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S&P GSCI Excess Return Index

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Abstract

Standard & Poor's Goldman Sachs Commodity Index™ (S&P GSCI) is the largest tradable commodity index fund in the world with more than $80 billion in S&P GSCI-related investments. Investors have been led to believe that investing in the S&P GSCI during periods of rising commodity prices will be profitable. However, the return performance of the S&P GSCI rarely equals the price change of its underlying spot commodities over the long run. This paper examines the historical excess returns of S&P GSCI futures holdings from 2007 to 2013, duplicating the official S&P GSCI trading methods, and finds that S&P GSCI excess returns differ from returns on corresponding investments in commodity futures due to the interaction between term structure effects and futures returns.

Key Words: S&P GSCI Spot Index, S&P GSCI Excess Return (ER) Index, commodity futures, contract replacement, term structure effects.

Introduction

Commodity index funds have grown in popularity since they were introduced in the early 1990s. According to the Commodity Futures Trading Commission (CFTC), in 2013 more than $260 billion was invested in long-only commodity index funds globally (CFTC 2013). Investors can gain exposure to returns from commodity indexes through over-the-counter (OTC) contracts with swap dealers, or they can buy investment funds whose returns are linked to a specific commodity index, including exchange-traded funds (ETFs) and structured notes (ETNs) (Irwin & Sanders 2012). Among the growing number of long-only commodity indexes, the largest one is the Standard & Poor's Goldman Sachs Commodity Index™ (S&P GSCI). Approximately $80 billion is invested in the S&P GSCI and its related subindexes (Standard & Poor's 2013a).

Unlike equity indexes such as the Standard & Poor's 500 index (S&P 500) and the Dow Jones Industrial Average Index (DJI), which hold common stocks, the S&P GSCI contains only commodity futures contracts (Standard & Poor's 2013b). Futures contracts expire and cannot be held indefinitely. Prior to expiration, each sooner-to-expire futures contract must be sold and replaced with a later-to-expire futures contract in the same commodity. The S&P GSCI portfolio turnover rate is much higher than equity indexes although the S&P GSCI makes no changes to its underlying commodity categories.

Investors have been led to believe that investing in the S&P GSCI during periods of rising commodity prices will be profitable (Weinschenk 2013). However, there has been a divergence between the S&P GSCI cumulative excess returns[1] and spot price changes

[1] The S&P GSCI excess return is different from the excess return in the equity market. We will discuss this difference in the "S&P GSCI Section" below.

since the S&P GSCI became tradable in the early 1990s. From 1991 to 2013, the annualized excess return of the S&P GSCI seldom outperformed the annualized spot price[2] changes of its underlying commodities. For instance, the S&P GSCI ER Index**,** which measures the cumulative excess returns of the S&P GSCI, had a 5-year return of only 18.73% from 2009 to 2013, a period when the S&P GSCI Spot Index increased by more than 77% (Figure 1). Standard & Poor's (2013b), which publishes the S&P GSCI, attributes the asymmetry of performance between the S&P GSCI Spot Index and the ER Index to term structure effect[3]. Term structure effect indicates the price difference between outgoing futures and incoming futures at contract replacement, so adding the cumulative term structure effect to the returns of the S&P GSCI Spot Index provides a measure of return for the S&P GSCI ER Index. Burton and Karsh (2009) also gave the same explanation.

The objective of this paper is to test if commodity futures term structure can explain the entire divergence between the S&P GSCI Spot Index and ER Index in the long run. In other words, we want to explore if contract replacement will bring side returns[4], either positive or negative, to the S&P GSCI investment. If the divergence is significantly different from the cumulative term structure effect described by Standard & Poor's, then side returns should be available within the S&P GSCI. Our results may include some information about the relationship between futures term structure and the S&P GSCI excess return, but this paper will not test the efficiency of futures term structure in predicting the excess returns of individual commodity futures. For simplicity, the effects of transaction costs, index fund management fees, and taxes are excluded from this study since the S&P GSCI does not include these effects in its indexes.

In this paper, we seek to better understand how the S&P GSCI replaces its futures holdings at contract replacement, and how its excess returns are measured by the official S&P GSCI Methodology. First, we provide some background regarding the analysis of S&P GSCI excess returns in the existing literature. Second, we give a brief overview of the S&P GSCI index structure, trading strategy, and return components. Third, a daily flow of funds model is used to duplicate the S&P GSCI trading method, and investigate S&P GSCI excess returns. Empirical procedures and data used in this paper are introduced. Finally, the results are discussed.

[2] Spot price in the S&P GSCI means the price of the S&P GSCI futures holdings, not the cash price.
[3] Term structure is classified as contango or backwardation. Under contango, the price of an outgoing futures is less than the price of an incoming futures at contract replacement. The opposite term structure is backwardation, where the price of an outgoing futures is higher than the price of an incoming futures at contract replacement.
[4] Side return in the S&P GSCI means the return that can only be received from the S&P GSCI investment, and cannot be received from individual futures investments by duplicating the S&P GSCI trading method.

Background

A number of researchers have examined the relationship between futures term structure and excess returns of long-only positions in individual commodity futures across time to explain excess returns of the S&P GSCI. Studies by Nash and Smyk (2003), Feldman and Till (2006), Erb and Harvey (2006), and Gorton, Hayashi, and Rouwenhorst (2007) support the strong relationship between term structure and futures excess returns, while Irwin and Sanders (2012) and Bessembinder et al. (2012) find evidence of independency between term structure and futures returns in the long run. All of these studies are limited in scope to whether or not term structure will affect futures returns, and do not explore the calculation procedure of the S&P GSCI excess return or how variations in excess returns of individual futures contracts can affect excess returns on the S&P GSCI.

Burton and Karsh (2009) analyzed the S&P GSCI excess return calculation procedure at contract replacement[5] (Table 1). They assumed the S&P GSCI owns 100 front month futures contracts of a specific commodity at a price of $110 per contract, and prepare to replace all of these contracts with deferred month futures at a price of $143 per contract. Because the total amount of funds that the S&P GSCI can collect from the sale of 100 front month futures is $110*100 = $11,000, Burton and Karsh claimed this amount of funds restricts the index to purchase only $11,000/$143 = 76.9 deferred month futures contracts. Using this method, the contract replacement procedure does not produce any gain and loss because the total fund balance after the replacement is still $11,000. According to Burton and Karsh, the S&P GSCI Spot Index only reflects the price information of its futures contracts and not returns available to investors. Therefore, changing the price from $110 to $143 at contract replacement does not affect investment returns. The only factor that will influence the index return performance is the price change of these 76.9 deferred month futures contracts after they become index holdings. From this, they conclude that "Whenever a commodity exhibits a contango curve, futures excess returns will underperform the spot price changes, while the opposite is true when the curve is backwardated. However, the outperformance of the excess returns versus spot price changes in a backwardation market does not represent a profit, which is the same as the underperformance in a contango environment does not represent a loss." Consequently, the divergence between the S&P GSCI Spot Index and ER Index is due to the cumulative term structure effect.

Much of the S&P GSCI-related literature is limited to the ability of term structure to forecast excess returns of commodity futures investments, and does not explore how the S&P GSCI excess return is calculated, or how variations in the excess returns of individual futures contracts can affect excess returns on the S&P GSCI. For example, Burton and Karsh do not explain the actual return performance of the S&P GSCI, in part because their model is different from what the S&P GSCI actually uses. This paper will analyze how the S&P GSCI replaces its futures holdings and measures its excess returns.

[5] The method used by Burton & Karsh to calculate the S&P GSCI excess return is not correct. The official S&P GSCI replaces futures contracts using another method, which will be discussed in the "S&P GSCI Section" below.

S&P GSCI

The S&P GSCI represents a static long-only investment in various commodity futures. Since the beginning of 2007, it has held long positions in futures contracts for the same 24 commodities. For diversification purposes and to make the S&P GSCI representative of the world commodity markets, the 24 commodities selected by the index come from six sectors: six energy products traded on NYMEX, five industrial metals traded in LME, eight agricultural products traded on CBOT, KCBT, and ICE, three livestock products traded on CME, and two precious metals traded on NYMEX (Standard & Poor's 2013b). The quantity weights of the 24-commodity futures in the S&P GSCI portfolio are determined by these commodities' average world production quantities in the last five years. In addition to the diversified 24-commodity index portfolio, the S&P GSCI also has subindexes that track each of its individual commodity futures as well as various combinations of the 24 commodities. For instance, the S&P GSCI Natural Gas Subindex reflects the performance of the natural gas futures contract traded on NYMEX.

The S&P GSCI component replacement procedure is different from equity indexes like the S&P 500. The S&P 500 assumes the entire dollar amount from the sale of Asset A will be used in the purchase of Asset B. However, in the S&P GSCI, the number of futures contracts of each individual commodity is held constant for the entire year, and is rebalanced once a year on the 4th business day of each January[6] based on the underlying commodities' world production data (Standard & Poor's 2013b). In each month within a year, the contract replacement requires the same number of futures contracts to be sold and bought for each commodity in order to keep the index composition constant on a quantity basis[7]. During pre-established contract replacement periods, 20% of the total number of contracts of a sooner-to-expire commodity futures contract will be sold and the same number of contracts of a later-to-expire contract will be bought each day from the 5th business day to the 9th business day of the month. Then, on the 10th business day of that month, all sooner-to-expire futures contracts have been replaced with the same number of later-to-expire contracts (CME 2005, Standard & Poor's 2007, Goldman Sachs). Therefore, the S&P GSCI is quantity weighted, unlike the S&P 500 which is capitalization weighted.

Because of the method that the S&P GSCI uses to trade futures at contract replacement, it needs two indexes to reflect its performance. These are the S&P GSCI Spot Index and the S&P GSCI ER Index. The daily percentage changes of the Spot Index and the ER Index are called spot return and excess return, respectively.

According to the Standard & Poor's (2013b), the calculation procedure for the S&P GSCI daily spot return on the contract replacement date simply replaces the outgoing futures prices with the incoming futures prices without any adjustments to the composition of the spot index. As a result, the spot index can only indicate the price changes of its futures

[6] The 4th business day of each January is the transition date between the old calendar year and new calendar year. It is the only date that the S&P GSCI rebalances the quantity weights of the 24 commodity holdings (Standard & Poor's 2013b).
[7] Notice that the contract replacement method actually used by the S&P GSCI is completely different from the way that Burton & Karsh used to calculate S&P GSCI excess returns.

holdings, and cannot be used to reflect the return performance that the S&P GSCI investor can receive. For instance, when a $110 January NYMEX crude oil futures contract is replaced with a $100 February NYMEX crude oil futures contract in the S&P GSCI, the price level of NYMEX crude oil futures in the index will decrease from $110 to $100, which indicates a (100-110)/110 = -9.09% spot return on the crude oil portion of the index. However, this $10 price decrease or -9.09% spot return does not represent an actual loss to investors, because the S&P GSCI spot index is assumed to be un-investable. The value of the S&P GSCI Spot Index expressed in index points is equal to the S&P GSCI total dollar value[8] divided by a constant. This constant will be adjusted only on the 4th business date of each January to keep the spot index unchanged when the new quantity weight of 24 commodity futures holdings has been used.

The S&P GSCI excess return means the pure return from commodity futures investment, not the return above the T-bill rate as in the equity market. It is comparable to the capital gain or loss of an equity investment. (S&P GSCI 2007). According to Standard & Poor's (2013b), the S&P GSCI ER Index measures the investment returns of the S&P GSCI excluding the entire term structure effect in the Spot Index. The equation that S&P GSCI uses to measure the official daily percentage change of the ER Index is:

$$\text{(1)}\quad \text{Official ER rate on day t} = \frac{\text{Total Dollars Obtained on day t from investment on day t}-1}{\text{Total Dollars Invested on day t}-1} - 1$$

However, the definitions of "total dollars invested" and "total dollars obtained" used by the official S&P GSCI Methodology in equation (1) are unclear. This paper examines how the daily percentage change of the S&P GSCI ER Index is measured, and if the divergence between the Spot Index and ER Index can be fully explained by the price difference between outgoing futures and incoming futures at contract replacement.

Empirical Procedures

We develop a daily flow of funds model to test the description of the term structure effect provided by Standard & Poor's. This flow of funds model separates the cumulative term structure effect from the total dollar value of the S&P GSCI, and re-measures the profits and losses of the S&P GSCI.

The daily flow of funds model will trade the same futures contracts and quantities as the official S&P GSCI, which sets the quantity weight for each of the 24-commodity futures holdings constant within each calendar year[9] and rebalances the index once a year at the end of the 4th business day of each January. In the rest of the year, during pre-established roll periods, 20% of the total number of contracts of a sooner-to-expire commodity futures contract will be sold and the same number of contracts of a later-to-expire contract will be bought each day from the 5th business day to the 9th business day of the month. Then, on

[8] S&P GSCI Index Total Dollar Value = Quantity of S&P GSCI Futures Holdings * Futures Price

[9] Calendar year is defined here to mean the S&P GSCI Year, which starts on the 5th business day of each January and ends on the 4th business of the next January.

the 10th business day of that month, all sooner-to-expire futures contracts have been replaced with the same number of later-to-expire contracts. Within each calendar year, the daily flow of funds model examines in detail the return generation and measurement process within the S&P GSCI. Actual daily profits and losses are measured in dollars rather than percentages to ensure that the term structure effect is excluded from the S&P GSCI investment returns.

The S&P GSCI total dollar value in each calendar year will be measured independently from other calendar years to avoid the influence from index rebalancing on the 4th business day of each January. In non-rolling periods, we measure the total dollar value of the S&P GSCI by equation (2) used by Standard & Poor's (2013b):

$$(2)\quad V_t = \sum_{i=1}^{24} Q_i * P_{i,t}$$

where V_t denotes the total dollar value of the diversified 24-commodity S&P GSCI futures holdings on day t, $P_{i,t}$ denotes the price of contract i on day t, and Q_i denotes the quantity of contract i included in the index. The range of i is from 1 to 24, which represents the 24 commodities used in the S&P GSCI from 2007 to 2013.

In contract replacement periods beyond the 4th business day of each January, Standard and Poor's (2013b) measures the total dollar value of the diversified 24-commodity futures holdings by equation (3):

$$(3)\quad V_t = \sum_{i=1}^{24} [\, Q_i * (CRW1_{i,t} * P1_{i,t} + CRW2_{i,t} * P2_{i,t})]$$

where $CRW1_{i,t}$ denotes the quantity roll weight of the outgoing contract i on day t, and $CRW2_{i,t}$ denotes the quantity roll weight of the incoming contract i on day t. $CRW1_{i,t}$ begins with 100% on the 5th business day in the rolling month, and decreases by 20% per day on the next 4 business days to 0%. $CRW2_{i,t}$ begins with 0% on the 5th business day in the rolling month, and increases by 20% per day on the next 4 business days to 100%. The summation of $CRW1_{i,t}$ and $CRW2_{i,t}$ is always equal to 100%. $P1_{i,t}$ is the price of the outgoing contract i on day t, and $P2_{i,t}$ is the price of the incoming contract i on day t. V_t and Q_i have the same meaning as in equation (2).

The S&P GSCI individual commodity subindexes, such as the S&P GSCI Crude Oil Subindex, hold a single commodity rather than multiple commodities. Without loss of generality, we simplify the analysis by assuming the quantity of futures contract to be 1[10], and treat the price of that individual futures contract as the total dollar value of the individual commodity subindex in non-rolling periods by using equation (4):

$$(4)\quad V_t = P_{i,t}$$

[10] For the S&P GSCI individual commodity subindexes, the quantity of futures contracts can be ignored because each individual commodity makes up 100% of the quantity position in the respective subindex.

In contract replacement periods beyond the 4th business day of each January, the total dollar value of the S&P GSCI individual commodity subindex, which assume holding only one contract, will be measured by equation (5):

$$(5)\ V_t = CRW1_{I,t} * P1_{I,t} + CRW2_{I,t} * P2_{I,t}$$

All of the variables in both equation (4) and equation (5) have the same meanings as the variables in equation (2) and equation (3).

The daily profit or loss of the S&P GSCI calculated by the daily flow of funds model is indicated in equation (6):

$$(6)\ M_t = (V_t - S_t) - V_{t-1} = F_t - F_{t-1}$$

M_t denotes the daily profit or loss of the S&P GSCI at the end of day t. V_t and V_{t-1} denotes the total dollar value of the S&P GSCI at the end of day t and day t-1, respectively. S_t denotes the term structure effect caused by contract replacement at the end of day t, which will be positive for contango and negative for backwardation. On non-rolling days, S_t will be zero, and the S&P GSCI daily profit or loss can be measured by taking the difference between V_t and V_{t-1} directly. In contract replacement periods beyond the 4th business day of each January, the daily term structure effect needs to be measured and deducted from the index total dollar value in order to calculate the daily profit or loss. F_t and F_{t-1} are investor fund balances in the S&P GSCI on day t and day t-1 respectively. The daily change in investor fund balance is the same as the daily profit or loss because both measure the daily returns to S&P GSCI investors. The daily term structure effect S_t is measured by equation (7) for the S&P GSCI:

$$(7)\ S_t = 20\% * \sum_{i=1}^{24}[\,Q_i * \left(P2_{i,t} - P1_{i,t}\right)]$$

and equation (8) for the individual commodity subindexes:

$$(8)\ S_t = 20\% * \left(P2_{i,t} - P1_{i,t}\right)$$

The daily investor fund balance F_t is measured by equation (9):

$$(9)\ F_t = V_t - \sum_{i=1}^{t} S_t$$

S_t in equations (7) and (8) denotes the term structure effect on day t, which is caused by the price difference between the outgoing contract and the incoming contract at contract replacement. $P1_{i,t}$ and $P2_{i,t}$ denote prices of the outgoing contract and the incoming contract respectively at the end of day t. The 20% component means the S&P GSCI replaces 20% of the total number of futures contracts each day, and will complete the replacement procedure in 5 days. $\sum_{i=1}^{t} S_t$ in equation (9) denotes the cumulative term structure effect from the beginning of the calendar year[11] to the end of day t. After deducting the cumulative term structure effect from the S&P GSCI total dollar value V_t on day t, the remaining dollars in the S&P GSCI at the end of day t represents the actual fund balance owned by an S&P GSCI investor, and named as F_t.

To test if the daily cumulative investment returns for the S&P GSCI ER Index is the same as the daily cumulative profits and losses measured by the daily flow of funds model, the S&P GSCI ER Index will be converted to the S&P GSCI investor fund balance by using equation (10):

$$\text{(10) } \mathrm{CF_t} = (1 + \mathrm{ER_t}) * \mathrm{CF_{t-1}} = \mathrm{V_0} * \prod_{i=1}^{t}(1 + \mathrm{ER_t})$$

CF_t denotes the daily investor fund balance at the end of day t converted from the official S&P GSCI ER Index. ER_t is the daily percentage change of the official S&P GSCI ER Index from the end of day t-1 to the end of day t. V_0 is the S&P GSCI index total dollar value at the end of the 4^{th} business day in January after the S&P GSCI finishes its annual rebalancing process.

The S&P GSCI investor fund balance F_t calculated by equation (9) excludes the influence of term structure effects by subtracting $\sum_{i=1}^{t} \mathrm{S_t}$ from the S&P GSCI total dollar value V_t at the end of day t. However, the investor fund balance CF_t in equation (10) is calculated by compounding the daily percentage changes of the official S&P GSCI ER Index. F_t is excluded from term structure effects as indicated in equation (9), but we will wait until later in this paper to explain how the ER_t is calculated by the official S&P GSCI ER Index[12]. If the investor fund balance CF_t calculated by equation (10) completely matches F_t calculated by equation (9), then the cumulative term structure effect determines the entire divergence between the S&P GSCI ER Index and Spot Index.

Data

The data used in this study includes the daily settlement index values of the S&P GSCI Spot Indexes and ER Indexes of the diversified 24-commodity S&P GSCI and Subindexes of selected individual commodities. Also used are the daily settlement prices for the futures of the 24 individual commodities used by S&P GSCI for 2007-2013.

The 24 commodity futures contracts in the S&P GSCI include: Brent Crude Oil, Gasoil, Cocoa, Coffee, Sugar #11, and Cotton #2, all traded at InterContinental Exchange (ICE); WTI Crude Oil, RBOB Gasoline, Heating Oil, Natural Gas, Gold, and Silver, all traded at New York Mercantile Exchange (NYMEX); Corn, Chicago Wheat, and Soybeans, all traded at Chicago Board of Trade (CBOT); Kansas Wheat, traded at Kansas City Board of Trade (KCBT); Live Cattle, Feeder Cattle, and Lean Hogs, all traded at Chicago

[11]When the S&P GSCI finishes rebalancing its index quantity weight at the end of the 4^{th} business day of January, a new S&P GSCI year starts.
[12] There is an equation available in the official S&P GSCI Methodology to calculate the daily percentage change of the S&P GSCI ER Index. However, the information required by this equation is unclear.

Mercantile Exchange (CME); and Aluminum, Copper, Lead, Nickel, and Zinc, all traded at London Metal Exchange (LME). The daily settlement prices for all except the LME commodity futures are collected from Barchart Advanced Commodity Service, the LME commodity futures prices are obtained from Thomson Reuters, and the daily settlement values for the S&P GSCI Spot Index, ER Index, and subindexes are provided by Standard & Poor's.

Simultaneously testing 24 commodities can be difficult, so we examined four individual commodity futures − NYMEX crude oil, NYMEX natural gas, CBOT corn, and CME live cattle − and their impacts on the returns of the S&P GSCI Crude Oil Subindex, the S&P GSCI Natural Gas Subindex, the S&P GSCI Corn Subindex, and the S&P GSCI Live Cattle Subindex, respectively. There are several reasons for selecting these particular individual commodities. First, these commodities have the largest dollar weights in the energy sector, agricultural sector, and livestock sector respectively in the S&P GSCI index, and experience large price fluctuations each year. Second, together these four commodities account for more than 42% of the dollar weight in the S&P GSCI (Standard & Poor's 2013b). Third, NYMEX crude oil and NYMEX natural gas futures undergo contract replacement each month, and the frequency in replacing these futures will be helpful to provide the maximum number of individual tests. Corn is storable commodity with an annual production cycle, so the price difference will be largest at the transition from old crop contract to new crop contract, and a large price difference between two futures at replacement time will be useful to test whether term structure effects contribute to index price divergence. Live cattle is a non-storable commodity with a continuous production cycle, so it does not have a stable term structure. After these four individual commodities have been tested, we will extend this approach to the full 24-commodity index.

The time frame under this study is from January 5, 2007 to January 7, 2014. There are two reasons to select this time period. First, the S&P GSCI maintains the same 24 commodities in the index during this period. Tracking investment returns of the same 24 commodities across years will be more consistent than tracking returns of different commodities in each year. Second, during this period, commodity prices rose to record levels, collapsed following the global financial crisis, and then recovered. These large fluctuations provide a range of market conditions for us to test our hypothesis.

Hypothesis Testing

Our first step is to use V_t from equations (2) to (5) to build the S&P GSCI Spot Index and four individual commodity subindexes by compounding the daily percentage changes of V_t. To confirm that these calculated spot index values are the same as the official values, we compare these calculated spot index values graphically and quantitatively against the corresponding official spot index values. Figure 2 through Figure 6 show that our calculated spot index values and corresponding official spot index values are closely matched with each other. Table 2 shows that the calculated and official values for the annual spot returns are matched as well. These results confirm that the commodity futures contracts and procedures used in our model are the same as those used in the official S&P GSCI.

Our next step is to test if the S&P GSCI investor fund balance F_t calculated by the daily flow of funds model in equation (9) (i.e., the calculated fund balance at the end of day t) matches the investor fund balance CF_t converted from the official S&P GSCI ER Index in equation (10) (i.e., the official fund balance at the end of day t). Both F_t and CF_t are cumulated by the funds that were invested in the S&P GSCI in the beginning of each calendar year plus daily profits or losses generated by the S&P GSCI futures holdings from the beginning of each calendar year to the end of day t. In equation (9), the daily flow of funds model calculates F_t by deducting the cumulative term structure effect $\sum_{i=1}^{t} S_t$ from the S&P GSCI total dollar value V_t. If the price difference between the outgoing futures and incoming futures at contract replacement can explain the entire divergence between the official S&P GSCI Spot Index and ER Index, then the CF_t calculated by equation (10) must be the same as the F_t calculated by equation (9). Both the daily flow of funds model and the official S&P GSCI start with the same investment fund balance and trade the same futures contracts. If the official excess return ER_t in equation (1) is fully explained by both the cumulative term structure effect $\sum_{i=1}^{t} S_t$ and the total dollar value V_t from equation (2) to equation (5), then F_t and CF_t should be the same. If F_t and CF_t are found to be different, then there will be other returns in addition to the cumulative term structure effects and total dollar value (Spot index) to explain the official S&P GSCI ER Index (ER in equation 1). In other words, the cumulative term structure effect will be insufficient to explain the entire divergence between the official S&P GSCI Spot Index and ER Index.

To avoid any influence from rounding error, which may affect the testing results, this paper uses a ratio-paired t test rather than difference-paired t test to see if F_t and CF_t differ significantly by testing all of their daily values within a year. We take the natural log of the difference between F_t and CF_t to get $\ln(\frac{Ft}{CFt})$, and assume that $\ln(\frac{Ft}{CFt})$ follows a normal distribution with mean of zero. If the test result is not statistically different from zero, then F_t and CF_t are equal. Otherwise, we will search for the reasons for the divergence between F_t and CF_t.

Results and Discussion

Results from using ratio-paired t-test to compare official and calculated investor daily fund balances CF_t and F_t are presented in Table 3. Only three cases were found in which CF_t and F_t are not statistically different: for the S&P GSCI in 2010, CME live cattle in 2012, and NYMEX crude oil in 2013. All other pairs of CF_t and F_t are found to be statistically different. This provides strong evidence that excess returns consist of more than just term structure effects.

In addition, annualized excess returns[13] calculated by the daily flow of funds model and the official S&P GSCI ER Index for all selected samples from 2007 to 2013 are divergent (Table 4). Although the ratio-paired t-test did not detect the daily differences between F_t and CF_t for the S&P GSCI in 2010, CME live cattle in 2012, and NYMEX crude oil in 2013, the difference of annualized excess returns between the daily flow of funds model and the official S&P GSCI ER Index model suggests the presence of daily differences between F_t and CF_t.

Next, we calculate daily Spot Indexes and ER Indexes for the seven years 2007-2013 based on the index total dollar value V_t from equations (2) to (5) and the daily fund balances F_t in equation (9). We then compare the seven-year return performance of each calculated Spot Index and ER Index with the corresponding official Spot Index and ER Index. Results are presented in Table 5, and show that the calculated and official spot returns are matched for the 24-commodity S&P GSCI and for each of the four individual commodity subindexes. However, none of the calculated ER Indexes have the same excess returns as the official ER Indexes. NYMEX crude oil, which accounts for more than 33% of the total dollar weight of the S&P GSCI, had a seven-year cumulative loss of 22.49% for the calculated Crude Oil ER Subindex compared to a loss of 36.87% for the official Crude Oil ER Subindex (Table 5 and Figure 7). CBOT corn, which provides approximately 4% of the dollar weight of the S&P GSCI, had a seven-year cumulative loss of 18.01% for the calculated Corn ER Subindex compared to a loss of 21.21% for the official Corn ER Subindex (Table 5 and Figure 8). The over-reporting of losses by the official S&P GSCI Crude Oil ER Subindex and to a lesser degree the official Corn ER Subindex help explain why the official S&P GSCI ER Index over-reported losses in the past seven years by 4.12% (Table 5 and Figure 9).

In contrast, the seven-year cumulative losses for NYMEX natural gas and CME live cattle are under-reported. Natural gas had a seven-year cumulative loss of 95.54% for the calculated ER Subindex compared to a loss of 93.98% for the official ER Subindex (Table 5 and Figure 10), and live cattle had a seven-year cumulative loss of 39.77% for the calculated ER Subindex compared to a loss of 35.42% for the official ER Subindex (Table 5 and Figure 11). Since the combined dollar weight of NYMEX natural gas and CME live cattle in the S&P GSCI is less than 6%, the under-reporting of losses by the Natural Gas ER Subindex and the Live Cattle ER Subindex is not large enough to offset the over-reporting of losses by the Crude Oil ER Subindex and the Corn ER Subindex. The calculated S&P GSCI ER Index had a loss of 12.41% compared to a loss of 16.53% for the official S&P GSCI ER Index (Table 5 and Figure 9).

Standard & Poor's uses term structure effect to explain the divergence between the official S&P GSCI Spot Index and ER Index, but the results generated by the daily flow of funds model does not support this explanation. The daily flow of funds model trades the same futures contracts in the same quantities as the official S&P GSCI. It yields the same spot returns but different excess returns (Table 5). By definition from equation (9), the difference between the calculated spot index and the calculated ER index is term structure

[13] Annualized excess returns of the daily flow of funds model and the official S&P GSCI are the annual percentage changes of F_t and CF_t, respectively.

effect. Because the calculated and official Spot Index values are identical, but the calculated and official ER Index values differ substantially, the difference between the official Spot Index and the official ER index consists of more than just the term structure effect.

In order to find the reason for the divergence between the official S&P GSCI ER Index and our calculated S&P GSCI ER Index, we further analyze the "total dollars invested on day t-1" and the "total dollars obtained on day t from investment on day t-1" from the official daily excess return ER_t in equation (1). We assume the difference between the "total dollars invested on day t-1" and the "total dollars obtained on day t from investment on day t-1" is the profit or loss M_t in equation (6). We know that CF_t in equation (10) is defined as a function of the daily percentage change of the official ER Index value from day t-1 to day t. Therefore, the daily percentage change of the official S&P GSCI ER Index value is a reverse function of CF_t, and the "total dollars invested on day t-1" in equation (1) is CF_{t-1}. The ratio-paired t test used earlier in this paper indicates that the official daily fund balance CF_t and the calculated daily fund balance F_t in equation (9) are statistically different, therefore, the calculated daily fund balance F_{t-1} is not the "total dollars invested on day t-1" specified in equation (1). We assume the "total dollars invested on day t-1" is the S&P GSCI total dollar value V_{t-1}, and use equation (11) to calculate the expected daily percentage change of the S&P GSCI ER Index:

$$(11)\quad \text{Expected Daily Percentage Change of ER Index} = \frac{M_t}{V_{t-1}}$$

where M_t is the daily profit or loss of the S&P GSCI at the end of day t measured by equation (6), and V_{t-1} is the S&P GSCI index total dollar value at the end of day t-1. We compound the expected daily percentage change calculated in equation (11) to rebuild the S&P GSCI ER Index and four individual commodity ER Subindexes in each calendar year, and then measure their expected annualized excess return rates from 2007 to 2013. All of these expected annualized excess return rates are compared with the annualized excess return rates reported from the official S&P GSCI ER Index and four individual commodity ER Subindexes. The expected annualized excess return rates are the same as the official annualized excess return rates with only negligible differences in a few cases (Table 6).

Based on the results presented in Table 6, the daily percentage changes of the official S&P GSCI ER Index and ER Subindexes are calculated by using the S&P GSCI total dollar value V_{t-1} at the end of day t-1 as expressed in equation (11), rather than the daily fund balance F_{t-1}. This calculation approach explains the divergence between the official S&P GSCI ER Index and the calculated ER Index.

The S&P GSCI ER Index is designed to measure investor return performance. Therefore, a better measure of daily return performance is to calculate the daily percentage change of the S&P GSCI ER Index by dividing the S&P GSCI daily profit or loss by the investor fund balance F_{t-1} on the previous day, rather than by the index total dollar value V_{t-1} on the previous day. Notice that F_{t-1} and V_{t-1} will be different whenever contract replacement occurs, so the difference between F_{t-1} and V_{t-1} is the cumulative price difference of the outgoing futures contracts and incoming futures contracts as described in equation (9). But this cumulative price difference cannot be treated as funds available to investors, and thus the daily excess return rate measured by the official S&P GSCI Methodology cannot precisely measure the return performance of S&P GSCI investors.

Figure 12 illustrates how the official S&P GSCI Corn ER Subindex has a different excess return measurement process from the calculated Corn ER Subindex, and consequently over-reports losses to investors. For simplicity, we assume that the S&P GSCI Corn Subindex invests in one bushel of corn in the corn futures contract, and the contract replacement period is a single day. Also recall that the quantities of each futures contract are fixed within any calendar year. Suppose in the contract replacement period, the Corn Subindex holds an $8 per bushel March position without any leverage, and replaces this $8 March position with a $7 per bushel May position. In effect, the March position has been replaced with the same quantity of the May position. One day later, the price of the May position goes down by $1 and is now worth only $6 per bushel. The actual loss received by the Corn Subindex investor is only $1, and the actual daily rate of return is (-$1)/$8 = -12.5%. However, if the daily excess return rate from Day 1 to Day 2 is calculated using equation (11), the daily excess return rate from day 1 to day 2 as reported by the official S&P GSCI Corn ER Subindex will be (-$1)/$7 = -14.28%. Furthermore, the starting fund that was invested in the S&P GSCI Corn Subindex on Day 1 is $8, so investors will lose $8*(-1/7) = -$1.14 from the Corn Subindex investment at the end of Day-2 when using the official method to measure excess returns. This is $0.14 more than the $1 actual loss, and this extra $0.14 loss explains why the official Corn ER Subindex underperforms the Calculated Corn ER Subindex based on the daily flow of funds model in Figure 8.

To further examine this difference, we take the natural log of the difference between the compounded official daily excess return rate and the compounded daily excess return rate calculated by daily flow of funds model in each calendar year, shown by equation (12):

$$(12)\ \ln[\prod_{i=1}^{t}(\frac{F_{t-1}+M_t}{F_{t-1}})] - \ln[\prod_{i=1}^{t}(\frac{F_{t-1}+M_t+\sum_{i=1}^{t-1}S_{t-1}}{F_{t-1}+\sum_{i=1}^{t-1}S_{t-1}})]$$

$$= \sum_{i=1}^{t}\ln\left(\frac{F_{t-1}+M_t}{F_{t-1}}\right) - \sum_{i=1}^{t}\ln\left(\frac{F_{t-1}+M_t+\sum_{i=1}^{t-1}S_{t-1}}{F_{t-1}+\sum_{i=1}^{t-1}S_{t-1}}\right)$$

$$= \sum_{i=1}^{t}\ln\left[\left(\frac{F_{t-1}+M_t}{F_{t-1}}\right)*\left(\frac{F_{t-1}+\sum_{i=1}^{t-1}S_{t-1}}{F_{t-1}+M_t+\sum_{i=1}^{t-1}S_{t-1}}\right)\right]$$

$$=\sum_{i=1}^{t}\ln\left(1+\frac{M_t*\sum_{i=1}^{t-1}S_{t-1}}{(F_{t-1})^2+F_{t-1}*M_t+F_{t-1}*\sum_{i=1}^{t-1}S_{t-1}}\right)$$

where F_{t-1} is the S&P GSCI investor fund balance at the end of day t-1 calculated by equation (9), $\sum_{i=1}^{t-1}S_{t-1}$ is the cumulative daily term structure effect from the beginning of the year to the end of day t-1 calculated by equations (7) and (8), M_t is the daily profit or loss in dollars received by the S&P GSCI calculated by equation (6), $\prod_{i=1}^{t}(\frac{F_{t-1}+M_t}{F_{t-1}})$ is the compounded daily excess return used by the daily flow of funds model, and

$\prod_{i=1}^{t}(\frac{F_{t-1}+M_t+\sum_{i=1}^{t-1}S_{t-1}}{F_{t-1}+\sum_{i=1}^{t-1}S_{t-1}})$ is the compounded daily excess return used by the official S&P GSCI from the beginning of the year to the end of day t derived from equation (11). The summation of F_{t-1} and $\sum_{i=1}^{t-1}S_{t-1}$ is V_{t-1}, which was introduced in equation (9). Because the ER indexes are compounded by daily excess return rates, using the natural log of the difference between the compounded daily excess return rates decomposes the daily difference in investment returns between the official S&P GSCI ER Index and the ER Index calculated by the daily flow of funds model. The final step in equation (12) indicates that if the futures holdings of the S&P GSCI experience a profit (i.e., M_t is positive) on day t, and if the cumulative term structure effect $\sum_{i=1}^{t-1}S_{t-1}$ is positive (i.e., contango exists) from the beginning of the year to the end of day t-1, then the official S&P GSCI ER Index will under-report profits. Conversely, if the futures holdings of the S&P GSCI experience loss (i.e., M_t is negative) on day t, and if the cumulative term structure effect $\sum_{i=1}^{t-1}S_{t-1}$ is negative (i.e., backwardation exists) from the beginning of the year to the end of day t-1, then the official S&P GSCI ER Index will over-report losses. It follows that if M_t is positive (i.e., the futures holdings experience a profit on day t) and cumulative term structure is negative (i.e., backwardation exists), then the official ER Index will over-report profits. If M_t is negative (i.e., the futures holdings experience a loss on day t) and cumulative term structure is positive (i.e., contango exists), then the official ER Index will under-report losses.

We use the existing return performance of both the S&P GSCI Crude Oil ER Subindex and the S&P GSCI Corn ER Subindex from 2007 to 2013 to illustrate our findings in equation (12). For example, NYMEX crude oil futures were in contango in both 2007 and 2009, a long-only position was profitable, and consequently NYMEX crude oil excess returns in 2007 and 2009 calculated by the daily flow of funds model are higher than the excess returns reported by the official S&P GSCI Crude Oil ER Subindex. For the S&P GSCI Corn ER Subindex, CBOT corn futures were in contango from 2007 to 2011. Except in 2009, when a long-only position would have experienced a substantial loss prior to the first contract replacement period, excess returns calculated by the daily flow of funds model are higher than the excess returns reported by the official S&P GSCI Corn ER Subindex when excess return is positive, and lower when excess return is negative. From 2012 to 2013 when CBOT corn futures were in backwardation, excess returns calculated by the daily flow of funds model are lower than the excess returns reported by the official S&P GSCI Corn ER Subindex when excess return is positive, and higher when excess return is negative. (Table 4).

Summary and Conclusions

This paper analyzes the reason for the divergence between the S&P GSCI Spot Index and ER Index. From 1991 when tradable investments based on the S&P GSCI first became available to investors to the end of 2013, cumulative excess returns have typically lagged to cumulative spot returns. The term structure effect, defined here as the difference between a commodity's outgoing and incoming futures prices when contract replacement occurs, is commonly used to explain this divergence, and the return performance of individual commodity futures is used to explain S&P GSCI excess returns. Little research has focused on how the official S&P GSCI excess return is measured. This paper demonstrates how the term structure effect cannot fully explain the divergence between returns for the S&P GSCI ER Index and Spot Index.

After a detailed analysis of the excess returns and spot returns of the S&P GSCI and four of its individual commodity futures holdings – NYMEX crude oil, NYMEX natural gas, CBOT corn, and CME live cattle – we find that cumulative term structure alone does not explain the entire divergence between the official S&P GSCI Spot Index and ER Index. Instead, the interaction between the daily profit or loss in dollars from the S&P GSCI futures holdings and cumulative term structure effect should also be taken into account. Based on the daily excess return equation used by the official S&P GSCI Methodology, this interaction may result in unexpected profits or losses in addition to the returns received from purely investing in individual commodity futures. Depending on our test results from 2007 to 2013, the official S&P GSCI ER Index is found to either under-report actual profits or over-report actual losses. It causes investors to receive lower returns from S&P GSCI index-based investments compared to the returns received from directly investing in the same amounts of futures contracts held by the S&P GSCI.

Because of this interaction between the daily profits or losses on the S&P GSCI futures holdings and the cumulative term structure effect, the official S&P GSCI excess return will be less than the actual return performance if those futures holdings experience profits when the cumulative term structure effect is in contango or losses when the cumulative term structure effect is in backwardation. For the four individual commodity futures holdings of the S&P GSCI that we examined, directly investing in NYMEX crude oil futures and CBOT corn futures would have generated higher returns than investing in the S&P GSCI Crude Oil ER Subindex and S&P GSCI Corn ER Subindex, respectively, from 2007 to 2013. This occurs because both NYMEX crude oil and CBOT corn were making profits from contango and losses from backwardation during this period. Results were less definitive for NYMEX natural gas and CME live cattle due to the lack of clear term structure effects during the period examined, but nonetheless are consistent with our findings regarding the interaction between profitability and cumulative term structure.

Although a more detailed examination of the relationship between term structure and commodity futures returns falls outside the scope of this study, the limited results presented here cast some doubt on the findings made by researchers such as Nash and Smyk (2003) and Erb and Harvey (2006) that backwardation is more profitable than contango when investing in futures contracts generally, or in the S&P GSCI Index specifically. Instead, our results are consistent with Bessembinder et al. (2012) and Irwin and Sanders (2012), who suggest that commodity futures return performance may be independent of commodity futures term structure in the long run.

The S&P GSCI is the largest tradable commodity index with GSCI-based investments totaling more than $80 billion (Standard & Poor's 2013a). As the largest commodity index investment portfolio, any small errors or inconsistencies in the S&P GSCI excess return measurement procedure can generate tremendous losses to its investors. The results of this research will be helpful for S&P GSCI investors to better understand how their investment returns are calculated. This study also exposes arbitrage opportunities that may exist between trading S&P GSCI-related investment products and individual commodity futures, since both trading methods invest in the same futures contracts but receive different investment returns.

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Table 1
S&P GSCI Contract Replacement Procedure Used by Burton & Karsh

Buy: Day t-1 Allocation t-1 / Price of Near Future t-1 = Number of Contracts purchased	$10,000 / $100 = 100 contracts
Sell: Day t Number of Contracts * Price of Near Future t = Total Value t	100 contracts * $110 = $11,000
Buy: Day t Allocation t / Price of Deferred Future t = Number of Contracts purchased	$11,000/$143 = 76.9 contracts
Sell: Day t+1 Number of Contracts * Price of Deferred Contract t+1 = Total Value t+1	76.9 * $157.3 = $12,100
Excess Return (Total Value-Initial Allocation) / Initial Allocation = Excess Return	($12,100 - $10,000) / $10,000 = 21%

Source: Burton & Karsh 2009

Table 2
Comparison of Annualized Spot Returns, Official S&P GSCI vs.
Calculated Using Daily Flow of Funds Model

	2007	2008	2009	2010	2011	2012	2013
S&P GSCI Official Spot Return	50.53%	-42.58%	54.47%	14.38%	6.65%	-2.00%	-5.16%
S&P GSCI Spot Return-Flow of Funds Model	50.53%	-42.58%	54.47%	14.38%	6.65%	-2.00%	-5.16%
Crude Oil Official Spot Return	68.87%	-55.17%	93.90%	6.92%	14.91%	-8.24%	0.51%
Crude Oil Spot Return-Flow of Funds Model	68.87%	-55.17%	93.90%	6.92%	14.91%	-8.24%	0.51%
Natural Gas Official Spot Return	22.88%	-26.33%	4.07%	-22.78%	-30.69%	8.19%	33.46%
Natural Gas Spot Return-Flow of Funds Model	22.88%	-26.33%	4.07%	-22.77%	-30.69%	8.19%	33.46%
Corn Official Spot Return	26.61%	-10.67%	0.24%	44.19%	6.89%	6.53%	-37.86%
Corn Spot Return-Flow of Funds Model	26.61%	-10.67%	0.24%	44.19%	6.89%	6.53%	-37.86%
Live Cattle Official Spot Return	2.19%	-9.33%	0.17%	24.21%	12.74%	10.53%	2.65%
Live Cattle Spot Return-Flow of Funds Model	2.19%	-9.33%	0.17%	24.21%	12.74%	10.53%	2.65%

Table 3
Ratio-Paired t-Tests for Daily Values of F_t and CF_t

	2007	2008	2009	2010	2011	2012	2013
S&P GSCI Ratio Paired T-Value	15.29	-8.32	15.91	**1.29**	6.63	-13.21	-23.20
S&P GSCI Ratio Paired P-Value	0.000	0.000	0.000	**0.199**	0.000	0.000	0.000
Crude Oil Ratio Paired T-Value	14.86	-2.04	16.29	-6.99	-3.39	-14.86	13.93
Crude Oil Ratio Paired P-Value	0.000	0.042	0.000	0.000	0.001	0.000	0.000
Natural Gas Ratio Paired T-Value	-11.02	-10.21	-8.19	-7.33	-7.79	3.79	**0.56**
Natural Gas Ratio Paired P-Value	0.000	0.000	0.000	0.000	0.000	0.000	**0.575**
Corn Ratio Paired T-Value	-10.44	-7.53	-11.16	11.56	18.82	-16.37	14.39
Corn Ratio Paired P-Value	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Live Cattle Ratio Paired T-Value	2.34	-10.54	-17.67	29.92	-4.31	**1.54**	-27.36
Live Cattle Ratio Paired P-Value	0.020	0.000	0.000	0.000	0.000	**0.125**	0.000

Table 4
Comparison of Annualized Excess Returns, Official S&P GSCI vs. Calculated Using Daily Flow of Funds Model

	2007	2008	2009	2010	2011	2012	2013
S&P GSCI Official ER	35.66%	-47.08%	16.45%	3.40%	3.20%	-2.26%	-4.25%
S&P GSCI ER - Flow of Funds Model	38.65%	-49.09%	23.02%	4.49%	3.25%	-2.34%	-4.26%
Crude Oil Official ER	51.97%	-57.68%	16.58%	-7.37%	4.80%	-12.70%	-0.65%
Crude Oil ER - Flow of Funds Model	58.84%	-57.54%	35.11%	-6.80%	5.16%	-12.82%	-0.44%
Natural Gas Official ER	-20.49%	-37.94%	-53.24%	-41.62%	-43.43%	-27.85%	15.48%
Natural Gas ER - Flow of Funds Model	-25.50%	-43.67%	-54.33%	-42.25%	-48.28%	-29.92%	17.04%
Corn Official ER	5.97%	-23.09%	-11.69%	24.02%	5.13%	17.28%	-28.40%
Corn ER - Flow of Funds Model	8.38%	-27.10%	-11.66%	29.56%	5.37%	14.46%	-24.83%
Live Cattle Official ER	-7.56%	-26.35%	-9.91%	13.41%	-0.48%	-2.59%	-4.23%
Live Cattle ER - Flow of Funds Model	-8.10%	-31.01%	-10.51%	14.19%	-0.66%	-2.38%	-4.14%

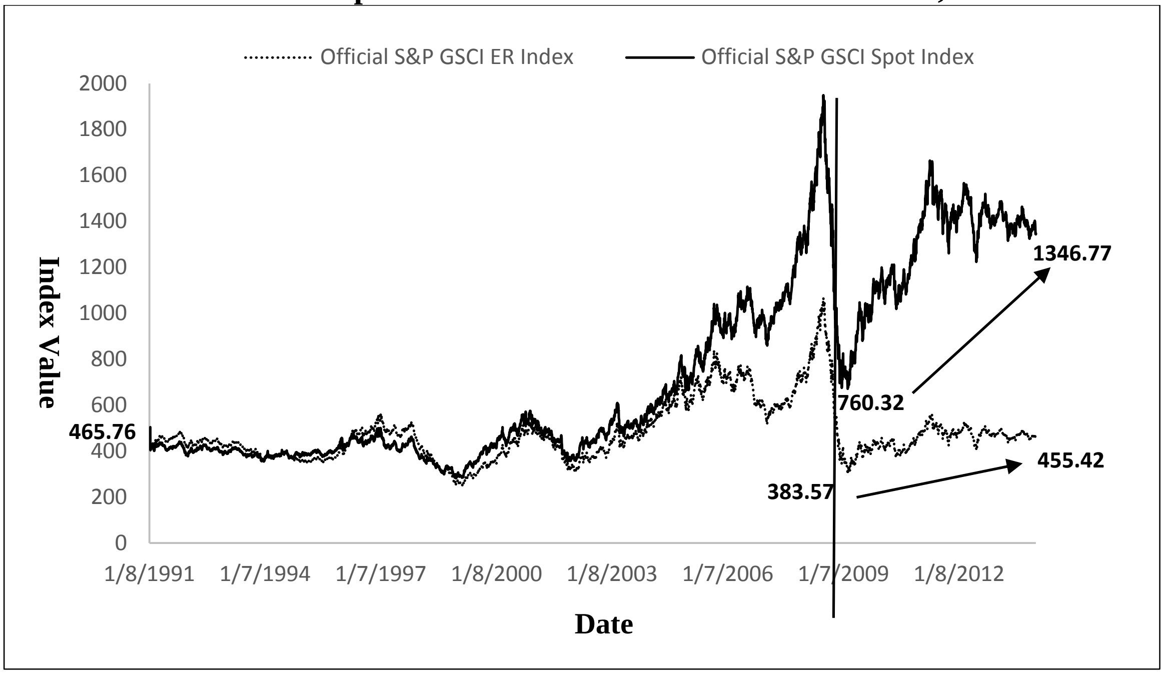
Table 5
Cumulative Spot Returns & Excess Returns 2007-2013, Official S&P GSCI vs. Calculated Using Daily Flow of Funds Model

	Official Spot Return	Spot Return-Flow of Funds Model	Official Excess Return	Excess Return-Flow of Funds Model
S&P GSCI	51.40%	51.40%	-16.53%	-12.41%
Crude Oil	66.25%	66.25%	-36.87%	-22.49%
Natural Gas	-30.48%	-30.48%	-93.98%	-95.54%
Corn	15.68%	15.68%	-21.21%	-18.01%
Live Cattle	47.48%	47.47%	-35.42%	-39.77%

Table 6
Annualized Excess Returns, Official S&P GSCI vs. Expected

	2007	2008	2009	2010	2011	2012	2013
S&P GSCI Official ER	35.66%	-47.08%	16.45%	3.40%	3.20%	-2.26%	-4.25%
S&P GSCI ER - Expected	35.74%	-47.06%	16.46%	3.36%	3.30%	-2.24%	-4.27%
Crude Oil Official ER	51.97%	-57.68%	16.58%	-7.37%	4.80%	-12.70%	-0.65%
Crude Oil ER - Expected	51.97%	-57.68%	16.58%	-7.37%	4.80%	-12.70%	-0.65%
Natural Gas Official ER	-20.49%	-37.94%	-53.24%	-41.62%	-43.43%	-27.85%	15.48%
Natural Gas ER - Expected	-20.49%	-37.95%	-53.24%	-41.62%	-43.44%	-27.85%	15.50%
Corn Official ER	5.97%	-23.09%	-11.69%	24.02%	5.13%	17.28%	-28.40%
Corn ER - Expected	5.97%	-23.11%	-11.69%	24.00%	5.12%	17.28%	-28.36%
Live Cattle Official ER	-7.56%	-26.35%	-9.91%	13.41%	-0.48%	-2.59%	-4.23%
Live Cattle ER - Expected	-7.56%	-26.35%	-9.91%	13.41%	-0.48%	-2.59%	-4.23%

Figure 1
Official S&P GSCI Spot Index vs. Official S&P GSCI ER Index, 1991–2013



Note: ER Index was set equal to S&P GSCI Spot Index at 465.76 on January 8, 1991 to allow comparison of the two indexes.

Figure 2
Official S&P GSCI Crude Oil Spot Subindex vs.
Calculated Crude Oil Spot Subindex Using the Daily Flow of Funds Model

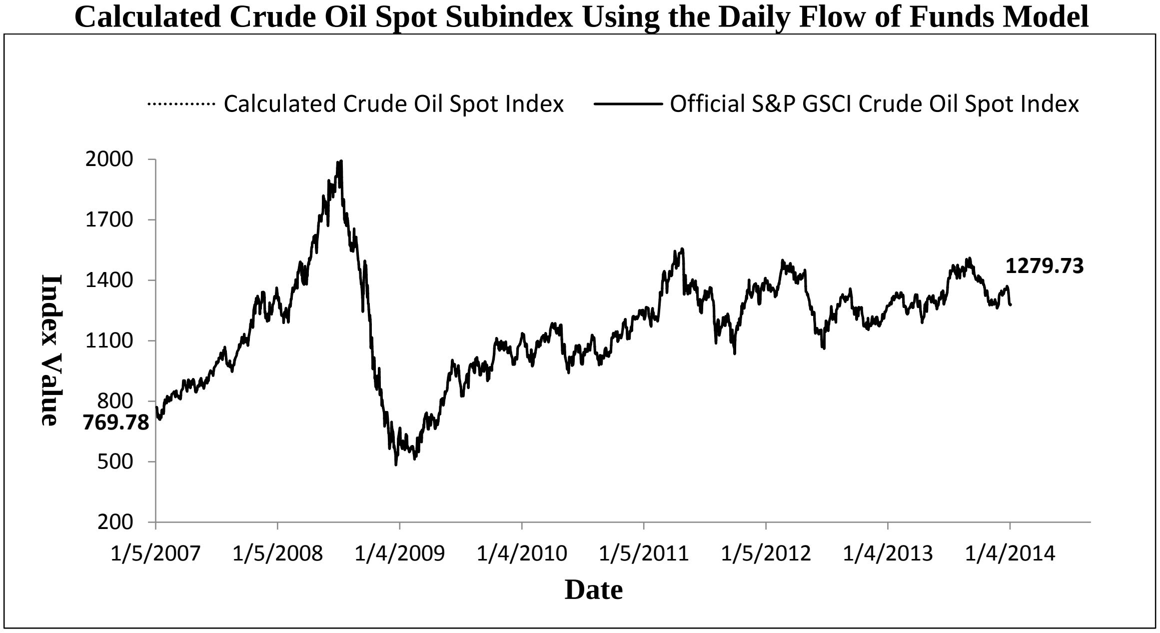


Figure 3
Official S&P GSCI Corn Spot Subindex vs.
Calculated Corn Spot Subindex Using the Daily Flow of Funds Model

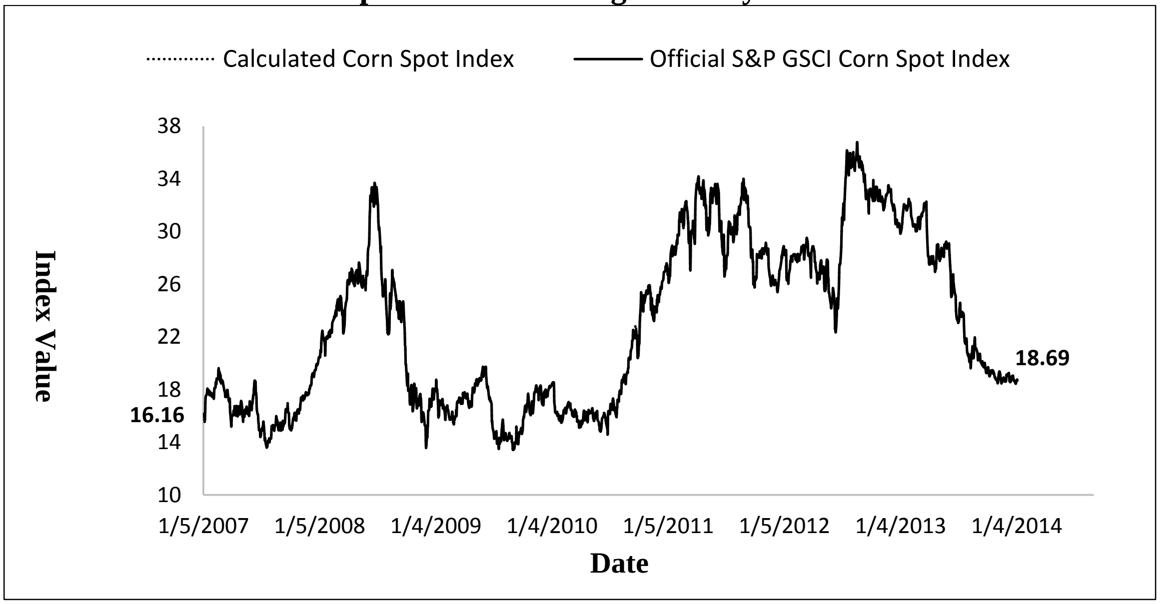


Figure 4
Official S&P GSCI Spot Index vs.
Calculated Spot Index Using the Daily Flow of Funds Model

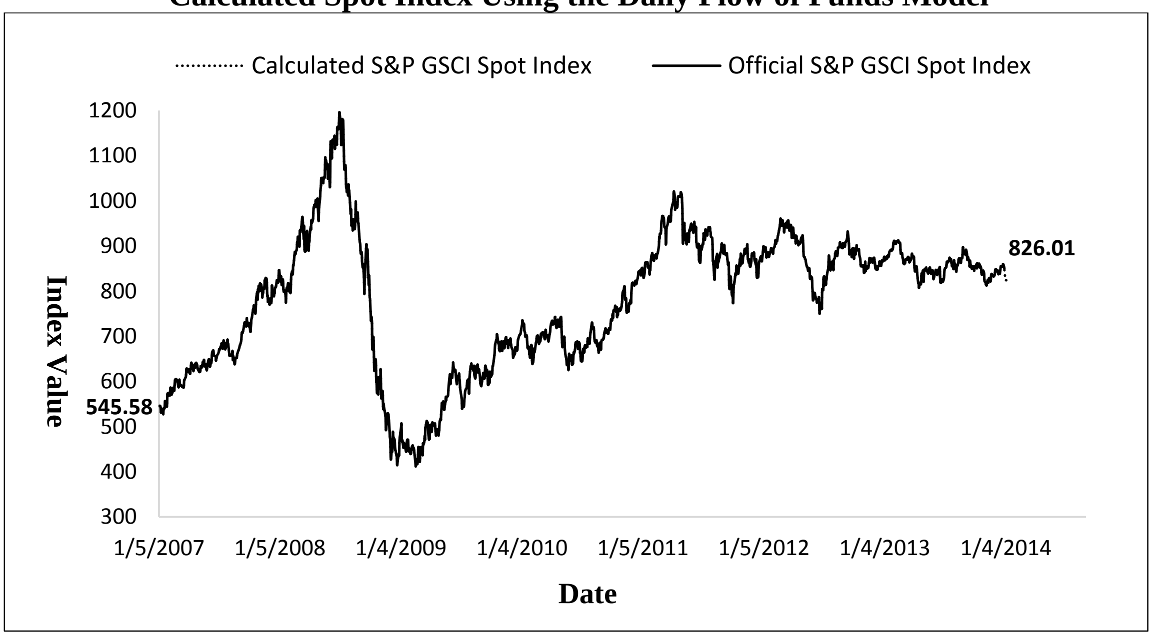


Figure 5
Official S&P GSCI Natural Gas Spot Subindex vs.
Calculated Natural Gas Spot Subindex Using the Daily Flow of Funds Model

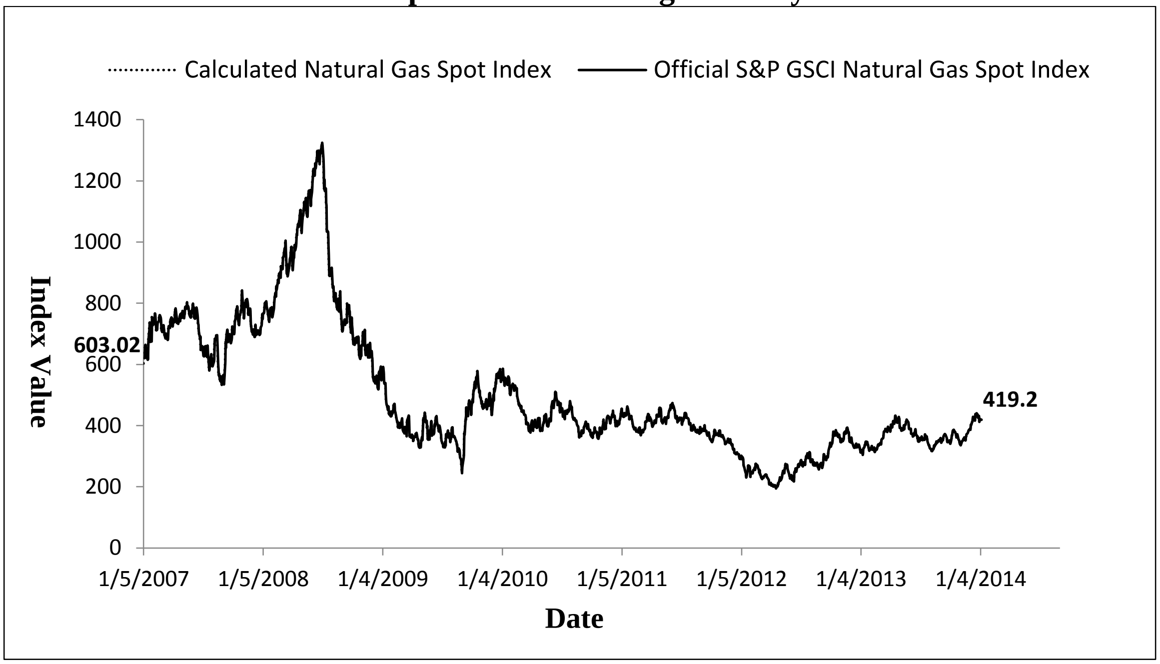


Figure 6
Official S&P GSCI Live Cattle Spot Subindex vs.
Calculated Live Cattle Spot Subindex Using the Daily Flow of Funds Model

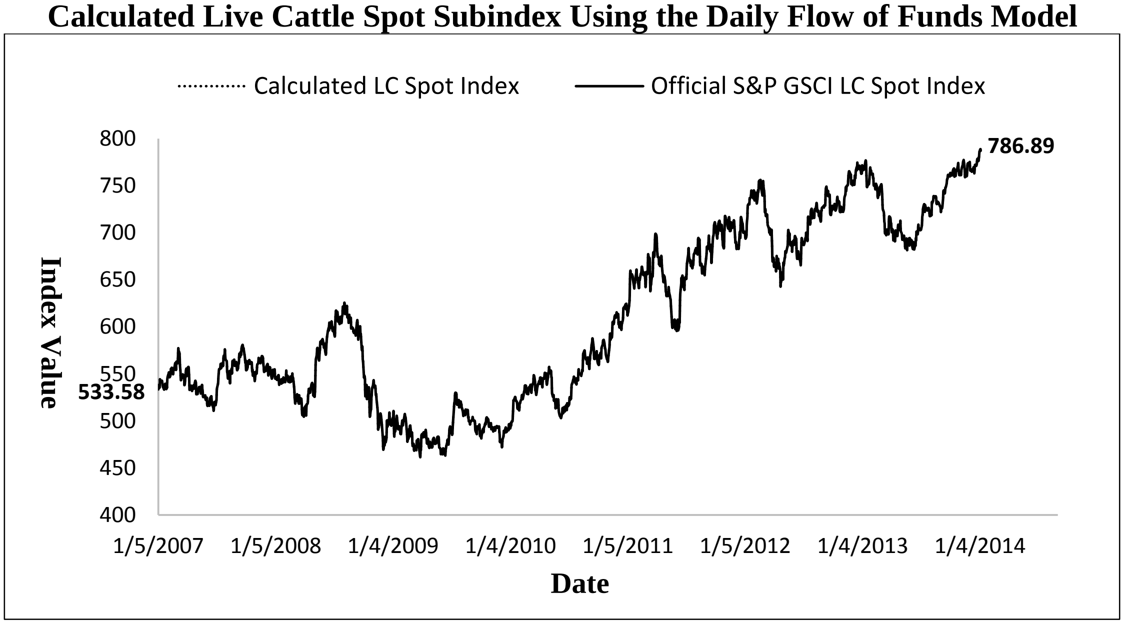


Figure 7
Official S&P GSCI Crude Oil ER Subindex vs.
Calculated Crude Oil ER Subindex Using the Daily Flow of Funds Model

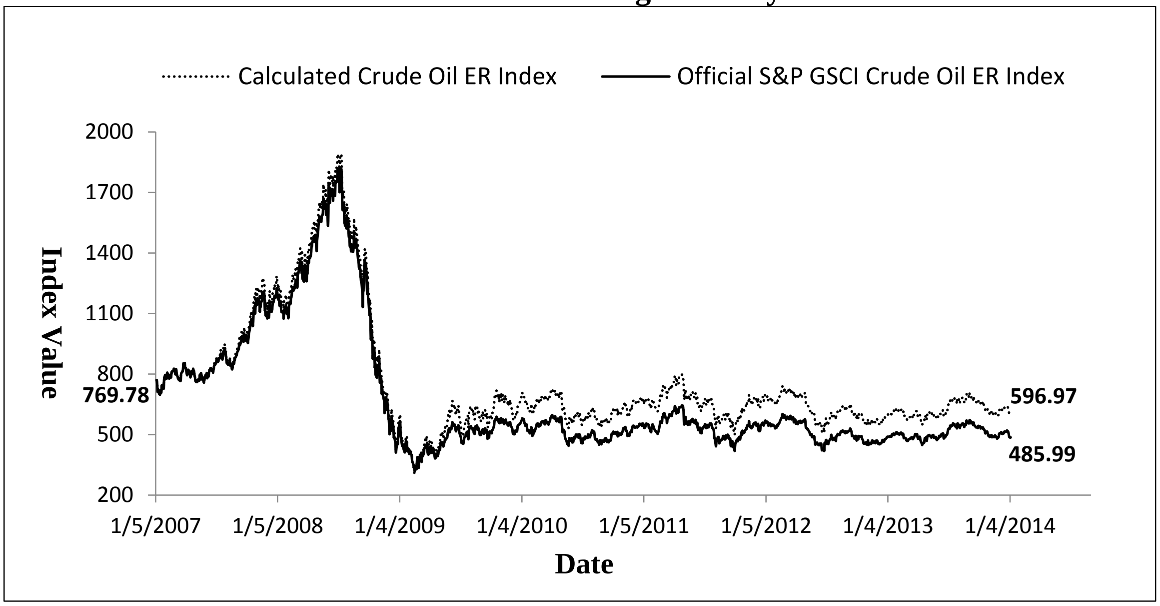


Figure 8
Official S&P GSCI Corn ER Subindex vs.
Calculated Corn ER Subindex Using the Daily Flow of Funds Model

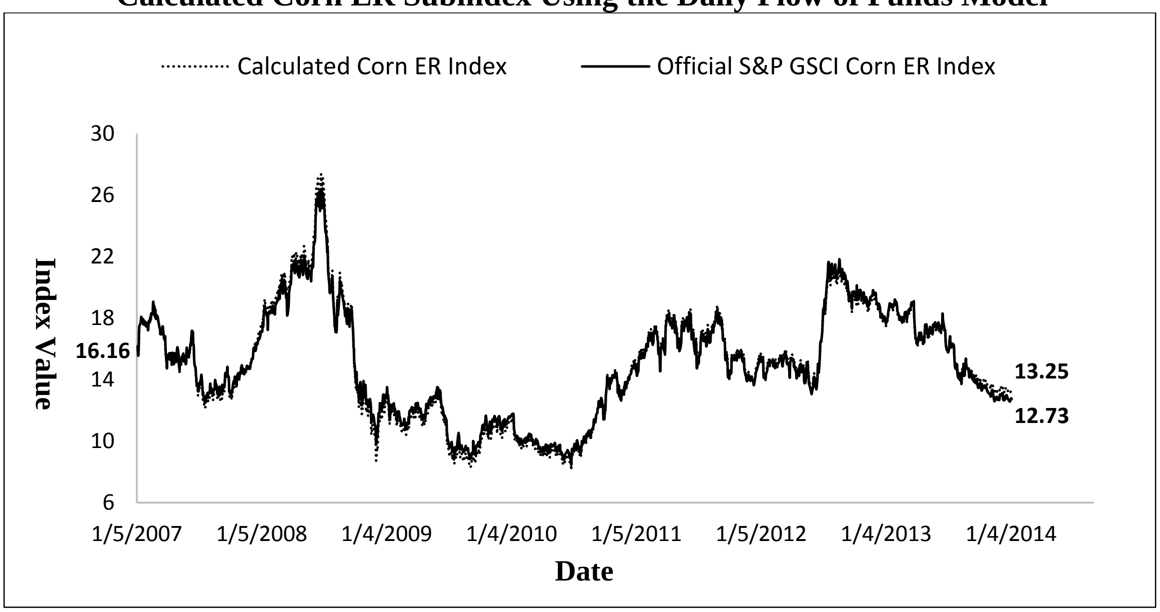


Figure 9
Official S&P GSCI ER Index vs.
Calculated ER Index Using the Daily Flow of Funds Model

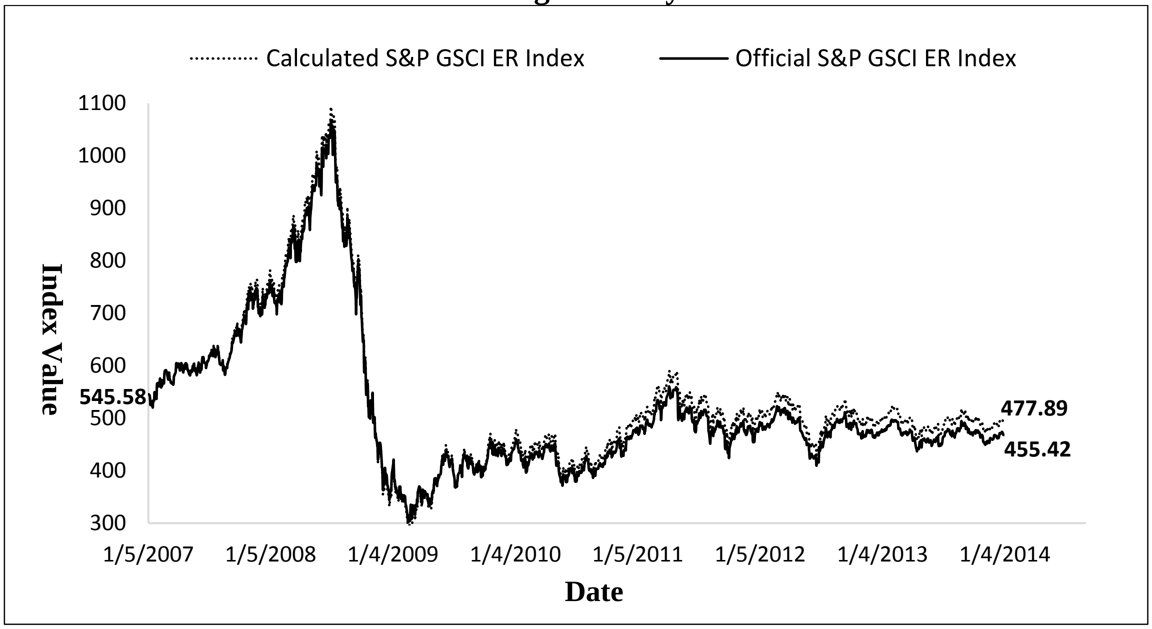


Figure 10
Official S&P GSCI Natural Gas ER Subindex vs.
Calculated Natural Gas ER Subindex Using the Daily Flow of Funds Model

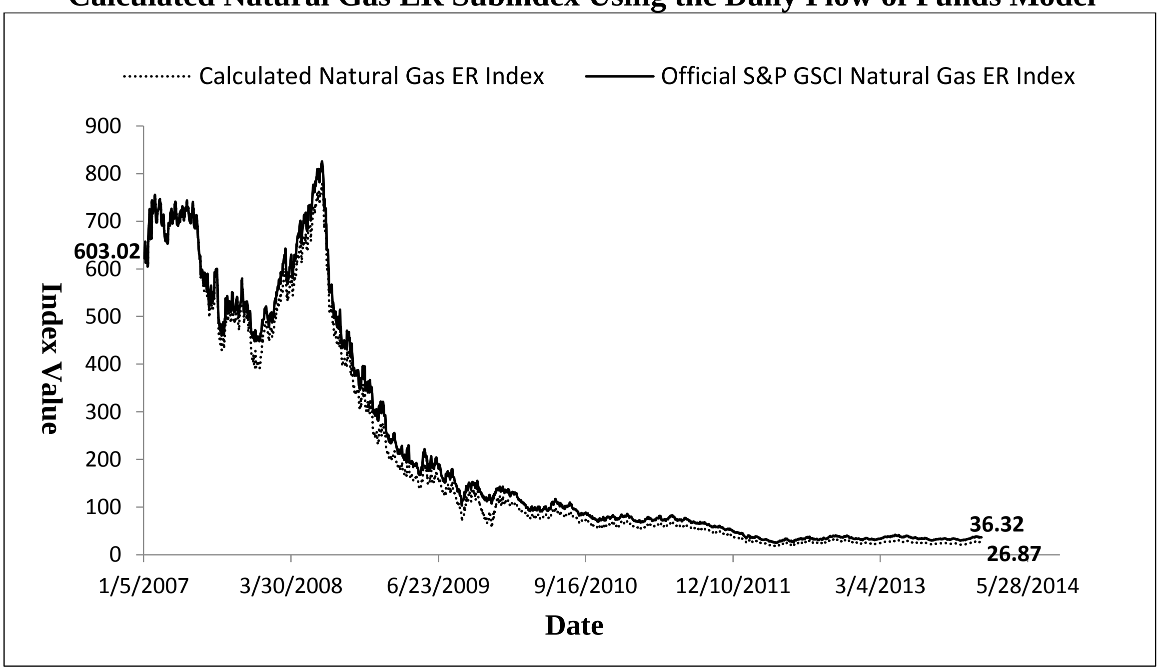


Figure 11
Official S&P GSCI Live Cattle ER Subindex vs.
Calculated Live Cattle ER Subindex Using the Daily Flow of Funds Model

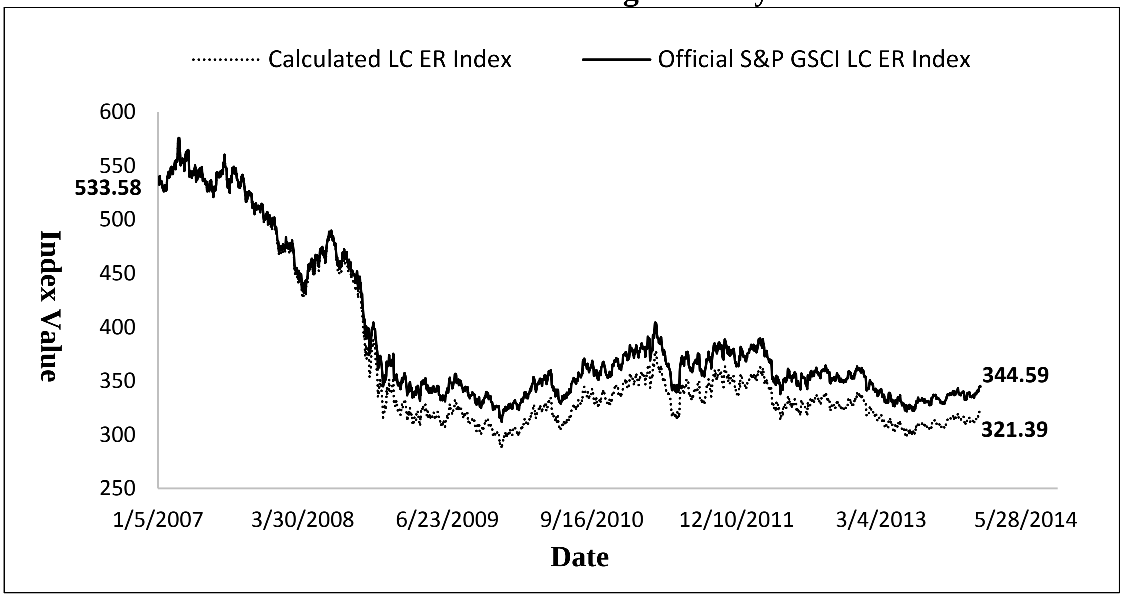


Figure 12
Illustration of How the Official S&P GSCI Corn ER Subindex
Over-Reports Losses to Investors

End of Day 1:

Step 1: Hold one March Contract at $8 without any leverage (before roll)

Fix Quantity Roll

Step 2: Hold one May Contract at $7 (after roll)

May Contract goes down
by $1 from day1 to day 2

End of Day 2:

Step 3: Hold one May Contract at $6

Actual Loss from Step 1 to Step 3 = $\$8 * (\frac{-1}{8}) = (\$-1)$

Starting Fund Balance — **Investor Fund Balance on Day 1**

the Official S&P GSCI Corn ER = $\$8 * (\frac{-1}{7}) = (-\$1.1429)$

Starting Fund Balance — **Index Total Dollar value on Day 1**