The “Roll Yield” Myth*

Hendrik Bessembinder

W.P. Carey School of Business

Arizona State University

400 East Lemon Street, Tempe, AZ 85287

Email: HB@ASU.EDU

February 2018

Financial Analysts Journal, *forthcoming*.

Abstract

It is often asserted that futures investors periodically pay or receive the difference in futures prices across contracts with different delivery dates. This "roll yield" is mythical - no such cash flow occurs, at the time of "roll" trades or on any other date. While the term is a misnomer, the "roll yield" does contain useful information. It explains when futures gains exceed or fall short of spot price changes, and for storable assets it provides information regarding benefits to the marginal holder of a spot position. This paper clarifies the actual role of the "roll yield".

*This paper draws on my keynote speeches at the 2017 Commodity and Energy Markets Conference, hosted by the Oxford University Mathematical Institute, and at the 2017 International Conference on Energy Finance in Hangzhou, China. I thank Kumar Venkataraman, Avi Kamara, Hillary Till, Allen Carrion, Bjorn Eraker, Craig Pirrong, Laura Tuttle, and two anonymous referees for helpful comments.

The "Roll Yield" Myth

Futures markets can provide an attractive venue for investors to gain exposure to broad classes of assets, including equity indices, interest rates, currencies, metals, agricultural and energy commodities, as well as market volatility. The futures markets tend to be liquid, their relatively small margin requirements allow investors to lever their capital, and investors can avoid paying out-of-pocket storage costs.

However, since individual futures contracts expire prior to their specified delivery dates, maintaining an ongoing position requires the investor to periodically exit near-to-expiration contracts and enter contracts with more distant expiration dates. It is often asserted that this "rolling" activity generates gains or losses to futures investors, the magnitude of which depends on the difference in futures prices across the contract exited versus the one entered, i.e. on the term structure of futures prices. This purported gain or loss is often referred to as the "roll yield".

As one example, a Wall Street Journal article, written on a date when the term structure of futures prices was downward sloping (i.e. near-delivery futures prices were higher than those for more distant delivery dates) for many commodities, contained the following assertions:

> "There is a compelling reason to own commodities as an inflation hedge or a source of diversification, but what makes it particularly attractive is that positive 'roll yield'…. How it works: A fund manager buys a futures contract for delivery next month. Right before it expires, the investor sells the contract, buys a cheaper one for delivery at a later date and pockets the difference…. It is a rare opportunity to earn a steady income from commodities…".[1]

As a second example, a Bloomberg column focused on crude oil contracts at a point in time when the term structure of futures prices was upward sloping (a condition often referred to as "contango") asserted that:

> "When the futures contracts that commodity funds own are about to expire, fund managers have to sell them and buy new ones….. When they buy the more expensive contracts -- more expensive thanks to contango – they lose money for their investors. Contango eats a fund's seed corn, chewing away its value. Here's an example…. fund managers sold contracts for June delivery of crude oil priced at $75.67 a barrel, on average …. managers replacing those futures with July contracts had to pay $79.68."[2]

These quotations are predicated on the notion that "selling" a futures contract at one price and simultaneously "buying" another contract on the same underlying good at a higher (lower) price involves a cash outflow (inflow). In fact, no such cash flow occurs – it is mythical. A futures investor does not earn or pay the difference in futures prices across contracts on the date that contract positions are rolled, or on any other date for that matter. Gains and losses on futures positions depend *only* on *changes* in the prices of individual contracts during the time an investor has an open positon, never on differences in prices across contracts. Assertions that a futures trader can "pocket the difference" between the futures prices for two different contracts, so as to generate a "steady income", or that "buying" a futures contract with a "more expensive" futures price (as compared to the contract simultaneously sold) involves a loss of investor monies reflect a fundamental misunderstanding of how gains and losses on futures positions are determined.

I use the phrase "roll yield myth" to refer to the mistaken notion that futures investors, on the date of roll trades or on other dates, pay or receive an amount proportional to the difference in futures prices across contracts with differing delivery dates. Unfortunately, the examples above are not unique. A full listing of the academic papers, financial press articles and books that assert or imply the existence of such a periodic cash flow to futures investors would be impractical.[3]

I conjecture that the "roll yield" myth is partially attributable to common references to the "buying" and "selling" of futures contracts. In fact, futures traders do not pay futures price when they "buy" or receive futures prices when they "sell". It would be more accurate to say that traders enter and exit futures contracts. The myth may also arise in part due to a lack of appreciation for the fact that while futures contracts with different delivery dates may focus on the same underlying asset, they refer to that asset at different points in time – a distinction which is relevant if the asset generates costs or benefits to its owner in the interim.

The myth may also derive from in part from misunderstanding of the following expression, versions of which have appeared in training materials and descriptive articles related to futures markets:

Collateralized Futures Gain or Loss =

Change in Spot Price + Accumulated "Roll Yield" + Interest on Collateral. (1)

Expression (1) defines the outcome to an investor who maintains a one-contract long futures position that spans one or more "rolls", where each roll involves an exit from a position in a near-to-expiration contract and a simultaneous entry of a position in a contract with a more distant expiration date. The Accumulated "Roll Yield" in expression (1) refers to the sum across rolls of "Roll Yields", defined for each roll as the more distant expiration futures price less the near-to-expiration futures price at the time of the roll trades.

To be clear, expression (1) is itself not mythical. It relies only on the simplifying assumption (which I will also adopt for ease of exposition) that the nearest-to-expiration futures price is an adequate proxy for the spot price at both the initial and final dates.[4] Further, I expect that many of those who have relied on expression (1) understand well that there is no actual cash flow associated with "roll yields." Still, as the quotations above demonstrate, some have indeed adopted the myth that futures investing involves periodic "roll yield" cash flows, and misunderstandings of expression (1) may contribute.

How can expression (1) be accurate, if the "roll yield" is not a cash flow to a futures investor? Let us focus for the moment on the futures gain excluding interest on collateral. Consider the following expression, which is correct by construction:

Long Futures Gain = [Long Futures Gain – Accumulated Roll Yield] + Accumulated Roll Yield. (2)

Expression (2) is a tautology. Indeed, any variable at all can be both added to and subtracted from the Futures Gain without altering the validity of the expression. However, expression (2) is not without economic interpretation. The term in brackets, [Long Futures Gain – Accumulated Roll Yield], is also the difference between the nearest-to-expiration futures price at the end of the period over which performance is evaluated and the futures price for the contract that was nearest to expiration at the beginning of the period. That is, the change in the spot price proxy differs from the actual futures gain by the amount of the accumulated "Roll Yield". The actual futures gain can therefore be obtained by adding the accumulated "Roll Yield" back to the change in the spot price proxy. Expression (2) can be restated as:

Long Futures Gain = Change in Spot Price + Accumulated "roll yield". (3)

In interpreting expression (3), it should be noted that the change in spot price is not the economic gain or loss to a holder of spot inventory. It excludes any out-of-pocket storage costs (e.g. warehousing and insurance costs), as well as the opportunity cost on the funds tied up in inventory. Further, it omits the positive cash flows given off by some assets, such as Treasury instruments or equity portfolios. It also omits "convenience yields" (discussed further below), which are non-cash benefits attributable to the owner's option to use the inventory for purposes, e.g. as an input to a production process, other than continued storage. Further, as emphasized, the accumulated "roll yield" is not a cash flow paid or received by those who hold futures positions. However, the sum of the two components on the right side of (3) does equal the gain to the periodically-rolled long futures position.

The use of the word "yield" quite naturally give the impression of a periodic cash flow. There would likely be less confusion regarding the "roll yield" if a more descriptive label were used instead. Since the magnitude of the "roll yield" is determined by (the opposite of) the futures term structure, the phrase "term structure effect" would be descriptive. Or, since the cost-of-carry relation (discussed further below) links the slope of the futures term structure to the net benefit paid or received by the marginal holder of the underlying asset, labels such as "net inventory benefit" would be descriptive in those markets where the underlying good is storable. Nevertheless, given the ingrained usage, I continue to refer to the "roll yield." Readers should keep in mind that the phrase "roll yield" simply refers to the difference in two futures prices at certain date, and does not imply a cash flow to those who hold futures positons.

It has periodically been noted, correctly, that the futures gain or loss is equal to the “roll yield” if the spot price does not change. In the case of a hypothetical asset whose price follows a random walk without drift it follows that the expected futures gain equals the expected roll yield. Of course, random outcomes will still cause the actual futures gain or loss to deviate unpredictably from the roll yield, often by large amounts. Further, these is little reason to exclude the possibility of drift in spot prices. Financial asset prices drift upward on average if the expected return on the asset exceeds the cash flow yield, and vice versa, and spot commodity prices are frequently expected to drift upward or downward on a seasonal basis or as temporary price shocks are dissipated.

Perhaps more important, while the observation is correct, it remains potentially misleading. Consider, as an analogy, “breakeven analysis” as taught in basic operations or business economics courses. Revenues and production costs are each presumed to be deterministic functions of output quantity. Breakeven output is defined as the quantity where revenues just equal costs. That is, given a specific economic outcome, i.e. the firm produces its breakeven quantity, revenues and costs are equal. However, this does not imply that production costs are a form of revenue or are a component of revenues. Similarly, given a specific economic outcome, i.e. the spot price does not change, the futures gain and the “roll yield” are equal. However, this does not imply that “roll yields” are a form of futures gain or are a component thereof.

Some also point to the fact that arbitrage causes the nearest-to-expiration futures price to converge to the spot price as the delivery date approaches (in markets where the underlying is a storable asset) to justify the notion that the “roll yield” comprises a gain or loss to a futures position.[5] However, this perspective is uninformative regarding what most observers point to as the “roll yield”: the differences in futures prices across contracts with differing maturity dates. Arbitrage does not imply that futures prices for different delivery dates should necessarily converge by any given trading date.

These shortcomings notwithstanding, expression (3) highlights a potential use of the "roll yield" concept. To the extent that the actual "roll yield" can be forecast (e.g. based on the current term structure of futures prices), it is also possible to forecast whether a futures position will over or under-perform relative to the change in the spot price. In any case, the *ex post* "roll yield" will explain the *ex post* differential in the outcome to a futures position as compared to the spot price change.

This article is not the first to point out misunderstandings of the "roll yield". See, for example, Main, Irwin, Sanders, and Smith (2016), Bhardwaj, Gorton, and Rouwenhorst (2015), and Bessembinder, Carrion, Tuttle, and Venkataraman (2016). Nevertheless, the myth that futures traders earn or pay a periodic "roll yield" persists. As recently as August 2017, the Wall Street Journal asserted that "….investors have to pay the difference in the prices of monthly futures when they roll over positions from one month to the next."[6] In this article I hope to put the myth to rest, while clarifying the ways in which the "roll yield" concept can be useful.

I next clarify how actual gains and losses to investors are determined, and discuss how this reality can be reconciled with expression (1). I illustrate the concepts with data from the Chicago Mercantile Exchange (CME) Crude Oil contract (ticker CL) from 1990 to 2013. In addition, I discuss the possibility that, even if the "roll yield" is not a component of the actual futures gain, it might comprise a relevant economic state variable with some ability to explain or predict actual returns to futures positons.

Futures Gains, Spot Prices, and Roll Yields.

While it is commonly said that traders "buy" or "sell" futures contracts, this phrasing is potentially misleading, as the market value of a futures contract is zero. That is, the market determines the futures price as the price for deferred delivery of the underlying good that is consistent with the futures contract having a zero market value. It would be more accurate to say that traders enter and exit long and short positions in futures contracts. Once a trader enters a futures position, gains or losses are added to or deducted from his or her "margin account" on a daily basis. The actual amount added to or subtracted from a trader's margin account depends *only* on the change in the futures price while the position is open. Long positions receive any increase in the futures price and pay any decrease, scaled by the position size. Conversely, short positions pay any increase in the futures price and receive any decrease, scaled by the position size.

A Numerical Illustration

As noted in the introduction, what is commonly referred to as the "roll yield" is determined by the slope of the futures term structure, which varies over time. Figure 1 displays CME Crude Oil (CL) futures settlement prices on two dates, May 5, 2006, and September 5, 2007. On the former date the term structure was upward sloping, and computed "roll yields" would have been negative. In particular, the futures price for the nearest-to-expiration (June 2006) contract was $70.19, while that for the second nearest (July 2006) contract was $71.90. On the latter date the term structure was downward sloping, and computed "roll yields" would have been positive. In particular, the nearest-to-expiration futures price (for the October contract) was $75.73, while the futures price for the November contract was $74.67.

Consider the experience of an investor who held a long futures position in the CL contract from the first to the last trading dates of September, 2007. Figure 2 displays daily settlement prices, and I will assume that each transaction occurred at the daily settle. The downward slope of the CL futures term structure during this month is evidenced on Figure 2 by the fact that the November futures price was always lower than the October futures price. However, as it turned out, prices trended upward during the month.

Assume the investor entered a long position in the October 2007 contract on September 4, the first trading day, when the futures price was $75.08. Assume also that the investor rolled her position on September 19 (one day before the expiration of the October contract), exiting the long position in the October contract at a futures price of $81.93, and entered a new long position in the November contract at the futures price of $80.85. Finally, assume the investor closed her long position in the November contract on September 28, the last day of trading for the month, when the futures price was $81.66.

The investor's gain for the month is $7.66 (times the 1,000 barrel contract size and the number of contracts). This reflects an $81.93 - $75.08 = $6.85 increase in the futures price for the October contract while it was held and an $81.66 - $80.85 = $0.81 gain on the November contract during the time it was held. The investor's gain is wholly determined by changes in the futures prices of contracts during the time periods that she held an open position. The "roll yield" of $1.08 (the price at which the investor "sold" the October contract minus the price at which she "purchased" the November contract) is *not* a component of the investor's actual $7.66 gain; the investor does not "pocket the difference" between the two futures prices at the time of the roll. More broadly, the difference in futures prices across contracts with different delivery dates is not a component of the actual futures gain or loss on *any* date.

It has been suggested to me that whether the "roll yield" is or is not a component of a futures investors' gain or loss is a matter of semantics. I differ. The change in the futures price while a position is open is added to or removed from the investor's margin account, thereby increasing or decreasing her purchasing power. The "roll yield" is not added to or subtracted from the margin account, and therefore does not affect her purchasing power. It is hard to imagine a distinction more fundamental in the world of economics.

Making Sense of the "roll yield"

So what is the interpretation of expression (1), which might appear to state that the "roll yield" is indeed a component of the futures gain or loss? The key is to view the "roll yield" simply as the difference between the actual futures gain and the change in the spot price. Stated alternatively, the futures price term structure (which defines what is commonly referred to as the "roll yield") reveals whether futures gains exceed or fall short of spot price changes.

To see this, make the common assumption that the nearest-to-expiration futures price is a good proxy for the spot price. On September 4 the October contract is nearest, with a futures price of $75.08. On September 28 the November contract is nearest, with a futures price of $81.66. The increase in the spot price proxy during the month is $81.66 - $75.08 = $6.58. This differs from the actual futures gain of $7.66 by $1.08, which is also the amount of the "roll yield".

It is, of course, not a coincidence that the change in the spot price proxy differs from the actual futures gain by the amount of the "roll yield". The spot price proxy shifted during the month from the October futures price to the November futures price. The spot price proxy was therefore reduced by the amount of the "roll yield" on the day of the roll trade, even while the actual futures gain on that date was unaffected by the "roll yield". Thus, expression (2) is verified for this example. To reconcile the change in the spot price proxy with the actual futures gain requires that the "roll yield" be added back.[7]

This example is not unique. Over any time period and any number of rolls, the change in the nearest-to-expiration contact futures price, i.e. the change in the spot price proxy, is less than the actual futures gain by the amount of the accumulated "roll yield." So, adding the accumulated "roll yield" to the change in the spot price proxy gives back the actual futures gain.

Adding Economic Interpretation: The Theory of Storage

While expressions (1) and (3) hold for any futures market, additional economic perspective can be gained by applying the "cost-of-carry" model, which springs from the theory of storage and dates at least to Working (1949), Kaldor (1939) and Brennan (1958). The theory of storage focuses on the costs and benefits of holding inventory, as well as relations between inventory levels, spot prices, and volatility. The cost-of-carry relation arises from comparing costs and benefits across futures versus spot positions and explains the slope of the futures term structure in terms of the net cost of holding inventory. The costs of holding inventory include foregone interest and any cash storage costs such as warehousing or insurance. If there are no benefits to holding inventory (other than possible price appreciation) the theory implies an upward sloping term structure of futures prices (often referred to as a "contango" market) and negative "roll yields."

However, in those cases where the underlying asset is financial, positive cash flows accrue to owners in the form of interest payments or dividends. Further, in some circumstances (typically when inventory levels are low) real assets can provide non-cash benefits, termed "convenience yields" that arise from the owner's option to use the inventory for purposes (e.g., as an input to production) other than continued storage (Kaldor, 1939 and Working, 1948).[8] In cases where the benefits to holding inventory exceed the costs the theory implies a downward sloping term structure of futures prices (often referred to as a "backwardated" market), and positive "roll yields".

The cost-of-carry relation implies that the slope of the futures term structure (the futures price for more distant delivery less the futures price for near term delivery) can be stated as:

Futures Term Structure =

Interest Foregone + Cash Storage Cost – Asset Cash Flow – Asset Convenience Yield, (4)

where each component of (4) applies for the time period between the two futures contract delivery dates. Note, though, that the cost-of-carry model arises from an indifference condition that pertains to the *marginal holder of inventory*. While this distinction may be immaterial in the case of financial assets, it can be important for commodities, where storage costs and, in particular, convenience yields, can differ across market participants.

Recognizing that the "roll yield" is the opposite of the futures term structure, and assuming for convenience that the foregone interest from holding inventory and the interest earned on a collateralized futures position just offset, expression (4) can be combined with expression (1) to provide an alternative decomposition of the return to a long futures position:

Collateralized Futures Gain or Loss =

Change in Spot Price - Cash Storage Cost + Asset Cash Flow + Asset Convenience Yield. (5)

The right side of expression (5) is the total gain or loss to the marginal owner of spot inventory, and reflects the condition that this marginal holder of inventory should be indifferent between holding a spot or a futures position. Stated alternately, in markets where the cost-of-carry relation holds, expression (1) is another way of stating that futures investors can gain exposure to the same spot price changes as an investor who holds inventory, but they effectively pay the same storage costs and earn the same overall return as the marginal holder of inventory.

Expression (5) does not imply that all investors should be indifferent between gaining long exposure to commodity spot price changes through spot versus futures positions. Those who can store the commodity at lower cost or who benefit from larger non-cash convenience yields, most often individuals or firms who have made real investments specific to the commodity involved, will tend to prefer storage. Those who would incur higher storage costs or who would not benefit from the option to use inventory for non-storage purposes, including most portfolio investors motivated by diversification, inflation protection, or the possibility of price appreciation, would tend to prefer futures positions. Further, since there are no well-developed markets for short selling physical commodities, those who wish to gain short exposure to commodity price changes are for practical purposes restricted to futures positions.

An Application to Crude Oil Futures

To illustrate the actual gains and losses to long futures investors, and to highlight the comparison to changes in spot prices, I study data for CME crude oil futures (ticker symbol CL) over the January 1990 to December 2013 period. I state gains and losses in dollars per barrel rather than as percentages, so that gains or losses over time can be stated as sums of the gains over shorter periods.

On January 2, 1990, the futures prices for the nearest-to-delivery (February 1990) CL contract was \$22.89 per barrel. On December 31, 2013 the futures prices for the nearest-to-delivery (February 2014) CL contract was \$98.42 per barrel. Thus, the increase in the spot price proxy over the full twenty four years was $75.53. This substantial increase in spot prices over the full period masks a great deal of yearly variation, ranging from an increase of $34.93 during 2007 to a decrease of $51.38 during 2008, as displayed in Table 1.

To measure the gain to a trader who held a continuous long futures position over the twenty four years I implement expression (3), based on “roll yields” calculated from the price of the nearest and second nearest to expiration contracts on the last day of trading for the expiring contract. The results, displayed in the left columns of Table 1, show that the actual gain to a continuous long CL futures position from 1990 to 2013 was $61.63 per barrel. This was less than the $75.53 increase in the spot price, reflecting that the term structure of CL futures prices was, on average, upward sloping on contract expiration dates during the twenty four years considered. It terms of the cost-of-carry model, the implication is that net storage costs were on average positive, and that the marginal holder of spot inventory also earned less than the full-sample increase in the spot CL price over the twenty four years.

The difference between the actual gain to a long futures position and the change in the spot price, attributable to the futures term structure and referred to as the “roll yield,” varied considerably across years, from $12.12 in 2000 to -$14.33 in 2006. According to the cost-of-carry model, high roll yields are associated with negative net storage costs, i.e. substantial positive convenience yields. Large convenience yields would typically be associated with periods of low inventory, i.e. times when it is particularly attractive to some market participants to have ready access to the underlying commodity. Negative roll yields, in contrast, would be associated with high net storage costs to the marginal investor, which we might anticipate to be associated with high levels of inventory, when additional capacity is scarce and costly.

The Effect of Alternative Roll Dates

The decomposition of CL futures returns discussed in the preceding section is based on the assumption that the roll out of the expiring CL contract occurs on the final day of trading in that contract.

In practice, most market participants roll prior to expiration – open interest in the expiring contract typically declines rapidly prior to contract expiration, and the market may become less liquid in the final days before expiration.

Table 1 also reports actual gains to long futures positions and the difference between spot price changes and futures gains, aka "roll yields" when futures are assumed to be rolled from the nearest contract to the second-nearest-to-expiration contract at the settlement prices in effect either five or fifteen days before the expiration of the nearest contract. The results show that the actual futures gains over the full twenty four years differed dramatically depending on the assumed roll date. Over the twenty four years the gain to a continuous long futures position based on expiration-date rolls is $61.63, while the gain is reduced to $41.40 with an assumed roll fifteen days before expiration and to just $20.70 with an assumed roll five days before expiration.[9] Correspondingly, "roll yields", which measure the difference between the increase in the spot price and the actual futures gains over the twenty four years, also differ dramatically, summing to -$34.74 per barrel when rolling fifteen days before expiration and to -$54.83 per barrel when rolling five days before expiration, as compared to -$13.90 with expiration-date rolls.

At first glance, the data on Table 1 might appear to support the intuition that gains to CL futures investors were depressed by large negative "roll yields." However, while the reduction in returns associated with rolling at the earlier dates might indeed be related to rolling activity, as discussed further below, it remains a fact that the "roll yield" involves no cash flow at all. Rather, the differential outcomes for long CL futures investors for different assumed roll dates as documented on Table 1 arise because of *changes in the prices of individual futures contracts* in the days before the assumed roll dates. These changes in futures prices can also be observed as changes in "roll yields." That outcomes to long futures investors were better if they rolled fifteen days before expiration than if they rolled five days before reveals that the futures price of the near-to-expiration contract declined (relative to that of the second-nearest contract) on average in the interval from fifteen to five days before expiration, thereby imposing losses on investors who maintained a position in the nearby contract during that interval (relative to those who rolled earlier). That outcomes to long futures investors were better if they rolled at expiration rather than five days before expiration reveals that the futures price of the near-to-expiration contract rose (relative to that of the second-nearest contract) on average in the final five days of trading in the nearest contract, implying gains for investors who remained in the nearest contract during the final five days of its life (relative to those who rolled earlier).

As noted, the cost-of-carry model explains the futures term structure in terms of the net costs or benefits of holding physical inventory. The data in Table 1, viewed through this lens, implies that crude oil storage costs rose (or convenience yields fell) on average between fifteen and five days before expiration of the nearest CL contract, and that net storage costs fell (or convenience yields rose), rather markedly, on average during the last five days before contract expiration.

The cost-of-carry relation can be viewed as a no-arbitrage condition that is enforced by the trades of the marginal holder of inventory. In practice, arbitrage is costly and is therefore an imperfect mechanism. Du, Tepper, and Verdelhan, (2018) document that the no-arbitrage "interest rate parity" condition, which is simply the cost-of-carry relation applied to currencies, is often violated by economically meaningful margins. That is, arbitrage mechanisms are imperfect in the highly liquid currency markets, even though there are no transport or storage costs and virtually any market participant can potentially engage in arbitrage trades. Spot commodity markets involve substantial storage and transport costs, are generally less liquid that currencies, and are difficult or impossible to short. If arbitrage is imperfect in currency markets, it is surely imperfect in commodity markets as well.

Imperfections in arbitrage open the door to additional explanations for price patterns, including those based on trading strategies. It is of interest to note the substantial time variation in the differential outcomes to long CL futures positons across roll dates. From 1990 through 2003, the accumulated differences are minor. Rolling fifteen days before expiration rather than five days before led to an improvement in the long futures gain of $1.40 per barrel, or ten cents per year on average. Similarly, rolling at the expiration date rather than five days before expiration led to accumulated improvement for a long futures investor of just $0.88 per barrel over the fourteen years.

In contrast, from 2004 to 2009 the divergence was much larger. Rolling fifteen days rather than five days before expiration led to an improvement of $19.30 per barrel for a long futures trader over these six years. Even more striking, rolling at the expiration date rather than five days before expiration led to accumulated improvement for a long futures investor of $35.51 per barrel over these six years.

There has been extensive discussion of the possible effects of increased participation by financial investors in commodities markets, aka "financialization" since about 2004. Mou (2011) argues that traders have engaged in "front running" of the "Goldman Roll".[10] Bessembinder, Carrion, Tuttle, and Venkataraman (2016) consider the possibility of "strategic trading" in the days surrounding the roll trades of the large US Oil Exchange Traded Fund. The fact that divergences in outcomes to long futures traders as a function of the roll date were modest prior to 2004 but were large in the years thereafter is consistent with the reasoning that price impacts of large roll orders and/or strategic trading in advance of predictable roll trades imposed losses on long futures investors in those years. However, that divergences in outcomes to long CL futures investors across different roll dates are more modest since 2010 is also consistent with the reasoning that that competition and liquidity provision have improved as these strategies have become better understood, as discussed in Bessembinder (2015).

The fact that alternative roll dates were associated with substantial divergences in long CL investor outcomes, particularly from 2004 to 2009, might seem to validate a focus on "roll yields" to gain understanding regarding outcomes to futures investors. However, it remains the case that there is no cash flow associated with a futures roll. A correct understanding is that *changes* in roll yields *reveal* differential gains or losses across open futures positions of different maturity.[11] In particular, decreases (to a smaller positive or more negative level) in "roll yields" in advance of an actual roll trade reveal costs (and increases in roll yields reveal benefits), precisely because changes in "roll yields" are attributable to changes in the futures prices that determine the actual gains and losses to futures investors.

The "Roll Yield" as an Economic State Variable

I have emphasized that the "roll yield" is misnamed, because there is no cash flow to or from a futures trader associated with the difference in prices across futures contracts at the time of a roll, or on any other date. However, since the "roll yield" can be observed as the difference in a pair of futures prices that are jointly determined (along with spot prices) in economic equilibrium, it is plausible that it contains useful information about market conditions. That is, the statement that the "roll yield" is not a component of the futures gain or loss does not preclude that it is a relevant economic state variable, similar for example to market interest rates or equity dividend yields (each of which have been shown to have forecast power for equity returns).

As Main, Irwin, Sanders, and Smith (2016) note, the "roll yield" (which reflects storage costs and convenience yields, according to the cost-of-carry model), can serve as a signal by which investors can identify futures market opportunities. The theory of storage implies that "roll yields" will be related to levels of inventory and in turn to spot price volatility. The cost-of-carry relation (expression 5) shows that positive convenience yields could (assuming there is no offsetting change in the rate of spot price appreciation) be associated with larger gains to long futures positions. This outcome might arise, for example, if positive convenience yields are associated with higher spot price volatility. More broadly, "roll yields" should have some predictive power for actual futures gains and losses if they are correlated with time-varying market-determined risk premia.

To provide evidence on this issue, I estimate simple ordinary least squares regressions for CL futures over the 1990 to 2013 period. The dependent variable is the actual daily gain or loss to a long futures trader, assuming that rolls occur five days before expiration. The explanatory variable is the prior day "roll yield", measured as the nearby CL futures price less the second nearby futures price, and scaled by the number of days between delivery dates. In light of the evidence in the prior section, I estimate the regression separately for the 1990 to 2003 and 2004 to 2013 periods.

Results, reported on Panel A of Table 2, indicate that roll yields had no explanatory power for actual daily futures gains and losses during the 1990 to 2003 period. The slope coefficient is 0.30, with a statistically insignificant t-statistic of 0.84. However, for the 2004 to 2013 period the slope coefficient is 1.58, with a t-statistic of 2.33, which would generally be taken to indicate statistical significance. That is, the "roll yield" does have statistically significant forecast power for CL futures gains during the 2004 to 2013 period. Note, though, that the regression adjusted R^2 is only .002, implying that "roll yields" statistically explain only 0.2% of the variation in actual daily futures gains, even in the post-2003 data.

A number of authors, including Erb and Harvey (2006) and Gorton and Rouwenhorst (2006), have documented that the "roll yield" has a degree of predictive power for commodity futures returns. Main, Irwin, Sanders, and Smith (2016) and Bhardwaj, Gorton, and Rouwenhorst (2015) each report that average "roll yields" have significant ability to explain average gains to long futures positions *across* commodities. Additional evidence indicating that the "roll yield" is useful in predicting gains to futures investors is provided, among others, by Fama and French (1987) and Szymanowska, De Roon, Nijman, and Van den Goorbergh (2014). Even more broadly, Koijen, Moskowitz, Pedersen, and Vrugt (2018) provide evidence that the "cost-of-carry" has forecast power for spot returns in an array of spot markets, including commodities, equities, currencies, and interest rate products.

Futures Gains and Losses, and Mean Reversion in the Underlying

Independent of the question of whether the "roll yield" measured at a point in time can *predict* subsequent futures gains or losses, the roll yield may have ability to *explain* contemporaneous futures gains and losses. As noted, expression (3) shows that, should the change in the spot price turn out to be zero, the actual "roll yield" and the actual gain to a long futures position will be equal. Of course, spot prices are highly volatile, so this insight may be of little practical import, particularly in the short run. However, it seems plausible that some commodity prices contain a "mean reverting" component, i.e. that some portion of a typical shock to spot prices is reversed over time. To the extent that spot price shocks are reversed in the long run so that net changes in spot prices are reduced, roll yields should have greater ex-post explanatory power for futures price changes over longer time intervals. Consistent with this reasoning, Erb and Harvey (2016) report that the correlation between "roll yields" and returns to the S&P Goldman Sachs Commodity Index over longer (ten year) horizons is remarkably high, exceeding seventy percent.

An interesting extension of this reasoning concerns VIX futures, which are cash-settled based on outcomes to the CBOE VIX index. The VIX is a measure of stock market volatility, derived from prices for equity index options. As such, the VIX is not an asset, much less a storable one. Still, the decomposition in expression (3) holds for VIX futures as well.

It seems plausible that the VIX is stationary (i.e. it has a constant long term mean), as volatility spikes and lulls are eventually followed by a return to typical market volatility. If so, VIX futures gains should be approximately equal to accumulated "roll yields" over any time interval that begins and ends with volatility near its long term mean. Indeed, Eraker and Wu (2017) show that actual VIX futures returns are almost equal to the accumulated (negative) "roll yields" over the 2006 to 2013 interval.[12]

Conclusions

It is often asserted that the act of "rolling" a futures position by exiting one futures contract and entering another leads to a gain or loss proportional to the difference between the two futures prices. This asserted gain or loss is referred to as a "roll yield." In fact, the "roll yield" as an actual cash gain or loss to a futures investor is a myth. The gains to those who hold futures positions are determined *solely* by changes in the prices of individual contracts while positions are held. Differences in futures prices across contracts are not a component of futures investors' actual gains and losses on the date that they roll their positions, or on any other date for that matter.

While the term is a misnomer, the "roll yield" can be informative. It is properly understood as the difference between the gain on a periodically-rolled futures position and the change in the underlying spot price over the same time interval. That is, when "roll yields" are positive the futures gain will exceed the change in the spot, and when "roll yields" are negative the futures gain will be less than the change in the spot. This interpretation holds even in markets where the underlying good is not readily storable (e.g. electricity futures) or where the underlying is not an asset (e.g. volatility futures). This definition also implies that, to the extent it is possible to forecast future roll yields (e.g. based on the current term structure of futures prices) then it is also possible to forecast periods when futures positions will outperform or lag changes in the underlying spot price.

In markets where the cost-of-carry relation holds reasonably well the "roll yield" can be interpreted in terms of the net benefit (non-cash convenience yields or other cash benefits less interest and storage costs) to the marginal holder of inventory. This follows from the simple principle of "no free lunch" – futures traders can obtain exposure to the same spot price changes as those who hold spot positions, but they also experience the same net storage costs paid or received by the marginal holder of inventory.

Changes in "roll yields" are informative about actual futures returns. Increases in "roll yields" in the days prior to an actual roll of a long futures position reveal adverse (to a long investor) changes in futures prices, and vice versa. The evidence indicates that changes in roll yields in the days prior to roll trades were particularly important for crude oil traders during the 2004 to 2009 period.

These findings imply that portfolio investors should not select futures market positions in anticipation of capturing positive "roll yields" as cash flows, and should not shun futures positions in fear of paying negative "roll yields." Rather, the focus should be on portfolio risk and on returns expected to accrue through changes over time in the price of individual futures contracts. While the "roll yield" is not a *component* of the actual return to rolled futures positions, there is some evidence that the "roll yield" has a degree of forecast power, and stronger *ex post* explanatory power, for actual futures gains and losses. That is, the potential relevance of the "roll yield" for portfolio decisions lies in the possibility that it may be an economically relevant state variable for changes in futures prices over time.

References

Bessembinder, Hendrik, 2015, "Predictable ETF Order Flow and Market Quality," *Journal of Trading*, 10, 17-23.

Bessembinder, Hendrik, Al Carrion, Laura Tuttle, and Kumar Venkataraman, 2016, "Liquidity, Resiliency, and Market Quality around Predictable Trades: Theory and Evidence, *Journal of Financial Economics*, 121, 142-166.

Bhardwaj, Geetesh, Gorton, Gary B. and Rouwenhorst, K. Geert, 2015, "Facts and Fantasies About Commodity Futures Ten Years Later", Available at SSRN: https://ssrn.com/abstract=2610772.

Brennan, Michael, 1958, "The Supply of Storage", *American Economic Review*, 48, 50-72.

Du, Wenxin, Tepper, Alexander and Verdelhan, Adrien, 2018, "Deviations from Covered Interest Rate Parity", *Journal of Finance*, forthcoming.

Erb, Claude, and Campbell Harvey, 2006, "The Strategic and Tactical Value of Commodity Futures," *Financial Analysts Journal*, 62, 69-97.

Erb, Claude, and Campbell R. Harvey, 2016, "Conquering Misperceptions about Commodity Futures Investing", *Financial Analysts Journal*, 72, 26-35.

Gorton, Gary, and Geert Rouwenhorst, 2006, Facts and Fantasies about Commodity Futures, *Financial Analysts Journal*, 62, 47-68.

Fama, Eugene and Kenneth French, 1987, "Commodity Futures Prices: Some Evidence on Forecast Power, Premiums, and the Theory of Storage," *Journal of Business* 60, 55-73.

Eraker, Bjorn and Yue Wu, 2017, "Explaining the Negative Returns to VIX Futures and ETNs: An Equilibrium Approach", *Journal of Financial Economics*, 125, 72-98.

Ilan Guedj, Guohua Li, and Craig McCann, 2011, "Futures-Based Commodities ETFs", 2011, *The Journal of Index Investing*, 1, 14-24.

Kaldor, Nichlolas, 1939. Speculation and Economic Stability. *The Review of Economic Studies* 1, 1–27.

Koijen, Ralph S. J., Moskowitz, Tobias J., Pedersen, Lasse Heje and Vrugt, Evert B., 2018, "Carry", *Journal of Financial Economics*, 127, 197-225.

Main, Scott, Scott H. Irwin, Dwight R. Sanders, and Aaron D. Smith, 2016, "How Could We Have Been So Wrong? The Puzzle of Disappointing Returns to Commodity Investments" working paper, available at http://farmdoc.illinois.edu/irwin/research/Main_Irwin_Sanders_Smith_JOCM.pdf.

Mou, Yiqun, 2011, "Limits to Arbitrage and Commodity Index Investment: Front-Running the Goldman Roll", working paper, available at SSRN: https://ssrn.com/abstract=1716841.

Szymanowska, Marta. , Frans De Roon, Theo Nijman, and Rob Van den Goorbergh , 2014. "An anatomy of commodity futures risk premia", *Journal of Finance* 69, 453–482.

Working, Holbrook, 1949, "The Theory of the Price of Storage", *American Economic Review*, 34, 1254-62.

Table 1: Changes in CL Spot Prices, Gains to Long Futures Positions,

and Accumulated Roll Yields

Reported are annual changes in spot prices, annual gains to long futures positions that are rolled each month from the nearest-to-expiration contract to second-nearest-to-expiration contracts, and the "roll yield" accumulated across the twelve rolls of each calendar year. The nearest-to-expiration futures price is used as a proxy for the spot price. Amounts are dollars per barrel. Roll trades are assumed to occur at daily futures settlement prices. Results are reported when the roll is assumed to occur on the expiration date of the nearest contract, five days before the expiration date of the nearest contract, and fifteen days before the expiration date.

		Rolling at Expiration Date		Rolling 5 Days Before		Rolling 15 Days Before	
Year	Δ Spot Price	Futures Gain	Roll Yield	Futures Gain	Roll Yield	Futures Gain	Roll Yield
1990	5.55	2.56	-2.99	6.75	1.20	5.81	0.42
1991	-9.32	-5.17	4.15	-5.14	4.18	-6.58	2.10
1992	0.38	-0.58	-0.96	-0.07	-0.45	0.26	-0.23
1993	-5.33	-8.83	-3.50	-8.20	-2.87	-7.30	-2.19
1994	3.59	5.18	1.59	4.86	1.27	4.58	1.37
1995	1.79	4.91	3.12	3.98	2.19	4.21	2.86
1996	6.37	18.47	12.10	15.35	8.98	14.32	8.14
1997	-8.28	-9.03	-0.75	-8.63	-0.35	-7.20	0.21
1998	-5.59	-10.64	-5.05	-10.48	-4.89	-9.46	-3.82
1999	13.55	13.68	0.13	13.81	0.26	14.91	2.31
2000	1.20	13.32	12.12	12.31	11.11	10.53	9.34
2001	-6.96	-7.25	-0.29	-6.64	0.32	-6.18	-0.31
2002	11.36	12.16	0.80	11.95	0.59	12.68	2.20
2003	1.32	10.65	9.33	8.70	7.38	9.37	7.68
2004	10.93	16.70	5.77	13.05	2.12	15.20	3.85
2005	17.59	12.08	-5.51	7.84	-9.75	10.35	-7.92
2006	0.01	-14.32	-14.33	-15.34	-15.35	-14.19	-14.67
2007	34.93	32.67	-2.26	29.79	-5.14	31.52	-1.88
2008	-51.38	-46.19	5.19	-54.19	-2.81	-51.38	-4.19
2009	34.76	24.00	-10.76	8.28	-26.48	14.31	-17.12
2010	12.02	3.82	-8.20	0.80	-11.22	1.97	-10.23
2011	7.45	0.75	-6.70	-1.03	-8.48	-0.35	-7.13
2012	-7.01	-10.43	-3.42	-11.83	-4.82	-11.74	-5.01
2013	6.60	3.12	-3.48	4.78	-1.82	5.76	-0.52
Total	75.53	61.63	-13.90	20.70	-54.83	41.40	-34.74

Table 2: Assessing the Predictive Power of the Futures Term Slope for Futures Gains

Reported are results of estimating OLS regressions of the daily gain to a long position in the CL futures contract on the prior day "roll yield", measured as the futures price for the nearest-to-expiration contract less the futures price for the second nearest contract, scaled by the number of trading days between delivery dates. The return series shifts from the nearest-to-expiration contract to the second-to-nearest contract five days before expiration. Units are dollars per barrel.

Regression Coefficients					
	Intercept		Slope		
Period	Coef.	T-stat	Coef.	T-stat	Adj. R^2
1990 to 2003	0.01	1.38	-0.30	-0.84	0.000
2004 to 2013	0.04	0.96	1.58	2.33	0.002

Figure 1: The Term Structure of CL Futures Prices on Two Selected Dates

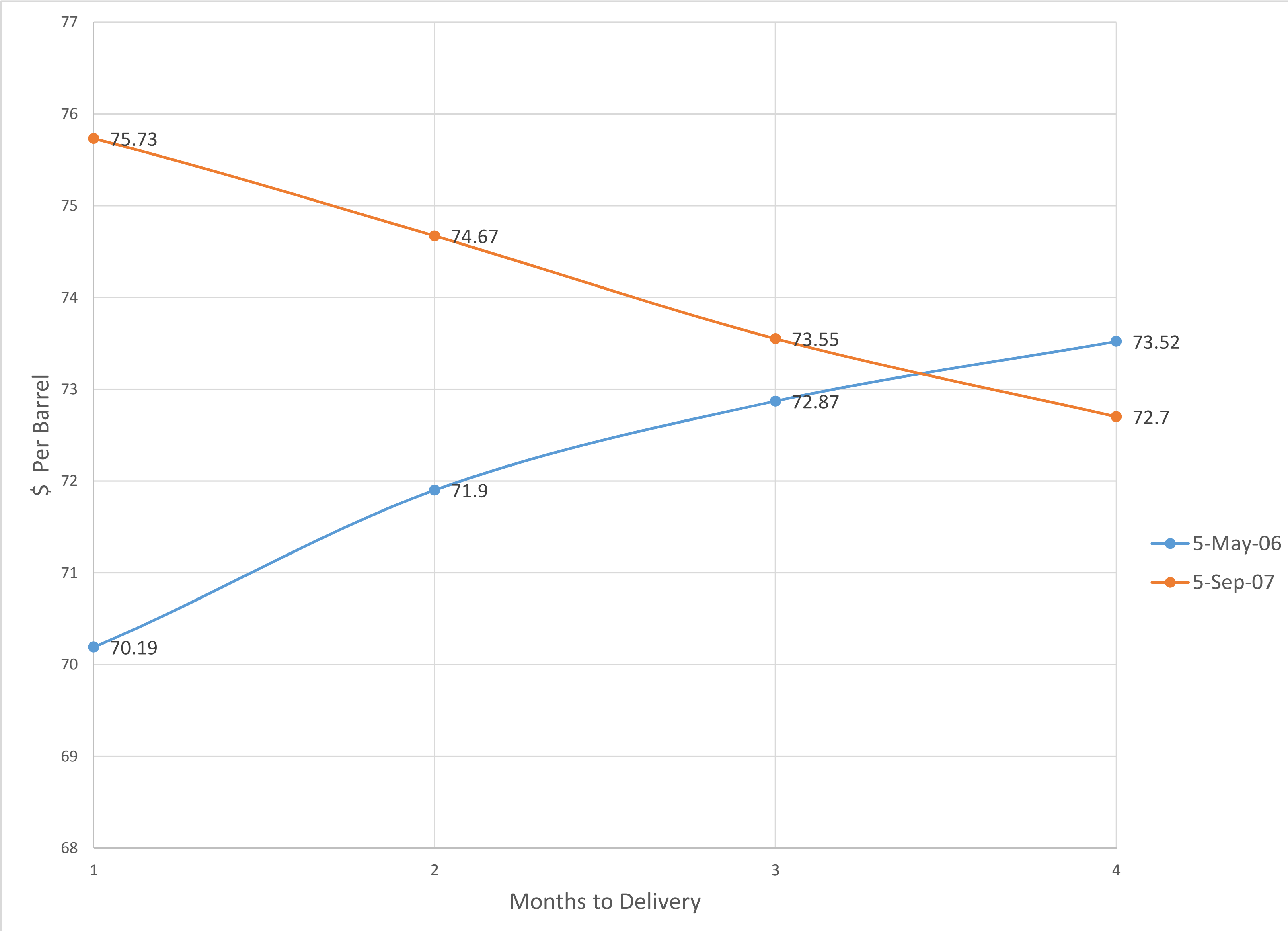
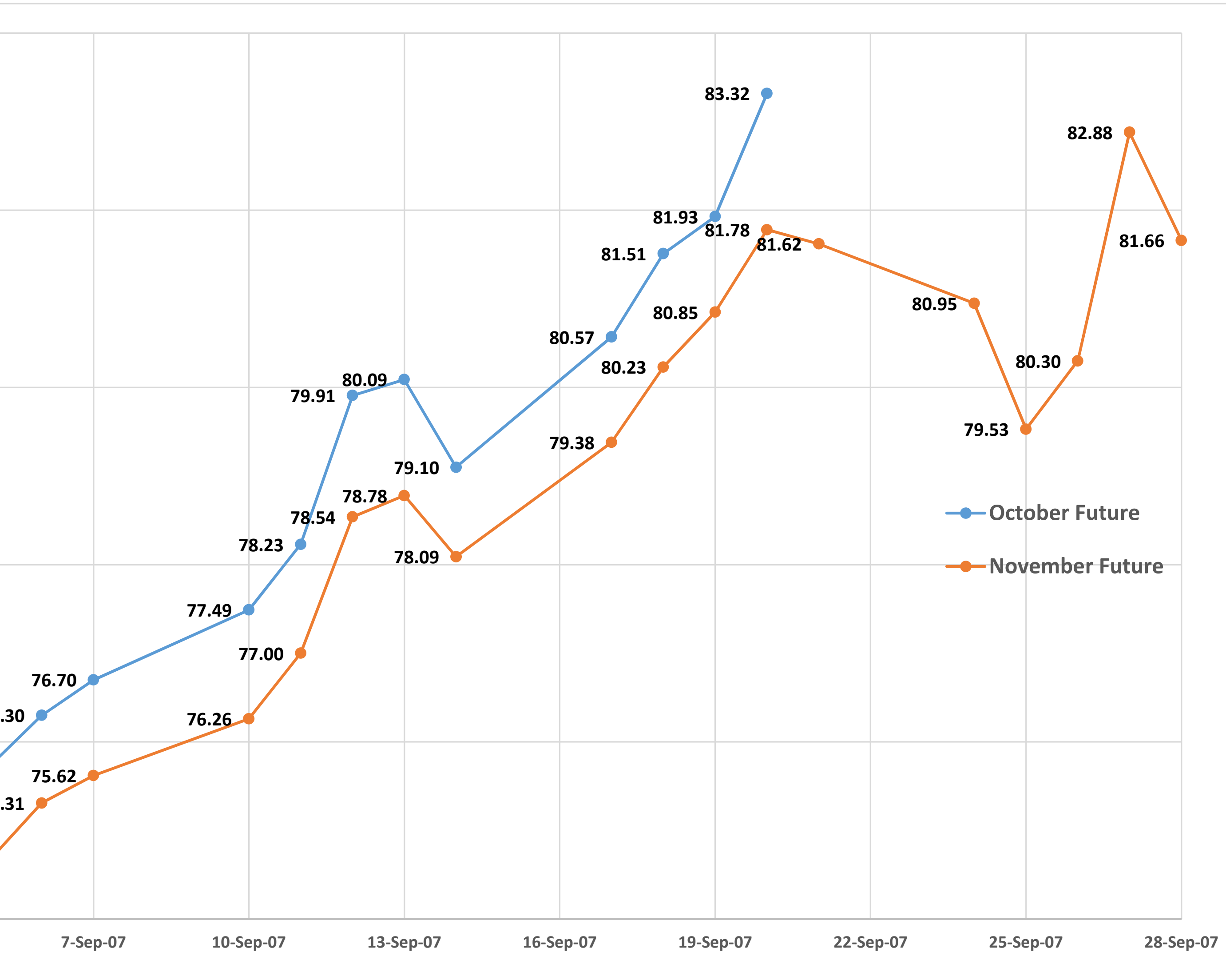


Figure 2: CME Crude Oil Futures Prices during September 2007



[1] "Winning by Waiting in Commodities", *The Wall Street Journal*, July 15, 2014. Available at https://www.wsj.com/articles/investors-cash-in-with-commodities-trading-strategy-1405466911.
[2] "ETFs Imperil Investors as Contango, Pre-Roll Conspire" Bloomberg Newsroom, July 22, 2010. Available at https://archive.is/XHHZV.
[3] For examples of academic papers asserting that roll trades lead to gains or losses in the amount of the difference in futures prices across contract delivery dates, see Mou (2011) and Guedj, Li, and McCann (2011). For additional examples from the financial press, see "Oil Investors Enjoy the Slopes" available at https://www.wsj.com/articles/SB10001424127887323971204578629942158096414 , "Buy, Hold & Lose: How a Commodities Roll Undercuts Investors", available at https://www.bloomberg.com/news/articles/2016-09-21/buy-hold-lose-how-commodities-roll-is-undercutting-investors, "Signs of Shift in Oil Balance Draw Investors Back In", available at https://www.wsj.com/articles/signs-of-shift-in-oil-balancedraw-investors-back-in-1486296002, "Commodity indices: 'rollover' practice hits investors", available at https://www.ft.com/content/453764e8-c586-11de-9b3b-00144feab49a, "Commodity Prices go Back to Basics", available at https://www.ft.com/content/347bd65c-b207-11e4-8396-00144feab7de, and "Oil Prices Flash A Buy Signal", available at https://www.wsj.com/articles/oil-prices-flash-a-buy-signal-1501585203.
[4] If the futures price is not a sufficiently good proxy for the spot price than expression (1) should be expanded to include the change in the "basis" (defined as the nearest-to-expiration futures price less the spot price) from the initial to the final date. In some cases authors and training materials present a version of expression (1) that refers to "spot return" instead of "change in spot price", in which case the expression is not typically correct.
[5] This perspective also relies on the assumption that the spot price does not change over time. If so, the difference between the nearby futures price and the spot price as of an earlier date will (assuming perfect convergence) indeed be equal to the gain or loss on the nearby future from the earlier date to the expiration date.
[6] See "Oil Prices Flash a Buy Signal", Wall Street Journal, August 2, 2017. Available at https://www.wsj.com/articles/oil-prices-flash-a-buy-signal-1501585203.
[7] To draw another analogy, the "roll yield" is similar to the identification of depreciation as a positive cash flow on certain accounting statements. Book depreciation (distinct from tax depreciation) is an accounting accrual with no cash flow consequences. However, it is deducted from revenues on the firm's income statement in the course of computing net income. To reconcile the firm's net income with its actual cash flow requires that depreciation be added back, even though it involves no cash, simply because it was previously deducted.
[8] The existence and magnitude of convenience yields is typically inferred from a futures term slope that is less than would be implied based on observable storage costs and cash flows.
[9] The astute reader will note that the difference between the futures gain and the "roll yield" is, for every year, equal to the change in the spot price when focusing on rolls at expiration or rolls five days before expiration, but not when focusing on rolls fifteen days before expiration. This reflects that the trading date that is fifteen days ahead of contract expiration often falls in the preceding calendar month, and in the case of January expirations, in the preceding calendar year, as compared to the expiration date.
[10] The "Goldman Roll" refers to the fact that the S&P Goldman Sachs Commodity Index shifts from tracking futures prices for nearest-to-expiration contracts to tracking prices for more distant contracts. Traders who wish to achieve futures gains that closely track the Index roll their futures positions simultaneous with changes in the index composition.
[11] A more precise statement is that changes in "roll yields" are relevant *except* when they arise due to a change in the pair of contracts used to compute the yield (e.g., the roll yield is computed from the February and March prices instead of the January and February prices). That is, somewhat ironically, *changes* in roll yields are relevant in determining actual gains and losses, *except* when they occur due to a "roll" trade.
[12] In the Eraker and Wu (2017) model the term structure of VIX futures can be either upward or downward sloping, depending in part on whether current volatility is above or below the long term mean, while the expected risk premium to a long futures position is always negative. Hence, their model does not imply a similarly strong linkage between "roll yields" and gains to long futures positions if initial volatility is above or below the long term mean.