Appendix A: Futures and Exchange Traded Products (ETPs) and Tracking Failures

A.1 ETPs Secured with Futures

Earlier in the semester when you were introduced to ETPs we reviewed a classification of funds called delta funds, which typically try to track the daily change in the spot price of the asset being tracked. These ETPs hold futures contracts as assets. You were cautioned that because a daily error or bias is a common tracking error for these funds, they are typically inadvisable for long term investments.

Now that you know about futures we can return to this subject. For an example we will use an ETP called the United States Gasoline Fund (UGA) offered by United States Commodity Funds. This fund’s stated investment objective is as follows:

The investment objective of UGA is for the daily changes in percentage terms of its units’ net asset value (“NAV”) to reflect the daily changes in percentage terms of the spot price of gasoline, as measured by the daily changes in the price of the futures contract on unleaded gasoline (also known as reformulated gasoline blendstock for oxygen blending, or "RBOB") for delivery to the New York harbor, traded on the NYMEX that is the near month contract to expire, except when the near month contract is within two weeks of expiration, in which case it will be measured by the futures contract that is the next month contract to expire (the "Benchmark Futures Contract"), less UGA’s expenses.

This fund attempts to track the daily delta in the spot price (note that the target is not a futures price) of the same crude oil that we have used as an example throughout this document.

Figure 13 – Asset Holdings of the UGA RBOB gasoline delta tracking ETP.

<table>
<thead>
<tr>
<th>Daily Holdings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security</td>
</tr>
<tr>
<td>Commodity Interests</td>
</tr>
<tr>
<td>NYMEX RBOB Gasoline RB JAN14</td>
</tr>
<tr>
<td>US Treasuries</td>
</tr>
<tr>
<td>Cash</td>
</tr>
</tbody>
</table>

Note that the Net Assets of UGA do not sum to the total of the notional value of the futures contracts plus cash and other liquid assets. The futures contract is not an asset. Cash and the Treasury Bill make up the assets for this ETP.

Source: United States Gasoline Fund of the funds featured at http://www.unitedstatescommodityfunds.com, on the date above.

Given how settlement works, which is to add or subtract the daily change in price, the delta, to the margin account, it is easy to see why futures are used as assets in these kinds of funds. Given that cash is the only asset of value in a futures

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1 In Chapter 6 Exchange Traded Products.
2 Stated "Fund Objective and Key Features" of the United States Gasoline Fund of the funds featured at http://www.unitedstatescommodityfunds.com, as of November 18, 2013. Bold and italics are my emphasis.
trading account, this implies that the fund's NAV is going to be equal to the fund's cash balance divided by the number of ETP units outstanding.

Figure 13, lists the assets of UGA on November 16, 2013. This relatively simple ETP holds a portfolio of 515 long near-term NYMEX (CMEGroup) futures contracts on New York RBOB gasoline. Given that each contract consists of 42,000 gallons (1,000 barrels - the same size as a crude oil contract) and the price at settlement was $2.6364 per gallon, each contract had a notional value of $110,728.80, so all 515 contracts had a combined notional value of $57,025,332 (referred to as Market Value in Figure 13).

Note that the cash value of the account, which includes the U.S. Treasury Bills, equals $56,956,581.66. Note also that the Total Net Assets used to calculate the NAV, which in this case divides those assets by the one million outstanding shares, is nearly identical to the cash value of the account, and certainly does not equal the sum of cash plus the notional value of the futures contract. That is because the futures contract is not an asset. It is a contract that merely changes the cash value of the account every day at settlement. The only asset in a futures-based ETP is the cash in the account.

Initial margin on a single contract as of that date was $4,675 per contract (the maintenance margin was $4,250), only 4.2% of the notional value of the contract, which implies a maximum potential leverage of more than 23 to 1. But Figure 13 should make it clear that this ETP is not leveraged at all, because the cash value of the account is approximately equal to the notional value of the futures contract. When daily settlement takes place, the notional value of the futures contract and the cash value of the ETP rise or fall by exactly the same amount. This implies that the NAV of the ETP will rise or fall by the same percentage of the price per gallon of gasoline in the futures contract, hence no leverage.

In summary, if an ETP is trying to match a price that is represented in a futures contract without leverage (1X long), this will be accomplished if the notional value of the futures contracts approximately equals the cash value (including other liquid assets like Treasury Bills) in the same contract.

This fund's NAV should be able to track the near-term futures prices with nearly 100% fidelity. This however does not imply that this fund will track the spot price of gasoline with 100% fidelity, because spot and futures prices are not the same and they don't even have exactly the same delta. It is for that reason that this fund's investment objective is actually a little misleading (as is typical for these delta funds secured with futures). It states that the objective is for the NAV "to reflect the daily changes in percentage terms of the spot price of gasoline" but then it adds "as measured by the daily changes in the price of the futures contract on unleaded gasoline."

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3 Because there are small payable and receivable cash accounts not reflected in these aggregated numbers, the actual cash shown will never exactly equal total net assets in these releases.
This stated objectively is bizarrely contradictory, because the daily change in the percentage terms of the spot price of gasoline \textbf{is not} measured by the daily change in the price of a futures contract.\footnote{No evidence is presented here but it is certainly available, and will be presented in future editions of this chapter. Simply glancing at data on the \textit{U.S. Energy Information Website} for energy spot prices makes the distinction clear. Unfortunately getting historical futures data for comparisons requires an expensive subscription to a data service.} Unfortunately the spot price and the price of a futures contract are not one and the same and the futures price does not necessarily match or perform the same as the spot price. There are even occasional directional differences (one goes up when the other goes down).

Bias or error might arise if the percentage change in the near-term futures contract is not nearly equal to the percentage change in spot price, because the latter, not the former, is the tracking target.

Nonetheless, Figure 14 - UGA tracks NY Harbor Gasoline with reasonable fidelity makes it clear that this ETP, which traded for the first time on February 28, 2008, has done a good job of tracking New York Harbor gasoline, nearly matching it perfectly from inception until around August 2012. After that a small tracking bias emerges because of the failure to accurately track a sharp plunge in gasoline prices during September and October 2012. But despite that glitch, most investors would be satisfied with the performance of UGA.

It should be obvious from the example above that any \textbf{2X delta tracking} ETP will try to hit their tracking target by holding cash equal to \textit{half} of the notional value of the futures that they hold and any \textbf{3X delta tracking} ETP will hold cash equal to \textit{one third} of the notional value of their futures. Because these funds are more leveraged, they embody more risk, although even 3 to 1 leverage is pretty tame in the futures markets.

\textbf{Figure 15 – Asset Holdings of the DNO short (inverse) crude oil delta tracking stock.}

<table>
<thead>
<tr>
<th>Security</th>
<th>Quantity</th>
<th>Price</th>
<th>Market Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commodity Interests</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NYMEX WTI Crude Oil CL JAN14</td>
<td>-170</td>
<td>93.68</td>
<td>$-15,925,600.00</td>
</tr>
<tr>
<td>US Treasuries</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US T BILL ZCP 11/21/13</td>
<td>1,000,000</td>
<td>100.00</td>
<td>$999,995.67</td>
</tr>
<tr>
<td>Cash</td>
<td>15,016,346</td>
<td>1.00</td>
<td>$15,016,345.81</td>
</tr>
</tbody>
</table>

The quantity and Market (notional) Value of the WTI January Crude Oil contract are shown as negative because DNO is \textit{short} in these contracts, which implies as the futures price of oil goes down, the cash value and hence the NAV will rise proportionately. This inverse ETP is \textit{not} leveraged.

Source: \textit{United States Short Oil Fund} of the funds featured at \url{http://www.unitedstatescommodityfunds.com} on the date above.

It should also be obvious that any \textbf{inverse delta tracking} ETP will differ from UGA by simply holding short positions rather than long positions, and a \textbf{2X inverse delta tracking} ETP will be short and hold cash equal to half the notional value of their futures contracts.
Figure 15 Asset Holdings of the DNO Short (inverse) Crude Oil Tracking Stock is an example of an inverse 1X unleveraged ETP. As can be seen the amount of cash and other liquid assets on hand are approximately equal to the notional value of the futures contracts held by DNO, at about $16 billion, which tells us the this ETP is not leveraged. But the negative values shown for quantity and market value indicate to us that the positions are short. This means that if the price of the oil futures contract rises by approximately 1%, then settlement will reduce the amount of cash in the account by 1%. Ideally, the NAV will also go down by 1%. (Note that here we are saying the tracking fidelity described is to the appropriate futures price of oil, in this case the Jan 14 contract, not the spot price of oil).

Figure 16 - The United States Short Oil Fund (DNO) tracking against its long USO counterpart shows exactly what we would expect when they hold nearly the same assets, except one long and the other short. They track as a near mirror image of each other. Of course this implies if one is biased in its tracking of its objective or of spot prices, the other will be biased as well.

Figures 13 and 15 makes it very clear that delta ETP managers must roll over their entire portfolio of futures contracts every month if they are collateralized with near-term futures, as most are. This will add to expenses and sometimes present the problem described below.

A.2 Contangos and the Possibility of Tracking Bias

The presence of a contango in any futures market, such as the contango in oil that was shown in Figure 12, can introduce serious tracking bias into a delta tracking ETP. More importantly, if the commodity ETP was purchased as a specific hedge against inflation, the hedge may not work!

A contango typically reflects the formation of inflationary expectation among market traders for either the commodity (oil) or the class of commodity (fuels), or for the economy as a whole (the consumer price index, including fuels). The traders have priced in those expectations in the futures chains.

Consider the price of crude oil reflected in Figure 12, which begins at the price of $43.15 per barrel for the January 2009 contract, but rises to $58.78 for the January 2010 contract. Such pricing would not be possible unless there was a consensus among traders that the spot price of oil was going to rise over that year. The logic is pretty easy to figure out. Large traders who were short in that contract were obliged to deliver oil and if they though spot oil was going to be close to $60 per barrel within a year, they would never agree to deliver one year out at the current spot price of below $45.

Futures prices are not a perfect indicator of expected future spot prices (or to be more general, not a perfect indicator of expected future inflation) but they are generally and directionally reliable. If futures prices one year out are 25% above spot prices, that is a pretty good indicator that the market in general believes that serious inflation is imminent.

Suppose that the inflationary expectations is shared by you and other small retail traders. You know that an ETP like USO is more or less supposed to track the spot price of oil as it rises, even if one day at a time given that it is a delta tracker. So you buy USO in the hope if hedging against inflation.

If the futures contract is already in contango because it already reflects inflationary expectations, you are out of luck. Your ETP will not even remotely track inflation – in fact the NAV may decline in value as the price of the commodity rises!
Figure 17 - The failure of USO to track WTI crude after 2009 (until January 2010) shows that USO tracked crude oil prices with reasonable fidelity until Spring 2009, then NYMEX WTI crude spot prices began to inflate from below $40 per barrel to above $80 per barrel during this period, more than a doubling of prices. USO prices began to rise but they flattened out after Summer 2009 and have flat-lined since. Of course USO does not promise to track spot prices over the long run - it is a delta tracking stock, but nonetheless the daily tracking bias indicates that USO was suitable only for short turn trades during the period shown, if that. The inset shows the daily percentage delta (which is what it is supposed to track) over the last 22 trading days of 2010, and most days perform well, but given that both observations must be on the same side of the 0 percent green line to be directionally tracking, it can be seen on some days (4 of the 22) that USO even fails to do that.

Remember that the futures contracts that collateralize these ETPs must be rolled over once a month as the contracts in the portfolio expire, and if the new contracts are in contango, the fund managers are buying into a new position that is more expensive than the position being cashed out. Further, we know that the spot price and the futures price of any futures contract must converge as the contract approaches expiration. If the futures price is a good inflation estimator, then the spot price will rise to the futures price as predicted, but the futures price of the contract will remain more or less flat! This implies that there is no gain in settlement, so the cash account of the ETP does not rise, which means that the ETP NAV does not rise!

Figure 18

Hypothetical Convergence of Prices in Contango over 10 Trading Days

<table>
<thead>
<tr>
<th>Day</th>
<th>Futures</th>
<th>Spot</th>
<th>Net</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>110.00</td>
<td>100.00</td>
<td>10.00</td>
</tr>
<tr>
<td>1</td>
<td>111.21</td>
<td>100.82</td>
<td>-9.21</td>
</tr>
<tr>
<td>2</td>
<td>110.84</td>
<td>101.76</td>
<td>-16.84</td>
</tr>
<tr>
<td>3</td>
<td>111.18</td>
<td>103.04</td>
<td>-18.82</td>
</tr>
<tr>
<td>4</td>
<td>111.42</td>
<td>104.37</td>
<td>-21.42</td>
</tr>
<tr>
<td>5</td>
<td>111.51</td>
<td>105.12</td>
<td>-24.51</td>
</tr>
<tr>
<td>6</td>
<td>111.20</td>
<td>106.10</td>
<td>-25.20</td>
</tr>
<tr>
<td>7</td>
<td>111.54</td>
<td>106.76</td>
<td>-25.54</td>
</tr>
<tr>
<td>8</td>
<td>111.21</td>
<td>107.94</td>
<td>-26.21</td>
</tr>
<tr>
<td>9</td>
<td>109.92</td>
<td>109.11</td>
<td>-0.82</td>
</tr>
<tr>
<td>10</td>
<td>110.00</td>
<td>110.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

This complicated concept may be best explained by example. Refer to Figure 18 Hypothetical Convergence of Prices in Contango over 10 Trading Days. This represents a stylized example of a crude oil futures contract in a 10-day contango, where the current spot price is $100 per barrel and the futures price ten days out is $110 per barrel. The contract is for 1,000 barrels, which implies that the notional value of a single contract is $110,000. In day zero when spot is $100, if we go long in the contract we pay $110.

The ten days shown on the tracking history of this example assumes that the futures price in day 0 was a good estimator of the future spot price on day 10 at $110. Therefore the spot price makes its irregular progress in that direction. The daily futures price keys off of the moving spot price somewhat, but knowing that the futures price must converge to the spot price on the 10th day, it never deviates much from the flat line, as shown.
When the 10th day arrives, there is no net gain through settlement in the cash account. That should be obvious – the final futures price neither rose nor fell from what the ETP paid for it. If that logic is not convincing, the net change in daily settlement is shown for each of the 10 days, and as can be seen, the net change is zero.

If settlement added no cash to the cash account, the ETP NAV, which is equal to total cash divided by the number of outstanding shares in the ETP, did not rise, so obviously the market-determined share price, which must roughly track the NAV, did not rise. The spot price of oil rose by 10% in 10 days and the NAV of the ETP that is supposed to track it did not rise by one penny!

From this example it should be obvious that if the spot price rises, but by less than 10% (say by 8% to 108) the NAV will actually fall in value despite rising spot prices. Only if the futures price underestimates the inflation and the spot price rises above the original futures price (say to 112) will the NAV rise in value.

We can conclude that during a contango, the manager of any delta ETP is faced with the same problem as a hedger - you cannot get a futures contract at any price that will meet your trading objective.

Contangos are likely to emerge in an inflationary environment, and that would be the same time that uninformed traders might be most attracted to long delta commodity ETPs like USO. Alas, now we have some strong theoretical reasons to believe that these delta tracking stocks would work the least when they are most in demand.

A.3 ETNs secured with Swaps

The curious reader may have wondered why when discussing 2X and 3X leveraged ETPs secured with futures that no examples were provided. There is a good reason for that. By 2013, almost none existed, at least not directly. Almost all such ETPs were ETNs, which you may remember, are not required to expose collateral in their public documents.

![Figure 19 – The ProShares Short Dow30 1X inverse ETN secured with Swaps](image)

A swap is a contract with a 3rd party who promises to pay you according to a performance metric (such as 1X inverse DOW) in exchange for a fee, like LIBOR + 2%. The 3rd party uses the futures contracts ... maybe.

To understand what they are secured with, take a close look at the collateral daily holdings statement of the DOG Short Dow 30 1X inverse ETN represented in Figure 19.
The primary *Dow Jones Industrial Average* tracking ETF is **DIA**, the SPDR Dow Jones Industrial Average ETF (and notice that we are referring to it as an ETF). **DIA**'s collateral holdings are shares of the stocks that make up the **DJIA**, not futures contracts or swaps. Obviously **DIA** will have a near-perfect tracking record, given that it holds the same stocks that make up the actual index in the same proportions as they are represented in the index.

**DOG** is designed to perform exactly the opposite of **DIA**, except only on a daily delta basis (although if there is no consistent bias, then it should track reasonably well in the long run also). But **DOG** doesn't short these stocks as one might bet. Nor does **DOG** directly own futures contracts (there *is* a robust futures contract in the **DJIA** trading at $10 per index point). **DOG** owns *swaps*, like the first listed, a **DJIA Industrial Average Swap** from Citibank.

So what are swaps?

First of all, the name is a little misleading.

They are not as exotic as the name implies. In a nutshell, this kind of swap allows a third party, in this case a bank, to absorb the tracking risk of the ETN. Generally, the third party, the bank, holds a contract with the ETN that promises to pay cash to or take cash from an ETN according to a performance metric. In this example of **DOG**, the banks listed in the swaps agree to collectively pay into the cash account of **DOG** (down at the bottom, at $273 million) an amount equal to 1% of that cash value, or around $27.3 million, if the **Dow Jones Industrial Average declines** by 1%, and to withdraw the same amount if the opposite happens.

What do the banks get in return for taking this risk? **ProShares** agrees to pay the banks holding the swaps a variable interest return, like the **London Interbank Offer Rate (LIBOR)** - a bank interbank lending interest rate) plus some stipulated percentage above that. In this example, if the **LIBOR** is 1.5% and the add-on is 2%, then **ProShares** is offering these banks a total of 3.5% of the notional value of the fund (daily, adjusted to the annual rate) to absorb this risk. The **LIBOR** is variable so this is a variable rate contract.

So how are the banks hedging or meeting this risk? First of all, we don't know and are not entitled to find out - that is the nature of ETNs. But there is nothing magic about a swap. Any bank would be taking a serious risk if they are not hedged, so they almost certainly are. How? With futures contracts of course. So in this case although **DOG** is not directly short in futures, the banks holding the swaps almost certainly are, or at least they are holding **options** on futures.5

The 2X and 3X ETNs, whether long or inverse, are increasingly secured with these swaps contracts and those in turn are *likely* secured with futures contracts or options on futures contracts. But because we don't know for sure how they are secured, and don't have the right to transparency, and because of the contango tracking issue, it should now be entirely obvious why delta ETPs and ETNs are not suitable for long-term buy and hold investments. They should only be used for short-term trading, and only then if you have researched them and you have a clear idea about what you are doing.

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5 Yes, there is such a things as options, that is puts and calls, on futures contracts. They work just like options on stocks in terms of their structure and pricing. We don't go into these in Economics 104 because we have to draw the line somewhere.