# The "Roll Yield" Myth

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Futures investors are frequently said to periodically pay or receive the difference in futures prices across contracts with different delivery dates. But this "roll yield" is mythical: No such cash flow occurs—at the time of roll trades or on any other date. However, although 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 article clarifies the actual role of the roll yield.

Futures markets can provide an attractive venue for investors to gain exposure to broad classes of assets, including equity indexes, interest rates, currencies, metals, agricultural and energy commodities, and 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.

Because individual futures contracts expire prior to their specified delivery dates, however, maintaining an ongoing position requires the investor to periodically exit near-to-expiration contracts and enter contracts with more distant expiration dates. A common assertion is that this "rolling" activity generates gains or losses to futures investors, the magnitude of which depends on the difference in futures prices for the contract exited versus the one entered—that is, 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 (Shumsky 2014), written on a date when for many commodities the term structure of futures prices was downward sloping (i.e., near-delivery futures prices were higher than those for more distant delivery dates), 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.

As a second example, a Bloomberg column (Robison, Loder, and Bjerga 2010) that focused on crude oil contracts at a time when the term structure of futures prices was upward sloping (a condition often referred to as "contango") asserted the following:

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CE Credits: 1

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> 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.

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 date. Gains and losses on futures positions depend *only* on *changes* in the prices of individual contracts during the time an investor has an open position, 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 with 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 on the date of roll trades, futures investors pay or receive an amount proportional to the difference in futures prices across contracts with differing delivery dates. Unfortunately, the examples given here 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 substantial and thus impractical here.[1]

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 prices when they buy or receive futures prices when they sell. A more accurate description would be to say that traders *enter* and *exit* futures contracts. The myth may also arise, in part, because of a lack of appreciation for the fact that although futures contracts with different delivery dates may focus on the same underlying good, they refer to that asset at different points in time—a distinction that is relevant if the asset generates costs or benefits for its owner in the interim.

The myth may also partly derive from a misunderstanding of the following equation, 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)

Equation 1 defines the outcome for 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 into a position in a contract with a more distant expiration date. The "Accumulated roll yield" in Equation 1 refers to the sum across rolls of roll yields, defined for each roll as the more distant expiration futures price minus the near-to-expiration futures price at the time of the roll trades.

To be clear, Equation 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.[2] Furthermore, I expect that many of those who have relied on Equation 1 understand well that there is no actual cash flow associated with roll yields. Still, as the media quotations given previously demonstrate, some authors have adopted the myth that futures investing involves periodic cash flows from roll yields, and misinterpretation of Equation 1 may contribute to this misunderstanding.

How can Equation 1 be accurate if the roll yield is not a cash flow to a futures investor? Focus for a moment on the futures gain excluding interest on collateral. Consider the following equation, which is correct by construction:

Long futures gain =
(Long futures gain – Accumulated roll yield) + Accumulated roll yield. (2)

Equation 2 is a tautology. Indeed, any variable at all can be both added to and subtracted from the long futures gain without altering the validity of the equation. However, Equation 2 is not without economic interpretation. The term in parentheses, "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 be obtained, therefore, by adding the accumulated roll yield back to the change in the spot-price proxy. Equation 2 can be restated as

$$\text{Long futures gain} = \text{Change in spot price} + \text{Accumulated roll yield.} \quad (3)$$

In interpreting Equation 3, note 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) and the opportunity cost on the funds tied up in inventory. Furthermore, it omits the positive cash flows given off by some assets, such as US Treasury instruments or equity portfolios. It also omits "convenience yields" (discussed later), which are noncash benefits attributable to the owner's option to use the inventory for purposes other than continued storage (e.g., as an input to a production process). In addition, as emphasized, the accumulated roll yield is *not* a cash flow paid or received by those who hold futures positions. The sum of the two components on the right side of Equation 3, however, does equal the gain to the periodically rolled long futures position.

The use of the word "yield" quite naturally gives the impression of a periodic cash flow. There would probably be less confusion about the roll yield if a more descriptive label were used. Because the magnitude of the roll yield is determined by (is the opposite of) the futures term structure, the phrase "term structure effect" would be descriptive. Or because the cost-of-carry relationship (discussed later) links the slope of the futures term structure to the net benefit paid or received by the marginal holder of the underlying good, a label 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 term "roll yield" simply refers to the difference between two futures prices at certain dates and does not imply a cash flow to those who hold futures positions.

Some analysts have periodically 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, 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. Furthermore, there is little reason to exclude the possibility of drift in spot prices. Financial asset prices drift upward (downward), on average, if the expected return on the asset exceeds (is lower than) the cash flow yield, and spot commodity prices are often expected to drift upward or downward on a seasonal basis or as temporary price shocks dissipate.

Perhaps more important, although 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 at which revenues just equal costs; that is, given a specific economic outcome (i.e., the company produces its breakeven quantity), revenues and costs are equal. This fact does not imply that production costs are a form of revenue, however, or are a component of revenue. Similarly, given a specific economic outcome (i.e., the spot price does not change), the futures gain and the roll yield are equal. This fact does not imply that roll yields are a form of futures gain or are a component of it.

To justify the notion that the roll yield represents a gain or loss to a futures position, 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 good is storable).[3] This perspective is not informative, however, about 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, Equation 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), one can also forecast whether a futures position will over- or underperform 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 for a futures position as compared with the spot-price change.

This article is not the first to point out misunderstandings of the roll yield,[4] but the myth that futures traders earn or pay a periodic roll yield persists. As recently as August 2017, an article in the *Wall Street Journal* (Sider 2017) 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." 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 also clarify how actual gains and losses to investors are determined and discuss how this reality can be reconciled with Equation 1. In addition, I discuss the possibility that even if the roll yield is not a component of the actual futures gain, it might represent a relevant economic state variable with some ability to explain or predict actual returns to futures positions.

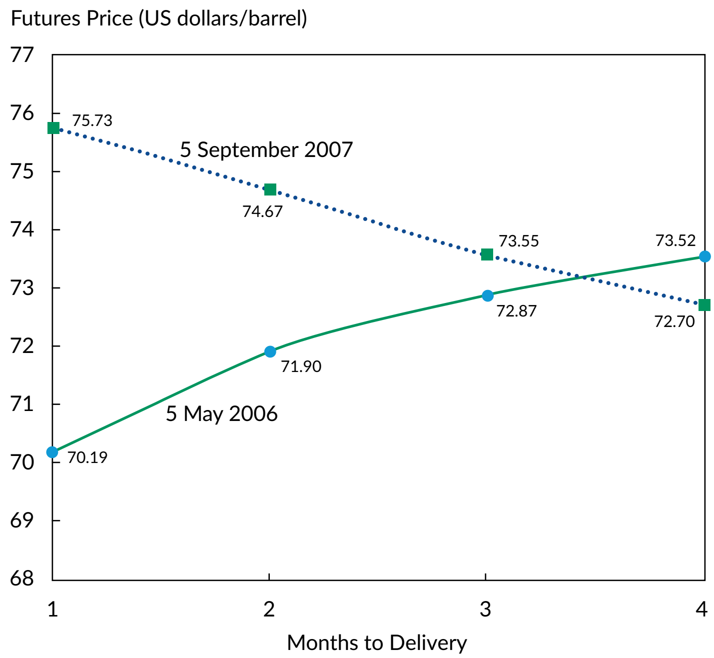
## Futures Gains, Spot Prices, and Roll Yields

Although traders are commonly said to "buy" or "sell" futures contracts, this phrasing is potentially misleading because 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. A more accurate way to describe what happens is 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, what is commonly referred to as the roll yield is determined by the slope of the futures term structure, which varies over time. I illustrate this concept with data from the Chicago Mercantile Exchange (CME) Crude Oil contract (ticker CL) from 1990 to 2013. **Figure 1** displays CME CL futures settlement prices on 5 May 2006 and 5 September 2007. On the 2006 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 contract (June 2006) was \$70.19, whereas for the second-nearest contract (July 2006), the price was \$71.90. On the 2007 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, whereas the futures price for the November contract was \$74.67.

Consider the experience of an investor who held a long futures position in the Crude Oil contract from

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



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 in Figure 2 by the fact that the November futures price was always lower than the October futures price. As it turned out, however, prices trended upward during the month.

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

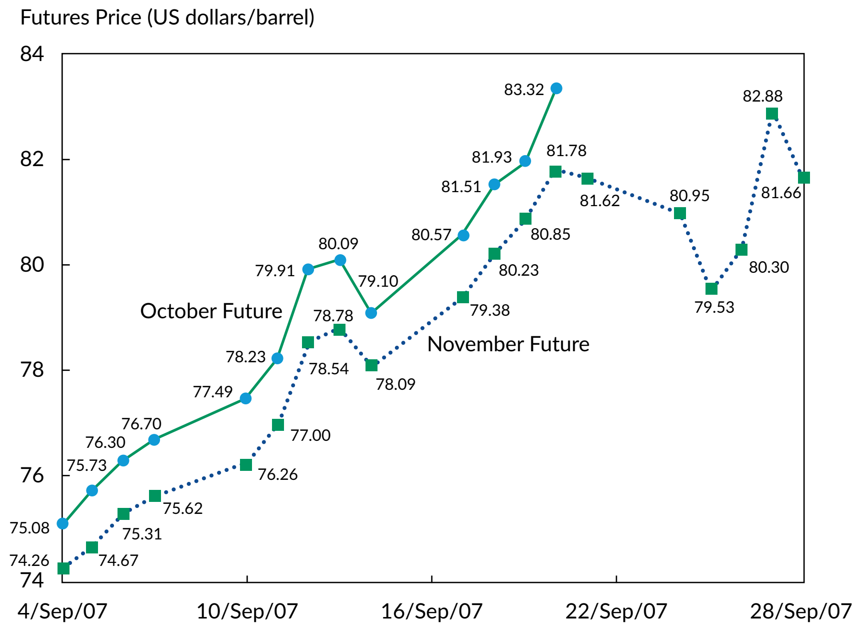
The investor's gain for the month is $7.66 (times the 1,000-barrel contract size and the number of contracts). This gain reflects an $81.93 – $75.08 = $6.85 increase in the futures price for the October contract while it was held and an $81.66 – $80.85 = $0.81 gain on the November contract during the 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. 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.

The suggestion has been made to me that whether the roll yield is or is not a component of a futures investor's 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 his or her purchasing power. The roll yield is not added to or subtracted from the margin account and, therefore, does not affect the investor's 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 Equation 1, which appears to state that the roll yield is 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 the truth of this statement, we will make the common assumption that the nearest-to-expiration

**Figure 2.** CL Futures Prices during September 2007



futures price is a good proxy for the spot price. On 4 September, the October contract is nearest, with a futures price of \$75.08. On 28 September, 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 total 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 thus 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, Equation 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.[5]

This example is not unique. Over any time period and any number of rolls, the change in the nearest-to-expiration contract 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.

## Economic Interpretation: The Theory of Storage

Although Equations 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 Kaldor (1939), Working (1949), and Brennan (1958). The theory of storage focuses on the costs and benefits of holding inventory and on relationships between inventory levels, spot prices, and volatility. The cost-of-carry relationship is determined by comparing costs and benefits across futures versus spot positions. It explains the slope of the futures term structure in terms of the net cost of holding inventory. The costs of holding inventory include forgone interest and any cash storage costs, such as warehousing or insurance. If no benefits come from 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.

When the underlying good is financial, however, positive cash flows accrue to owners in the form of interest payments or dividends. Furthermore, in some circumstances (typically when inventory levels are low), real assets can provide noncash benefits, termed “convenience yields,” that arise from the owner’s option to use the inventory for purposes other than continued storage (e.g., as an input to production; Kaldor 1939; Working 1949).[6] When the benefits of 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 relationship implies that the slope of the futures term structure (the futures price for more-distant delivery minus the futures price for near-term delivery) can be stated as

Futures term structure =
Interest forgone + Cash storage cost – (4)
Asset cash flow – Asset convenience yield,

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

Recognizing that the roll yield is the opposite of the futures term structure and assuming for convenience that the forgone interest from holding inventory and the interest earned on a collateralized futures position just offset, we can combine Equation 4 with Equation 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 + (5)
Asset cash flow + Asset convenience yield.

The right side of Equation 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 relationship holds, Equation 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.

Equation 5 does not imply that all investors should be indifferent between gaining long exposure to commodity spot-price changes through spot and futures positions. Those who can store the commodity at lower cost or who benefit from larger noncash convenience yields—most often, individuals or companies that have made real investments specific to the commodity involved—will tend to prefer storage. Those who would incur high storage costs or who would not benefit from the option to use inventory for nonstorage purposes—including most portfolio investors motivated by diversification, inflation protection, or the possibility of price appreciation—would tend to prefer futures positions. In addition, because no well-developed markets exist 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 with changes in spot prices, I use data for CME Crude Oil contract futures for the period January 1990 to December 2013. 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 2 January 1990, the futures price for the nearest-to-delivery (February 1990) Crude Oil contract was $22.89 per barrel. On 31 December 2013, the futures price for the nearest-to-delivery (February 2014) Crude Oil contract was $98.42 per barrel. Thus, as displayed in **Table 1**, the increase in the spot-price proxy over the full 24 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.

To measure the gain to a trader who held a continuous long futures position over the 24 years, Equation 3 is used with roll yields calculated from the prices of the nearest-to-expiration and second-nearest 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 total, less than the $75.53 increase in the spot price, reflects that the term structure of CL futures prices was, on average, upward sloping on contract expiration dates during the 24-year period. In terms of the cost-of-carry model, the implication is that net storage costs were, on average, positive and the marginal holder of spot inventory also earned less than the full-sample increase in the spot CL price over the 24 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 over the 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—that is, substantial positive convenience yields. Large convenience yields would typically be associated with periods of low inventory—that is, times when having ready access to the underlying commodity would be particularly attractive to some market participants. Negative roll yields, in contrast, would be associated with high net storage costs to the marginal investor, which might 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 rollout of the expiring Crude Oil 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. So, Table 1 also reports actual gains to long futures positions and the difference between spot-price changes and futures gains—also known as roll yields—when futures are assumed to be rolled from the nearest-to-expiration contract to the second-nearest contract at the settlement prices in effect either 5 or 15 days before the expiration of the nearest contract.

Table 1 shows that the actual futures gains over the full 24 years depended dramatically on the assumed roll date. Over the 24 years, the gain to a continuous long futures position based on expiration date rolls is $61.63; the gain is reduced to $41.40 when the roll is assumed to take place 15 days before expiration and to only $20.70 with a roll assumed to occur 5 days before expiration.[7] Correspondingly, roll yields, which measure the difference between the increase in the spot price

**Table 1. Changes in CL Spot Prices, Gains to Long Futures Positions, and Accumulated Roll Yields (dollars per barrel)**

| | | Rolling at Expiration Date | | Rolling 5 Days before Expiration | | Rolling 15 Days before Expiration | |
|---|---|---|---|---|---|---|---|
| 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 |

*Notes:* Roll trades were assumed to occur at daily futures settlement prices. Results are reported when the roll was assumed to occur on the expiration date of the nearest contract, 5 days before the expiration date of the nearest contract, and 15 days before the expiration date.

and the actual futures gains over the period, also differ dramatically. They sum to –$34.74 per barrel when rolling 15 days before expiration and to –$54.83 per barrel when rolling 5 days before expiration, as compared with –$13.90 for expiration-date rolls.

At first glance, the data in Table 1 might appear to support the intuition that gains to CL futures investors were depressed by large negative roll yields. The reduction in returns associated with rolling at the earlier dates might, indeed, be related to rolling activity, as discussed later, but the fact remains 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 in 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 15 days before expiration than if they rolled 5 days before expiration reveals that the futures price of the nearest-to-expiration contract declined (relative to that of the second-nearest contract), on average, in the interval from 15 days to 5 days before expiration. The result was to impose 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 5 days before expiration reveals that the futures price of the nearest-to-expiration contract rose (relative to that of the second-nearest contract), on average, in the final 5 days of trading in the nearest contract, which implies gains for investors who remained in the nearest contract during the final 5 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. Viewed through this lens, the data in Table 1 imply that crude oil storage costs rose (or convenience yields fell), on average, between the 15 days and 5 days before expiration of the nearest Crude Oil contract and that net storage costs fell (or convenience yields rose) rather markedly, on average, during the last 5 days before contract expiration.

The cost-of-carry relationship 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 (forthcoming) documented that the no-arbitrage "interest rate parity" condition, which is simply the cost-of-carry relationship applied to currencies, is often violated by economically meaningful amounts. That is, arbitrage mechanisms are imperfect in the highly liquid currency markets, even though the market entails no apparent transport or storage costs and virtually any market participant can engage in arbitrage trades. Spot commodity markets involve substantial storage and transport costs, are generally less liquid than currencies, and are difficult or impossible to short. If arbitrage is imperfect in currency markets, it is surely imperfect in commodity markets.

Imperfections in arbitrage open the door to additional explanations for price patterns, including those based on trading strategies. Note the substantial time variation in the differential outcomes to long CL futures positions at the different roll dates. From 1990 through 2003, the accumulated differences are minor. Rolling 15 days before expiration rather than 5 days before led to an improvement in the long futures gain of $1.40 per barrel, or 10 cents per year, on average. Similarly, rolling at the expiration date rather than 5 days before expiration led to accumulated improvement for a long futures investor of only $0.88 per barrel over the 14 years.

From 2004 to 2009, the divergence was much larger. Rolling 15 days rather than 5 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 5 days before expiration led to accumulated improvement for a long futures investor of $35.51 per barrel over the six years.

Extensive discussion has been going on in the literature about the possible effects of increased participation by financial investors in commodities—that is, financialization of commodities—since about 2004. Mou (2011) argued that traders have engaged in front running of the "Goldman Roll."[8] Bessembinder, Carrion, Tuttle, and Venkataraman (2016) considered the possibility of "strategic trading" in the days surrounding the roll trades of the large United States Oil Fund (an exchange-traded fund). Divergences in outcomes for long futures traders as a function of the roll date were modest prior to 2004 but were large in the years thereafter. This fact 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 the years after 2004. Divergences in results for long CL futures investors with different roll dates have been more modest since 2010. This outcome is also consistent, however, with the reasoning 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 about outcomes for futures investors. Still, however, no cash flow is associated with a futures roll. A correct understanding is that *changes* in roll yields *reveal* differential gains or losses for open futures positions of different maturities.[9] 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 no cash flow to or from a futures trader is associated with the difference in prices for futures contracts at the time of a roll. Because the roll yield can be observed, however, as the difference in a pair of futures prices that are jointly determined (together with spot prices) in economic equilibrium, the roll yield plausibly 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. It may be similar, for example, to market interest rates or equity dividend yields (each of which has been shown to have forecasting power for equity returns).

As Main, Irwin, Sanders, and Smith (2016) noted, the roll yield (which, according to the cost-of-carry model, reflects storage costs and convenience yields) 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 relationship (Equation 5) shows that positive convenience yields (assuming no offsetting change in the rate of spot-price appreciation) could 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. Broadly, roll yields should have some predictive power for actual futures gains and losses if they are correlated with time-varying market-determined risk premiums.

To provide evidence on this issue, I estimated simple ordinary least-squares regressions for CL futures for the 1990–2013 period. The dependent variable was the actual daily gain or loss to a long futures trader under the assumption that rolls occurred five days before expiration. The explanatory variable was the prior day's roll yield measured as the nearest CL futures price minus the second-nearest futures price and scaled by the number of days between delivery dates. In light of the evidence in the prior section, I estimated the regression separately for the 1990–2003 period and the 2004–13 period.

As reported in **Table 2**, regressions for the 1990–2003 period indicate that roll yields had no explanatory power for actual daily futures gains and losses during the period. The slope coefficient is –0.30, with a statistically insignificant *t*-statistic. For the 2004–13 period, however, the slope coefficient is 1.58, with a *t*-statistic of 2.33. Thus, the roll yield did have statistically significant forecasting power for CL futures gains during the later period. Note, however, that the regression-adjusted $R^2$ is only 0.002, 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 et al. (2016) and Bhardwaj, Gorton, and Rouwenhorst (2015) reported 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 was provided by, among others, Fama and French (1987) and Szymanowska,

**Table 2. Assessing the Predictive Power of the Futures Term Slope for Futures Gains: Regression Results**

| | Regression Coefficients | | | | |
|---|---|---|---|---|---|
| | Intercept | | Slope | | |
| Period | Coef. | *t*-Stat. | Coef. | *t*-Stat. | Adj. $R^2$ |
| 1990–2003 | 0.01 | 1.38 | –0.30 | –0.84 | 0.000 |
| 2004–2013 | 0.04 | 0.96 | 1.58 | 2.33 | 0.002 |

*Notes:* "Coef." is "coefficient"; "*t*-Stat" is the "*t*-statistic." The return series shifts from the nearest-to-expiration contract to the second-nearest contract five days before expiration. Units were measured in dollars per barrel.

De Roon, Nijman, and Van den Goorbergh (2014). More broadly, Koijen, Moskowitz, Pedersen, and Vrugt (2018) provided evidence that the cost of carry has forecasting power for spot returns in an array of spot markets, including commodities, equities, currencies, and interest rate products.

**Futures Gains and Losses: Mean Reversion in the Underlying Asset.** Independent of the question of whether the roll yield measured at a point in time can *predict* subsequent futures gains or losses is the idea that the roll yield may *explain* contemporaneous futures gains and losses. As noted previously, Equation 3 shows that if the change in the spot price turns 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. Some commodity prices, however, may contain a mean-reverting component; that is, some portion of a typical shock to spot prices reverses over time. If spot-price shocks reverse 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. Indeed, Erb and Harvey (2016) reported, consistent with this reasoning, that the correlation between roll yields and returns to the S&P Goldman Sachs Commodity Index over long horizons (10 years) is remarkably high, exceeding 70%.

An interesting extension of this reasoning concerns VIX futures, which are cash-settled on the basis of outcomes to the Chicago Board Options Exchange Volatility Index (the VIX). 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 Equation 3 holds for VIX futures. Plausibly, the VIX is stationary (i.e., it has a constant long-term mean) because 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) showed that actual VIX futures returns are almost equal to the accumulated (negative) roll yields over the 2006–13 interval.[10]

## Conclusion

Many writers have 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, however, 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 for different 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.

Although 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 good's spot price over the same interval. That is, when roll yields are positive, the futures gain will exceed the change in the spot price, and when roll yields are negative, the futures gain will be less than the change in the spot price. This interpretation holds even in markets where the underlying good is not readily storable (e.g., electricity futures) or where the underlying good is not even an asset (e.g., volatility futures). This characteristic implies that to the extent one can forecast future roll yields (e.g., based on the current term structure of futures prices), one can also forecast periods when futures positions will outperform or lag changes in the underlying good's spot price.

In markets where the cost-of-carry relationship holds reasonably well, the roll yield can be interpreted in terms of the net benefit (noncash convenience yield or other cash benefit minus interest and storage costs) to the marginal holder of inventory. This characteristic 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 (decreases) in roll yields in the days prior to an actual roll of a long futures position reveal adverse (beneficial) changes (to a long investor) in futures prices. The evidence indicates that changes in roll yields in the days prior to roll trades were particularly important for crude oil traders during the 2004–09 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 for 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. The roll yield is not a *component* of the actual return to rolled futures positions, but some evidence suggests that the roll yield has a degree of forecasting 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.

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## Notes

1. For examples of academic papers, see Mou (2011); Guedj, Li, and McCann (2011). For additional examples from the financial press, see Blas (2009); Denning (2013); Nussbaum and Javier (2016); Sider (2017); Terazono (2015); Yang and Sider (2017).

2. If the futures price is not a sufficiently good proxy for the spot price, then Equation 1 should be expanded to include the change in the "basis" (defined as the nearest-to-expiration futures price minus the spot price) from the initial date to the final date. Some authors and training materials present a version of Equation 1 that refers to "spot return" instead of "change in spot price," in which case, the expression is not typically correct.

3. This observation 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 futures from the earlier date to the expiration date.

4. See, for example, Main, Irwin, Sanders, and Smith (2016); Bhardwaj, Gorton, and Rouwenhorst (2015); Bessembinder, Carrion, Tuttle, and Venkataraman (2016).

5. 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. It is deducted from revenues on the company's income statement, however, in the course of computing net income. To reconcile the company'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.

6. The existence and magnitude of convenience yields are typically inferred from a futures term slope that is less than would be implied by observable storage costs and cash flows.

7. 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 5 days before expiration but not when focusing on rolls 15 days before expiration. The reason is that the trading date that is 15 days ahead of contract expiration often falls in the calendar month preceding the expiration date, and for January expirations, it often falls in the preceding calendar year.

8. 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 simultaneously with changes in the index composition.

9. A more precise statement is that changes in roll yields are relevant *except* when they result from 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 that they reveal actual gains and losses *except* when they occur because of a roll trade.

10. In the Eraker and Wu (2017) model, the term structure of VIX futures can be either upward or downward sloping, depending partly on whether current volatility is above or below the long-term mean. In contrast, the expected risk premium to a long futures position is always negative. Hence, the Eraker–Wu model does not imply a strong link between roll yields and gains to long futures positions if initial volatility is above or below the long-term mean.

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