The Impact of Commodity Futures Characteristics on the Roll Return

PETER PRINS, ANDRES TRUJILLO BARRERA, JOOST M.E. PENNINGS

Abstract

This research studies the impact of the roll return on long-only futures investments. It is analyzed how commodity futures characteristics and the roll horizon influence the performance of roll strategies. The roll horizon is defined as the difference between the roll date and the maturity date of the futures contract which is entered. Evidence is found that seasonality, storability, the settlement method and the roll horizon influence the roll return. However, these results are not robust to different periods. Hence, it is concluded that commodity futures characteristics and the roll horizon do not influence the roll return.

Keywords: Commodities, roll return, commodity characteristics, roll strategies

1. Introduction

In the last decade commodity index investments have become an accepted alternative for institutional investors (Irwin & Sanders, 2012). Commodities not only yield equity-like returns, but also provide a hedge against inflation. Also, commodities provide a natural hedge in portfolios because of its negative correlation with equities and bonds (Gorton & Rouwenhorst (2006), Erb & Harvey (2006)).

Although long-only index funds have attracted significant cash-inflows during the last decade, their returns are often disappointing when compared to the spot returns of the underlying commodities (Main, Irwin, Sanders, & Smith, 2013). For example, an investment in the iShares GSCI Commodity Index Trust would have yield a capital loss of approximately 39.6% in the period July 2006 to September 2011 while the commodities constituting this index reported, in general, spot price increases (Main et al., 2013).

Since futures contracts mature and long-only index funds wish to keep their exposure, these funds sell maturing futures and "roll" their positions into more deferred contracts. Typically, at each point in time multiple futures contract are traded that differ in time-to-maturity (Szymanowska, De Roon, Nijman, & Van Den Goorbergh, 2014). The difference in time-to-maturity and the date at which is rolled, i.e. the roll date, is referred to as the roll horizon. The question arises to which contract long-only futures investors should should roll their position to increase performance, i.e. does the roll horizon influence the investor's performance? If so, can commodity and futures characteristics explain this change in performance? Which roll strategy is optimal for a commodity futures given its characteristics?

Roll returns

The roll return stems from futures price convergence to the expected future spot price (de Groot, Karstanje, & Zhou, 2014). Whether the roll return is positive or negative depends on whether the futures market is in contango or in backwardation. The futures market is in contango (backwardation) when the expected future spot price is lower (higher) than the price of the futures (Gorton, Hayashi, & Rouwenhorst, 2013; Grauer & Litzenberger, 1979; Miffre, 2000). When the market is in contango (backwardation), contracts maturing in the near future are relatively less (more) expensive as deferred contracts. The relationship between near and deferred

futures is referred to as futures' term structure. If the futures term structure is in contango (backwardation) the roll return of a long position is negative (positive) (de Groot et al., 2014) .

Roll strategies

To analyze the roll return, the following roll strategies are created and created and examined:

Front Month Roll – roll every maturing futures on the last trading day of the month before the maturity month into the next maturing futures contract. In this research research, this strategy is often used as a benchmark because the first generation long-only index funds use this strategy (or a close equivalent) to roll futures positions (Miffre, 2012).

Last Day Roll – roll every maturing futures on the last trading day into the next maturing contract.

Deferred Roll – roll every maturing futures on the last trading day of the month before the maturity month into the last futures contract for which a price is available. Thus, this strategy rolls into the contract with the most deferred maturity date.

Annual Fixed Month Roll – roll futures to a predefined month in the following year. This strategy rolls on the last trading day 'x' months before the predefined month. For example, if 'x' equals one this strategy rolls on the last trading day one month prior to the maturity month, if 'x' equals two this strategy roll on the last trading day two months prior to the maturity month, etc. The variable 'x' depends on the hypothesis that is tested.

Note that the roll horizon is the same for both the Front Month Roll strategy and the Last Day Roll strategy. The only difference between these strategies is the roll date.

The influence of the following commodity futures characteristics on the performance of these strategies are examined: storability, seasonality and the settlement method.

Performance is measured by excess return and by the Sharpe ratio. The excess return of a futures position is the sum of the spot return and the roll return ($R_{excess} = R_{spot} + R_{roll}$). The Sharpe ratio is a measure of reward per unit of variability (Sharpe, 1966). Using historical data the Sharpe ratio is calculated as follows:

$$S_{i,z,t} = \frac{\bar{R}_{total,i,z,t} - \bar{R}_{f,t}}{\sigma_{total,i,z,t}} \quad (1)$$

Where S is commodities i's Sharpe ratio using strategy z in time period t, $\bar{R}_{total,i,z}$ is commodities i's mean collateralized futures return using strategy z in time period t, $\bar{R}_f$ is the mean risk free rate in time period t, and $\sigma_{i,z}$ is the standard deviation of commodity i's collateralized futures return using strategy z in time period t.

Examining how commodity futures characteristics influence the relative performance of various roll strategies is the main contribution of this paper. Another important contribution is determining the effect of the roll horizon and roll date on the performance of long-only futures investors.

This research finds that the roll horizon influences the performance of long-only futures investors. The Front Month Roll strategy is found to underperform strategies with longer roll horizons (e.g. the Deferred Roll strategy and the Annual Fixed Month Roll strategy). This is an interesting finding as most of the first long-only index funds use roll strategies similar to the Front Month Roll strategy (Miffre, 2012). Hence, these funds have an opportunity to increase performance by changing the roll horizon or roll date.

This research also finds partial evidence that commodity characteristics influence the roll return. So is the performance of the Deferred Roll strategy is higher for non-storable commodities in comparison to storable commodities. Furthermore, the performance of the Front Month Roll strategy is higher for cash settled futures in comparison to futures settled by physical delivery. In addition, rolling the old crop futures prior to a key production period is likely to increase the performance of a strategy.

However, these results are not robust as they are sensitive to time. The observed time variation in relative performance cannot be explained by the roll horizon nor by commodity characteristics as these are stable over time. Therefore, this research concludes that neither the roll horizon nor commodity characteristics influence the roll return in a predictable way.

The remainder of this paper is structured as follows. In the next section the hypotheses are derived. Subsequently, the data and methodology is explained after which the results are presented and discussed. Then the robustness of the results are analyzed. Finally, we conclude.

2. Model

In this section hypotheses are formulated about whether the roll horizon influences the roll return (hypotheses 1 and 2). Subsequently, hypotheses are derived about the influence of commodity futures characteristics on the roll return (hypotheses 3,4,5 and 6).

2.1 Influence of the roll horizon on the roll return.

2.1.1 Deferred Roll strategy

Trading deferred futures lowers monthly average costs, therefore it increases the return of long only futures investments. This is achieved by reducing fixed storage costs and transaction costs.

Fixed storage costs

In the cost of carry model futures contracts are priced according to the prevailing interest rate, the cost of storage and the convenience yield (Working, 1948). Kastens and Dhuyvetter (1999) note that handling and elevating are one-time events in grain storage. Thus, handling and elevating are fixed cost that can be attributed to the cost of storage, hence, these fixed costs are included in the futures price. Rolling maturing contracts into more deferred futures allows long-only futures investors to spread these costs over longer time periods in comparison to a strategy that rolls more often, e.g. the Front Month Roll strategy. Hence, rolling maturing contracts into more deferred futures (i.e. applying a longer roll horizon) reduces the average cost of storage. Hence, rolling maturing contracts into more deferred futures could increase the performance of long-only futures investors.

Transaction costs

Strategies rolling maturing contracts into more deferred futures roll less often compared to strategies with a shorter roll horizon, e.g. the Front Month Roll strategy. Hence, rolling maturing contracts into more deferred futures lowers the number of transactions and thus decreases transaction costs. Lower transaction costs result in higher excess returns.

Samuelsons' maturity effect

Rolling deferred futures increases excess returns because storage and transaction costs are reduced, leading to a higher Sharpe ratio (equation 1). In addition, rolling maturing futures to deferred futures also increases the Sharpe ratio as volatility is reduced. This is due to

Samuelson's maturity effect which holds that volatility increases as futures near maturity (Samuelson, 1965).

Based on these arguments the following hypothesis is derived:

Hypothesis 1: the performance of the Deferred Roll strategy is higher than the performance of the Front Month Roll strategy.

As highlighted in the introduction, in this research performance is measured by both excess return and the Sharpe ratio. Hence, hypothesis 1 and the following hypotheses are tested using both performance measures.

2.1.2 Annual Fixed Month Roll strategy

Crops must be planted and can only be harvest during a specific period each year. Corn, for instance, can only be harvested once a year. Since consumers demand corn throughout the year, corn is stored between harvests. The period between harvests is called the crop year. The first futures that matures after (before) the new harvest is called the 'new crop' ('old crop') futures.

Asymmetric cost of carry returns potentially increase the price volatility of a season's old crop contract in comparison to a season's new crop contract. At any point in time an unexpected increase or decrease in demand can occur. Stocks decrease throughout the crop year and are lowest just before harvest. Hence, at the end of a crop year there is a relatively low stock to absorb a demand shock. Thus, the change of a stock-out increases during the crop year.
A stock-out would lead to an exponential increase in the price of old crop contracts which are settled after the demand shock took place. If the demand shock where negative, the prices of the futures settled after the demand shock would drop but to a lesser extent as the increase in the price in case of a positive demand shock. This asymmetric return to the cost of carry (Working, 1948) could result in relatively high price volatility of the last old crop contract (Williams & Wright, 1991; p. 209-212). Hence, annually rolling the last old crop futures would lead to a relative low Sharpe ratio compared to another roll strategy.

Similarly to the Deferred Roll strategy, rolling a futures once a year would lead to lower storage and transaction costs in comparison to the Front Month Roll strategy. Hence, it is expected that the performance in excess return terms is higher for the Annual Fixed Month Roll strategy in comparison to the Front Month Roll strategy. Due to the increase in excess return and the increase in volatility the effect on the Sharpe ratio is ambiguous and can only be determined empirically.

Therefore, the following hypothesis is tested:

Hypothesis 2: the performance of the Annual Fixed Month Roll strategy is higher than the performance of the Front Month Roll strategy

2.2 Influence of commodity futures characteristics on the roll return

In this section hypothesis are formulated concerning how futures characteristics influence the roll return.

2.2.1 Seasonality

Till (2000) finds a weather fear premium for commodities for which the production is sensitive to the weather. The weather fear premium is premium that arises in due to upcoming meaningful weather events. When these events are upcoming the futures price is systematically to high (Till, 2000). If the fear premium is large enough (i.e. the fear premium outweighs the loss due to perishability), annually rolling last season's old crop futures might result in even higher performance if the position is rolled when the weather fear premium is high.

Hypothesis 3: the performance of a strategy that rolls the last old crop futures prior to the key production period is higher than the performance of a strategy that rolls the last old crop futures one month prior to the maturity month.

Hypothesis 3 is empirically tested for corn using the Annual Fixed Month Roll strategy. The key production period of corn is July (Till, 2000). In the case of corn the Annual Fixed Month Roll strategy rolls every maturing September futures to next years September futures on the last trading day in August. Hypothesis 3 compares this roll strategy to the Annual Fixed Month Roll

strategy that rolls every maturing September at the end of June which is three months before maturity. The hypothesis holds that the latter strategy outperforms the former.

2.2.2 Storability

Storability is important since arbitrage might work through storage. If a commodity is non-storable the convenience yield is not incorporated in the futures price. These futures thus cannot profit from backwardation arising from the convenience yield. However, these futures might still be in backwardation in accordance with the risk premium theory. Since investors have a relatively good insight in near future marketings (for example USDA reports) in comparison to marketings further in the future (Sanders, Garcia, & Manfredo, 2008)[i], the uncertainty regarding future marketings further in the future is relatively high. Hence, the risk of deferred futures of non-storable commodities is higher relative to the risk of storable commodities. Since storage works as a smoothing mechanism, storage reduces the risk of deferred storable commodity futures (e.g. Gustafson (1958), Tomek & Gray (1970)). According to standard financial theory lower risks should be accompanied with lower returns. Hence, the following hypothesis is derived:

Hypothesis 4: the performance of the Deferred Roll strategy is higher for non-storable commodities in comparison to storable commodities.

2.2.3 Settlement method

A futures contract can either be settled by physical delivery or by cash. When a futures is cash settled the seller of a futures does not have the obligation to deliver the future's underlying, as opposed to a futures that is settled by physical delivery. Long-only futures investors do not take physical delivery, hence they typically close their position prior to the first notice day. This may negatively affect futures prices at the end of the month prior to the maturity month. Cash settled futures do not face this issue. Therefore, it is hypothesized that the return of the Front Month Roll strategy is relatively higher for cash settled futures in comparison to futures settled by physical delivery:

Hypothesis 5: the performance of the Front Month Roll strategy is higher for cash settled futures as it is for physically delivered futures.

An overview of how the various roll strategies are related to the hypotheses is depicted in Table 1.

Table 1 – Research design: hypotheses and roll strategies

	Front Month Roll	**Deferred Roll**	**Annual Fixed Month Roll**
Front Month Roll	H5: Commodity Characteristic	H1	H2
Deferred Roll	H1	H4: Commodity Characteristic	
Annual Fixed Month Roll	H2		H3: Commodity Characteristic

Table 1 – Table 1 is provides an overview which strategies are used to test a certain hypothesis.

As can be seen in Table 1 no hypotheses are derived for the relationship between the Annual Fixed Month Roll strategy and the Deferred Roll strategy because both strategies may coincide. Furthermore, no hypotheses are derived for the Last Day Roll strategy. This strategy is the benchmark for hypotheses 4 and 5.

3. Data and Methodology

3.1 Data

Futures prices are daily settlement prices up to January 2015 obtained from Thomson Reuters Datastream. Characteristics of the selected commodities are shown in Table 2.

Crop seasons

Of the eleven commodities studied in this research most do not have a specific crop season. This holds for non-crop commodities such as feeder cattle, live cattle and lean hogs. However, this also holds for oranges (the input for frozen concentrated orange juice), coffee and cocoa. These commodities are harvested almost throughout the entire year. Hence, for these commodities the old crop/new crop futures are not specified in Table 2.

Contract changes

Since lean hogs futures and feeder cattle futures are cash settled since February 1997 and September 1986 respectively, these commodities are analyzed from these dates onwards.

Data availability

Hypothesis 2 is tested for contracts with maturities from 2006 onwards, because since 2006 for every crop commodity a contract is available thirteen months in the future and for every crop commodity this contract is priced.

3.2 Methodology

Strategies and roll returns

To compare roll returns of various roll strategies over time and to account for round turn transaction costs (to be discussed) futures prices are transformed into continuous ratio-adjusted time series. The Continuous Ratio-Adjusted Time Series (CRATS) is computed as follows. First, the roll dates are determined. Second, the ratio between the price of contract to which is rolled and the contract from which is rolled is calculated:

$$Ratio = \frac{F_{t+1}}{F_t} \quad (2)$$

Where F_t is the price of the contract from which is rolled and F_{t+1} is the price of the contract to which is rolled. Third, each price up to the point of the roll date is multiplied by the ratio.

$$\left\{\left[P_{adjusted_{t,n}}\right]\right\}_{t,n=1}^{T,N} with \begin{cases} P_1 = [P_1] & if\ n = 1 \\ P_n = \begin{bmatrix} P_{n-1} \times Ratio \\ P_{t,n} \end{bmatrix} & if\ n > 1 \end{cases} \quad (3)$$

Where $P_{adjusted_{t,n}}$ is a vector containing adjusted futures prices for futures in time period t to T, *Ratio* is the adjustment ratio as defined above, n is a futures contract identifier, P_{n-1} is a vector containing all futures prices up to and including the futures price at the roll date and P_n is a vector of all futures prices since the last roll date up to and including the next roll date.

Table 2 – Sample and commodity characteristics

Commodity	Number of futures	Start date	End date	Exchange	Storable	Cash settled	Old Crop / New Crop	Settlement months	Tick size	Contract multiplier
Corn	23	17-09-2007	12-12-2014	CME	Yes	No	9/12	5,7,9,12	0.0025	5000
Soybean	125	21-09-1995	14-11-2014	CME	Yes	No	7/11	1,3,5,7,8,9,11	0.0025	5000
Wheat	169	05-02-1980	28-11-2014	KCBT	Yes	No	5/7	3,5,7,9,12	0.0025	5000
Oats	94	06-01-1995	12-12-2014	CME	Yes	No	5/7	3,5,7,9,12	0.0025	5000S
FCOJ	203	01-10-1979	7-11-2014	CME	Yes	No		1,3,5,7,8,11	0.0005	15000
Sugar	135	01-10-1979	30-09-2014	ICE	Yes	No		3,5,7,10	0.0001	112000
Coffee	267	18-04-1980	14-11-2014	ICE	Yes	No		3,5,7,9,12	0.0005	37500
Cocoa	169	16-11-1979	15-12-2014	ICE	Yes	No		3,5,7,9,12		
Feeder Cattle	268	08-05-1980	21-11-2014	CME	No	Yes		1,3,4,5,8,9,10,11	0.00025	50000
Live Cattle	203	05-02-1980	31-12-2014	CME	No	No		2,4,6,8,10,12	0.00025	40000
Lean Hogs	250	15-10-1979	28-11-2014	CME	No	Yes		2,4,5,6,7,8,10,12	0.00025	40000

Table 2 – This table provides an overview of the commodities analyzed and the commodity futures characteristics. FCOJ is used as an abbreviation for frozen concentrated orange juice. The thick size is the thick size in dollars per pricing unit. The contract multiplier is the amount of units traded per contract.

For each trading strategy and commodity a CRATS is calculated. The final adjusted price vectors are than transformed into return vectors according to (4).

$$[R_{n+1}] = \frac{P_n - P_{n+1}}{P_{n+1}} \times 100\% \ (4)$$

Where P denotes the ratio adjusted price vector, P_n the price in row n, P_{n+1} is the price in row $n+1$ and R is the return vector based on the ratio adjusted price vector.

The return of one strategy relative to another strategy is then calculated as follows:

$$Relative\ Performance = \frac{(1 + r_{1,t})}{(1 + r_{2,t})} \ (5)$$

Where r_1 is the total return of a certain trading strategy in time period t and r_2 is the total return of another trading strategy in time period t.

Transaction costs

Transaction costs are incorporated using the approach of Szakmary, Shen, & Sharma (2010). They include fixed brokerage costs and proxy bid ask spreads. Szakmary et al. (2010) conclude that the effective bid-ask spreads is generally less than or equal to the value of one tick per contract. Hence, they calculate transaction costs as a percentage of the futures price as follows:

$$TC = \frac{F + TS \times CM}{P \times CM} \ (6)$$

Where TC are transaction costs, F are fixed brokerage costs, TS is the tick size of the futures contract, CM is the contract multiplier and P is the price of the futures. In line with Szakmary et al. (2010) fixed brokerage costs are assumed to be $10.

The transaction costs are accounted for by adjusting the ratio determined in (3):

$$Ratio = \frac{F_{t+1}}{F_t} + TTC \ (7)$$

Where TTC is the total cost of rolling a futures position, i.e. buying and selling. The other variables are as previously defined.

Fully collateralized futures returns

The value of a futures contract is zero at origination. Hence, entering a futures contract, either long or short, does not require an initial cash outlay. Therefore, to compare futures returns to returns of other financial assets researchers typically make the assumption that futures are fully collateralized. A fully collateralized futures position is one in which the buyers and sellers of a futures contracts make an additional investment in another asset with a value equal to the futures price (Gorton & Rouwenhorst, 2006). A fully collateralized different futures also ensures a similar comparison of futures because one does not have to take into account differences in margins over time and across commodities.

The return of a fully collateralized futures position equals the return of the futures position (spot and roll return) plus the return on collateral:

$$R_{total,i,z} = \bar{R}_{s,i} + R_{i,z} + \bar{R}_c \quad (8)$$

Where $R_{total,i,z}$ is commodities i's collateralized futures return using strategy z, $\bar{R}_{s,i}$ is commodity's i spot return, $R_{i,z}$ is commodity's i roll return using strategy z and $\bar{R}_c$ is the return on collateral.

Erb and Harvey (2006) point out that it is customary in commodity index construction to use US T-bills as collateral. In line with this custom, the fully collateralized futures positions are analyzed using CRATS.

In addition to fully collateralized returns, excess returns are studies. Excess return is defined as the return of a fully collateralized futures position minus the return on a risk free asset. If the US T-bill approximates a risk free asset, excess return is calculated as follows:

$$R_{excess,i,z} = \bar{R}_{s,i} + R_{i,z} \quad (9)$$

Where $R_{excess,i,z}$ is commodities i's excess collateralized futures return using strategy z and the other variables are as previously defined.

Since US T-bills mature T-bill positions need to be rolled and by rolling transaction costs are incurred. These costs are neglected since they are negligible for US T-bills[ii]. The effect of transaction costs is studied in more detail in the robustness section.

3.3 Hypotheses testing

This section explains how the hypotheses are tested. In the following section it will be discussed how the influence of the roll date on the roll return is analyzed (hypotheses 1,2 and 3). Subsequently, the testing procedure concerning the influence of commodity characteristics on the roll return is introduced (hypotheses 4 and 5).

Roll date on the roll return

To determine whether different roll dates (i.e. roll strategies) influence the roll return, the roll strategies are compared as follows:

$$\alpha = R_{x,i} - R_{x,j} (10)$$

Where α is the difference in the performance of trading strategies *i* and *j*. $R_{x,i}$ and $R_{x,j}$ are respectively commodity's *x*'s return using strategy *i* and *j*. If there are no differences between the strategies α equals zero. The α is analyzed using a *t*-test with HAC standard errors. If the α is significantly larger than zero, then the roll return of roll strategy *x* is higher than the roll return of strategy *y* and it can be concluded that the roll date influences the roll return.

Commodity characteristics on the roll return

To test whether commodity characteristics influence the relative performance of roll strategies, equally weighted portfolios are constructed based on the settlement method and storability of commodities.

Performance differences are studied using the following equation (and by using equation 9):

$$\gamma = (R_{i,z} - R_{j,z}) - (R_{i,q} - R_{j,q}) (11)$$

Where γ is the difference in the performance of trading strategies *i* and *j* of the equally weighted portfolios of commodities with characteristics *q* and *z*. By using (9) we can rewrite (11) to:

$$\gamma = R_{\Delta roll,i,j,z} - R_{\Delta roll,i,j,q} (12)$$

Where γ is the difference in performance. $R_{\Delta roll,i,j,z}$ and $R_{\Delta roll,i,j,q}$ are, respectively, the difference in the roll returns between strategies *i* and *j* of the equally weighted portfolios of commodities with characteristics *q* and *z*.

The endogenous variable γ is analyzed using a *t*-test with HAC standard errors. If the γ is larger than zero, then the roll yield of roll strategy *i* is higher relative to strategy *j* for commodities with characteristic *z* in comparison to commodities with characteristic *q*.

When hypothesis 4 is tested strategy *i* is the Deferred Roll strategy. When hypothesis 5 is tested strategy *i* is the Front Month Roll strategy. In both cases the performance is tested twice. Once relative to *j* being the Last Day Roll strategy and once relative to *j* being the Two Month Ahead Roll strategy.

Sharpe ratio

Both the influence of the roll date and the influence of commodity characteristics on the roll return are also tested using the Ledoit and Wolf (2008) test static. This test static assesses whether the Sharpe ratios of different strategies vis-a-vis another are statistically significant.

The Sharpe ratio analysis increases the practical relevance of the results as Woodard, Egelkraut, Garcia and Pennings (2011) find that the assumption of a fully collateralized futures only marginally influences the Sharpe ratio in comparison to a levered futures position. Hence, the results of the Sharpe ratio also extends to long-only futures investors which do not fully collateralize their futures positions.

4. Results

Table 3 displays the summary statistics resulting from the CRATS for non-collateralized futures. The results of the CRATS of collateralized futures are not reported as they are only marginally different from the non-collateralized returns. The results of the CRATS for collateralized futures are available on request.

The results in Table 3 indicate large differences among commodities in return and standard deviation. In line with Park and Irwin (2010) positive excess kurtosis is found and skewness is positive for some commodities while negative for others.

In keeping with the previous sections the results of the influence of the roll return will first be studied. Subsequently, the influence of commodity characteristics on the roll return are analyzed.

Table 3: Results CRATS with transaction costs

Panel A: Last Day Roll strategy						
Commodity	**Corn**	**Soybean**	**Wheat**	**Oats**	**FCOJ**	**Sugar**
Total return	-72%	305%	69%	769%	30.96%	-75%
Mean annual return	-3.89%	9.04%	1.56%	12.25%	0.79%	-4.14%
Annualized Standard Deviation	23.71%	25.57%	23.51%	32.33%	30.34%	38.42%
Skewness	0.07	0.47	0.24	0.20	1.11	-0.01
Kurtosis	3.57	11.88	3.51	3.47	17.39	2.77
Start date	3/21/1980	9/21/1995	4/2/1980	8/31/1995	7/31/1979	10/1/1979
End date	30/11/2011	10/31/2011	2/28/2014	7/31/2013	8/30/2013	5/31/2012
Commodity	**Coffee**	**Cocoa**	**Feeder cattle**	**Lean hogs**	**Live cattle**	
Total return	-43%	-91%	302%	661%	1338%	
Mean annual return	-1.73%	-6.75%	4.31%	6.02%	8.19%	
Annualized Standard Deviation	36.06%	30.36%	12.27%	22.01%	14.52%	
Skewness	0.58	0.19	-0.14	-0.26	-0.11	
Kurtosis	9.67	2.72	2.32	2.89	1.36	
Start date	10/2/1979	11/16/1979	9/5/1980	10/25/1979	2/6/1980	
End date	2/29/2012	04/30/2014	4/30/2014	5/30/2014	10/31/2013	

Panel B: Front Month Roll strategy						
Commodity	**Corn**	**Soybean**	**Wheat**	**Oats**	**FCOJ**	**Sugar**
Total return	-89%	135%	-20%	43%	-60%	-66%
Mean annual return	-6.72%	5.43%	-0.64%	1.93%	-2.63%	-3.20%
Annualized Standard deviation	23.23%	24.28%	23.00%	31.43%	29.42%	36.97%
Skewness	0.06	-0.13	0.22	0.05	0.90	0.05
Kurtosis	3.43	2.41	3.62	2.70	15.90	2.59
Start date	3/21/1980	9/21/1995	4/2/1980	1/6/1995	7/31/1979	10/1/1979
End date	30/11/2011	10/31/2011	2/28/2014	7/31/2013	8/30/2013	5/31/2012
Commodity	**Coffee**	**Cocoa**	**Feeder cattle**	**Lean hogs**	**Live cattle**	
Total return	-68%	-89%	64%	-27%	121%	
Mean annual return	-3.42%	-6.14%	1.51%	-0.89%	2.37%	
Annualized Standard deviation	35.60%	29.96%	13.57%	22.68%	14.56%	
Skewness	0.55	0.19	-0.13	-0.04	-0.07	
Kurtosis	9.77	2.66	1.42	1.18	1.24	
Start date	4/18/1980	11/16/1979	9/5/1980	10/25/1979	2/5/1980	
End date	9/26/2014	3/31/2014	4/30/2014	5/30/2014	8/30/2013	

Panel C: Deferred Roll strategy						
Commodity	**Corn**	**Soybean**	**Wheat**	**Oats**	**FCOJ**	**Sugar**
Total return	-59%	70.19%	26%	98%	-60%	13%
Mean annual return	-2.75%	3.36%	0.67%	3.87%	-2.64%	0.38%
Annualized Standard deviation	19.52%	20.99%	21.05%	24.92%	23.98%	31.14%
Skewness	0.41	-0.09	29.49	0.02	0.06	0.09
Kurtosis	9.84	3.41	1861.59	4.01	4.27	4.14
Start date	3/21/1980	9/21/1995	4/2/1980	1/6/1995	7/31/1979	10/1/1979
End date	11/30/2011	10/31/2011	2/28/2014	7/31/2013	7/31/2013	4/30/2012
Commodity	**Coffee**	**Cocoa**	**Feeder cattle**	**Lean hogs**	**Live cattle**	
Total return	-81%	-86%	174%	278%	59%	
Mean annual return	-4.91%	-5.57%	3.11%	3.91%	1.38%	
Annualized Standard deviation	30.81%	26.62%	11.99%	18.37%	11.57%	
Skewness	0.23	0.14	-0.16	0.56	-0.05	
Kurtosis	7.36	2.74	2.08	11.58	2.37	
Start date	4/18/1980	11/16/1979	5/8/1980	10/25/1979	2/5/1980	
End date	9/26/2014	3/31/2014	4/30/2014	5/30/2014	8/30/2013	

Panel D: Annual Fixed Month Roll strategy (contracts start 2006)				
Commodity	**Corn**	**Soybean**	**Wheat**	**Oats**
Total return	25%	158%	37%	36%
Annualized return	2.06%	17.08%	4.09%	3.91%
Annualized Standard deviation	25.43%	25.52%	30.44%	28.91%
Skewness	0.04	-0.21	-0.03	0.08
Kurtosis	3.36	2.29	1.68	2.85
6/21/2002	2/2/2005	6/17/2005	6/17/2005	3/30/2005
8/30/2013	10/31/2011	4/30/2013	4/30/2013	4/30/2013
Total returns in time period				
Last Day Roll strategy	9.02%	151.81%	35.33%	54.29%
Front Month Roll strategy	-15.00%	125.50%	33.44%	8.55%
Deferred Roll strategy	132.99%	118.38%	100.24%	112.39%

Table 3: this table depicts the summary statistics of the simulation approach for each commodity and roll strategy examined.

4.1 Influence of roll date on the roll return

Table 4 shows the excess return (above the diagonal) and the Sharpe ratios (below the diagonal) of the roll strategies relative to each other. For corn, for example, the results in Table 4 show that the excess return of the Front Month Roll strategy is 0.68 times (or 32%) the excess return of the Annual Fixed Month Roll strategy. This result is significant at a 10% confidence interval. The Sharpe ratio of the Annual Fixed Month Roll strategy is 5.94 times higher as the Sharpe ratio of the Front Month Roll. This difference is significant at a 1% confidence interval. Hence, for corn, the Annual Fixed Month Roll strategy outperforms the Front Month Roll strategy both in excess return and Sharpe ratio terms.

Hypothesis 1

Hypothesis 1 holds that the performance of the Deferred Roll strategy is higher than the performance of the Front Month Roll strategy. Table 4 shows that the Deferred Roll strategy outperforms the Front Month Roll strategy for seven out of the eleven commodities in terms of excess return. In terms of Sharpe ratio performance the Deferred Roll strategy performs better than the Front Month Roll strategy for five commodities. Hence, there is insufficient evidence in support of hypothesis 1.

Hypothesis 2

Hypothesis 2 holds that the performance of the Annual Fixed Month Roll strategy is higher than the performance of the Front Month Roll strategy. This is inline with the results presented in table 4. This table shows that for every commodity the Annual Fixed Month Roll strategy performs better as the Front Month Roll strategy in excess return terms. Hence, long-only futures investors who rolled the last old crop contract outperformed long-only futures investors who used the Front Month Roll strategy. The Annual Fixed Month Roll strategy also performs better in terms of the Sharpe ratio compared to the Front Month Roll strategy except for Wheat. For wheat, the Sharpe ratio of the Annual Fixed Month Roll strategy is significantly lower. All in all these results indicate that the performance of the Annual Fixed Month Roll strategy is higher than the performance of the Front Month Roll strategy.

Table 4: Relative performance trading strategies

	LDR		FMR		DR		AFMR	
Storable and physically delivered								
Corn								
Last Day Roll	1.00		2.54		0.31		0.87	
Front Month Roll	1.53	***	1.00		0.12		0.68	*
Deferred Roll	1.16	***	0.76	***	1.00		1.86	
Annual Fixed Month Roll	2.63	***	5.94	***	1.22		1.00	
Soybean								
Last Day Roll	1.00		1.73	***	2.27		0.98	
Front Month Roll	0.62		1.00		1.32	***	0.88	
Deferred Roll	0.34	***	0.55	***	1.00		0.85	
Annual Fixed Month Roll	1.08		1.16	***	1.15	***	1.00	
Oats								
Last Day Roll	1.00		6.07	**	4.05		1.13	
Front Month Roll	0.30	***	1.00		0.67		0.80	***
Deferred Roll	0.39	***	1.31	***	1.00		1.56	
Annual Fixed Month Roll	0.89	***	1.98	***	0.53	***	1.00	
Wheat								
Last Day Roll	1.00		2.10	**	1.26		0.99	
Front Month Roll	0.48	***	1.00		0.60	***	0.98	***
Deferred Roll	0.66		1.38		1.00		1.46	
Annual Fixed Month Roll	0.96	***	0.99		0.68		1.00	
FCOJ								
Last Day Roll	1.00		3.25		3.00			
Front Month Roll	0.31	**	1.00		0.92			
Deferred Roll	0.05	***	0.15	***	1.00			
Sugar								
Last Day Roll	1.00		0.73		0.21			
Front Month Roll	1.18	***	1.00		0.29			
Deferred Roll	2.04	***	1.73	***	1.00			
Coffee								
Last Day Roll	1.00		1.70		2.09			
Front Month Roll	0.61	***	1.00		1.23			
Deferred Roll	-0.07	***	-0.12	***	1.00			
Cocoa								
Last Day Roll	1.00		0.80	**	0.88			
Front Month Roll	0.79	***	1.00		1.10	***		
Deferred Roll	1.05	***	1.33	***	1.00			

Table 4 (continued)

	LDR		FMR		DR	
Non-storable and physically delivered						
Live cattle						
Last Day Roll	1.00		7.44		10.04	
Front Month Roll	0.38		1.00		1.35	
Deferred Roll	0.29	***	0.76	***	1.00	
Non-storable and cash settled						
Feeder cattle						
Last Day Roll	1.00		2.50	***	1.45	
Front Month Roll	-0.99	***	1.00		0.58	**
Deferred Roll	-0.27		0.27	***	1.00	
Lean hogs						
Last Day Roll	1.00		11.72	*	2.51	
Front Month Roll	0.20	***	1.00		0.21	
Deferred Roll	0.80	***	4.06	***	1.00	

Table 4 – This table shows the relative performance of the trading strategies in the rows relative to the trading strategies in the column. The values above the diagonal represent relative absolute performance, while the values below the diagonal represent relative Sharpe ratio performance. To test whether a strategy significantly outperforms another strategy the Ledoit and Wolf (2008) test was used. The LDR, FMR, AFMR and DR variables in the column reference respectively to the Last Day Roll strategy, Front Month Roll strategy, Annual Fixed Month Roll strategy and Deferred Roll strategy. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

Hypothesis 3

Hypothesis 3 holds that annually rolling the last old crop futures prior to the key production period results in a higher performance than rolling the last old crop futures using the Front Month Roll strategy. This hypothesis is studied for the commodity corn following Till (2000). The results are displayed in Table 5.

The results in Table 5 are in line with the hypothesis 3. Rolling the last crop contract prior to the key production period results in a higher total excess return and a higher Sharpe ratio compared to annually rolling the last old crop contract one month prior to expiration.

Table 5: Results for the analysis of hypothesis 2 for corn

	$AFMR_3$	$AFMR_1$
Total excess return	-40.18%	-71.00%
Sharpe ratio	0.005	-0.005
Difference excess return	30.82%	
Difference Sharpe ratio	0.01***	

Table 5 – $AFMR_3$ is the Annual Fixed Month Roll strategy which rolls 3 months prior to September, i.e. one month before the key production period. $AFMR_1$ represents the Annual Fixed Month Roll strategy that rolls 1 month before September. The time period studied ranges from 1 July 1983 to July 2012. The total return is the total return over this period and the Sharpe ratio is calculating using a fully collateralized futures position. *** $p < 0.01$ ** $p < 0.05$ * $p < 0.10$

4.2 Influence commodity characteristics on the roll return

In order to test whether commodity characteristics influence the relative performance of roll strategies, equally weighted portfolios are constructed based on commodity characteristics. Summary statistics and results of the equally weighted portfolios analysis are reported in Table 6. The summary statistics indicate positive excess kurtosis which is in line with the previous findings. Skewness is negative for each portfolio. What stands out are the large differences among the portfolios as indicated in Panel B. These difference are caused by differences in the roll and the spot return. The influence of the roll return will be discussed next.

Hypothesis 4

Hypothesis 4 holds that the performance of the Deferred Roll strategy is higher for non-storable commodities in comparison to storable commodities. As can be seen from Table 6, the performance of the Deferred Roll strategy is higher for non-storable commodities in comparison to storable commodities. This holds for both excess return as well as the Sharpe ratio. However, the difference in excess returns is not significant while the difference in Sharpe ratios is significant at the 10% confidence interval. Hence, there is partial evidence in support of hypothesis 4.

Table 6: Summary statistics equally weighted portfolios (2005-2011)

	LDR	FMR	DR	DR-FMR	FMR-LDR
Non-Storable					
Total return	-10.78%	-31.53%	3.49%	47.98%	
Annualized return	-1.88%	-6.10%	0.57%	6.73%	
Annualized Standard deviation	12.37%	13.67%	11.23%	0.04%	
Skewness	-0.16	-0.15	-0.20	-0.12	
Kurtosis	1.46	0.84	1.64	4.81	
Sharpe ratio	-0.016	-0.035	-0.004	0.073	
Storable					
Total return	43.49%	13.48%	47.04%	29.50%	
Annualized return	6.18%	2.12%	6.62%	4.39%	
Annualized Standard deviation	20.38%	17.12%	17.48%	3.81%	
Skewness	-0.34	-0.41	-0.44	0.27	
Kurtosis	2.57	2.90	3.11	5.91	
Sharpe ratio	0.019	0.006	0.022	0.042	
Difference Excess Return				18.48%	
Difference Sharpe ratio				0.031*	
Cash Settled					
Total return	-28.07%	-35.63%	-9.64%		-10.33%
Annualized return	-5.33%	-7.06%	1.67%		1.80%
Annualized Standard deviation	12.37%	13.67%	11.23%		5.22%
Skewness	-0.16	-0.15	-0.20		-0.18
Kurtosis	1.46	0.84	1.64		7.86
Sharpe ratio	-0.033	-0.037	-0.016		-0.041
Physical delivery					
Total return	41.30%	13.48%	45.12%		-21.53%
Annualized return	5.91%	2.12%	6.38%		-3.95%
Annualized Standard deviation	18.93%	17.12%	16.28%		3.41%
Skewness	-0.38	-0.41	-0.48		-0.90
Kurtosis	2.72	2.90	3.29		24.05
Sharpe ratio	0.019	0.006	0.022		-0.105
Difference Absolute Performance					-11.20%
Difference Sharpe ratio					0.064***

Table 6 - This table shows the results of equally weighted portfolios based on commodity characteristics. Equally weighted portfolios are calculated using different roll strategies (columns). LDR, FMR, and DR stand for respectively the Last Day Roll strategy, Front Month Roll strategy, and Deferred Roll strategy. The roll strategy DR-FMR (FMR-LDR) refers to net zero positions being long in a position following the Deferred Roll strategy (Front Month Roll strategy) and short in a position that follows the Front Month Roll strategy (Last Day Roll strategy). *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$

Hypothesis 5

Hypothesis 5 holds that the performance of the Front Month Roll strategy is higher for cash settled futures as it is for physically delivered futures. As reported in Table 6, the performance of the Front Month Roll strategy is higher for cash settled futures in comparison to futures settled by physical delivery. This holds for both the absolute return as well as the Sharpe ratio. Similar to hypothesis 4, there is no significant difference in the absolute returns while the difference in Sharpe ratios is significant at the 1% confidence interval. Hence, hypothesis 5 is partially confirmed.

5. Robustness and Limitations

Liquidity

The above analysis does not take liquidity risk into account. Therefore, the results should be interpreted with care. In the literature, liquidity is often represented by the bid-ask spread for a given number of futures (Pennings, Kuiper, Hofstede and Meulenberg; 1998). Wang et al. (2014) shows that the bid-ask spread is relatively high for deferred futures in comparison to near futures. Hence, liquidity risk is likely to be higher for the Deferred Roll strategy in comparison to both the Front Month Roll strategy and Last Day Roll strategy. Therefore, liquidity risk might have influenced the results.

To see how liquidity influenced the performance of the Deferred Roll strategy, the most illiquid contracts at any given date are excluded from the investment opportunity set, which is the set of contracts that are eligible for investment. The Amivest liquidity measure (Amivest) is used as a proxy for liquidity (Amihud, Mendelson, & Lauterbach, 1997).[iii] Amivest measures the trading volume per unit change in the futures price. The measure is calculated as the average in period *t* of daily volume divided by the daily absolute change in the futures price:

$$Amivest = \frac{\sum_t V_{j,t}}{\sum_t |R_{j,t}|} \quad (13)$$

Where *t* is the number of trading days in a certain month, and $V_{j,t}$ and $|R_{j,t}|$, respectively, are the volume and absolute change in the futures price for futures contract *j* on day *t*. In this study the

Amivest liquidity measure is calculated using a rolling monthly window. Because there are approximately 260 trading days per year, t is set to be equal to 22 ($\approx$ 260 / 12).

Contracts are included in the investment opportunity set from the date from which Amivest exceeds ten. In the following sections the robustness of the Deferred Roll strategy is checked with regard to liquidity. The hypotheses that include the Deferred Roll strategy are hypotheses 1 and 4. These hypotheses will be examined in turn.

Robustness hypothesis 1

In section 4.1, it was found that the Deferred Roll strategy outperforms the Front Month Roll strategy for seven out of the eleven analysed commodities in terms of excess return. Furthermore, in terms of Sharpe ratio performance, the Deferred Roll strategy was found to perform better than the Front Month Roll strategy for five out of the eleven commodities. Therefore, it was concluded that there is insufficient evidence in support of hypothesis 1.

The relative performance results given the liquidity constrained investment opportunity set are reported in Table 7. These results show that the Deferred Roll strategy outperforms the Front Month Roll strategy in only four out of the eleven commodities in terms of excess return. In terms of Sharp Ratio performance, the Deferred Roll strategy outperforms the Front Month Roll strategy for six out of the eleven commodities. This increase indicates that the risk reduction that stems from lower liquidity risk outweighs the loss in return. Nonetheless, the results indicate that the conclusion drawn with regard to hypothesis 1 is robust to liquidity.

Robustness hypothesis 4

In section 4.2, partial support for hypothesis 4 was found. Hypothesis 4 states that the performance of the Deferred Roll strategy is higher for non-storable commodities in comparison to storable commodities. The results in favor of hypothesis 4 become weaker when the investment opportunity set is restricted to liquid contracts. The difference in excess returns and Sharpe ratios between the Deferred Roll strategy of storable commodities and the Deferred Roll strategy of non-storable commodities, decreases to 4.2 and 3.8 basis points respectively. Hence, the conclusion drawn before with regard to hypothesis 4 is not robust to liquidity. Thus, the finding that the performance of the Deferred Roll strategy is higher for non-storable commodities

in comparison to storable commodities is likely due to differences in liquidity and not due to differences in commodity characteristics.

Table 7: Relative performance Deferred Roll strategy with liquidity threshold

	Excess Return	Sharpe Ratio		Excess Return	Sharpe Ratio
Corn			**Coffee**		
LDR/DR	0.83***	0.83***	*LDR/DR*	1.72***	0.28***
FMR/DR	0.31***	1.32***	*FMR/DR*	1.01***	0.56***
Soybean			**Cocoa**		
LDR/DR	1.36***	-3.10***	*LDR/DR*	0.99***	0.88***
FMR/DR	1.25***	-2.21***	*FMR/DR*	1.00***	0.94***
Oats			**Live Cattle**		
LDR/DR	11.22***	5.52***	*LDR/DR*	3.43***	4.37***
FMR/DR	1.54***	2.07***	*FMR/DR*	0.50***	-0.67***
Wheat			**Feeder Cattle**		
LDR/DR	1.04***	1.22	*LDR/DR*	0.91***	0.10
FMR/DR	0.50***	0.65	*FMR/DR*	0.94***	0.39**
FCOJ			**Lean Hog**		
LDR/DR	3.88***	-0.19***	*LDR/DR*	1.11***	1.30***
FMR/DR	1.15***	0.50***	*FMR/DR*	1.00***	0.65***
Sugar					
LDR/DR	0.91***	0.50***			
FMR/DR	1.27	0.42***			

Table 7: This tables displays the relative performance of the Last Day Roll (LDR) and Front Month Roll (FMR) to the Deferred Roll (DR) strategy. This analysis takes into account a minimum liquidity threshold. *** $p < 0.01$, ** $p < 0.05$, *$p < 0.1$

Time sensitivity

In this section the robustness of the results over time are examined. Since commodity futures characteristics are relatively constant it is expected that the relative performance of the different trading strategies do not differ across commodities with different characteristic.[iv] Furthermore, for a certain commodity it is expected that the relative performance of one strategy vis-à-vis another strategy remains above 1 or below 1 for each time period.

The following three decades are analysed 1980-1989, 1990-1999 and 2000-2009. Oats and soybean futures are not analyzed in 1980-1989 due to data constraints. The results of Table 4 are reproduced for each time period. Based on these results column charts were constructed for the excess return performance measure. These charts are displayed in figure 2.1 through 2.6.

As is clear from these charts the relative excess return of the different trading strategies varies considerably through time. The relative excess return of different trading strategies also varies over time for commodities with different characteristics. For example, the average excess return of the Last Day Roll strategy relative to the Front Month Roll strategy equals 1.18 for storable commodities and 2.62 for non-storable commodities in the 1980's. In the 1990's, however, the relative excess returns equals respectively 1.31 and 1.28 (averages are not tabulated). Hence, commodity characteristics are unlikely to influence the roll performance. This stands in contrast with the partial evidence found in the previous section.

When the Sharpe ratio is analyzed over time similar conclusions are reached. For brevity these results are not reported but are available on request.

Figure 2.1: Last Day Roll / Front Month Roll

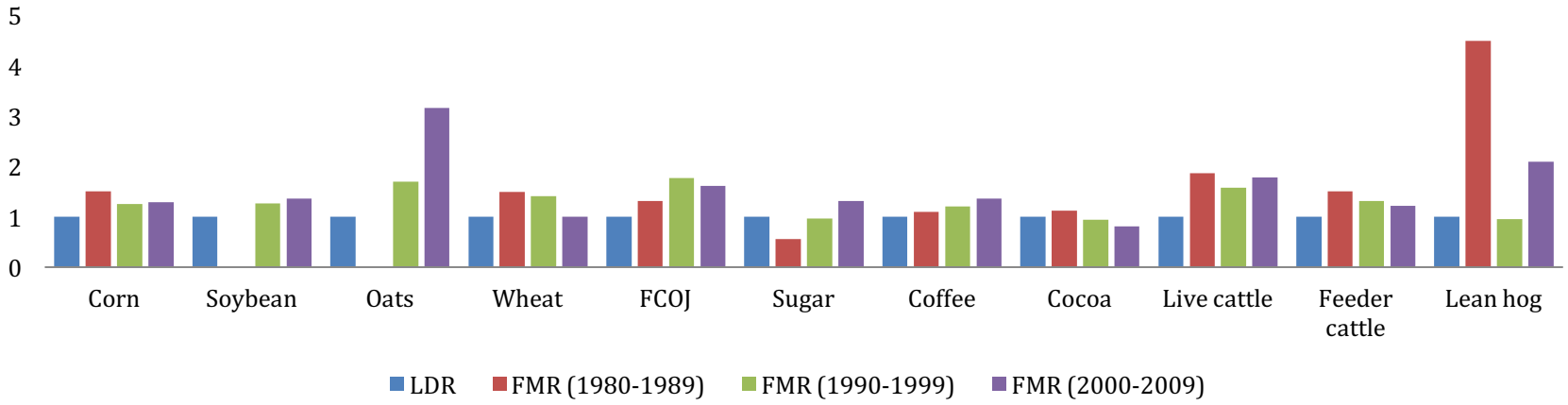

Figure 2.2: Last Day Roll / Deferred roll

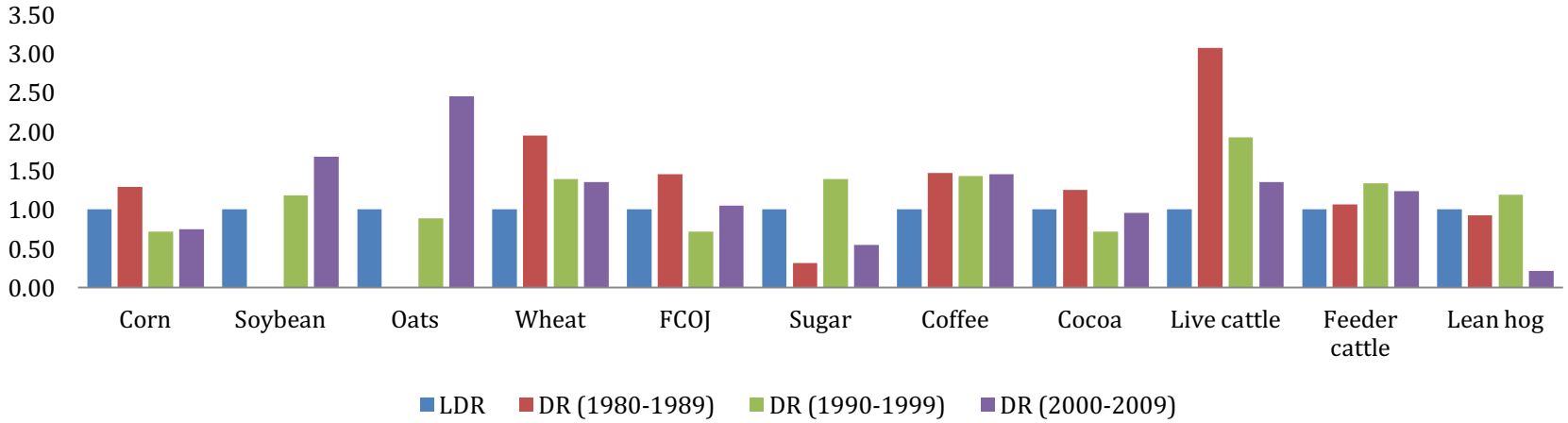

Figure 2.3: Front Month Roll / Last Day Roll

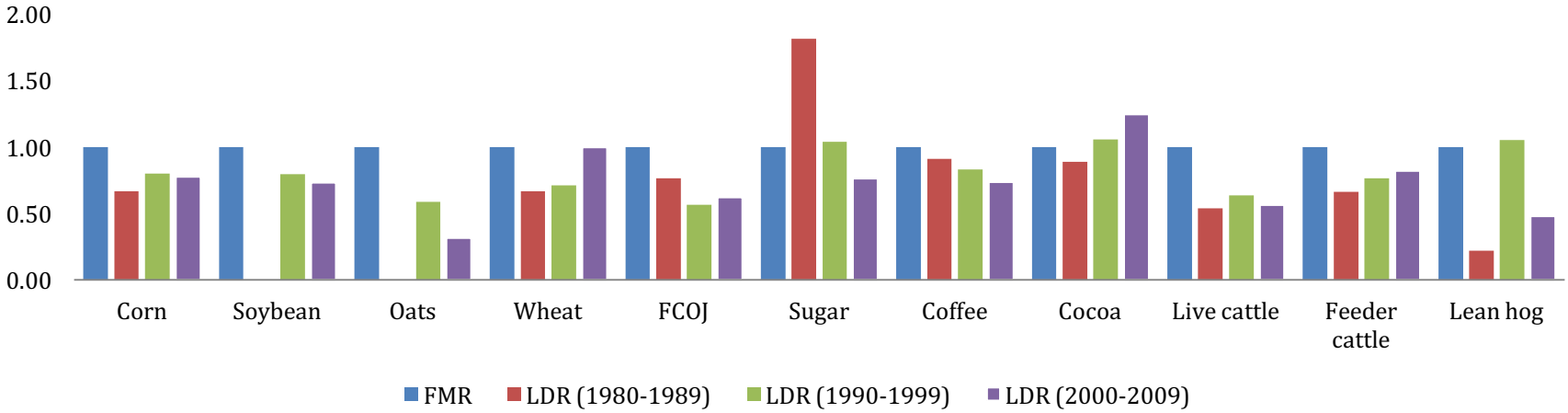

Figure 2.4: Front Month Roll / Deferred Roll

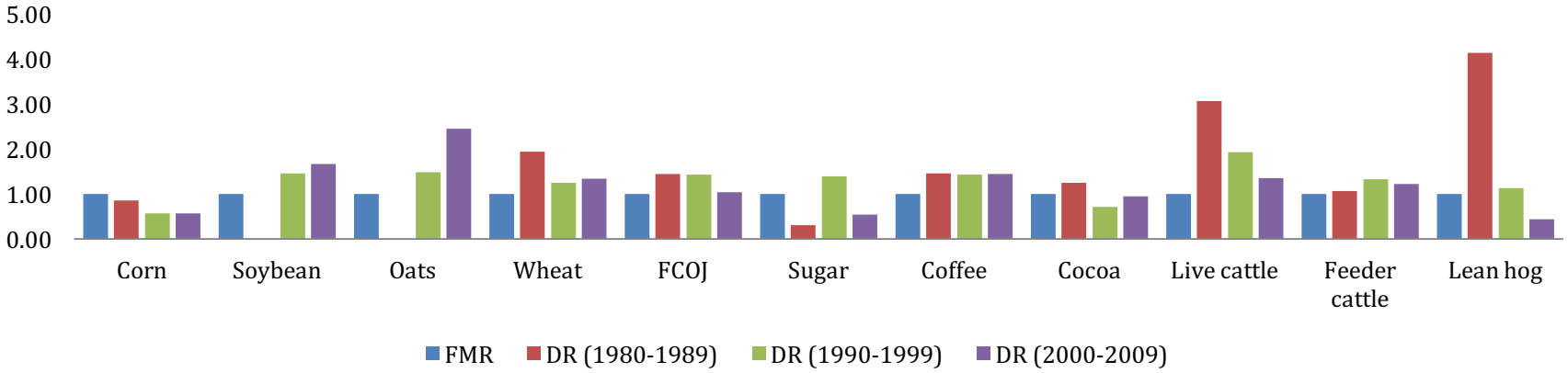

Figure 2.5: Deferred Roll / Last Day Roll

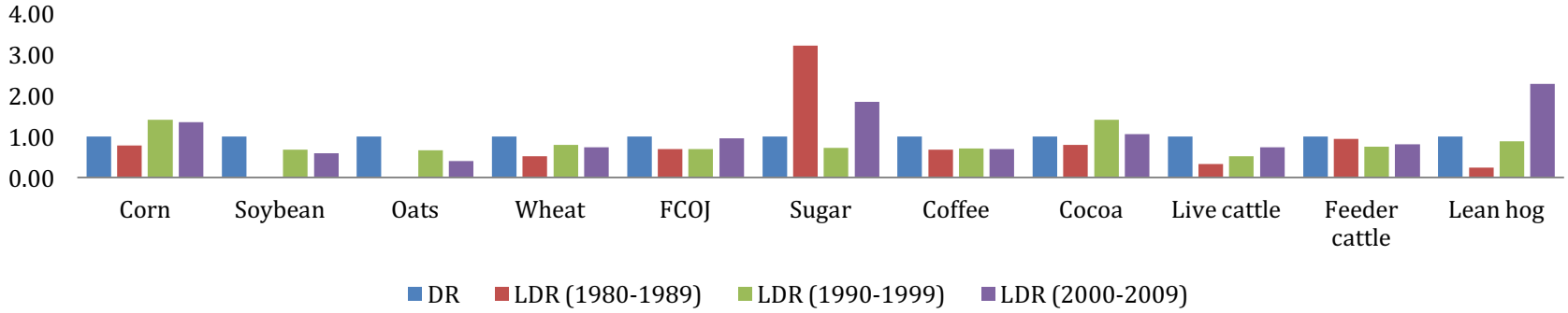

Figure 2.6: Deferred Roll / Front Month Roll

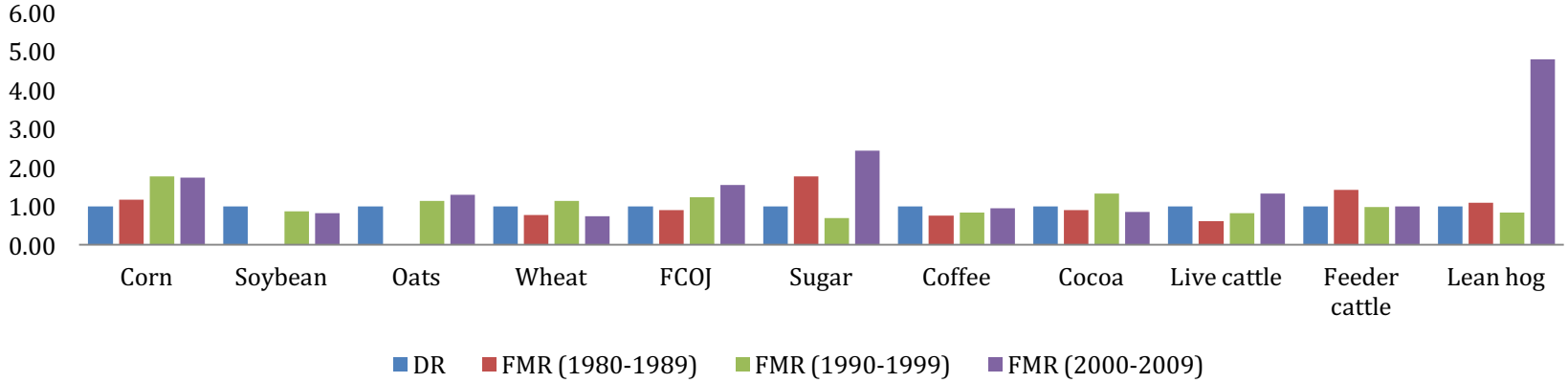

Figure 2 – The figures 2.1 through 2.6 show the relative excess return of various trading strategies across different time periods. The LDR, FMR and DR variables correspond to respectively the Last Day Roll strategy, Front Month Roll strategy and Deferred Roll strategy. As can be seen in the graphs the relative performance of the various strategies differ across time and differ between commodities with different characteristics across time. The Annual Fixed Month Roll strategy is not examined over time due to data constraints.

6. Conclusion

Long-only futures investors intend to follow commodity spot markets. However, these investors tend to perform poorly albeit commodity spot price increases. In this paper it was studied whether the performance of long-only index funds could be increased by altering the roll strategy. Using four different roll strategies the influence of the roll horizon, roll date and the influence of commodity characteristics on the roll yield were analyzed. In specific, the following commodity futures characteristics were studied: storability, seasonality and the settlement method. To gauge the relative performance of the different roll strategies, performance was measured by both excess return and the Sharpe ratio.

This research finds that the Deferred Roll strategy is more beneficial compared to a Front Month Roll strategy. In addition, a strategy that rolls annually only the old crop contract (i.e. the Annual Fixed Month Roll strategy) is more beneficial than a Front Month Roll strategy. Furthermore, rolling the old crop futures prior to a key production period is likely to increase a strategy's performance. However, this conclusion is based on only one commodity, namely corn. Based on these findings it can be concluded that the roll horizon does influence the roll performance.

In addition to the influence of the roll horizon on the roll return, it was found that the performance of the Front Month Roll strategy is higher for cash settled futures in comparison to futures settled by physical delivery. In addition, the performance of the Deferred Roll strategy is higher for non-storable commodities compared to storable commodities. Based on these findings it can be concluded that commodity characteristics influence roll performance.

However, these conclusions are invalidated as the results are not robust. It was found that hypothesis 4 is not robust to liquidity. This implies that higher performance of the Deferred Roll strategy for non-storable commodities in comparison to storable commodities is likely due to differences in liquidity and not due to differences in commodity characteristics. In addition, it was found that the relative performance of different roll strategies varies over time. This time variation cannot be explained by the roll horizon nor by commodity characteristics as these are stable over time. The time variation in the relative performance of roll strategies might be caused by unobserved factors. Determining these factors and their influence on the relative performance of roll strategies is left for future research.

Due to the time variation in the relative performance, this research cannot conclude that neither the roll horizon, the roll date, nor commodity characteristics influence the roll return in a systematic way. Hence, it is concluded that long only futures investors cannot systematically increase performance by relying on one of the proposed roll strategies.

7. References

Amihud, Y., Mendelson, H., & Lauterbach, B. (1997). Market microstructure and securities values: Evidence from the Tel Aviv Stock Exchange. *Journal of Financial Economics*. doi:10.1016/S0304-405X(97)00021-4

De Groot, W., Karstanje, D., & Zhou, W. (2014). Exploiting commodity momentum along the futures curves. *Journal of Banking & Finance*, *48*, 79–93. doi:10.1016/j.jbankfin.2014.08.008

Erb, C. B., & Harvey, C. R. (2006). Strategic and Tactical Futures Value of Commodity. *Financial Analysts Journal*, *62*(2), 69–97.

Gorton, G. B., Hayashi, F., & Rouwenhorst, K. G. (2013). The fundamentals of commodity futures returns. *Review of Finance*, *17*, 35–105. doi:10.1093/rof/rfs019

Gorton, G. B., & Rouwenhorst, K. G. (2006). Facts and Fantasies about Commodity Futures. *Financial Analysts Journal*, *62*(2), 47–68.

Grauer, F. L. a, & Litzenberger, R. H. (1979). The Pricing of Commodity Futures Contracts, Nominal Bonds and Other Risky Assets under Commodity Price Uncertainty. *Journal of Finance*, *34*(1), 69–83. doi:10.2307/2327144

Gustafson, R. L. (1958). *Carryover Levels for Grains: A Method for Determining Amounts That Are Optimal under Specified Conditions*. *USDA Technical Bulletin 1178*.

Irwin, S. H., & Sanders, D. R. (2012). Financialization and Structural Change in Commodity Futures Markets prised by the size of the commodity futures. *Journal of Agricultural and Applied Economics*, *3*(August), 371–396.

Kastens, T. L., & Dhuyvetter, K. C. (1999). Post-Harvest Grain Storing and Hedging with Efficient Futures. *Journal of Agricultural and Resource Economics*, *24*(99), 482–505.

Ledoit, O., & Wolf, M. (2008). Robust performance hypothesis testing whit the Sharpe ratio. *Journal of Empirical Finance*, *15*(5), 850–859. doi:10.1016/j.jemp

Marshall, B., Nguyen, N., Visaltanachoti, N., 2012. Commodity liquidity measurement and transaction costs. Review of Financial Studies, 25(2), 599–638.

Main, S., Irwin, S. H., Sanders, D. R., & Smith, A. (2013). How Could We Have Been So Wrong ? The Puzzle of Disappointing Returns to Commodity Index Investments. In *Proceedings of the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management*. St. Louis, MO. Retrieved from http://www.farmdoc.illinois.edu/nccc134

Miffre, J. (2000). Normal Backwardation is Normal. *The Journal of Futures Markets*, *20*(9), 803–821. doi:10.1002/fut.3990120108

Miffre, J. (2012). *Comparing First , Second and Third Generation Commodity Indices*.

Park, C., & Irwin, S. H. (2010). A Reality Check On Technical Trading Rule Profits in the U.S. Futures Markets. *Journal of Futures Markets*, *30*(3), 633–659. doi:10.1002/fut

Pennings, J. M., Kuiper, W. E., Hofstede, F. T., & Meulenberg, M. T. (1998). The price path due to order imbalances: evidence from the Amsterdam Agricultural Futures Exchange. *European Financial Management*, *4*(1), 47-64.

Samuelson, P. A. (1965). Proof That Properly Anticitpated Prices Fluctuate Randomly. *Industrial Management Review*, *2*(6), 41–49. doi:10.1109/SP.2006.16

Sanders, D. R., Garcia, P., & Manfredo, M. R. (2008). Information content in deferred futures prices: Live cattle and hogs. *Journal of Agricultural and Resource Economics*, *33*(1), 87–98.

Sharpe, W. F. (1966). Mutual Fund Performance. *The Journal of Business*, *39*(1), 119–138.

Szakmary, A. C., Shen, Q., & Sharma, S. C. (2010). Trend-following trading strategies in commodity futures: A re-examination. *Journal of Banking and Finance*, *34*(2), 409–426. doi:10.1016/j.jbankfin.2009.08.004

Szymanowska, M., De Roon, F., Nijman, T., & Van Den Goorbergh, R. (2014). An Anatomy of Commodity Futures Risk Premia. *Journal of Finance*, *69*(1), 453–482. doi:10.1111/jofi.12096

Till, H. (2000). Passive Strategies in the Commodity Futures Markets, 1–8.

Tomek, W. G., & Gray, R. W. (1970). Temporal Relationships among Prices on Commodity Futures Markets: Their Allocative and Stabilizing Roles. *American Journal of Agricultural Economics*, *52*(3), 372. doi:10.2307/1237388

Williams, J. C., & Wright, B. D. (1991). *Storage and commodity markets*. Cambridge: Cambridge University Press.

Woodard, J. D., Egelkraut, T. M., Garcia, P., & Pennings, J. M. E. (2011). Effects of full collateralization in commodity futures investments. *Journal of Derivatives & Hedge Funds*, *16*(4), 253–266. doi:10.1057/jdhf.2010.19

Working, H. (1948). Theory of the Inverse Carrying Charge in Futures Markets. *Journal of Farm Economics*, *30*(1), 1–28.

Notes

[i] Sanders, Garcia and Manfredo (2008) find that live cattle futures beyond the eighth month contract do not provide any additional information. Furthermore, they find that the live cattle futures market is not particularly rational. For live hogs they do find that every contract (up to and including the twelve month out contracts) provides unique information and the markets seems rational.

[ii] Park and Irwin (2010) state that the round turn transaction costs for US T-bills equals 1 basis point.

[iii] Marshall Nguyen and Visaltanachoti (2012) study the performance of liquidity measures and conclude that the Amihud liquidity measure has the largest correlation with liquidity benchmarks, followed by the Amivest, and Effective Tick measures. Because our data provider does not provide dollar trade volume.

[iv] Commodities futures contracts change as exchanges try to align the terms and conditions of futures to encompass the mainstream of the commodity in the marketplace. This study accounts for changes with regard to the settlement method.