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# Do Roll Returns Really Exist? An Analysis of the S&P GSCI

by

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**Practitioner's Abstract:** *Roll returns for the S&P GSCI commodity index are analyzed using index calculation procedures for the S&P 500 stock market index. S&P GSCI daily index values are calculated and validated against the official index values for the five-year period January 2007-December 2011. Index values are then calculated using divisor adjustment methods for the S&P 500. Roll returns are found to be caused by the unique index calculation procedures used by the S&P GSCI during roll periods.*

**Key Words**: commodity index, divisor, normalizing constant, roll returns, S&P GSCI, S&P 500

## Introduction

Roll returns – the result of replacing a futures contract nearing expiration with a later-to-expire futures contract – have been a major selling point used by investment firms to potential customers for commodity index products; see Barclays Bank PLC (2012), BlackRock (2013), Carl (2012), Blanch and Schels (2006), Shemilt and Unsal (2004) and Stockton (2007) for representative examples. Of the various commodity indexes, the S&P GSCI is the most widely used index of global commodity futures prices (Standard & Poor's 2012b). According to Standard & Poor's (2012c), $80 billion of commodity-linked investments are currently benchmarked to the S&P GSCI.

There is a substantial body of work dealing with the economic theory underlying roll returns, and Sanders and Irwin (2011) review five decades of research on this subject. One unanswered question is how it is possible for long-only commodity indexes to generate positive returns, when long positions on the individual futures markets underlying these indexes have zero returns on average. Erb and Harvey (2006) explain this discrepancy by suggesting the existence of a diversification return that occurs with portfolios of commodities, in what they call "turning water into wine." Gorton and Rouwenhorst (2005) suggest that index rebalancing serves as an embedded trading strategy that contributes to the positive returns.

To date, no studies have explored in detail the impact of the commodity index calculation process on index returns, particularly during roll periods. Likewise, there appear to be no studies that independently calculate daily index values to directly observe commodity index behavior. This paper investigates the rolling process used by the S&P GSCI. Specifically, the index calculation procedure is first replicated using daily prices for each of the 24 component commodities in the S&P GSCI, and daily index values are calculated and validated against the official index values from January 2007 through December 2011. This time span covers 60 roll periods and includes periods of both rising and falling commodity prices, as well as periods of both contango (an upward-sloping forward price curve) and backwardation (a downward-sloping forward price curve). Then the S&P GSCI is recalculated using divisor adjustment procedures employed by the S&P 500 stock market index. Finally, S&P GSCI roll returns are calculated using two different methods. It is shown that roll returns are the direct result of the index calculation procedures used by the S&P GSCI during roll periods.

## Overview of the S&P GSCI[1]

The S&P GSCI – originally called the Goldman Sachs Commodity Index before it was acquired by Standard & Poor's[2] and re-branded in February 2007 – was developed by Goldman Sachs in the late 1980s, and was modeled after the S&P 500 index for common stocks. While the S&P 500 is capitalization-weighted (i.e., price per share times number of shares outstanding), the S&P GSCI is world-production weighted (i.e., futures price times five-year average of world production values), with production expressed in terms of futures contract equivalents or "contract production weights." The S&P GSCI currently contains 24 commodities. While the list of individual commodities is unchanged since 2006, the quantities (i.e., contract production weights) of the individual commodities are adjusted annually on the fourth business day of January.

The S&P GSCI uses futures prices for non-spot contract months, generally the second listed contract month but occasionally the third or fourth contract month for certain commodities. In addition, not all contract months are used for certain commodities due to differences in liquidity levels. The list of eligible contract months used for each commodity is determined in advance and published at the beginning of each year. As a particular futures contract approaches delivery or expiration, the long position in that commodity is rolled into the next eligible contract month over a five-business-day period, with 20% of the contract production weight of the commodity moved from the outgoing or "old" contract month to the incoming or "new" month each business day, using the respective daily settlement prices for those futures contracts. Not every commodity rolls every calendar month, due to differences in the number of contract months listed and liquidity levels. Of the 24 commodities currently in the S&P GSCI, 11 roll every calendar month and 13 roll intermittently.

The S&P GSCI on day *d* is calculated as:

$$S\&P\ GSCI_d = \frac{\sum_i \left(CPW_{i,y} \times P_{i,d}\right)}{NC_y} \qquad (1)$$

where $CPW_{i,y}$ = contract production weight for commodity *i* for year *y*, $P_{i,d}$ = daily futures settlement price for commodity *i* on day *d*, and $NC_y$ = normalizing constant (divisor) for year *y*.

The normalizing constant serves as the index divisor, and is intended to maintain continuity and allow comparisons of index values from different time periods. When the index was first developed, a normalizing constant value was selected to produce an S&P GSCI value of 100 on January 2, 1970. Thereafter, the normalizing constant is revised once each year to reflect changes in contract production weights using:

$$NC_y = NC_{y-1} \times \frac{\sum_i (CPW_{i,y} \times P_{i,d})}{\sum_i (CPW_{i,y-1} \times P_{i,d})} \qquad (2)$$

where $NC_{y-1}$ = normalizing constant for previous year *y-1*, $CPW_{i,y}$ = contract production weight for commodity $i$ for current year *y*, $CPW_{i,y-1}$ = contract production weight for commodity $i$ for previous year y-1, and $P_i$ = daily futures settlement price for commodity $i$ on day *d*.

A new normalizing constant is introduced once each year, beginning on the fifth business day of January. The new normalizing constant replaces the old normalizing constant in 20% increments each day of the five-day January roll period.

**Overview of the S&P 500[3]**

The S&P 500 index consists of 500 common stocks representing the leading companies in the largest industries of the US economy. First published in 1957, it represents approximately 75% of the value of the US equities market, and is widely considered the best single gauge of the large-capitalization segment. According to Standard & Poor's, over $4.8 trillion of investments are benchmarked to the S&P 500 (Standard & Poor's 2011).

The S&P 500 on day *d* is calculated as:

$$S\&P\ 500_d = \frac{\sum_i \left(Q_{i,d} \times P_{i,d}\right)}{Divisor_d} \qquad (3)$$

where $Q_{i,d}$ = number of shares outstanding for company $i$ on day *d* and $P_{i,d}$ = price per share for company $i$ on day *d*.

Notice that $Q_{i,d}$ and $P_{i,d}$ in Equation 3 for the S&P 500 are comparable to $CPW_{i,y}$ and $P_{i,d}$ respectively in Equation 1 for the S&P GSCI. The divisor provides continuity and allows comparisons of index values from different time periods. When the index was first developed, a divisor value was selected to produce an S&P 500 value of 10 (ten) for the period 1941-1943. Thereafter, the divisor is revised each time there is a change in the index composition due to events such as the replacement of one company with another or a change in the number of shares following a stock split using:

$$Divisor_d = Divisor_{d-1} \times \frac{\sum_i (Q_{i,d} \times P_{i,d})}{\sum_i (Q_{i,d-1} \times P_{i,d})} \qquad (4)$$

where $Divisor_{d-1}$ = divisor for previous day *d-1*, $Q_{i,d}$ = number of shares outstanding for company *i* for current day *d*, $Q_{i,d-1}$ = number of shares outstanding for company $i$ for previous day *d-1*, and $P_{i,d}$ = price per share for company $i$ on day *d*.

Notice that $Q_{i,d}$, $Q_{i,d-1}$, and $P_{i,d}$ in Equation 4 for the S&P 500 are comparable to $CPW_{i,y}$, $CWP_{i,y-1}$, and $P_{i,d}$ , respectively in Equation 2 for the S&P GSCI.

**The Divisor, the Normalizing Constant and Roll Returns**

Despite the use of similar formulas for the divisor and normalizing constant, in practice the operation of the divisor in the S&P 500 is far different from that of the normalizing constant in the S&P GSCI. Each time there is a company substitution, stock split or other change to the composition of the S&P 500, there is an immediate revision to the divisor. In contrast, changes to the composition of the S&P GSCI result in a revision to the normalizing constant only once a year. In other words, unlike the S&P 500 divisor, the S&P GSCI normalizing constant is never adjusted for composition changes that include the monthly rolling of futures contracts, where the quantity (contract production weight) remains the same but the prices for the old and new futures contracts are almost always different.

Standard & Poor's (2012a) explains the connection between divisor adjustments and index stability as follows:

> **The Index Divisor**
>
> Throughout all the calculations there is one concept that is crucially important to understanding how indices are calculated – the index divisor…
>
> An index is not exactly the same as a portfolio. For instance, **when a stock is added to or deleted from an index, the index level should not jump up or drop down; while a portfolio's value would usually change as stocks are swapped in and out. To assure that the index's value, or level, does not change when stocks are added or deleted, the divisor is adjusted to offset the change in market value of the index.** Thus, the divisor plays a critical role in the index's ability to provide a continuous measure of market valuation when faced with changes to the stocks included in the index. In a similar manner, some corporate actions that cause changes in the market value of the stocks in an index should not be reflected in the index level. Adjustments are made to the divisor to eliminate the impact of these corporate actions. (p.5; emphasis added)

This principle can be extended to futures contracts. Paraphrasing from above, if we replace "stock" with "futures contract" in the explanation above, then "when a [futures contract] is added to or deleted from an index (i.e., rolled), the index should not artificially jump up or drop down (i.e., exhibit roll return)… To assure that the index's value, or level, does not change when [futures contracts] are added or deleted, the divisor is adjusted to offset the change in the market value of the index." Therefore, in the presence of a properly-adjusted divisor, roll return should not exist. Standard & Poor's (2012a) confirms this point in a later section:

> **Divisor Adjustments**
>
> The key to index maintenance is the adjustment of the divisor. Index maintenance – reflecting changes in shares outstanding, capital actions, **addition or deletion of stocks to the index – should not change the level of the index. If the S&P 500 closes at 1250 and one stock is replaced by another after the market close, the index should open at 1250 the next morning if all of the opening prices are the same as the previous day's closing prices.** This is accomplished with an adjustment to the divisor. (p.7; emphasis added)

If the "addition or deletion [of futures contracts] to the index should not change the level of the index," then it follows that roll return indicates the failure to properly adjust the normalizing constant to account for the differing prices of old and new futures contracts for the same commodity.

No such adjustments for differing prices are made to the S&P GSCI normalizing constant for futures contract substitutions during any of the 11 non-January roll periods. Instead, the S&P GSCI effectively treats old and new futures contracts for the same commodity as perfect substitutes with identical prices. For the January roll period only, prices for both old and new futures contracts are used to adjust the normalizing constant, but only on the first day of the five-day roll period; the remaining four days of the January roll period all use the same prices as the first day of the January roll period. As a result, adjustments to the normalizing constant are applied inconsistently across monthly roll periods (January versus all others) and within the January roll period (Day 1 versus Days 2-5).

**Measurement of Roll Returns**

To evaluate the effects of the normalizing constant practices described above, the S&P GSCI was replicated and index values were calculated for each day beginning January 2, 2007 (i.e., the first business day of 2007) and ending December 30, 2011 (i.e., the last business day of 2011). This five-year period was selected because it contains periods of both rapidly rising and rapidly falling commodity prices as well as an extended period of stable to moderately increasing prices, providing a wide range of market conditions for observing roll returns.

Normalizing constant and contract production weight values were obtained from the S&P GSCI Index Methodology publications for 2007-2011. Daily S&P GSCI values were provided by Standard & Poor's, daily prices for the five London Metals Exchange contracts were purchased from Thomson Reuters, and daily prices for the remaining 19 commodities were downloaded from Barchart.com. Excel spreadsheets were constructed to calculate a total of 1,261 daily S&P GSCI values, and these calculated values were validated against the official values from Standard & Poor's.

Next, normalizing constant values were adjusted during each of the 300 roll days in this five-year period, using the same methodology employed by the S&P 500 stock index to adjust the divisor when there is a change to one or more of the underlying index components. For the 11 non-January roll periods each year, Equation 2 was used with the modifications noted above; for January roll periods only, when new contract production weights are being phased in and old contract production weights are being phased out, Equation 2 was further modified so that the products of the contract production weights and corresponding prices were weighted by the appropriate daily roll weights (e.g., 80% old and 20% new, etc.) Index values were then calculated using these adjusted normalizing constant values, which we will refer to as the "NC-adjusted GSCI."

The difference between each day's official and NC-adjusted values represents the roll return plus any other index distortions caused by improper adjustment of the normalizing constant, which we will refer to as "gross roll return."

In addition, what we will refer to as "net roll return" – the roll return during roll days only – were calculated for each of the 300 roll days using:

$$Roll\ Return_d = \frac{\sum_i [0.2 \times CPW_{i,y} \times (P_{i,d} - P_{i,d-1})]}{NC_d} \qquad (5)$$

where $CPW_{i,y} =$ contract production weight for commodity $i$ in year *y*, $P_{i,d}$ = daily settlement price for commodity $i$ on current day $d$, $P_{i,d-1}$ = daily settlement price for commodity $i$ on previous day *d-1*, and *NC* = normalizing constant on day *d*.

Contract production weights are multiplied by 0.2 because only 20% of the contracts are rolled on any single day of the monthly roll period. For January roll periods only, when new contract production weights are being phased in and old contract production weights are being phased out, Equation 5 was modified by incorporating the appropriate daily roll weights (e.g., 80% old and 20% new, etc.). Roll returns were calculated only during roll periods because no roll returns are generated during non-roll periods.

**Results**

Figure 1 shows the official S&P GSCI and NC-adjusted GSCI values from January 5, 2007 (the fourth business day of 2007, and the first day of the January 2007 roll period) through December 30, 2011 (the last business day of 2011). Both indexes started with the official S&P GSCI value of 406.3545 for January 5, 2007. From this common point, the two indexes diverge with the official index values consistently higher than the corresponding NC-adjusted index values, suggesting that official S&P GSCI calculation methods may cause the index values to overstate actual returns.

Figure 2 shows the gross roll return, which is the difference between the official and NC-adjusted values. This figure uses the same scaling and is equivalent to the gap between the two lines shown in Figure 1. As explained above, the difference between each day's official and NC-adjusted values represents the roll return plus any other index distortions caused by improper adjustment of the normalizing constant. The steady upward trend over time reflects cumulative effects embedded in both the official and corrected versions of the S&P GSCI. These cumulative effects can be seen in Equation 2, for example, which causes past values to be reflected in current values.

Figure 2 also shows the cumulative net roll return which was calculated using Equation 5. Notice that the gross and net roll returns exhibit similar direction and magnitude. Differences occur because the gross values also capture any other distortions, both positive and negative, that may occur as the result of an improperly adjusted divisor. These distortions can occur on non-roll days as well as roll days, since divisor adjustments (and maladjustments) affect the index calculation every day. In contrast, net roll returns are calculated only on roll days.

Figure 3 shows the daily gross roll return values and daily net roll return values; recall that net roll returns were calculated only on roll days so the series is discontinuous. Individual values tend to be small and random, and increase gradually over time. Surprisingly, backwardation – often associated with the steep increase in commodity prices from early 2007 to mid-2008 – and contango – often associated with the steep decrease in commodity prices between mid-2008 and early 2009 – appear to have little effect on either gross or net daily roll returns.

## Summary and Conclusions

The title of this paper asks the question, “Do roll returns really exist?” Based on the results for the S&P GSCI presented here, the answer appears to be “Yes, but only because of distortions caused by the index divisor.” If the normalizing constant for the S&P GSCI operated in the same manner as the divisor for the S&P 500, there would be no roll return, so roll returns “exist” only in an artificial sense.

A search of the finance literature produced no studies of roll returns in connection with stock index behavior. Since stock indexes are far bigger in dollar terms, far more numerous and have existed far longer than commodity indexes, the lack of roll return research on stock indexes suggests that roll return is due to something unique to commodity indexes. As demonstrated in this paper, that “something” is the manner in which the normalizing constant (index divisor) is adjusted when futures contracts are substituted.

Our analysis also illustrates how commodity indexes can have positive returns when the individual futures contracts in the index have zero returns on average. For the S&P GSCI, positive index returns are not the result of a divine miracle as suggested by Erb and Harvey, but instead can be explained by the index calculation procedures used during roll periods. Further research is needed to determine whether the shortcomings identified in the S&P GSCI normalizing constant also exist in the divisors of other commodity indexes.

## References


Barclays Bank PLC. *iPath Commodity ETNs*, September 2012. Downloaded from http://www.ipathetn.com/static/pdf/ipath-commodity-etns.pdf

BlackRock. *Accessing Commodities: iShares S&P GSCI Commodity Indexed Trust*, March 2013. Downloaded from http://us.ishares.com/content/stream.jsp?url=/content/en_us/repository/resource/accessing_commodities.pdf

Blanch, F. and S. Schels. *Selecting a Commodity Index.* Merrill Lynch Commodities, September 2006. Downloaded from http://gmi.ml.com/pdf/MLCXResearch.pdf

Carl, P. *Roll Yield in Commodities.* William Blair & Company, June 2012. Downloaded from http://www.paychex.com/a/d/white-papers/advisors/Roll-Yield-in-Commodities.pdf

Erb, C.B. and C. Harvey. "The Strategic and Tactical Value of Commodity Futures." *Financial Analysts Journal* 62(2006):69-97.

Gorton, G. and K.G. Rouwenhorst. "A Note on Erb and Harvey (2005)." *Yale ICF Working Paper No. 06-02*, May 2005.

Sanders, D.R. and S.H. Irwin. "'Investing' in Commodity Futures Markets: Are the Lambs Being Led to Slaughter?" *Proceedings of the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management*, 2011.

Schemilt, H. and S. Unsal. *The Case for Commodities as an Asset Class.* Goldman, Sachs & Company, June 2004. Downloaded from https://faculty.fuqua.duke.edu/~charvey/Teaching/BA453_2006/GSCI_Strategic_June_2004.ppt

Standard & Poor's. *S&P US Equity Indices: A Directory*, 2011. Downloaded from http://www.standardandpoors.com/servlet/BlobServer?blobheadername3=MDT-Type&blobcol=urldata&blobtable=MungoBlobs&blobheadervalue2=inline%3B+filename%3DFS_SP_US_Equity_Indices_Directory_LTR.pdf&blobheadername2=Content-Disposition&blobheadervalue1=application%2Fpdf&blobkey=id&blobheadername1=content-type&blobwhere=1244018000478&blobheadervalue3=UTF-8

Standard & Poor's. *Index Mathematics Methodology*, January 2012a. Downloaded from https://www.sp-indexdata.com/idpfiles/emdb/prc/active/methodology/methodology-index-math.pdf

Standard & Poor's. *S&P GSCI Index Methodology*, January 2012b. Downloaded from http://www.spindices.com/documents/methodologies/methodology-sp-gsci.pdf

Standard & Poor's. "S&P Indices Estimates Assets Tracking the S&P GSCI Family." S&P Indices Index Announcement, May 21, 2012c. Downloaded from http://www.spindices.com/documents/index-news-and-announcements/20120521-gsci-assets-estimate.pdf

Standard & Poor's. *S&P US Indices Methodology*, June 2012d. Downloaded from https://www.sp-indexdata.com/idpfiles/indexalert/prc/active/whitepapers/Methodology_SP_US_Indices_Web.pdf

Stockton, K.A. *Understanding Alternative Investments: The Role of Commodities in a Portfolio*. Vanguard Investment Counseling & Research, 2007. Downloaded from https://institutional.vanguard.com/iam/pdf/commodities_WP.pdf

**Figure 1. Comparison of Official S&P GSCI and NC-Adjusted GSCI Index Values**

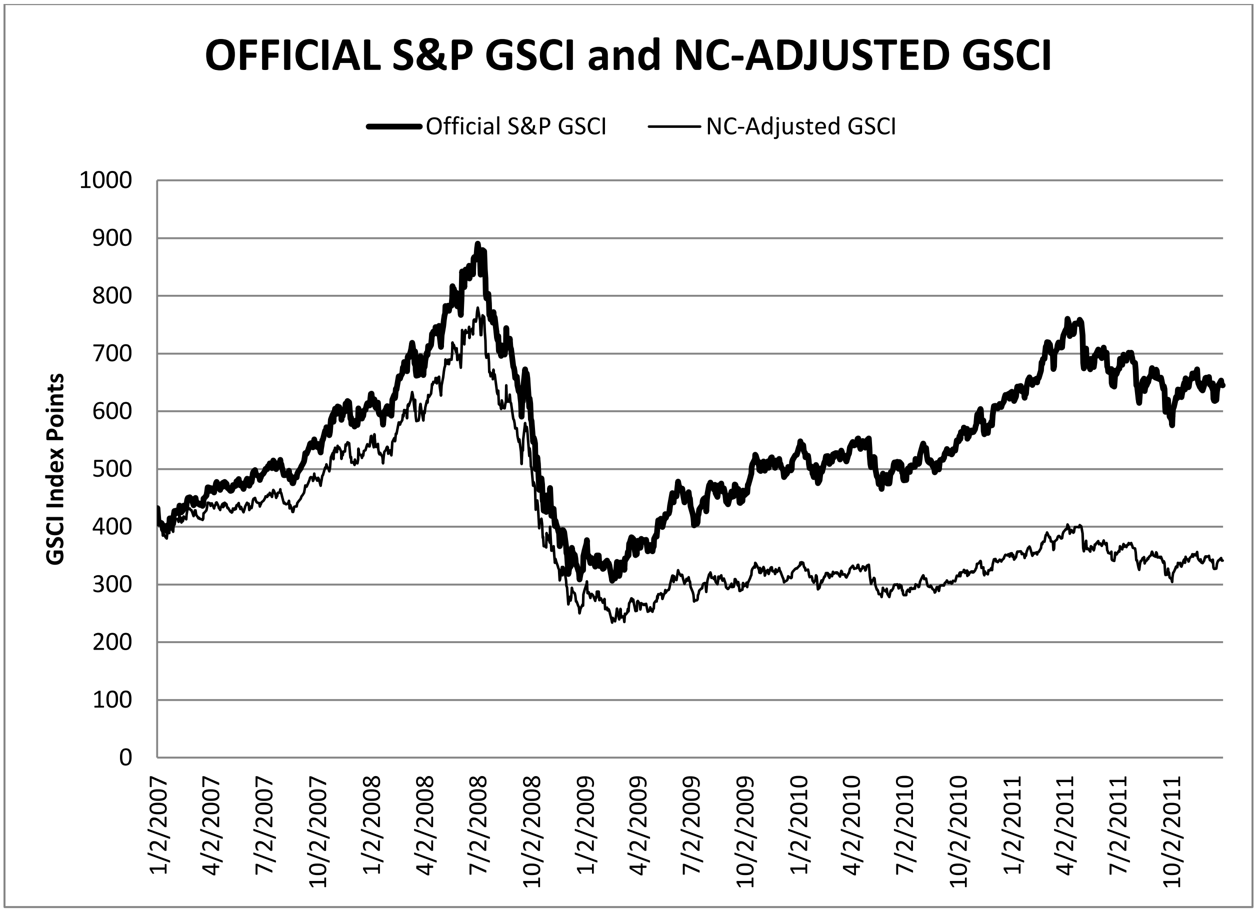


**Figure 2. Comparison of Gross and Net Cumulative Roll Returns**

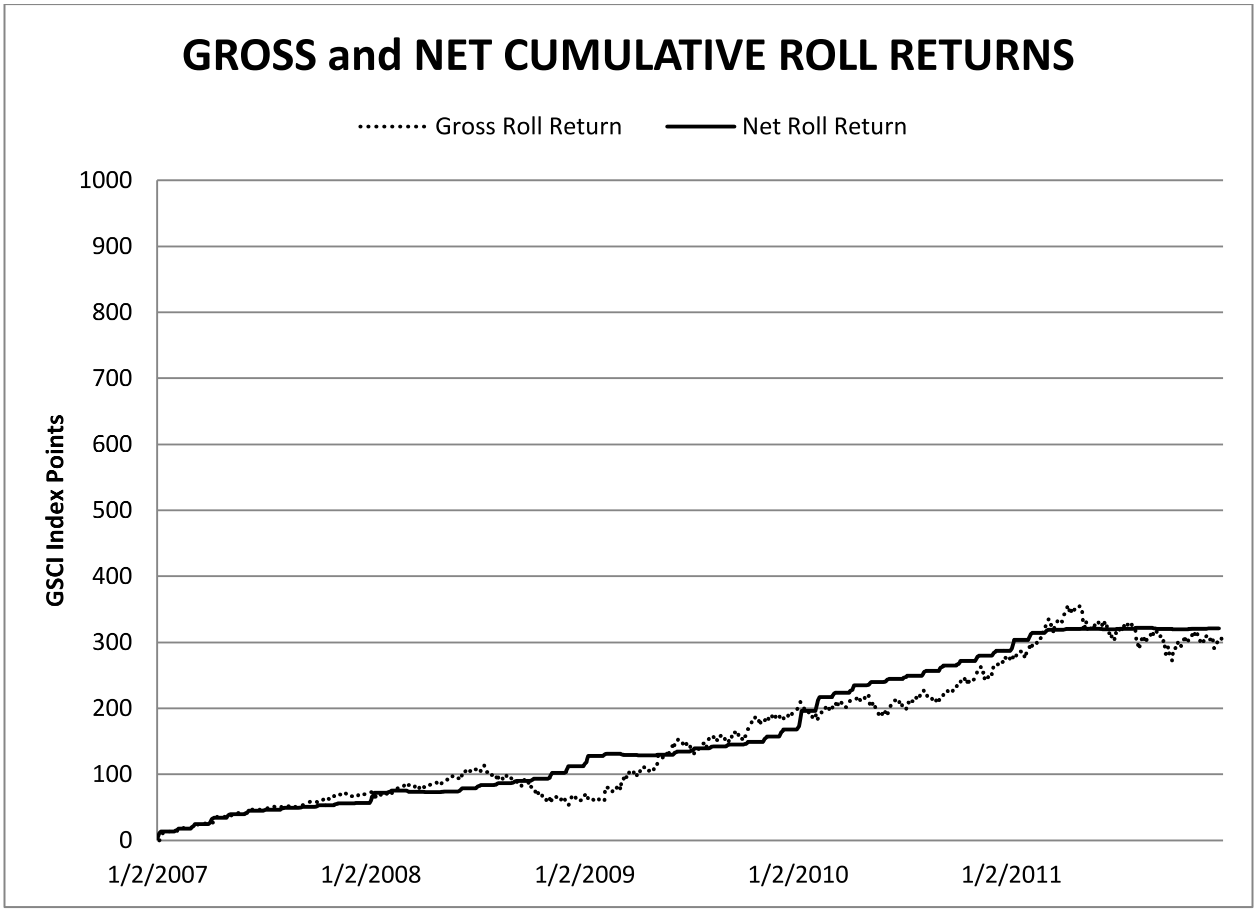
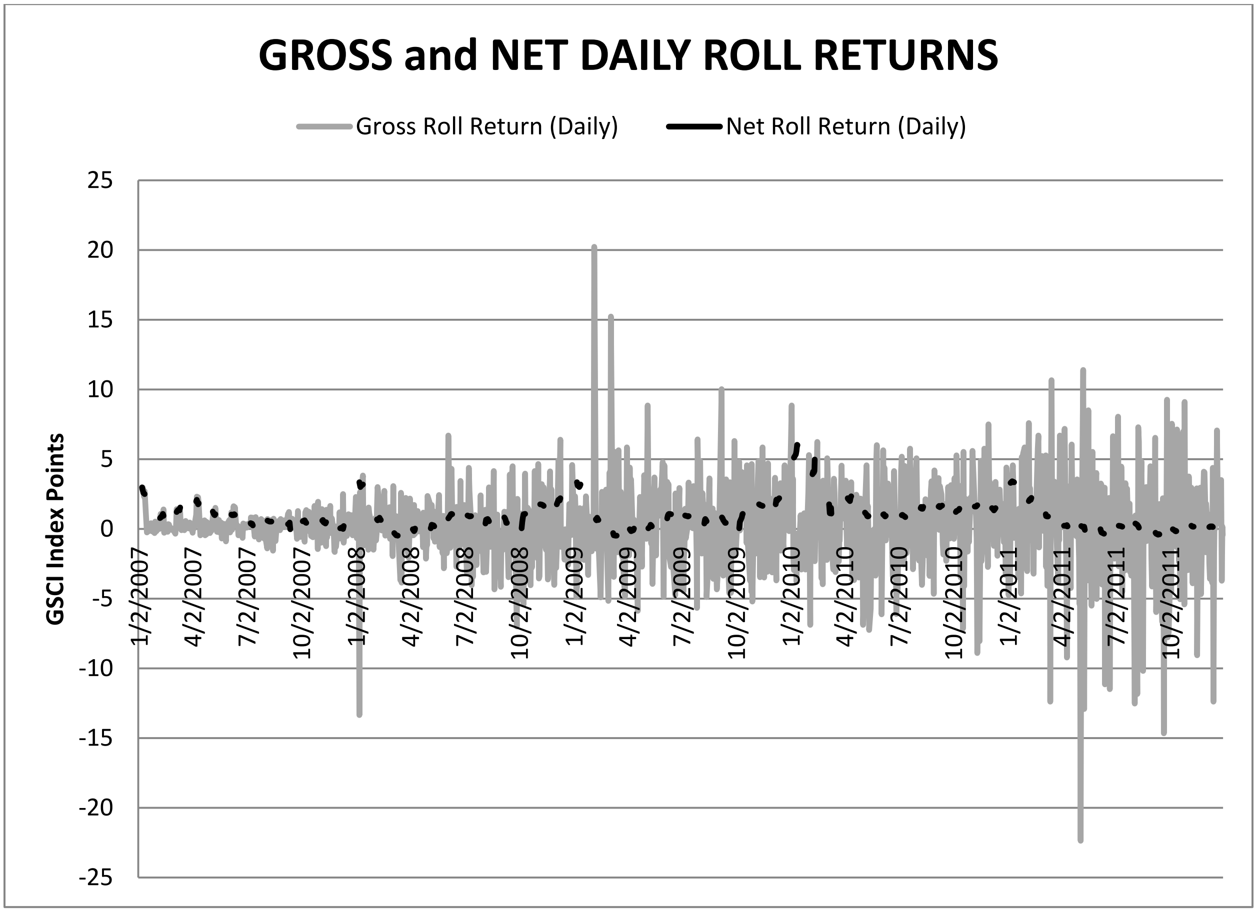


**Figure 3. Comparison of Gross and Net Daily Roll Returns**



**Endnotes**

[1] Complete details on the calculation of the S&P GSCI can be found in Standard & Poor's, *S&P GSCI Index Methodology*.

[2] Standard & Poor's has made no substantive structural changes to the S&P GSCI since acquiring the index from Goldman Sachs in February 2007.

[3] Complete details on the calculation of the S&P 500 can be found in Standard & Poor's, *S&P US Indices Methodology*.