give an expression similar to

$$\frac{\int_i E_t^i P[S_\tau] - S_t}{S_t} - y_t^\tau \approx \tilde{C}_t - \tilde{R}P_t^\tau + \mathcal{E}_t^\tau, \quad (6)$$

where  $i$  indexes investors and the additional term  $\mathcal{E}_t^\tau$  captures the effects of forecast errors and/or limits to arbitrage on spot and futures price determination.<sup>7</sup>

There is likely to be some disagreement among market participants about virtually every source of fundamental risk, including the future of global demands, the prospects for supply, future financing costs, etc. Saporta, Trott, and Tudela (2009) document large errors in forecasting demand for oil, typically on the side of under estimation of demand and mostly related to the non-OECD Asia and the Middle East regions. Additionally, they document substantial revisions to forecasts of market tightness, based on data reported by the U.S. Energy Information Administration (EIA), especially during 2007.<sup>8</sup> The International Energy Agency (IEA (2009)) points to substantial revisions to their monthly estimates of demands for the U.S. and, regarding non-OECD inventories, IEA (2008a) observes that “detailed inventory data [for China] continues to test observers’ powers of deduction. As we have repeatedly stressed in this report, these data are key to any assessment of underlying demand

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<sup>7</sup>See Xiong and Yan (2010) and Nimark (2009) for formal derivations of terms analogous to  $\mathcal{E}$  in the context of term structure models.

<sup>8</sup>Market tightness is defined as total consumption (excluding stocks) minus the sum of non-OPEC and OPEC production. After comparing news about, and revisions in forecasts of, supply and demand for oil during 2008, these authors conclude that “Based on the news about the balance of demand and supply in 2008 ... it seems that one can justify neither the rise in prices in the first half of 2008, nor the fall in prices in the second half (page 222).”

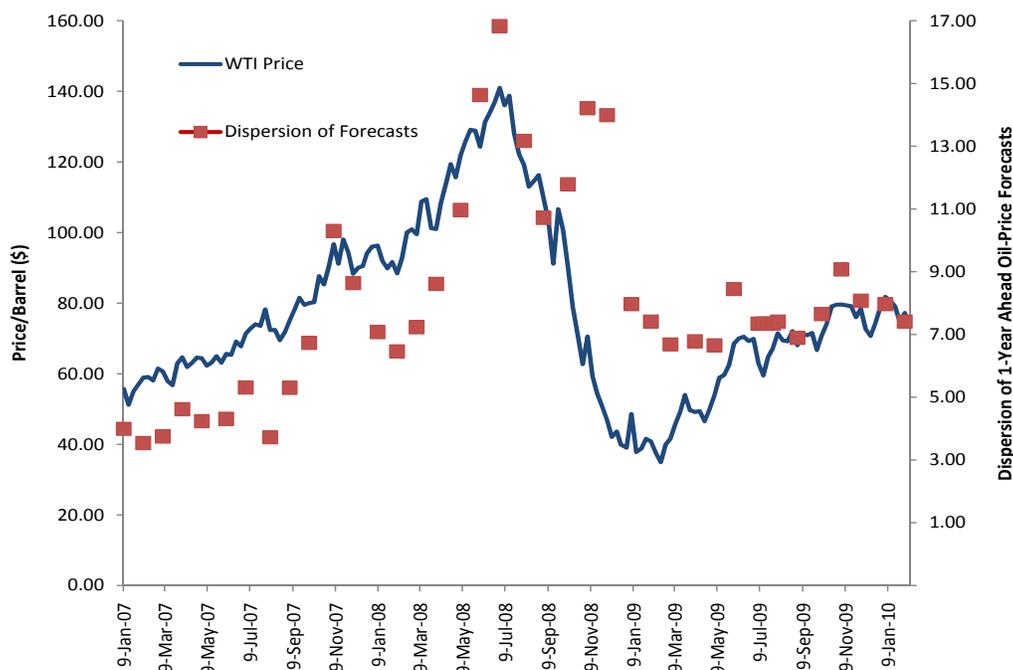


Figure 2: The front-month NYMEX WTI futures price (solid line, left scale) plotted against the cross-sectional dispersion of forecasts of oil prices one-year ahead by the professionals surveyed by Consensus Economics (squares, right scale).

trends... (page 15)” [Sornette, Woodard, and Zhou \(2008\)](#) document significant differences in the total world supplies for liquid fuels published by the IEA and the EIA, particularly from 2006 until 2008. The timeliness of non-OECD data is highly variable (IEA), and OPEC quotas and measured production levels are quite vague ([Hamilton \(2009b\)](#)).

Direct evidence on the extent of disagreement about future oil prices on the part of professional market participants comes from comparing the patterns in the cross-sectional standard deviations of the one-year ahead forecasts of oil prices by the professionals surveyed by Consensus Economics.<sup>9</sup> Larger values of this dispersion measure correspond to greater disagreement among the professional forecasters surveyed. [Figure 2](#) shows a strong positive correlation between the degree of disagreement among forecasters and the level of the WTI oil price. This comovement is consistent with the positive relationship between price drift and dispersion in investors beliefs found in theory and documented in equity markets.

How might this heterogeneity of beliefs impact oil prices? In a “rational expectations”

<sup>9</sup>Consensus Economics surveys over thirty of (in their words) “the world’s most prominent commodity forecasters” and asks for their forecasts of oil prices in the future. The series plotted in [Figure 2](#) is the cross-forecaster standard deviation for each month of their reported forecasts. I am grateful to the IMF for providing this series, as reported in their *World Economic Forum*.

equilibrium (*REE*) the source of different views across investors is private information. Investors share common priors and they do not disagree about public information. In contrast, in a “differences of opinion” equilibrium (*DOE*) investors can disagree even when their views are common knowledge. Accordingly, in a *DOE* investors can agree to disagree even when they share common information— they disagree about the interpretation of public information. Under a *REE* it is difficult to generate the volume of trade observed in commodity markets, because investors share common beliefs (see the “no-trade” theorems of [Milgrom and Stokey \(1982\)](#) and [Tirole \(1982\)](#)). In contrast in a *DOE*, because investors may disagree about the interpretation of public information, it is possible to generate rich patterns of comovement among asset returns, trading volume, and market price volatility (e.g., [Cao and Ou-Yang \(2009\)](#) and [Banerjee and Kremer \(2010\)](#)).

When market participants have different information sets, behavior in the spirit of Keynes’ “beauty contest” may arise naturally. It is typically optimal for each participant to forecast the forecasts of others ([Townsend \(1983\)](#), [Singleton \(1987\)](#)). That is, participants will try to guess what other participants are thinking and to adjust their investment strategies accordingly. Within present value models that share many of the same intertemporal considerations involved in pricing commodities,<sup>10</sup> [Xiong and Yan \(2010\)](#) and [Nimark \(2009\)](#) show that groups of traders that hold different views will naturally engage in speculative activity with each other. Indeed, [Allen, Morris, and Shin \(2006\)](#) show that this heterogeneity leads investors to overweight public opinion and this, in turn, exacerbates volatility in financial markets.

In addition to excessive volatility, differences of opinion can give rise to drift in commodity prices and momentum-like trading in response to public announcements.<sup>11</sup> Conditional on past performance, there may be periods when commodity prices tend to drift in the same direction. [Banerjee, Kaniel, and Kremer \(2009\)](#) show that such price drift does not arise naturally in a *REE*, but it typically symptomatic of a *DOE* in which investors disagree about the interpretation of public information and in which they are uncertain about the views held by other investors. Both of these suppositions seem plausible in commodity markets.

[Adam and Marcet \(2010a\)](#), taking a complementary approach, show how boom and bust cycles in asset prices can result from Bayesian learning by investors. Investors in their model are “internally” rational in the sense of [Adam and Marcet \(2010b\)](#)— they make fully optimal dynamic decisions given their subjective beliefs about variables that impact prices and are beyond their control. However investors may not agree on how public information

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<sup>10</sup>These authors study bond markets. As we have seen, analogous to the discounting in bond markets, commodity markets involve present values tied to financing cost, convenience yields, and storage costs.

<sup>11</sup>There is extensive empirical evidence that announcements of public information lead post-announcement drift and momentum in common stock markets; see, for instance, [Zhang \(2006\)](#) and [Verardo \(2009\)](#).

about fundamentals translate into a specific price level. Nor do investors know the utility weights that other investors assign to specific economic events. For both of these reasons internally rational investors try to infer from market prices information about fundamental economic variables and the end result is not a *REE*. They show that a model of stock price formation embodying these features produces boom/bust cycles in stock prices that match those experienced historically.

Three implications of this literature, particularly as they relate to the roles of speculation in commodity markets, warrant emphasis. First, it is not necessary for investors with heterogeneous beliefs to have private information in order for their actions to impact commodity prices. Rather, so long as they have differences of opinion about the interpretation of public information and find it useful to learn from past prices, then their actions can induce higher volatility, price drift, and booms and busts in prices. Second, the documented comovement among futures prices on commodities that are and are not in an index, or among spot prices across markets with and without associated futures contracts, is not evidence against an important role for speculation underlying this comovement.<sup>12</sup> Participants in all commodity markets should find it optimal to condition on prices in other markets when drawing inferences about future spot prices, and this includes wholesalers and speculators.<sup>13</sup>

Third, the fact that investors are learning about both fundamentals and what other investors know or believe about future commodity prices may mean that the release of a seemingly small amount of new information about supply or demand has large effects on prices. Indeed, it is possible that prices change owing to changes in investors perceptions or risk appetite and absent the release of any new information.<sup>14</sup>

### 3 Demand/Supply, Inventories, and Speculation

Many of the arguments against a significant role for speculative trading in the recent boom/bust in oil prices highlight the historical linkages between supply/demand and inventory

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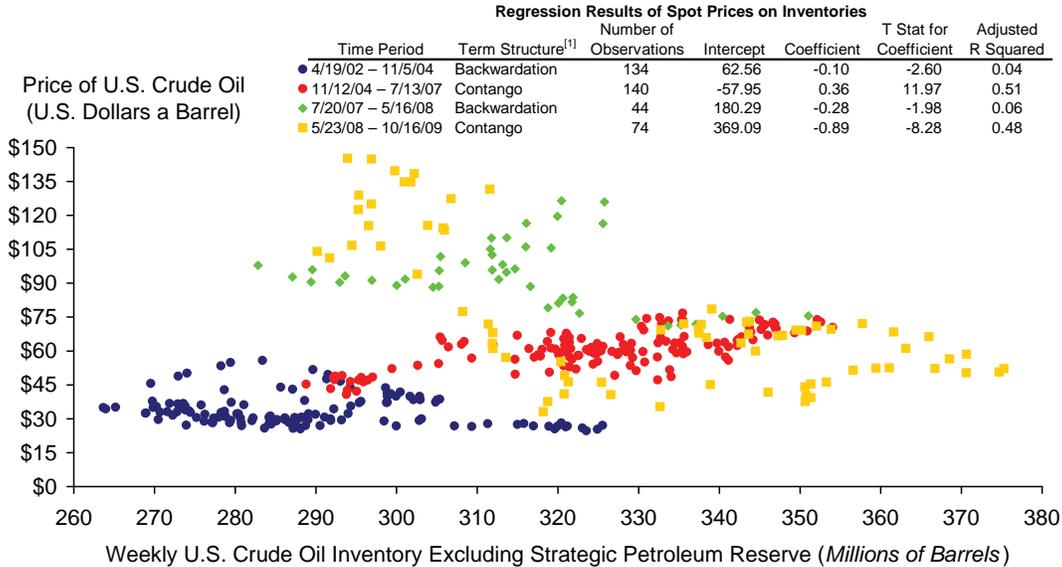
<sup>12</sup>It follows that the presence of heterogeneous beliefs and learning could invalidate both of the following claims in [Irwin and Sanders \(2010\)](#): (i) for index investors to have had a material affect on commodity prices “would have required a large number of sophisticated and experienced traders in commodity futures markets to reach a conclusion that index fund investors possessed valuable information that they themselves did not possess (page 8).” and (ii) “if index buying drove commodity prices higher then markets without index fund investment should not have seen prices advance (page 9).”

<sup>13</sup>The perception that there are links between flows into index funds and agricultural commodity prices is evident from [Corkery and Cui \(2010\)](#) who cite concerns about pension fund investments in commodities exacerbating fluctuation in food prices and, thereby, food shortages in poorer nations.

<sup>14</sup>[Tang and Xiong \(2011\)](#) conclude that “the price of an individual commodity is no longer simply determined by its supply and demand. Instead, prices are also determined by ... the risk appetite for financial assets, and investment behavior of diversified commodity index investors (page 30).”

### Crude Oil Spot Price vs. U.S. Stocks 4/19/02 – 10/16/09

Source: Energy Information Administration; *Bloomberg*



Note 1: Contango and Backwardation are defined using the spot price and the three-month futures price.

Figure 3: U.S. commercial inventories of crude oil plotted against the spot price of oil, for various recent subperiods.

accumulation. Specifically, a widely held view is that speculative trading that distorts prices on the upside must be accompanied by increases in inventories.<sup>15</sup> From Figure 3 it is seen that prior to 2003 there was a strong negative relationship between the price of oil and the amount of oil stored in the U.S. for commercial use (net of strategic petroleum reserves). This relationship turned significantly positive from 2004 to 2007. It weakened in 2007 and turned negative, and then was weakly positive again during the first half of 2008. Of course the price of oil is set in global markets, and during this period several major emerging economies where stockpiling crude oil in strategic reserves. These reserves are omitted from Figure 3 and, even if one wanted to include them, the inventory data for emerging economies has been much less reliable than for the G7. So this figure can, at best, only give a partial picture of the historical inventory/price relationship.

Conceptually, the links between speculative trading— dynamic strategies based on the shapes of conditional distributions of future spot prices— and spot commodity prices surely

<sup>15</sup>For instance, the IEA expresses the view that “if speculators are driving spot oil prices, an imbalance in the form of higher stocks should be apparent (IEA (2008b)).”

more complex than what emerges from models with static (non-forward looking or strategic) demands on the part of a homogenous class of agents. In a dynamic uncertain environment, time-varying expectations and volatility influence optimal inventory behavior. For instance, [Pirrong \(2009\)](#) shows that in a model with time-varying volatility, but otherwise similar features to Hamilton's framework, there is not a stable relationship between inventories and prices and that a positive inventory-price relationship may arise as a consequence of increased demand- or supply-side uncertainty. Thus, there is not an unambiguously positive theoretical relationship between changes in prices and inventories.

Equally importantly, the impact of inventory adjustments on the volatility of prices depends critically on what one assumes about the nature of uncertainty about supply and demand. Many storage models (e.g., [Deaton and Laroque \(1996\)](#)) assume that, subsequent to a surprise change in inventories induced by a shock to demand, inventories revert to a long-run mean. It is this response pattern that led [Verleger \(2010\)](#), among others, to expect inventory adjustments to have a stabilizing effect on oil prices. However, these models of storage cannot simultaneously explain the high degree of persistence in oil prices and the high level of oil price volatility over the past 30 years ([Dvir and Rogoff \(2009\)](#)).

Arbitrageurs (those who store to make a profit from price changes) are confronted with two opposing implications of a positive income or demand shock. The price of oil increases and there is a drop in effective availability, both of which encourage a reduction in optimal storage. On the other hand, the persistent nature of aggregate demand means that both income and prices are expected to be higher in the future. [Dvir and Rogoff \(2009\)](#) show that when growth has a trend component, the expectation that prices will be higher in the future encourages an *increase* in inventories and this effect dominates the reduction in storage induced by the immediate post-shock increase in prices. On balance, storage (by arbitrageurs, refiners or consumers) may amplify the effects of demand shocks on prices.<sup>16</sup> [Aguilar and Gopinath \(2007\)](#) argue that shocks to growth contribute more to variability in output in emerging than in developed economies.

At the core of many demand-based explanations for oil prices is the view that inelastic demand, combined with a relatively steeply sloped supply curve, implied that small changes in demand translated into large changes in prices, both on the upside and downside of the boom/bust. This same reasoning implies that small changes in strategic inventory positions can also have large changes in prices. Once expectations-based behavior is introduced, optimal inventory management can potentially further amplify the effects of differences of opinion

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<sup>16</sup>While this amplification mechanism has some characteristics of the precautionary demand studied by Pirrong, the economic mechanism underlying it is not driven by uncertainty about demand, but rather by expectations of rising prices.

### U.S. Crude Inventory Level excl. SPR vs. WTI Contango 1/5/04 – 10/23/09

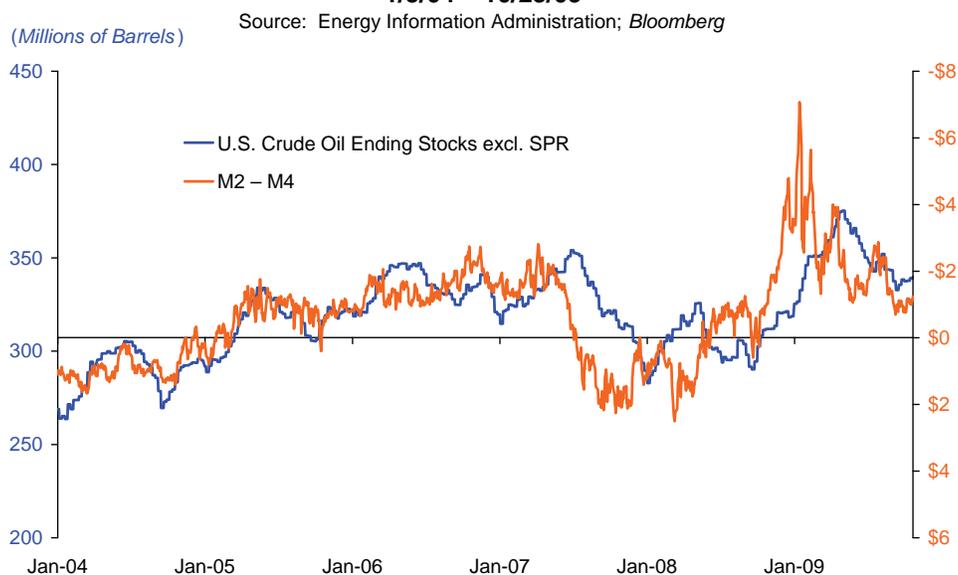


Figure 4: U.S. Commercial Inventories of Crude Oil Plotted Against the Spread Between Two-Month and Four-Month Futures Prices

and learning on commodity prices.

Figure 4 plots the level of non-strategic U.S. crude oil inventories against the spread between the futures prices for two- and four-month contracts ( $M2 - M4$ , inverted scale). Spreads that are above the zero line occur when the futures market is in contango, and spreads below this line indicate backwardation. There is a clear tendency throughout the period of 2004 through 2009 for inventories to increase when the futures market is in contango.<sup>17</sup> A notable feature of Figure 4 that seems consistent with the an amplification effect of strategic behavior based on expected future prices is that, at least from 2007 onwards, steepening and flattening of the forward curve preceded changes in inventories: a steeper forward curve anticipated accumulations of inventories.

## 4 Investor Flows and Oil Prices

Teasing out the relative contributions of the risks associated with fundamental factors in demand and supply through the channels encompassed in models such those of Hamilton (2009a) and Pirrong (2009) from the effects of price drift owing to learning and speculation

<sup>17</sup>These patterns are even stronger when inventory levels from Cushing or Padd2 are used.

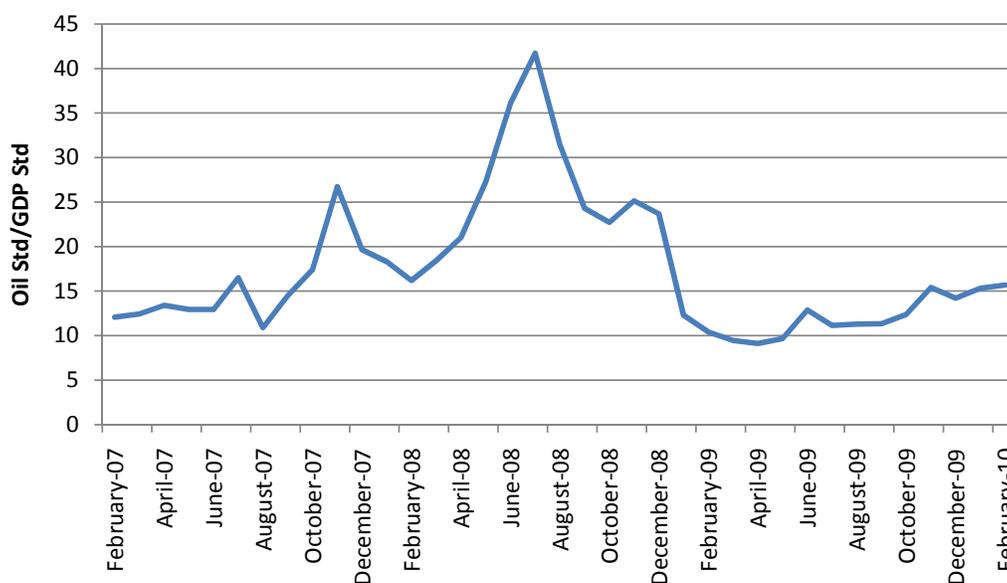


Figure 5: Ratio of the dispersions in forecasts for the price of oil and world economic growth (real GDP growth).

based on differences of opinion will require much richer structural models than have heretofore been examined. In an attempt to provide some guidance to such endeavors, the remainder of this paper explores the historical correlations between differences of opinion, trader flows, and excess returns in oil markets, particularly for the 2008/09 boom and bust.

The comovement of the price of oil and the dispersion of forecasts of this price documented in [Figure 2](#) suggests that professional participants in this market held different views and that these differences of opinion increased during the boom. Of relevance to the subsequent discussion is whether this increase in dispersion coincided with increased dispersion in forecasts of world economic growth. Some evidence on this question is provided in [Figure 5](#) which plots the ratio of the forecast dispersion for the price of oil to the corresponding dispersion of forecasts of growth for the world economy.<sup>18</sup> At least relative to the dispersion in opinions about world economic growth, there was something special about oil markets during 2008. Dispersion in views about economic growth did not rise substantially from its mid-2008 value until the spring of 2009 when the financial crisis was more pronounced.

<sup>18</sup>For the purpose of these calculations the world is considered to be the G7 plus Brazil, China, India, Mexico, and Russia. I am grateful to the IMF for providing me with these dispersion measures.

## 4.1 What Is Known About Investor Flows and Commodity Prices?

Of particular interest to policy makers and academics alike is the question of whether the growth in index investing— exposure to commodities through index-linked products— contributed to price volatility, a higher level of oil prices and greater disagreement among market participants about the future course of oil prices. It seems reasonable to presume that the growth in index investing affected the trading strategies of at least some other large investors. [Buyuksahin, Haigh, Harris, Overdahl, and Robe \(2008\)](#), for instance, argue that prior to the early 2000’s, the prices of long- and short-dated futures contracts behaved as if these contracts were traded in segmented markets. They find that, since the middle of 2004, the prices of one- and two-year futures have become cointegrated with the nearby contract. No doubt related to this closer integration of futures along the maturity spectrum are the increased trading activities of hedge funds engaged in spread trades ([Buyuksahin, Haigh, Harris, Overdahl, and Robe \(2008\)](#)) and the incentives for index-fund managers to purchase longer-dated exposures through futures when the market is in contango. Very little is known publicly about the degree to which different groups of commodity investors were effectively trading against each other, either based on revealed positions of classes of investors, observed order flow, or by following momentum strategies.<sup>19</sup>

Many have characterized index traders as “passive investors.”<sup>20</sup> As noted by [Stoll and Whaley \(2009\)](#), patterns similar to [Figure 1](#) (in their case for agricultural commodities) reflect the fact that a portion of the imputed position of index traders in any given commodity is driven by the movement in the underlying commodity price, as opposed to changes in the sizes of the positions of index traders. Nevertheless, overall position sizes did change. Even under the conservative estimates of position sizes by index investors in [Stoll and Whaley](#), they doubled between 2006 and the middle of 2008, and then declined rapidly by nearly one half as of early 2009. [Figure 6](#) overlays time paths of crude oil prices and the imputed positions of index investors in crude oil during the first and second halves of 2008. This data also shows a substantial increase and then decline in index positions, with medium-term patterns that closely track those of oil prices during the “boom and bust.”

Moreover, the increased correlation between excess returns on commodities and global equity returns during 2004 - 2009 documented in [Tang and Xiong \(2011\)](#) and [Buyuksahin](#)

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<sup>19</sup>Some information about positions was available from the CFTC and mutual funds, or was observed (by traders) through financial institutions’ own trading operations. There is extensive empirical evidence that order flow information in markets is a valuable input into the trading strategies of large financial institutions. See, for example, the evidence on currency markets in [Evans and Lyons \(2009\)](#).

<sup>20</sup>For instance, [Stoll and Whaley \(2009\)](#) express the view that commodity index investors “do not take a directional view on commodity prices. They simply buy-and-hold futures contracts to take advantage of the risk-reducing properties they provide ([Stoll and Whaley \(2009\)](#), page 17).”

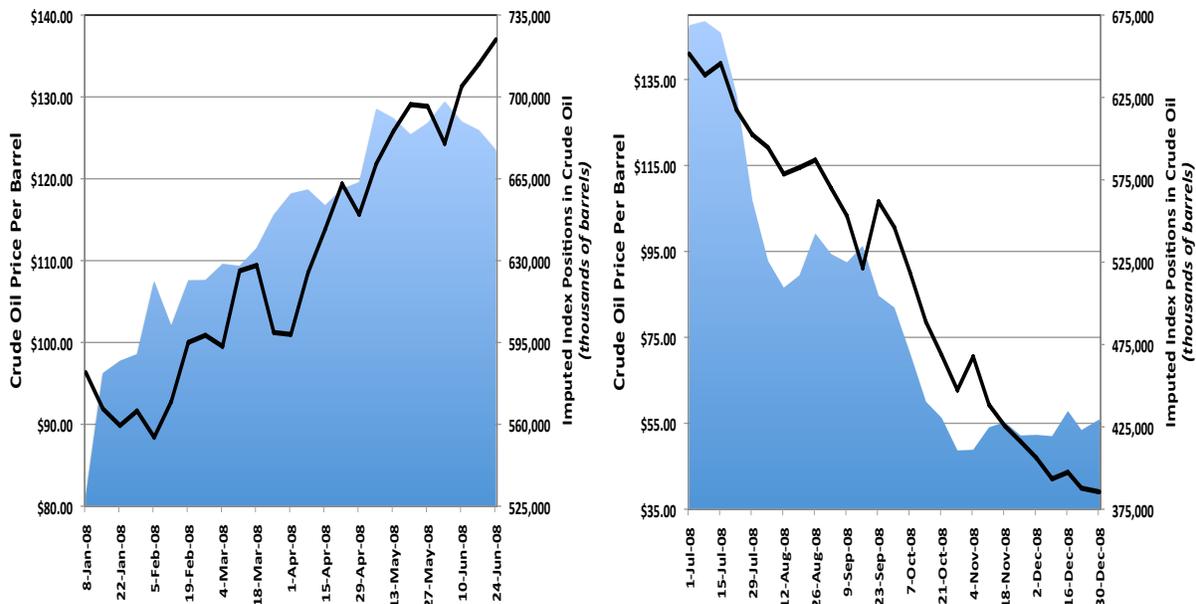
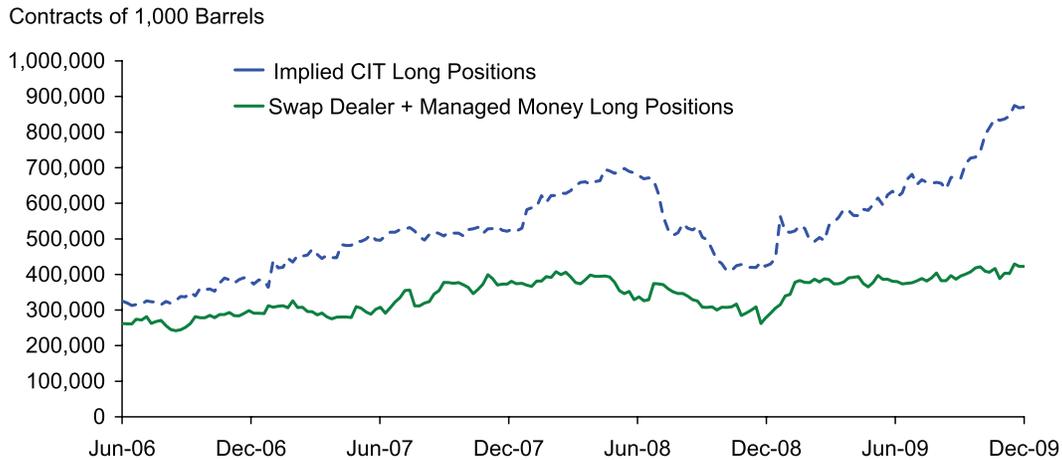


Figure 6: Crude oil prices (near futures contract) and imputed positions of index investors (barrels of oil) during the first (left) and second (right) halves of 2008.

and Robe (2010) suggests that either index investors held positions in both asset classes until the global economy weakened, at which point many simultaneously unwound their long positions, or that different investors were engaged in correlated trading strategies induced by similarly optimistic views about emerging economies.

Another, complementary issue that naturally arises in discussions of the impact of any given class of investors on commodity prices is whether large increases in desired long or short positions can impact prices in the futures and spot markets. In any market setting where there are limits to the amount of capital investors are willing to commit to an asset class— that is, where there are limits to arbitrage— the answer is generally yes. Price increases in responses to increased demands for long positions are typically necessary to induce other investors to commit more capital to taking the opposite side of these transactions. Acharya, Lochstoer, and Ramadorai (2009) and Etula (2010) document significant connections between the risk-bearing capacity of broker-dealers and risk premiums in commodity markets.

Though index traders have received much of the negative publicity in discussions of the 2008 boom/bust in oil prices, it is of interest to examine the impacts of the trading activities of all large classes of investors on prices during this period. The CFTC is now making available position reports on four categories of traders, back to 2006: traditional commercial (commodity wholesalers, producers, etc.), managed money (e.g., hedge funds), commodity swap dealers, and “other.” In addition, research staff at the CFTC have undertaken several studies of trader positions using internal proprietary data that has a much finer breakdown of market participants into categories of traders and is available daily.



Source: Commodity Futures Trading Commission; Energy Information Administration; *Bloomberg*

Figure 7: CIT-imputed commodity index long positions plotted against the swap dealer and managed money positions as reported by the CFTC’s Commitment of Traders report.

Overall, most of the evidence from this literature suggests that position changes in futures markets by managed money or commodity swap dealers either have weak or no (statistically significant) impact on prices and there is some evidence that hedging activity tends to stabilize prices (reduce price volatility).<sup>21</sup> However, knowing whether price changes lead or lag position changes over short horizons (a few days) is of limited value for assessing the price pressure effects of flows into commodity derivatives markets. Of more relevance is whether flows affect returns and risk premiums over weeks or months.<sup>22</sup> The imputed flows of funds into index positions displayed in [Figure 1](#) suggests that such intermediate-term price-pressure effects may well have been present.

Prior to 2009 the Commitment of Traders Report (COT) only reported information for the broad categories of “commercial” and “non-commercial” traders. [Figure 7](#) redisplay the imputed long positions of index investors from the CIT reports that is in [Figure 1](#),<sup>23</sup> along with the “swap dealers and managed money” category from the COT report. The latter is the data often used in empirical studies of the impact of index investor flows on futures

<sup>21</sup>See, for example, [Boyd, Buyuksahin, Harris, and Haigh \(2009\)](#), [Buyuksahin and Robe \(2009\)](#), [Buyuksahin and Harris \(2009\)](#), and [Brunetti and Buyuksahin \(2009\)](#).

<sup>22</sup>Similarly, evidence that any particular group of investors acquires positions after say a price decline does not contradict the view that this group is inducing systematic pressure for prices to move up or down.

<sup>23</sup>Implied CIT positions are calculated by dividing the imputed dollar amount of total index positions in NYMEX WTI crude oil futures by the value of a contract, calculated as the front-month futures contract price per barrel multiplied by 1000.

prices. Clearly these two series are very different, particularly from the fourth quarter of 2007 through the third quarter of 2008, and then again through the second half of 2009. This graph lends support to the view that the CFTC’s COT data does not give a reliable picture of the overall demand for and supply of commodity risk exposure.

Perhaps the most compelling evidence to date that index flows and “limits to arbitrage” have, together, had economically important effects on futures prices is provided by [Mou \(2010\)](#)’s analysis of excess returns around the dates of the rolls of the futures positions in the GSCI index. He argues that speculators made substantial profits effectively at the expense of index investors, particularly for energy-related contracts. Moreover, the profitability of the trading strategies Mou examines were decreasing in the amount of arbitrage capital deployed in the futures markets and increasing in the proportion of futures positions attributable to index fund investments.<sup>24</sup>

## 4.2 New Evidence on the Impact of Trader Flows on Oil Prices

In the light of this conflicting evidence on the impact of trader positions on futures prices, I explore complementary statistical relationships using the imputed flows by index and managed-money investors. Specifically, I compute weekly time-series of excess returns from holding positions in futures at different maturity points along the yield curve. The maturities are the 1, 3, 6, 9, 12, 15, 18, 24, and 36 month contracts, and the sample period is September 12, 2006 through January 12, 2010. Details of the excess return calculations are presented in the Appendix.

I include the following list of predictor variables for excess returns, with  $n$  set to one week or four weeks, depending on the holding period of the futures position:

***RSP $n$***  and ***REM $n$*** : the  $n$ -week returns on the S&P500 and the MSCI Emerging Asia indices, respectively. Inclusion of these returns controls for the possibility that investors were pursuing trading strategies in oil futures that conditioned on recent developments in global equity markets.

***REPO $n$*** : the  $n$ -week change in overnight repo positions on Treasury bonds by primary dealers. [Etula \(2010\)](#) in the context of futures trading, and [Adrian, Moench, and Shin \(2010\)](#) more generally, argue that the balance sheets of financial institutions affect their willingness to commit capital to risky investments. This in turn implies that risk premiums may depend on the costs to these institutions of financing their trading activities. The growth in overnight repo positions is one indicator of balance-sheet flexibility.

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<sup>24</sup>While the profitability of such positions declined leading up to the boom of 2008, they remained positive suggesting that there were limits to the amount of speculative capital investors were willing to deploy.

**IIP13**: the thirteen-week change in the imputed positions of index investors in millions, computed using the same algorithm as in [Masters \(2009\)](#). In contrast to most of the extant literature, I focus on changes in index positions measured over three months (thirteen weeks) rather than over a few days or a week.<sup>25</sup>

**MMSPD13**: the thirteen-week change in managed-money spread positions in millions, as constructed by the CFTC. [Erb and Harvey \(2006\)](#) and [Fuertes, Miffre, and Rallis \(2008\)](#) document that simple spread trades based on the term structure of futures prices led to large historical returns. [Buyuksahin and Robe \(2011\)](#) argue that increased positions of hedge funds in commodity futures affected the correlations between energy futures and returns on the *S&P500* index, and thereby the distribution of oil futures prices. Spread positions were the largest component of open interest during my sample period ([Buyuksahin, Haigh, Harris, Overdahl, and Robe \(2008\)](#)), and the disaggregated COT reports show that managed money accounts showed substantial growth in spread positions. Spread trades are not signed: trades that are long or short the long-dated futures are treated symmetrically.

**OI13**: the thirteen-week change in aggregate open interest in millions, as constructed by the CFTC. [Hong and Yogo \(2010\)](#) find that increases in open interest over an annual window predict monthly excess returns on futures. One explanation for this finding is that investors are learning about fundamental macroeconomic information from both past prices and open interest. I account for this potential effect by conditioning on the three-month change in aggregate open interest in oil futures.

**AVBAS $n$** : the  $n$ -week change in average basis. Defining the basis at time  $t$  of a futures contract with maturity  $T_i(t)$  to be<sup>26</sup>

$$B_i(t) = \left( \frac{F_t^{T_i}}{S_t} \right)^{1/(T_i(t)-t)} - 1, \quad (7)$$

as in [Hong and Yogo \(2010\)](#), then *AVBAS1* is the average of these values for maturities  $i \in \{1, 3, 6, 9, 12, 15, 18, 21, 24\}$ . In computing (7) I account for the time-varying maturity of the futures contracts. Hong and Yogo condition on their measure of basis to capture possible

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<sup>25</sup>The flows computed using the methodology in [Masters \(2009\)](#) is not without its limitations. However, for analyzing forecasts of changes in futures prices, it is not necessary that *IIP13* be a perfect measure of the flow of funds into index positions. Some measurement errors seem inevitable. If the proportion of each index made up of any one agricultural product is small, mismeasurement is likely to be amplified through the scaling process. Further, valuation is done at the near-contract futures price (as was the case in [Tang and Xiong \(2011\)](#)), and this might not have been how index traders positioned the actual fund flows in oil markets. Supporting this construction, the evidence in [Buyuksahin, Haigh, Harris, Overdahl, and Robe \(2008\)](#), based on proprietary CFTC data, suggests that the net positions of commodity swap dealers were primarily in short-dated futures contracts (three months or under).

<sup>26</sup>Note that this measure of the basis has the opposite sign of the basis in [Figure 4](#).

effects of hedging pressures on subsequent returns on futures positions.<sup>27</sup>

Of equal interest is that  $AVBAS_n$  is a proxy for the net convenience yield in commodity markets. Recall from (5) that expected excess returns in commodity markets are in general influenced by variation in convenience yields, changes in market risk premiums, and factors related to agents' learning from market prices or forecasting the forecasts of others. To the extent that  $AVBAS_n$  is a reasonable proxy for the convenience yield in oil markets, conditioning on  $AVBAS_n$  allows me to highlight the effects of other conditioning variables on risk premiums or other factors related to limits to arbitrage or speculative behavior.<sup>28</sup>

Finally, I condition on the lagged value of the realized  $n$ -week excess return on oil futures positions. [Stoll and Whaley \(2009\)](#) find that, once lagged returns on futures positions are included in predictive regressions, there is no incremental predictive power for flows into commodity index investment. However, for a much broader set of commodities, [Hong and Yogo \(2010\)](#) find a very strong predictive relationship between current open interest and subsequent returns on futures positions, with open interest effectively driving out the forecasting power of lagged returns.

I estimated the forecasting equations

$$ERmM_{t+n}(n) = \mu_{nm} + \Pi_{nm}X_t + \Psi_{nm}ERmM_t(n) + \varepsilon_{m,t+n}(n), \quad (8)$$

where  $ERmM_t(n)$  is the 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, and the data were sampled at weekly intervals. The fitted values from these regressions are typically interpreted as expected excess returns in futures markets. This is a natural interpretation when  $X_t$  represents information that was readily available to at least some market participants at the time the forecasts were formed. The variables  $IIP13$  and  $MMSPD13$  were constructed (by the CFTC) based on information at the time of the forecast. However this data was released by the CFTC starting in 2009 and, as such, was not readily available to market participants

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<sup>27</sup>There is an extensive literature examining links between net positions of hedgers and the forecastability of commodity returns— the “hedging pressure” hypothesis ([Keynes \(1930\)](#), [Hicks \(1939\)](#)). In two recent explorations of this issue [Gorton, Hayashi, and Rouwenhorst \(2007\)](#) find no support for the hedging pressure hypothesis, while [Basu and Miffre \(2010\)](#) argue that systematic hedging pressure is an important determinant of risk premiums. Both use the aggregated CFTC data on commercial and non-commercial traders in futures markets, a very coarse categorization that, as can be seen from [Figure 7](#), is not reliably informative about the trading activities of such classes of investors as index investors or hedge funds.

<sup>28</sup>[Gorton, Hayashi, and Rouwenhorst \(2007\)](#) extend the model of [Deaton and Laroque \(1996\)](#) to allow for risk averse speculators (maintaining mean reverting demand) and show that inventories are negatively related to expected excess returns in futures markets. They also establish a link between the futures basis and inventories. These authors and [Hong and Yogo \(2010\)](#), among others, present empirical evidence that a high basis (high  $M2 - M4$  in [Figure 4](#)) predicts high excess returns on futures positions, consistent with the theory of normal backwardation and compatible with the theory of storage.

Variable	RSP1	REM1	REPO1	IIP13	MMSPD13	OI13	AVBAS1
Contemporaneous Predictors							
ER1M(1)	0.35	0.40	0.10	0.21	0.16	0.12	-0.43
ER3M(1)	0.43	0.48	0.08	0.24	0.19	0.15	-0.26
ER6M(1)	0.45	0.50	0.06	0.25	0.17	0.15	-0.21
ER12M(1)	0.44	0.51	0.04	0.25	0.15	0.14	-0.17
ER24M(1)	0.41	0.48	0.04	0.25	0.12	0.13	-0.12
Lagged Predictors							
ER1M(1)	0.03	-0.17	-0.21	0.25	0.18	0.12	-0.25
ER3M(1)	0.11	-0.10	-0.20	0.26	0.19	0.13	-0.32
ER6M(1)	0.13	-0.09	-0.19	0.26	0.18	0.13	-0.30
ER12M(1)	0.16	-0.10	-0.19	0.26	0.16	0.12	-0.24
ER24M(1)	0.15	-0.11	-0.17	0.25	0.13	0.11	-0.18

Table 1: Correlations among the one-week excess returns on futures positions and the contemporaneous and lagged values of the predictor variables.

during my sample period. Therefore, a finding of economically important effects of these variables on  $ERmM_{t+n}(n)$  represents evidence of price pressure effects of flows by these investor classes on futures prices (controlling for other variables in  $X_t$ ), but not necessarily evidence that investors conditioned on these variables in forecasting future oil prices.

The correlations among the  $ERmM(1)$  and both contemporaneous and first-lagged values of the conditioning variables  $X$  are displayed in [Table 1](#). The contemporaneous correlations between the excess returns and the predictor variables have signs that are consistent with previous findings in the literature. The correlations of the excess returns with emerging market stock returns ( $REM1$ ) and the growth in repo positions by primary dealers ( $REPO1$ ) change sign when these conditioning variables are lagged one period. Moreover, when investor flows are measured over periods of weeks, rather than days as in much of the literature, they have sizable correlations with excess returns. I elaborate on these findings below.

The correlations between changes in oil futures prices and both index and managed-money flows are positive. For the signed index positions, this is consistent with positive (momentum-type) price pressure effects. Notice also that the thirteen-week change in open interest is positively correlated with oil price changes. This finding is consistent with the strong positive correlation of these variables found by [Hong and Yogo \(2010\)](#) using monthly data over a much longer sample period. They interpret these correlations as indicative of open interest embodying information about future economic activity that investors find useful for predicting future commodity prices. Such a role of open interest would naturally arise in economic environments where investors learn from past prices and trading volumes as in the

models discussed in [Section 2](#). Supporting such an informational role, Hong and Yogo also find that open interest has predictive content for bond returns and inflation in the U.S.

To explore these comovements more systematically and jointly, I estimated the parameters in [\(8\)](#) using linear least-squares projection. The null hypotheses are that the elements of  $\Pi$  are zero: excess returns on futures positions are not predictable by the variables in  $X_t$ , after conditioning on lagged information about excess returns. Economic theory allows for the possibility that other transformations of the conditioning information (more lags or nonlinear transformations) have incremental predictive content for excess returns. Accordingly, following [Hansen \(1982\)](#) and [Hansen and Singleton \(1982\)](#), robust standard errors are computed allowing for serial correlation and conditional heteroskedasticity in  $\varepsilon_{t+n}$ .<sup>29</sup> Estimates of  $\Pi$  along with their asymptotic “t-statistics” are displayed in [Tables 2](#) and [3](#) for  $n = 1$  and 4, respectively.

In interpreting these results, it is useful to bear in mind that, assuming that futures returns and the predictor variables are covariance stationary, the null hypothesis that the coefficient on investor flows in projections of weekly returns on intermediate-term growth rates in investor flows has the same economic content as the null hypothesis that short-term flows impact futures prices over intermediate-term horizons ([Hodrick \(1992\)](#), [Singleton \(2006\)](#)). Consistent with most prior studies, including weekly changes in index positions has little predictive content for the weekly excess returns. These observations suggest that, if present, the price drift in futures markets related to learning and speculative trade is manifested over return horizons of a few weeks or months. Correlations between futures prices and flow variables sampled at high frequency are likely to be dominated by noise that obscures the presence of this longer-horizon comovement.

The adjusted  $R^2$ 's in these projections provide compelling evidence that excess returns on futures positions in oil markets had a significant predictable component during this sample period. From [Figure 8](#) it is seen that the volatilities of the one-week excess returns decline, and the mean excess returns are increasing, in the contract month. Thus, the low adjusted  $R^2$ 's for the longer maturity contracts in [Table 2](#) imply that the predictor variables explain smaller percentages of relatively less volatile, but larger on average, returns.

Consider first the coefficients on the growth in open interest ( $OI13$ ). Interestingly, for the case of  $n = 1$ , the coefficients on  $OI13$  (partial correlations) switch sign and shrink in absolute value relative to the correlations in [Table 1](#), and they are small relative to their estimated standard errors. After conditioning on the trading patterns of index investors and hedge funds, at least for the sample period around the 2008 boom/bust, open interest does not have significant predictive content for one-week excess returns. Nevertheless, market participants

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<sup>29</sup>Specifically, I use the [Newey and West \(1987\)](#) construction allowing for five lags.

Contract	RSP1	REM1	REPO1	IIP13	MMSPD13	OII3	AVBASI	$R_{Lag}$	Adj $R^2$
1	0.332 (1.44)	-0.342 (-2.44)	-0.201 (-2.89)	0.272 (3.51)	0.357 (4.36)	-0.103 (-2.17)	-4.165 (-6.26)	-0.219 (-2.05)	0.27
3	0.361 (1.99)	-0.242 (-2.02)	-0.170 (-2.76)	0.218 (3.71)	0.284 (4.43)	-0.082 (-1.87)	-3.661 (-6.48)	-0.152 (-2.10)	0.27
6	0.391 (2.35)	-0.261 (-2.27)	-0.150 (-2.64)	0.197 (3.49)	0.245 (4.14)	-0.072 (-1.74)	-3.022 (-5.59)	-0.105 (-1.62)	0.25
9	0.424 (2.67)	-0.275 (-2.46)	-0.142 (-2.58)	0.187 (3.45)	0.222 (3.95)	-0.067 (-1.73)	-2.551 (-4.72)	-0.090 (-1.40)	0.24
12	0.437 (2.84)	-0.283 (-2.60)	-0.133 (-2.49)	0.179 (3.42)	0.202 (3.83)	-0.064 (-1.73)	-2.141 (-3.97)	-0.075 (-1.14)	0.22
18	0.430 (2.99)	-0.286 (-2.79)	-0.119 (-2.35)	0.166 (3.42)	0.174 (3.61)	-0.058 (-1.72)	-1.657 (-3.13)	-0.054 (-0.75)	0.20
24	0.412 (2.98)	-0.287 (-2.87)	-0.107 (-2.21)	0.157 (3.46)	0.159 (3.40)	-0.053 (-1.67)	-1.329 (-2.60)	-0.046 (-0.59)	0.18
36	0.378 (2.85)	-0.294 (-2.99)	-0.093 (-2.05)	0.145 (3.52)	0.144 (3.02)	-0.048 (-1.60)	-0.981 (-2.10)	-0.033 (-0.40)	0.16

Table 2: Estimates and robust test statistics for the futures excess return forecasting model over the horizon of one week ( $ERmM(1)$  is the dependent variable).

Contract	RSP4	REM4	REPO4	IIP13	MMSPD13	OII3	AVBAS4	$R_{Lag}$	Adj $R^2$
1	0.023 (.061)	0.246 (1.22)	0.097 (1.39)	0.987 (4.36)	0.972 (6.95)	-0.447 (-3.91)	-1.33 (-.688)	-0.229 (-2.04)	0.38
3	-0.137 (-.521)	0.342 (2.36)	0.038 (.564)	0.927 (4.54)	0.934 (7.03)	-0.374 (-3.36)	0.121 (.095)	-0.279 (-2.59)	0.41
6	-0.200 (-.783)	0.351 (2.58)	0.015 (.237)	0.880 (4.32)	0.833 (6.71)	-0.338 (-3.22)	0.539 (.452)	-0.271 (-2.33)	0.39
9	-0.216 (-.854)	0.330 (2.52)	0.015 (.248)	0.846 (4.30)	0.756 (6.40)	-0.322 (-3.21)	0.707 (.611)	-0.254 (-2.10)	0.37
12	-0.222 (-.886)	0.312 (2.48)	0.017 (.295)	0.811 (4.25)	0.689 (6.11)	-0.306 (-3.14)	0.782 (.693)	-0.238 (-1.92)	0.36
18	-0.219 (-.902)	0.276 (2.36)	0.023 (.432)	0.744 (4.20)	0.588 (5.60)	-0.278 (-2.97)	0.776 (.726)	-0.211 (-1.68)	0.33
24	-0.213 (-.915)	0.250 (2.30)	0.029 (.571)	0.687 (4.15)	0.531 (5.34)	-0.255 (-2.83)	0.706 (.701)	-0.190 (-1.49)	0.31
36	-0.212 (-.993)	0.237 (2.43)	0.036 (.787)	0.613 (4.06)	0.480 (4.95)	-0.236 (-2.78)	0.412 (.454)	-0.175 (-1.37)	0.28

Table 3: Estimates and robust test statistics for the futures excess return forecasting model over the horizon of four weeks ( $ERmM(4)$  is the dependent variable).

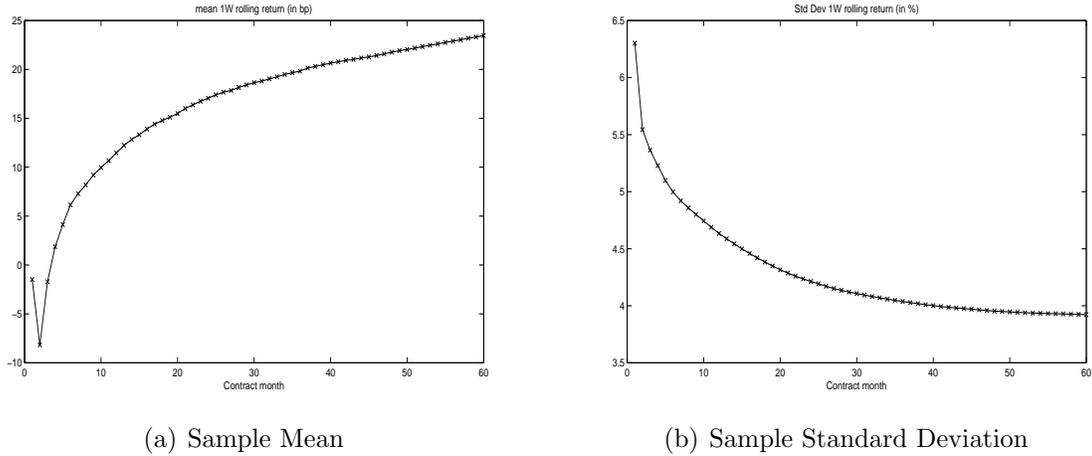


Figure 8: Sample moments in basis points of the weekly excess returns on futures.

who did not observe the information about investor flows summarized by ( $IIP13$ ,  $MMSPD13$ ) may well have found it informative to condition on order-flow information when estimating risk premiums in futures markets. The sample correlation between  $IIP13$  ( $MMSPD13$ ) and  $OI13$  was 0.56 (0.45).

Interestingly,  $OI13$  has a statistically significant negative effect on the four-week excess returns  $ERmM(4)$  (Table 3) for all contract maturities. This negative effect, which declines monotonically with the maturities of the futures contracts, is the opposite of the finding in Hong and Yogo (2010). However, they did not condition on the investor flows  $IIP13$  or  $MMSPD13$  and the negative coefficients may well reflect interactions in the ways these three variables are informative about monthly holding period returns in futures markets.

Perhaps the most striking findings in Tables 2 and 3 are the statistically significant predictive powers of changes in the index investor ( $IIP13$ ) and managed money spread ( $MMSPD13$ ) positions on excess returns in crude oil futures markets. Increases in flows into index funds over the preceding three months predict higher subsequent futures prices. These effects are significant for contracts of all maturities, after controlling for lagged futures returns and the other conditioning variables in  $X_t$ . The flow variable  $IIP13$  is capturing price pressures associated with intermediate-term persistent flows of funds into index positions.

The significant positive relationship between futures excess returns and index investor flows is seen visually from a comparison of  $IIP13$ , the four-week moving average of  $ER1M(1)$ , and the price of the one-month futures contract (Figure 9).<sup>30</sup> Other notable features of this figure are: (i) both the futures returns and  $IIP13$  start to decline in the spring of 2008

<sup>30</sup>This series is the price of the generic one-month futures contract,  $CL1$ , from Bloomberg.

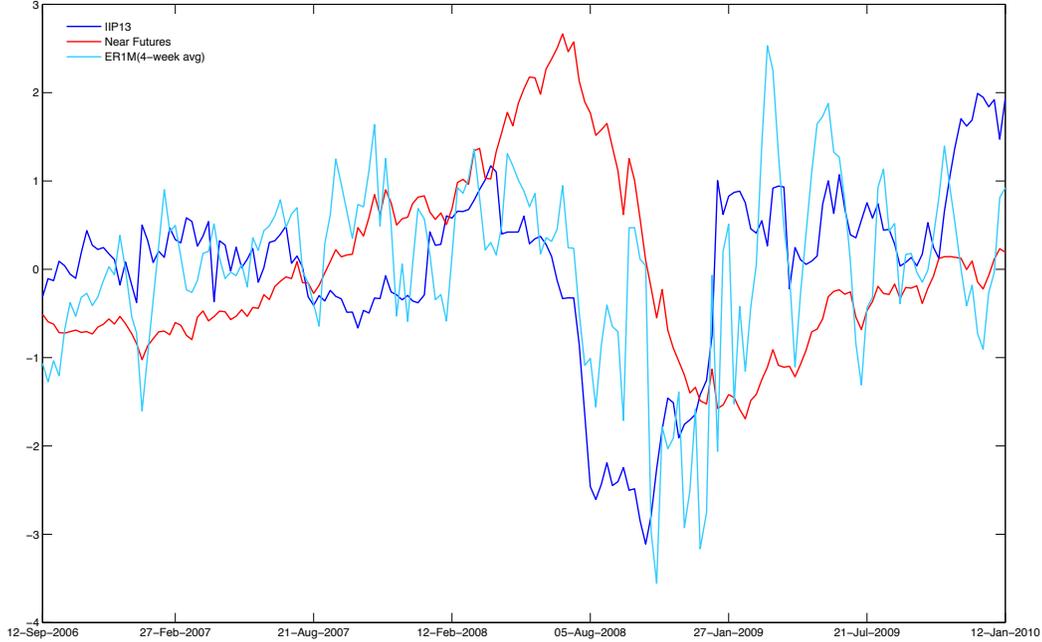


Figure 9: Investor flows ( $IIP13$ ) and the four-week moving-average of the one-week futures return ( $ER1M$ ) plotted against the price of the one-month futures contract.

prior to the peak in oil prices, (ii) the thirteen-week growth in index positions turns sharply negative shortly after the peak in prices, and (iii) the return to positive growth in index positions during late 2008 appears to lead the recovery in futures returns.

There is also a significantly positive effect of flows into managed money spread positions on future oil prices. The weekly excess returns embody the roll returns once per month. Therefore, the predictive power of  $MMSPD13$  might in part reflect the growth in spread trading by hedge funds in anticipation of the Goldman roll for index funds (Mou (2010)). Alternatively, Boyd, Buyuksahin, Harris, and Haigh (2010) present evidence of herding behavior by hedge funds during this sample period. Whatever the motives of the professionals categorized as “managed money” traders, their net effect on excess returns was positive: increases in spread positions were associated with future increases in oil contract prices. Ceterus paribus, the marginal effects of growth in index and managed-money positions on  $ERmM(1)$  were comparable: holding  $m$  fixed, the hypothesis that the coefficients in columns five and six of Table 2 are the same cannot be rejected for any of the contract months.

With  $n = 1$  the coefficients on the lagged futures returns for the one- and three-month contracts are marginally significant, but for all other contracts they are statistically insignificant. Additionally, the absolute values of the estimates decline rapidly with the maturity of the futures contract. Thus, there is weak evidence of reversals in the prices of the short-dated futures contracts, after accounting for the other conditioning information. Increasing the

holding period to  $n = 4$  weeks does not alter the signs of these coefficients, though they remain statistically significant for contracts out to about one year in length.

More generally, and importantly for interpreting the evidence regarding the boom and bust in oil prices, these findings suggest that the significant predictive content of the conditioning variables  $X_t$  is fully robust to inclusion of the lagged return (see also below). This stands in contrast to the results from focusing on returns and conditioning variables over daily intervals as, for instance, in [Buyuksahin and Harris \(2009\)](#) and [Stoll and Whaley \(2009\)](#).

The coefficients in [Table 2](#) on the lagged returns on emerging market equity positions ( $REM1$ ) are negative and statistically significant. In contrast, the signs on the coefficients on  $REM4$  in the projections for four-week excess returns  $ERmM(4)$  are positive, as are the contemporaneous correlations between the  $ERmM(1)$  and  $REM1$ . To explore this change of sign in more depth, I project  $ERmM_{t+j}(1)$  onto  $X_t$  (for the case of  $n = 1$ ) and  $ERmM(1)_t$ , for  $j = 1, 2, 3, 4$ . The coefficients on  $REM1_t$  in these projections effectively trace out the conditional impulse response function of  $ERmM(1)$  to an innovation in  $REM1$ . They start negative, turn positive in week two and peak at a larger positive number at week three. This pattern suggests that, after controlling for the other variables in  $X_t$ , positive innovations in (favorable news about) emerging market growth predicted reversals in futures prices in the subsequent week, perhaps as a consequence of limits to capital market intermediation or learning mechanisms that lead to short-term over-shooting of prices. Then, over somewhat longer horizons, such news predicts positive futures returns.

The negative and statistically significant effects of  $REPO1$  on excess returns are consistent with the model of [Etula \(2010\)](#) in which risk limits and funding pressures faced by broker-dealers impact risk premiums in commodity markets. The *OTC* commodity derivatives market is substantially larger than the markets for exchange traded products and servicing the *OTC* markets requires a substantial commitment of capital by broker-dealers. As funding conditions improve—reflected here through an increase in the repo positions of primary dealers—the effective risk aversion of broker-dealers declines and, hence, so should the expected excess returns in commodity futures markets. This effect of funding liquidity on excess returns declines (in absolute value) with contract maturity, while remaining statistically significant. Moreover, the statistically insignificant effects on  $ERmM(4)$  in [Table 3](#) indicate that any partial effects of funding liquidity were short-lived after conditioning on trader positions.

Finally, increases in the average basis ( $AVBAS1$ ) are associated with declines in excess returns. The coefficients on  $AVBAS1$  are both more negative and statistically significant for the short-maturity contracts.  $AVBAS1$  shows small bilateral correlations with the other conditioning variables. For instance, its correlations with ( $REPO1, IIP13, MMSPD13, OI13$ ) are  $(-0.15, -0.05, -0.05, -0.08)$  so the weekly average basis represents distinct information

about future returns. Over monthly horizons the effect of *AVBAS4* is not statistically significant. This finding aligns with those in studies of earlier sample periods (e.g., [Fama and French \(1987\)](#)), and also to those in [Hong and Yogo \(2010\)](#) who examine monthly excess returns over the longer sample period 1987-2008.

As noted previously, *AVBAS1* is a proxy for the convenience yield on oil markets. Some insight into whether my results are documenting the effects of risk premiums and expectational errors or convenience yields on excess returns can be gleaned from examining the errors from forecasting future spots prices using futures prices. Toward this end I projected  $S_{t+4} - F_t^{t+4}$  (the spot price one month ahead minus the one-month futures price) onto the conditioning variables  $X_t$  (for the monthly horizon).<sup>31</sup> The adjusted  $R^2$  in this projection is 0.39, similar to the result for ER1M in [Table 3](#). Only the investor flow variables *IIP13* and *MMSPD13* enter with statistically significant coefficients. That these flow variables have predictive content suggests that they are impacting commodity prices through risk premiums or speculative expectational terms, consistent with the conceptual frameworks outlined above. Of equal interest is the finding that neither *OI13* nor *REM4* enter significantly. It seems that, for this horizon, traders' reactions to news about emerging market equity returns and open interest helped shaped the futures curve, but not so much spot market risk premiums.

The reported findings are robust to inclusion of several other conditioning variables. In preliminary regressions I also included the one-week change in the Cushing, OK inventory of crude oil in millions, as reported on Bloomberg, to check the robustness of the results to the inclusion of inventory information. There is a statistically weak negative effect of inventory information on the excess return for the one-month contract. Beyond one month the coefficients are all small relative to their estimated standard errors.

Additionally, I estimated the predictive regressions with additional lags of excess returns included as predictor variables and the pattern of results in [Table 2](#) remained qualitatively the same. The inclusion of past information about returns does not materially affect the predictive content of the investor flow variables.

Finally, some argue that the trading patterns of index and managed-money investors are linked to speculation about global economic growth. A relevant question then is whether measures of global economic growth also had predictive power for excess returns on futures. As a proxy for aggregate demand, I follow [Kilian \(2009\)](#) and [Pirrong \(2009\)](#), as well as many oil-market practitioners, and use shipping rates based on the Baltic Exchange Dry Index (BEDI). The growth rate of the BEDI over the previous three months does explain

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<sup>31</sup>Using data on three shortest maturity futures contracts a cubic spline was used to interpolate for the one-month futures price. Two different interpolations schemes were examined and they gave qualitatively identical results.

an additional 2 – 3% of the variation in excess returns, and its coefficients are marginally statistically significant. However, BEDI has very little effect on the explanatory power of the other predictors: they continue to explain most of the variation in futures returns.

## 5 Concluding Remarks

The trading patterns of investors who are learning about economic fundamentals, both from public announcements and market prices, may contribute to drift in commodity prices that looks like a boom followed by a bust. This phenomenon is entirely absent, essentially by assumption, from many of the models of oil price determination that focus on representative suppliers, consumers, and hedgers. My empirical evidence suggests that growth in positions of index investors and managed-money accounts had significant positive effects on returns in oil futures markets around the time 2008 boom/bust in oil prices, after accounting for stock returns in the U.S. and emerging economies, open interest, and lagged futures returns.

The welfare costs of trading based on imperfect information are potentially amplified by the fact that the costs to individual investors of near-rational behavior – following slightly suboptimal investment or consumption plans– is negligible and yet this behavior might be quite costly for society as a whole (Lucas (1987) and Cochrane (1989)).<sup>32</sup> When investors make small correlated errors around their optimal investment policies, financial markets amplify these errors and generate price changes that are unrelated to fundamental supply/demand information (Hassan and Mertens (2010)). If index investors are just slightly too optimistic (in market rallies) or pessimistic (in market downturns) relative to the true state of the world then their errors, while inconsequential for their own welfare, may be material for society as a whole.<sup>33</sup> Frictions associated with multi-period contracting over labor and physical capital will likely exacerbate the social costs of any price drift.

More broadly, it is the dynamic interactions of the trading activities of index investors, hedge funds, broker/dealers in commodity markets, and commercial hedgers that ultimately set prices in commodity spot and futures markets. Just as index investors are, in part, adjusting their positions based on their views about global supplies and demands, other

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<sup>32</sup>Such suboptimal plans may arise out of misinterpretations of public information say about future economic growth in developing countries, because of small costs to sorting through the complexity of global economic developments and their implications for commodity prices, or because of over-confidence about future economic growth as in Dumas, Kurshev, and Uppal (2006).

<sup>33</sup>Recent research by Qiu and Wang (2010) shows that when market participants have heterogeneous information, and so asset prices depend on the expectations of the expectations of others, prices tend to be more volatile and the overall welfare of society is lowered. Additionally, if index traders impart noise to market prices through their trading activities, then this could also reduce the efficiency with which futures and spot markets perform their roles in price discovery.

market participants are doing likewise and they are positioning based on their views about what index and other classes of investors are doing. This may well explain the significant effects of hedge fund spread positions on excess returns in oil markets documented here.

Finally, much of the literature on commodity pricing abstracts from the impact of the extensive array of derivatives contracts in commodity markets (e.g., commodity swaps) on market-price dynamics. Adding derivatives markets may improve price discovery and mitigate some of the informational problems highlighted above. A key step towards a better understanding of the effects of interactions among various market participants on price behavior is the collection and dissemination of more detailed information about the trading patterns in *OTC* commodity derivatives, as well as exchange traded futures.

## Appendix: Construction of Excess Returns

Let  $F_t^{T_i(t)}$  denote the futures contract with expiration  $T_i(t)$ . The futures-price-term-structure consists of points  $F_t^{T_1(t)}, \dots, F_t^{T_N(t)}$ . Let  $D(s) > s$  denote the first time after  $s$  that the generic futures curve switches contracts. Then, for all  $i = 1, \dots, N - 1$ , and all  $s$ ,

$$T_{i+1}(D(s) - 1) = T_i(D(s))$$

The excess rolling return in generic contract  $i$ , between  $s$  and  $t$  is given by

$$\begin{aligned} & \frac{F_t^{T_i(t)}}{F_s^{T_i(s)}} - 1 && \text{if } t < D(s) \\ & \frac{F_{D(s)-1}^{T_i(D(s)-1)}}{F_s^{T_i(s)}} \cdot \frac{F_t^{T_i(t)}}{F_{D(s)-1}^{T_{i+1}(D(s)-1)}} - 1 && \text{if } D(s) \leq t < D^{(2)}(s) \\ & \frac{F_{D(s)-1}^{T_i(D(s)-1)}}{F_s^{T_i(s)}} \cdot \frac{F_{D^{(2)}(s)-1}^{T_i(D^{(2)}(s)-1)}}{F_{D(s)-1}^{T_{i+1}(D(s)-1)}} \cdot \frac{F_t^{T_i(t)}}{F_{D^{(2)}(s)-1}^{T_{i+1}(D^{(2)}(s)-1)}} - 1 && \text{if } D^{(2)}(s) \leq t < D^{(3)}(s) \end{aligned}$$

and so forth.

By construction these are the net returns from holding one long position in the generic  $i$ -month contract, liquidating the position the day before the generic curve “moves the contracts one month down,” and going long one unit in the following month  $i + 1$  (which the day after, by definition will be generic contract  $i$ ). This strategy is followed from  $s$  until  $t$ .

The riskfree rate does not enter these calculations. The rationale is (following, for instance, [Etula \(2010\)](#)) that investing in a futures position, does not require an initial capital injection. In practice, however, the futures trading strategies are met with margin calls. For this reason [Hong and Yogo \(2010\)](#) consider a fully collateralized return of the form (say if  $t < D(s)$ )

$$\frac{F_t^{T_i(t)}}{F_s^{T_i(s)}} R_{s,t}^f$$

My calculations omit the multiplying factor  $R_{s,t}^f$  from the construction of excess returns.

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