Do Speculators Drive Crude Oil Futures Prices?

Bahattin Büyükşahin and Jeffrey H. Harris***

The coincident rise in crude oil prices and increased number of financial participants in the crude oil futures market from 2000–2008 has led to allegations that "speculators" drive crude oil prices. As crude oil futures peaked at $147/bbl in July 2008, the role of speculators came under heated debate. In this paper, we employ unique data from the U.S. Commodity Futures Trading Commission (CFTC) to test the relation between crude oil prices and the trading positions of various types of traders in the crude oil futures market. We employ Granger Causality tests to analyze lead and lag relations between price and position data at daily and multiple day intervals. We find little evidence that hedge funds and other non-commercial (speculator) position changes Granger-cause price changes; the results instead suggest that price changes precede their position changes.

1. INTRODUCTION

The summer 2008 spike in crude oil prices to $147/bbl jolted the U.S. economy and pinched consumers at the gas pump. In reaction to oil prices, U.S. total oil consumption fell by 6.7 percent from 20.8 million barrels per day in 2005 to 19.4 million barrels a day in 2008. Given the predominance of crude oil in the U.S. economy, the price spike also generated substantial attention from regulators, legislators and market critics who decried the existence of excessive speculation in the crude oil futures markets. Indeed, the rise in participation by

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* Corresponding author. Senior Oil Market Analyst, International Energy Agency (IEA), 9 rue de la Federation, 75739 Paris Cedex 15, France. E-mail: bahattin.buyuksahin@iea.org.

** Professor of Finance, Alfred Lerner College of Business and Economics, University of Delaware. E-mail: harrisj@lerner.udel.edu.

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non-commercial traders during the preceding eight years (see Büyükşahin et al. (2009)) provided great fodder for causal connections with concurrent price increases. In this paper we apply rigorous econometric techniques to determine whether position changes of any particular group of traders led crude oil futures price changes from 2000–2009.

For perspective, we first calculate Working's (1960) speculative index in the crude oil futures market from 2000 through 2008. Working's index is predicated on the fact that long and short hedgers do not always trade simultaneously or in the same quantity, so that speculators fill the role of satisfying unmet hedging demand in the marketplace. We find that the speculation index has also risen steadily from 2001 through mid-2008 (concurrent with the rise in non-commercial participation), but has been relatively stable in the nearby contract since early 2006.

Utilizing more disaggregated data on daily trader positions, we implement Granger causality tests to determine lead and lag relations between price changes and net position changes of various traders in the crude oil futures markets. We execute Granger causality tests in two sub-periods—from July 2000 through June 2004, a period marked by relatively stable participation and prices, and from July 2004 through March 2009, the period marked by extreme price movements and increased participation in the crude oil futures markets. We find that the changing net positions of any specific trader group do not lead to price changes in either sub-period or over the entire sample period. We also examine net position changes of various combinations of non-commercial and commercial traders and find similar results. No single group or combination of groups (even those commonly considered speculators) systematically Granger-cause prices in nearby contracts.

Instead, the Granger-causality runs from price changes to position changes, suggesting that most groups of traders are generally trend followers. Commercial traders (in total), manufacturers, commercial dealers, producers, swap dealers and hedge funds are each shown to be trend followers. Notably, non-commercial traders (in total) and the combined group of swap dealers and non-commercial traders also exhibit trend following behavior over the full sample period as well as during sub-periods. These results also hold for daily net position changes in futures as well as for the combined position changes from futures and futures-equivalent options positions. These results are also robust to two-, three-, four- and five day measurement intervals for net position and price changes. Although open interest (including non-commercial participation) is greatest in the nearby contract, we also examine price and position changes in the first, second, and third deferred contracts, finding similar results.

Our analysis updates, enhances and confirms similar findings in the Interagency Task Force Interim Report on Crude Oil (ITF (2008)), which concludes that the sharp increase in crude oil prices through July 2008 can be explained by the fundamentals of the crude oil market. Notably, our update includes an analysis of the significant price collapse (from $147/bbl to below $40/bbl) from July 2008 through March 2009. We show that the price collapse has not been accompanied by a significant drop in the speculation index, casting further doubt on claims that speculator position changes have systematic effects on futures market prices during this period.

Two of the most important functions of futures markets are the transfer of risk and price discovery. In a well-functioning futures market, hedgers interested in reducing their exposure to price risk find counterparties. In a market without speculative interest, long hedgers must find short hedgers with an equal and opposite hedging need. In fact, many traditional hedgers have dual liquidity needs, intending to offset their futures positions before physical delivery of crude oil. Speculators enhance liquidity and reduce search costs by taking the opposing positions when long hedgers do not perfectly match short hedgers. In this regard, speculators provide immediacy and facilitate the needs of hedgers by mitigating price risk, while adding to overall trading volume, which contributes to more liquid and well-functioning markets.

Of course, excessive speculation has the potential to disrupt markets as well. Shleifer and Summers (1990) note that herding can result from investors reacting to common signals or overreacting to recent news. As de Long et al. (1990) show, rational speculators trading via positive feedback strategies can increase volatility and destabilize prices. Our results, however, complement findings by Boyd et al. (2009) and Brunetti et al. (2010) who, respectively, find that herding among hedge funds is countercyclical and does not destabilize the crude oil futures markets during recent years.

In this paper, we identify groups of traders based on self-reported lines of business collected and audited by the CFTC. Commercial traders consist of dealers, producers, manufacturers, and other entities typically involved with crude oil as a commodity. Non-commercial traders include floor brokers, floor traders and hedge funds. Although non-commercial traders are typically considered speculators, commercial swap dealers who use futures markets to hedge over-the-counter positions are considered speculators by some, since they lack direct exposure to the underlying crude oil commodity. In fact, swap dealers commonly take positions for commodity index funds that view commodities as a distinct asset class, raising concerns that these funds convey the herding mentality from unsophisticated traders into futures markets. Overall, the growth in hedge fund and swap dealer positions in crude oil futures markets (Büyükşahin et al. (2009)) has led to claims that these traders destabilize markets and drive prices inexplicably high. Despite these claims, there is surprisingly limited empirical evidence that this trading activity affects prices or volatility. Notably, however, the CFTC's Staff Report on Swap Dealers and Index Traders (CFTC (2008)) shows that total swap dealer positions declined over the first six months of 2008 while crude oil futures prices rose from \$100 to \$140.

One limitation of our analysis is that the distinction between hedging and speculation in futures markets is less clear than it may appear. Traditionally, traders with a commercial interest in or an exposure to a physical commodity have been called hedgers, while those without a physical position to offset have been called speculators. In practice, however, commercial traders may “take a view” on the price of a commodity or may not hedge in the futures market despite having an exposure to the commodity, positions that could be considered speculative.

Traditional speculators can be differentiated based upon the time horizons during which they operate. Scalpers, or market makers, operate at the shortest time horizon—sometimes trading within a single second. These traders typically do not trade with a view as to where prices are going, but rather “make markets” by standing ready to buy or sell at a moment’s notice. The goal of a market maker is to buy contracts at a slightly lower price than the current market price and sell them at a slightly higher price, perhaps at only a fraction of a cent profit on each contract. Skilled market makers can profit by trading hundreds or even thousands of contracts a day. Market makers provide immediacy to the market. Absent a market maker, a market participant would have to wait until the arrival of counterparty with an opposite trading interest.

Other types of speculators take longer-term positions based on their view of where prices may be headed. “Day traders” establish positions based on their views of where prices might be moving within minutes or hours, while “trend followers” take positions based on price expectations over a period of days, weeks or months. These speculators can also provide liquidity to hedgers in futures markets. Through their efforts to gather information on underlying commodities, the activity of these traders serves to bring information to the markets and aid in price discovery.

While hedging and speculating are often considered opposing activities and are generally identified with commercial and non-commercial traders, respectively, in practice both groups can contribute to price discovery in futures markets. Futures prices reflect the opinions of all traders in the market. Moreover, the actions of those who can but choose not to enter the futures market can also contribute to price discovery. For example, a commercial trader holding physical inventory, but choosing not to hedge using futures markets (by taking a short position) not only withholds downward pressure on the futures price, but may also signal that prices are expected to rise in the future.

Activities that occur in other markets and other instruments can also impact futures markets. There are three potential activities that might impact futures trading on U.S. exchanges: (i) the trading of OTC derivatives contracts; (ii) the trading on exempt commercial markets (ECMs); and (iii) the trading on foreign boards of trade. Futures markets comprise only one venue for hedging price risk. In the context of risk management, market participants may be involved concurrently in over-the-counter (OTC) transactions, trades on ECMs, and transactions in foreign markets. Crude oil traders, for example, can hedge cash market positions using a combination of futures, swaps, bilateral forward contracts, cleared broker and ECM transactions.

The traditional speculative stabilizing theory of Friedman (1953), that profitable speculation must involve buying when the price is low and selling when the price is high, has come under strong criticism. Some argue that there is a possibility that speculative trading might lead to higher prices if speculators increase their accumulation of inventories (e.g. Kilian and Murphy (2010) and Pirrong (2008)). Alquist and Kilian (2010) formally link forward looking behavior and inventory building. Their model predicts that increased uncertainty about future oil supply shortfalls will lead the real price of oil to overshoot in the immediate short-run with no response from inventories. The real price of oil gradually declines as inventories are accumulated slowly over time. Kilian and Murphy (2010) develop a structural model for crude oil that allows for shocks to the speculative demand. In their model, a positive shock to speculative demand increases both the real price of oil and oil inventories. They find no evidence that the 2003–2008 price surge had much to do with speculative demand shocks.

As suggested by Hamilton (2009b), crude oil inventories have been significantly lower than historical levels in late 2007 and early 2008 when crude oil price changes were most dramatic. On the other hand, Davidson (2008) argues that the absence of higher inventories does not necessarily indicate the absence of excess speculation in the market. Using the Marshallian concept of "user cost", Davidson argues if oil prices are expected to rise in the future more rapidly than current interest rates, then commercial producers can enhance total profits by leaving more oil underground today for future production.[1] If oil producers do take the user costs of foregone profits into account in their profit maximizing production decisions, then producers may limit current production and above ground inventories may not rise. In this regard, Davidson (2008) points out that traditional hedgers, such as oil producers, might be involved in speculation. A similar argument is made by Parsons (2009), who argues that change in term structure for oil to a long lasting and deep contango late in 2004 can explain steady above-ground stockpiles of oil. Kilian and Murphy (2010), however, find no evidence that a negative oil supply shock played an important role in the spike in crude oil prices between 2003 and mid-2008.

Kilian (2008) and Kilian (2009) propose a structural decomposition of the real price of oil into three components: shocks to flow of supply of crude oil; shocks to the global demand for all commodities; and demand shocks that are specific to the crude oil market. Their empirical analysis provides evidence that the recent price hike is primarily result of global demand shocks rather than supply shortages or crude oil specific demand shocks. Hamilton (2009a, 2009b) and Smith (2009) suggest that the cause of the 2007–08 oil price increase is the result of stagnant production and strong demand of crude oil, which lowered the short-run price elasticity of oil to historically low levels.[2] Hamilton (2009a) further suggests that both factors—stagnant production and low short-run price elastic-

1. User cost can be defined as the present value of future net benefit that is lost due to the use of the resource at present. Of course, user costs relate only to exhaustible resources.

2. Smith (2009) also provides an excellent review of the structure of the oil market and fundamentals that affected price level of crude oil in 2008.

ity—are needed for speculation to drive prices too high, but that financial speculation (by non-commercial entities) would also cause inventories to rise. He concludes that supply and demand fundamentals provide a more plausible explanation for the 2008 price spike.[3] However, Hamilton (2009b) suggests that it is possible for speculators to drive up prices without any change in inventories if the short–run price elasticity of demand is close to zero (an approximate condition of the oil market).

Kilian (2008) and Kilian and Murphy (2010) attribute the 2003–08 increase in crude oil prices to demand driven by the global business cycle rather than a negative oil supply shock or speculative demand. Kilian and Murphy (2010) estimate short-run oil price elasticity at a significantly negative –0.24, much higher than existing estimates in the literature and, if accurate, further undermines speculation as an explanation for recent oil price increases. Kilian and Hicks (2009) present further evidence that shocks to global aggregate demand driven by the business cycle were the main explanation of the 2003–2008 oil price surge and the subsequent drop.

Our paper contributes to a rich empirical literature evaluating trader positions and prices in futures markets. Using aggregated public CFTC Commitments of Traders (COT) data Brorsen and Irwin (1987) and Irwin and Yoshimaru (1999) fail to find a link between hedge fund positions, price volatility and price levels, respectively. Brown et al. (2000) find no link between fund positions and falling currency values around the 1997 Asian financial crisis. Sanders et al (2004) using weekly aggregated COT data, find uni-directional causality from returns to net positions, rather than the opposite. Although these findings are suggestive, researchers generally acknowledge that results from highly aggregated COT data should be interpreted with caution. More recent research using disaggregated data from the CFTC provides further evidence on the relations between trader positions and price movements. Irwin and Holt (2004), for example, find a small positive relation between hedge fund trading volume and volatility for 13 different futures markets during 1994.[4] Haigh, Hranaiova and Overdahl (2007), using directed graph analysis, show that hedge funds enhance the price discovery function of the crude oil and natural gas futures markets.[5] Brunetti et al. (2010) also find that speculative activity in five different futures markets (including crude oil) does not lead price changes, but reduces risk by enhancing market liquidity.

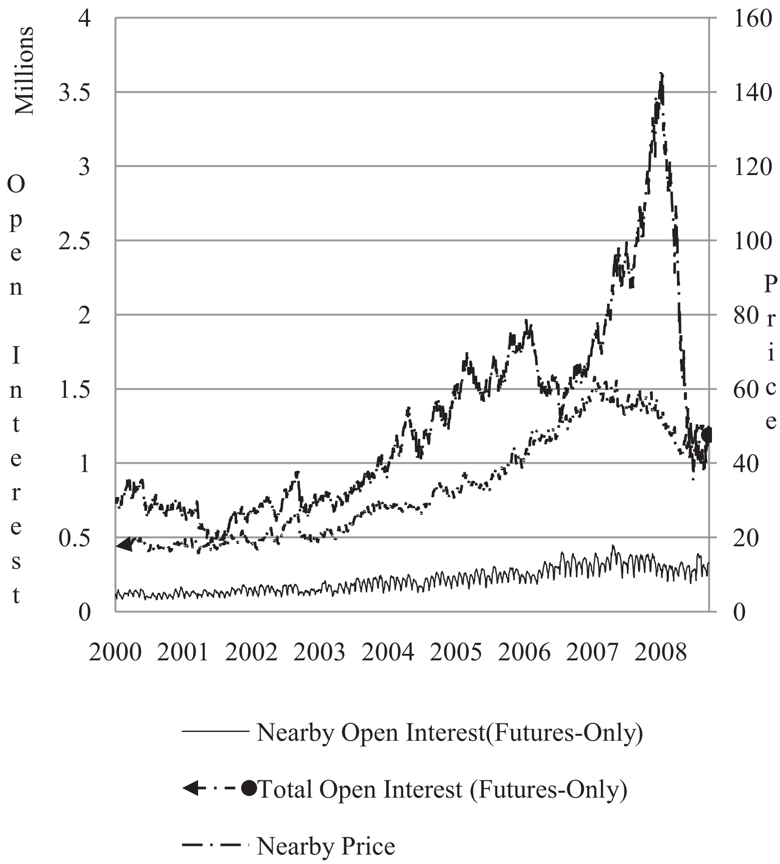
The remainder of the paper proceeds as follows. In section 2, we describe our data and methodology. In section 3, we analyze Granger causality tests between trader positions and rate of return as well as positions and volatility. We conclude in section 4.

3. The Interagency Task Force Interim Report on Crude Oil (ITF (2008)) draws similar conclusions.

4. This study also suffers from an aggregation problem since they used total hedge fund positions as a proxy for nearby positions.

5. Boyd et al. (2009) analyze herding among hedge funds, finding that the moderate level of herding among hedge funds serves to stabilize prices.

Figure 1: Open Interest and Price of Crude Oil



2. DATA AND METHODOLOGY

We analyze daily position and pricing data for NYMEX light sweet crude oil (West Texas Intermediate grade, henceforth WTI) futures and options on futures contracts over the time period of July 5, 2000 through March 18, 2009. Figure 1 portrays open interest and the prices for both the nearby contract and the average of prices from all contract maturities.[6] Open interest in crude oil futures peaked in July 2007 and has since declined slightly. However, open interest futures-equivalent options continued to rise until July 2008. Though visu-

6. We define the nearby contract as the current month until the open interest of the next month's contract exceeds that of the current month, whereby the first deferred contract becomes our nearby contract.

ally interesting, this inspection of open interest and price data provides little evidence on the relation between these two variables.

The position data utilized in this study comes from the CFTC's Large Trader Reporting System (LTRS), a collection of position-level information on the composition of open interest across all futures and options-on-futures contracts for each market. LTRS data is collected by CFTC market surveillance staff to help the Commission fulfill its mission of detecting and deterring futures market manipulation. This data is filed daily by traders whose positions meet or exceed the CFTC's reporting levels. For the WTI oil futures and options market used in this study, the threshold has been 350 contracts since May 16, 2000 and was 300 contracts prior to that date. Many smaller positions are voluntarily reported as well, so that our data includes more than 90% of all WTI futures positions during our sample period (See Tables 1a and 1b).

The CFTC has historically published weekly COT reports identifying positions of two broad trader categories: "commercial" and "non-commercial."[7] A "commercial" entity files a statement with the CFTC that indicates it is commercially "engaged in business activities hedged by the use of the futures or option markets." To ensure that traders are classified accurately and consistently, CFTC staff can audit the trader's business practices and exercise judgment in reclassifying a trader based on the trader's use of the markets. Entities that are "non-commercial" are mostly financial traders, such as hedge funds, mutual funds, floor brokers and traders not registered with the CFTC under the Commodity Exchange Act.

Using the publicly-available weekly COT reports for the WTI crude oil futures market, Tables 1a and 1b clearly reveal the overall growth of this market since 2000. The tables show the average open interest in WTI crude oil futures and sum of futures-equivalent (delta-adjusted) options positions for the aggregated commercial, non-commercial and non-reportable trader categories. Table 1a shows that open interest more than doubled during the entire sample period, from fewer than 500,000 contracts in 2000 to more than 1.2 million contracts in 2007.[8] For each category and year, long and short positions are reported as fractions of the total open interest. In 2008, on the short (*long*) side of the 1,279,534 contracts, 52.7% (*51.0%*) of all positions were held by commercial traders and 14.3% (*16.8%*) were held by reporting non-commercial traders, with the remaining split between 26.8% non-commercial spread positions (i.e., calendar spread positions constructed with long and short futures positions) and 6.2% (*5.4%*) in outright short (*long*) non-commercial futures positions.

7. COT reports also include position data for non-reporting traders, which include smaller traders. This category comprises the difference between total open interest and the aggregate positions of reporting traders. Since 2009 the CFTC now partially disaggregates "commercial" positions into swap dealers and producer/merchants and "non-commercial" positions into managed money (hedge funds) and others.

8. Using the average price of all contracts, the notional value of outstanding contracts grew from about $12 billion in 2000 to $75 billion in 2009. At the 2008 peak of crude oil prices (average price around $101.5) the notional value of futures contracts stood at approximately $130 billion.

Table 1a: Open Interest in Crude Oil Futures, 2000–2009

	Non-commercials (%)			Commercials (%)		Non-Reportables (%)		Total Open Interest
Year	**Long**	**Short**	**Spread**	**Long**	**Short**	**Long**	**Short**	
2000	8.9	7.9	6.6	75.0	76.1	9.4	9.3	448754
2001	4.9	11.5	7.7	78.8	70.5	8.6	10.3	438955
2002	10.5	8.2	13.7	64.7	68.9	11.1	9.2	486083
2003	13.3	12.8	9.3	68.0	67.7	9.4	10.2	542454
2004	17.5	12.0	9.6	64.2	69.3	8.8	9.1	689326
2005	14.5	13.2	15.4	62.7	62.2	7.3	9.1	817174
2006	15.6	13.1	19.6	58.9	60.5	6.0	6.8	1063986
2007	14.9	11.6	21.7	58.2	61.0	5.3	5.7	1393664
2008	16.8	14.3	26.8	51.0	52.7	5.4	6.2	1279534
2009	17.5	15.7	23.4	52.9	54.7	6.2	6.2	1200124

Table 1b: Open Interest in Crude Oil Futures and Futures-Equivalent Options, 2000–2009

	Non-commercials (%)			Commercials (%)		Non-Reportables (%)		Total Open Interest
Year	**Long**	**Short**	**Spread**	**Long**	**Short**	**Long**	**Short**	
2000	6.5	3.1	14.1	71.6	74.6	7.8	8.2	618590
2001	3.8	4.8	15.1	74.1	72.1	7.0	8.0	626904
2002	6.4	2.9	21.3	64.3	69.2	8.0	6.6	779618
2003	8.9	4.1	20.5	63.4	67.6	7.2	7.8	830327
2004	12.5	4.2	21.4	59.3	67.4	6.8	7.0	1033835
2005	9.4	5.1	27.2	58.2	61.3	5.2	6.3	1344618
2006	10.1	6.3	30.3	55.4	58.7	4.2	4.6	1740532
2007	9.3	5.3	30.8	56.4	60.1	3.5	3.7	2409755
2008	8.2	4.7	41.4	47.6	50.8	2.8	3.1	2887494
2009	7.6	4.1	36.9	52.6	56.1	2.9	2.9	2888548

Tables 1a and 1b provide average open interest in futures and futures plus futures equivalent options, respectively, since 2000. Open interest data are from the weekly Commitment of Traders (COT) Reports from July 5, 2000 through April 28, 2009 Weekly CFTC COT reports categorize traders as "commercials, who have declared an underlying hedging purpose, and "non-commercials", who have not. For each category, the long and short positions are reported as fractions of the overall open interest.

One significant finding revealed in Table 1a is that the share of non-commercials in crude oil futures more than doubled from 15.5% to 41% of the long open interest during our sample period. However, this increased non-commercial participation does not directly imply excessive speculation. As suggested by Working (1960), the level of speculation is meaningful only in comparison with the level of hedging in the market. Increased speculative positions naturally arise with increased hedging pressure in the market. In order to assess the ade-

Table 2: Working's (1960) Speculative Index in Crude Oil Futures Market, 2004–2008

Speculative Index, 2004–2008 (Nearby Contract)					
2004	1.20	1.20	1.35	1.11	0.04
2005	1.21	1.22	1.39	1.10	0.05
2006	1.37	1.37	1.56	1.19	0.08
2007	1.39	1.39	1.57	1.27	0.07
2008	1.41	1.40	1.56	1.31	0.05
Average	1.32	1.33	1.57	1.10	0.11
Speculative Index, 2004–2008 (All Contracts)					
2004	1.17	1.17	1.21	1.15	0.01
2005	1.23	1.23	1.28	1.15	0.03
2006	1.28	1.28	1.32	1.23	0.02
2007	1.30	1.27	1.42	1.22	0.07
2008	1.39	1.39	1.44	1.33	0.02
Average	1.27	1.26	1.44	1.15	0.08

Table 2 provides descriptive statistics for Working's (1960) Speculative Index for nearby and all contracts between 2004 and 2008. This index is calculated as follows:

$$T = \begin{cases} 1 + \dfrac{SS}{HL+HS} & \text{if } HS \geq HL \\ 1 + \dfrac{SL}{HL+HS} & \text{if } HL \geq HS \end{cases}$$

where *SS* is short speculator (non-commercial) positions, *SL* is long speculator positions, *HS* is short hedge (commercials) positions and *HL* is long hedge positions (Irwin et al (2009)).

quacy of speculative activity in the crude oil market relative to hedging activity, we calculate Working's (1960) speculative index in the nearby contract and for all maturities.[9]

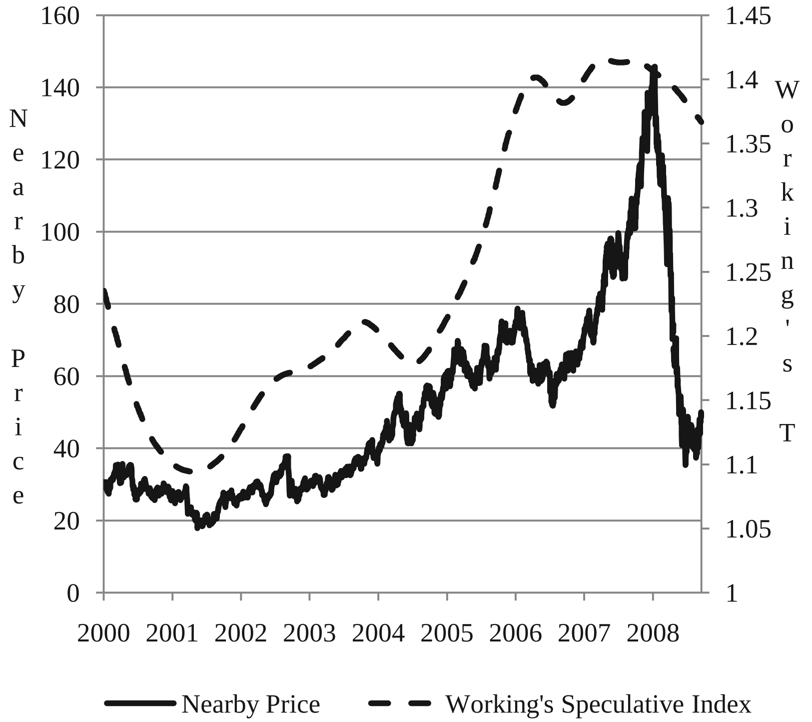
Table 2 presents descriptive statistics on the Working's speculative index for nearby contracts and all maturities from 2004 to 2008. In general, the speculative index displays a higher value in nearby contracts relative to all contracts. For instance, the 1.20 speculative index in the nearby contract during 2000 indicates 20% speculation in excess of what is minimally necessary to meet short hedging needs. The speculative index value has risen over time to average 1.41

9. Working's speculative index is calculated as follows:

$$T = \begin{cases} 1 + \dfrac{SS}{HL+HS} & \text{if } HS \geq HL \\ 1 + \dfrac{SL}{HL+HS} & \text{if } HL \geq HS \end{cases}$$

where *SS* is short speculator (non-commercial) positions, *SL* is long speculator positions, *HS* is short hedge (commercials) positions and *HL* is long hedge positions (Irwin et al. (2009)).

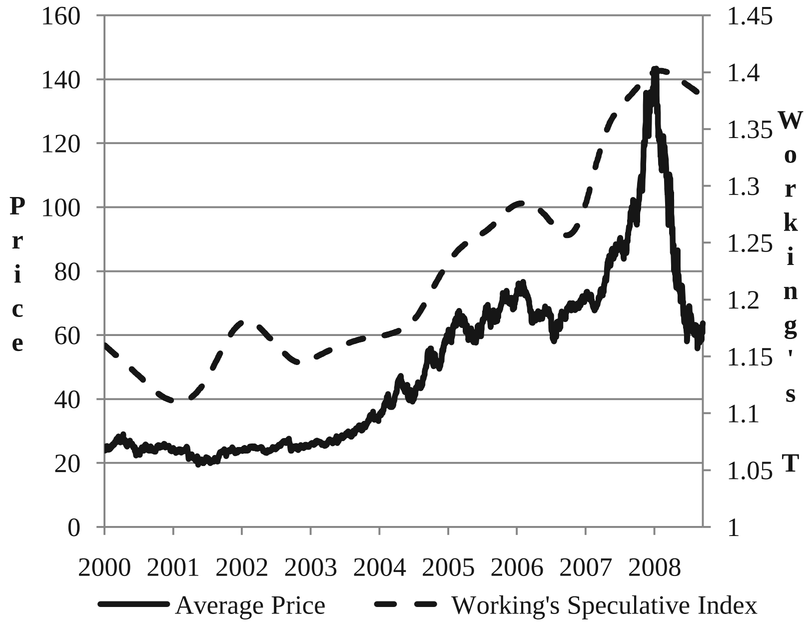
Figure 2a: Working's Speculative Index, 2000–2009 (Nearby Futures)



in 2008, implying that speculation in excess of minimal short and long hedging needs increased to 41%. Of course, this increase can also result from speculators increasing spread trades. Although potentially alarming, a speculative index of 1.41 is comparable to historical index numbers in other markets (see Irwin et al. (2009)). For example, Peck (1981, 1982) reports the speculative index ranging from 1.15 to 1.68 for agricultural products, depending on time period and commodity. As Working (1960) also notes, the speculative index measures excess speculation in technical terms, not in economic terms. Since the speculative index does not necessarily indicate excessive speculation, we apply additional analyses to speculator positions in the crude oil futures market.

Figures 2a and 2b present the dynamics of Working's speculative index for nearby and all contracts over our sample period. Although prices and the speculative index appear to generally rise and fall together, the correlation between daily price changes and changes in the speculative index is –0.007 (–0.018) for nearby (all) contracts. The figures also show that even though prices decline from \$147 to \$35 between July 2008 and January 2009, the speculative index has remained relatively constant during the same period.

Figure 2b: Working's Speculative Index, 2000–2009 (All Maturities)



We analyze disaggregated commercial trader position data by sub-category of "dealer/merchants" (including wholesalers, exporter/importers, and crude oil marketers), "manufacturers" (including refiners and fabricators), "producers", and "commodity swap dealers" (including swap dealers and arbitrageurs/broker dealers). Traders in the dealer/merchant, manufacturer and producer sub-categories are often considered traditional hedgers. The commodity swap dealer sub-category, whose activity has grown significantly since 2000 (see Figure 3a), incorporates the positions of non-traditional hedgers, including "entities whose trading predominantly reflects hedging of over-the-counter (OTC) transactions involving commodity indices—for example, swap dealers holding long futures positions to hedge short OTC commodity index exposure opposite institutional traders such as pension funds" (CFTC, 2008).

The most active non-commercial sub-categories in the crude oil futures market are floor brokers and traders and hedge funds (including commodity pool operators, commodity trading advisors, associated persons controlling customer accounts, and other managed money traders).[10] Many of the large commodity

10. A commodity pool is defined as an investment trust, syndicate or a similar form of enterprise engaged in trading pooled funds in futures and options on futures contracts principally to provide smaller investors the opportunity to invest in futures markets with greater diversification and professional trade management—similar to a mutual fund company. Unlike mutual funds, however, commodity pools may be either long or short derivative contracts. A commodity pool operator solicits

Figure 3a: Growth of Commercial Trader Open Interest

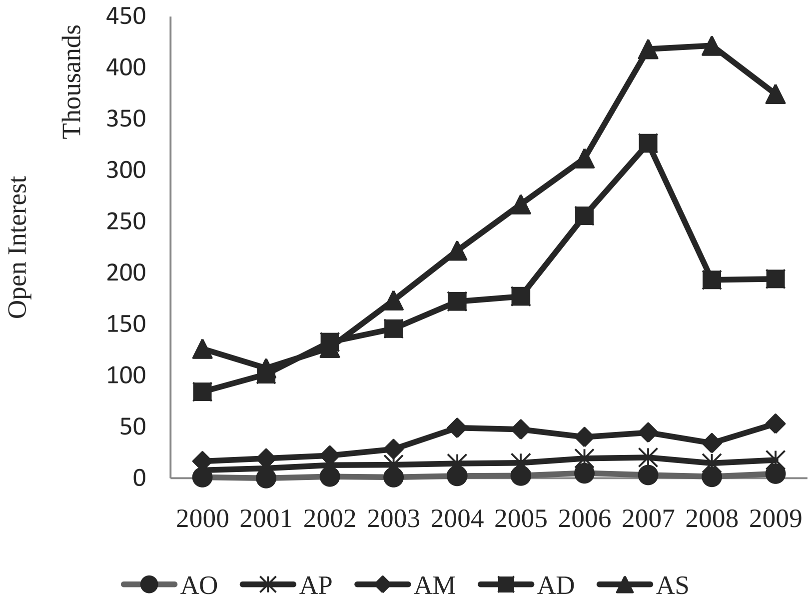


Figure 3a presents growth of commercial traders' open interest from 2000 to 2009. Commercial traders include "Dealers/Merchants" (AD), "Manufacturers" (AM), "Producers" (AP), "Other Commercials" (AO), and "Commodity Swaps/Derivatives Dealers" (AS).

trading advisors, commodity pool operators, and associated persons are considered to be hedge funds and hedge fund operators, and accordingly, we conform to the academic literature and to common financial parlance by referring to these collectively as hedge funds. Our hedge fund group also includes CFTC-identified participants who are known to be managing money. Lastly, non-registered participants are traders that have not yet been categorized or do not fit any other category and who are not registered under the Commodity Exchange Act.

Figures 3a and 3b present the growth of commercial and non-commercial traders, respectively. During the sample period, commodity swap dealers have increased their open interest more than threefold while dealer merchant positions doubled. On the non-commercial side, the biggest increase in open interest was recorded for hedge funds and non-registered participants.

For each group of traders, we use two measures of the group's daily positions to assess changes in the market. We use the net position of each group's daily net position in futures-only and futures plus adjusted options, which may

funds from others for investing in futures and options on futures while a commodity-trading advisor manages the accounts (effectively the equivalent of an advisor in the securities world).

Figure 3b: Growth of Non-Commercial Trader Open Interest

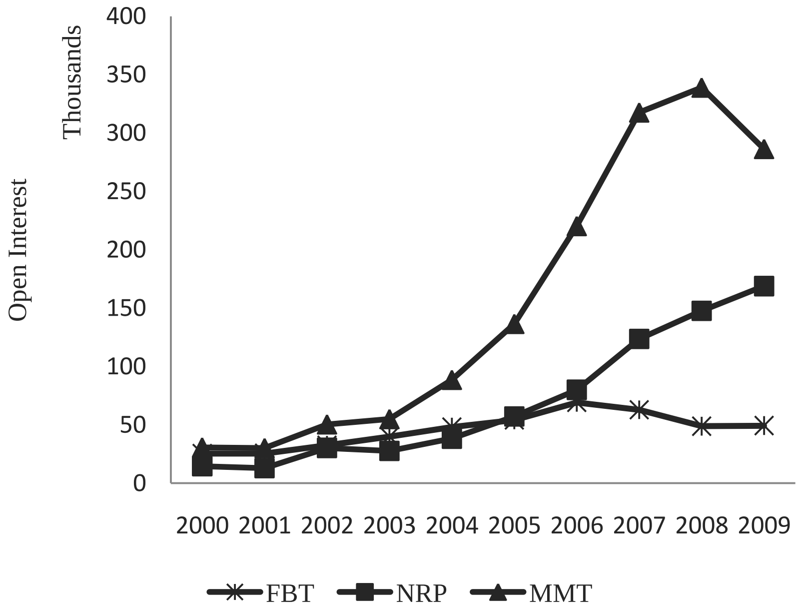


Figure 3b presents growth of non-commercial traders' open interest from 2000 to 2009. Non-commercial traders are "Managed Money Traders" (MMT), "Floor Brokers & Traders" (FBT), and "Non-Registered Participants" (NRP).

be net short or long. Over time, the net positions of different trader categories display dynamic changes. From Tables 3a and 3b, we see that the net positions (long—short) of both commercial and non-commercial traders fluctuate significantly from year to year in nearby contracts. In general, however, commodity swap dealers have net futures positions which increase significantly during the sample period. Non-registered participants consistently take net long positions over time. Both swap dealers and non-registered participants take positions in the opposite direction of the other traders on average. Contrary to common belief, hedge funds as a group took net short positions in the nearby contract during the 2008 run-up of crude oil prices. In addition, we observe that most trader subcategories' net positions in nearby contracts increase in magnitude during the sample period, most notably for commodity swap dealers, which more than double positions in the nearby futures and more than triple positions in all maturities since 2004.

Looking at the time series properties of the price and net positions data, we find non-stationary prices but stationary (in both levels and first differences) net nearby positions (see Table 4). Since both net position levels and changes are stationary, we provide our analysis along both dimensions for different trader types. In addition to our different trader types, we also construct three aggregate

Table 3a: Average Daily Net Futures Positions of the Major WTI Traders (Nearby Contract)

	Dealer/ Merchants	Manufacturers	Producers	Swap Dealers	Other	Hedge Funds	Floor Brokers & Traders	Non-Registered Participants	Price
2000	−12103.4	−11065.2	193.5	44574.2	485.4	13282.4	−2849.7	−7263.8	31.4
2001	−242.0	−8023.9	−56.6	36617.0	−21.6	−8572.2	−5621.6	−3094.6	25.9
2002	−25157.3	−17017.6	−5065.7	42677.9	343.3	15317.3	−5340.4	1224.5	26.1
2003	−27127.7	−23783.3	−6468.4	39030.0	390.6	29331.6	−11990.6	1784.7	30.8
2004	−47185.0	−29237.9	−10743.9	53885.8	290.3	44992.9	−9660.6	1259.6	41.4
2005	−59738.0	−30733.3	−9663.2	85620.3	281.1	25491.0	−7285.3	3357.7	57.0
2006	−55527.7	−25246.4	−9550.7	90792.0	−269.3	1645.5	−9455.5	12728.4	66.8
2007	−66087.7	−27365.2	−8073.3	117983.2	−1209.3	−18643.1	−4633.2	19320.7	72.5
2008	−55788.9	−16530.7	−4955.6	100288.8	−638.6	−11052.5	−6791.5	5350.2	99.8
2009	−107037.5	−18750.0	−9221.4	96796.2	3827.6	16804.8	−9918.9	34299.3	43.4

Table 3b: Average Daily Net Futures plus Futures Equivalent Options Positions of the Major WTI Traders (Nearby Contract)

	Dealer/ Merchants	Manufacturers	Producers	Swap Dealers	Other	Hedge Funds	Floor Brokers & Traders	Non-Registered Participants	Price
2000	−14800.1	−13516.8	411.4	47243.0	31.6	12987.3	−209.5	−4995.2	31.4
2001	−1370.5	−10210.9	−79.4	32901.5	199.7	−8424.9	−266.1	−458.9	25.9
2002	−27997.5	−17971.0	322.5	40356.6	−4814.4	14721.8	−802.6	2940.9	26.1
2003	−33038.4	−26372.3	332.8	34121.2	−7110.4	30542.7	−1104.1	4284.5	30.8
2004	−51427.4	−31373.2	−41.7	49384.9	−11116.7	45123.8	−67.3	3955.4	41.4
2005	−60036.7	−30286.9	−736.2	81930.1	−10036.7	23014.8	−1793.9	5991.6	57.0
2006	−57039.8	−26691.2	−1825.8	89927.4	−10049.6	1865.0	−5685.6	15020.4	66.8
2007	−67627.1	−26511.1	−1379.5	122404.5	−8662.4	−20401.7	−2859.9	15367.0	72.5
2008	−54854.1	−16093.7	−937.5	93219.6	−5043.0	−11758.4	−2729.8	7805.0	99.8
2009	−108569.4	−18174.8	3776.6	88249.5	−9226.0	19963.6	−6241.2	38260.3	43.4

Table 3a and 3b present the annual average net position of various trader groups between 2000 and 2009 in the WTI nearby futures and futures plus futures equivalent options, respectively. Prior to August 2003, the “NC” category sums the positions of presently inactive commercial traders. However we ignore NC category in our discussions.

Table 4a: Augmented Dickey Fuller Tests for Prices and Position Data in Futures-Only and Futures plus Futures Equivalent Options in the Crude Oil Market (2000–2009)

	Futures-Only Nearby Contract		Futures and Futures Equivalent Options Nearby Contract	
	Level	First Difference	Level	First Difference
Price	–0.98	–23.36	–0.98	–23.37
Dealer/Merchants	–9.36	–11.75	–9.57	–9.16
Manufacturers	–12.46	–4.89	–13.14	–5.48
Producers	–8.20	–7.73	–7.99	–7.64
Swap Dealers	–9.21	–7.22	–9.85	–9.38
Other	–1.71	–3.73	–2.53	–3.40
Hedge Funds	–5.51	–5.95	–5.64	–7.42
Floor Brokers and Traders	–4.65	–4.54	–7.15	–6.84
Non-Registered Participants	–5.03	–5.11	–5.77	–7.75
All Commercials	–6.13	–5.55	–6.81	–8.76
Non-Commercials	–6.41	–4.59	–7.21	–8.20
Non-Commercials plus Swap Dealers	–9.72	–12.25	–9.81	–10.35

Table 4a presents the unit root tests on the price and net positions for various trader groups between 2000 and 2009 in the WTI futures and futures plus futures equivalent options, respectively. Starting with a maximum of five lags, we use the Akaike information criterion to determine optimal lag length. The critical value for ADF test statistics are –3.43, –2.86 and –2.56 for 1, 5 and 10 percent level of significance. If the calculated value is lower than critical value, then the series is said to be stationary at the relevant level of significant.

net position variables: Net position of all commercials, non-commercials, and non-commercial plus commodity swap dealers. Since commodity swap dealers also include commodity index traders, we combine swap dealers with other non-commercial traders for a more inclusive set of potential speculative positions. Although CFTC (2008) calculations suggest that not more than 50 percent of swap dealers in the crude oil market can be considered commodity index traders, our combined category of swap dealers and other non-commercial traders assumes that all swap dealer activities are linked to commodity index trading.

Our preliminary analysis of the relation between price changes and net nearby positions taken by different trader types starts by considering correlations. Tables 5a and 5b report correlation coefficients between price changes and the positions of different types of traders. The reported contemporaneous correlation suggests a positive and significant relation between net positions of hedge funds and price change in nearby futures contracts. This positive and statistically significant correlation also holds in the case of net position change. The relation between hedge fund positions and price changes displays similar patterns in futures and futures equivalent options contract.

In the case of commodity swap dealers, we do not observe a statistically significant correlation between prices and net positions or net position change in

Table 4b: ARDL Cointegration Results for Prices and Positions Data in Futures-Only and Futures plus Futures Equivalent Options in the Crude Oil Market (2000–2009)

	Futures-Only Nearby Contract Unit root t-test	Futures and Futures Equivalent Options Nearby Contract Unit-root t-test
Dealer/Merchants	−1.5359	−1.5642
Manufacturers	−1.4422	−1.38
Producers	−1.4467	−1.4555
Swap Dealers	−1.1916	−1.5772
Other Commercial	−1.4357	−1.4057
Hedge Funds	−1.2625	−1.261
Floor Brokers & Traders	−1.4256	−0.9812
Non-Registered Participants	−1.7492	−1.3734
All Commercials	−1.0903	−1.2195
Non-Commercials	−1.1155	−1.183
Non-Commercials plus Swap Dealers	−1.7433	−1.6076

Table 4b presents the ARDL cointegration tests on the price and net positions for various trader groups between 2000 and 2009 in the WTI futures and futures plus futures equivalent options, respectively. ARDL cointegration tests fail to reject the absence of cointegration between price and net position of different traders' type.

nearby contracts. The insignificant correlation between the level of net positions of swap dealers and the price change persists when we include futures equivalent options in our analysis. On the other hand, there is a statistically significant positive correlation between the first difference changes in net futures plus futures equivalent options positions of swap dealers and the change in the nearby price.

As expected, the correlation between net positions of traditional hedgers and price changes is negative and statistically significant. This implies that traditional hedgers move in the opposite direction of prices. This result holds not only for futures positions but also for combined positions (futures plus delta adjusted options). The simple correlation analysis provides three main results. First, hedge fund net positions move in the same direction as market prices. Second, traditional commercial hedger net positions are negatively correlated with price changes. Third, the correlation between commodity swap dealer net positions in nearby contracts and price changes is zero as expected, since these traders generally do not change their long positions in nearby contracts.

Of course, correlations between price changes and net position changes of various groups of market participants do not, and cannot, indicate causation. We employ a more formal analysis of the interaction between daily price changes and position changes by directly examining whether various groups of traders change positions in advance of price changes.

Intuitively, in order to realize gains from price changes, positions must be established prior to those price changes. Prices then may respond to those

Table 5a: Correlations: Net Futures Positions (Nearby Contract)

	ΔPrices	Dealer/ Merchants	Manu- facturers	Pro- ducers	Swap Dealers	Other Commer- cials	Hedge Funds	Floor Brokers & Traders	Non- Registered Partici- pants	All Commer- cials	Non- Commer- cials
ΔPrices	1.000										
Dealer/Merchants	−0.021	1.000									
Manufacturers	−0.063	0.420	1.000								
Producers	−0.029	0.422	0.480	1.000							
Swap Dealers	−0.010	−0.680	−0.378	−0.317	1.000						
Other Commercials	−0.030	−0.175	0.062	−0.035	−0.039	1.000					
Hedge Funds	0.095	−0.182	−0.362	−0.305	−0.410	0.231	1.000				
Floor Brokers & Traders	0.004	0.127	0.094	0.094	−0.184	−0.346	−0.164	1.000			
Non-Registered Participants	−0.018	−0.456	−0.176	−0.205	0.269	−0.089	−0.230	0.229	1.000		
All Commercials	−0.065	0.277	0.356	0.309	0.425	−0.176	−0.880	−0.109	−0.153	1.000	
Non-Commercials	0.088	−0.342	−0.409	−0.366	−0.338	0.102	0.850	0.191	0.257	−0.965	1.000
Non-Commercials plus Swap Dealers	0.054	−0.911	−0.667	−0.575	0.726	0.037	0.222	−0.040	0.449	−0.291	0.401

Table 5a presents the correlation between price and net position changes for various trader groups between 2000 and 2009 in the WTI nearby futures contracts.

Table 5b: Correlations: Change in Net Futures Positions (Nearby Contract)

	ΔPrices	Dealer/-Merchants	Manu-facturers	Pro-ducers	Swap Dealers	Other Commercials	Hedge Funds	Floor Brokers & Traders	Non-Registered Partici-pants	All Commer-cials	Non-Commer-cials
ΔPrices	1.000										
Dealer/Merchants	–0.134	1.000									
Manufacturers	–0.158	0.246	1.000								
Producers	–0.105	0.176	0.216	1.000							
Swap Dealers	0.018	–0.548	–0.385	–0.264	1.000						
Other Commercials	–0.145	–0.031	0.035	0.031	–0.006	1.000					
Hedge Funds	0.339	–0.400	–0.312	–0.190	–0.176	–0.070	1.000				
Floor Brokers & Traders	–0.068	0.067	0.083	0.020	–0.182	0.005	–0.184	1.000			
Non-Registered Participants	–0.061	–0.226	–0.086	–0.051	0.160	0.078	–0.279	0.108	1.000		
All Commercials	–0.216	0.525	0.335	0.193	0.253	0.032	–0.784	–0.077	–0.093	1.000	
Non-Commercials	0.281	–0.501	–0.331	–0.210	–0.141	–0.024	0.778	0.182	0.313	–0.851	1.000
Non-Commercials plus Swap Dealers	0.219	–0.801	–0.547	–0.363	0.692	–0.022	0.427	–0.012	0.355	–0.419	0.617

Table 5b presents the correlation between price changes and net position changes for various trader groups between 2000 and 2009 in the WTI nearby futures contracts.

Table 5c: Correlations: Net Futures and Futures Equivalent Positions (Nearby Contract)

	ΔPrices	Dealer/ Merchants	Manu- facturers	Pro- ducers	Swap Dealers	Other Commer- cial	Hedge Funds	Floor Brokers & Traders	Non- Registered Partici- pants	All Commer- cials	Non- Commer- cials
ΔPrices	1.000										
Dealer/Merchants	–0.033	1.000									
Manufacturers	–0.066	0.412	1.000								
Producers	–0.039	0.454	0.487	1.000							
Swap Dealers	0.015	–0.662	–0.358	–0.347	1.000						
Other Commercial	–0.051	–0.020	0.108	0.134	–0.211	1.000					
Hedge Funds	0.089	–0.235	–0.387	–0.305	–0.414	0.116	1.000				
Floor Brokers & Traders	0.024	0.307	0.069	0.077	–0.320	0.078	0.102	1.000			
Non-Registered Participants	–0.071	–0.454	–0.124	–0.235	0.356	0.024	–0.247	–0.401	1.000		
All Commercials	–0.050	0.320	0.379	0.316	0.405	–0.189	–0.932	–0.091	–0.023	1.000	
Non-Commercials	0.067	–0.377	–0.435	–0.393	–0.326	0.137	0.939	0.073	0.083	–0.972	1.000
Non-Commercials plus Swap Dealers	0.063	–0.912	–0.659	–0.618	0.734	–0.106	0.273	–0.258	0.404	–0.306	0.403

Table 5c presents the correlation between price and net position changes for various trader groups between 2000 and 2009 in the WTI nearby futures plus futures equivalent options.

Table 5d: Correlations: Change in Net Futures and Futures Equivalent Positions (Nearby Contract)

	ΔPrices	Dealer/ Merchants	Manu- facturers	Pro- ducers	Swap Dealers	Other Commer- cial	Hedge Funds	Floor Brokers & Traders	Non- Registered Partici- pants	All Commer- cials	Non- Commer- cials
ΔPrices	1.000										
Dealer/Merchants	–0.139	1.000									
Manufacturers	–0.164	0.263	1.000								
Producers	–0.146	0.195	0.219	1.000							
Swap Dealers	0.098	–0.569	–0.399	–0.276	1.000						
Other Commercial	–0.255	0.064	0.045	0.048	–0.060	1.000					
Hedge Funds	0.314	–0.432	–0.310	–0.210	–0.143	–0.163	1.000				
Floor Brokers & Traders	–0.052	0.041	0.014	0.015	–0.175	0.038	–0.084	1.000			
Non-Registered Participants	–0.162	–0.251	–0.100	–0.063	0.173	0.110	–0.305	–0.054	1.000		
All Commercials	–0.167	0.551	0.357	0.209	0.197	0.092	–0.801	–0.124	–0.117	1.000	
Non-Commercials	0.230	–0.556	–0.364	–0.243	–0.108	–0.104	0.856	0.150	0.164	–0.914	1.000
Non-Commercials plus Swap Dealers	0.237	–0.840	–0.571	–0.389	0.725	–0.120	0.479	–0.036	0.251	–0.476	0.606

Table 5d presents the correlation between price and net position changes for various trader groups between 2000 and 2009 in the WTI nearby futures plus futures equivalent options.

positions, or more precisely, the signal conveyed on establishing those positions. If specific trader categories were systematically establishing positions in advance of profitable price movements, then a pattern of position changes preceding price changes would emerge. Conversely, evidence that price changes lead position changes would suggest that market participants adjust their positions to reflect new information. Price changes that systematically precede position changes indicate a trend following behavior.

We statistically test whether one variable leads another through Granger causality tests. However, even Granger causality tests do not prove a causal relation between variables, but rather only indicate a statistical probability of one variable leading another. Nonetheless, Granger causality provides useful information as to whether trading activity precedes, in a forecasting sense, price movements and/or *vice versa*. In the next subsection, we provide a brief description of these Granger causality tests.

3. TESTING GRANGER CAUSALITY

The Granger causality test is based on a bivariate VAR representation of two weakly stationary and ergodic time series $\{X_t\}$ and $\{Y_t\}$:

$$X_t = A(L)X_t + B(L)Y_t + \varepsilon_{X,t}$$

$$Y_t = C(L)X_t + D(L)Y_t + \varepsilon_{Y,t}$$

where $A(L)$, $B(L)$, $C(L)$, $D(L)$ are one sided lag polynomials of order a, b, c, and d, in the lag operator L. The regression errors, $\{\varepsilon_{X,t}\}$ and $\{\varepsilon_{Y,t}\}$, are assumed to be independent and normally distributed with mean zero and constant variance. Testing the non-causality from Y to X hypothesis; i.e. the null hypothesis of "Y does not Granger-cause X" , requires testing whether the past values of Y are useful in the prediction of the current value of X, after controlling for the contribution of past values of X. The null hypothesis of non-causality from Y to X will be rejected if the coefficients on the past values of Y (elements in $B(L)$) are jointly significantly different from zero. However, this implies unidirectional causality from Y to X. Bidirectional causality requires Granger causality in both directions; in which case, the coefficients on elements in both $B(L)$ and $C(L)$ are jointly different from zero.

Since the test results are sensitive to the lag selection, it is important to choose the appropriate lag length to ensure that the residuals have no serial correlation, no conditional heteroskedasticity and do not deviate too much from Gaussian white noise. To find the optimal lag used in the estimation, we employ the Akaike and Schwarz information criteria—both criteria suggest one lag.

Standard Granger-causality tests require variables to be at least weakly stationary. Our unit root tests show that the price variable is I(1) while net position variables are I(0). Therefore, we run first order differenced vector autoregressions (VARs) to test for Granger-causality between our variables. However, these tests are only valid if variables are I(1) and not cointegrated. One solution to this problem is to conduct pre-test for the absence of cointegration between these variables and if they are not cointegrated, execute standard Granger causality tests. Alternatively, we estimate Dolado and Lutkepohl (1996) Granger causality tests which are robust to the integration and cointegration properties of the data.

We first pre-test for cointegration between price and position variables using the auto-regressive distributed lag (ARDL) approach developed by Pesaran and Shin (1999) which provides consistent, unbiased estimators of long-run parameters in the presence of I(0) and I(1) variables. The ARDL estimation results show that there is no cointegration between prices and net positions of our various trader groups (see Table 4b).

We analyze Granger causality between daily price change and position changes by various trader groups and combination of trader groups between July 5, 2000 and March 18, 2009. In addition to daily changes, we consider two-, three-, four- and five day price and position changes to see whether the time horizon/measurement interval affects the dynamic between price changes and position changes.

In our first tests we analyze the relation between the price and net position changes as well as net position changes of different trader types for our full sample. Analyzing price changes and net position changes for eleven trader types (eight trader types plus three aggregate types implies (10!*2*2) one-way relations for futures and futures plus futures-equivalent options positions). However, our interest is in the relation between prices and positions rather than relations among positions of various traders. Therefore, we present 44 one-way relations for net position changes and price changes for futures and futures plus delta-adjusted options positions.

Tables 6a, 6b and 6c present results for Granger causality between price changes and net positions as well as net position changes for the nearby futures and futures plus options during our full sample period. We estimate causality results for individual trader groups as well as for aggregate non-commercial traders, commercial traders, and the combined positions of non-commercial and swap dealer groups (to some, these represent aggregate speculative positions in the crude oil futures market). As shown in Table 6, there are unidirectional causalities from price changes to net position changes as well as to the net positions of most trader types. Results from the nearby contract show no unidirectional or bi-directional causality running from positions or position changes to price changes for any trader type, or for any measurement interval (from one to five days).

Granger causality results in Table 6a suggest that we reject the null hypothesis of Granger non-causality from price changes to net position changes and from price changes to net positions for aggregate trader groups as well. However, the reverse non-causality test cannot be rejected. This result holds for futures as well as futures plus futures-equivalent options contracts. Except for the positions of non-commercial traders combined with swap dealers, we observe that unidirectional causality from price changes to position is weakening as we increase the number of days in the measurement interval.

Table 6a: Granger Causality Tests: Price and Position Change (Nearby)

	Non-Commercials (Futures Only)				Non-Commercials (Futures and Options)			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.000**	**(0.001)**	0.466	(0.227)	**0.000**	**(0.000)**	0.805	(0.376)
2	0.083	(0.670)	0.363	(0.185)	**0.001**	(0.046)	0.645	(0.246)
3	0.693	(0.952)	0.593	(0.172)	0.062	(0.208)	0.163	(0.372)
4	0.164	(0.080)	0.342	(0.187)	0.858	(0.941)	0.101	(0.394)
5	0.270	(0.137)	0.139	(0.254)	0.527	(0.615)	0.040	(0.496)
	Commercials (Futures Only)				**Commercials (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.000**	**(0.002)**	0.873	(0.358)	**0.000**	**(0.000)**	0.643	(0.452)
2	0.077	(0.927)	0.398	(0.259)	**0.001**	(0.022)	0.645	(0.287)
3	0.785	(0.552)	0.429	(0.360)	0.104	(0.315)	0.342	(0.476)
4	0.161	(0.027)	0.097	(0.406)	0.642	(0.953)	0.057	(0.598)
5	0.140	(0.067)	0.043	(0.481)	0.659	(0.723)	0.027	(0.649)
	Non-Commercials and Swap Dealers (Futures Only)				**Non-Commercials and Swap Dealers (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.000**	(0.019)	0.983	(0.552)	**0.000**	**(0.000)**	0.313	(0.376)
2	**0.000**	(0.054)	0.946	(0.348)	**0.000**	**(0.005)**	0.973	(0.171)
3	**0.002**	(0.263)	0.209	(0.425)	**0.000**	(0.053)	0.153	(0.378)
4	0.031	(0.837)	0.417	(0.497)	**0.000**	(0.341)	0.376	(0.432)
5	0.008	(0.530)	0.293	(0.440)	**0.000**	(0.109)	0.305	(0.377)

Table 6a presents the Granger causality results for price and net position changes. It also shows the Granger-causality results for price changes and the level of net position in parentheses. **Bolded** probabilities indicate the rejection of Granger non-causality at 1 percent level of significance. The reported numbers represent *p*-values.

A similar pattern of causality is observed for individual trader groups in the nearby futures contracts. The non-causality from price changes to net positions and price changes to positions is rejected at least in the daily price change for futures-only and futures plus delta adjusted options position for the biggest two categories of non-commercials: hedge funds and floor brokers and traders. However, we fail to reject non-causality from position changes to price changes for these groups at 5 percent level of significance in both futures and futures plus options contracts. There is very weak evidence of causality from the level of net futures plus options positions of floor brokers and traders to price changes at the 5 percent level of significance (see Table 6b).

For commercials, on the other hand, price changes lead net position changes (and level of net positions) of dealer/ merchants, manufacturers and pro-

Table 6b: Granger Causality Tests (Non-Commercials): Price and Position Change

ΔDay	Hedge Funds (Futures Only)				Hedge Funds (Futures and Options)			
	ΔPrice→ ΔPosition		ΔPosition→ ΔPrice		ΔPrice→ ΔPosition		ΔPosition→ ΔPrice	
1	**0.000**	**(0.000)**	0.991	(0.234)	**0.000**	**(0.000)**	0.813	(0.229)
2	**0.001**	(0.116)	0.245	(0.113)	**0.000**	(0.051)	0.170	(0.113)
3	0.039	(0.348)	0.956	(0.235)	0.012	(0.153)	0.990	(0.242)
4	0.867	(0.284)	0.656	(0.288)	0.388	(0.793)	0.624	(0.298)
5	0.717	(0.731)	0.223	(0.405)	0.299	(0.670)	0.215	(0.396)

ΔDay	Floor Brokers & Traders (Futures Only)				Floor Brokers & Traders (Futures and Options)			
	ΔPrice→ ΔPosition		ΔPosition→ ΔPrice		ΔPrice→ ΔPosition		ΔPosition→ ΔPrice	
1	**0.004**	**(0.002)**	**0.007**	(0.317)	0.435	(0.168)	0.439	(0.044)
2	0.199	(0.138)	0.198	(0.690)	0.615	(0.725)	0.990	(0.088)
3	0.477	(0.519)	0.075	(0.234)	0.228	(0.309)	0.643	(0.046)
4	0.388	(0.218)	0.154	(0.239)	0.461	(0.819)	0.447	(0.062)
5	0.348	(0.189)	0.372	(0.357)	0.382	(0.875)	0.725	(0.113)

Table 6b presents the Granger causality results for price and net position changes. It also shows the Granger-causality results for price changes and the level of net positions in parentheses. **Bolded** probabilities indicate the rejection of Granger non-causality at 1 percent level of significance. The reported numbers represent *p*-values.

ducers in nearby futures contracts. When we extend our analysis to include futures equivalent options positions, price changes also lead swap dealer position changes. We do not observe any Granger causality from net position changes (or level of net positions) of commercial traders to price changes in any of our specifications.

In summary, we observe unidirectional causality from the level and net position changes of some types of traders to price changes. However, the reverse causality is rejected for all different types of traders.[11] This result holds for non-commercial traders in total, for hedge funds and swap dealers individually, and for the positions of non-commercial traders combined with swap dealers. Notably, we find no statistical evidence over the past eight and a half years that position changes by any group of traders systematically precede price changes. This result holds both for all net position changes of all commercial participants and for net positions held by traders in commercial sub-categories: manufacturers, dealer/merchants, producers, and other commercial entities.

11. In unreported results we also analyze the relation between price changes and trader positions in the first, second and third deferred futures as well as futures plus futures equivalent options positions. Our results for these contracts are in line with the nearby contract analysis and are available from authors upon request.

Table 6c: Granger Causality Tests (Commercials): Price and Position Change

	Dealer/Merchants (Futures Only)				**Dealer/Merchants (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.000**	**(0.001)**	0.254	(0.844)	**0.000**	**(0.000)**	0.133	(0.696)
2	**0.010**	(0.096)	0.805	(0.846)	**0.000**	**(0.006)**	0.933	(0.399)
3	0.152	(0.346)	0.151	(0.916)	**0.008**	(0.063)	0.179	(0.765)
4	0.667	(0.933)	0.226	(0.926)	0.089	(0.324)	0.286	(0.841)
5	0.508	(0.670)	0.100	(0.989)	0.047	(0.147)	0.157	(0.710)
	Manufacturers (Futures Only)				**Manufacturers (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.000**	**(0.001)**	0.155	(0.155)	**0.000**	**(0.005)**	0.216	(0.166)
2	**0.000**	(0.096)	0.171	(0.082)	**0.000**	**(0.007)**	0.249	(0.080)
3	**0.003**	(0.346)	0.805	(0.248)	**0.001**	(0.099)	0.726	(0.215)
4	**0.004**	(0.933)	0.895	(0.359)	**0.001**	(0.177)	0.868	(0.321)
5	**0.010**	(0.670)	0.912	(0.297)	**0.003**	(0.097)	0.850	(0.304)
	Producers (Futures Only)				**Producers (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	0.013	(0.017)	0.086	(0.670)	**0.006**	(0.147)	0.099	(0.609)
2	0.239	(0.043)	0.280	(.0577)	0.132	(0.302)	0.310	(0.505)
3	0.587	(0.241)	0.219	(0.380)	0.419	(0.816)	0.252	(0.328)
4	0.365	(0.383)	0.354	(0.671)	0.250	(0.837)	0.413	(0.598)
5	0.065	(0.295)	0.742	(0.690)	0.031	(0.486)	0.865	(0.568)
	Other (Futures Only)				**Other (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	0.809	(0.141)	0.543	(0.772)	0.648	(0.833)	0.945	(0.946)
2	0.554	(0.345)	0.074	(0.877)	0.881	(0.806)	0.236	(0.991)
3	0.196	(0.822)	0.048	(0.749)	0.952	(0.792)	0.313	(0.779)
4	0.319	(0.848)	0.010	(0.719)	0.782	(0.570)	0.114	(0.694)
5	0.854	(0.490)	0.167	(0.893)	0.543	(0.520)	0.858	(0.722)
	Commodity Swaps/Derivative Dealers (Futures Only)				**Commodity Swaps/Derivative Dealers (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	0.186	(0.427)	0.456	(0.533)	**0.000**	(0.218)	0.437	(0.972)
2	0.076	(0.585)	0.507	(0.696)	**0.000**	(0.072)	0.763	(0.856)
3	0.146	(0.542)	0.333	(0.595)	**0.001**	(0.132)	0.463	(0.994)
4	0.117	(0.637)	0.767	(0.576)	**0.003**	(0.250)	0.972	(0.970)
5	0.055	(0.786)	0.749	(0.732)	**0.002**	(0.131)	0.965	(0.834)

Table 6c presents the Granger causality results for price and net position changes. It also shows the Granger-causality results for price changes and the level of net positions in parentheses. **Bolded** probabilities indicate the rejection of Granger non-causality at 1 percent level of significance. The reported numbers represent p-values.

Table 7a: Granger Causality Tests: Price and Position Change: Sample Period 2000–2004

	Non-Commercials (Futures Only)				**Non-Commercials (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.002**	(0.082)	0.121	(0.270)	**0.000**	(0.066)	0.116	(0325)
2	0.045	(0.729)	0.224	(0.519)	0.011	(0.772)	0.207	(0.580)
3	0.723	(0.098)	0.054	(0.365)	0.976	(0.072)	0.051	(0.412)
4	0.153	**(0.003)**	0.042	(0.213)	0.368	**(0.002)**	0.052	(0.262)
5	0.043	**(0.000)**	0.016	(0.164)	0.156	**(0.000)**	0.027	(0.217)
	Commercials (Futures Only)				**Commercials (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.003**	(0.019)	0.217	(0.201)	**0.001**	(0.015)	0.261	(0.258)
2	0.012	(0.615)	0.494	(0.515)	**0.003**	(0.548)	0.501	(0.585)
3	0.802	(0.084)	0.118	(0.297)	0.853	(0.082)	0.14	(0.361)
4	0.142	**(0.001)**	0.039	(0.152)	0.351	**(0.001)**	0.059	(0.205)
5	0.027	**(0.000)**	0.011	(0.121)	0.111	**(0.000)**	0.017	(0.166)
	Non-Commercials and Swap Dealers (Futures Only)				**Non-Commercials and Swap Dealers (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.000**	(0.643)	0.074	(0.167)	**0.000**	(0.968)	0.064	(0.125)
2	0.019	(0.140)	0.064	(0.245)	**0.000**	(0.291)	0.078	(0.226)
3	0.686	**(0.007)**	0.069	(0.161)	0.092	(0.012)	0.078	(0.146)
4	0.842	**(0.001)**	0.112	(0.091)	0.309	**(0.002)**	0.124	(0.082)
5	0.748	**(0.001)**	0.088	(0.067)	0.462	**(0.002)**	0.107	(0.072)

Table 7a presents the Granger causality results for price and net position changes. It also shows the Granger-causality results for price changes and the level of net positions in parentheses. **Bolded** probabilities indicate the rejection of Granger non-causality at 1 percent level of significance. The reported numbers represent *p*-values.

In fact, many trader groups are shown to be trend followers over the full sample period, including commercial traders in total and manufacturers, dealer/merchants, producers, swap dealers and hedge funds individually. Notably, swap dealers and hedge funds, as well as the positions of non-commercial traders combined with swap dealers, also exhibit trend following behavior over the full sample period.

Given distinct price patterns across the full sample period, we also test for Granger causality separately for two sub-periods. The first sub-period spans the beginning of July 2000 to June 2004 where prices are largely stable. The second sub-period covers the period from July 2004 to March 2009 when crude

Table 7b: Granger Causality Tests (Non-Commercials): Price and Position Changes: Sample Period 2000–2004

	Hedge Funds (Futures Only)				Hedge Funds (Futures and Options)			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.004**	(0.447)	0.118	(0.193)	**0.004**	(0.405)	0.155	(0.186)
2	0.134	(0.470)	0.123	(0.351)	0.105	(0.540)	0.165	(0.352)
3	0.408	**(0.007)**	0.047	(0.226)	0.508	**(0.010)**	0.068	(0.222)
4	0.074	**(0.000)**	0.056	(0.150)	0.116	**(0.000)**	0.076	(0.152)
5	0.029	**(0.000)**	0.023	(0.113)	0.043	**(0.000)**	0.035	(0.188)
	Floor Brokers and Traders (Futures Only)				**Floor Brokers and Traders (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	0.901	(0.972)	0.901	(0.652)	0.752	(0.938)	0.433	(0.330)
2	0.217	(0.039)	0.833	(0.673)	0.460	(0.059)	0.43	(0.376)
3	**0.009**	**(0.003)**	0.989	(0.933)	0.091	(0.012)	0.152	(0.928)
4	**0.007**	**(0.001)**	0.769	(0.897)	0.048	**(0.004)**	0.238	(0.690)
5	0.024	**(0.008)**	0.963	(0.834)	0.088	(0.017)	0.238	(0.724)

Table 7b presents the Granger causality results for price and net position changes. It also shows the Granger-causality results for price changes and the level of net positions in parentheses. **Bolded** probabilities indicate the rejection of Granger non-causality at 1 percent level of significance. The reported numbers represent *p*-values.

oil prices rise and fall precipitously.[12] During the first sub-period crude oil prices fluctuated between \$20 and \$40 per barrel. During the second sub-period crude oil prices rise to over \$147 per barrel in July 2008 and rapidly decline to \$30 per barrel thereafter. This second sub-period also coincides with a significant increase in participation of commodity swap dealers in crude oil futures markets.

Tables 7a, 7b and 7c show Granger causality results for the first sub-period for aggregate, non-commercial and commercial traders, respectively. The results are in line with those reported for the full sample. The findings suggest unidirectional causality from position changes to price changes for all our aggregate categories, especially in the futures and options combined positions. Individual trader group results also confirm our full sample results. In this period, the net position changes of hedge funds and commodity swap dealers are Granger-caused by price changes. Hedge funds and swap dealers appear to react to past price changes.

Tables 8a, 8b and 8c provide Granger causality results for the second sub-period. Here again there is strong evidence of uni-directional causality from

12. Our analysis of July 2004 to July 2008 (when crude oil prices rose continuously to a peak) also yields similar results.

Table 7c: Granger Causality Tests (Commercials): Price Changes and Position Changes: Sample Period 2000–2004

	Dealer/Merchants (Futures Only)				**Dealer/Merchants (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.000**	(0.130)	0.520	(0.398)	**0.000**	(0.601)	0.479	(0.481)
2	**0.001**	(0.912)	0.564	(0.709)	**0.000**	(0.649)	0.579	(0.831)
3	0.190	(0.142)	0.417	(0.444)	0.048	(0.189)	0.450	(0.547)
4	0.695	**(0.001)**	0.314	(0.265)	0.318	**(0.008)**	0.0321	(0.334)
5	0.920	**(0.005)**	0.089	(0.188)	0.667	**(0.009)**	0.100	(0.252)
	Manufacturers (Futures Only)				**Manufacturers (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.005**	(0.586)	0.267	(0.192)	**0.000**	(0.752)	0.210	(0.120)
2	0.872	(0.106)	0.170	(0.197)	0.368	(0.198)	0.140	(0.147)
3	0.172	(0.033)	0.080	(0.098)	0.561	(0.061)	0.070	(0.080)
4	0.134	(0.025)	0.065	(0.081)	0.463	(0.044)	0.063	(0.067)
5	0.046	**(0.009)**	0.135	(0.077)	0.236	(0.021)	0.120	(0.070)
	Producers (Futures Only)				**Producers (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	0.928	(0.762)	0.183	(0.806)	0.667	(0.364)	0.355	(0.885)
2	0.967	(0.875)	0.209	(0.873)	0.698	(0.600)	0.263	(0.962)
3	0.610	(0.469)	0.104	(0.874)	0.416	(0.290)	0.162	(0.959)
4	0.666	(0.517)	0.268	(0.963)	0.560	(0.374)	0.445	(0.965)
5	0.503	(0.856)	0.476	(0.910)	0.490	(0.967)	0.715	(0.940)
	Other (Futures Only)				**Other (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	0.655	(0.999)	0.085	(0.125)	0.192	(0.498)	0.063	(0.057)
2	0.440	(0.196)	0.145	(0.148)	0.244	(0.133)	0.200	(0.102)
3	0.163	(0.048)	0.164	(0.320)	0.098	(0.035)	0.189	(0.245)
4	0.309	(0.069)	0.206	(0.502)	0.261	(0.109)	0.275	(0.418)
5	0.118	**(0.006)**	0.084	(0.612)	0.084	(0.007)	0.159	(0.508)
	Swap Dealers (Futures Only)				**Swap Dealers (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.000**	(0.053)	0.279	(0.393)	0.011	(0.074)	0.211	(0.162)
2	**0.000**	(0.085)	0.128	(0.228)	0.052	(0.157)	0.135	(0.121)
3	**0.002**	(0.156)	0.288	(0.228)	0.257	(0.196)	0.296	(0.136)
4	0.031	(0.215)	0.449	(0.247)	0.615	(0.258)	0.435	(0.137)
5	0.211	(0.377)	0.440	(0.265)	0.966	(0.469)	0.437	(0.188)

Table 7c presents the Granger causality results for price and net position changes. It also shows the Granger-causality results for price changes and the level of net positions in parentheses. **Bolded** probabilities indicate the rejection of Granger non-causality at 1 percent level of significance. The reported numbers represent *p*-values.

Table 8a: Granger Causality Tests: Price and Position Change: Sample Period: 2004–2009

	Non-Commercials (Futures Only)				Non-Commercials (Futures and Options)			
	ΔPrice→ ΔPosition		ΔPosition→ ΔPrice		ΔPrice→ ΔPosition		ΔPosition→ ΔPrice	
ΔDay								
1	0.025	(0.115)	0.371	(0.148)	**0.000**	**(0.001)**	0.884	(0.275)
2	0.180	(0.738)	0.252	(0.139)	**0.004**	(0.051)	0.496	(0.193)
3	0.625	(0.759)	0.806	(0.121)	0.037	(0.065)	0.275	(0.292)
4	0.293	(0.278)	0.696	(0.111)	0.536	(0.400)	0.263	(0.255)
5	0.354	(0.456)	0.408	(0.161)	0.223	(0.123)	0.131	(0.346)
	Commercials (Futures Only)				**Commercials (Futures and Options)**			
	ΔPrice→ ΔPosition		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
ΔDay								
1	**0.001**	(0.014)	0.975	(0.250)	**0.000**	**(0.000)**	0.661	(0.349)
2	0.258	(0.940)	0.313	(0.210)	**0.007**	(0.024)	0.571	(0.244)
3	0.688	(0.920)	0.590	(0.276)	0.066	(0.095)	0.426	(0.401)
4	0.334	(0.192)	.028	(0.252)	0.349	(0.227)	0.160	(0.418)
5	0.402	(0.402)	0.169	(0.321)	0.251	(0.106)	0.101	(0.473)
	Non-Commercials and Swap Dealers (Futures Only)				**Non-Commercials and Swap Dealers (Futures and Options)**			
	ΔPrice→ ΔPosition		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
ΔDay								
1	**0.000**	(0.025)	0.686	(0.087)	**0.000**	**(0.000)**	0.525	(0.045)
2	**0.000**	(0.042)	0.603	(0.044)	**0.000**	**(0.001)**	0.627	(0.016)
3	**0.002**	(0.158)	0.428	(0.061)	**0.000**	**(0.009)**	0.302	(0.061)
4	0.019	(0.512)	0.760	(0.066)	**0.000**	(0.076)	0.685	(0.056)
5	**0.003**	(0.277)	0.598	(0.066)	**0.000**	(0.015)	0.584	(0.060)

Table 8a presents the Granger causality results for price and position changes. It also shows the Granger-causality results for price changes and the level of net positions in parentheses. **Bolded** probabilities indicate the rejection of Granger non-causality at 1 percent level of significance. The reported numbers represent *p*-values.

price changes to the net position changes of different trader types. Specifically, the net position changes of non-commercials, commercials as well as non-commercials combined with swap dealers is preceded by price changes. However, we again fail to observe bidirectional causality between price changes and net position changes of any individual trader groups. Although we observe some weak evidence of causality from the level of net positions of non-commercials combined with swap dealers, we fail to see this causality in the individual groups that comprise this aggregate group.

For robustness and as an alternative to these Granger causality tests, we also employ modified Granger-causality test developed by Dolado and Lutkepohl (1996). Their methodology avoids the possible pre-test biases of unit root and

Table 8b: Granger Causality Tests (Non-Commercials): Price and Position Change: Sample Period 2004–2009

	Hedge Funds (Futures Only)				Hedge Funds (Futures and Options)			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.000**	**(0.000)**	0.921	(0.134)	**0.000**	**(0.000)**	0.767	(0.128)
2	**0.002**	(0.063)	0.148	(0.061)	**0.000**	(0.024)	0.099	(0.060)
3	0.023	(0.089)	0.798	(0.142)	**0.005**	(0.026)	0.780	(0.143)
4	0.538	(0.990)	0.964	(0.149)	0.180	(0.381)	0.981	(0.150)
5	0.379	(0.395)	0.500	(0.235)	0.111	(0.095)	0.459	(0.223)
	Floor Brokers and Traders (Futures Only)				**Floor Brokers and Traders (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.002**	**(0.001)**	**0.004**	(0.229)	0.449	(0.203)	0.324	(0.037)
2	0.109	(0.049)	0.181	(0.575)	0.743	(0.917)	0.873	(0.081)
3	0.200	(0.186)	0.052	(0.188)	0.387	(0.446)	0.440	(0.049)
4	0.153	(0.052)	0.115	(0.205)	0.726	(0.961)	0.299	(0.063)
5	0.184	(0.056)	0.305	(0.292)	0.540	(0.945)	0.569	(0.117)

Table 8b presents the Granger causality results for price and position changes. It also shows the Granger-causality results for price changes and the level of net positions in parentheses. **Bolded** probabilities indicate the rejection of Granger non-causality at 1 percent level of significance. The reported numbers represent *p*-values.

cointegration. Their solution is to estimate a level VAR model with one-additional lag (to optimal lag chosen by AIC criterion) and then apply a conventional Wald test on the first p-lag (rather than the $p+1$ lag) with standard asymptotic χ^2– distributions. In order to ensure that the residuals have no serial correlation, no conditional heteroskedasticity and do not deviate too much from Gaussian white noise, it is important to choose the appropriate lag length in an undifferenced VAR system. In our case, we test optimal lag length using AIC by setting the maximum lag at five days.

The resulting optimal lag length, augmented lag length, and Wald test results for Granger-causality between price levels and position levels are provided in Table 9. For each trader category the optimal lag is from two to five days, with VAR order of three to five. Results from Dolado and Lutkepohl (1996) Granger causality tests largely comport with our previous tests. For futures positions alone, we find that prices significantly lead positions for dealer/merchants, manufacturers, all commercials combined, the combination of non-commercials and swap dealers, and hedge funds. When considering combined futures and options positions we also find prices significantly lead swap dealer and all non-commercial positions as well.

More notably, we find little or no evidence that trader positions lead prices. Only floor brokers and dealer futures positions marginally lead prices, an

Table 8c: Granger Causality Tests (Commercials): Price and Position Changes: Sample Period 2004–2009

	Dealer/Merchants (Futures Only)				**Dealer/Merchants (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.000**	**(0.003)**	0.273	(0.523)	**0.000**	**(0.000)**	0.127	(0.217)
2	0.077	(0.109)	0.957	(0.354)	**0.004**	**(0.006)**	0.997	(0.116)
3	0.267	(0.237)	0.180	(0.553)	0.028	(0.025)	0.185	(0.324)
4	0.782	(0.668)	0.337	(0.486)	0.156	(0.094)	0.401	(0.321)
5	0.496	(0.328)	0.219	(0.421)	0.054	(0.030)	0.303	(0.251)

	Manufacturers (Futures Only)				**Manufacturers (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.000**	**(0.008)**	0.068	(0.049)	**0.000**	**(0.002)**	0.097	(0.051)
2	**0.000**	**(0.008)**	0.061	(0.024)	**0.000**	**(0.001)**	0.091	(0.023)
3	**0.001**	(0.046)	0.428	(0.086)	**0.000**	(0.015)	0.364	(0.074)
4	**0.001**	(0.072)	0.608	(0.124)	**0.000**	(0.024)	0.622	(0.107)
5	**0.001**	(0.033)	0.380	(0.111)	**0.000**	**(0.007)**	0.726	(0.117)

	Producers (Futures Only)				**Producers (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.008**	(0.154)	0.164	(0.198)	**0.002**	(0.111)	0.143	(0.425)
2	0.205	(0.433)	0.476	(0.422)	0.074	(0.317)	0.489	(0.341)
3	0.458	(0.860)	0.443	(0.287)	0.241	(0.781)	0.447	(0.233)
4	0.275	(0.952)	0.603	(0.511)	0.159	(0.909)	0.603	(0.426)
5	0.082	(0.764)	0.971	(0.565)	0.041	(0.756)	0.996	(0.453)

	Other (Futures Only)				**Other (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	0.742	(0.412)	0.797	(0.428)	0.792	(0.716)	0.840	(0.469)
2	0.458	(0.412)	0.149	(0.544)	0.974	(0.917)	0.353	(0.555)
3	0.112	(0.287)	0.102	(0.489)	0.735	(0.843)	0.446	(0.438)
4	0.223	(0.379)	0.025	(0.521)	0.936	(0858)	0.165	(0.429)
5	0.672	(0.808)	0.377	(0.703)	0.692	(0.901)	0.924	(0.479)

	Swap Dealers (Futures Only)				**Swap Dealers (Futures and Options)**			
ΔDay	**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**		**ΔPrice→ ΔPosition**		**ΔPosition→ ΔPrice**	
1	**0.004**	(0.123)	0.632	(0.934)	**0.000**	(0.150)	0.620	(0.284)
2	**0.006**	(0.015)	0.741	(0.707)	**0.000**	(0.057)	0.985	(0.204)
3	0.040	(0.073)	0.485	(0.922)	**0.000**	(0.151)	0.637	(0.360)
4	0.043	(0.070)	0.930	(0.982)	**0.002**	(0.256)	0.848	(0.437)
5	0.024	(0.035)	0.914	(0.810)	**0.002**	(0.153)	0.857	(0.295)

Table 8c presents the Granger causality results for price and net position changes and for price changes and the level of net positions in parentheses. **Bolded** probabilities indicate the rejection of Granger non-causality at 1 percent level of significance. The reported numbers represent p-values.

Table 9: Dolado and Lutkepohl (1996) Granger Causality Tests: Price and Positions: Sample Period 2004–2009

		Futures Only				Futures and Options			
		Price→ Position		Position→ Price		Price→ Position		Position→ Price	
Trader Group	**Lag/ VAR Order**	χ^2	*p*-value	χ^2	*p*-value	χ^2	*p*-value	χ^2	*p*-value
Dealer/Merchants	4/5	27.86	**(0.000)**	1.42	(0.842)	38.60	**(0.000)**	3.22	(0.521)
Manufacturers	4/5	24.23	**(0.000)**	4.59	(0.332)	31.48	**(0.000)**	4.66	(0.325)
Producers	2/3	4.13	(0.126)	2.44	(0.295)	5.74	(0.0567)	2.24	(0.326)
Other	2/3	0.21	(0.899)	3.77	(0.152)	0.32	(0.851)	1.87	(0.392)
Swap Dealers	4/5	5.73	(0.219)	1.06	(0.901)	20.93	**(0.000)**	1.69	(0.793)
Non-Commercials	4/5	12.67	(0.013)	2.37	(0.667)	19.66	**(0.001)**	4.39	(0.356)
Commercials	3/4	16.89	**(0.000)**	1.17	(0.761)	19.98	**(0.000)**	2.36	(0.502)
Non-Commercials and Swap Dealers	4/5	19.40	**(0.000)**	1.68	(0.794)	46.52	**(0.000)**	1.90	(0.754)
Hedge Funds	4/5	27.69	**(0.000)**	0.46	(0.977)	26.23	**(0.000)**	0.48	(0.975)
Floor Brokers and Dealers	3/4	10.88	(0.012)	8.52	(0.037)	5.80	(0.122)	1.91	(0.591)
Non-Registered Participants	4/5	2.87	(0.580)	4.51	(0.341)	6.86	0.144	6.27	(0.180)

Table 9 presents Dolado and Lutkepohl (1996) Granger causality tests for prices and net positions. **Bolded** probabilities indicate the rejection of Granger. non-causality at 1 percent level of significance. The reported numbers represent *p*-values

effect that disappears when considering their combined futures and options positions. Importantly, we find no evidence that speculative groups like hedge funds, swap dealers, non-commercials more generally, or the various combined positions of these traders lead crude oil prices during our sample period. Rather, the increased participation of these traders largely reflect strong trend-following behavior.

4. CONCLUSIONS

The increased participation of traditional speculators as well as commodity index traders in the crude oil futures market raises the question of whether these traders predict market prices. The recent increase and eventually fast decline in crude oil prices has been linked to speculators. Based on our linear Granger causality tests, we fail to find that these traders positions lead prices. Conversely, our results suggest that price changes leads the net positions and net position changes of speculators and commodity swap dealers, with little or no feedback in the reverse direction. This uni-directional causality suggests that traditional speculators as well as commodity swap dealers are generally trend followers.

Indeed, Granger causality results should not be interpreted as "cause" and "effect" relations but should be interpreted as lead and lag relations between prices and positions. In this light, our results should not necessarily be interpreted as price changes causing position changes. However, the lack of even Granger causality (let alone true causality) between positions and prices undermines the prospect that speculative trading interest has driven recent dramatic price swings in the crude oil futures market. Rather, we believe it more likely that both prices and positions react to the same common factors, such as global demand and supply.

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