Prepared Testimony of
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to

The Permanent Subcommittee on Investigation of the U.S. Senate
Committee on Homeland Security and Governmental Affairs
and
The Subcommittee on Energy of the U.S. Senate
Committee on Energy and Natural Resources

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Mr. Chairman, members of the Subcommittee on Investigation and the Subcommittee on Energy, it is my pleasure to discuss today developments in world oil markets. In my testimony, I will briefly describe the market changes that have occurred this year and then explore some of the widely cited explanations for these changes. My analysis leads to the following conclusions.

First, the rise in light sweet crude prices to almost $100 per barrel in November came about because the U.S. Department of Energy has been removing a significant share of the daily volume of this type of crude from the market for storage in the Strategic Petroleum Reserve. The volumes have amounted to as much as 0.3 percent of the global supply of light sweet crude available. DOE's actions may have added as much as 10 percent to the light sweet crude price, given the very low estimated price elasticity of demand for crude and the likely even lower price elasticity of demand for light sweet crude. This conclusion is supported by the fact that producers of sour crude oils such as Saudi Arabia have had to institute price cuts of as much as $10 per barrel for sour crude.

Second, prices have been pushed higher because private firms have been reducing inventories. Over the last six months, U.S. refiners liquidated as much as 50 million barrels of crude oil stocks. This liquidation occurred because holding stocks was no longer profitable. The decline in profitability can be traced to the turmoil in financial markets and to greater sophistication on the part of investors who acquire commodities as an asset class. The change in profitability makes it almost impossible for OPEC to inject additional oil into inventories owned by private companies even if commanded to do so by the Secretary of Energy and the International Energy Agency's Executive Director.

Third, light sweet crude demand has been boosted by new environmental regulations requiring the removal of almost all sulfur from diesel fuel sold in the United States, Canada, and Europe. The need to manufacture diesel containing less than 10 parts per million of sulfur for sale to motorists and truckers—and soon other diesel users—creates an op-

erating hurdle for refiners that is more easily met with low-sulfur crudes. This has created added demand for light sweet crude.

Fourth, the price rise cannot be explained by international events such as the dispute between Turkey and the Kurds or concern over Iran's nuclear program. To the contrary, the international scene has become calmer, as demonstrated by the declining American casualty rate in Iraq. All things being equal, prices would have decreased if the only recent change was one experienced in the international arena. As I suggest below, there is no risk premium for crude.

Fifth, the current oil price increase has not been spurred by speculation.

I conclude by suggesting that Congress and the Bush administration could change the current market environment by altering the management of the strategic reserve. A policy where storage of sour crudes is accelerated and stocks of light sweet crudes sold off would allow the United States to fill the strategic reserve faster and relieve some, if not all of, the upward pressure on crude prices. Ultimately, this strategy would leave the U.S. SPR with a billion or more barrels of sour crude that almost all refiners could process. However, it would also require relaxing certain EPA regulations during a severe emergency, as was done after Hurricane Katrina.

**Background**

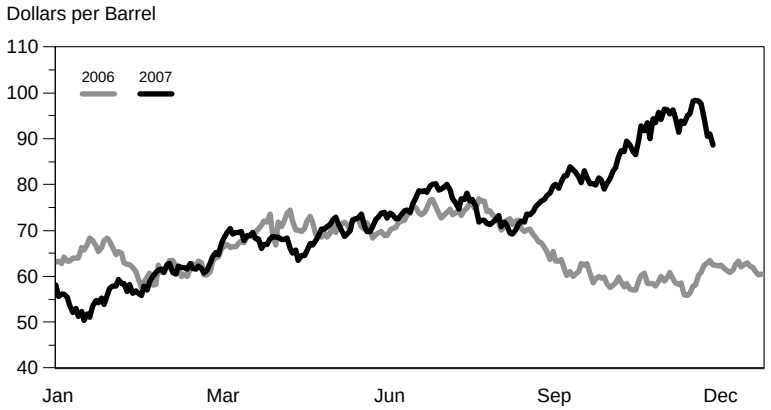
Oil prices in 2007 closely tracked oil prices in 2006 through the first eight months of the year. As can be seen from Figure 1 (page 3), there was almost no difference in prices between 2006 and 2007 from February 1 to August 15.

I should note that the WTI prices shown in Figure 1 for January 30, 2007, through July 25, 2007, are not the cash prices published by *Platts* or *Petroleum Argus*. Rather, they were generated by taking Dated Brent prices and adding the traditional spread between WTI and Brent of $1 per barrel. The adjustment is required because the Cushing WTI market faced a unique and very local problem from February to July due to a fire that closed Valero's McKee refinery. The McKee refinery is located near the West Texas fields and historically has processed West Texas Intermediate crude. For the managers of that refinery, WTI is not just a paper concept, it is real oil. When fire shut the refinery, Valero reversed a pipeline, injecting more light sweet crude into Cushing and depressing WTI prices by as much as $8 per barrel relative to Brent.

I will add that such market anomalies are not unusual. Wyoming produces a very sweet crude that, due to logistical constraints, goes only to refineries in Colorado and Wyoming. Normally, Wyoming Sweet trades at prices close to WTI. However, in 2006 Wyoming Sweet traded at a discount of as much as $30 per barrel to WTI when a large refinery in Colorado was closed for maintenance.

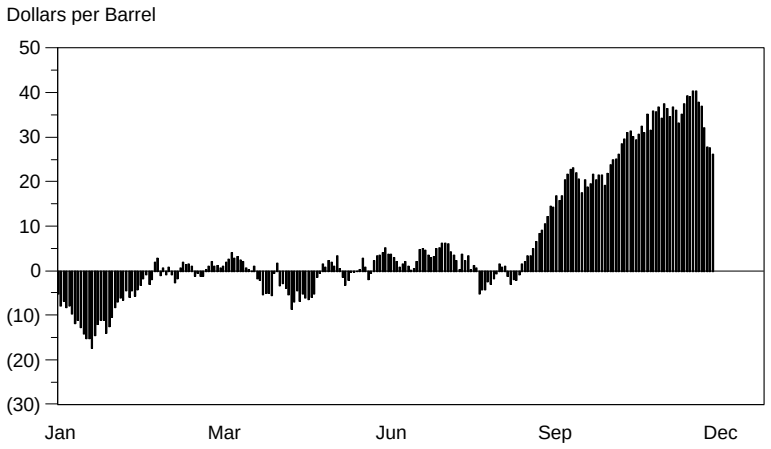
The message to take from Figure 1 is that 2006 and 2007 markets were very similar until mid-August. After August 20, though, markets changed. Figure 2 captures the magnitude of the shift. The graph shows the difference between prices in 2006 and 2007. By my reckoning, the recent price increase ranks as one of the three or four largest jumps in crude prices over a short period of time in the last 30 years. The other increases of a similar magnitude occurred during the Iranian Revolution, Iraq's invasion of Iran a year later, and Iraq's 1990 invasion of Kuwait. The current increase is that large.

**Figure 1**
**Daily WTI Prices in 2006 and 2007***




Note: WTI prices between January 30, 2007, and July 25, 2007, have been adjusted to remove the impact of a Valero refinery fire (see text).
Source: Platts; PKVerleger LLC.

**Figure 2**
**Difference between WTI Prices in 2006 and 2007**




Source: Platts; PKVerleger LLC.

With this background, it is important to ask what happened to oil markets. In other words, what factors can explain the sudden price rise that puts 2007 on par with 1979, 1980, and 1990?

**International turmoil does not explain the price rise.**

Economic historians looking at these markets 15 or 20 years from now will no doubt begin by trying to find international events that could have triggered the 2007 price rise. They will find a few tidbits. For example, market analysts rushed to cite Turkey's threat

to invade the Kurdish area of Iraq as an explanation. Others pointed to rising tensions between the United States and Iran as a cause.

However, these explanations simply do not hold. Turkey's threat to invade Iraq is not on par with Iraq's invasion of Iran. It's not even close. Furthermore, the tensions between the United States and Iran cannot explain an almost 50-percent hike in crude prices. No, the typical blaming of international events does not work this time.

I will go further. Often, one hears analysts speak of a risk premium in oil prices. Today, there is no risk premium. Indeed, I doubt there ever has been a risk premium in the price of oil.

**Growing demand in India and China also does not explain the price rise.**

Future economic historians seeking to explain the 2007 price increase will likely turn to the prospective consumption growth in China and India as a reason for the oil price surge that began in August. Some will no doubt find that the prospect of smaller increases in output from countries such as Venezuela, Russia, and Kazakhstan added further upward pressure to prices.

These arguments will have great appeal. However, they will fail again because no great revelation regarding China, India, or Russia appeared in August 2007. The Energy Information Administration (EIA), the International Energy Agency (IEA), the National Petroleum Council, and others have been issuing warnings regarding these countries for years. While new information keeps emerging gradually, nothing startling came out this summer. Hence, it is hard to attribute the sudden price boost to oil buyers waking up to the fact that the global economy was expanding and oil use was rising.

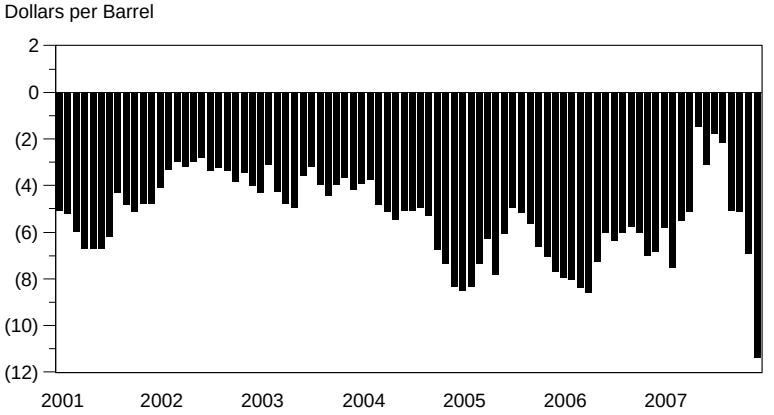
**One cannot attribute the price rise to a global crude oil shortage.**

It may surprise many to discover that some oil producers have had a difficult time selling their crude this fall. One indication of their problems can be seen in the differential between crude oil sold by Saudi Arabia and WTI. Saudi Arabia prices the crude it sells to U.S. customers off WTI prices. Each month the Saudi oil company, Aramco, announces a differential to WTI for firms buying Saudi crude for delivery to the United States in that month. For example, buyers lifting Arab Light Crude from Saudi Arabia this month will pay the WTI price that prevails 50 days from now less $11.65. (The delay allows for the oil's transit time from Saudi Arabia to the United States.) Aramco adjusts this differential every month to reflect changes in market conditions.

As can be seen from Figure 3 (page 5), the differential set by Saudi Arabia for oil loaded in August was $2.15 per barrel. Five months later, the Saudis boosted the discount to $11.65. As every shopper knows, discounts do not deepen when supplies are tight. Rather, they increase when goods do not sell. Apparently, Saudi Arabia has been having trouble selling its oil.

The repeated hikes in the Saudi discount seem to undercut the calls for OPEC countries to boost production coming from energy officials, such as Secretary Bodman, in consuming countries. The cuts suggest a seller—like a department store—trying to move unattractive product.

**Figure 3**
**Discount Offered for Arab Light Purchased FOB Saudi Arabia for Delivery to U.S. Gulf Coast**




Source: Platts; Petroleum Argus.

**Speculation does not seem to explain the price rise. To the contrary, "speculation" may have declined as prices rose.**

Speculators have been the villains in commodity markets for over 100 years. Williams notes the frequent attack on speculators in agricultural markets in a number of his papers.[1] Even today, one hears again and again of farmers complaining about speculators.

However, to blame speculators is to blame "the man behind the tree," the man who is not really there. (Senator Russell Long of Louisiana often used this line: "Don't tax me; don't tax you; tax the man behind the tree.") Many of market participants who might be described as speculators are really investors—individuals or funds trying to earn a return for themselves or constituents such as retirees. Over the last two decades, an extensive literature on commodities as an asset class has emerged. Experts on finance assert that commodities are an asset class and suggest that investors diversify their portfolio between equities, debt, and commodities. Some large pension funds have gone further. The California Public Employees Retirement System, for example, puts a portion of its assets in physical commodities, and Harvard owns forests in its endowment.

Many investors put money into commodities by purchasing futures, prompted by research that shows that commodity futures outperform equities in firms that own energy and other commodity resources. These investors have been guided by academics such as Gary Gorton and Geert Rouwenhorst.[2] Last December, OPEC and the EU convened a meeting of experts to discuss the impact of this development. I and four other U.S. citizens were

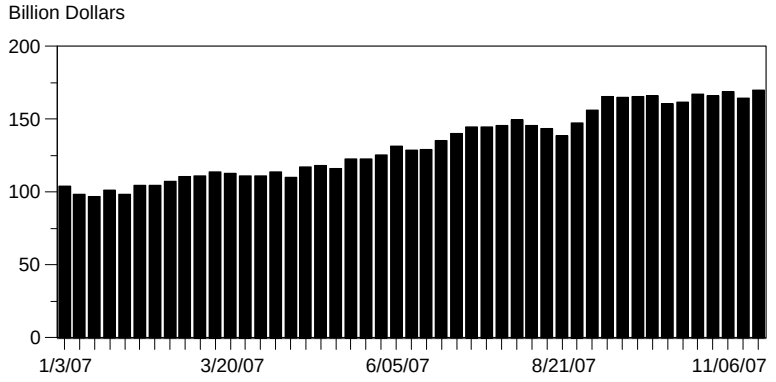
[1] See, for example, Jeffrey C. Williams, *The Economic Function of Futures Markets* (Cambridge, England: Cambridge University Press, 1985).
[2] Gary Gorton and Geert Rouwenhorst, "Facts and Fantasies about Commodity Futures," *Financial Analysts Journal* 62, No. 2 (2006).

invited to speak. Tragically, no official from the U.S. government joined representatives from the IEA, the EU, OPEC, and various governments of OPEC and EU members.

However, the Commodity Futures Trading Commission (CFTC) has noted the emergence of commodities as an asset class. Beginning in January, the CFTC has reported data on agricultural futures contracts held by investors. These data allow one to estimate the money invested in commodities—and the money invested in oil futures. In Figure 4, I show the total amount invested in commodities by this new group of participants. The approach used to back into the calculation is explained in Appendix A, which reproduces a report I issued in January.

Figure 4 shows the amount invested in commodities has increased from $100 billion in January to $170 billion at the end of November. Note that most of the growth occurred before the middle of August, that is, before crude prices started their remarkable rise.

**Figure 4**
**Estimated Amount Invested in the Two Principal Commodity Futures Asset Instruments**




Note: The two instruments are the S&P GSCI and the Dow Jones-AIG indexes.
Source: PKVerleger LLC.

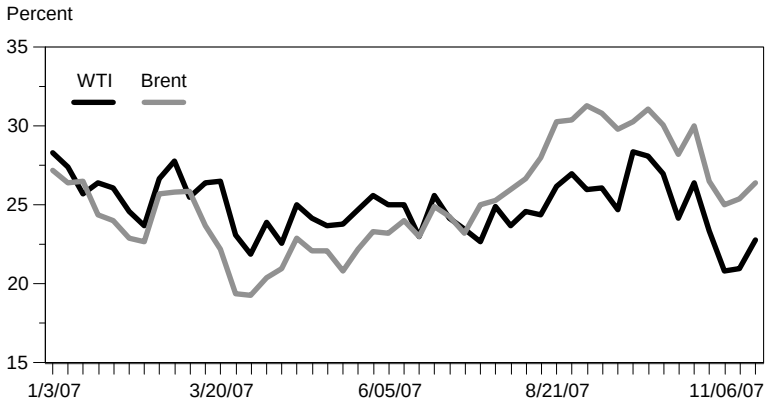
The CFTC data also allow one to calculate the percentage of open interest in crude oil or petroleum product futures contracts held by investors in these commodities. (Again, the basis of the calculation is explained in Appendix A.) Figure 5 (page 7) shows the movement of this percentage from beginning of the year. Note that the share rose during the early summer and then *declined* from the end of September. This suggests that commodity investors had a *diminishing influence on oil prices as prices rose*. This is hardly the empirical result one would expect if speculators were really causing the price increase.

Lastly, we show in Figure 6 (page 7), the rise and fall in open interest in the three principal crude oil futures contracts: NYMEX Light Sweet Crude (also referred to as WTI), ICE Light Sweet Crude, and the International Petroleum Exchange Brent Crude contract. The graph extends from 1991 to November 20, 2007. Data are shown as of each Friday. I note that open interest peaked at the end of September at almost three million contracts and has since dropped to 2.5 million contracts. The decrease in October and November is hardly consistent with a hypothesis that attributes the price rise to speculation. To the contrary, the data seem to exonerate speculators.

**Changes in expectations do not explain the price increase.**

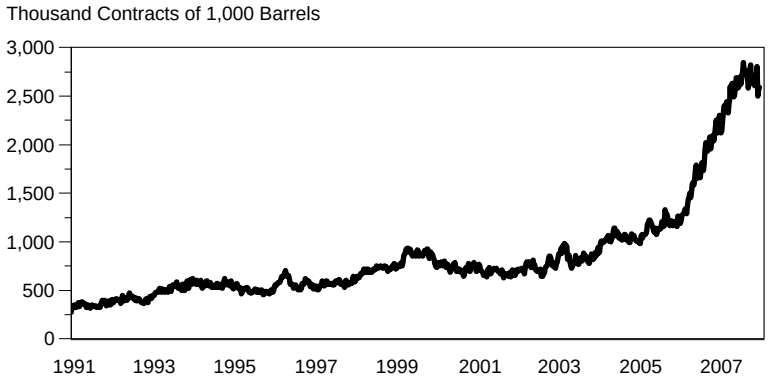
Expectations often determine the actions taken in markets. For example, owners of a nonrenewable resource may be willing to produce for $10 if prices are expected to be $10 in five years. On the other hand, they will be disinclined to produce today if prices in five years are expected to be $100. Instead, they may well sell future production for $100 and wait. In such circumstances, consumers will bid up current prices to a level that will encourage output if the production is needed.

**Figure 5**
**Percentage of Open Interest in WTI and Brent Futures Accounted for by Investment in Two Principal Commodity Indices**




Source: PKVerleger LLC.

**Figure 6**
**Total Open Interest in Three Principal Crude Futures Contracts, January 1991 to November 2007**




Note: The three contracts are the NYMEX Light Sweet Crude contract, the ICE Sweet Crude contract, and the IPE Brent contract.
Source: NYMEX; ICE; IPE.

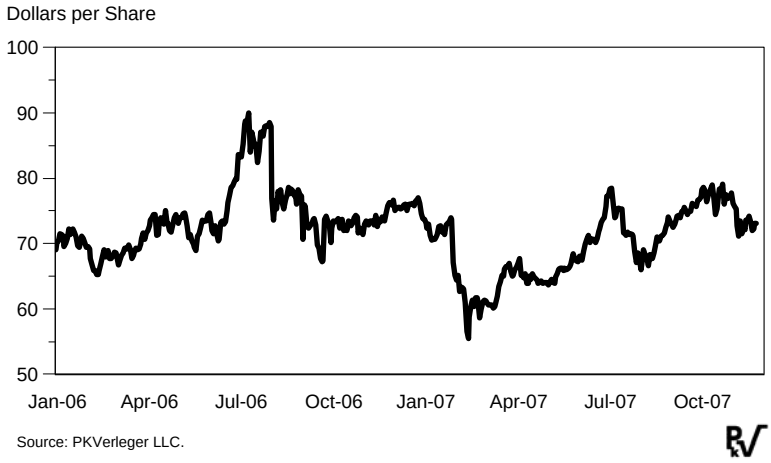
Markets today show good indications of expectations. Share prices of royalty trusts, for example, tend to provide a useful guide to changes in expectations because buyers are paying for a stream of income represented by payments for oil. Under specific circumstances, the share prices of these instruments represent an unbiased view of the likely trend in future prices. Furthermore, increases in these share prices will indicate changes in expectations that may require increases in cash prices.

One widely observed instrument is the BP Prudhoe Bay Royalty Trust (BPT). The trust was created in 1989 by BP. Its shareholders receive 16 percent of the first 90,000 barrels

per day of royalty production from the Prudhoe Bay Unit. Movement in share prices measures the shifts in market expectations of future oil prices. Empirical research has demonstrated that predictions derived from the trust have been systematically more accurate than projections generated by other approaches, including those employed by DOE. This finding is not surprising because those investing in the trust have more at stake financially than model builders do.

Figure 7 shows the daily movement in the BPT share price from January 2006 through November 28, 2007. Inspecting these data reveals the absence of any real trend. While detailed modeling of the trust suggests investors expect prices to be slightly higher in, say, 2020 than they did a year ago, the changes are probably within the margin of error. The basic message, then, is that expectations regarding the long-run oil price have not changed much.

**Figure 7**
**Share Price of the BP Prudhoe Bay Royalty Trust as an Indicator of Expections of Long-Run Oil Prices**




This finding may come as a surprise. Recently, the International Energy Agency issued a warning regarding future supply-and-demand imbalances in conjunction with the release of its 2007 *World Energy Outlook*. The study's clear implications were that IEA economists had much different and higher expectations for future prices in 2007 than they did in 2006. Investors do not seem to have reached such a conclusion. As can be seen from Figure 7, BPT share prices have been stable.

**Oil company decisions to liquidate stocks may have exacerbated the oil price rise somewhat.**

Inventories are the most misunderstood economic phenomenon in the energy business. Time and again, one reads statements by energy policy officials commenting on low stocks. Invariably, these officials call on OPEC to boost output so stocks will rise. The economic ignorance displayed in these appeals is appalling.

My favorite quote appeared in November. While attending the World Energy Congress, U.S. Energy Secretary Bodman called on OPEC to boost oil production. As the November 13 *Financial Times* reported, "Samuel Bodman, the U.S. energy secretary, urged

OPEC on Tuesday to raise production at its weekend summit. He said the price of oil was at such high levels in part because developed countries' stocks were below their five-year averages."[3] The story then continued:

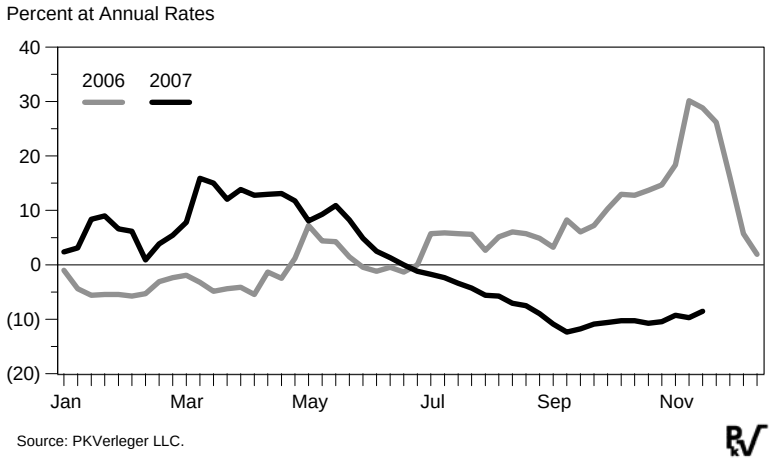
> But Mr. Bodman told reporters at the World Energy Congress in Rome: "I have asked that that be reconsidered. I have asked them to increase production." He said he was trying to draw OPEC's attention to the fact that the inventory numbers were "troubling."[4]

Bodman's statement makes it sound as if commercial inventories will increase if OPEC boosts production. But doesn't something else have to happen for this to occur? Don't companies have to agree to buy the oil? Suppose, given the current financial crisis, that companies choose not to buy the oil? What happens then?

The data demonstrate that companies accumulate incremental stocks oil only if it is profitable to do so. Since May, it has not been profitable. Since May, companies have been dumping stocks. This story is told with two charts.

Figure 8 shows data on "returns to storage" for crude in 2006 and 2007. Returns to storage will be a new concept here because, to my knowledge, neither the Energy Information Administration nor any other organization follows the idea. However, the concept goes back to John Maynard Keynes, who, whatever his other vices, was one of the world's great commodity traders. Returns to storage measure the financial return earned by purchasing a physical unit of a commodity, selling a future for delivery at a later date, and storing the commodity. If, for example, one buys crude for $50 per barrel and sells a future for delivery a year hence at $100 per barrel, one earns a return of 100 percent. The trade, referred to as cash and carry, can be very profitable.

**Figure 8**
**Crude Oil Returns to Storage Adjusted for the Cost of Money**



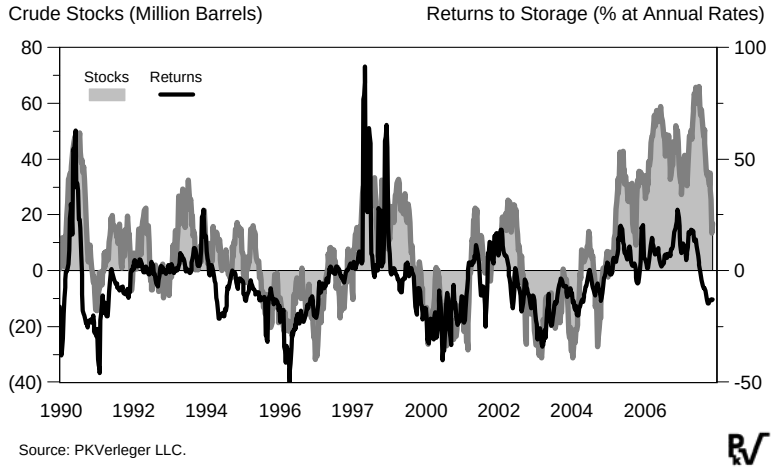

[3] Ed Crooks and Javier Blas, "U.S. Urges OPEC to Raise Production," *Financial Times*, November 13, 2007.
[4] Crooks and Blas.

Rumor has it that Keynes once filled the basements of several colleges with wheat when the returns were really high.

Figure 8 shows that returns to storage for crude oil were positive through the second half of 2006 and the first half of 2007. Since the end of May 2007, though, returns have been negative. Logically, one would expect stocks to have accumulated during the second half of 2006 and the first half of 2007 and then be liquidated from June 2007 forward.

The data on inventory accumulation and liquidation confirm this hypothesis. Figure 9 shows that stocks tend to rise with positive returns and decline when returns are negative. Figure 9 shows the deviations of U.S. inventories from trend from 1990 to 2007. (Note: during this period, we have observed a steady decline in the "normal" level of inventories held by commercial firms. This decrease is explained by improved operating efficiencies in the sector.)

**Figure 9**
**Deviation from Trend of Commercially Held Crude Stocks, 1990 to 2007, vs. Returns to Storage Adjusted for the Cost of Money**




As can be seen from Figure 9, stocks decline when returns fall below zero while tending to rise when returns are positive. The explanation for this effect is quite simple. Financial officers of firms holding oil stocks have a wide number of options. They can invest their cash in commercial paper, Treasury bills, or inventories. They can even borrow to acquire additional stocks. Their decisions are driven by the returns offered by various instruments.

This finding, while intuitively obvious, seems to have escaped many who follow the oil market. Recently, though, the financial market's effect on oil and the rest of the economy has become painfully apparent. In particular, the subprime crisis has caused many lenders to withdraw from the commercial paper market. In turn, the cost of borrowing has increased, raising the cost of holding oil stocks. At the same time, buyers who had lifted forward prices to a premium over cash prices have liquidated positions, in part to obtain cash. This has made it expensive to hold inventories and so stocks have dropped.

Econometric research on the relationship between inventories and price spreads suggests the stock reduction caused by the financial crisis may have added a dollar or two to crude

prices. In other words, the stock decline tied to the financial problems explains a small part of the $30 price rise.

**Conclusion: The rapid climb in oil prices since August cannot be explained by any of the traditional factors.**

International events certainly did not push prices higher. If anything, they forced prices lower. Expectations of strong future growth in consumption did not change markedly after August and thus also must be rejected as a cause of the price rise.

Speculators also do not seem to have played a role in the run-up from $70 to $98 per barrel. Passive investors who buy commodities as an alternative asset class may have reduced ownership of oil as prices rose if they maintained a diversified portfolio and followed the formulas recommended by Goldman Sachs or the managers of the Dow Jones-AIG index. Financial turmoil since August would have further discouraged investors.

Expectations regarding future oil prices also did not change significantly.

Only shifts in inventory management and option hedging could have contributed to the price rise. But these influences certainly cannot explain a $30-per-barrel increase. Indeed, it is difficult to ascribe more than $5 of any increase to these factors.

**By deduction, then, the cause of the increase must lie elsewhere. The one and only significant change was DOE's decision to begin filling the Strategic Petroleum Reserve.**

After more than a year and a half of inaction, the Department of Energy renewed its program to fill the SPR. On August 23, 2007, DOE acquired 97,973 barrels of light sweet crude. Deliveries continued through November, with 5.2 million barrels of crude delivered. An additional 2.2 million barrels were projected to be delivered in December and January.

The mix of crude going into the SPR was approximately 33 percent sweet and 66 percent sour. Table 1 (page 12) presents the details, including type of crude, month of delivery, and total.

As can be seen from Figure 10 (page 12), the oil volumes held in the SPR have increased sharply. The fluctuations in the amounts stored correspond to the surge in crude prices. Indeed, reviewing the history of 2006 and 2007, DOE's action appears to be the single major activity that differentiated 2007 from 2006. Yet despite the evidence, DOE has continued to deny responsibility for the price rise. Indeed, Secretary Bodman seems to have a penchant for belittling such claims without bothering to examine the facts. Recently *Platts* quoted him as calling "the current fill rate, which moves an average

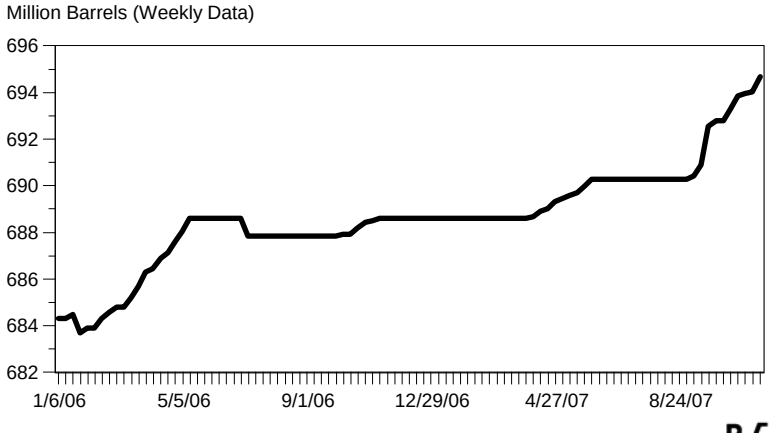
55,000 b/d of royalty-in-kind oil into the reserve, 'modest.'" The Secretary also said, according to *Platts*, that the fill program "'does not materially' lift the price of oil."[5]

Table 1. Rate of Fill for the U.S. Strategic Petroleum Reserve, August 2007 to January 2008

| | Sour Crude (Barrels) | Sour Crude (Barrels per Day) | Sweet Crude (Barrels) | Sweet Crude (Barrels per Day) | Sulfur Content of Sour Crude (%) | Sulfur Content of Sweet Crude (%) |
|---|---|---|---|---|---|---|
| Aug 2007 | | | 166,273 | 11,085 | | 0.37 |
| Sep 2007 | 1,895,017 | 63,167 | 472,749 | 15,758 | 1.26 | 0.34 |
| Oct 2007 | 547,018 | 17,646 | 781,375 | 25,206 | 1.37 | 0.34 |
| Nov 2007 | 1,103,514 | 36,784 | 278,779 | 9,293 | 1.05 | 0.28 |
| Dec 2007 | 2,000,000 | 64,516 | 1,000,000 | 32,258 | 1.46 | 0.32 |
| Jan 2008 | | | 250,000 | 8,065 | | 0.28 |
| Total | 5,545,549 | 40,776 | 2,949,176 | 21,685 | | |
| Rate of Fill – January through June 2008 | | | | 39,200 | | |

Source: Communication from Committee Staff from data supplied by U.S. DOE.

**Figure 10**
**Crude Stocks Held in the U.S. Strategic Petroleum Reserve in 2006 and 2007**




The Secretary's statement might be correct if DOE were adding only sour crude to the reserve. Sour crude, as noted above, is in surplus. However, more than a third of the oil added to the SPR is light sweet crude. Today, sweet crude constitutes less than one quarter of the world's supply and probably less than one half of this production is available to the market. Thus DOE is taking more than a "modest" amount of the available sweet crude from the market. Indeed, the market impact may be significant given the very low price elasticities of demand for crude, especially light sweet crude.

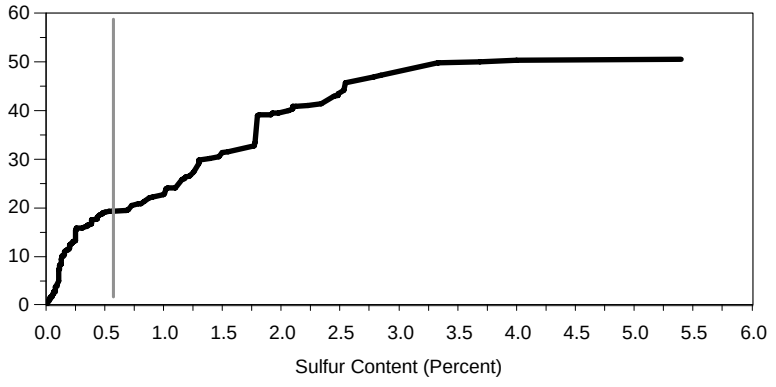
The empirical impact of DOE's actions on light crude prices depends on several factors, including

[5] *Platts Global Alert*, November 8, 2007.

- The size of the market for sweet crude,
- The ability of consumers to substitute sour crude for sweet crude, and
- The price elasticity of demand for sweet crude.

*The size of the sweet crude market may be as large as 20 million barrels per day or as small as five million barrels per day.* Figure 11 shows the distribution of the global crude market by sulfur content. The data are taken from the Energy Intelligence Group's *International Crude Oil Market Handbook*. As can be seen from Figure 11, EIG identified a total of 20 million barrels per day of global production as having a sulfur content of 0.5 percent or less. It is this output—and not total world production—that must be used to measure market size.

**Figure 11**
**Cumulative Distribution of Global Crude Production in 2006 as Reported by Energy Intelligence Group**




Source: Energy Intelligence Group.

However, a significant portion of the 20 million barrels of light sweet crude production is captured under long-term supply arrangements and thus not available to DOE or to the firms that might want to replace the light sweet crude they would have otherwise received had DOE not acted. Some light sweet crude is produced in China, for example, and stays in China. Some light sweet crude is tied permanently to Asian consumers, while other volumes are linked directly to European refiners. Thus the pool of oil from which DOE is pulling may be smaller than five million barrels per day. This means DOE may be taking between 0.1 and 0.5 percent of the light sweet crude from the market.

This supply cannot be replaced. Middle Eastern countries can raise production of sour crude to compensate for increased demand tied to the SPR filling. There is, in contrast, no surplus capacity to produce light sweet crude. DOE is shrinking the market.

*The price impact of removing light sweet crude from the market depends in part on the ability of refiners to replace sweet crude with sour crude.* In theory, refineries are flexible. The best ones should be able to substitute crude oils with higher sulfur content for the lost supplies of sweet crude. However, new regulations limiting the sulfur content of diesel fuel bring this assumption into question. Recent reports by the International

Energy Agency suggest these requirements make it much more difficult for refiners to substitute sour for sweet crude. In particular, desulfurization units at refineries often limit the amount of product that can be made. This means product volumes are lost when sweet crudes are removed from markets. Regulations requiring the reduction of sulfur in diesel fuel appear to impose especially severe constraints on refiners.

Refiners and traders have stated privately that light sweet crude is particularly valuable given new regulations limiting the sulfur content of gasoline and diesel fuel. However, other than a few mentions in the *IEA Monthly Oil Market Report*, very little has been written on the intrinsic value of light sweet crude.

In one private arbitration, refining engineers explained that light sweet crude was of particular value because it could be taken to the distillation unit directly and thus did not clog units that pretreated heavier, sourer crudes. In addition, the engineers explained that more crude could be processed and more product could be made in facilities where desulfurization or hydro-treating units constrained total refining operations. I have yet to find citations explaining these claims in detail, although I have read such statements made under oath in legal proceedings.

*The price impact of removing light sweet crude from the market price depends on the price elasticity of demand for crude oil.* Professor Nordhaus recently published an estimate of the price elasticity of demand for crude of -0.04.[6] This elasticity is measured in regard to refiner demand for all crude oil. Because light sweet crude oil has special properties, the price elasticity of demand for light sweet crude may be lower, say, -0.02. The latter elasticity implies that a one-percent reduction in the light sweet crude supply would require a price increase of between 25 and 40 percent to balance the market.

As noted above, we calculated that DOE's SPR action has taken between 0.1 and 0.5 percent of the sweet crude supply from the market. Using the elasticities given earlier, one can estimate that DOE's actions added between five and 20 percent to the price of oil. On average, it appears that DOE's SPR program probably added $10 per barrel.

**Option hedging may have magnified the price rise.**

The November 29, 2007 *New York Times* carried a detailed report on airline fuel hedging practices. In one of the few good articles on petroleum to appear in the *Times* in years, Jeff Bailey disclosed a secret that a few of us have known for a long while: Southwest Airlines has fuel management practices that are very different from all other airlines.[7] Through hedging, Southwest has held its fuel cost to a $51-per-barrel basis in 2007, 2008, and 2009, while other airlines are dealing with prices between 50 and 100 percent higher. Southwest's hedges enabled it to book a profit on fuel of $429 million for the first half of 2007. The profit might jump to $1 billion in the second half of the year.

[6] William Nordhaus, "Who's Afraid of a Big Bad Oil Shock," *Brookings Papers on Economic Activity* 2, 2007 (forthcoming).
[7] Jeff Bailey, "An Airline Shrugs at Oil Prices," *The New York Times*, November 29, 2007.

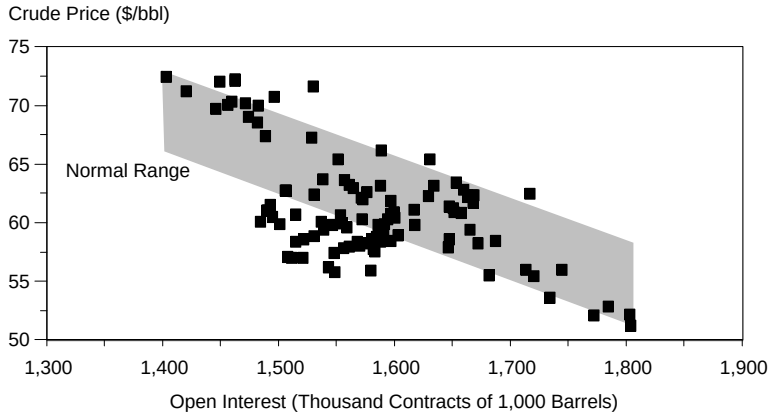
Southwest achieved its position through the purchase of options: instruments that allow it to buy crude at the strike price ($51-per-barrel crude equivalent) if market prices are higher. Should prices fall below $51, though, Southwest is not obligated to act.

Southwest is not the only firm to use options. Many large consumers and some speculators have purchased call options with strike prices between $60 and $100 per barrel, while several producers have hedged production by acquiring puts. Bailey reported on the position of a number of airlines that had purchased calls at strike prices ranging from $62 per barrel (Alaska Airlines) to $99 (Delta).

The institutions that write call options hedge their exposure to Southwest and others following the same strategy: they purchase futures as prices rise. Thus as prices went from $70 per barrel on August 18 to $95 in early November, the financial institutions that had written these calls bought additional futures. Their buying helped to raise prices.

Bankers refer to this process as "delta" hedging. The procedures and the effects are well known. Indeed, delta hedging was widely credited for a large fraction of the decline in copper prices that occurred in 1996 when Sumitomo's effort to manipulate copper prices failed. Last year, delta hedging of puts written to oil producers seemed to accelerate the price decline. The action clearly exaggerated the decrease. I am relatively certain WTI prices would never have dropped below $65 per barrel early in 2007 (they actually went to $51) had they not been pushed down by delta hedging.

**Figure 12**
**Light Sweet Crude Prices vs. Open Interest in Crude Futures, August 2006 to January 2007**




Source: NYMEX; PKVerleger LLC.

The decrease can be seen from Figure 12. This graph shows open interest in crude oil futures on the horizontal axis and price on the vertical axis.[8] Under the delta hedging hypothesis, one would expect to observe falling prices associated with rising open interest because the financial firms that had written put options would need to sell more futures contracts. Precisely such a relationship was observed. As can be seen from Figure 12, during the fall of 2006, there was a relatively close correlation between open interest and prices. In other words, delta hedging pushed prices down.

[8] In this graph, the open interest represents the combined total of NYMEX and ICE contracts.

The shaded area in Figure 12 represents a normal range. This is a calculated from a regression of prices on open interest. It shows a two-standard-deviation range of the predicted price given open interest for the fall period.

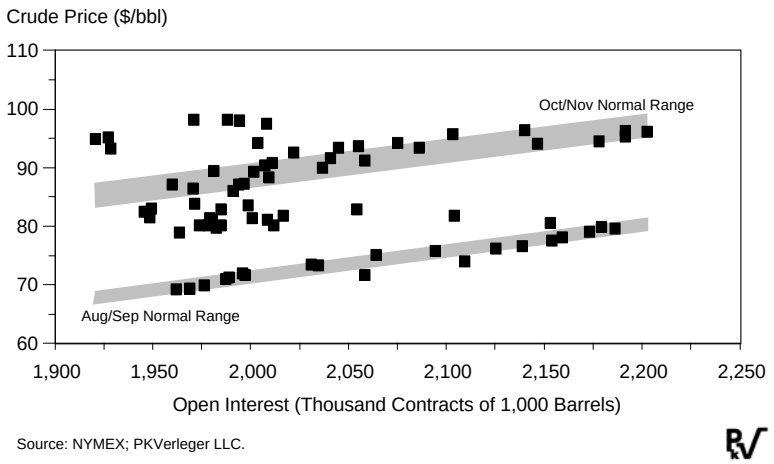
The link to delta hedging in the fall of 2006 was confirmed in discussions with traders. From time to time in markets, one reads or hears that large price moves on a single day were triggered by computer purchases or sales made by financial firms seeking to cover options written by the firms to consumers or producers.

This fall we have observed precisely the opposite effect. Figure 13 shows a scatter diagram of open interest and prices for the August to November 2007 period. Two normal ranges are shown. The first, at the bottom of the graph, is for the August/September period when call options were being hedged for November. The second range at the top shows the normal range calculated for the hedging of December options during the October/November period. Again, we note the shaded area. In 2007 the curves are upward sloping, suggesting it was calls, not puts being hedged.

These data indicate that the price increases tied to DOE's purchases of sweet crude oil were magnified by option hedging.

**The market chaos caused by DOE's filling of the SPR can only be mitigated if sour crude is added to the reserve. Regretfully, DOE will do the opposite in the first half of 2008.**

**Figure 13**
**Light Sweet Crude Prices vs. Open Interest in Crude Futures, August 2007 to November 2007**




Source: NYMEX; PKVerleger LLC.

I understand from Committee Staff that DOE will add 39,200 barrels per day of light sweet crude to the SPR over six months beginning in January 2008 under a contract announced in November. This rate doubles the rate of the oil being recovered over the last four months of 2007. I suppose I should welcome the announcement. However, I do not.

Let me put the news in perspective. For the first half of 2008, DOE will take between 0.2 and 0.8 percent of the light sweet crude oil supply available to U.S. refiners off of the

market. Applying the Nordhaus price elasticities, this action will boost crude prices between two and five percent. If the price elasticity of demand for light sweet crude is half of the Nordhaus elasticity, the price increase will be between five and ten percent.

This price rise will be magnified by delta hedging of options. Indeed, one can expect prices to move well above $100 per barrel if the relationships suggested here hold. Extrapolation of this fall's evidence could take prices as high as an unbelievable $120 if adult supervision is not brought to bear on DOE. The situation could be made even worse by the arrival of the gasoline season. As noted above and in more detail elsewhere, new environmental regulations place an extra premium on sweet crude in the spring and summer. It will be a disaster for motorists. I suspect it will also be a disaster for the U.S. economy.

I hope events prove me incorrect. I hope my economic analysis is faulty. However, DOE's current action is needlessly risking the health of the U.S. economy. As an alternative, DOE could fill the reserve with sour crude oil, that is, crude having sulfur content above one percent. In theory, DOE could sell sweet crude while acquiring sour crude. Given relative prices, DOE could acquire 12 barrels of sour crude for every 10 barrels of sweet crude sold. Such a policy would accelerate the filling of the reserve and provide even greater protection to the U.S. economy in the event of a true catastrophe.

Properly managed, such a policy would not affect product availability during a crisis. Instead, in the event of troubles, certain environmental regulations could be relaxed to assure Americans of an adequate supply of product. For example, it might be necessary to allow diesel fuel sulfur standards to rise to 200 parts per million.

While some will criticize the necessity of modifying sulfur standards, I note that such changes may be necessary if hurricanes shut down several Gulf Coast refineries for a prolonged period, *even if the SPR has sweet crude*. It is well understood—but never stated—that fuel specifications have to be relaxed after a severe hurricane.

Today, I would argue that the American economy and American consumers would be much better off if DOE changed the mix of crudes being added to the strategic reserve. If I am right, it could make the difference between seeing $60-per-barrel prices next summer and $120-per-barrel prices.

I thank the Committee for its attention.

## Appendix A

### CFTC Data on Commitments of Traders: Statistics on Commitments of Index Funds[9]

On January 8, 2007, the CFTC issued new information on commitments of "Index Funds" in agricultural futures. These data provide a unique view into the size of the two largest passive long commodity funds, the Goldman Sachs Commodity Index (GSCI) and the Dow Jones-AIG Commodity Index (DJ-AIG). Based on a quick review of the data and the application of some simple algebra, we draw the following conclusions:

> The DJ-AIG index has roughly $40 billion invested in it.
>
> The GSCI has between $60 and $66 billion invested in it.
>
> Total investment in commodities is approximately $100 billion, which roughly matches published figures from other sources.

The CFTC does not present information on index trading in metals or oils. However, one can back out rough estimates. As of Wednesday, January 3, 2007, it appeared that commodity investors accounted for more than 20 percent of the long positions in WTI and Brent, more than 25 percent of the long position in the RBOB gasoline contract, and more than 35 percent of the long position in distillate heating oil.

**Background**

The CFTC explained the new data as follows:

> ***Supplemental Report*** – Based upon the information contained in the report of futures-and-options combined in the short format, the Supplemental Report shows an additional category of "Index Traders" in selected agricultural markets. These traders are drawn from the Noncommercial and Commercial categories.
>
> Coming from the Noncommercial category are positions of managed funds, pension funds, and other investors that are generally seeking exposure to a broad index of commodity prices as an asset class in an unleveraged and passively managed manner. Coming from the Commercial category are positions for entities whose trading predominantly reflects hedging of over-the-counter transactions involving commodity indices—for example, a swap dealer holding long futures positions to hedge a short commodity index exposure opposite institutional traders, such as pension funds.

[9] Originally published as *Notes at the Margin Supplement to January 8 Issue*, January 9, 2007.

All of these traders—whether coming from the Noncommercial or Commercial categories—are generally replicating a commodity index by establishing long futures positions in the component markets and then rolling those positions forward from future to future using a fixed methodology.

Some traders assigned to the Index Traders category are engaged in other futures activity that could not be disaggregated. As a result, the Index Traders category, which is typically made up of traders with long-only futures positions replicating and index, will include some long and short positions where traders have multi-dimensional trading activities, the preponderance of which is index trading. Likewise the Index Traders category will not include some traders who are engaged in index trading, but for whom it does not represent a substantial part of their overall trading activity.

We summarize the basic statistics from the new CFTC reports in Table 1. There we show the contract, the net position of index funds in the contract, and the percentage of open interest in the contract accounted for by index funds.

Table 1. Net Position of Index Funds in 12 Agricultural Contracts

| Contract | Total Open Interest | Net Position of Index Traders | Index Traders as a Percentage of Total Open Interest |
|---|---|---|---|
| Wheat: Chicago Board of Trade | 513,744 | 201,104 | 39.1 |
| Wheat: Kansas City Board of Trade | 127,957 | 29,963 | 23.4 |
| Corn: Chicago Board of Trade | 1,962,900 | 421,579 | 21.5 |
| Soybeans: Chicago Board of Trade | 497,953 | 129,727 | 26.1 |
| Soybean Oil: Chicago Board of Trade | 287,650 | 67,869 | 23.6 |
| Cotton No. 2: New York Board of Trade | 244,076 | 82,389 | 33.8 |
| Lean Hogs: Chicago Mercantile Exchange | 180,870 | 83,346 | 46.1 |
| Live Cattle: Chicago Mercantile Exchange | 267,023 | 94,995 | 35.6 |
| Feeder Cattle: Chicago Mercantile Exchange | 30,462 | 7,373 | 24.2 |
| Cocoa: New York Board of Trade | 162,595 | 13,666 | 8.4 |
| Sugar No. 11: New York Board of Trade | 786,586 | 156,614 | 19.9 |
| Coffee C: New York Board of Trade | 177,345 | 36,982 | 20.9 |

Source: CFTC Supplemental Report on Commitments of Traders.

## Calculating the Size of Individual Funds

The data published by the CFTC can be used to gauge the size of the two principal funds, the DJ-AIG and the GSCI, because neither fund contains all 12 agricultural commodities. For example, the GSCI contract includes Kansas City wheat and feeder cattle but the DJ-AIG does not. On the other hand, the DJ-AIG includes soybean oil while the GSCI does not. This means that one can gauge the size of each fund ***if one assumes there are no other index funds in the market***. (This assumption is extreme because there is at least one other fund, the Deutsche Bank Index. However, it apparently is quite similar to the DJ-AIG.)

If one makes this assumption, one can calculate the size of the index by determining the value of the index position in the futures contract unique to the index (for example, soy-

bean oil for the DJ-AIG) and then dividing this value by the percentage weight in the index assigned to that commodity. For the DJ-AIG index, the calculation works as follows:

> Index funds held 67,874 soybean oil contracts on January 3.
>
> The value of the contracts on January 3 was roughly $1.2 billion.
>
> The DJ-AIG market share for the index was 3.1 percent.
>
> Thus the total size of the DJ-AIG index was approximately $39 billion (1.2 divided by .031).

A similar calculation for the GSCI yielded estimates of $59 and $66 billion. These market values were then tested against the other commodities. Specifically, we multiplied the estimated value of the GSCI index by the index weight for CBOT wheat and the estimated value of the DJ-AIG index by its weight for CBOT wheat. The sum of the two values 92 percent of the estimated index investment in wheat. Percentages for the other commodities were generally between 95 and 105 percent, although weights differed considerably. This test provides initial confirmation that the sizes are roughly correct.

Table 2. First Approximation of the Share of DJ-AIG and GSCI in Principal Energy Funds

| Commodity | Dollar Value of Contracts (Millions) | DJ-AIG Allocation (%) | GSCI Allocation (%) | Percent of Market Accounted for by Index Investors |
|---|---|---|---|---|
| Natural Gas | $128,769 | 7.1 | 7.4 | 5.6 |
| WTI | $99,570 | 10.6 | 31.2 | 23.1 |
| NY Harbor RBOB | $9,747 | 3.2 | 2.4 | 27.6 |
| NY Harbor Heating Oil | $14,909 | 3.1 | 8.0 | 40.5 |
| Brent | $33,343 | | 15.0 | 27.0 |
| Gasoil | $16,526 | | 4.4 | 16.0 |

Source: Weights taken from Alvin Ying et al., *Commodity Index Monitor*, December 2006; PKVerleger LLC.

## Calculating the Market Share in Petroleum

Our estimate of fund size was used to calculate the aggregate index positions in energy markets. The calculations are shown in Table 2. Column 1 shows the estimated value of the individual market (price multiplied by open interest on January 3, 2007). Columns 2 and 3 show the share of total investment in the fund to the individual contract. Column 4 shows our estimate of the total fund investment in the commodity as a percentage of the commodity's value.