February 7, 2007

Market Growth, Trader Participation and Pricing in Energy Futures Markets

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Abstract

We use a unique dataset on futures trader positions to document major changes in the size and term structure of the U.S. crude oil futures market. We show that, as recently as 2000 trading activity in this market was heavily concentrated at the near end of the maturity spectrum. Since then, overall open interest has grown two-fold, with trader activity at the back end of the maturity spectrum increasing over twice as much as the market as a whole. The market growth in long-term (>3 years) positions generally started in 2004, which coincides with the growth in participation by commodity swap dealers in the futures markets. An analysis of the composition of traders participating in the market shows that almost all large-trader categories (commodity swap dealers and arbitrageurs; hedge funds; commercial dealers; and commercial producers) now carry aggregate net positions in long-term contracts comparable in magnitude to the size of their net positions in short-term (<3 months) contracts prior to 2003. Amidst this market growth, the prices of one-year and two-year futures became co-integrated with the price of the near-month futures for the first time in 2004. We provide evidence that the pricing convergence is linked to the growth in futures trading by commodity swap dealers and arbitrageurs. Our results have significant implications for those interested in the effectiveness of hedges constructed with long-term crude oil futures contracts and for those interested in the quality of information contained in futures prices across the term structure.

Keywords: Energy futures, Maturity Spectrum, Trader categories, Evolution.
JEL codes: G10, G13, L89

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I. Introduction

Various types of hedgers and speculators interact in derivatives markets. Floor brokers for example, may take positions, process information, and discover prices in these markets while serving clients. In addition, arbitrageurs in derivatives markets may also serve to alleviate price discrepancies and to improve the transfer of risk amongst investors.[1] As derivatives markets continue to expand, a natural question is to what extent changes in the magnitude and the composition of trading affect pricing. In this paper, we use a unique dataset of New York Mercantile Exchange (NYMEX) trader positions to document the significant growth in West Texas Intermediate (WTI) crude oil futures market since 2000.[2] We utilize proprietary details about trader positions from the Commodities Futures Trading Commission's (CFTC) Large Trader Reporting System (LTRS) to show that this growth can be traced to a diverse set of trader types.[3] We find that increased participation by dealer/merchants, hedge funds and especially commodity swap dealers and arbitrageurs contribute significantly to improved price efficiency in one- and two-year contracts. In this regard, we demonstrate how increased participation by both commercial and non-commercial traders can enhance market quality in commodity markets.

The NYMEX crude oil futures market has grown steadily this century across all futures expiration dates. In nearby contracts (those expiring within three months) where price discovery is centered, daily net positions have grown by 145% from early 2000 through mid-2006. Growth has been even more dramatic in long-dated contracts (those expiring in three years or more), exceeding 262% over this same time frame. Contracts for six or more years did not exist prior to 1999. As recently as 2000, the crude oil futures market was relatively illiquid at the far end, with open interest in long-dated contracts amounting to less than 4.5% of total open interest. For most categories of traders, however, we find that growth in the long-dated market has now made the size of daily net positions in long-dated futures comparable in magnitude to the size of the nearby market in 2000.

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[1] See Basak and Croitoru (2006).

[2] These contracts comprise the world's largest-volume futures market on a physical commodity (Source: Nymex).

[3] The CFTC provides historical public data in weekly Commitment of Traders (COT) Reports which aggregate these trader types into broad "Commercial" and "Noncommercial" traders. Each of these groups are quite heterogeneous and these reports do not break down activity by different maturities. On January 5, 2007 the CFTC began publishing COT—Supplemental reports which also include aggregate futures and options positions of Index Traders, but only for 12 agricultural commodities.

Our uniquely detailed position data allow us to examine how various types of traders contribute to the development of both nearby and long-dated markets. We show that these markets have experienced greater participation from nearly every type of trader at all term horizons. In nearby contracts, commodity swap dealers have accounted for a major part of growth, with floor brokers, dealer/merchants and manufacturers also contributing significant proportions. In long-dated contracts, growth stems from an even wider set of participants with hedge funds, commodity swap dealers, floor brokers, dealer/merchants and producers each contributing substantially.

Notably, this period of significant market growth coincides with changes in the fundamental relation between futures prices at different maturities as well. More specifically, we find that prices of nearby, one- and two-year futures contracts first become statistically significantly co-integrated in July, 2004 and have remained significantly linked through mid-2006 (the end of our study period). We provide evidence that this pricing convergence is linked to the growth in the market activity of dealer/merchants, hedge funds and commodity swap dealers in the one- and two-year contracts. For example, we attribute the growth in hedge fund trading, which is mainly in the form of calendar spread trading, to be significantly responsible for the pricing convergence.[4] We hypothesize that dealer/merchants, hedge funds and commodity swap dealers convey information from clients and swap markets to the futures market and provide competition for order flow in these contracts which enhances price discovery and linkages between these market prices.

The development of price co-integration across contracts could allow traders to hedge and arbitrage across futures contracts more effectively. The significance of this development cannot be overstated, since the lack of derivative market integration can lead to poor market liquidity and detrimental outcomes for traders who might rely on its existence for price discovery and hedging purposes. For instance, in the early 1990s, when the vast majority of exchange-

[4] For example, according to the CFTC's January 23rd 2007 COT report spread trading by Non-Commercial traders – a category dominated by hedge funds (see Haigh, Hraniova and Overdahl (2007)) accounted for 28.4% of all open positions, whereas outright long and outright short trading by the Non-Commericals contributed just 8.4% and 6.5% of total open interest respectively.

traded crude oil futures had a maturity of less than four months, Metallgesellschaft AG lost over $1.3 billion while executing a hedging strategy that went awry. Contributing to these losses was the company's inability to hedge long-term oil delivery commitments with a matching-maturity portfolio of futures contracts and its inability to efficiently roll over large short-term positions without experiencing large price impacts.[5]

As the Metallgesellschaft case illustrates, limitations in the maturity structure of commodity futures markets can be a significant impediment to implementing effective hedging strategies. Therefore, our results document that the growth in dealer/merchants, hedge fund and commodity swap dealer participation during the past few years marks an important milestone in the development of longer-term futures markets. Furthermore, our results provide empirical support for the notion that greater participation by specific types of traders, such as arbitrageurs, help to alleviate price discrepancies as modeled by Basak and Croitoru (1996).

Our results linking market development to the participation of specific traders is important for academics who have written at length about the market impact of different types of traders, risk management and speculative strategies, price discovery, and commodity forward pricing curves. We show that specific trader types, particularly financial traders who may have little vested interest in the underlying commodity, can add important dimensions toward integrating derivative markets and making markets in general more informationally efficient. The fact that increased arbitrageur and swap dealer activity explains much of the convergence in nearby, one- and two-year futures prices complements evidence in Roll et al. (2006) that market liquidity is related to the efficacy of arbitrage activities.

Our results are also crucial for policy makers, who look to futures prices as reliable indicators of market expectations when implementing monetary and fiscal policies. We show that futures prices at various contract horizons can display varying degrees of reliability, depending not only on overall market activity but also on the types of trader types taking positions in the contracts. Policy makers also make decisions that affect the development of

[5] See Culp and Miller (1995) and Marthinsen (2005) for discussions of Metallgesellschaft AG's energy-derivatives trading.

derivatives markets.[6] Our results provide evidence that longer-term futures contracts have been developing organically in the competitive market. Our results also demonstrate a strong link between the trading positions taken by specific categories of traders and the price linkages between futures contracts.

The remainder of the paper proceeds as follows. Section II places our contribution within the related academic literature. Section III describes the data. Section IV documents significant changes in the term structure of the crude oil futures market since 2000. Section V analyzes the impact of those structural changes on futures pricing. Section VI concludes.

II. Related Work

A number of papers have used the publicly-available CFTC's Commitment of Traders (COT) reports, mostly to shed some light on speculative and hedging activity in futures markets.[7] Our analysis highlights two limitations of these reports. First, they are highly aggregated, in that they only differentiate between two broad categories of traders ("commercial" vs. "non-commercial" categories) that are rather heterogeneous. In the case of WTI crude oil futures, the "commercial trader" group includes such diverse participants as commodity swap dealers, oil manufacturers, oil producers, and commercial dealers. One would expect these various sub-categories to hold different types of positions – and our analysis confirms this intuition. Most strikingly, as we illustrate later in the paper, whereas the commercial category as a whole is typically *net short* in near-months (<3 months) oil futures, we document that one of the commercial sub-categories (commodity swaps dealers) almost always holds a *net long* position in near-month contracts. In the first half of 2006, for instance, commercial traders as a whole were on average net short (-) 56,540 contracts. This aggregate figure, however, was the sum of a net long position of (+) 90,140 for commodity swaps dealers and a short net position of (-) 146,680 contracts for all the other commercial sub-categories. Second, the publicly available reports do not break down activity at different maturities, which obscures possible differential

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[6] As evidence of policy maker interest, we note that the United States Congress has held a number of hearings in the last two years on the topics of energy prices and volatility in oil markets. Likewise, the International Monetary Fund (IMF) has been devoting entire chapters of its high-profile, semi-annual World Economic Outlook to the implications of increasing energy prices and volatility for the macroeconomy (IMF (2005, 2006)).

[7] See, e.g., Hartzmark (1987, 1991); Bessembinder (1992); Leuthold, Garcia & Lu (1994); Chang, Chou & Nelling (2000); de Roon, Nijman & Veld (2000); Wang (2003); Piazzesi & Swanson (2006); and references cited therein.

evolutions at the near- and far-ends of the market. Identifying such divergences is a major element of the present study.

To our knowledge, the only papers providing some evidence on the maturity structure of oil (or any commodity) futures markets are Neuberger (1999) and Ederington & Lee (2002).[8] In the process of rationalizing the use of short-maturity contracts to hedge long-term oil price risk, Neuberger (1999) provides some summary data on crude-oil futures market activity at different maturities from 1987 to 1994. Although the NYMEX first successfully introduced futures contracts on WTI light sweet crude oil in 1983, contract maturities beyond 12 months did not exist until 1989. By 1994, contracts had become available with intermediate maturities (up to 3 years), but Neuberger states that, "even in the last two years of that dataset, only 3% of the contracts traded had a maturity beyond 1 year" (p. 438). One of only a handful of papers using the disaggregated (non-public) version of the CFTC's COT data is Ederington & Lee (2002) who analyze *heating*-oil NYMEX futures position from June 1993 to March 1997 to document trading patterns across various types of traders in that market.[9] For their sample period, monthly expiration dates were available up to 18 months into the future, yet they find that large traders in their sample held 40.2% of their open interest in the upcoming winter months and 71.4% in the shortest-three maturity contracts. In sum, both the Neuberger and Ederington and Lee paper's provide evidence consistent with the idea that prior to recent years there was precious little activity in far-month oil futures contracts.

Certainly, crude-oil futures with maturities of up to seven years have been available since 1999. However, using data between 1999 and 2002, Lautier (2005) finds that short-, medium- and long-term crude oil futures were priced during that time period as if these contracts traded in segmented markets.[10] More generally, the view that longer-term futures may be too illiquid to be useful for hedging purposes has remained a piece of conventional wisdom in many policy circles (where, amidst a generalized rise in energy prices, questions have been raised on how to

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[8] Many studies, in contrast, tackle the issue of the term structure of futures *prices*. See, e.g., Routledge, Seppi & Spatt (2000) and references cited therein. Litzenberger & Rabinowitz, 1995 investigate the theory and empirical evidence behind backwardation in oil futures markets.

[9] The other studies are Chang, Pinegar & Schachter (1997); Weiner (2002); and, Haigh, Hranaiova & Overdahl (2007). Those studies focus mostly on identifying the impact of various types of "non-commercial" traders (as opposed to "hedgers") in some specific futures markets.

[10] See also Pilipović, 1998; Simon and Lautier, 2005; and references cited therein.

stimulate the growth of long-term hedging markets) as well as in academic circles (where papers devising short-term hedging strategies for long-term price risk remain predicated on the notion that long-maturity contracts, if at all available, are still highly illiquid – see, e.g., Veld-Merkoulova and de Roon, 2003). A key contribution of our study is to show that, since 2004, this conventional wisdom no longer applies in that (i) market activity in long-dated contracts (>3 years) now routinely exceed typical levels of activity in short-term (<3 months) contracts just a few years ago and (ii) the prices of nearby and far-month contracts have become co-integrated.

The present paper is also part of a large literature on the role of specific categories of traders in financial markets. Hedge funds, in particular, have drawn a lot of attention from academics, investors, regulators, and the general public in recent years. Much of this scrutiny has focused on the concern that speculators, such as hedge funds, might exert a disproportionate and destabilizing effect on financial markets, which could ultimately lead to higher trading costs.[11] Brunnermeier and Nagel (2004) find that hedge funds did not exert a correcting force on stock prices during the technology bubble. Haigh, Hranaiova & Overdahl (2007) document that hedge fund activity does not affect prices in energy futures markets but hedge funds are vital to the functioning of the market through the liquidity they provide to other participants. By contrast to these papers, our pricing analysis deals with the impact of various categories of traders on the linkages between markets rather than on the absolute price levels in a single market.[12] Still, our results complement the research in that we find that hedge fund activity was beneficial to price discovery in the sense that their trading activity assists in bringing in line the prices of crude oil futures at different maturities.[13]

Our analyses indicates that commodity swap dealers/arbitrageurs are instrumental in co-integrating nearby, one- and two-year crude oil futures prices. Indeed, U.S. investors have greatly increased their exposure to commodity prices through commodity index investing in the

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[11] Chan, Getmansky, Haas and Lo (2005) provide a concise review of the large academic literature on hedge funds. The evidence on whether funds are destabilizing is mixed. For example, Fung and Hsieh (2000) argue that funds exerted a significant market impact during the European Exchange Rate Mechanism (ERM) crisis in the early 1990s. By contrast, Choe *et al*. (1998), Fung *et al*. (2000), Goetzmann et al. (2000) and others conclude that hedge funds were not responsible for the Asian crisis in the late 1990s.

[12] Haigh, Hranaiova & Overdahl (2007) also abstract from the questions related to the maturity structure of trader positions that are at the heart of our analysis.

[13] Our study is also part of a literature interested in who trades derivatives, and why. Examples include Ederington and Lee (2002) in the case of heating oil futures markets, and Evans and Lyons (2005) in the case of foreign exchange derivatives.

last several years, and some of that exposure has found its way into futures markets. We document the growth in market activity by commodity swap dealers/arbitrageurs, and show empirically that this growth helps explain the improving price discovery between nearby, one- and two-year futures contracts. These findings complement recent academic research on possible advantages of investing in commodity futures markets (e.g., Erb and Harvey, 2006; Rouwenhorst and Gorton, 2006); the theoretical results of Basak and Croitoru (2006) on the role of financial traders with respect to price efficiency; and, the empirical finding that liquidity and the efficacy of arbitrage activities are related (Roll et al. (2006)).[14]

III. Data

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 from the first week of January 2000 through the first week of May 2006. The position data compiled for this study originate from the CFTC's Large Trader Reporting System (LTRS). Specifically, to help it fulfill its mission of detecting and deterring futures market manipulation, the CFTC's market surveillance staff collects position-level information on the composition of open interest across all futures and options-on-futures contracts for each market. These data must be filed daily by traders whose positions meet or exceed the CFTC's reporting threshold. For the WTI oil futures and options market in our sample period, this threshold has been 350 contracts since May 16, 2000; prior to that date, it was 300 contracts. Many other similar positions are voluntarily reported and are included in the database. We find that more than 90% of all WTI futures positions end up being reported to the CFTC during our sample period.

The CFTC receives information on individual positions for every trading day. However, here we focus on the Tuesday reports, for two reasons. First, and most importantly, the Tuesday data are those which the CFTC summarizes in the weekly Commitment of Traders (COT) Report that it makes available to the public every Friday at 3:30 p.m. Consequently, our findings are

[14] Improved price discovery (shown through increased cointegration) and risk transfer are closely related (see Mattos and Garcia (2006)) and our results would suggest that increased cointegration in the crude oil market should lead to improved hedging opportunities.

directly comparable with those of the large number of extant studies that rely on COT data.[15] Second, perhaps because the Tuesday reports are publicly available, they receive particular attention within the Commission in terms of reconciling conflicting or erroneous reports.

A. Publicly Available Data

When the CFTC publishes its crude oil COT report, traders are pooled into two broad categories – "Commercial" and "Non-commercial."[16] The CFTC classifies all of a trader's reported futures positions in a given commodity as commercial if the trader uses futures contracts in that particular commodity for hedging as defined in (the CFTC's) regulations. A trading entity generally gets classified as 'commercial' by filing a statement (with the CFTC) that it is commercially 'engaged in business activities hedged by the use of the futures or option markets.' In order to ensure that traders are classified with accuracy and consistency, the Commission staff may exercise judgment in re-classifying a trader if it has additional information about the trader's use of the markets (CFTC, 2004). 'Non-commercials' comprise many types of mostly financial traders, such as hedge funds, mutual funds, floor brokers, etc., as well as those traders whose positions have been reported event though they are not registered with the CFTC under the CEA.

Table 1 shows the type of information contained in the publicly-available weekly COT reports of the WTI futures market and, while doing so, gives a snapshot of the overall growth of this market since 2002. For the third week of July each year, Table 1 shows the open interest in WTI light sweet crude oil futures and futures-equivalent (delta-adjusted) options positions for commercial (left panel) and non-commercial (right panel) traders. For each category and each year, the long and short "positions" are reported as fractions of the overall weekly open interest. For example, on the short [*long*] side of the 773,500 open interest on July 16, 2002, 67.2% [*59.3%*] of all positions were held by commercial traders and 1.5% [*7.6%*] were held by

[15] A minor difference is that the large trader datasets we use includes *all* positions reported to the CFTC by reporting firms – even those positions of traders small enough that they have no regulatory obligation to do so. In other words, even our aggregate data are a bit more precise than the publicly available ones. A second difference is COT frequency, which is less than weekly in studies using pre-2000 data. Precisely, starting in 1962, COT data were compiled on an end-of-month basis and published on the 11th or 12th calendar day of the following month. The CFTC switched to mid-month and month-end reports in 1990; to every 2 weeks in 1992; and, to weekly in 2000.

[16] COT reports also provide data on the overall long and short positions of non-reporting traders (NRP), which are the differences between the overall open interest and, respectively, the long and short positions of reporting traders.

reporting non-commercial traders, with the rest split between 24.3% in spread positions (i.e. calendar spread positions constructed with both long and short futures positions) by reporting non-commercial traders and 7% [*8.8%*] in short [*long*] positions held by non-reporting traders. Table 1 shows that open interest has more than doubled during that period, from less than 800,000 contracts in 2002 to more than 1.7 million contracts in 2006 (each contract is for 1,000 barrels of oil, or approximately $75,000 at mid-2006 prices – so that July-2006 open interest stood at more than $112 billion in notional value outstanding).

B. LTRS Data

Whereas the publicly available data only identify the commercial and non-commercial categories for crude oil, the data provided for this study break down these two very broad categories into their respective components. That is, each reporting trader is classified into one of the trader groups in the CFTC's large-trader reporting system (LTRS). Table 2 provides a list of these groups or sub-categories. Table 2.A provides a list of the 'commercial' sub-categories, while Table 2.B provides a similar decomposition for the 'non-commercial' category. In both Tables 2.A and 2.B, we highlight (in bold) which sub-categories are active in the crude oil market.

1. Commercial Sub-Categories

In Table 2.A, the main sub-categories are "dealer/merchant", which includes wholesalers, exporter/importers, crude oil marketers, etc.; "manufacturer", which includes refiners, fabricators, etc; "producer", a self-explanatory grouping; and "commodity swap dealers", gathering all reporting swap dealers as well as arbitrageurs/broker dealers (financial swap dealers and arbitrageuers/broker dealer sub-categories were merged with commodity swap dealers partway through our sample data).[17]

Traders in the dealer/merchant, manufacturer and producer sub-categories are sometimes referred to as "traditional" hedgers. The commodity swap sub-category, whose activity we will see has grown significantly since 2000, incorporates the positions of "non-traditional" hedgers,

[17] Haigh, Hranaiova & Overdahl (2007) identified, for the time period August 2003 – August 2004 in the WTI futures market, 27 commodity swap dealers, of which only one was an arbitrageur/broker dealer and only one was a financial swap dealer.

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, 2006).

2. Non-Commercial Sub-Categories

In Table 2.B, the most active sub-categories are "floor brokers & traders", a group including all reporting floor brokers and floor traders; and "hedge funds", which comprise all reporting commodity pool operators (CPOs), commodity trading advisors (CTAs), "associated persons" (APs) controlling customer accounts as well as other "managed money" (MM) traders. Despite these clear distinctions in groups that comprise 'hedge funds", a point of terminology is in order at this stage. Hedge fund activity in energy derivatives markets has been a subject of intense scrutiny in recent years by academic researchers, market participants, policy makers and the media. However, there is no accepted definition of a "hedge fund" in futures markets, and there is nothing in the statute governing futures trading that defines a hedge fund. Furthermore, there is nothing that requires hedge funds to be categorized in the LTRS. Still, many hedge fund complexes are either advised or operated by CFTC-registered CPOs and/or CTAs and APs who may also control customer accounts. Through its LTRS, the CFTC therefore obtains positions of the operators and advisors to hedge funds, even though it is not a requirement that these entities provide the CFTC with the name of the hedge fund (or another trader) they are representing.[18] It is clear that many of the large CTA's, CPO's, and APs are considered to be hedge funds and hedge fund operators. Accordingly, we will conform to the academic literature and to common financial parlance by referring to these three types of institutions collectively as "hedge funds." In addition, for the purposes of this paper, market surveillance staff at the CFTC also identified

[18] 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. A commodity pool is similar to a mutual fund company or any investment company in the security industry, except that it invests pooled money in the futures and options markets. Like securities counterparts, a commodity pool operator (CPO) might invest in certain markets, such as financial markets, like foreign currency or treasury bonds, or commodity markets like wheat, coffee and feeder cattle. Unlike operators of mutual funds, however, commodity pools may be either long or short derivative contracts. The principle objective of the CPO is that it provides smaller investors the opportunity to invest in futures and options markets with greater diversification while at the same time having access to professional trading management. The CPO is the entity that solicits funds from others for the purpose of pooling the funds for use in investing in futures and options on futures interests. The commodity-trading advisor (CTA) actually manages the accounts and funds invested in the CPO and is the equivalent of an advisor in the securities world.

other participants who were not registered in any of these three categories but were known to be managing money and so these were also included in the hedge fund category (see bottom of Table 2). Finally, NR represents those traders that have not yet been categorized or do not fit any other category. "Non-reporting participants" are reporting traders who are not registered under the Commodity Exchange Act (CEA).

We use LTRS data on both futures and options positions. Because our goal is to provide a picture of the overall market for exchange-traded crude oil derivatives, all of the results we report are for the sum of the futures and futures-equivalent (i.e., delta-adjusted) options positions – both short and long. The options positions account for approximately 25% of the total market, and we obtain qualitatively similar conclusions for changes in futures only (not reported) although available.

IV. Large Trader Positions

For each group of traders, we use three measures of the group's daily positions to assess changes in the market. (i) We start with the net position of each group's daily net position, which may be short (-) or long (+). To provide a clear overall picture, we present annual or monthly averages of those daily figures in Figures 1-3 and discuss those exhibits in Section IV.A. (ii) To the extent that most traders hold different types of positions (long or short) at different maturities and at different points in time, the mere averaging out daily positions is bound to understate the extent of the futures market growth. In Section IV.B, we therefore carry out a similar analysis – but after first taking the absolute value (+) of each position. That is, we take the absolute value, every day, of the net position in each contract for each trader category; we then sum up these absolute values appropriately (e.g., for all commercial groups, for all positions less than 3 months, etc.), and compute the various monthly or annual averages. Table 3 and Figures 4-6 provide either annual or monthly averages of those daily figures. Whereas the analysis of Section IV.A tells us about the direction of different traders' positions during sample sub-periods, the analysis in Section IV.B provides us with an idea of the magnitude of these positions.[19]

[19] The absolute values computed in Section IV.B capture market growth for traders who have an underlying hedging motive and, hence, hold mostly outright (long or short) positions. To the extent that many non-commercial traders

A. Net Positions

From Table 1, we see that the net positions (long – short) of commercial and non-commercial traders range from -3.7% (2005 commercial positions) to 9% (2003 non-commercial positions) of the open interest across all contract maturities. Figure 1 provides a more complete picture, by breaking down annual average net positions by contract maturity for commercial and non-commercial traders, while Figures 2 and 3 provide a further disaggregation by trader type. All three Figures are drawn based on the net daily positions in each contract for each trader category. For each trading day in the sample period, we sum up the net positions appropriately (e.g., for all commercial groups, or for all positions less than 3 months, etc.), and then compute the relevant annual (Figures 1-2) or monthly (Figure 3) averages.

1. Net Positions for Commercial and Non-Commercial Traders – Broad Changes since 2000

Figure 1 shows the evolution of annual average daily net positions of commercial and non-commercial traders over time. Several patterns emerge from the Figure. First, and least surprising, is the fact that non-commercial and commercial traders on average take opposite-direction positions. As shown in Section IV.B, the difference is made up of small (non-reporting) traders, who comprise about 12% of the market at short maturities (<3 months) but only 3% of the market at long maturities (>3 years).

Second, one cannot generalize from the fact that, in the three near-month contracts, commercial traders are typically net short (-) whereas non-commercial traders are generally net long (+). Instead, the direction of the two groups' respective net exposures varies with contract maturity, period of observation, etc. Whereas non-commercials generally have long (+) net positions on average, especially in the three nearest-months contracts, they also tend to hold short (-) positions in contracts with maturities beyond 4 or 5 years. Another example is found in 2001, when commercial traders (i.e., "hedgers") were net long (+) near-months contracts, with

hold spread positions (i.e., are long at some maturity and short at another), however, it should be helpful to also have a measure of the open interest, in each contract maturity, for each trader category. This is beyond the scope of the current paper.

their average net short (-) position that year approximately equal to one third of their average net long (+) position the following year.

Third, the annual average net positions of both of these two broad categories (commercial and non- commercial traders) have more than tripled since 2000, averaging approximately 60,000 contracts a day that is each Tuesday in 2006.[20] These growth rates are impressive in their own right. They also hide a large amount of heterogeneity among different types of commercial trader. These variations are the topic of the next subsection.

2. Trader Heterogeneity

Figure 2 provides a vivid illustration of the heterogeneity of trader participation within the broad commercial group. Most strikingly, whereas the commercial category as a whole is typically net *short* (-) in near-months (<3 months) crude oil futures, we see that one of the commercial sub-categories (commodity swaps dealers which include commodity index traders) almost always holds a net *long* (+) position in near-month contracts. From January 1st to May 9th 2006, for example, commercial traders as a whole were on average net short 56,540 (-) contracts. However, this aggregate figure was the sum of an average net long position of 90,140 (+) for commodity swaps dealers and of an average net short position of 146,680 (-) contracts for all the other (i.e., for the traditional) commercial sub-categories.

Figure 3 provides information similar to, but more detailed than, that in Figure 2. Figure 3 shows the monthly (rather than annual) average daily net positions in futures and adjusted (i.e., futures-equivalent) options positions, by contract maturity, of the four most important commercial trader types: dealer/merchant, manufacturer, producer, and commodity swaps dealer. The daily net positions in each contract for each reporting trader are summed up (e.g., for all contracts with less than 3 months until maturity, etc.), and the monthly averages are then plotted. The graphs are scaled to allow for easy comparisons of the relative sizes of the net positions held by different trader categories. Two patterns readily emerge. First, all of these trader types have

[20] The apparent drop in net positions between 2004 and 2006, which is most obvious for the near-months contracts, is an artifact of the change in composition of this broad category discussed in Section IV.A.2. Figure 4, drawn in a similar fashion to Figure 2 but with the absolute values of net positions, shows continuous growth between 2001 and 2006.

held both short (-) and long (+) net positions in at least some months of the sample period, in contracts of all maturities. This finding indicates that one ought to be careful when trying to make generalizations about the positions held by any given trader category. Second, for most trader categories, while the magnitude of their net positions (be they long or short) in short-term contracts has increased over the course of the sample period, the most dramatic change is the quintupling of net positions taken by commodity swap dealers.

B. Market Growth

While the growth in market activity is apparent in Figures 1-3, the growth is partly obscured in these figures by the periodic changes in the direction of the net positions taken by various types of traders. That is, when these successive net long (+) and short (-) positions are averaged, the resulting picture could understate the actual growth of the market.

To tackle this issue, Figures 4, 5 and 6 as well as Table 3 carry out a similar analysis using the absolute values of daily trader positions. In these Figures and in Table 3, we first take the absolute value of the daily net positions in each contract for each trader group, then sum up the resulting numbers appropriately (e.g., for all positions less than 3 months, etc.), and finally compute annual or monthly averages. Because net positions make up a relatively constant fraction of open interest for all contract maturities and across the sample period (ratios not reported here), these figures provide a useful indication not only of the magnitude of the net positions but also of the market as a whole.

Figure 4 shows continuous market growth between 2001 and 2006, with the largest proportional increases at maturities less than 3 months and more than 3 years. Figures 5 and 6, together with Table 3, provide additional details of those changes, and allow us to make several observations.

(i) First, commodity swap dealers' net positions increased by an order of magnitude, from just over 10,000 contracts in 2000 to almost 100,000 contracts in 2006. This massive growth started in 2002, and accelerated sharply from mid-2004 onward.

(ii) Second, Figure 5 illustrates that almost all large-trader categories at the end of our observation period carry aggregate net positions in long-term (>3 years) contracts that are comparable in magnitude to their analogous positions in short-term (<3 months) contracts prior to 2003.[21] Precisely, for five out of the six major large trader categories in the crude oil futures market (commodity swaps dealers; hedge funds; commercial dealers/merchants; commercial producers; and, floor brokers and traders), there are at least some months in 2006 when the category's average daily net position in long-term contracts exceeded the corresponding figure for short-term contracts in at least some month prior to 2003. As Table 3 shows, the average absolute value of daily net trader positions in 2006 even exceeds the corresponding figures for the entire year 2000, in the case of swap dealers and floor brokers and traders.

(iii) Third, there are some exceptions to the overall increases in trader participation at longer maturities. One is commercial oil manufacturers (refiners, fabricators, etc.), a category that holds large net positions in short-term futures contracts but virtually none at long maturities. Another exception is small traders (those with individual positions small enough that they do not report their positions to the CFTC large-trader database), who account for approximately 12% of net positions in near-term contracts but for only 3-4% of net positions in long-term contracts. Fourth, the strongest market growth has taken place at contract maturities of less than 3 months and more than 3 years. By comparison, net trader positions in intermediate-maturity contracts have grown relatively less.

(iv) Finally, most of the growth of net positions in long-term (>3 years) contracts has taken place since the end of 2003.

In the next Section, we investigate whether this market growth in general, or some of its aspects, has had consequences for pricing and price discovery in the benchmark market for crude oil futures.

V. Pricing

Price discovery and risk transfer are critical functions performed by futures markets. Garbade and Silber (1983) show theoretically that risk transfer and price discovery are interrelated, and that the ability of a market to simultaneously perform these functions depends on the strength of the linkage between the derivative markets and the markets underlying those

[21] Alhough, as discussed in Section IV.A, not always similar in direction.

derivatives. These authors illustrate that trading provides the linkage between cash and futures prices, leads to a closer correlation between the prices, to a more efficient transmission of information, and to improved hedging opportunities. A natural question is whether the growth in futures market activity that we documented in Section IV has had consequences for the pricing of crude oil futures and, consequently, the ability to better manage risk. Intuitively, price discovery should improve in markets as they become less thinly traded. In this Section, we focus on identifying changes in the relationships between the prices of futures contracts at different maturities. Specifically we focus on the prices of the near-month, 1-year and 2-year futures contracts.[22]

A. Methodology

A large volume of research has attempted to evaluate the degree of interconnectivity between prices from different markets employing time-series techniques that are appropriate for non-stationary and co-integrated data. In particular, much work on applied co-integration analysis has relied on Johansen's multivariate approach (Johansen, 1988, 1991; Johansen and Juselius, 1990).

Simply stated, assume an n-dimensional vector of non-stationary time series, Y_t, (n = 3 here – nearby, one-year and two year contract). Assuming all variables are non-stationary and the existence of co-integration, then the data generation process can be written (Johansen and Juselius, 1990) as an error-correction representation as follows:

$$\Delta Y_t = \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \Pi Y_{t-1} + \varepsilon_t \ . \tag{1}$$

Equation (1) is a Vector AutoRegression (VAR) (in first differences) with the short run parameters being captured by the Γ_i matrix, and the inclusion of the lagged-level component, which is commonly known as the Error Correction Term. The combination of these two is known as the Error Correction Model (ECM). There are three cases of interest. First, if Π is full

[22] In this paper, we focus on nearby month, 1-year and 2-year futures because over this period of time monthly contracts are traded out 2 years enabling us to create rolling daily positions at these different maturities while at the same time ensure the one year interval between the maturities remain constant.

rank, then Y_t is stationary in levels – and, indeed, a VAR in levels is an appropriate model. Second, if Π has zero rank, implying it contains no long run information and the appropriate model would be a VAR in first differences and third, if the rank of Π is a positive number *r* and is less than *p* there exist matrices β and α with dimensions *p* x *r* such that Π is a (3x3) coefficient matrix that may be factored as $\alpha\beta'$. The β matrix is a matrix of co-integrating parameters and the matrix α is a matrix of weights (commonly known as the speed of adjustment parameters) with which each co-integrating vector enters the *n* equations. Hypothesis tests can conveniently be conducted on these matrices. Assuming non stationary oil futures prices, we can examine the long run relationships between the contract maturities by determining the number of co-integrating vectors, r as follows:

$$H_1(r):\ \Pi = \alpha\beta' \qquad (2)$$

The trace test (Johansen, 1991) is conducted to determine *r*. The null hypothesis for the trace test is that there are most r ($0 \le r \le p$) co-integrating vectors.

To examine the stability of the long and short run relationships between nearby and distant futures markets for crude oil in this paper, we apply recursive co-integration techniques (Hansen and Johansen, 1993, 1999). These techniques allow us to test for the level of co-integration between price series during our sample period. The recursive technique allows us to recover two ECM representations. In the "Z-representation," all the parameters of the ECM (β and α) are re-estimated during the recursions, while under the "R-representation" the short-run parameters (α) are kept fixed to their full sample values and only the long run parameters (β) are re-estimated.

In this study, we define Y_t as composed of three elements, which represent the nearby, one year and two year price series for crude oil futures. Under both of these representations, we perform the trace tests to visually inspect the time path of the statistics to identify any changes to the co-integrating relationships amongst the price series. From equation (1) the Trace test is calculated as

$$\text{Trace}_j = T\sum_{i=j}^{p}\ln(1-\hat{\lambda}_i),\ j = 1,\ldots, p\text{-}1, \tag{3}$$

and each statistic is scaled by the 90% quantile of the trace distribution derived for the selected model.

B. Estimation of the Error Correction Model

We use Tuesday settlement prices from January 4, 1999 through May 9, 2006, provided by Bridge CRB, for the near-month (or "Nearby"), one-year out and two-year out WTI crude oil futures contracts. The first year of data (52 weeks) is utilized to start the cointegration modeling (in particular, the recursive analysis) so that the price and position samples match the starting date for our position sample, i.e., January 4, 2000.

Table 4 provides summary statistics of these three price series between January 2000 and May 2006. It is worth noting that the maximum of each of these price series are roughly seven times larger than the corresponding minimums which reflects the increase in oil prices during our sample period.[23]

In order to implement our Error Correction Model, we first check the order of integration of each of the price series within the futures maturity spectrum. As can be seen from Table 5, each series is integrated of the first order confirming that the analyses will be conducted on the differenced price series. We then estimate the ECM using the maximum likelihood technique outlined by Johansen and Juselius (1990). The lag length order was selected based on lag reduction statistics and 8 lags were deemed to be the optimal lag length.[24]

Table 6 presents the decision rule based on the trace tests for the number of co-integrating vectors. We first fail to reject the null hypotheses on $r \leq 1$. At $p = 0.079$ there

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[23] The simple unconditional correlations between the three price series are greater than 0.95, which suggests a close link between the series. We also analyzed the correlation between spot price data and the three futures prices series. The unconditional correlation between spot prices and nearby, one year and two year contracts are 0.999, 0.98 and 0.97. Consequently given that spot prices and nearby prices are effectively identical we infer that using spot instead of nearby prices would yield similar results.

[24] These results are excluded to conserve space but are available upon request.

appears to be some weak evidence of the existence of two co-integrating vectors. However, to keep the analysis tractable, we estimate our ECM with one co-integrating vector.[25] We also test the individual elements of β' against zero in the factorization $\alpha\beta' = \Pi$ and investigate the possibility of weak exogeneity of each of the series (testing whether each element of the α vector is equal to zero) and the results are presented in the lower portion of Table 6. In particular, the middle panel explores the possibility that one of the three series is not in the co-integrating space. We reject the null that price *i* is not present in the co-integrating space for each series. With respect to the short-run adjustment toward the long run relationships, α, we also test for weak exogeneity on each market. For each market we test for whether or not it responds to perturbations in the co-integrating space. Inspection of the lower panel of Table 6 suggests that both the nearby and 1-year contracts are weakly exogenous and that the 2 year contract does all the adjusting to the long-run equilibrium. Implications of this finding are explored below.

In order to study the development of the level of cointegration between contracts of differing maturities we apply recursive cointegration techniques which also allows us to examine the stability and possible strengthening of the relationship over time. This technique has been employed in other studies (e.g., convergence across stock markets, interest rates in different countries etc) by Bremnes et al., 1997; Diamandis et al., 2000, Yang et al., 2004, but has yet to be been applied to price discovery in futures markets. Following Hansen and Johansen (1993,1999), here we conduct the rank constancy test based on what is known as the "R-representation" whereby the short-run parameters captured in the Γ_i matrix are held fixed to their full sample values and only the long run parameters in equation (1) are re-estimated at each time interval. The mathematics behind the 'R-representation' are excluded to conserve space and interested readers are directed to Hansen and Johansen (1993, 1999). Recursive cointegration analysis is conducted on the single cointegrating vector tying the three time series together and

[25] Residuals from this estimated ECM seem to be well behaved. Specifically, Lagrangian Multiplier tests for first and second order autocorrelation using an auxiliary regression, as described by Godfrey (1988, Chapter 5) are conducted. We reject both orders of autocorrelation comfortably with *p*-values of 0.994 and 0.536 respectively. The test statistics for no conditional heteroskedasticity are rejected, but Rahbek et al. (2002) show that the rank test for cointegration is robust to moderate ARCH effects, so this appears not to be a problem in this case (these results are excluded to conserve space but are available upon request).

Figure 7 presents a time series plot of the normalized trace statistic (normalized by the 5% level of significance) for each week between January 2000 and May 2006.

As shown in Figure 7, results based on recursive cointegration are far more informative than the standard Johansen cointegration technique to the extent that they illustrate the change in the long run relationship between the series. As can be seen from the time series plot, the 3 contract maturities were not in long run cointegration in January 2000 (the trace value was below 1) but the series tended toward 1 (moving toward cointegration) in 2002 and 2003. On the 6th July 2004 all series became cointegrated and have essentially remained cointegrated ever since.

In addition to the time path of the trace statistic we are also able to recover the speed of adjustment parameters (α) for each of the series in the cointegrating vector. Each speed of adjustment parameter measures the degree to which each variable (contract maturity price series) responds to the deviation from the long-run equilibrium relationship. The 'larger' (in absolute value) the speed of adjustment, the faster the speed of adjustment from the previous period's deviation from long run equilibrium. At the opposite end of the spectrum a small value implies that the price series in question is unresponsive to last period's equilibrium error. A speed of adjustment equal to zero implies that a series is weakly exogenous. Thus the absence of Granger causality for cointegrated variables requires the additional condition that the speed of adjustment coefficient be equal to zero. As can be seen from Table 6, results suggest that both the nearby and one year contracts are weakly exogenous, and it is the two year contract that adjusts toward the long run equilibrium. Thus, the two year contract cannot cause changes in the nearby and one year contract as they do not adjust to perturbations. The opposite is not true.

The recursive estimates of the speed of adjustment parameters and the 5% confidence intervals for all three series are presented in Figure 8. As can be seen in the time series plots for the vast majority of the time the speed of adjustment parameters for the nearby and one year contract are statistically indistinguishable from zero. Interestingly, around the same time that the maturities became cointegrated (mid-2004), the second year maturity speed of adjustment parameter become statistically significantly different than zero. It has, for the most part, remained statistically different than zero since that time.

C. Explaining the Convergence between Price Series

We examine the growing convergence between crude oil futures contracts more rigorously in Tables 7 and 8. To this end, we use the trace statistic (plotted in Figure 7) as the dependent variable and use position data from the various categories of traders as explanatory variables. In this manner, our tests capture changes in the level of participation over time that can be tied to the concurrent increase in the trace statistic.[26]

We first estimate simple regressions explaining the change in the level of cointegration using positions scaled by the mean (long plus short positions divided by the mean) for each category of trader independently in Table 7. We estimate several specifications, reporting the relation between each individual trader type and the cointegration Trace statistic independently. We report three specifications in Table 7 as follows:

Spec 1: $Trace_t = \alpha + \beta_5(Near + One \text{ Year} + Two \text{ Year}) + \varepsilon_t$

Spec 2: $Trace_t = \alpha + \beta_1(Near) + \beta_4(One \text{ Year} + Two \text{ Year}) + \varepsilon_t$

Spec 3: $Trace_t = \alpha + \beta_1(Near) + \beta_2(One \text{ Year}) + \beta_3(Two \text{ Year}) + \varepsilon_t$

For example, in specification 1 we use the pooled activity in all three contracts (nearby, one-year and two-year) by trader category separately in a robust OLS regression to explain movements in the Trace statistic. As indicated in the lower portion of Table 7, swap dealer, hedge fund and non-reporting dealer positions appear to be significantly related to the strengthening of the cointegration level among the different contract maturities. Notably however, the explanatory power of swap dealer positions (with an adjusted R^2 of 0.21) greatly exceeds the explanatory power of all other trader category positions. Dealer/merchant, producer

[26] Other studies employing recursive cointegration techniques attempt to explain changes in the level of cointegration over time by commenting on changes (often abrupt) in trace values using information on actual (usually one-time) events. For instance, Phylaktis and Ravazzolo (2006) explain convergence in international stock markets using information on foreign ownership restrictions and Yang, Kolari and Sutanto (2004) attribute a sudden change in cointegration levels between stock markets to the global emerging markets crisis during 1997-1998. In a similar vein to our paper, Haigh (2000) examines the development of cointegration across time but fails to link trading volume in freight futures contracts to increased cointegration levels in pricing within freight markets.

and floor trader positions are generally unrelated to cointegration levels whereas manufacturer and others show some marginal contribution to cointegration over time.

Specification 2 parses out the incremental explanatory power of nearby positions from the analysis. As shown in the middle portion of Table 7, partially disaggregating positions by contract length uniformly increases the explanatory power of these regressions (the adjusted R^2 for non-reporting traders increases by 0.43, for instance). Furthermore, positions in the nearby contract tend to be most strongly related to cointegration over time. Aggregate one- and two-year commodity swap dealer positions continue to explain a large proportion of the price convergence. Aggregate one- and two-year positions are significant for most non-commercial traders (floor traders and hedge funds) as well.

Specification 3 (upper portion of Table 7) fully disaggregates the effects of nearby, one- and two-year contract positions across trader type. With these specifications, we continue to see an increase in the explanatory power of most regressions. As with Specification 2, we continue to see that positions in nearby contracts contribute significantly to cointegration for all trader categories except dealer/merchants. Significance of one- and two-year contract positions is less significant for most traders, except for producers and commodity swap dealers where all three (nearby, one- and two-year) positions remain strongly related to increased cointegration among these contracts over time.

We also estimate models based on the positions of all trader categories concurrently in Table 8. Similar to the individual trader position regressions we estimate several specifications that attempt to explain the development of cointegration among nearby, one- and two-year contract prices. To illustrate, the equivalent pooled model for specification three used in the individual regression is as follows:

$$\begin{aligned}
Trace_t &= \alpha + \beta_1(AD\ Near) + \beta_2(AD\ One\ \text{Year}) + \beta_3(AD\ Two\ \text{Year}) + \beta_4(AM\ \ Near) + \\
&\beta_5(AM\ \ One\ \text{Year}) + \beta_6(AM\ \ Two\ \text{Year}) + \beta_7(AO\ Near) + \beta_8(AO\ One\ \text{Year}) + \\
&\beta_9(AO\ Two\ \text{Year}) + \beta_{10}(AP\ Near) + \beta_{11}(AP\ One\ \text{Year}) + \beta_{12}(AP\ Two\ \text{Year}) \\
&+ \beta_{13}(AS\ Near) + \beta_{14}(AS\ One\ \text{Year}) + \beta_{15}(AS\ Two\ \text{Year}) + \beta_{16}(FBT\ Near) + \\
&\beta_{17}(FBT\ One\ \text{Year}) + \beta_{18}(FBT\ Two\ \text{Year}) + \beta_{19}(MMT\ Near) + \beta_{20}(MMT\ One\ \text{Year}) + \\
&\beta_{21}(MMT\ Two\ \text{Year}) + \beta_{22}(NRP\ Near) + \beta_{23}(NRP\ One\ \text{Year}) + \beta_{24}(NRP\ Two\ \text{Year}) + \varepsilon_t.
\end{aligned}$$

Inclu

ding multiple trader categories within the same regression adds significant explanatory power, with the adjusted R^2 for these models ranging from 0.56 to 0.75. When nearby, one- and two-year contracts are pooled, several trader group positions are significantly linked to the development of cointegration. Notably, commodity swap dealers have the greatest positive influence on cointegration. Only non-reporting traders share the positive relation in pooled data.

When we disaggregate data, the influence of commodity swap dealer positions is strongly significant in one- and two- year positions, both individually and when pooled. Commodity swap dealer positions in the nearby contract is not significantly related to the development of cointegration over time. However, in disaggregated data, we also find that other trader positions are significantly related to cointegration. Notably, dealer/merchant positions in the two-year contract, hedge fund positions in the one-year contract and non-reporting trader positions in the nearby contract are also strongly related to the development of cointegration over time. While these other trader groups also help to explain the convergence in the price series, commodity swap dealer positions dominate in terms of explaining convergence, whether we focus on disaggregated or pooled regressions.

To summarize, we find that nearby contract prices (which are highly correlated with cash prices), one- and two-year futures prices have become more cointegrated over time primarily because commodity swap dealers have increased positions at one- and two-year horizons. This result holds when examining individual trader positions in isolation (Table 7) and when controlling for all other trader positions in the market (Table 8). As such, increased commodity swap dealer participation in crude oil futures markets over 2000-2006 has generated better price discovery in one- and two-year futures markets. The improved linkages among these contracts allow for better, more efficient risk management in the markets for crude oil.

VI. Conclusions

In this paper, we document major changes in the size and term structure of the benchmark U.S. market for crude oil futures since the turn of the millennium. In particular, we document the growth especially at the far end of the market. We show that, as recently as 2000, activity was heavily concentrated at the near end of the maturity spectrum. Since then, overall open interest has more than doubled, with trader activity at the back end of the maturity spectrum increasing over twice as much as the market as a whole. The market growth in long-term (>3 years) positions generally started in 2004. An analysis of the composition of traders participating in the market shows that almost all large-trader categories (commodity swap dealers, hedge funds, commercial dealer/merchants, commercial producers) now carry aggregate net positions in long-term contracts comparable in magnitude to the size of their net positions in short-term (<3 months) contracts prior to 2003.

We document that, in the wake of this market growth, the prices of one-year and two-year futures became co-integrated with the price of the near-month futures in 2004. Price discovery and risk transfer are critical functions performed by futures markets, and the ability of a market to simultaneously perform these functions depends on the strength of the linkage between the derivative and underlying markets. To explore this issue, using unique position level data we investigate, for the first known time, the question of which class of trader is responsible for the strengthening cointegration between nearby and distant futures contracts in crude oil. We find that the growth of activity by a class of traders, known as commodity swap dealers, explains much of this convergence. This class of traders, more than any other, by its trading activity allows other categories of traders to better manage risk with futures contracts several years into the future. The major changes we document have potentially significant implications for those interested in the effectiveness of hedges constructed with crude oil futures and for those interested in the quality of information contained in futures prices across the term structure.

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Table 1: Open Interest in Crude Oil Futures and Options, 2002-2006

	Non-Commercial (%)			Commercial (%)		Total Open Interest
	long	short	spread	long	short	
2002	7.6	1.5	24.3	59.3	67.2	773,550
2003	14.0	5.0	18.6	60.4	67.6	779,513
2004	11.8	4.6	19.6	62.1	68.5	1,026,123
2005	9.4	5.1	26.5	58.5	62.2	1,303,209
2006	12.1	6.3	30.9	52.5	58.3	1,706,416

Notes: **Table 1** provides a snapshot of open interest changes since 2002. Open interest data are from the weekly Commitment of Traders Reports from July 16, 2002 through July 19, 2006. For each year, the snapshot is for the third week of July. We report the open interest for the sum of futures and *adjusted* options (i.e., total) positions of commercial and non-commercial traders. When the CFTC publishes its weekly Commitment of Traders Report, reporting traders are categorized into two broad groups: "Commercials" (left panel), who have declared an underlying hedging purpose, and "Non-commercials" (right panel), who have not. For each category, the long and short positions are reported as fractions of the overall open interest. For example, on the short [*long*] side of the 773,500 open interest on Tuesday, July 16, July 2002, 67.2% [*59.3%*] of all positions were held by commercial traders and 1.5% [*7.6%*] were held by reporting non-commercial traders, with the rest split between 24.3% in spread positions (i.e., calendar spread positions constructed with long and short futures positions) by reporting non-commercial traders and 7% [*8.8%*] in outright short [*long*] positions held by non-reporting traders.

Table 2: Large trader categories

Table 2A: Commercial Traders

CFTC Code	*CFTC Name*	*Present in WTI futures & options markets*
18	Co-Operative	
AD	**Dealer/Merchant**	**Y**
AM	**Manufacturer**	**Y**
AO	Agricultural/Natural Resources – Other	Y (*very small*)
AP	**Producer**	**Y**
AS	**Commodity Swaps/Derivatives Dealer**	**Y**
FA	Arbitrageur or Broker/Dealer	Y *(merged into AS)*
FB	Non U.S. Commercial Bank	
FC	U.S. Commercial Bank	
FD	Endowment or Trust	
FE	Mutual Fund	
FF	Pension Fund	
FG	Insurance Company	
FH	Hedge Fund	
FM	Mortgage Originator	
FO	Financial – Other	
FP	Managed Account or Pool	
FS	Financial Swaps/Derivatives Dealer	Y *(merged into AS)*
FT	Corporate Treasurer	
LF	Livestock Feeder	
LO	Livestock – Other	
LS	Livestock Slaughterer	
18	Co-Operative	

Table 2B: Non-commercial Traders

CFTC Code	*CFTC Name*	*Present in WTI futures & options markets*
HF	**Hedge Funds**	**Y**
FBT	**Floor Broker /Trader**	**Y**
FCM	Futures Commission Merchant	Y *(very small)*
IB	Introducing Broker	Y *(very small)*
NR	**NON-REPORTING TRADER**	**Y**

Notes: **Table 2** lists the trader sub-categories in the CFTC's large-trader reporting system (LTRS). Bolded entries are those on which most of our analysis focuses. When the CFTC publishes its weekly Commitment of Traders Report, these various sub-categories are aggregated in two broad groups: "Commercials" (Table 2A), who have declared an underlying hedging purpose, and "Non-commercials" (Table 2B), who have not. In **Table 2A**, "Dealer/Merchant" (AD) includes wholesalers, exporter/importers, crude oil marketers, shippers, etc. "Manufacturer" (AM) includes refiners, fabricators, etc. "Agricultural / Natural Resources – Other" (AO) may include, for example, end users. "Commodity Swaps/Derivatives Dealers" (AS) aggregate all reporting "Swaps/Derivatives Dealers" (FS) and "Arbitrageurs or Broker Dealers" (FA), two categories that were merged in the CFTC's internal reporting system part-way through our sample period. In **Table 2B**, "Hedge Funds" (HF) aggregate all reporting Commodity Pool Operators (CPO), Commodity Trading Advisors (CTAs), "Associated Persons" (APs) controlling customer accounts as well as other "Managed Money" (MM) traders. "Floor Brokers & Traders" (FBT) aggregate all reporting floor brokers and floor traders. NR represents those traders that have not yet been categorized or do not fit any other category. "Non-reporting participants" (NR) are reporting trader who is not registered under the Commodity Exchange Act (CEA). Note: FH under the Commercial category includes hedge funds in financial contracts that are shown to be hedging. This category has very few participants and is not relevant to our study.

Table 3: Absolute Value of Net Positions at ≠ Maturities: Changes Since 2000

Panel A: Commercial vs. Non-commercial Categories

	<3 month			3-36 months			>3 years		
	2000	2006	growth	2000	2006	growth	2000	2006	growth
Commercial	106,027	268,974	154%	192,348	203,242	6%	14,820	42,344	186%
Non-commercial	34,997	76,327	118%	39,390	100,500	155%	2,222	19,352	771%
Total	**141,025**	**345,301**	**145%**	**231,739**	**303,742**	**31%**	**17,042**	**61,696**	**262%**

Panel B: Traditional vs. Non-traditional Commercial Traders

	<3 month			3-36 months			>3 years		
	2000	2006	growth	2000	2006	growth	2000	2006	growth
Other Commercial	10,624	100,493	846%	37,917	55,691	47%	2,517	14,612	481%
Traditional	95,403	168,481	77%	154,431	147,551	-4%	12,302	27,732	125%
Total	106,027	268,974	154%	192,348	203,242	6%	14,820	42,344	186%

Panel C: Individual Trader Sub-categories

	<3 month			3-36 months			>3 years		
	2000	2006	growth	2000	2006	growth	2000	2006	growth
Dealers (AD)	31,709	75,836	139%	69,957	68,589	-2%	3,664	12,852	251%
Manufacturers (AM)	28,678	59,365	107%	25,219	23,451	-7%	3,926	2,324	-41%
Other Commercials (AO)	3,906	6,389	64%	5,262	6,396	22%	-	686	-
Producers (AP)	28,862	26,891	-7%	53,337	49,115	-8%	4,707	11,870	152%
Swap Dealers (AS)	10,624	100,493	846%	37,917	55,691	47%	2,517	14,612	481%
Floor Brokers (FBT)	2,913	11,237	286%	20,077	31,785	58%	720	4,145	475%
Hedge Funds (HF)	26,662	43,913	65%	16,361	55,889	242%	1,019	11,198	999%
Non-Reporting (NRP)	5,422	21,177	291%	2,953	12,826	334%	482	4,009	731%
Total	**138,777**	**345,301**	**149%**	**231,082**	**303,742**	**31%**	**17,035**	**61,696**	**262%**

Notes: **Table 3** shows the yearly averages (2000-2006) of the absolute values of the net futures and adjusted options positions of commercial and non-commercial traders by contract maturity. "**Commercial**" traders include AD = Dealer/Merchant, AM = Manufacturer, AO = Agricultural and Natural Resource - Other, AP = Producer, AS = Commodity Swaps / Derivatives Dealer (which includes FS = Financial Swaps / Derivatives Dealer FA = Arbitrageur or Broker/Dealer). "**Non-commercial**" traders include FBT = Floor Broker / Floor Trader; HF = Hedge Fund; as well as, the reported positions of traders not subject to the reporting requirement and the positions of traders that have not yet been categorized or do not fit any other category. After taking the absolute value of the daily net positions in each contract for each trader group, figures are summed up appropriately (e.g., for all commercial groups, or for all positions less than 3 months, etc.), and the annual averages are then computed. Table 3 is directly comparable to Figures 4-6 below.

Table 4: Descriptive statistics and correlation analysis on weekly prices

	Nearby	1-year contract	2-year contract
Mean	34.67	32.01	30.43
Median	29.99	25.46	23.70
Standard deviation	14.01	15.33	15.07
m_3	0.96	1.35	1.45
m_4	0.09	0.62	0.82
Minimum	11.37	12.92	14.06
Maximum	74.61	76.96	74.07

Unconditional Correlations

	Nearby	1-year contract	2-year contract
Nearby	1		
1-year contract	0.98	1	
2-year contract	0.97	1.00	1

Notes: Table 3 provides summary statistics of the daily settlement price series for the near-month, 1- and 2-year out WTI sweet crude oil futures contracts between 1/4/2000 and 5/9/2006. In line with the analysis of trader positions, the prices used are those for Tuesday settlements. m_3 and m_4 represent sample skewness and kurtosis respectively.

Table 5: Augmented Dickey-Fuller (ADF) tests for order of integration on futures prices

Test is on the estimated coefficient θ_1 from the following prototype model:

$$\Delta X_t = \theta_0 + \theta_1 X_{t-1} + \sum_{k=1}^{K} \beta_k \Delta X_{t-k}$$

Price Series	K	HO: *I*(1) vs. HA: *I*(0) ADF	HO: *I*(2) vs. HA: *I*(1) ADF
Nearby	0	-0.49	-21.59
1-yr contract	1	1.98	-22.01
2-yr contract	1	2.71	-22.50

Notes: Critical values are taken from Fuller (1976). They are –2.57 (10%), –2.88* (5%) and –3.46 (1%). Therefore, based on these results are series are I(1). The optimal lag length (K) is based on the Schwarz Bayesian Criterion (1978).

Table 6. Cointegration Analysis of Prices

Trace tests on order of cointegration[a]		
λ_{trace} *test statistic*	H_O:	*critical value(p-value)*
45.21	r = 0	35.07 (0.002)
22.82	r ≤ 1	20.16 (0.020)
8.23	r ≤ 2	9.14 (0.076)

Tests for exclusion from the cointegrating vector[b]		
	H_O:	$\chi^2_{(1)}$ *value(p value)*
Nearby	$\beta_N = 0$	1.11 (0.291)
1 yr contract	$\beta_1 = 0$	2.94 (0.087)
2 yr contract	$\beta_2 = 0$	2.99 (0.084)
Tests for weak exogeneity[b]		
	H_O:	$\chi^2_{(1)}$ *value (p value)*
Nearby	$\alpha_I = 0$	0.02 (0.291)
1 yr contract	$\alpha_B = 0$	1.20 (0.273)
2 yr contract	$\alpha_G = 0$	3.09 (0.079)

Notes:

[a] Tests are on eigenvalues with the Π matrix. The λ_{trace} statistic is $-N(\sum_{i=r+1}^{2}\ln(1-\lambda_i))$, where λ_i are ordered (largest to smallest) eigenvalues on Π.

[b]Tests are based on the following: $T = N(\ln(1-\lambda_R) - \ln(1-\lambda_U))$, where λ_R is the eigenvalue calculated with the restriction and λ_U the eigenvalue calculated without the restriction. Based upon these results all 3 futures appear to be a part of the co-integrating relationship (at the p = 0.08 level), and both the nearby and the 1 yr contract are weakly exogenous.

Table 7. Explaining the Trace Statistic with Position Data from Individual Categories

	Constant	Near	1-year	2-year	1-year + 2-year	Near + 1-year + 2-year	$\overline{R^2}$
Dealer/Merchants	30.49***	0.694	-2.874***	1.240***			0.03
Manufacturers	27.59***	2.543**	-1.568**	0.985***			0.05
Other Ag & Nat Resource	32.30***	-2.89***	-0.24	0.38***			0.07
Producers	26.80***	4.25***	-2.30***	0.80***			0.09
Swap Dealers	17.92***	5.68***	7.14***	-1.17***			0.40
Floor Brokers/Traders	22.87***	5.30***	0.79	0.60*			0.10
Hedge Funds	23.61***	5.08***	1.10*	-0.24			0.16
Non-reporting	22.14***	7.54***	0.10	-0.21*			0.50
Dealer/Merchants	28.77***	0.527			0.126		0.00
Manufacturers	26.65***	2.65**			0.13		0.02
Other Ag & Nat Resource	32.12***	-2.99***			0.21**		0.06
Producers	25.51***	4.17***			-0.06		0.04
Swap Dealers	21.30***	6.34***			0.96***		0.35
Floor Brokers/Traders	22.98***	5.30***			0.640***		0.15
Hedge Funds	23.91***	5.20***			0.22***		0.16
Non-reporting	22.19***	7.59***			-0.11		0.50
Dealer/Merchants	29.15***					0.13	0.00
Manufacturers	29.08***					0.159*	0.01
Other Ag & Nat Resource	29.13***					0.14*	0.00
Producers	29.32***					0.08	0.00
Swap Dealers	24.45***					1.70***	0.21
Floor Brokers/Traders	26.57***					1.00	0.06
Hedge Funds	28.31***					0.42***	0.05
Non-reporting	27.70***					0.62***	0.07

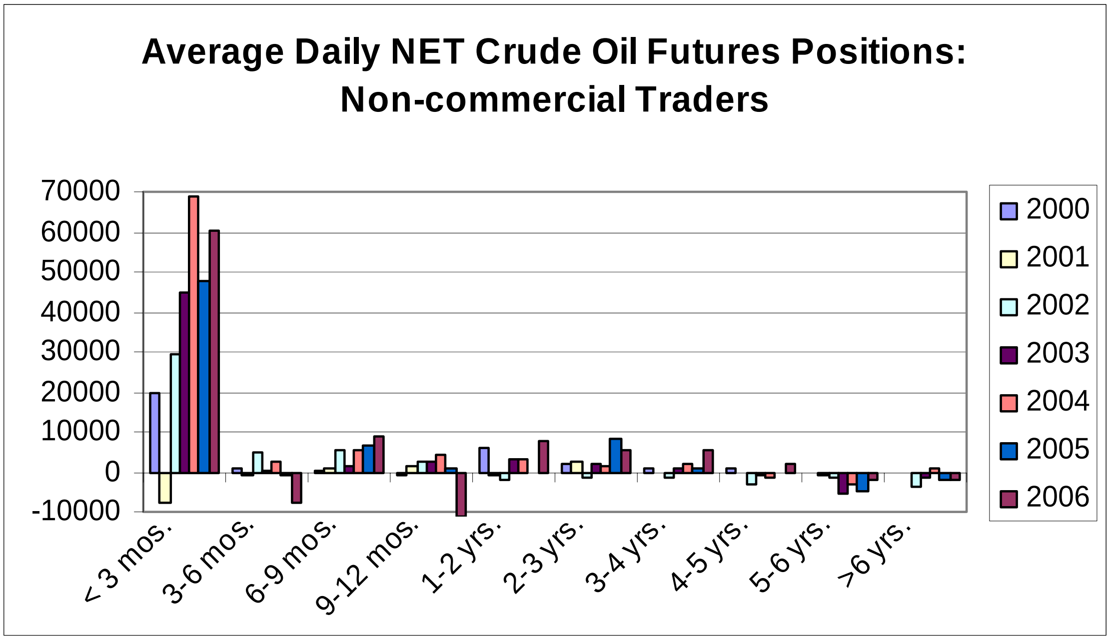
Columns labeled *"Near", "1-year"* and "*2-year"* contain the parameter estimates associated with nearby, one year and two futures positions respectively. *"1-year + 2-year"* is associated with the sum of one and two year positions and "*Near + 1-year + 2-year"* reflects the pooling of nearby, one year and two year positions. *, **, and *** represent significance at the 10%, 5% and 1% levels respectively. All regressions are run using Newey-West estimators.

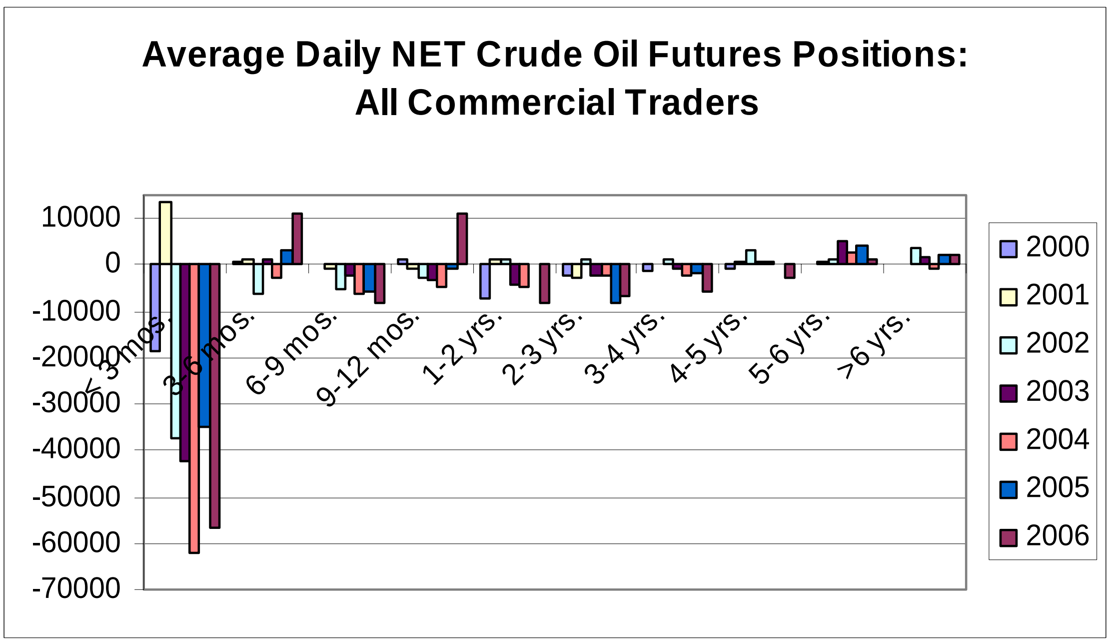
Table 8. Explaining the Trace Statistic with Position Data from Multiple Categories

		(1)	(2)	(3)	(4)
	Constant	31.61***	29.96***	29.12***	25.50***
Dealer/Merchants	Near	-6.08***	-4.45***	-3.85***	
	1-year			-4.91***	
	2-year			2.71***	
	(1-year + 2-year)		-0.21		
	(Near + 1-year + 2-year)				-0.75***
Manufacturers	Near	0.04	-0.82	0.23	
	1-year			-0.72**	
	2-year			-0.30	
	(1-year + 2-year)		-0.29**		
	(Near + 1-year + 2-year)				-0.45***
Other Ag & Nat Resource	Near	-1.49***	-0.79**	-0.60*	
	1-year			-0.08	
	2-year			-0.44***	
	(1-year + 2-year)		-0.29*		
	(Near + 1-year + 2-year)				-0.15
Producers	Near	-3.57***	-2.42**	-2.67***	
	1-year			0.12	
	2-year			0.01	
	(1-year + 2-year)		-0.69***		
	(Near + 1-year + 2-year)				-1.50***
Commodity Swap Dealers	Near	1.52	0.09	-1.33	
	1-year			3.88***	
	2-year			3.02***	
	(1-year + 2-year)		3.19***		
	(Near + 1-year + 2-year)				5.55***
Floor Brokers/Traders	Near	-0.19	-0.40	-0.66	
	1-year			-0.07	
	2-year			-0.28	
	(1-year + 2-year)		-1.15***		
	(Near + 1-year + 2-year)				-1.52***
Hedge Funds	Near	-2.73***	-2.44**	-2.74***	
	1-year			0.47***	
	2-year			-1.59***	
	(1-year + 2-year)		-0.12		
	(Near + 1-year + 2-year)				-0.413
Non-reporting	Near	10.45***	9.79***	10.98***	
	1-year			0.21	
	2-year			-0.96***	
	(1-year + 2-year)		0.10		
	(Near + 1-year + 2-year)				0.59***
	$\overline{R}^2$	0.72	0.72	0.75	0.56

Columns labeled *"Near"*, *"1-year"* and "*2-year*" contain the parameter estimates associated with nearby, one year and two futures positions respectively. *"1-year + 2-year"* is associated with the sum of one and two year positions and "*Near + 1-year + 2-year*" reflects the pooling of nearby, one year and two year positions. *, **, and *** represent significance at the 10%, 5% and 1% levels respectively. All regressions are run using Newey-West estimators.

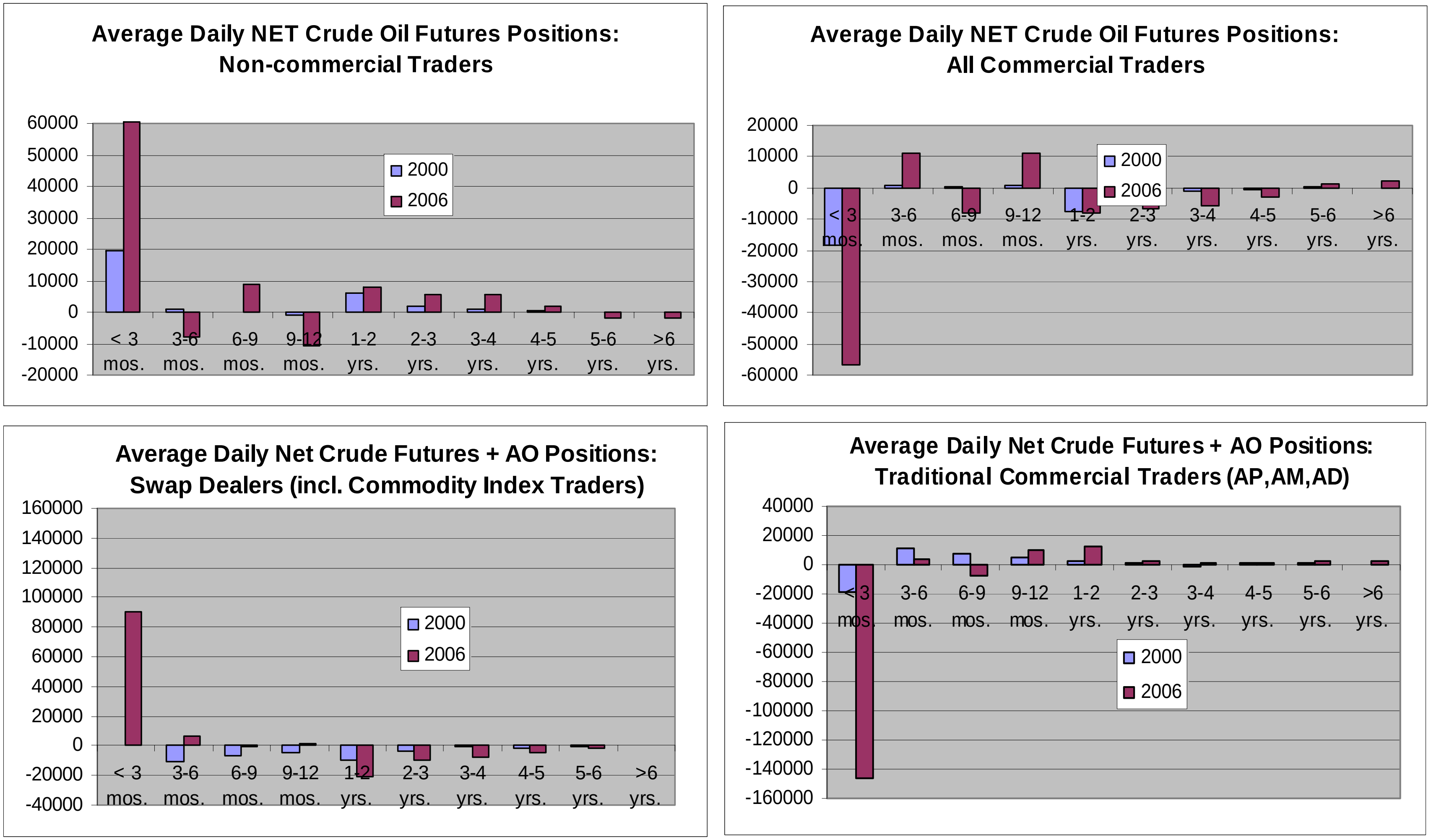
Figure 1: Net Positions at ≠ Maturities: Snapshot of Changes Since 2000





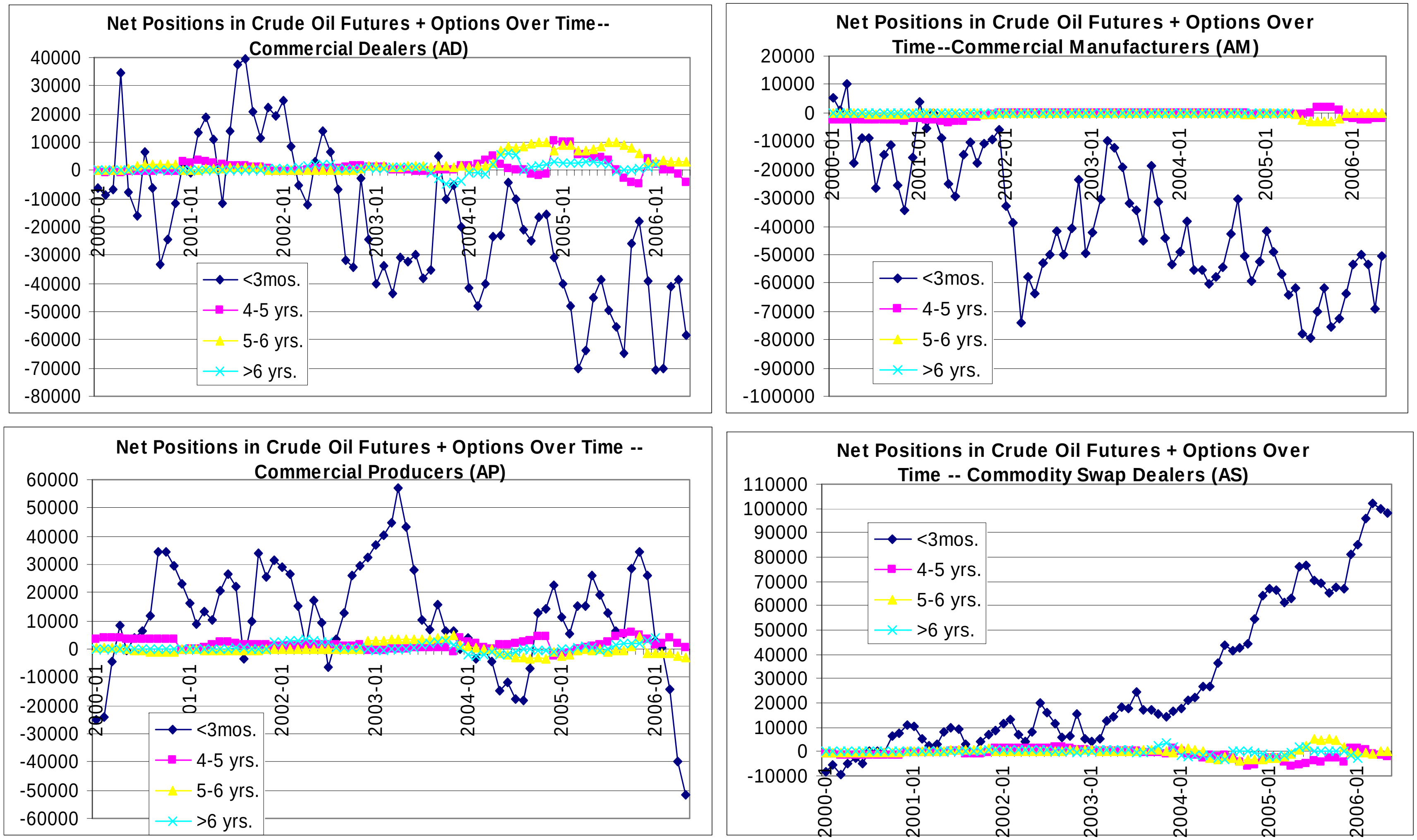
***Notes:* Figure 1** shows the average annual net position of commercial and non-commercial traders by contract maturity. "**Commercial traders**" include AD = Dealer/Merchant, AM = Manufacturer, AO = Agricultural and Natural Resource - other, AP = Producer, AS = Commodity Swaps/Derivatives Dealer, (which includes FS = Financial Swaps / Derivatives Dealer FA = Arbitrageur or Broker/Dealer). "**Non-commercial traders**" include HF = Hedge Fund, FBT = Floor Broker/Floor Trader, , as well as the reported positions of traders not subject to the reporting requirement and the positions of traders that have not yet been categorized or do not fit any other category. The daily net positions in each contract for each reporting trader are summed up appropriately (e.g., for all commercial traders, for all positions less than 3 months, etc.), and the annual averages are then computed. Figure 1 is directly comparable to Figure 4 below.

Figure 2: Illustrating the Heterogeneity of the Commercial Trader Group



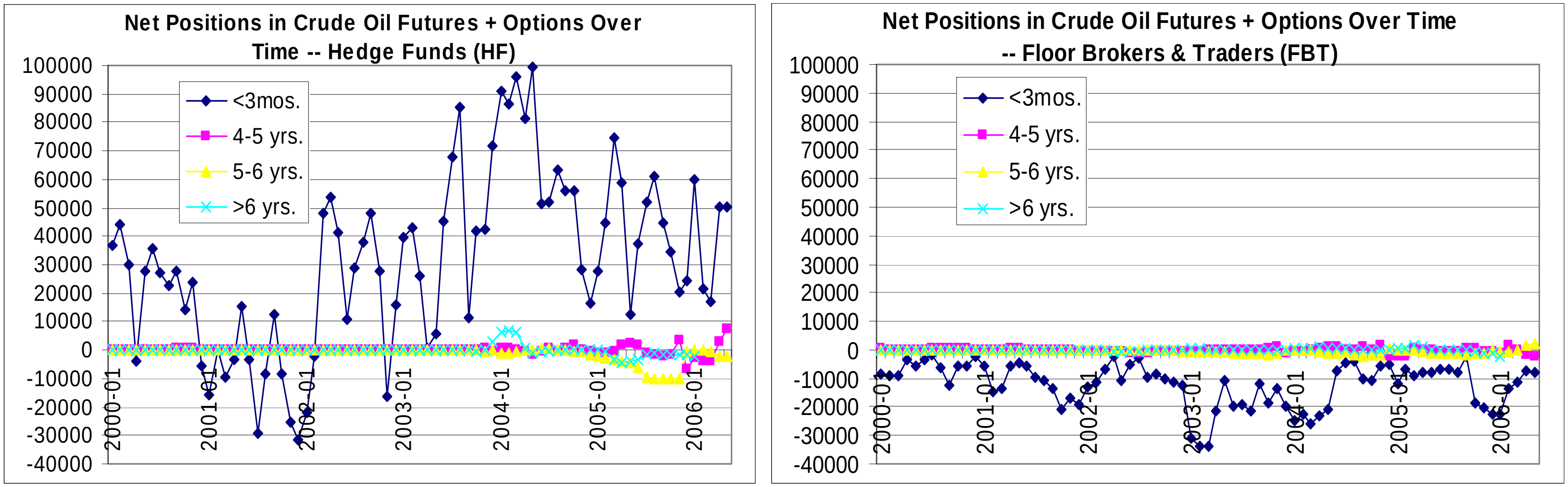
Notes: **Figure 2** shows the average annual net futures + adjusted options (i.e., futures equivalent) positions of commercial and non-commercial traders by contract maturity. "**Non-commercial traders**" include mostly FBT = Floor Broker/Floor Trader and HF = Hedge Fund. "**Commercial traders**" include mostly AD = Dealer/Merchant, AM = Manufacturer, AP = Producer, and AS = Commodity Swaps/Derivatives Dealer, (which includes FS = Financial Swaps / Derivatives Dealer FA = Arbitrageur or Broker/Dealer). The daily net positions in each contract for each reporting trader are summed up appropriately (e.g., for all commercial traders, for all positions less than 3 months, etc.), and the annual averages are then computed. The bottom figures decompose the overall net position of all commercial traders between the traditional commercial categories (commercial crude oil dealers, manufacturers, and producers) and the "new kid on the block", i.e., the Commodity Swaps/Derivatives Dealer.

Figure 3a: Net Positions of the Major Commercial Trader Types, 2000-2006



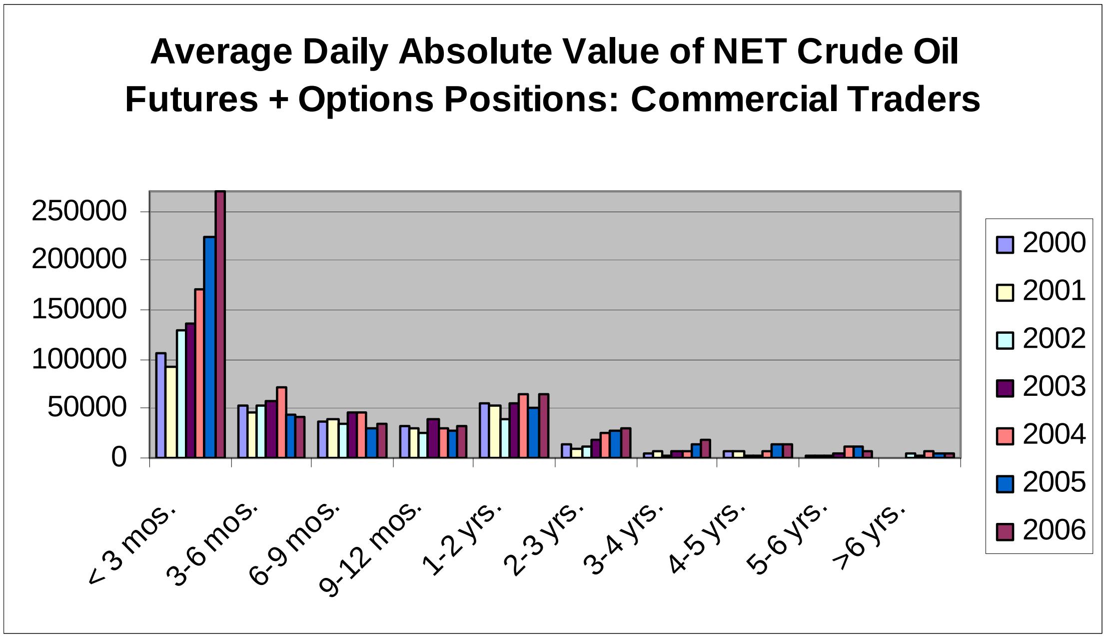
Notes: **Figure 3a** shows the average monthly net futures + adjusted options (i.e., futures equivalent) positions, by contract maturity, of the four most important commercial trader types: AD = Dealer/Merchant, AM = Manufacturer, AP = Producer, and AS = Commodity Swaps/Derivatives Dealer (which includes FS = Financial Swaps / Derivatives Dealer FA = Arbitrageur or Broker/Dealer). The daily net positions in each contract for each reporting trader are summed up appropriately (e.g., for all contracts with less than 3 months until maturity, etc.), and the monthly averages are then plotted. The graphs are scaled to allow for easy comparisons of the relative sizes of the net positions held by different trader categories. Figure 3a is directly comparable to Figures 5a and 6a below.

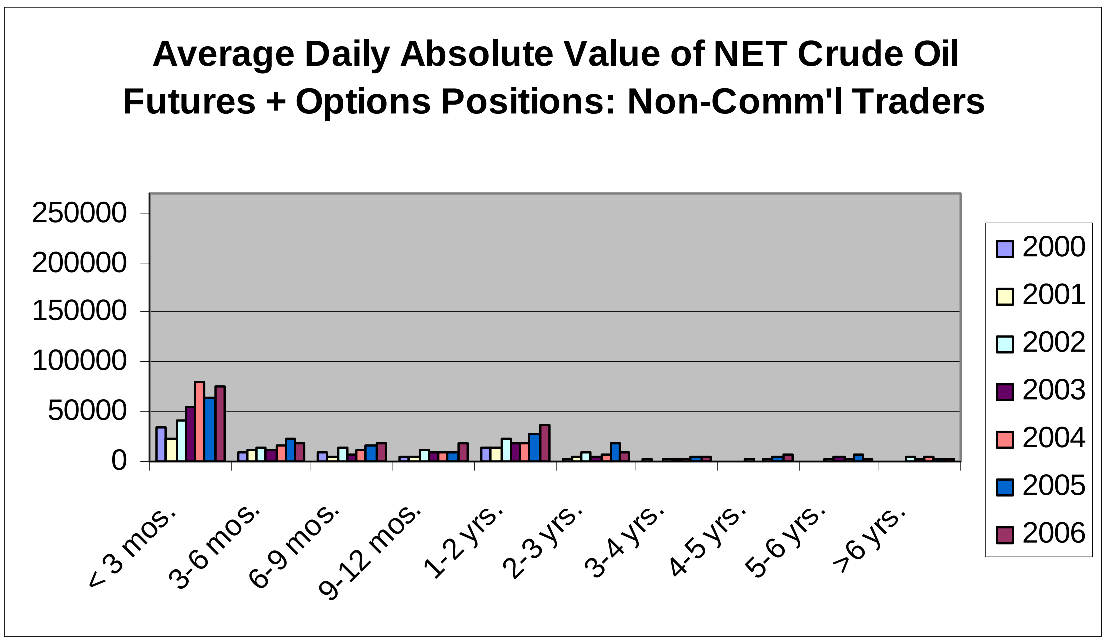
Figure 3b: Net Positions of the Major Non-Commercial Trader Types, 2000-2006



Notes: **Figure 3b** shows the average monthly net futures + adjusted options (i.e., futures equivalent) positions, by contract maturity, of the two most important non-commercial trader types: HF = Hedge Fund, FBT = Floor Broker/Floor Trader. The daily net positions in each contract for each reporting trader are summed up appropriately (e.g., for all contracts with less than 3 months until maturity, etc.), and the monthly averages are then plotted. The graphs are scaled to allow for easy comparisons of the relative sizes of the net positions held by different trader categories. Figure 3b is directly comparable to Figures 5b and 6b below.

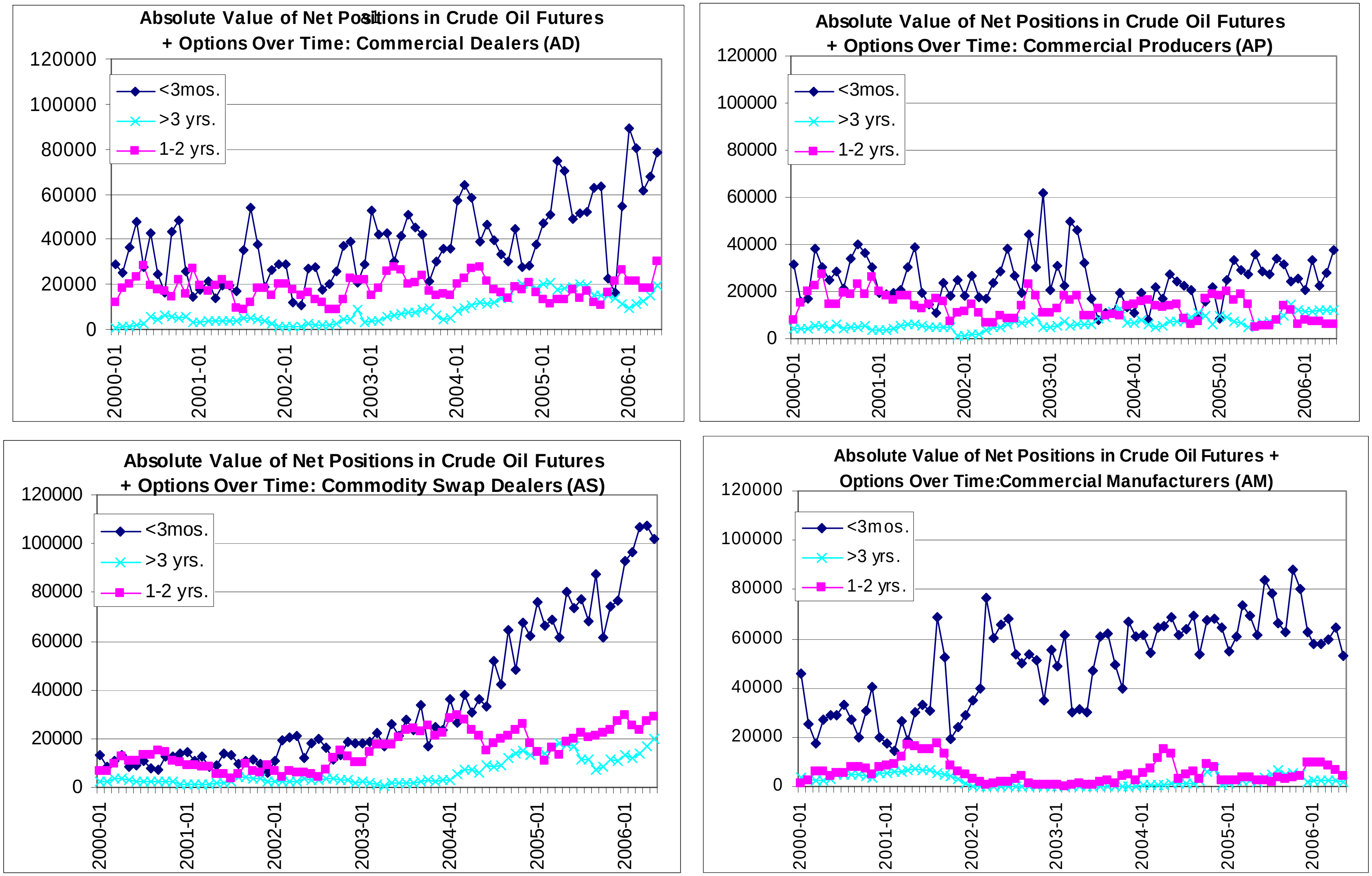
Figure 4: Absolute Value of Net Positions at ≠ Maturities: Changes Since 2000





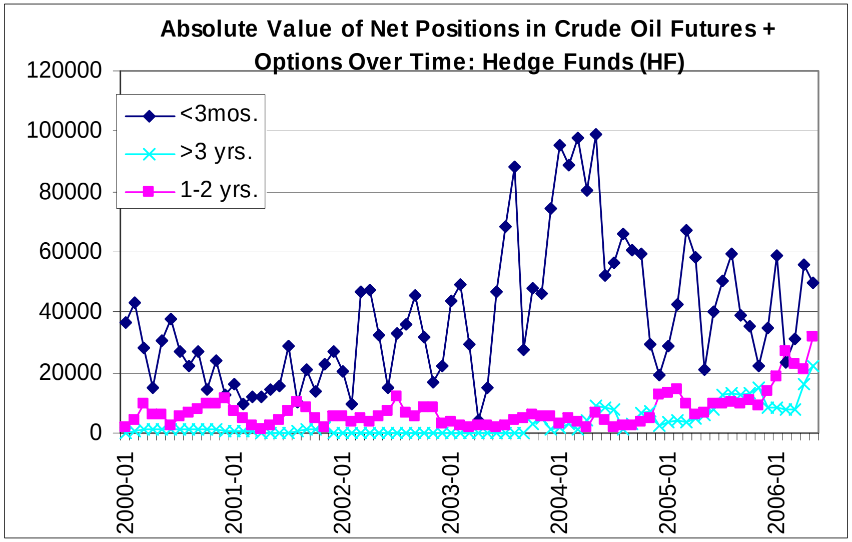
***Notes:* Figure 4** shows the yearly averages (2000-2006) of the absolute values of the net position of commercial and non-commercial traders by contract maturity. "**Commercial**" traders include AD = Dealer/Merchant, AM = Manufacturer, AO = Agricultural and Natural Resource - Other, AP = Producer, AS = Commodity Swaps / Derivatives Dealer (which includes FS = Financial Swaps / Derivatives Dealer FA = Arbitrageur or Broker/Dealer). "**Non-commercial**" traders include HF = Hedge Fund, FBT = Floor Broker / Floor Trader, , as well as the reported positions of traders not subject to the reporting requirement and the positions of traders that have not yet been categorized or do not fit any other category. After taking the absolute value of the daily net positions in each contract for each trader group, figures are summed up appropriately (e.g., for all commercial groups, or for all positions less than 3 months, etc.), and the annual averages are then computed. Figure 4 is directly comparable to Figure 1 above.

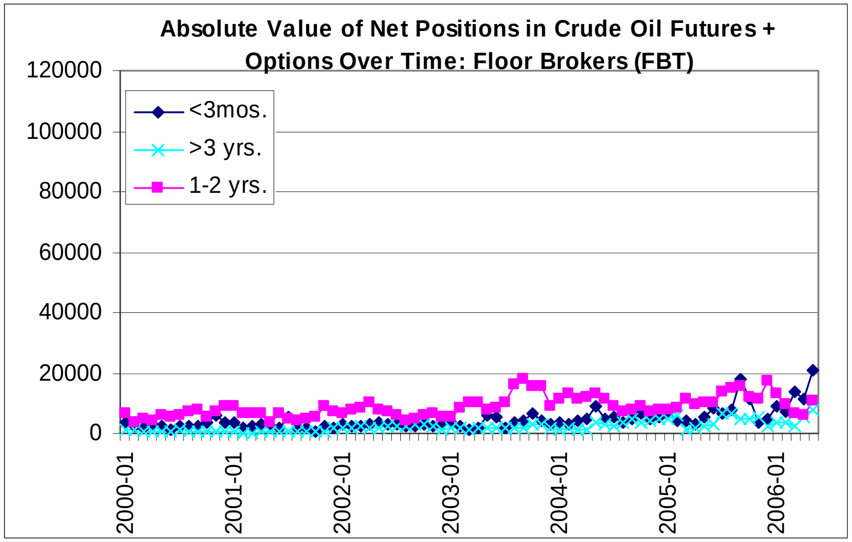
Figure 5a: Magnitude of Short- vs. Long-term Net Positions of Commercial Trader Types, 2000-2006



Notes: **Figure 5a** shows the average monthly magnitudes of the net futures + adjusted options (i.e., futures equivalent) positions, by contract maturity, of the four commercial trader types: AD = Dealer/Merchant, AP = Producer, AM = Manufacturer,, and AS = Commodity Swaps/Derivatives Dealer (which includes FS = Financial Swaps / Derivatives Dealer FA = Arbitrageur or Broker/Dealer). After taking the absolute value of the daily net positions in each contract for each trader group, figures are summed up appropriately (e.g., for all positions less than 3 months, etc.), and the annual averages are then computed. The graphs are scaled to allow for easy comparisons of the relative sizes of the net positions held by different trader categories. Figure 5a is directly comparable to Figure 3a above and to Figure 6a below.

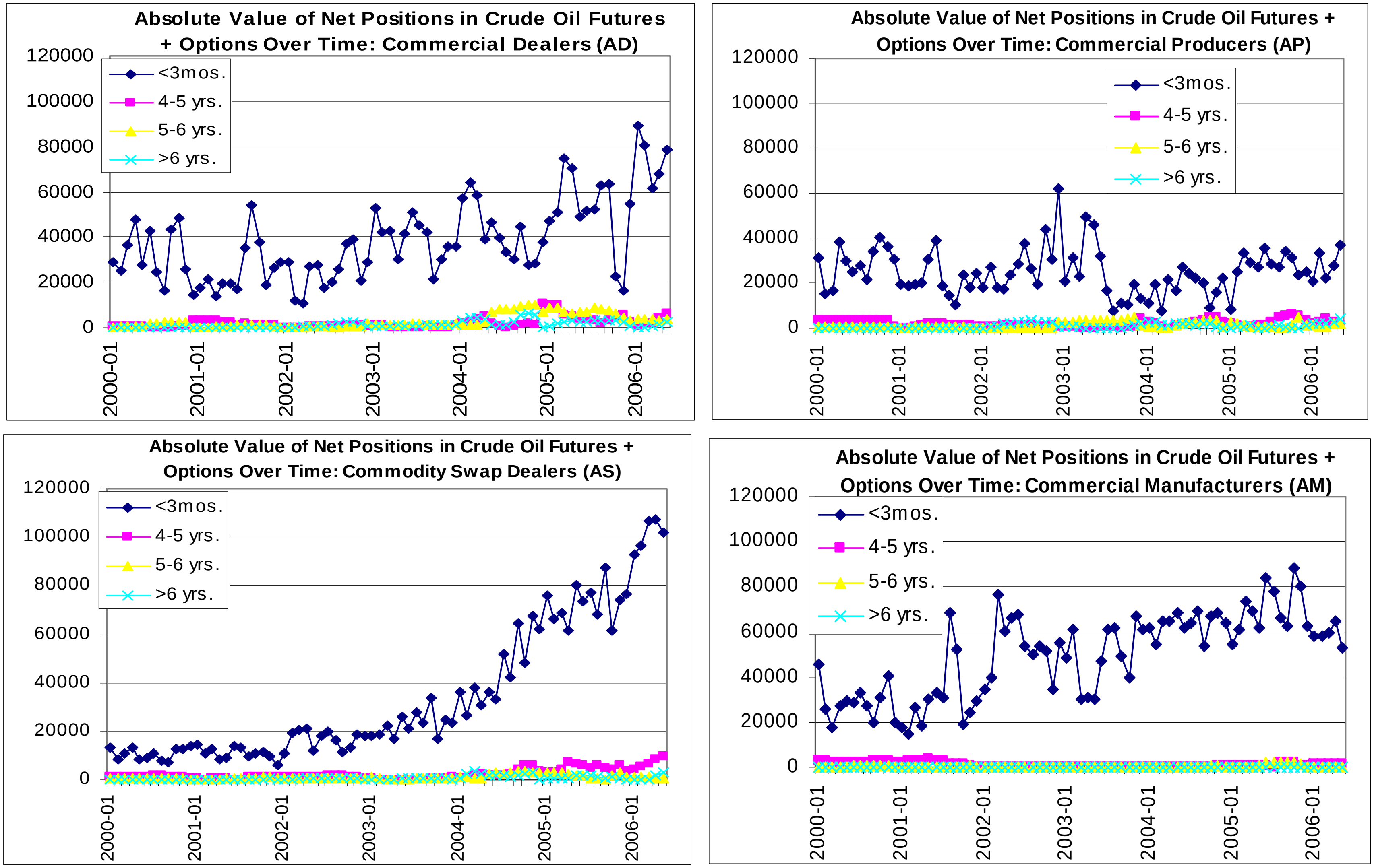
Figure 5b: Magnitude of Short- vs. Long-term Net Positions of the Major Non-Commercial Trader Types, 2000-2006





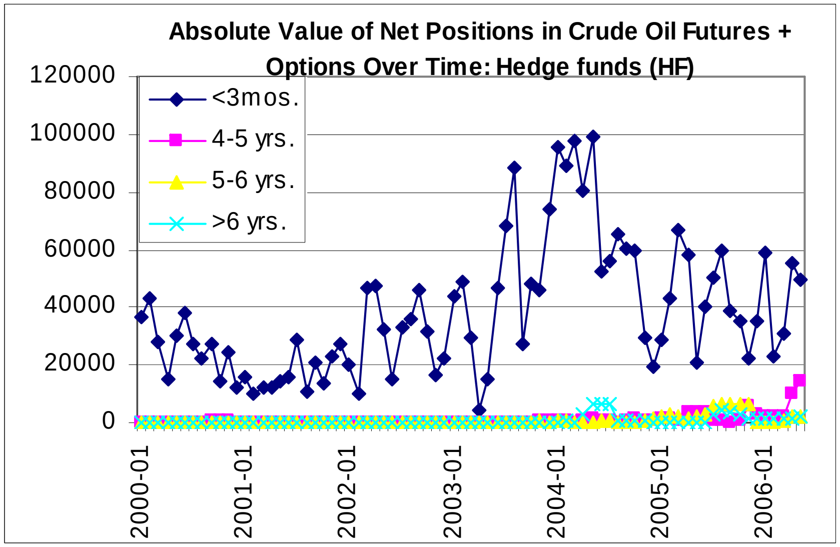
Notes: **Figure 5b** shows the average monthly magnitudes of the net futures + adjusted options (i.e., futures equivalent) positions, by contract maturity, of the two major non-commercial trader categories: HF = Hedge Fund, and FBT = Floor Broker/Floor Trader. After taking the absolute value of the daily net positions in each contract for each trader group, figures are summed up appropriately (e.g., for all positions less than 3 months, etc.), and the annual averages are then computed. The graphs are scaled to allow for easy comparisons of the relative sizes of the net positions held by different trader categories. Fig. 5b is directly comparable to Figure 3b above and to Figure 6b below.

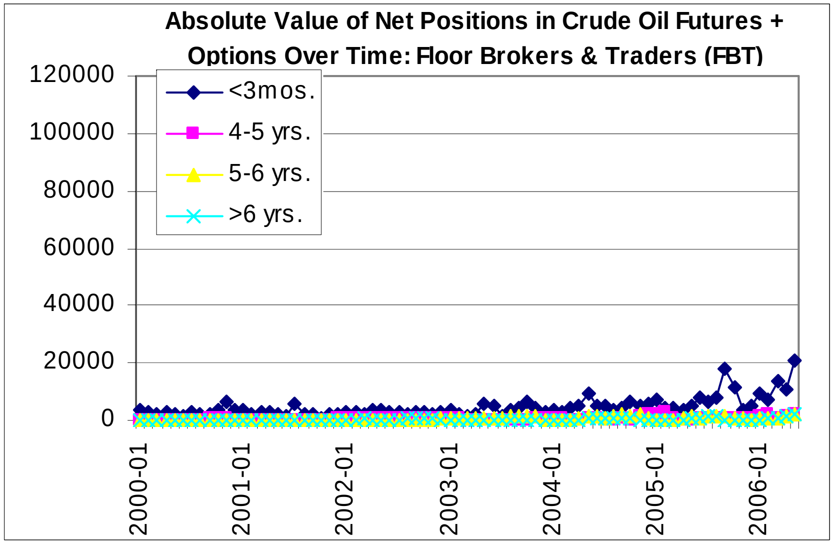
Figure 6a: Magnitude of Short- vs. Very Long-term Net Positions of Commercial Trader Types, 2000-2006



Notes: **Figure 6a** shows the average monthly magnitudes of the net futures + adjusted options (i.e., futures equivalent) positions, by contract maturity, of the four commercial trader types: AD = Dealer/Merchant, AP = Producer, AM = Manufacturer,, and AS = Commodity Swaps/Derivatives Dealer (which includes FS = Financial Swaps / Derivatives Dealer FA = Arbitrageur or Broker/Dealer).. After taking the absolute value of the daily net positions in each contract for each trader group, figures are summed up appropriately (e.g., for all positions less than 3 months, etc.), and the annual averages are then computed. The graphs are scaled to allow for easy comparisons of the relative sizes of the net positions held by different trader categories. Figure 6a is directly comparable to Figures 3 and 5 above.

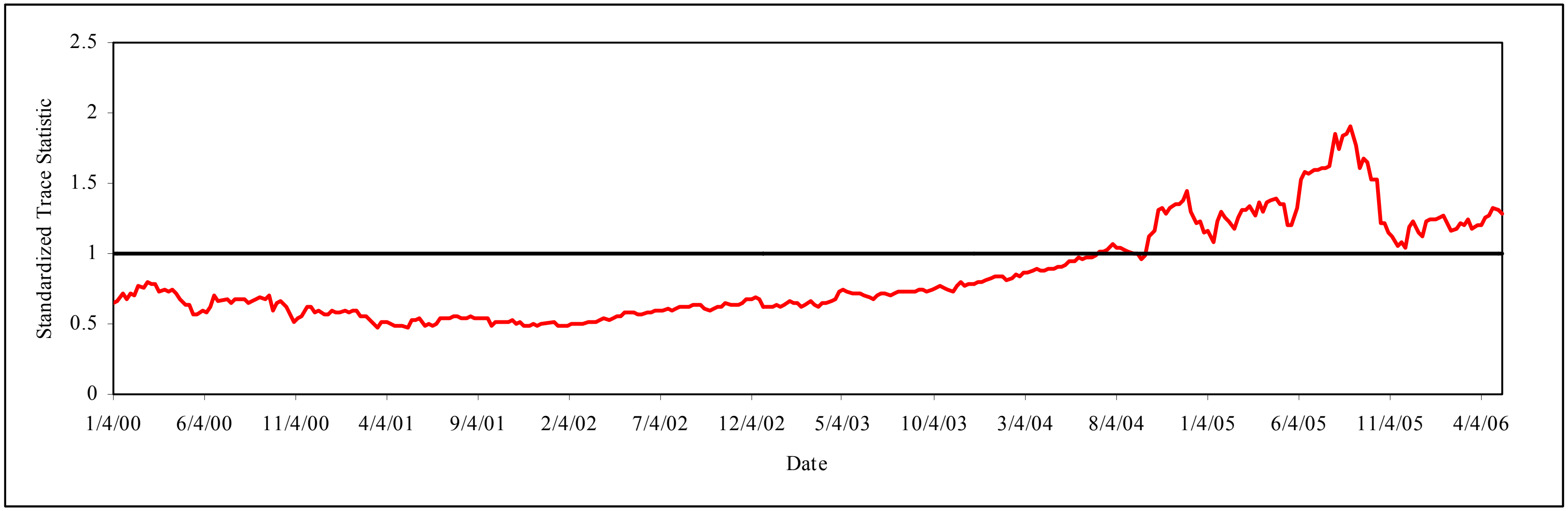
Figure 6b: Magnitude of Short- vs. Very Long-term Net Positions of the Major Non-Commercial Trader Types, 2000-2006





Notes: **Figure 6b** shows the average monthly magnitudes of the net futures + adjusted options (i.e., futures equivalent) positions, by contract maturity, of the two major non-commercial trader categories: MMT = Managed Money Trader, and FBT = Floor Broker/Floor Trader. After taking the absolute value of the daily net positions in each contract for each trader group, figures are summed up appropriately (e.g., for all positions less than 3 months, etc.), and the annual averages are then computed. The graphs are scaled to allow for easy comparisons of the relative sizes of the net positions held by different trader categories. Figure 6b is directly comparable to Figures 3b and 5b above.

Figure 7. Recursively Calculated Trace Test Statistic Scaled by the 5% Critical value for Nearby, One & Two Year Contracts.



The R-1 form of the trace statistic is represented by the light (red) line. The 5% critical value is represented by the solid black line.

Figure 8. The Time Paths of the Speed of Adjustment Parameters (and 5% confidence interval)