Futures-Based Commodities ETFs

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Commodities Exchange Traded Funds (ETFs) have become popular investments since first introduced in 2004. These funds offer investors a simple way to gain exposure to commodities, which are thought of as an asset class suitable for diversification in investment portfolios and as a hedge against economic downturns. However, returns of futures-based commodities ETFs have deviated significantly from the changes in the prices of their underlying commodities. The pervasive underperformance of futures-based commodities ETFs compared to changes in commodity prices calls into question the effectiveness of these ETFs for diversification or hedging.

This paper examines the sources of the deviation between futures-based commodities ETF returns and the changes in commodity prices using crude oil ETFs. We show that the deviation in returns is serially correlated and that a significant portion of this deviation can be predicted by the term structure of the oil futures market. We conclude that only investors sophisticated enough to understand and actively monitor commodities futures market conditions should use these ETFs.

Diversification is a fundamental principle of prudent investment management. By mixing a variety of different investments, diversification reduces the overall risk of a portfolio without reducing expected portfolio returns. Bodie and Rosanky [1980] show that by investing in commodity futures, investors can decrease the volatility of an all-stock portfolio without reducing their expected return. Gorton and Rouwenhorst [2006] demonstrate that returns to investments in commodities futures from 1959 to 2004 were negatively correlated with returns to S&P 500 stocks and long-term corporate bonds and yet positively correlated with inflation.

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Masters [2008] and a 2008 Commodity Futures Trading Commission (CFTC) study[2] report that commodity index related investments purchased by institutional investors increased from about $15 billion in 2003 to more than $200 billion in 2008.[3] However, until recently, there was no simple way for retail investors to invest in commodities without using futures contracts. Investing in futures contracts is not simple; investors need to open a margin account, find the right contracts to purchase, and as futures contracts come close to expiration, "roll-over" the maturing contracts into new contracts to avoid physical delivery of the underlying commodity. In addition, futures contracts are highly leveraged[4], are usually traded only in large blocks, and are marked-to-market daily, which exposes investors to volatility risks in the futures price movement. These features of futures contracts have made it complex for unsophisticated investors to diversify into commodities.

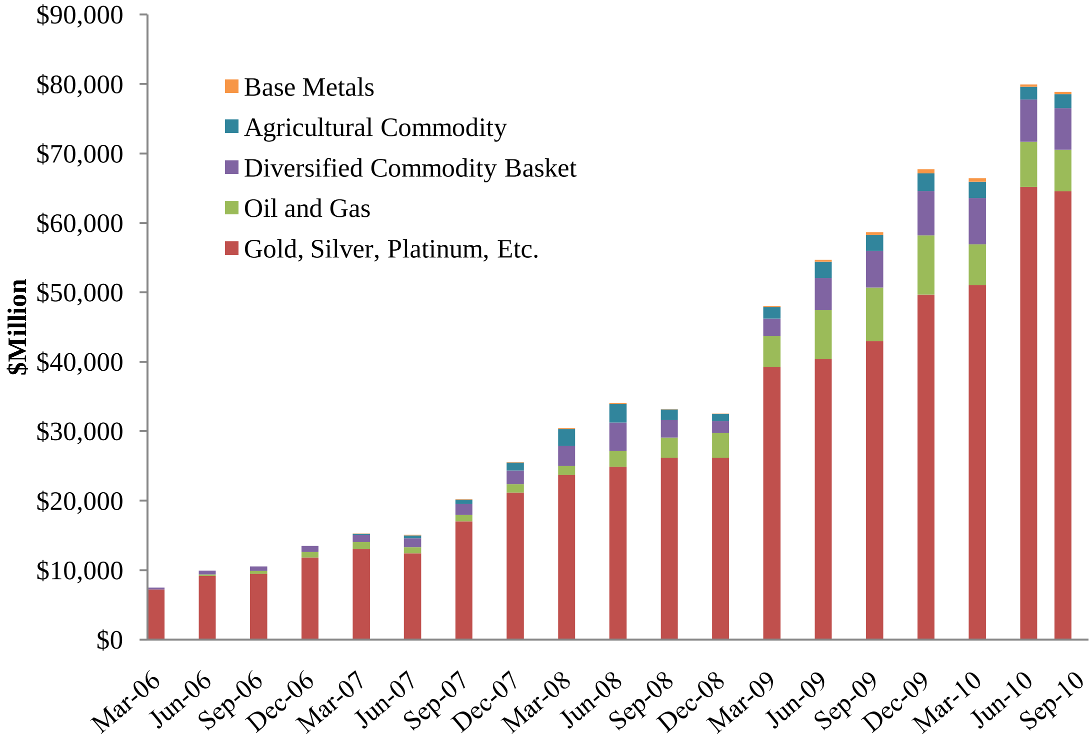
The first commodity ETF in the U.S. was State Street's SPDR Gold Trust ETF (GLD) issued on November 12, 2004. Since then, the amount invested in commodities ETFs has grown from virtually nothing in 2005 to more than $80 billion by September 2010. *See* Exhibit 1.

[2] http://www.cftc.gov/ucm/groups/public/@newsroom/documents/file/cftcstaffreportonswapdealers09.pdf

[3] California Public Employees' Retirement System (CALPERS), the nation's largest public pension, had invested almost $500 million in commodities in 2007, and in December 2007, formalized an allocation of 5% of its $245 billion of assets to a new asset class that includes commodities: http://www.calpers.ca.gov/index.jsp?bc=/about/press/pr-archive/pr-2008/feb/new-asset-class.xml

[4] Futures contracts are inherently leveraged investments because each contract only requires a small fraction of the contract's notional amount as an initial investment (the initial margin requirement). Chance [2002] points out that the initial margin requirements for futures contracts are "*usually less than 10% of the futures price.*"

Exhibit 1. Total assets invested in commodities ETFs in the US markets, in millions.



Commodities ETFs differ from traditional equity or fixed income ETFs in an important way. Traditional ETFs hold at least a representative sample of the underlying stocks and bonds in their benchmark index and thus need to rebalance their portfolio only when the composition of their benchmark index changes. For example, the SPDR S&P 500 ETF, SPY, holds all the 500 stocks that comprise the S&P 500 Index, and the Wilshire 5000 Total Market ETF, WFVK, holds about 1,200 of the stocks that comprise the Wilshire 5000 Index.[5] If the marginal storage cost is low, as with most precious metals, commodities ETFs can hold the physical commodity.[6] However, for commodities that cannot be stored or would incur high marginal storage cost, such as energy and agricultural commodities, ETFs use futures contracts to gain exposure to commodities.

[5] Contrary to what its name may indicate, the Wilshire 5000 does not include 5,000 stocks but all the stocks in the U.S. markets that meat eligibility criteria: http://www.wilshire.com/Indexes/Broad/Wilshire5000/. The Wilshire 5000 membership count has ranged from 3,069 on Feb. 28, 1971 to 7,562 on July 31, 1998. As of December 31, 2010 the index included 3,927 companies.

[6] GLD, the gold ETF sold by SPDR Gold Trust, is the largest commodities ETF with total assets in October 2010 exceeding $55 billion. However, GLD is also one of only few commodities ETFs that, similarly to their equity counterparts, holds the underlying assets.

In this paper, we study the expanding class of commodity ETFs that use futures contracts to gain exposure to commodity markets. By using short-term futures contracts, these ETFs are likely to generate returns that significantly differ from the changes in both the underlying commodity's spot price and futures price. First, we describe the dynamics of futures market and relate the dynamics to the returns of futures-based commodity ETFs. We then describe the different investment strategies that ETFs employ to track commodity prices using three examples of crude oil ETFs - United States Oil Fund (USO), United States 12 Month Oil Fund (USL), and PowerShares DB Oil Fund (DBO). Finally, we analyze the deviation of the ETFs' monthly returns from the monthly change in crude oil spot prices. We show that a substantial portion of this deviation can be explained and predicted by the past return deviations and the prevailing conditions in the futures market.

The Dynamics of Futures Market

Storing most commodities for investment purposes is costly and impractical. If an investor wants to invest in a commodity, he or she will likely buy futures contracts. However, to avoid physical delivery, as futures contracts expire, an investor will have to replace an expiring contract with a new contract that expires later, a process known as "rolling-over". If the selling price of the expiring contract, which is close to the spot price at maturity, is lower (higher) than the purchase price, the investor will incur a loss (gain). This is referred to as a "roll-over" gain or loss. The expected roll-over gain or loss, which is the difference between the expected future spot price at maturity and the current futures contract price at which the investor purchases it, is correlated with the term structure of the futures market.[7]

The term structure of futures market is the yield curve describing the relationship between the prices of futures contracts and their time to maturity. An upward (downward) sloping term structure curve refers to a market condition where the longer-term futures contract is trading at a higher (lower) price than the nearer-term futures contract.[8] Much

[7] See the following section for a detailed explanation.

[8] Hull [2006] defines the curve as the following: "The futures price of gold increases as the time to maturity increases. This is known as a normal market. By contrast, the futures price of crude oil is a decreasing

academic literature and commodity trading practitioners frequently uses the term "backwardation" [9] when referring to a "downward sloping term structure", where the near-term future price is higher than long-term future price. For clarity, we use the terms "upward sloping term structure" if the longer-term futures price is higher than the near-term futures price; and "downward sloping term structure" if the longer-term futures price is lower than the near-term futures price.

As Gorton and Rouwenhorst [2005] have shown, the term structure of futures price may contain important information for predicting the expected futures spot price and therefore the roll-over return. Erb and Harvey [2006] directly use the slope of term structure as the measure of roll-over return. However, it is important to note that the changes of the yield curve over time, which determine the roll-over return, are different from the term structure of the yield curve, which represents the prices of futures contracts over different maturities at one specific point of time.

The dynamics of the term structure of futures market will have a potentially important impact on any purchaser of a futures contract, including the ETFs that use futures contracts to track an underlying commodity. The return of such an investment will not only depend on the return of the spot price of the commodity but will also depend on whether the contract was purchased when the term structure of the futures prices was upward- or downward-slopping. Once a futures contract expires, an investor needs to roll-over their investment into a new futures contract.

Rolling over into new contracts can be done in a variety of ways that involve different combinations of futures contracts that the ETFs can choose from. Next, we investigate different methodologies employed by three crude oil based ETFs to better understand the relationship between the term structure of the futures market and the return of futures-based ETFs.

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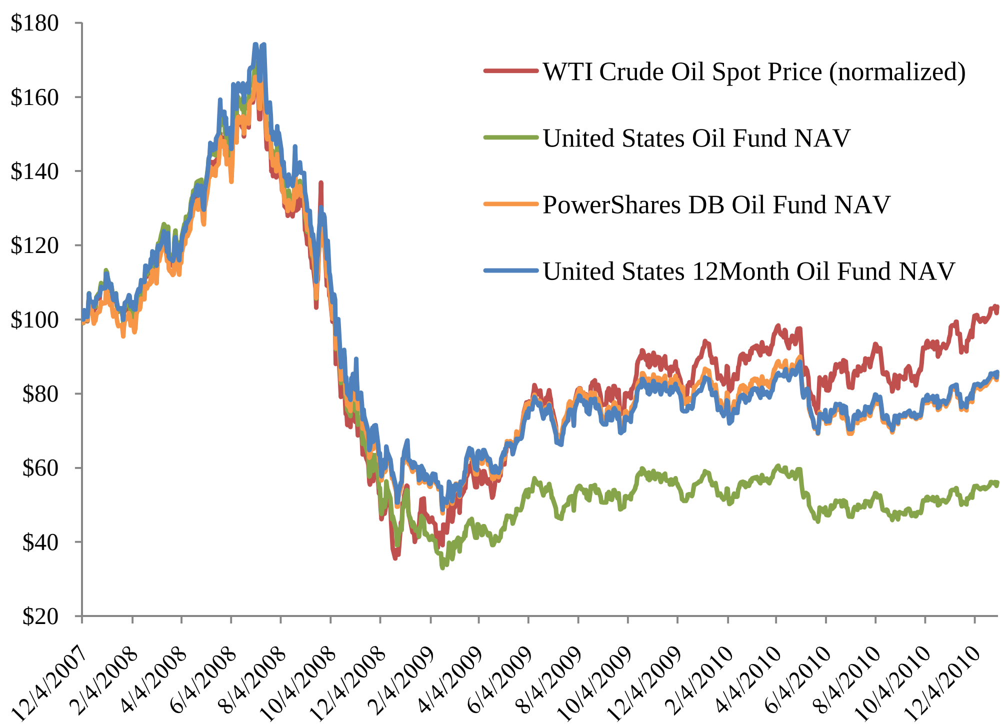
function of maturity. This is known as an inverted market." For accuracy and tractability, we use the terms "upward slopping term structure" or "downward slopping term structure" in crude oil futures market.

[9] The term "contango" and "backwardation" are used frequently in commodity market literatures, but Hull [2006] defines the following: "When the futures price is below the expected future spot price, the situation is known as normal backwardation; and when the futures price is above the expected future spot price, the situation is known as contango." Hull's definition of backwardation market is defined over a time series, which is a different concept from what we call "downward-sloping term structure" which is defined over a cross-section of futures contracts.

Futures-Based Commodity ETFs – Case Study of Crude Oil ETFs

Crude oil futures contracts have maturities ranging from one month to nine years. The West Texas Intermediate (WTI) light, sweet crude oil spot price is a common, widely cited crude oil benchmark.[10] We survey ETFs that use three different strategies to gain exposure to crude oil price movement. Exhibit 2 shows the value of $100 invested in these three ETFs compared to a theoretical investment in the oil spot price from December 4, 2007 to December 31, 2010. None of these ETFs track the changes of the oil spot price perfectly and their returns differ across ETFs. For example, the holding period return for the United States 12-Month Oil Fund from January 2, 2009 to December 31, 2010 was 33.5%, but over the same period, the WTI crude oil spot price increased by 97.2%.

Exhibit 2. Performance of the USO, USL, and DBO ETFs compared to the oil spot price



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[10] "Sweet" crude oil is a low sulfur petroleum. Gasoline is usually processed from low sulfur crude oil and hence is in high demand. Usually, when the media refers to the price of a barrel of oil it usually refers to a barrel of WTI Crude, to be delivered to Cushing, Oklahoma. See http://www.eia.doe.gov/dnav/pet/TblDefs/pet_pri_spt_tbldef2.asp for the U.S. Energy Information Administration definition of WTI.

In general, the correlations between daily changes of the three ETFs' NAVs and changes in crude oil price are high. Exhibit 3 summarizes these correlations over different time periods. Exhibit 3 Panel A shows that despite these high correlations, holding period returns deviated substantially from the returns one would have expected from the trend in spot prices. From December 31, 2008 to December 31, 2009, the oil spot price increased by 77.9%, while USO's NAV increased only by 14.1%, a difference of 63.8% in holding period return. Similarly, in 2009 USL's NAV increased only by 29.2% and DBO's NAV increased only by 35.6%, resulting in a deviation of 48.7% and 42.3% from the spot price return, respectively.

Exhibit 3. Correlations and deviations of returns between the daily NAV change of oil ETFs and the daily change of the WTI crude oil spot price and the WTI crude oil six month futures contract.

	USO		**USL**		**DBO**	
Issue Date	4/10/2006		12/5/2007		1/5/2007	
	Daily Correlation with	Return Deviation from	Daily Correlation with	Return Deviation from	Daily Correlation with	Return Deviation from
Panel A: Spot Price:						
Issue Date - 12/31/2008	91.0%	-14.4%	89.6%	11.5%	89.8%	0.9%
12/31/2008 - 12/31/2009	93.4%	-63.8%	85.2%	-48.7%	83.6%	-42.3%
1/1/2009 - 12/31/2010	93.8%	-91.3%	86.2%	-67.5%	85.1%	-65.8%
Panel B: Six Month Futures Contract:						
Issue Date - 12/31/2008	97.8%	-25.2%	99.7%	-0.4%	98.7%	-10.0%
12/31/2008 - 12/31/2009	94.6%	-37.0%	99.5%	-21.9%	96.8%	-15.5%
1/1/2009 - 12/31/2010	94.7%	-59.6%	99.5%	-35.8%	97.1%	-34.1%

Since these ETFs use futures contracts, in Exhibit 3 Panel B, we report the correlations and deviations from the six month futures contract return. These ETFs have even higher correlation with daily changes in the price of futures contracts. Despite correlations as high as above 99% in the case of USL, holding period returns deviated substantially from the returns one would have expected from the trend in futures prices. From December 31, 2008 to December 31, 2009, the holding period return for USO was 37% less than the change in the price of the six months futures contract. During the same period, USL's holding period return was 21.9% less and DBO's holding period return was 15.5% less than the change in the price the six months futures contract. The latter two ETFs even had higher daily NAV return correlations with the daily change of six-month futures contract. [11]

Clearly, the high daily correlation does not indicate how closely the ETF's holding period returns track the changes in spot prices or futures oil prices. In order to better understand these ETFs and why they do not track the WTI spot price well, we start by describing the investment strategy of each one.

United States Oil Fund (USO)

The United States Oil Fund (USO) is an ETF that invests in oil futures contracts traded on the New York Mercantile Exchange (NYMEX) and was first offered on April 10, 2006. USO invests in near-month futures contracts and rolls-over their futures contract to the next month futures contract every month when the near-month futures contracts are two-weeks close to expiration.[12] The contract with the shortest maturity is the near-month futures contract, typically expiring in less than 22 days. Due to their short maturity, near-month futures prices historically have been very close to crude oil spot price. As a futures contract comes close to expiration, the futures price will converge to the spot price.

In practice, USO's monthly roll-over requires USO to sell all their futures contracts each month and replace them with new futures contracts.[13] We describe USO's roll-over strategy in Exhibit 4. For example, on January 6, 2009, USO sold contracts expiring on January 20, 2009 for $48.58, and bought contracts expiring on February 20, 2009 for $53.13. The following month, on February 6, 2009, USO sold the contract expiring on February 20, 2009, for $40.17 and bought the new contract expiring on March 20, 2009 for $46.15. From January 6, 2009 to February 6, 2009, USO's buying

[11] USL and DBO hold a portfolio of futures contracts that spans from near-month contract to 13-month contract. USO only holds near-month or 2-month contract.

[12] USO sells the expiring contracts two weeks earlier before the expiration date is mainly due to liquidity concerns – if the USO sells the contracts on the last day before expiration, there might not be enough liquidity in the market to allow USO to unwind their large positions in these contracts.

[13] USO had historically used one-day window to roll-over contracts, but changed to four-day roll-over window since March 2009 contract. Expiration date is when the front-month futures contract stops trading, defined as the third business day prior to the 25th calendar day (or the first business day before the 25th calendar day if the 25th is not a business day) of the month prior to the delivery month. Throughout the paper we use the delivery month to refer to a particular futures contract, e.g., a March 2009 contract means the delivery month is March 2009, and the trading of this contract expires on February 20, 2009.

and selling of the contract expiring on February 20, 2009 generated a loss of 24.4% (40.17/53.13-1), excluding fees, interest or other expenses. Over the same time period, the WTI crude oil spot price declined from $48.58 to $40.17, a decline of only 17.3%.

Exhibit 4. Futures Contracts Transactions by USO. (b) – bought; (s) – sold.

Contract Name	Expiration Date	Trading Date 1/6/09		Trading Date 2/6/09		Trading Date 3/6/09
February 09	1/20/09	$48.58 (s)				
March 09	2/20/09	$53.13 (b)	→	$40.17 (s)		
April 09	3/20/09			$46.15 (b)	→	$45.52 (s)
May 09	4/21/09					$47.72 (b)

United States 12 Month Oil Fund (USL)

United States 12 Month Oil Fund (USL) was first issued on December 5, 2007. USL holds 12 equally-weighted oil futures contracts, starting from the near-month futures contract[14] to the next 11 delivery month futures contracts. This strategy is fundamentally similar to USO's strategy, as USL uses short-term futures contracts. However, USL sells every month the near-month futures contract and buys a contract that has roughly 12 months to expiration, turning over only one twelfth of its portfolio every month.

Exhibit 5 illustrates USL's roll-over procedure. On December 5, 2008, USL bought the January 2010 contract for $55.51 and sold it on December 7, 2009 for $73.93. This contract represented only one twelfth of USL's investment portfolio. Over the 12 months holding period this contract had a return of 33.2%. USL's monthly return depends on the changes in the values of all the twelve contacts it holds. In Exhibit 5 column 5, we show that on December 7, 2009, USL held 12 contracts spanning from February 2010 to February 2011. On that date, USL sold the January 2010 contract and rolled over this investment by buying the January 2011 futures contract at $84.23. One month later, on January 6, 2010, USL sold the expiring February 2010 contract at $73.93 and bought the February 2011 contract for $85.56.

[14] Unless the near-month futures contract expires within two weeks, it will be replaced (rolled-over) by the 13th delivery month contract, i.e. 12th expiring-month contract. For example, if the near-month futures contract is February 2009 contract, which expires on January 20, 2009, on and around January 6, 2009, USL will replace this contract with the February 2010 contract, which expires on January 20, 2010. http://sec.gov/Archives/edgar/data/1405528/000114420407066283/v096430_424b3.htm

Exhibit 5. Futures Contracts Transactions by USL. (b) – bought; (s) – sold; (h) – hold

		Trading Date				
Contract Name	Expiration Date	12/5/08	1/6/09	…	12/7/09	1/6/10
January 10	12/21/09	***$55.51 (b)***	$63.09		***$73.93(s)***	
February 10	1/22/10		***$63.70(b)***		$75.91	***$73.93(s)***
March 10	2/20/10				$77.55	$83.75
…						
January 11	12/21/10				*$84.23(b)*	$88.32
February 11	1/22/11			…		*$85.56(b)*

PowerShares DB Oil Fund (DBO)

The PowerSshares DB Oil Fund tracks the Deutsche Bank Liquid Commodity Index–Optimum Yield Crude Oil Excess Return™ index. The fund contributes to a Master Fund that trades selective crude oil futures contracts; based on their "Optimum Yield" method that does not fully disclose which specific contracts they hold at any given month, with the eligible contracts having delivery months ranging from 2 months to 13 months from the current month.[15] This strategy is similar to USO's and USL's strategies in that it also buys and sells futures contracts. However, DBO can choose any combinations of futures contracts it believes will deliver a higher risk adjusted return instead of pre-committing to a specific contract as USO does or to an equally-weighted set of contracts as USL does. [16] As we have shown in Exhibit 1, this flexibility in choosing the futures contracts does not generate a higher correlation or a smaller deviation from the spot price, as the fund is still exposed to the same fundamental risks in the crude oil futures market.

To summarize the different strategies employed by ETFs, as an illustration, we plot in Exhibit 6 the term structure of the oil future contracts on December 22, 2010. These are the twelve contracts[17] that the ETFs use to generate exposure to oil price changes. On

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[15] http://sec.gov/Archives/edgar/data/1367305/000119312510222042/d424b3.htm, page 8

[16] Page 6,"All Indexes, … are rolled in a manner which is aimed at potentially maximizing the roll benefits in backwardated markets and minimizing the losses from rolling in contangoed markets".

[17] DBO considers the near-month to 13th delivery-month contracts. USL consists of near-month to 12th delivery- month contracts.

December 22, 2010, the term structure was upward slopping, meaning that the longer term futures contracts traded at a higher price than the nearer-term futures contracts. The term structure was upward-slopping and concave, i.e. the slope was steeper between the second-month and near-month contracts than it was for any other two adjacent contracts. As this curve changes daily, the choice of which contract to purchase and the evolution of its price until it converges to the spot price highlights the downside of USO's methodology of investing in only one contract and rolling over the entire contract every month. USL and DBO hold a diversified set of contracts, and thus these ETFs expose their investments to the average of the slopes instead of exposing their investments only to one slope.

Exhibit 6. Term structure in WTI Crude Oil futures market on December 22, 2010.

The Predictive Power of the Term Structure

Decomposition of Returns

In this section we explore the source of the deviation of the ETFs' monthly returns from the crude oil spot price's monthly change. All the three ETFs we analyze use similar methodologies that expose them to term structure risks. Therefore, they suffer from the same fundamental problem – as long as the previous month's term structure is upward sloping, an investment in a futures contract will eventually have a lower return than the change of the spot price. Conversely, if the term structure is downward sloping, an investment in the futures contract will usually have a higher return than the change of the spot price.

Following the methodology used in Fama and French [1987], Gordon and Rouwenhorst [2005], and Gorton, Hayashi and Rouwenhorst [2007], we decompose in Equation (1) the log expected return from holding a futures contract from time *t* to maturity time *T*:

$$ln\frac{E_t[S(T)]}{F(t,T)} = ln\frac{E_t[S(T)]}{S(t)} + ln\frac{S(t)}{F(t,T)} \tag{1}$$

where *S(t)* is the spot price at time *t* and $E_t[S(T)]$ is the expected future spot price at time *T*. *F(t,T)* is the price of a futures contract purchased at time *t* to be delivered at time *T*, i.e. this is the price at time *t* that the buyer of the futures contract agreed to pay for the delivery of the commodity at time *T*. Futures contracts are marked-to-market and any change in the price needs to be settled daily. At time *T*, the futures contract will expire and its price will converge to the realized spot price, *S(T)*.

Equation (1) shows that the log expected return from holding a futures contract from time *t* to time *T* is equal to the log return from the expected change in the spot price from time *t* to time *T*, plus the difference between the log of the current spot price and the log of the current price of the futures contract. The second term in Equation (1), the difference between the current spot price and the current price of the future contract, is the term structure of the yield curve at time *t*. Thus, Equation (1) shows that the term structure directly affects the return from holding a futures contract to maturity. If the term structure is upward sloping, this term is negative, which implies that the roll-over return from holding a futures contract will be lower than the change in the spot price. This decomposition illustrates the impact that the term structure has on the return from any strategy that rolls-over futures contracts and hence its importance in understanding the return of futures-based ETFs.

We divide our analysis to three steps: First, we discuss the distribution of the term structure slopes in history. Second, we test whether the distribution is persistent over time.

Last, we analyze the predictive power of the term structure on the deviation of the ETFs' monthly returns from the changes in spot prices even before the ETFs were launched.

The Term Structure of the Futures Market

The slope of the term structure of futures contracts has a dramatic effect on the holding period returns from the strategies employed by ETFs. There are different theories that attempt to explain the term structure of futures contracts. Storage Theory (see Pindyck (2001), Brennan and Schwartz (1985), and Litzenberger and Rabinowitz (1995)) argues that in the short-run, the supply and demand imbalances, oil storage (inventory cost) and interest rate play a key role in determining both the spot price and the futures price of crude oil. When there is low oil inventory, or a sudden reduction in production, or an increased demand, there will be high demand for current delivery of crude oil so that the futures price will be lower than the spot price. When there is high inventory of crude oil, or no unexpected fluctuations in supply or demand, the opposite will be true – the futures price will be higher than the spot price. Another theory, the Risk Premium Theory argues that futures contracts can be viewed as insurance for hedging needs of commodity producers, who should pay a risk premium to the investors of the futures contract. The risk premium is essentially the excess of an asset's expected future spot price over its futures price. If such a risk premium were zero, the holder of the asset could simply lock the future asset price by shorting the futures contact. In this way, the uncertain price risk is transferred to the holder of futures contact. The holder of the asset therefore locks in a return higher than the risk free rate. Obviously this arbitrage cannot exist, thus the futures price must be sold at a discount to the expected spot price. Fama and French (1987) test both theories and find results consistent with both.

We first inquire whether this market condition is persistent over time. The potential persistence is important, as it would indicate that knowing the current market condition would allow investors to have information on the likelihood that the fund's methodology will generate a positive or a negative deviation in the following month.

Following Litzenberger and Robinowitz [1995] and Gorton, Hayashi, and Rouwenhorst [2008][18] we analyze the spread between the second-month futures price and the near-month futures price as a measure of the slope of the term structure. A positive (negative) spread indicates an upward (downward) slopping term structure. In Exhibit 7 we summarize the frequencies of positive and negative spreads over different periods.

Exhibit 7. Frequency of positive or negative spreads between the second-month and near-month crude oil future contracts.

Time Period	**Positive Spread**	**Negative Spread**
3/30/1983-12/31/1991	26%	74%
1/1/1992-3/31/2006	50%	50%
4/1/2006-12/31/2010	82%	18%

The frequencies in Exhibit 7 indicate that there can be long sustained time periods with substantially higher frequencies of either positive or negative spreads. Between 1983 and 1991, 74% of the days exhibited a negative spread while between 2006 and 2010, 82% of the days exhibited positive spreads. Sustained time periods with a positive spread can be very costly to any investor rolling-over futures contract as they will incur the cost of an upward-slopping term structure as highlighted in the second term on the RHS of Equation (1). It is worth noting that there are also time periods in which there is no clear sustained positive or negative spread as was experienced in the oil futures market between 1992 and 2006. Since the spread has an important effect on the performance of any investment that rolls-over futures contracts, knowing in advance whether those market conditions would be persistent could allow investors to increase their risk-adjusted returns.

The Persistence of the Term Structure

We follow the methodology in Fattouh [2009] and use a Markov Regime Switching model to estimate the transition probability between two random states of upward- and downward-sloping term structures. The Markov Regime Switching model allows us to assume that there are two states of the world and the time series variables behave differently conditional on which state of the world we are in. In this case, the

[18] Litzenberger and Rabinowitz [1995] also used the spread of 3, 4, 5, 6, 7 etc.-month futures contract over near-month. In this paper we focus on the second-month and near-month because USO's strategy only involves with these two contracts.

states of the world are whether the term structure slope is positive or negative. We use oil futures market data (weekly)[19] from January 1, 1992 to August 31, 2010 and find that the conditional probability of observing a positive slope in the current time period, given a positive slope in the prior period, is 95.5%. The expected duration is 22 weeks for a positive slope and 5 weeks for a negative slope.

The Predictability of the ETFs' Monthly Return Deviation

In this section we investigate whether the crude oil ETFs' return deviation from the spot price movement is predictable given current and past market conditions.

We replicate USO's and USL's investment strategies from January 1992 till immediately before their issue date.[20] We define the ETF monthly return deviation as the difference between the ETF's monthly NAV return and the crude oil spot price's monthly change.[21] Consistent with the literature, we compute the term structure as the difference between the second-month futures contract price and the near-month futures contract price, on each monthly roll-over date.[22] We then regress the ETF's monthly return deviation on the contemporaneous and lagged term structures, controlling for first-order autocorrelation. Exhibit 8 summarizes the results of three regression models for each ETF.

Model (1) tests whether the ETF monthly return deviation is serially correlated. We find that the ETF monthly return deviation is serially correlated. This result indicates that knowledge of the ETF deviation of the previous month is in itself informative for an investor. However, this serial correlation can simply be due to the serial correlation in the term structure we highlighted in the previous section. In model (2) we test this hypothesis by adding two term structure variables, the contemporaneous and the lagged term structure. The lagged term structure has a significant and negative coefficient in both ETFs, which is consistent with Equation (1) – the upward-sloping term structure will

[19] We use weekly data because one of our explanatory variable - the crude oil stock/inventory data - is published by the U.S. Energy Information Administration on a weekly basis: http://www.eia.doe.gov/oil_gas/petroleum/data_publications/weekly_petroleum_status_report/wpsr.html

[20] We do not report results for DBO as we cannot replicate their strategy, but we perform the same analysis over the short period when data is available and the results are qualitatively similar.

[21] For consistency with the futures contract prices, we use the Bloomberg spot price and not the EIA spot price. Both spot prices have a correlation of 99.99%, and our results are qualitatively similar when using the EIA spot price.

[22] We assume one-day roll-over window to simply the analysis, as USO switched to 4-day roll-over window since January 2009 where they roll-over contracts proportionally over the period.

have a negative effect on the roll-over performance relative to the spot price movement. Lastly, in order to account for the full term structure curve, we add another ten slopes[23] and their lagged variables in model (3). For clarity of exposition we do not report the individual variables but report an F-test that tests the significance of adding these twenty variables. For USO, adding the variables is marginal, as it uses only the second month contract. The result of the test for USL is significant as USL invests in all the twelve month futures contracts, increasing the adjusted R-square from 74.3% to 81.5%.

Exhibit 8. Regression results of USO and USL (t-statistics in parenthesis, *** significance at 1% level, ** significance at 5% level, * significance at 10% level). F-test is to test whether the 10 more months of the term structure and their lagged value are jointly significant (p-values are reported in parenthesis). $F_t(2) – F_t(1)$ is defined as the difference between 2-month future contract and near-month future contract at time t, $F_{t-1}(2)$-$F_{t-1}(1)$ is the lagged term structure.

	USO Replication			USL Replication		
Model	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Intercept	0.0006 (0.600)	0.0003 (0.511)	-0.0004 (-0.570)	0.011*** (2.93)	0.007*** (3.39)	-0.001 (-0.64)
Lagged Deviation	0.793*** (16.72)	0.272*** (6.93)	0.254*** (6.09)	0.291*** (4.163)	0.212*** (5.49)	0.113*** (2.91)
$F_t(2)$-$F_t(1)$		-0.001 (-0.73)	0.001 (0.32)		0.018*** (15.96)	0.039*** (4.24)
$F_{t-1}(2)$-$F_{t-1}(1)$		-0.026*** (-15.08)	-0.034*** (-10.19)		-0.024*** (-21.48)	-0.016* (-1.86)
F-test (P-value)			1.51 (0.0847)			19.98 (<0.0001)
Num Obs	170	170	170	189	189	189
Adj R-Square	62.2%	87.6%	88.4%	8%	74.3%	81.5%

Exhibit 8 illustrates two important results. First, the ETF monthly return deviation from the spot price change over one month is positively serially correlated. Second, as we expect from Equation 1, the term structure has a significant role in determining the difference between the return of any investment that rolls-over futures contracts and the change in the spot price. As we have shown in previous sections, the term structure of crude oil market is persistent over time. Our analysis indicates that the roll-over return is dependent on the past term structure of the market. Moreover, the

[23] There are 12 contracts which define 11 slopes, for example, $F_t(2) – F_t(1)$ is the slope between 2-month future contract and near-month future contract at time t, $F_t(3)$-$F_t(2)$ is the slope between 3-month future contract and 2-month future contract at time t, and so on.

under-performance of an ETF's monthly return from the change in the spot price over the same time period may persist over time and can be predicted given current and past market conditions. Our results show that an investment in future-based commodity ETFs needs to be monitored carefully by investors to prevent pervasive underperformance compared to changes in the spot price.

Conclusion

Investors seeking to diversify their investments have been encouraged to include commodities as part of their portfolio, since returns to an investment in commodities historically have had low correlations with investments in stocks and bonds. Until recently, investing in commodities was complicated for individual investors because the exposure to the price movements of precious metals, oil, gas, and agricultural commodities was mainly accomplished through futures contracts. The introduction of commodity ETFs that offer such exposure without the need to buy futures contracts directly has filled the perceived need for retail investments in commodities. There are now over $80 billion invested in commodities ETFs. However, except for precious metals, other commodities cannot be directly held by the ETFs, which require the fund managers to use futures contracts to generate a return that is correlated with changes in the underlying commodity.

We study three crude oil ETFs that use different investment strategies through crude oil futures contracts to illustrate that even though these ETFs have high correlations in daily changes with the spot price, over time, their returns deviate substantially from the change of the crude oil spot price. These deviations are due to the roll-over practice of the futures contracts that these ETFs need to perform when the contracts they hold are close to expiration. These roll-overs are costly to ETF investors when the term structure of the oil future contracts is upward slopping.

Furthermore, we show that these deviations are not random but are serially correlated and depend on the past condition of the crude oil term structures. Therefore, these ETFs are not appropriate investments for unsophisticated buy-and-hold investors looking for a long-term hedge against the crude oil spot price, as they require knowledge of the oil futures contracts term structure and periodic monitoring.

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