January 6, 2006

The Tactical and Strategic Value of Commodity Futures

(Unabridged Version)

Claude B. Erb
Trust Company of the West,
Los Angeles, CA 90017 USA

Campbell R. Harvey
Duke University,
Durham, NC 27708 USA
National Bureau of Economic Research,
Cambridge, MA 02138 USA

ABSTRACT

Investors face a number of challenges when seeking to estimate the prospective performance of a long-only investment in commodity futures. For instance, historically, the average annualized excess return of individual commodity futures has been approximately zero and commodity futures returns have been largely uncorrelated with one another. However, the prospective annualized excess return of a rebalanced portfolio of commodity futures can be "equity-like". Certain security characteristics, such as the term structure of futures prices, and some portfolio strategies have historically been rewarded with above average returns. Avoiding naïve extrapolation of historical returns and striking a balance between dependable sources of return and possible sources of return is important. This is the unabridged version of our 2006 publication in the Financial Analysts Journal.

Keywords: Strategic asset allocation; Tactical asset allocation; Diversification return; Portfolio rebalancing; Roll return; Momentum; Market timing; Convenience yield; Contango; Backwardation; Normal backwardation; Storability; Commodity correlation; Commodity risk factors; Commodity term structure; Commodity trading strategies.

JEL Classification: G11, G12, G13, E44, Q11, Q41, Q14.

We benefited from conversations with Gary Gorton, Geert Rouwenhorst, Tadas Viskanta, Hilary Till and Lisa Plaxco, participants at the 2005 Q-group meeting in Key Largo, the 2005 SQA meeting in New York City, as well as the detailed suggestions of three anonymous referees. We appreciate the research assistance of Jie Yang and Paul Borochin. E-mail Cam.Harvey@duke.edu or Claude.Erb@tcw.com.

1. Introduction

Previous research suggests that long-only portfolios of commodity futures have had average returns similar to the Standard and Poor's 500 stock index. Examples include Bodie and Rosansky's (1980) analysis of an equally-weighted paper portfolio of commodity futures from 1949 to 1976 and Gorton and Rouwenhorst's (2005) study of an equally-weighted paper portfolio of commodity futures from 1959 to 2004. Both studies find equity-like average returns. Figure 1 reinforces the possibility that an index of commodity futures might have equity-like returns. Since 1969, the 12.2% compound annualized return of the Goldman Sachs Commodity Index (GSCI) compares favorably with an 11.2% return for the Standard and Poor's 500. In contrast to the two paper portfolios, the GSCI is a widely used index of commodity futures performance. Given this evidence, should investors have the same long-term return expectations for portfolios of commodity futures as they might have for equities?

It is often dangerous for investors to extrapolate past performance into the future. Arnott and Bernstein (2002) point out that the past high excess returns for U.S. equities do not prove that the forward looking equity risk premium is high. They argue that forward-looking returns should be based on an understanding of the fundamental drivers of equity returns such as earnings growth, dividend yields and changes in valuation levels. Past returns will only be a guide to the future if the future return drivers are the same as in the past. Dimson, Marsh and Staunton (2004) present a similar cautionary argument for global equities and suggest reasons that future equity returns in many countries might be lower than those observed in the past.

A common message of these analyses seems to be that historical returns are an incomplete guide to investment prospects. The challenge for investors contemplating a long-only[i] investment in commodity futures is to develop a framework for thinking about prospective returns. This requires an examination of the historical returns of individual commodity futures and portfolios of commodity futures. It also requires an analysis of the drivers of these returns, if there are any.

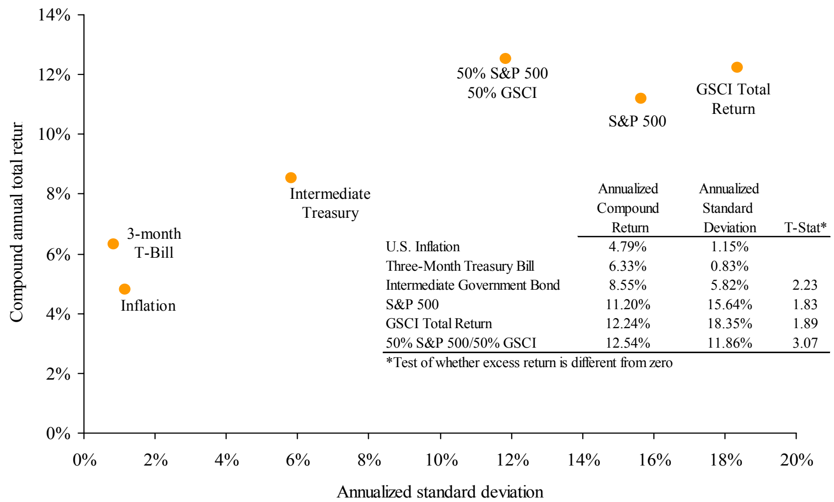
There are a few key results that follow from this research. The average compound, geometric, excess return of the average commodity futures has, historically, been close to zero. This raises an important question for investors considering a long-only investment in commodity futures: how can a commodity futures portfolio have "equity-like" returns when the average returns of the portfolio's constituents have been close to zero? It turns out that portfolios of commodity futures that periodically rebalance might have "equity-like" excess returns. This potential rebalancing return is attributable to portfolio diversification, not to seemingly fundamental influences such as the rate of inflation, economic growth or risk premia. This rebalancing or diversification return is very reliable.

It is also possible that portfolios of commodity futures that overweight those commodity futures with relatively high returns might have “equity-like” excess returns. Of course, finding securities with above average returns has never been an easy task. In the search for above average returns, investors might turn to characteristics that in the past have been associated with above average returns. One such characteristic is the term structure of futures prices which has historically been highly correlated with the cross-sectional dispersion of returns amongst individual commodity futures. That is, commodity futures with more attractive term structure characteristics have had higher returns than commodity futures with less attractive term structure characteristics. With the benefit of hindsight, the term structure of commodity futures prices allows investors to identify commodity futures that performed well in the past. However, the risk for an investor is that if the historical pay-off from investing in commodity futures with above average term structure characteristics is an example of a feature of the data which might disappear in the future. As an example of a disappearing inefficiency, Cochrane (1999) points out that, subsequent to the publication of research popularizing the “small firm effect”, the historically demonstrated return from investing in “small cap stocks” declined sharply.

Momentum is another characteristic that an investor might pursue in the search for above average returns. Historically, there has been a pay-off from investing in commodity futures with past relatively high returns. Given that historically observed returns from investing in certain characteristics might not persist in the future, it is difficult to judge the dependability characteristics-based investing.

Finally, a diversified portfolio of commodity futures seems to be an excellent diversifier of a traditional stock and bond portfolio, as well as a questionable hedge of inflation and pension liabilities.

Figure 1
Return and Risk
December 1969 to May 2004



	Annualized Compound Return	Annualized Standard Deviation	T-Stat*
U.S. Inflation	4.79%	1.15%	
Three-Month Treasury Bill	6.33%	0.83%	
Intermediate Government Bond	8.55%	5.82%	2.23
S&P 500	11.20%	15.64%	1.83
GSCI Total Return	12.24%	18.35%	1.89
50% S&P 500/50% GSCI	12.54%	11.86%	3.07

*Test of whether excess return is different from zero

Note: GSCI inception date is December 1969. During this time period, the S&P 500 and the GSCI had a monthly return correlation of -0.03.
This low correlation drives the lower standard deviationfor a rebalanced portfolio.
The standard deviation is: $(0.52x0.15642 + 0.52x0.18352 + 2x0.5x0.5x0.1564x0.1835)^{1/2}$ which equals 0.118.

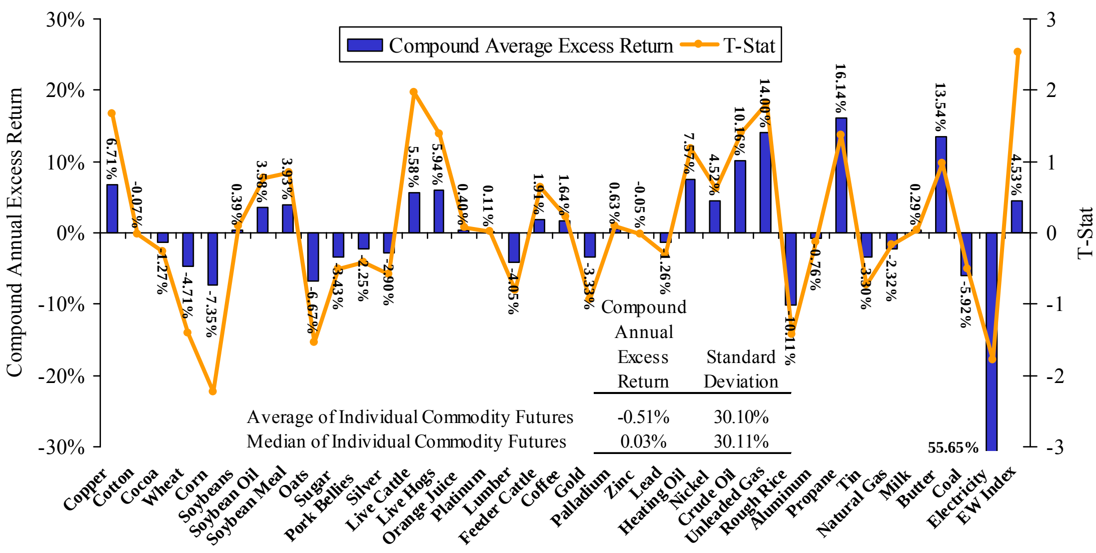
2. Historical Returns

2.1 Individual commodity futures returns

Historically, the average and median compound annual excess return of individual commodity futures has been close to zero. Focusing on the annualized, geometric, excess return is consistent with the approach both Ibbotson and Peng (2003) and Dimson, Marsh and Staunton (2002) use to measure the historical equity risk premium. Excess return is simply a security's total return in excess of the risk free rate of return. Figure 2 shows that of the 36 individual commodity futures that Gorton and Rouwenhorst (2005) studied, 18 had geometric excess returns that were greater than zero and 18 had geometric excess returns that were less than zero. Propane's excess return of 16.14% was the highest of any commodity future in the sample, and electricity's excess return of -55.65% was the lowest in the sample. The equally weighted average of the 36 individual compound excess returns was -0.51% and the average t-statistic of the 36 commodity futures mean returns was 0.04. The median geometric excess return of the 36 commodity futures was 0.03%. The average annual standard deviation of the 36 commodity futures was 30%. Bottom line, the average return of the average commodity futures was not statistically different from zero. Alternatively, the average commodity futures had an average geometric "risk premium" of zero.

The returns in Figure 2 cover different time periods and is drawn from the Gorton and Rowenhorst (2005) appendix. For instance, there are 546 monthly (45.5 annual) returns for corn and only 20 monthly (1.7 annual) returns for electricity. Looking at commodity futures returns over a comparable time period, later in the paper, echoes the previous observation: the average geometric excess return of the average commodity futures has been close to zero. Interestingly, though, the return of an equally weighted, and monthly rebalanced, portfolio of commodity futures in Figure 2 had a statistically significant return of about 4.5%. This raises an important question for investors considering a long-only investment in commodity futures: how can a portfolio have "equity-like" returns when the average and median return of the portfolio's constituents is zero?

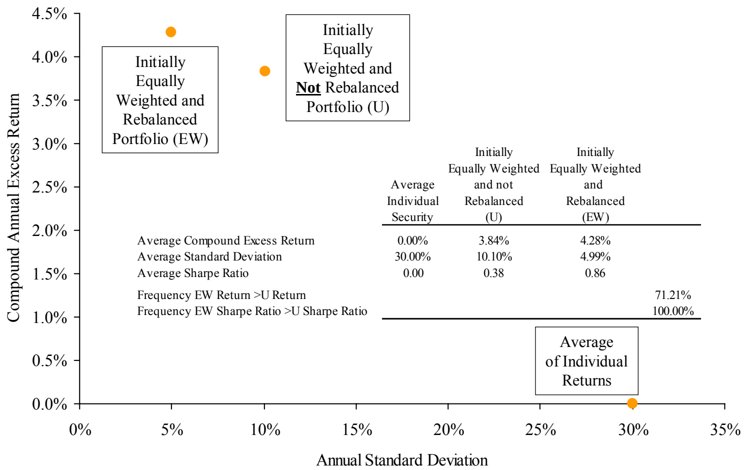
Figure 2
Compound Average Annual Excess Return Individual Commodity Futures



The geometric return of a portfolio can significantly exceed the weighted average geometric return of its constituents if the securities in a portfolio have low correlations with one another and the securities have high average standard deviations. For investors used to investing in bond and stock portfolios, this may or may not seem obvious. When investing in a bond portfolio, such as the Lehman Aggregate, it is reasonable to believe that the return of a bond portfolio should be close to the weighted average return of the portfolio's constituents. For instance, if an unrebalanced bond portfolio consisted of two bonds, each of which had a return of zero, it is unlikely that the portfolio would have a positive rate of return. This intuition can also hold for an equity portfolio. Siegel (2005) presents data indicating that the weighted average geometric return of the original constituents of the S&P 500 was about 11.0% over the period March 1957 to December 2003, similar to the performance of the S&P 500 and what Siegel calls the "total descendants" portfolio. However, this intuition does not seem to hold when examining the returns of rebalanced portfolios of commodity futures.

Figure 3 shows the results of a simple "turning water into wine" experiment. Start with 40 uncorrelated securities, each with an average geometric excess return of 0.0% and a geometric standard deviation of 30%. In other words each of these hypothetical securities has return and risk similar to average return and risk of the commodity futures in Figure 2. Another way of looking at this is that each of these securities has a geometric "risk premium" of zero (this is also equivalent to assuming an approximately 4.6% annual arithmetic excess return). Then create 10,000 45 year return histories for each of the 40 securities, as well as an equally weighted-annually rebalanced portfolio and an initially equally weighted portfolio that does not rebalance. Not surprisingly, on average the individual securities have average geometric excess returns of 0.0%. However, the equally weighted, rebalanced portfolio has an average geometric return of 4.3%. An initially equally weighted portfolio that does not rebalance had an average geometric return of 3.8%. The equally weighted rebalanced portfolio outperformed the unrebalanced portfolio in 71% of the 10,000 simulations and had a higher Sharpe ratio 100% of the time. This last observation is consistent with the findings of Plaxco and Arnott (2002) that the Sharpe ratios of rebalanced portfolios tend to be higher than the Sharpe ratios of unrebalanced portfolios. When the return of a portfolio is greater than the average return of a portfolio's constituents, and the portfolio constituents have average geometric risk premia of zero, then a portfolio weighting decision, not a geometric risk premium, is the source of incremental return.

Figure 3
Compound Average Annual Excess Return (Turning Water into Wine)
10,000 Simulations



	Average Individual Security	Initially Equally Weighted and not Rebalanced (U)	Initially Equally Weighted and Rebalanced (EW)	
Average Compound Excess Return	0.00%	3.84%	4.28%	
Average Standard Deviation	30.00%	10.10%	4.99%	
Average Sharpe Ratio	0.00	0.38	0.86	
Frequency EW Return >U Return				71.21%
Frequency EW Sharpe Ratio >U Sharpe Ratio				100.00%

2.2 Do equally weighted portfolios measure asset class returns?

A number of prominent studies of the returns from investing in portfolios of commodity futures have focused on the performance of equally-weighted portfolios. A reason suggested for looking at an equally-weighted commodity futures portfolio is that its performance is supposed to measure the return from investing in the average portfolio constituent. By extension, the return from the average portfolio constituent might be a guide to the average return of the aggregate commodity futures "market".

Bodie and Rosansky (1980) calculate the returns for an equally-weighted cash collateralized portfolio of commodity futures over the time period 1949 to 1976. Their equally-weighted portfolio starts with ten futures contracts and ends with 23 commodity futures contracts. They find that their portfolio has statistically significant excess returns that were similar in magnitude to those of the S&P 500. Fama and French (1987) calculate the performance of an equally weighted portfolio of up to 21 commodity futures, over the time period 1967 to 1984, and find only marginal evidence of statistically significant portfolio returns. Gorton and Rouwenhorst (2005) investigate the performance of an equally-weighted cash collateralized commodity futures portfolio over 1959 to 2004. Their portfolio initially consists of 9 commodity futures and ends up with 36. They find that their equally weighted portfolio of commodity futures had statistically significant returns similar to that of stocks. In each of these cases, an equally-weighted portfolio was used as the measure of commodity futures performance and the composition of the portfolios changed over time. How relevant are equally weighted portfolios for investors seeking to assess the attractiveness of an asset class?

It is unusual to infer the long-term performance of any asset class from the performance of an equally-weighted portfolio. For example, Arnott, Hsu and Moore (2005) point out that equally weighted equity portfolios lack the liquidity and capacity found in traditional market capitalization weighted equity market indices and, importantly, have return characteristics that are not representative of the aggregate equity market. An equally weighted portfolio requires the same investment in every portfolio security regardless of how large or small the investment opportunity happens to be. For instance, consider a market with just two securities, where one security has a value of 1 and the other security has a value of 100. The aggregate market value is 101, yet the equally weighted portfolio only has a value of 2. In the context of the equity market, unless the aggregate equity market is itself equally weighted, an equally-weighted equity portfolio will not be representative of the aggregate equity market. As a result, the return of an equally weighted portfolio might be higher or lower than the "market", but it is not the "market".

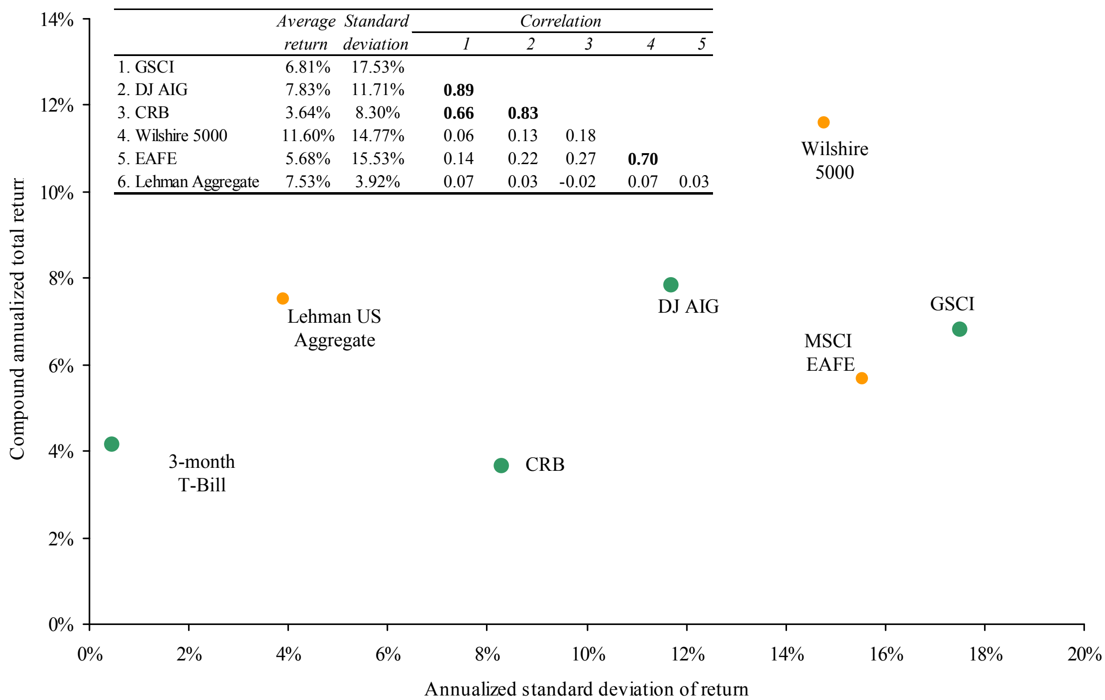
The difference in return between the market-capitalization weighted Wilshire 5000 stock index and the monthly rebalanced and equally weighted Wilshire 5000 provides a concrete example of the difficulty of inferring the return of an aggregate asset class from an equally-weighted portfolio. For instance, from December 1970 to May 2004, the market-capitalization weighted Wilshire 5000 stock index had a compound annualized return of 11.4% and the equally-weighted Wilshire 5000 had a return of 20.3%, a return difference of 8.8%. In this case, the return of an equally weighted equity portfolio was almost twice as high as the return of the aggregate stock market. However, most investors would not consider an equally-weighted equity portfolio 'representative' of the equity market because it is dominated by small-capitalization securities (small and micro cap securities represent about 12% of the market capitalization of, and about 72% of the number of securities in, the Wilshire 5000). If an equally weighted equity portfolio is not representative of the return of the equity "market", should an investor believe that an equally weighted commodity futures portfolio represents the return of the commodity futures "market"? Unless it is possible to answer this question in the affirmative, it is unclear that an equally weighted commodity futures portfolio should be used to measure the return of a 'commodity asset class' or that the returns of an equally weighted commodity portfolio can be used to make return comparisons with other asset classes such as the aggregate stock market or the aggregate bond market[ii].

2.3 Do commodity indices measure asset class returns?

Even if the message of equally weighted paper portfolios might be difficult to decipher, an examination of commodity futures indices might reveal some answers. The three most commonly used commodity futures indices are the Goldman Sachs Commodity Index (GSCI, traded on Chicago Mercantile Exchange), the Dow Jones-AIG Commodity Index (DJ AIG, traded on the Chicago Board of Trade), and the Reuters-CRB Futures Price Index (CRB, traded on the New York Board of Trade).[iii] As of May 2004 the GSCI represented 86% of the combined open interest of the three indices, with the DJ AIG accounting for 10% of open interest and the CRB making up the remaining 4% of open interest[iv]. Each of these indices is intended by to be a broad representation of investment opportunities in the aggregate commodity futures market. It is natural to expect that return and risk of broad-based indices should be similar.

Interestingly, Figure 4 shows that the three commodity indices have experienced different levels of return and volatility. The comparison of index returns starts in 1991 because this is earliest common time period for all three indices. The GSCI had twice the volatility of the CRB commodity index during the common time period for all three indices. The DJ AIG Commodity Index and the GSCI had average returns similar to the Lehman Aggregate Bond Index and the CRB had a return similar to three-month Treasury bills, underperforming the Lehman Aggregate by 4% per annum. What are possible reasons for the return and risk differences amongst these indices?

Figure 4
Return and Risk
January 1991 to May 2004



	Average return	*Standard deviation*	*Correlation 1*	*2*	*3*	*4*	*5*
1. GSCI	6.81%	17.53%					
2. DJ AIG	7.83%	11.71%	**0.89**				
3. CRB	3.64%	8.30%	**0.66**	**0.83**			
4. Wilshire 5000	11.60%	14.77%	0.06	0.13	0.18		
5. EAFE	5.68%	15.53%	0.14	0.22	0.27	**0.70**	
6. Lehman Aggregate	7.53%	3.92%	0.07	0.03	-0.02	0.07	0.03

Comparison begins in January 1991 because this is the inception date for the DJ AIG Commodity Index

2.4 Commodity indices are strategies

Asset weights and asset returns drive portfolio returns. The return and risk differences amongst these three commodity indices can partially be explained by the different weights of individual commodity futures contracts in each of the indices. Different portfolio weights imply that each of these indices suggest different definitions of the aggregate commodity futures market. As Table 1 shows, the GSCI currently invests in 24 underlying futures contracts, the DJ AIG index invests in 20 and the CRB index invests in 17 different futures contracts. The GSCI is heavily skewed towards energy exposure because its portfolio weighting scheme is based on the level of worldwide production for each commodity.[v] The DJ AIG Commodity Index focuses primarily on futures contract liquidity data, supplemented with production data, to determine portfolio weights.[vi] The CRB index has traditionally been a geometrically averaged and equally weighted index.[vii] Given the earlier observation that the average individual commodity futures has had an average excess return of zero, it is not surprising that the geometrically averaged and equally weighted CRB has had an excess return of approximately zero. The higher returns of the GSCI and the DJ AIG can be seen as a pay-off to overweighting individual commodity futures which turned out to have above average returns. The composition of these three indices differ from one another because there is no agreed upon way to define the composition of the aggregate commodity futures market as there is with the aggregate equity market or the aggregate bond market. For instance, the composition of the aggregate stock and bond markets is driven by market capitalization, the outstanding value of stocks and bonds. However for every futures contract that one investor is long, there is another investor who is short the same futures contract. The outstanding value of long and short futures contracts is exactly offsetting and as a result there is no commodity futures market capitalization.[viii] Lacking a market capitalization based portfolio weighting scheme, commodity indices can best be thought of as commodity portfolio strategies.

Table 1

The Composition of Commodity Indices

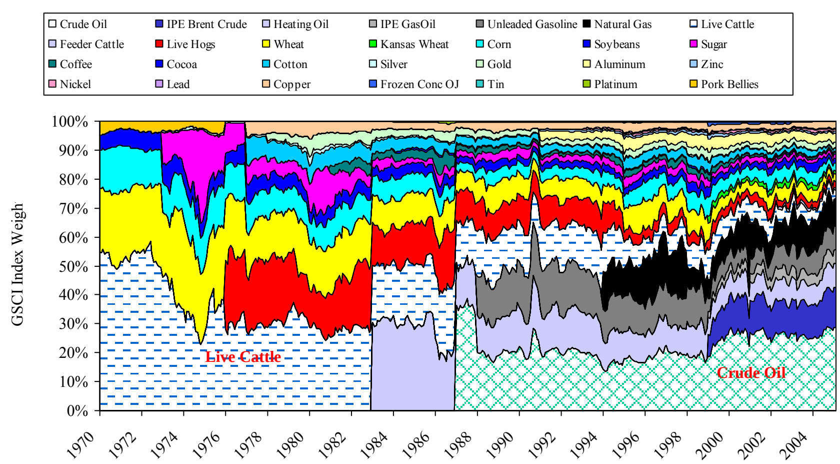
(as of May 2004)

	Portfolio Weights		
Commodity	**CRB**	**GSCI**	**DJ AIG**
Aluminum	-	0.029	0.071
Cocoa	0.059	0.003	0.020
Coffee	0.059	0.006	0.028
Copper	0.059	0.023	0.067
Corn	0.059	0.031	0.051
Cotton	0.059	0.011	0.018
Crude Oil	0.059	0.284	0.167
Brent Crude Oil	-	0.131	-
Feeder Cattle	-	0.008	-
Gas Oil	-	0.045	-
Gold	0.059	0.019	0.053
Heating Oil	0.059	0.081	0.047
Lead	-	0.003	-
Hogs	0.059	0.021	0.051
Live Cattle	0.059	0.036	0.067
Natural Gas	0.059	0.095	0.099
Nickel	-	0.008	0.019
Orange Juice	0.059	-	-
Platinum	0.059	0.000	-
Silver	0.059	0.002	0.022
Soybeans	0.059	0.019	0.051
Soybean Oil	-	0.000	0.017
Sugar	0.059	0.014	0.038
Unleaded Gas	-	0.085	0.054
Wheat	0.059	0.029	0.038
Red Wheat	-	0.013	0.000
Zinc	-	0.005	0.023
Total	1.000	1.000	1.000
Number of Futures Contra	17	24	20
Gini coefficient	0.00	0.65	0.32

Data Source: Goldman Sachs, Dow Jones AIG

Another issue complicating historical analysis of commodity index returns is that the weights of the constituents within a commodity futures index can vary substantially over time. For example, Figure 5 shows the variation in the portfolio weights of the constituents of the GSCI since the inception of the index. The GSCI initially consisted of just four commodity futures: cattle, corn, soybeans and wheat. For the first decade of the index's return history, cattle represented the largest portfolio exposure. Over time new commodity futures contracts have been added to the GSCI. More recently, cattle represents less that 5% of the GSCI and crude oil is the single largest portfolio constituent at about 29%. If returns differ from one commodity futures to another, as Figure 2 suggests, and if portfolio composition and weights change over time, as Figure 5 suggests, then historical index performance is at best a murky guide to prospective index returns.

Figure 5
The Changing Mix of Commodity Futures Contracts in the GSCI Index
December 1969 to May 2004



2.5 Comparing returns over a common time period

Knowing that individual commodity portfolio asset weights vary provides only half of the answer to understanding the return of a diversified commodity futures portfolio. The other element to explore is, of course, the returns of the individual commodity futures that make up a portfolio. The earlier exploration of individual commodity futures returns looked at the since-inception return of a number of individual commodity futures. However, it is useful to compare the returns of individual commodities with one another over a common time period. Dimson, Marsh and Staunton (2002), focusing on the question of how similar or dissimilar national equity market returns have been, point out that a desirable characteristic of a good index is an ability to allow comparisons amongst the constituents of the index over a common time period. They chose a common starting point of 1900 for the countries included in their global stock market index. As a result they can ask whether national equity market returns have been similar or not, and, if returns are not similar, speculate as to reasons for the lack of similarity. The same argument suggests that a common time period can be useful when investigating the returns for individual commodity futures and commodity futures portfolios. A common time period makes it possible to investigate, through a cross-sectional examination of returns, the reasons for the possible differences in returns of the portfolio constituents. Dissimilar time period returns have a certain archival value, however, it is hard to say that they improve investor appreciation of investment opportunities. For instance, what value would there be in an "apples-to-oranges" comparison of 50 years of copper futures performance to 20 years of heating oil futures performance?

A challenge, then, is to find an objective way to identify the broadest cross-section of individual commodity futures contracts that most fully captures the current breadth of choices and simultaneously provides the longest historical time series. If the number of investment choices increases with the passage of time, there will always be a trade-off between the size of the common time period and the size of the universe of securities. Given the importance of energy in both the GSCI and the Dow Jones AIG indices, one way to address this issue is to ask when energy first entered either of these indices. Heating oil was the first energy contract to enter the GSCI, in December 1982,[ix] and since the GSCI antedates the Dow Jones AIG index, December 1982 is a plausible start date for the cross-sectional comparison of individual commodity futures returns. Given that the GSCI has a greater number of individual constituents than either the Dow Jones AIG index or the CRB, and since the constituents of the GSCI are screened for a minimum level of liquidity, choosing from the constituents of the GSCI is a convenient way to select from a liquid and investable universe of commodity futures contracts. This process of identification yields the 12 individual commodities listed in Table 2.

Table 2 presents the historical excess returns of the overall GSCI, six GSCI sectors, and twelve individual constituents of the GSCI that have been available since December 1982. Over this sample, the GSCI had a compound annualized excess return of 4.49%, higher than the 3.45% excess return for the Lehman Aggregate bond index and lower than the 7.35% excess return for the S&P 500. The energy sector of the GSCI provided a return of 7.06% and the non-energy sector had a return of -0.12%. The GSCI sector returns reflect the performance of the commodity futures listed in Table 2 as well as the returns of commodity futures that were added to the GSCI subsequent to December 1982. Among the twelve individual commodities, heating oil had an annual return of 5.53% and silver had a return of -8.09%. Table 2 suggests that over the common time period there were substantial differences in the returns of the individual commodity futures. Combining differences in individual commodity futures returns with the asset weight differences of the various commodity futures indices suggests a reason for differences in the returns of commodity futures indices. Of course, the fact that individual returns within a universe of commodity futures have differed in the past does not guarantee that they will differ in the future. However, the return dispersion, and the lack of statistical significance, in these data is consistent with the data presented by Bodie and Rosansky and Gorton and Rouwenhorst.

In Table 2, an initially equally weighted buy-and-hold portfolio experienced an average annual geometric excess return of 0.70%, an equally weighted, rebalanced monthly, portfolio had an average annual geometric excess return of 1.01%, the equally-weighted average geometric excess return of the 12 individual commodities was -1.71%, and the equally-weighted average geometric excess return of the five commodity futures sectors was 0.99%. The difference in return between the GSCI and these four averages reflects the significant energy exposure of the GSCI. Till (2003) suggests that an important determinant of an individual commodity future's return comes from the difficulty of storing that commodity. Till identifies four of the commodity futures in Table 2 as being difficult to store: heating oil, copper, live cattle and live hogs. The average geometric excess return of these four "difficult to store" commodity futures is 3.5% and the average geometric excess return of the other not difficult to store commodity futures is -4.3%.

Table 2
Historical Excess Returns
December 1982 to May 2004

	Geometric mean	Arithmetic mean	Standard deviation	T-stat	Skew	Kurtosis	Sharpe ratio	Auto-correlation	Difficult storage
Overall									
GSCI	4.49%	5.81%	16.97%	1.22	0.51	1.98	0.26	0.11	
Sectors									
Non-Energy	-0.12%	0.36%	9.87%	-0.06	0.09	-0.01	-0.01	0.01	
Energy	7.06%	11.52%	31.23%	1.05	0.73	2.28	0.23	0.15	
Livestock	2.45%	3.48%	14.51%	0.78	-0.19	0.93	0.17	0.05	
Agriculture	-3.13%	-2.15%	14.35%	-1.01	0.20	0.85	-0.22	-0.01	
Industrial Metals	4.00%	6.41%	22.82%	0.81	1.27	5.92	0.18	0.06	
Precious Metals	-5.42%	-4.46%	14.88%	-1.69	0.29	2.21	-0.36	-0.18	
Components									
Heating Oil	5.53%	10.51%	32.55%	0.79	0.64	1.94	0.17	0.04	Yes
Live Cattle	5.07%	5.94%	13.98%	1.68	-0.51	2.74	0.36	0.02	Yes
Live Hogs	-2.75%	0.17%	24.21%	-0.53	-0.04	1.14	-0.11	-0.04	Yes
Wheat	-5.39%	-3.32%	21.05%	-1.18	0.16	0.17	-0.26	-0.01	No
Corn	-5.63%	-3.32%	22.65%	-1.15	1.37	9.16	-0.25	0.00	No
Soybeans	-0.35%	1.92%	21.49%	-0.08	0.44	1.86	-0.02	0.01	No
Sugar	-3.12%	3.69%	38.65%	-0.37	1.60	7.03	-0.08	0.03	No
Coffee	-6.36%	0.85%	39.69%	-0.74	1.12	3.09	-0.16	0.01	No
Cotton	0.10%	2.60%	22.64%	0.02	0.61	1.37	0.00	0.05	No
Gold	-5.68%	-4.81%	14.36%	-1.83	0.30	2.33	-0.40	-0.14	No
Silver	-8.09%	-5.30%	25.03%	-1.49	0.46	2.05	-0.32	-0.15	No
Copper	6.17%	9.15%	25.69%	1.11	1.03	3.92	0.24	0.06	Yes
Portfolios									
EW Buy-and-Hold	0.70%	1.26%	10.61%	0.31	0.05	0.69	0.07	0.01	
EW Rebalanced Portfolio	1.01%	1.51%	10.05%	0.46	0.01	0.37	0.10	-0.04	
Average of 12 Commodities	-1.71%	1.51%	8.17%	-0.72	0.60	2.57	0.23	0.07	
EW Rebalanced-Avg. of 12	2.72%	0.00%	1.88%	0.78	-0.60	-2.20	-0.13	-0.11	
Lehman Aggregate	3.45%	3.50%	4.65%	3.43	-0.20	0.48	0.74	0.12	
S&P 500	7.35%	8.30%	15.30%	2.22	-0.76	2.70	0.48	-0.01	
MSCI EAFE	5.84%	7.18%	17.29%	1.56	-0.22	0.38	0.34	0.05	

2.5 A common time period makes it possible to calculate correlations

Asset return correlations are important for asset allocation analyses. Focusing on a common time period makes it possible to explore the correlations of a universe of commodity futures. Focusing on a common time period also makes it possible to ask: is it a "commodity futures market" or is it a "market of commodity futures"? Is the "market" a collection of securities that behave in a similar way, or is the "market" a collection of dissimilar securities? Table 3 shows that the average level of commodity return correlations is low. As an example, heating oil and silver excess returns were essentially uncorrelated (0.02). The average return correlation of the twelve commodity futures with the GSCI was 0.20. The average correlation of individual commodities with one another was only 0.09.[x] For instance, heating oil's average correlation with the other eleven commodities is 0.03, its highest correlation of 0.15 is with gold and its lowest correlation of -0.07 is with coffee. The average correlation of the commodity sectors (energy, livestock, agriculture, industrial metals and precious metals) with the GSCI is 0.33. However, this correlation is driven by the 0.91 correlation between the overall GSCI and the energy sector. To a large degree, commodity futures have been uncorrelated with one another. Hence, it is more meaningful to think of a market of individual dissimilar commodity futures rather than a homogeneous market of similar commodity futures.

Table 3
Excess Return Correlations
Monthly observations, December 1982 to May 2004

	GSCI	Non-Energy	Energy	Livestock	Agriculture	Industrial Metals	Precious Metals	Heating Oil	Cattle	Hogs	Wheat	Corn	Soybeans	Sugar	Coffee	Cotton	Gold	Silver
Non-Energy	0.36																	
Energy	0.91	0.06																
Livestock	0.20	0.63	0.01															
Agriculture	0.24	0.78	0.01	0.12														
Industrial Metals	0.13	0.31	0.03	-0.02	0.17													
Precious Metals	0.19	0.20	0.14	0.03	0.08	0.20												
Heating Oil	0.87	0.08	0.94	0.04	0.00	0.05	0.13											
Cattle	0.12	0.50	-0.03	0.84	0.07	0.03	0.01	0.00										
Hogs	0.21	0.52	0.06	0.81	0.13	-0.06	0.05	0.06	0.37									
Wheat	0.25	0.66	0.06	0.18	0.79	0.05	0.06	0.06	0.12	0.17								
Corn	0.14	0.58	-0.03	0.10	0.78	0.12	-0.01	-0.04	0.05	0.11	0.52							
Soybeans	0.20	0.58	0.02	0.11	0.72	0.18	0.14	0.05	0.03	0.14	0.43	0.70						
Sugar	0.03	0.21	-0.06	-0.05	0.35	0.14	0.05	-0.04	0.02	-0.10	0.11	0.12	0.09					
Coffee	-0.01	0.15	-0.04	-0.07	0.23	0.07	0.01	-0.07	-0.06	-0.06	0.00	0.03	0.07	-0.01				
Cotton	0.11	0.25	0.06	0.00	0.27	0.17	0.04	0.05	-0.06	0.06	0.05	0.11	0.18	-0.02	-0.01			
Gold	0.20	0.16	0.16	0.01	0.07	0.18	0.97	0.15	-0.02	0.04	0.07	-0.01	0.14	0.02	0.00	0.03		
Silver	0.08	0.19	0.02	0.02	0.10	0.19	0.77	0.02	-0.01	0.05	0.03	0.09	0.13	0.07	0.04	0.04	0.66	
Copper	0.15	0.36	0.04	0.01	0.22	0.94	0.20	0.07	0.03	-0.02	0.08	0.16	0.23	0.14	0.11	0.19	0.18	0.21

Average Correlations	
GSCI with commodity sectors	0.34
GSCI with individual commodities	0.20
Heating oil with other commodities	0.03
Individual commodities	0.09

3. Return decomposition and expected returns

3.1 Decomposition of commodity futures returns

It is possible to decompose the annualized total return of a diversified cash collateralized commodity futures portfolio into three components:

Commodity Portfolio Total Return = Cash Return + Weighted Average Excess Return + Diversification Return

Similarly, the return of an individual commodity futures contract can be decomposed into two components:

Individual Commodity Total Return = Cash Return + Excess Return

The excess return is simply the change in the price of a futures contract. If, for instance, an investor purchases a gold futures contract for $400 an ounce and later sells the contract for $404 an ounce, the excess return on this position would be 1%. The diversification return is a synergistic "the whole is greater than the sum of the parts" benefit attributable to portfolio rebalancing. For a portfolio consisting of two or more assets, a positive diversification return simply means that the compound return of a portfolio will be greater than the weighted average compound return of the individual portfolio constituents. The diversification return is due to the reduction in variance as investors form diversified portfolios and an impact of not rebalancing.[xi] The geometric average return of a portfolio will be positively impacted by this reduction in variance. The diversification return can be a significant source of return for a rebalanced portfolio, and typically will be a less significant source of return for an unrebalanced portfolio. We explore the diversification return in more detail in section 3.6.[xii]

A number of theoretical frameworks have been proposed for understanding the source of commodity futures excess returns: the CAPM perspective, the insurance perspective, the hedging pressure hypothesis and the theory of storage. None of these perspectives is the final word on commodity price determination or the prospective returns from investing in commodity futures, yet they are part of the evolution of thought with regards to commodity price determination and investing.

3.2 Expected returns: The CAPM perspective

Lummer and Siegel (1993) and Kaplan and Lummer (1998) argue that the long-run expected return of an investment in the cash collateralized GSCI should be similar to that of Treasury bills. For the cash collateralized GSCI, this is equivalent to saying that the expected excess return should be zero. Given that commodities tend to have low correlations with other commodities as well as with stocks and bonds, this view is consistent with the pioneering work of Dusak (1973) who documented low stock market betas and postulated low expected returns for wheat, corn and soybeans in the context of the Capital Asset Pricing Model of Sharpe (1964) and Lintner (1965). However, it is important to recognize that finding that the stock market does not drive the returns of a commodity futures index, or the returns of individual commodity futures, does not necessarily imply that expected commodity futures excess returns should be zero. It simply says that the stock market might not drive commodity futures returns.

Investors have a number of ways to question a CAPM explanation of commodity futures returns. From a theoretical perspective, Roll (1977) observed that the CAPM suggests that there should be a linear relationship between the return of an asset and the return of the "market portfolio". The "market portfolio" consists of stocks, bonds, real estate, works of art, consumer durables such as autos and furniture as well as human capital. Roll contended that testing the relationship between an asset and the stock market was not the same thing as testing the relationship between an asset and the unobservable and unmeasurable "market portfolio". Additionally, Black (1976) noted that commodity futures are not capital assets. Rather, Black pointed out, commodity futures are similar to "sports bets" and as a result commodity futures, as well as bets on college football games, are not included in the "market portfolio". If commodity futures are not included in the "market portfolio," it is challenging to figure out why the CAPM should explain commodity futures returns. Furthermore, as Fama and French (1992) show, the CAPM has not historically been a very robust model of expected returns. If the CAPM does a poor job of describing expected equity returns, as Fama and French suggest, why should the CAPM do a good job of estimating expected commodity futures returns? Bottom line, there seems to be no convincing reason that the CAPM should explain commodity futures returns.

3.3 Expected returns: The insurance perspective

Gorton and Rouwenhorst (2005) point out that Keynes' (1930) theory of normal backwardation, in which hedgers use commodity futures to avoid commodity price risk, implies the existence of a commodity futures risk premium. If this risk premium is large enough, then returns could be similar to that of equities. The presence of a backwardation return was also the focus of earlier work by Bodie and Rosansky (1980) and Fama and French (1987).

Keynes (1930) advanced the theory of normal backwardation in which he suggested that the futures price for a commodity should be less than the expected spot price in the future. If today's futures price is below the spot price in the future, then as the futures price converges towards the spot price at maturity, excess returns should be positive. Keynes' insight was that commodity futures allow operating companies to hedge their commodity price exposure, and since hedging is a form of insurance, hedgers must offer long-only commodity futures investors an insurance premium. Normal backwardation suggests that, in a world with risk-averse hedgers and investors, the excess return from a long commodity investment should be viewed as an insurance risk premium[xiii]. Under normal backwardation, investors who go long commodity futures should receive a positive risk premium, and it is for this reason that normal backwardation provides a rationale that a long-only portfolio of commodity futures is an efficient way to allocate capital.

Normal backwardation should also affect the cross-section of commodity futures excess returns. That is, a relatively more normally backwardated commodity future should have a higher return than a relatively less normally backwardated commodity future. However, since it is impossible to know what the expected future spot price is, normal backwardation is unobservable. Normal backwardation is primarily a belief that long-only investors in commodity futures should receive a positive excess rate of return. Even though normal backwardation is unobservable, historical evidence of positive excess returns for individual commodity futures could be a good indicator of the existence of normal backwardation.

To test for individual commodity futures normal backwardation risk premiums, Kolb (1992) looked at twenty-nine different futures contracts and concluded that "normal backwardation is not normal". Specifically, he noted that nine commodities exhibited statistically significant positive returns, four commodities had statistically significant negative returns and the remaining sixteen commodity returns were not statistically significant. Kolb looked at individual commodity futures and, hence, he missed the potential increase in the power of statistical inference that might have come from forming portfolios of commodity futures. However, his work shows that some commodity futures had positive returns and some commodity futures had negative returns. Since normal backwardation suggests that all commodity futures should have positive returns, Kolb's work indicates how challenging it is to prove the existence of normal backwardation.

Bodie and Rosansky (1980), Fama and French (1987) and Gorton and Rouwenhorst (2005) report the performance of individual commodity futures, as well as equally weighted portfolios of commodity futures, and their evidence on individual commodity futures returns supports Kolb's finding that it is difficult to prove the existence of normal backwardation for the average individual commodity futures. However, Bodie and Rosansky and Gorton and Rouwenhorst report statistically significant returns for an equally weighted portfolio, which they believe supports a finding of normal backwardation for a periodically rebalanced equally weighted portfolio. It is important to realize that these statistically significant portfolio returns do not prove the existence of normal backwardation since, as Figure 3 illustrates, just rebalancing an equally weighted portfolio can be a source of statistically significant returns.

3.4 Expected returns: The hedging pressure hypothesis

The hedging pressure hypothesis is an attempt to explain the lack of consistent empirical support for the theory of normal backwardation. Cootner (1960) and Deaves and Krinsky (1995) note that Keynes' theory of normal backwardation assumes that hedgers have a long position in the underlying commodity and that they seek to mitigate the impact of commodity price fluctuations by short selling commodity futures. As a result the futures price is expected to rise over time, providing an inducement for investors to go long commodity futures. They suggest that both backwardated commodities, where the spot price is greater than the futures price, and contangoed commodities, where the spot price is less than the futures price, might have risk premia if backwardation holds when hedgers are net short futures and contango holds when hedgers are net long futures. Bessembinder (1992) finds substantial evidence, over the time period 1967 to 1989, that average returns for sixteen nonfinancial futures are influenced by the degree of net hedging[xiv]. In other words, commodities in which hedgers were net short had, on average, positive excess returns and commodities in which hedgers were net long had, on average, negative excess returns.

De Roon, Nijman and Veld (2000) analyze twenty futures markets over the period 1986 to 1994 and find that hedging pressure plays an important role in explaining futures returns. Anson (2002) distinguishes between markets that provide a hedge for producers (backwardated markets), and markets that provide a hedge for consumers (contango markets). He points out that a commodity producer such as Exxon, whose business requires it to be long oil, can reduce exposure to oil price fluctuations by being short crude oil futures. Hedging by risk averse producers cause futures prices to be below the expected spot rate in the future. Alternatively, a manufacturer such as Boeing is a consumer of aluminum, it is short aluminum, and it can reduce the impact of aluminum price fluctuations by purchasing aluminum futures. Hedging by risk averse consumers causes futures prices to be higher than the expected spot rate in the future. In this example, Exxon is willing to sell oil futures at an expected loss and Boeing is willing to purchase aluminum futures at an expected loss. Alternatively, investors receive a risk premium, a positive excess return, for going long backwardated commodity futures and for going short contangoed commodity futures. This line of reasoning suggests that a portfolio that goes long backwardated futures and short contangoed futures is an attractive way to allocate capital. The losses incurred by the hedgers provide the economic incentive for the capital markets to provide price insurance to hedgers. Both normal backwardation and the hedging pressure hypothesis reflect a view that commodity futures are a means of risk transfer and that the providers of risk capital charge an insurance premium. The hedging pressure hypothesis is more flexible than the theory of normal backwardation in that it does not presume that hedgers only go short futures contracts. However, unless an investor has a reliable measure of hedging pressure, it is hard to say how an investor can use this concept in practice.

3.5 Expected returns: The theory of storage

The theory of storage focuses on the role that inventories of commodities play in the determination of commodity futures prices. In this framework, inventories allow producers to avoid stockouts and production disruptions. The more plentiful inventories are, the less the likelihood that a production disruption will affect prices. The less plentiful inventories are, the more likely it is that a production disruption will affect prices. As a result, there is a benefit from having a level of inventories that will reduce the impact of production disruptions. This benefit was described by Kaldor (1939) and by Brennan (1991) as a convenience yield.

The convenience yield is high when desired inventories are low and the convenience yield is low when desired inventories are high. In the theory of storage, the price of a commodity futures contract is driven by storage costs, the interest rate and the convenience yield. If, for instance, inventories are plentiful and both storage costs and the convenience yield are zero, then the difference between the spot price of a commodity and the futures price will be the interest cost until the maturity of the contract. For example, if the spot price of a commodity is 100 and the one year interest rate is 10%, the one year commodity futures price should be 110. However, if desired inventories are in short supply, then the convenience yield may be high. To expand on the previous example, if inventories were low and the convenience yield was 5% then the one year commodity futures price would be 105. If the convenience yield was 15% then the commodity futures price would be 95. The convenience yield conceptually links desired inventories with commodity futures prices. By observing, or estimating, a high convenience yield it is possible to infer that desired inventories are low. As a result the convenience yield can be thought of as a risk premium linked to inventory levels that helps explain observed futures prices. In contrast, the theory of normal backwardation is a belief that producers' risk aversion regarding commodity price risk yields a positive expected return, a risk premium, from owning a commodity futures contract.

The convenience yield suggests that inventories might be low for difficult to store commodities and as a result difficult to store commodities might have high convenience yields.

Conversely, inventories should be plentiful for easy to store commodities and as a result easy to store commodities should have low convenience yields. Now imagine an investor who is contemplating investing in commodity futures for the next ten years. What the investor needs to know is how high the convenience yield will be over the next ten years for difficult to store commodities and how low the convenience yield will be over the next ten years for easy to store commodities. Unfortunately the theory of storage does not provide an answer for this question nor is it likely that there is an answer.

3.6 Drivers of the cross-section of average commodity futures returns over a common period

3.6.1 The term structure of futures prices and the 'roll' return

The term structure of futures prices depicts the relation between futures prices and the maturity of futures contracts. While there are competing theories of commodity price determination, the term structure of futures prices is a market reality that investors face every day. Figure 6 illustrates the term structure of futures prices for crude oil and gold at the end of May 2004[xv]. The futures price for crude oil declines as the time horizon increases, from a price of $40.95 per barrel of oil for the July 2004 futures contract to a price of $36.65 for the June 2005 futures contract. This is an example of market backwardation[xvi], in which the futures price for a commodity is lower than the current spot price. Typically, the current spot price is the futures contract with the shortest time to maturity, the nearby futures contract. In this example, the futures price for gold increases as the time horizon increases. This relationship is known as contango. Crude oil is backwardated in Figure 6 but it is worth noting that crude oil is not always backwardated. Historically crude oil futures have been backwardated about 66% of the time.[xvii] Gold is in contango in Figure 6 and gold has always been in contango. Interestingly, while gold is a standard component of many commodity futures indices, some have argued that gold is really a currency, not a commodity, and that a gold futures is best thought of as a financial futures.

An upward or downward sloping term structure of futures prices creates the possibility of a futures price "roll return". In fixed income parlance, an upward sloping yield curve produces a return attributable to the passage of time known as 'rolling down the yield curve'. In the oil futures example, the futures price for July 2005 is $36.65 and the July 2004 price is $40.95. If the term structure of oil remained unchanged between July 2004 and July 2005, then the roll return from buying the July 2005 oil contract and holding the position for one year is 11.7%

($40.95/$36.65 -1). For gold, assuming no change in the term structure of gold futures prices, the roll return is -1.4% ($398.30/$404.00-1).

Figure 6
Term Structure of Commodity Prices
May 30, 2004

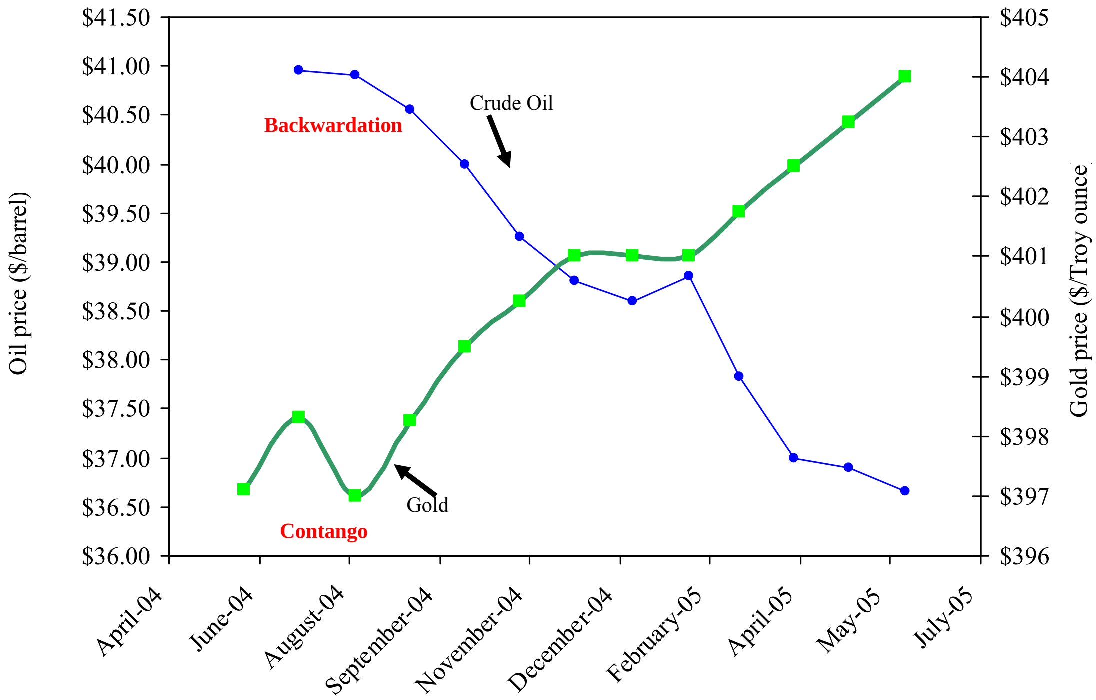
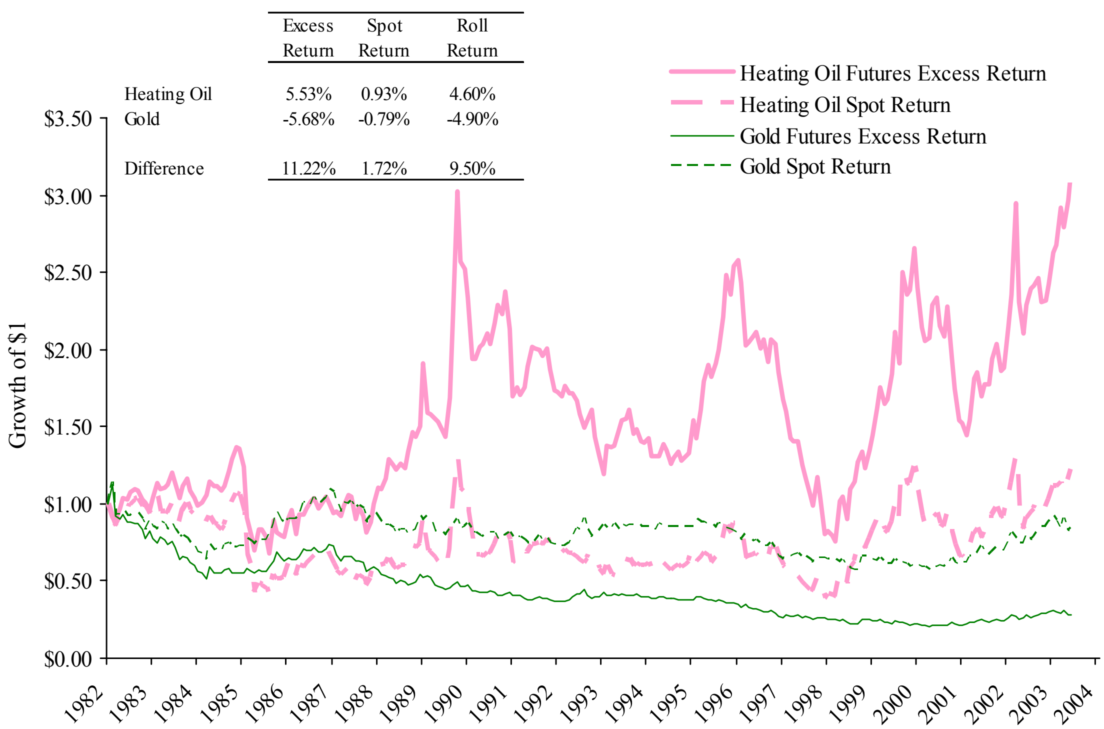


Figure 7 shows that, since 1982, the geometric average excess return for heating oil futures was 5.5% per annum. The average excess return consists of a spot return and a roll return. The spot return is the change in the price of the nearby futures contract. Since futures contracts have an expiration date, investors who want to maintain a commodity futures position have to periodically sell an expiring futures contract and buy the next to expire contract. This is called rolling a futures position. If the term structure of futures prices is downward sloping, an investor rolls from a higher priced expiring contract into a lower priced next nearby futures contract. This suggests that the term structure of futures prices drives the roll return.

For heating oil, the spot return was about 0.9% and the roll return was about 4.6%. The roll return was positive because the energy markets were typically, but not always, in backwardation. The excess return for gold futures was about -5.7% per annum, the spot price return was -0.8% and the roll return was about -4.8%. The roll return was negative because the gold futures market has always been in contango. The average spot return of heating oil and gold futures was close to zero. This is just a reflection of a time period specific historical experience and it says nothing about future spot returns. The 11.2% average excess return difference between heating oil and gold was largely driven by a 9.5% difference in roll returns. The 1.7% difference in spot returns was a relatively minor source of the overall cross-sectional return difference between heating oil and gold. This example illustrates that excess returns and spot returns need not be the same if roll returns differ from zero. However, it is important to recognize that roll returns can be positive as well as negative. In addition, investors should beware the fallacy of composition and resist extrapolating the roll return of an individual commodity future to all other commodity futures. This point is worth remembering since it is not uncommon for marketers of long-only commodity strategies to highlight in their presentation materials only the excess returns of backwardated commodity futures.[xviii]

Figure 7
Excess and Spot Returns
December 1982 to May 2004



3.6.2 Roll returns: the past and the future of the cross-section of commodity futures returns

How important have roll returns been in explaining the cross-section of individual commodity futures excess returns from December 1982 to May 2004? In Figure 8 roll returns explain 91% of the long run cross-sectional variation of commodity futures returns over the time period December 1982 to May 2004. Three commodities (copper, heating oil, and live cattle) had, on average, positive roll returns and positive excess returns. Corn, wheat, silver, gold and coffee had, on average, negative roll returns and negative excess returns. The average excess return for the positive roll return commodities was 4.2% and the average excess return for the negative roll return commodities was -4.6%. The almost 9% excess return difference between the positive roll return portfolio and the negative roll return portfolios consists of a 7.5% difference in roll returns and a 1.4% difference in spot returns.

Figure 8 is inconsistent with the idea of normal backwardation. Long-only normal backwardation suggests that average commodity futures excess returns should be positive, for *both* backwardated and contangoed commodity futures. Under normal backwardation, what matters is the degree of normal backwardation, which, unfortunately, is unobservable. Normal backwardation suggests that all of the observations in Figure 8 should lie in the northeast and the northwest quadrants. Figure 8 does not, therefore, empirically provide any support for long only normal backwardation. Of course, just as it is impossible to disprove the existence of that which is unobservable, Figure 8 does not disprove the existence of normal backwardation. However, Figure 8, and the individual commodity futures return data of Bodie and Rosansky and Gorton and Rouwenhorst, provides little support for the idea that normal backwardation is an explanation of actual individual commodity futures returns.

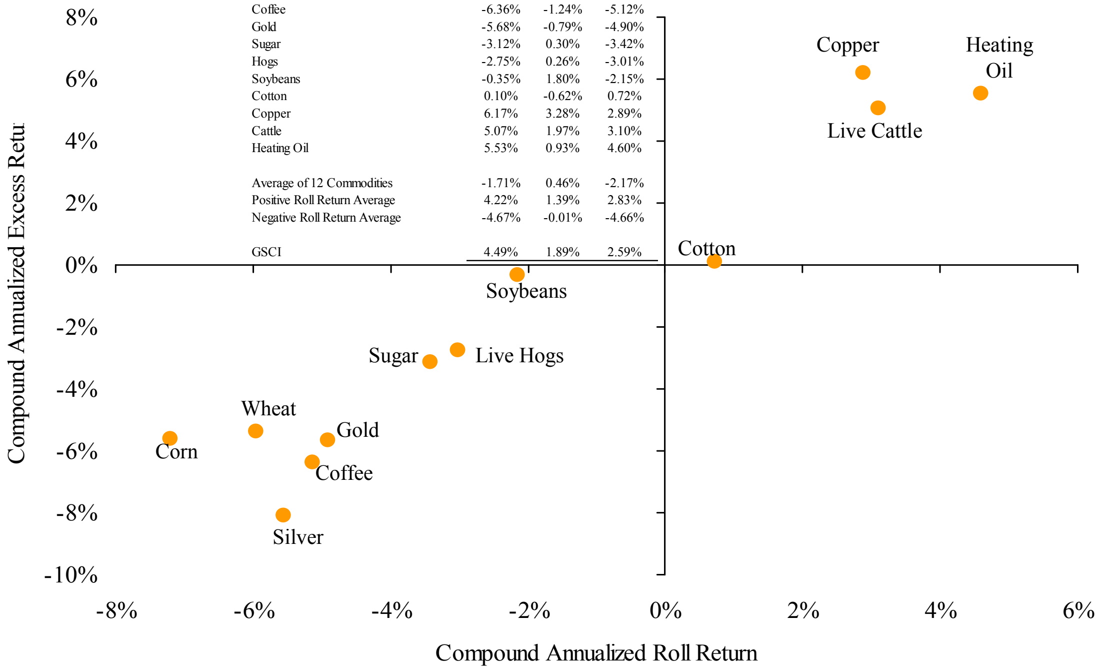
For investors thinking about how to invest in the future, Figure 8 must be viewed with some caution. Figure 8 does not suggest that roll returns explained 91% of the daily, weekly, monthly, quarterly or annual cross-section of returns for these 12 commodity futures during the time period studied. Nor, more importantly, does Figure 8 suggest that roll returns will explain 91% of the cross-sectional variation of commodity futures returns over any particular future time horizon.

Figure 8 points out that when substantial roll return differences amongst various commodity futures persist for a long period of time, then it might be rewarding to invest in commodity futures with relatively high roll returns. Conversely, if roll return differences were insignificant then security selection might not be very rewarding. Figure 8 is, however, completely silent on the important issue of what roll returns will be in the future. In reality, investors do not know what the average term structure of prices will look like in the future. As a result, knowing that roll returns have been an important driver of past returns provides no insight as to the future level of roll returns. For a broadly diversified portfolio of commodity futures a risk averse investor might very well want to assume a future roll return of zero (or less).

Figure 8
Excess Returns and Roll Returns
December 1982 to May 2004

	Intercept	Intercept T-Stat	Roll Coefficient	Roll T-Stat	Adjusted R Square
Compound Annualized Excess Return	0.89%	1.84	1.20	10.97	91.57%

	Excess Return	Spot Return	Roll Return
Corn	-5.63%	1.57%	-7.19%
Wheat	-5.39%	0.57%	-5.96%
Silver	-8.09%	-2.54%	-5.55%
Coffee	-6.36%	-1.24%	-5.12%
Gold	-5.68%	-0.79%	-4.90%
Sugar	-3.12%	0.30%	-3.42%
Hogs	-2.75%	0.26%	-3.01%
Soybeans	-0.35%	1.80%	-2.15%
Cotton	0.10%	-0.62%	0.72%
Copper	6.17%	3.28%	2.89%
Cattle	5.07%	1.97%	3.10%
Heating Oil	5.53%	0.93%	4.60%
Average of 12 Commodities	-1.71%	0.46%	-2.17%
Positive Roll Return Average	4.22%	1.39%	2.83%
Negative Roll Return Average	-4.67%	-0.01%	-4.66%
GSCI	4.49%	1.89%	2.59%



3.7 Measuring the time-series variation in individual commodity futures returns

The analysis so far has focused on the cross-section of average returns from December 1982 to May 2004. During this time period the roll return was the dominant driver of the performance differences amongst individual commodity futures. However, when examining how individual commodity futures returns vary over time, a different story emerges. Table 4 shows that most of the time-series variation of commodity futures excess returns is driven by spot return variation. The average excess return standard deviation for the twelve individual commodity futures was 25.16%, the average spot return standard deviation was 26.76%, the average roll return standard deviation was 9.14% and the average correlation between spot and roll returns was -0.29. Clearly spot returns have been more important in explaining the excess return volatility of individual commodity futures than roll returns.[xix]

Table 4 also shows that over the time period December 1982 to May 2004 no individual commodity futures and no commodity futures sector had a statistically significant average excess or spot return. Some of the roll returns were statistically significant and, as previously noted, roll returns have been highly correlated with excess returns. However, the high volatility of spot returns converted even the most significant roll return into an insignificant excess return. As a result, given the nature of this sort of statistical test, it is not possible to assert that any of the average spot and excess returns were statistically different from zero in this sample. This finding is broadly consistent with an analysis of the returns of individual commodity futures returns reported in the work of Bodie and Rosansky (1980) and Gorton and Rouwenhorst (2005).

It is always difficult to interpret the meaning of 'lack of statistical significance'. One interpretation suggests that the data are consistent with the idea that the average commodity futures return is zero. Another possibility is that with the passage of time the standard errors of the average returns will decline and the statistical significance of the returns will rise. There are challenges with this line of thought. Given the return and risk of the energy sector, for instance, it would take about 78 years for the excess returns to pass conventional tests of statistical significance. Given the return and risk of the GSCI, it would take about 57 years of data to feel comfortable that the returns of the GSCI were significant. These time horizons are probably too long for most investors to tolerate. Another possibility is that future average returns will be much higher than anything observed in the past. However, the data currently available to investors suggest that, so far, excess returns on average have not been statistically significant.

Table 4
Historical Excess, Spot and Roll Returns Returns
December 1982 to May 2004

	Excess Return			Spot Return			Roll Return		
	Geometric mean	Standard deviation	T- stat	Geometric mean	Standard deviation	T- stat	Geometric mean	Standard deviation	T- stat
Overall									
GSCI	4.49%	16.97%	1.22	1.89%	16.93%	0.52	2.59%	4.25%	2.83
Sectors									
Non-Energy	-0.12%	9.87%	-0.06	0.67%	10.39%	0.30	-0.80%	4.21%	-0.88
Energy	7.06%	31.23%	1.05	1.69%	31.02%	0.25	5.37%	7.34%	3.38
Livestock	2.45%	14.51%	0.78	1.20%	15.82%	0.35	1.25%	7.77%	0.74
Agriculture	-3.13%	14.35%	-1.01	0.64%	15.06%	0.20	-3.77%	5.04%	-3.46
Industrial Metals	4.00%	22.82%	0.81	3.17%	21.62%	0.68	0.83%	6.89%	0.56
Precious Metals	-5.42%	14.88%	-1.69	-0.84%	15.05%	-0.26	-4.58%	1.71%	-12.38
Components									
Heating Oil	5.53%	32.55%	0.79	0.93%	33.09%	0.13	4.60%	9.16%	2.33
Live Cattle	5.07%	13.98%	1.68	1.97%	16.71%	0.54	3.10%	8.70%	1.65
Live Hogs	-2.75%	24.21%	-0.53	0.26%	31.45%	0.04	-3.01%	20.62%	-0.68
Wheat	-5.39%	21.05%	-1.18	0.57%	21.76%	0.12	-5.96%	9.33%	-2.96
Corn	-5.63%	22.65%	-1.15	1.57%	24.52%	0.30	-7.19%	8.42%	-3.96
Soybeans	-0.35%	21.49%	-0.08	1.80%	22.73%	0.37	-2.15%	6.48%	-1.54
Sugar	-3.12%	38.65%	-0.37	0.30%	39.79%	0.03	-3.42%	12.18%	-1.30
Coffee	-6.36%	39.69%	-0.74	-1.24%	39.65%	-0.14	-5.12%	8.90%	-2.67
Cotton	0.10%	22.64%	0.02	-0.62%	27.25%	-0.11	0.72%	14.16%	0.24
Gold	-5.68%	14.36%	-1.83	-0.79%	14.57%	-0.25	-4.90%	2.24%	-10.11
Silver	-8.09%	25.03%	-1.49	-2.54%	25.05%	-0.47	-5.55%	2.48%	-10.37
Copper	6.17%	25.69%	1.11	3.28%	24.54%	0.62	2.89%	7.09%	1.88
12 commodity average									
Average	-1.71%	25.16%	-0.32	0.46%	26.76%	0.10	-2.17%	9.14%	-2.29
Median	-2.93%	23.43%	-0.45	0.43%	24.79%	0.08	-3.21%	8.80%	-1.42

Recognizing that spot returns are volatile, it makes sense to ask if there is a way to explain the volatility of spot prices. The empirical finance literature has proposed a number of measures that might explain the variation over time of stock and bond returns. Can these measures explain commodity futures price volatility? Given the low return correlations between individual commodities it is reasonable to assume that the hunt for a set of common influences on commodity futures spot price returns will not be rewarding. In spite of this cautionary view, inflation, the most often mentioned driver of commodity prices, provides a good starting point for the exploration of the drivers of return volatility.

3.8. Does inflation drive commodity prices?

3.8.1 Inflation hedges – but what component of inflation?

Over the 1970 to 1999 period, Greer (2000) shows that the Chase Physical Commodity Index had a time series correlation of 0.25 with the annual rate of inflation and a time series correlation of 0.59 with the change in the annual rate of inflation. Strongin and Petsch (1996) find that the GSCI does well during periods of rising inflation (especially relative to stocks and nominal bonds). As a result, it makes sense to explore the relationship between the Consumer Price Index (CPI) and the constituents of commodity futures indices.

Figure 9
Consumer Price Index Composition, 2003

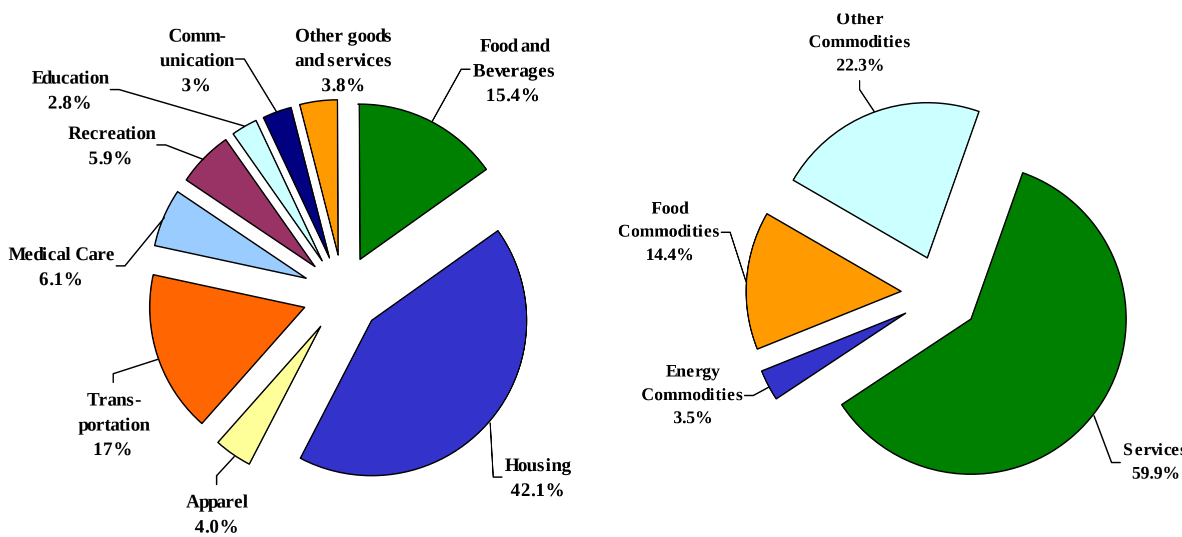


Figure 9 shows two ways of categorizing the components of the CPI. Commodities have about a 40% weight in the CPI and services have a 60% weight. Energy commodities make up only about 4% of the CPI, food commodities constitute about 14% of the CPI and other commodities account for the remaining commodity exposure of the CPI. It is clear that a broad-based commodity futures index excludes many items measured in the CPI. For instance, the single largest component of the CPI is the owners' equivalent rent of a primary residence. It is possible that a commodity futures index could be a good hedge of the 40% of the CPI that consists of commodities, but what of the other 60%? It seems reasonable to expect that the greater the overlap between the composition of a commodity index and the composition of the CPI the higher the correlation of returns. The mismatch between the composition of a commodity futures index, such as the GSCI, and an inflation index, such as the CPI, limits the ability of commodity futures to be an effective CPI inflation hedge.

3.8.2 Have commodity futures hedged expected and unexpected inflation?

Actual, or realized inflation, can be decomposed into two components: expected inflation and unexpected inflation, the difference between actual and expected inflation. Assuming, for purposes of convenience, that year-over-year changes in the rate of inflation are unpredictable, a good proxy for unexpected inflation is simply the actual change in the rate of inflation[xx]. For ease of comparison with the findings of Greer and Strongin and Petsch, Figure 10 shows that, since 1969, contemporaneous changes in the annual rate of inflation have seemingly explained 43% of the GSCI's annual excess return time series variation.[xxi] That is, average GSCI excess returns have been positive when year-over-year unexpected inflation rises, and the GSCI excess return has been negative when year-over-year inflation falls. Given the historical changes in the composition of the GSCI and the fact that many commodity futures seem to be largely uncorrelated with one another, it is hard to figure out what this overall unexpected inflation correlation means. Since the inflation beta of a commodity futures portfolio is just a weighted average of the portfolio's constituent inflation betas, a better way to understand the behavior of a broad based commodity futures investment is to look at the inflation sensitivity of individual commodity futures.

Figure 10
GSCI Excess Return and Unexpected Inflation
Annual Observations, 1969 to 2003

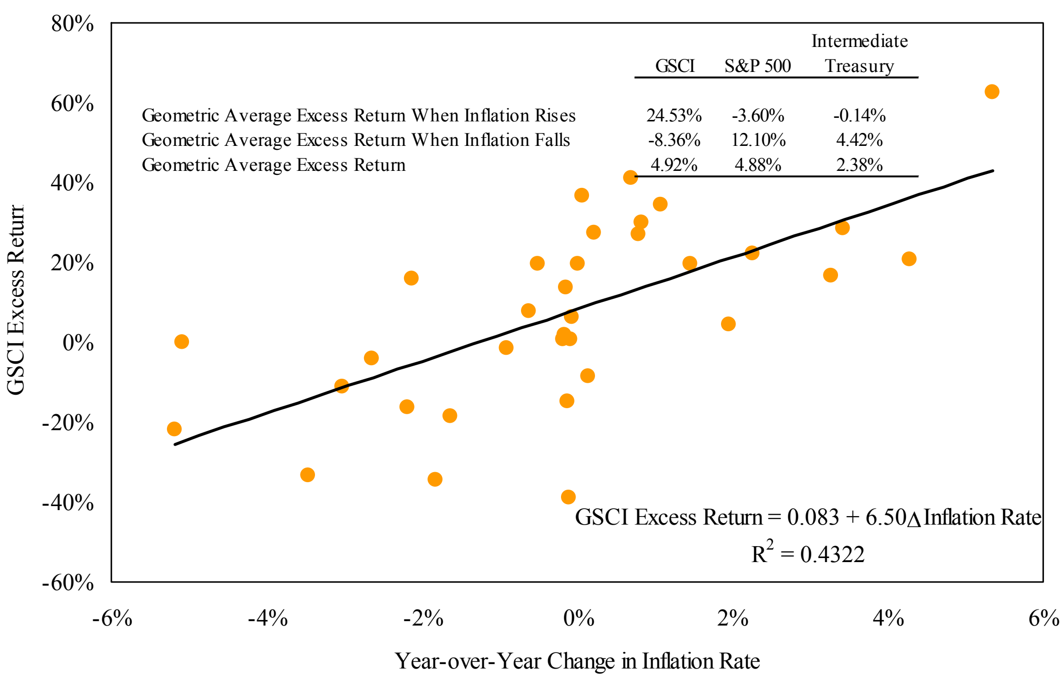


Table 3 shows that individual commodity futures excess returns are largely uncorrelated with one another. This suggests that commodity inflation sensitivity should vary from one commodity futures to another. Table 5 shows the historical sensitivity of commodity excess returns (index, sector and components) to actual prior annual inflation and actual changes in the annual rate of inflation over the 1982-2003 period. The GSCI has a positive, but statistically insignificant, actual inflation beta and a positive, and significant, unexpected inflation beta. Three sectors (energy, livestock and industrial metals) and three individual commodity futures (heating oil, cattle and copper) have significant unexpected inflation betas. The precious metals sector has a statistically significant negative inflation beta, as do gold and silver. No other sectors or individual commodities have significant positive inflation betas. Though some commodities respond positively to changes in the rate of inflation, others have negative or insignificant inflation change betas. Indeed, the equally weighted average of the twelve commodities has a positive, but insignificant, inflation beta[xxii].

During the time period studied, not all commodity futures were good inflation hedges. The inflation betas in Table 5 are a measure of the sensitivity of commodity futures returns to changes in the rate of inflation during a specific time period. There is no reason to believe that the magnitude or the sign of the inflation coefficients will remain constant in the future. An investor might believe that inflation betas are knowable and constant over time, but it is challenging to figure out where to find the evidence to support this view. For instance, gold is often thought of as an inflation hedge yet the time period specific measured negative inflation beta for gold could reflect the genuine inflation sensitivity of gold or it could reflect the inability of the inflation model to explain the time period specific return dynamics of gold. The regressions R^2s suggest that inflation can explain some of the return variation of individual commodity futures. However, at best, inflation only “explains” only a modest fraction of return variability. Some commodity futures might be a good inflation hedges. However, it is hard to find empirical evidence that all commodity futures are good inflation hedges or that the average commodity futures is a good inflation hedge.

Table 5

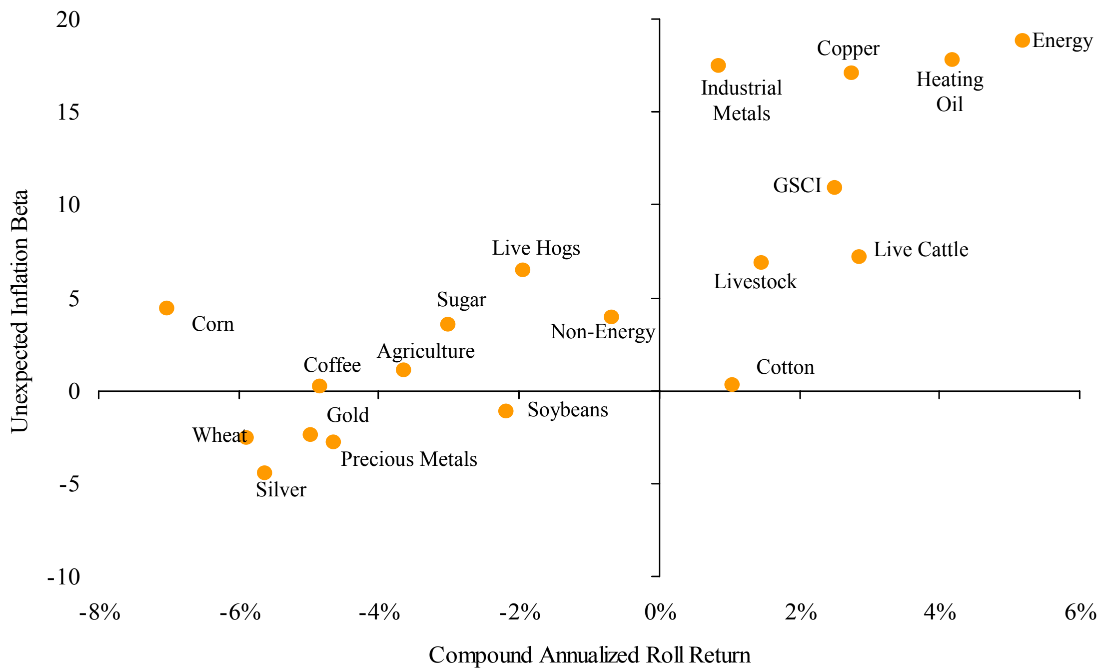
Commodity Excess Return And Change in Annual Inflation

Annual Observations, 1982 to 2003

	Intercept	Intercept T-Stat	Inflation Coefficient	Inflation T-Stat	ΔInflation Coefficient	ΔInflation T-Stat	Adjusted R Square
GSCI	-5.27%	-0.38	3.92	0.93	10.88	**2.98**	28.0%
Non-Energy	-5.37%	-0.64	1.84	0.71	3.94	1.77	6.0%
Energy	-9.02%	-0.36	7.50	0.97	18.80	**2.81**	24.5%
Livestock	-11.90%	-1.15	4.73	1.49	6.88	**2.51**	17.6%
Agriculture	-7.60%	-0.67	1.68	0.48	1.06	0.35	-9.6%
Industrial Metals	6.71%	0.26	1.20	0.15	17.44	**2.59**	26.7%
Precious Metals	20.93%	2.36	-8.02	**-2.95**	-2.78	-1.19	26.2%
Heating Oil	-6.40%	-0.26	6.07	0.81	17.76	**2.73**	23.9%
Cattle	-7.07%	-0.75	4.00	1.38	7.19	**2.87**	24.0%
Hog	-20.39%	-1.23	6.32	1.24	6.47	1.48	2.0%
Wheat	-13.24%	-0.87	3.09	0.67	-2.58	-0.64	-0.1%
Corn	-23.02%	-1.37	5.91	1.15	4.44	1.00	-2.6%
Soybeans	20.50%	1.17	-5.95	-1.11	-1.10	-0.24	-2.8%
Sugar	1.39%	0.06	-0.06	-0.01	3.56	0.61	-7.7%
Coffee	4.25%	0.11	-0.81	-0.07	0.24	0.02	-11.0%
Cotton	6.74%	0.31	-0.51	-0.08	0.30	0.05	-11.0%
Gold	19.16%	2.02	-7.50	**-2.58**	-2.38	-0.95	20.3%
Silver	24.83%	2.16	-10.18	**-2.89**	-4.45	**-1.46**	24.3%
Copper	7.15%	0.27	1.43	0.18	17.08	2.45	23.8%
EW Twelve Commodities	1.16%	0.14	0.15	0.06	3.88	1.74	10.3%

Why might some commodity futures be better inflation hedges than others? With the usual caveat that these results only describe a specific time period, Figure 11 shows that average roll returns are highly correlated with unexpected inflation betas. In fact, average roll returns explain 67% of the cross-sectional variation of commodity futures unexpected inflation betas. Commodities such as copper, heating oil, and live cattle had positive roll returns and high unexpected inflation betas. Commodities such as wheat, silver, gold and soybeans had negative roll returns and negative unexpected inflation betas. What explains the historical linkage between roll returns and inflation betas? Table 2 shows some commodities that Till (2000, 2003) suggests are difficult to store, and it is these commodities that seem to have had high roll returns and positive unexpected inflation betas. The difficulty of storage could be a general, or time period specific, link between roll returns and unexpected inflation betas.

Figure 11
Unexpected Inflation Betas and Roll Returns
December 1982 to December 2003



A time period specific analysis of the inflation hedging ability of this specific universe of commodity futures yields a number of observations. First, individual commodity futures have experienced varying exposures to unexpected inflation. Second, the unexpected inflation hedging efficacy of an individual commodity future has historically been correlated with its roll return. Third, the ability of a commodity futures portfolio to serve as an inflation hedge is driven by the composition of the portfolio. Fourth, a portfolio that historically maximized the ability to hedge inflation focused on commodity futures that are difficult to store.

3.8.3 Are commodity futures sensitive to other "market risk" factors?

Even though commodity returns seem to be largely uncorrelated with one another, perhaps they exhibit some common connection to other pervasive risk factors. For instance, research by Bailey and Chan (1993) estimated a connection between the commodity futures basis (the spread between spot commodity and futures prices) and a number of factors[xxiii] over the 1966 to 1987 period. The focus here is on being thorough, not hopeful, in the search for systematic risk influences. The very low correlations between commodity futures makes it challenging to believe that uncorrelated individual commodity futures are in some way correlated with one or many common factors.

A simple starting point for a multifactor examination of commodity futures returns is the five-factor model of Fama and French (1993). This model contains three equity market risk factors (market excess return, a high minus low book to market return (HML) and a small minus large capitalization return (SML)), as well as a term spread return (long-term bond excess return) and a default spread (corporate bond return minus government bond return). While Fama and French find that these last two factors are priced for bonds but not for stocks, they might be important for commodity futures. Finally, following Ferson and Harvey (1993) and Dumas and Solnik (1995), it might be worthwhile to consider the foreign exchange rate exposure of commodity futures. Significant exposure to these factors would support the case for a commodity futures risk premium associated with these risk factors. Absence of significant exposure to these factors is not, however, an indication that the expected return of commodity futures is zero. Rather it is just a sign of lack of correlation with certain proposed risk factors that have been widely studied in the empirical finance literature.

Table 5 presents the unconditional (i.e. assumed constant) monthly betas of commodity excess returns relative to a common set of risk factors. None of the Fama and French (1993) factors are significant in the regression from 1982-2004. The GSCI has a statistically significant negative beta with regard to the change in trade weighted dollar. The non-energy sector has a statistically significant, but small, equity risk premium beta and energy has a statistically significant negative dollar beta. Reinforcing the earlier observation that commodity futures have low correlations with one another, there are no uniformly positive or negative sensitivities to these risk factors across individual commodities. Nor are there any risk factors that seem to be more important than others in explaining the time series variation of individual commodity futures returns.

Table 6

Unconditional Commodity Futures Betas

Monthly Observations, December 1982 to May 2004

	S&P 500 Excess Return	Term Premium	Default Premium	SMB	HML	ΔDollar
GSCI	-0.05	-0.05	-0.25	0.07	-0.06	-0.57 **
Non-Energy	0.10 **	-0.11	-0.03	0.05	0.00	-0.05
Energy	-0.14	-0.17	-0.07	0.04	-0.07	-1.05 **
Livestock	0.06	0.05	-0.23	0.05	0.04	0.09
Agriculture	0.09	-0.01	-0.12	0.06	-0.02	0.10
Industrial Metals	0.16 *	-0.32 **	1.18 ***	0.19	-0.05	-0.35
Precious Metals	-0.08	-0.15	0.42	0.14 *	-0.03	-0.83 **
Heating Oil	-0.13	-0.22	-0.14	0.06	-0.16	-0.91 **
Cattle	0.07	0.01	-0.10	0.11	-0.01	0.21
Hogs	0.03	0.15	-0.45	-0.04	0.13	-0.08
Wheat	0.11	0.04	-0.42	0.19 *	-0.12	-0.18
Corn	0.11	0.00	0.13	0.09	-0.01	0.55 *
Soybeans	0.04	-0.07	0.13	-0.02	0.08	-0.07
Sugar	0.05	-0.11	-0.43 *	0.16	-0.09	0.12
Coffee	0.13	-0.15	0.38	-0.25 *	0.16	-0.22
Cotton	0.18	-0.41	0.88	-0.08	0.03	0.46
Gold	-0.15 **	-0.12	0.39	0.12 ***	-0.04	-0.91 ***
Silver	0.08	-0.52 ***	1.16 ***	0.32 **	-0.02	-0.39
Copper	0.21 **	-0.31 *	1.15 ***	0.16	0.00	-0.42
Twelve Commodity Average	0.06	-0.14 **	0.22	0.07	0.00	-0.15

Note: *, **, *** significant at the 10%, 5% and 1% levels.

The message of this risk analysis is simple. Traditional risk measures do not drive commodity futures returns. Reaffirming the earlier work of Dusak (1973), the beta of both a diversified commodity futures portfolio and individual commodity futures with the equity market is indistinguishable from zero. The five additional risk factors do not seem to be useful in explaining the returns of a commodity futures portfolio or the returns of individual commodity futures. The only significant driver of the returns of the GSCI is its beta with respect to foreign exchange rate changes. However, since there is no consensus as to the existence of an average foreign exchange risk premium, exposure to a factor with an uncertain risk premium helps explain return volatility but it does nothing for a traditional risk based explanation of average return. Among the individual commodities, there are some scattered betas that are significant (6 of the 72 betas are significant at the 1% level and 3 of the beats are significant at the 5% level). Of these nine significant betas, eight are concentrated in gold and silver. Given that some believe that gold is a financial futures it is hard to say what this means for a risk based explanation of commodity futures. In short, the limited risk exposure of commodity futures against a set of standard risk factors does not support the case that these risk factors explain the returns of commodity futures.

The preceding analysis highlights the inability of inflation and a grab bag of "risk factors" to explain the time series of commodity futures returns. Table 4 points out that individual commodity futures returns have not, on average, been statistically different from zero. Should an investor just give up and assume that the return from investing in a portfolio of commodity futures will be zero also? The answer is no.

3.9 Turning water into wine: The diversification return

One of the potential compound return drivers of a commodity futures portfolio is the diversification return, a term coined by Booth and Fama (1992). The diversification return is the difference between a portfolio's geometric return and the weighted average geometric return of a portfolio's constituents. Under certain circumstances, the diversification return can appreciably raise the geometric return of a fixed weight, or rebalanced, commodity futures portfolio. As Erb and Harvey (2006a) show, with some minor and technical qualifications,[xxiv] unrebalanced portfolios, such as market capitalization weighted portfolios, are unlikely to benefit from a diversification return to the same extent as fixed-weight, rebalanced, portfolios. It is important not to confuse any of the returns generated by rebalancing with risk premia. Campbell (2000) calls portfolio diversification the one "free lunch" in finance because it allows an investor to reduce a portfolio's standard deviation of return without reducing the portfolio's arithmetic return. The diversification return can be seen as the one free lunch that can raise a portfolio's geometric return.

Table 7 illustrates the mechanics of the portfolio diversification return for an equally weighted portfolio using historical annual excess returns for the GSCI heating oil index and the S&P 500 over the 1993 to 2003 period. Heating oil has a geometric annual excess return of 8.21%, the S&P 500 has a geometric annual excess return of 6.76%, and the equally weighted average of these two returns is 7.49%. The geometric excess return of an equally weighted annually rebalanced portfolio is 10.95%. The diversification return is simply the difference between 10.95% and 7.49%, or 3.46%. In this "turning water into wine" example, the return of the rebalanced portfolio is much higher than the return of either of the two portfolio constituents.

Where does this incremental return come from? From variance reduction. Start with the idea that the geometric return of an asset can be approximated as the asset's arithmetic return less one half the asset's variance[xxv]. While variance measures the volatility of an individual security, a portfolio's variance is simply the weighted average of the covariances of individual securities with the portfolio. The equally weighted average variance of heating oil and stocks is 11.44% and the variance of the equally weighted portfolio is 4.52%, a difference in variance of 6.91%. One half of 6.91 is 3.46%; 3.46% is the variance reduction benefit, and the diversification return, of the equally weighted portfolio. As a rule of thumb, Erb and Harvey (2006a) find that the geometric return of a rebalanced portfolio will be greater than the weighted average geometric return of the portfolio's constituents.

Table 7 also lays out the diversification return for an initially equally weighted but unrebalanced portfolio (let-it-run portfolio). In this instance, the diversification return has two components: a variance reduction benefit and an impact of not rebalancing. The variance reduction benefit for the unrebalanced portfolio is equal to one half the difference between the weighted average individual security variance of 10.68% and the unrebalanced portfolio variance of 3.53%, or 3.57%. Notice that in this case the let-it-run portfolio has a *lower* variance, and a larger variance reduction benefit, than the equally-weighted portfolio. The second component of the unrebalanced portfolio's diversification return is the impact of not rebalancing. This is simply the covariance between an asset's weight in a portfolio and the asset's return. For instance, the impact of not rebalancing heating oil is -2.51%, the covariance between the portfolio weight of heating oil in the unrebalanced portfolio and the return of heating oil. The impact of not rebalancing the S&P 500 position is -0.97%, the covariance between the portfolio weight of the S&P 500 in the unrebalanced portfolio and the return of the S&P 500. The sum of these two values is -3.48%, the total impact of not rebalancing.

Another way to think of the impact of not rebalancing is as a "covariance drag". The actual arithmetic return of the unrebalanced portfolio, 9.28%, is simply the portfolio's weighted average arithmetic return, 12.75%, less the covariance drag, -3.48%. The -3.48% covariance drag almost completely offsets the 3.57% variance reduction benefit of the unrebalanced portfolio. Erb and Harvey (2006a) find the geometric return of an unrebalanced portfolio will often approximate the weighted average geometric return of a portfolio's constituents.

The label 'diversification return' might seem somewhat novel or confusing. Some who read Booth and Fama (1992) might not realize that there is more to the diversification return than just a variance reduction benefit. Table 7 makes clear that the diversification return includes both a variance reduction effect and any impact from not rebalancing.

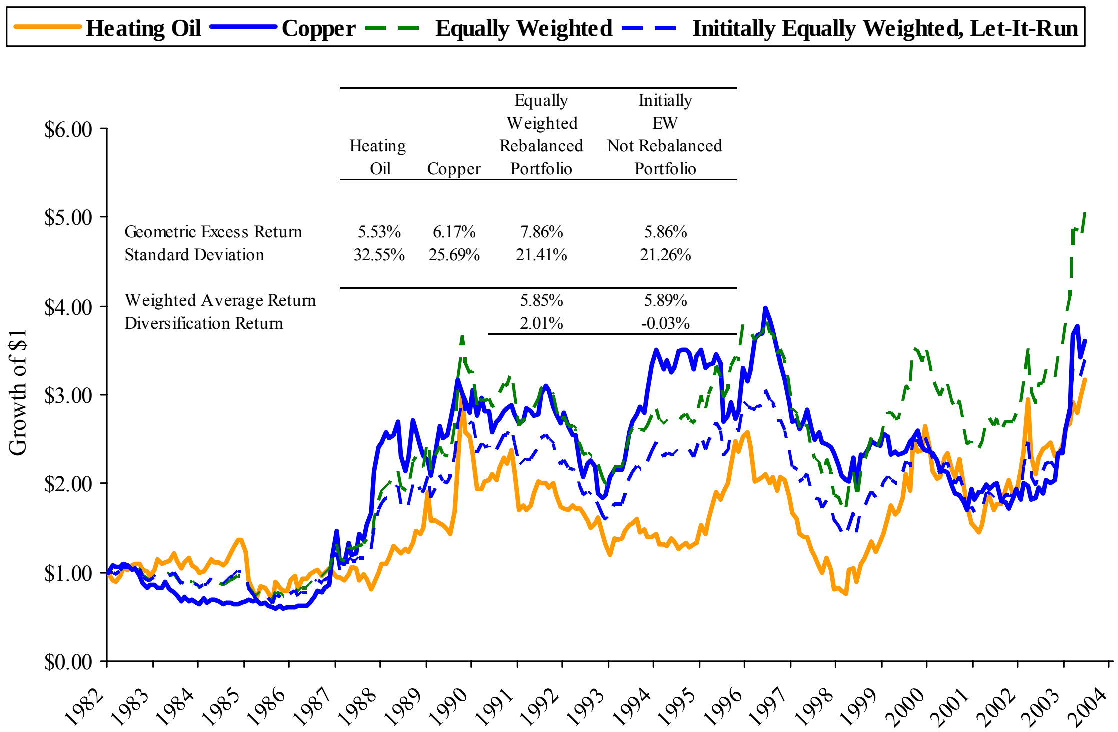
Table 7

The Diversification Return

					Portfolio weights (fixed)		Portfolio weights (let it run)	
	Heating Oil Excess Return	S&P 500 Excess Return	Equally Weighted Excess Return	Initially Equally Weighted Excess Return	Equally Weighted Heating Oil	Equally Weighted S&P 500	Initially Equally Weighted Heating Oil	Initially Equally Weighted S&P 500
1994	19.96%	-2.92%	8.52%	8.52%	50.0%	50.0%	50.0%	50.0%
1995	7.73%	31.82%	19.78%	18.51%	50.0%	50.0%	55.3%	44.7%
1996	67.37%	17.71%	42.54%	42.66%	50.0%	50.0%	50.2%	49.8%
1997	-35.06%	28.11%	-3.48%	-9.13%	50.0%	50.0%	58.9%	41.1%
1998	-50.51%	23.51%	-13.50%	-7.67%	50.0%	50.0%	42.1%	57.9%
1999	73.92%	16.30%	45.11%	29.31%	50.0%	50.0%	22.6%	77.4%
2000	66.71%	-15.06%	25.82%	9.77%	50.0%	50.0%	30.4%	69.6%
2001	-36.62%	-15.97%	-26.30%	-25.49%	50.0%	50.0%	46.1%	53.9%
2002	41.40%	-23.80%	8.80%	1.78%	50.0%	50.0%	39.2%	60.8%
2003	21.90%	27.62%	24.76%	24.50%	50.0%	50.0%	54.5%	45.5%
Average Portfolio Weights					50.0%	50.0%	44.9%	55.1%
Arithmetic Average	17.68%	8.73%	13.21%	9.28%				
Geometric Average	8.21%	6.76%	10.95%	7.51%				
Standard Deviation	43.51%	19.85%	21.26%	18.79%				
Variance	18.93%	3.94%	**4.52%**	**3.53%**				
Return Decomposition								
Weighted Average ArithmeticReturn			13.21%	12.75%				
Impact of Not Rebalancing			0.00%	-3.48%	0.0%	0.0%	-2.51%	-0.97%
Portfolio Arithmetic Return			13.21%	9.28%				
Portfolio Geometric Return			10.95%	7.51%				
Weighted Average Geometric Return			7.49%	7.41%				
Diversification Return			3.46%	0.10%				
Weighted Average Portfolio Variance			11.44%	10.68%				
Portfolio Variance			4.52%	3.53%				
Variance Reduction			6.92%	7.15%				
Variance Reduction Benefit			3.46%	3.57%				
Impact of Not Rebalancing			0.00%	-3.48%				
Diversification Return			3.46%	0.10%				

The example in Table 7 has only ten annual observations. What happens if a portfolio can rebalance monthly, rather than annually? Figure 12 illustrates the diversification return with two commodity futures, heating oil and copper using monthly data from December 1982 to May 2004. Heating oil has a geometric average excess return of 5.53% and copper has a geometric average excess return of 6.17%. An equally-weighted portfolio that rebalances monthly has a geometric excess average return of 7.86%, and a diversification return of 2.01%. A portfolio that initially has 50% invested in heating oil and 50% in copper, and did not rebalance, has a return of 5.86% and a diversification return of -0.03%. The diversification return of the rebalanced portfolio is positive because of a variance reduction benefit, and the diversification return of the unrebalanced portfolio is negative because the covariance drag is greater than the variance reduction benefit.

Figure 12
The Diversification Return With Two Commodity Futures
December 1982 to May 2004



	Heating Oil	Copper	Equally Weighted Rebalanced Portfolio	Initially EW Not Rebalanced Portfolio
Geometric Excess Return	5.53%	6.17%	7.86%	5.86%
Standard Deviation	32.55%	25.69%	21.41%	21.26%
Weighted Average Return			5.85%	5.89%
Diversification Return			2.01%	-0.03%

Figure 3 shows positive returns for both rebalanced and unrebalanced portfolios. Does Figure 3 pose a problem for the preceding analysis of the diversification return? The answer is no. The geometric excess returns of the rebalanced portfolios in Figure 3 are entirely driven by the variance reduction return. The geometric excess returns of the unrebalanced portfolios in Figure 3 are driven by changing portfolio asset mixes. On average and over a long enough time period, unrebalanced portfolios can potentially end up being dominated by the portfolio constituents with the best sample specific performance. As a result, the geometric return of an unrebalanced portfolio can often be approximated as the weighted average geometric return of the portfolio constituents. This suggests that on average it is best to assume that the diversification return of an unrebalanced portfolio will be close to zero. Furthermore, as Figure 3 points out, even with a long time horizon, the return-to-risk ratio of an unrebalanced portfolio will, on average, be lower than the return-to-risk ratio of a rebalanced portfolio.

What are those circumstances that lead to a rebalancing pay-off? There is a fairly simple formula for the diversification return of an equally weighted rebalanced portfolio:[xxvi]

$$\textit{Expected Equally Weighted Rebalanced Portfolio Diversification Return} = \frac{1}{2}\left(1-\frac{1}{K}\right)\overline{\sigma}^{2}\left(1-\overline{\rho}\right)$$

All this says is that the diversification return rises as the average variance ($\overline{\sigma}^{2}$) of the securities in a portfolio rises, as the average correlation ($\overline{\rho}$) of the securities in the portfolio falls and as the number of securities, *K*, in the portfolio rises. Some investors might be skeptical and assert that historical demonstration of the diversification return is just the result of a time period specific mean reverting strategy in which it made sense to "sell winners and buy losers". As the above equation shows, this is need not be the case. The equation allows an investor to calculate the expected, base case, diversification return when asset returns are serially uncorrelated. How close to "real world" results have the predictions of this model been?

Table 8 illustrates how a rebalanced portfolio's expected diversification return varies with these inputs. For example, for an equally weighted portfolio of 30 securities with average security standard deviations of 30% per annum and average security correlations ranging from 0.0 to 0.3, the diversification return ranges from 3.05% to 4.35%.

Table 8
Diversification Return Drivers

		Diversification Return				
		Number of Securities In Portfolio				
Average Correlation	Average Standard Deviation	10	15	20	25	30
0.00	10%	0.45%	0.47%	0.48%	0.48%	0.48%
0.10	10%	0.41%	0.42%	0.43%	0.43%	0.44%
0.20	10%	0.36%	0.37%	0.38%	0.38%	0.39%
0.30	10%	0.32%	0.33%	0.33%	0.34%	0.34%
0.00	20%	1.80%	1.87%	1.90%	1.92%	1.93%
0.10	20%	1.62%	1.68%	1.71%	1.73%	1.74%
0.20	20%	1.44%	1.49%	1.52%	1.54%	1.55%
0.30	20%	1.26%	1.31%	1.33%	1.34%	1.35%
0.00	30%	4.05%	4.20%	4.28%	4.32%	4.35%
0.10	30%	3.65%	3.78%	3.85%	3.89%	3.92%
0.20	30%	3.24%	3.36%	3.42%	3.46%	3.48%
0.30	30%	2.84%	2.94%	2.99%	3.02%	3.05%
0.00	40%	7.20%	7.47%	7.60%	7.68%	7.73%
0.10	40%	6.48%	6.72%	6.84%	6.91%	6.96%
0.20	40%	5.76%	5.97%	6.08%	6.14%	6.19%
0.30	40%	5.04%	5.23%	5.32%	5.38%	5.41%

The diversification return is a pay-off to one of the few high confidence ways, rebalancing a portfolio, that an investor can boost portfolio geometric return. When asset variances are high and correlations are low, the diversification return can be very high. Bodie and Rosansky, for example, reported an equally weighted portfolio geometric excess return of 8.52% for their commodity futures portfolio. The average standard deviation of the securities in their portfolio was about 40% per annum. If commodity futures correlations averaged 0.10, in line with the evidence of Table 3, then the expected diversification return of their portfolio was close to 7% -- almost all of the return of their equally weighted portfolio. Gorton and Rouwenhorst reported a 4.52% excess return for their equally weighted portfolio and the average standard deviation of the securities in their portfolio was about 30%. Depending upon assumed average correlations, this suggests a diversification return in the range of 3-4.5%, almost all of the excess return of the Gorton and Rouwenhorst commodity futures portfolio. In yet another example of the diversification return, De Chiara and Raab (2002) document a 2.8% diversification return for the rebalanced Dow Jones AIG index during the time period 1991 to 2001.

Thoughtful investors quickly learn to be skeptical of stories suggesting easy ways to boost investment returns. There are two circumstances that could result in the elimination of a portfolio's diversification return. A portfolio's diversification return would be zero is all of the assets in a portfolio had standard deviations of return of zero. A portfolio's diversification return would also be zero if the correlations of all assets in the portfolio were exactly one. At the margin, negative autocorrelation of returns might boost the base case diversification return and positive autocorrelation of returns might lower the base case diversification return. However, until the day arrives that all standard deviations are zero and all correlations are one, the diversification return is likely to be a valuable source of return[xxvii].

Two last points merit attention. First, it is easier for an investor to calculate the forward looking return of a rebalanced portfolio than it is to calculate the forward looking return of an unrebalanced portfolio. For a rebalanced portfolio, all an investor needs are estimates of expected returns, volatilities and correlations. Many investors are aware of these concepts, even if they ignore them in practice. The return of an unrebalanced portfolio is more complex since it requires the calculation of the return of a rebalanced portfolio and a path dependent estimate of the impact of not rebalancing. This path dependency makes extrapolation of the historical impact of not rebalancing problematic and highlights the challenges of naively using the historical return of an unrebalanced portfolio as the basis for forward looking expectations. Second, the return of an unrebalanced, buy-and-hold, portfolio might be higher than that of a rebalanced portfolio. Of course, if an unrebalanced portfolio outperforms a rebalanced portfolio it is important to determine if the higher return was due to greater capital efficiency, a higher Sharpe ratio, or to a greater level of risk. Plaxco and Arnott (2002) and Erb and Harvey (2006b) point out that rebalanced portfolios typically have higher Sharpe ratios than unrebalanced portfolios, suggesting that the possible outperformance of a buy-and-hold portfolio might often be due to greater risk.

3.10 The need for long-term expected returns

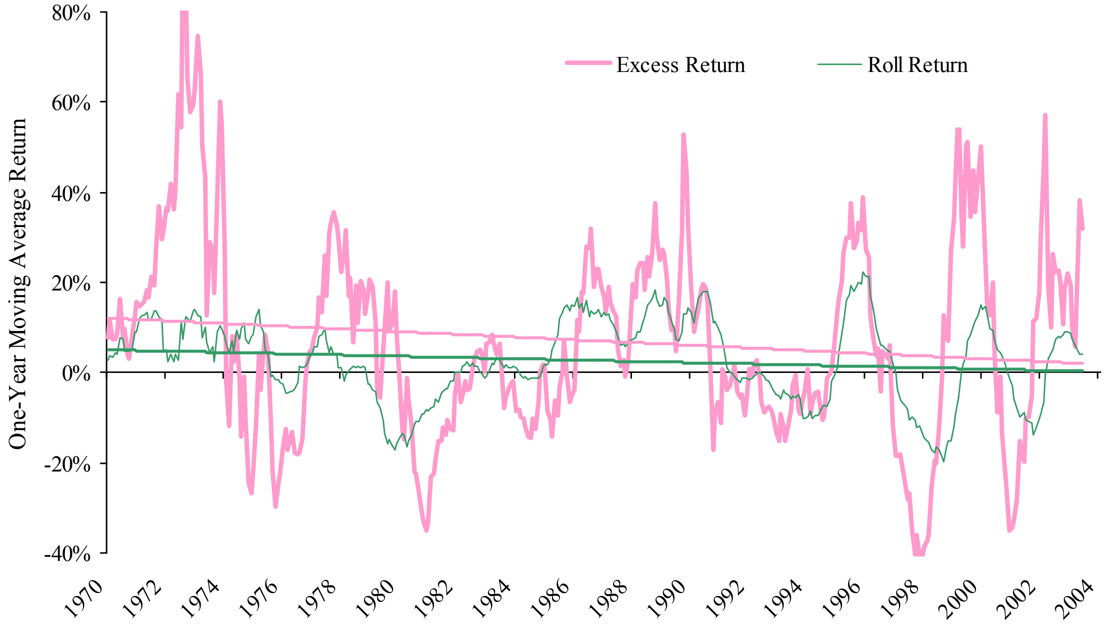
The preceding analysis sets the stage for establishing long term return expectations for a portfolio of commodity futures. One way to derive forward looking return expectations for a long-only commodity futures investment is to focus on the building blocks of excess return for a commodity futures portfolio: the diversification return, the roll return and the spot return. The easiest decision an investor can make is whether or not to rebalance a portfolio. If an investor rebalances a commodity futures portfolio, it might be possible to achieve a diversification return of, say, 3%, similar to the historical diversification return of the rebalanced Dow-Jones AIG. Depending upon the actual composition of a portfolio and the average volatilities and correlations of the portfolio constituents, the diversification return could be higher or lower than 3%. If the portfolio is not rebalanced, the diversification return will probably be close to zero, or perhaps, negative. Table 4 illustrated the challenge that investors face when assessing spot and roll returns using historical data: historically individual commodity futures excess and spot returns have not been statistically significant. Essentially it is unlikely that any long-term forecast of positive excess return or positive spot return for an individual commodity future is statistically supported by historical experience. Roll and spot returns for individual commodity futures must also be estimated with caution. High, or low, roll and spot returns in the past are not a guarantee of high, or low, roll and spot returns in the future. As a result, there is no one best estimate of the expected return of a commodity futures portfolio, though the diversification return is the easiest return driver to estimate.

3.11 The persistence of returns and the case for strategic asset allocation

Why does an investor have to bother with a forecast of expected return for a commodity futures portfolio? Isn't it possible just to extrapolate history? Figure 1 shows that historically the long-only GSCI had an excess return of about 6% per annum. However, this 6% excess return measures the performance of a commodity futures portfolio that has dramatically changed its composition over time. As a result it is hard to figure out what the 6% return measures. Figure 13 shows that rolling one-year GSCI excess and roll returns have exhibited a declining return trend over time. While this trend does not guarantee that returns will be higher or lower in the future, it points out, however, that excess returns have not been a constant 6% per annum.

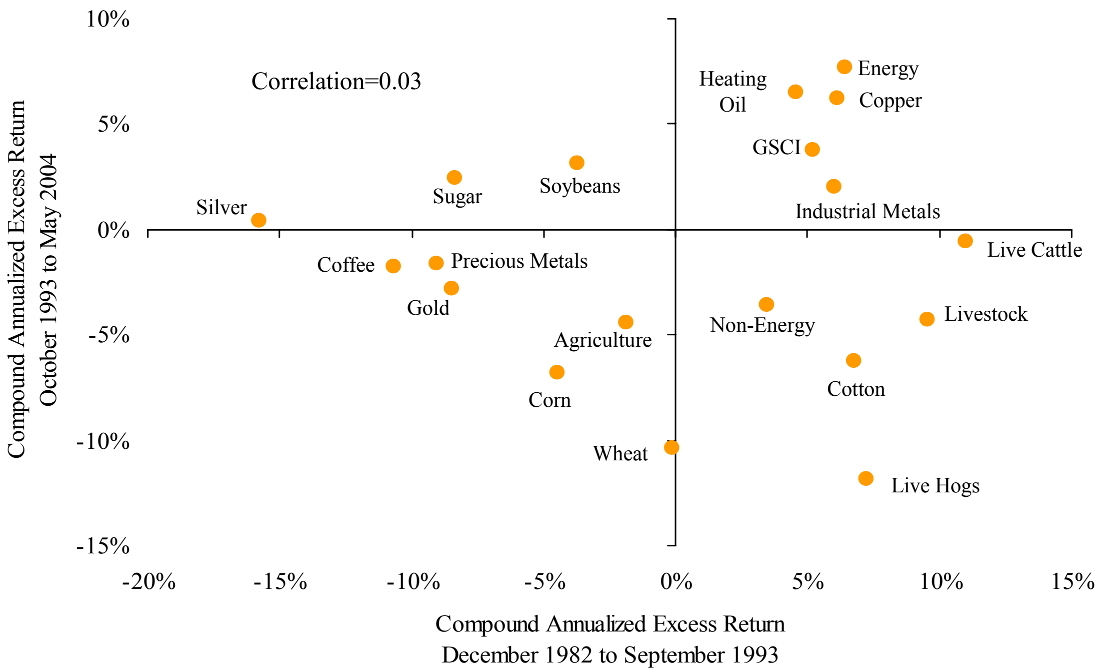
There is no all encompassing reason for the declining excess and roll returns in Figure 13. It might just be statistical noise. It might be the result of increased institutional investment in commodity futures driving up prices and driving down prospective returns. It might be the result of the way that the composition of the GSCI was cobbled together over time. Or there could be any number of meaningful or irrelevant explanations for the declining return trend in Exhibit 13. Additionally, even though the term structure of commodity prices may have been an important historical driver of realized commodity futures excess returns, there is no incontrovertible way to determine what the term structure of futures prices will look like in the future. For instance, crude oil futures are often, though not always, backwardated, but it is not obvious that crude oil futures will on average be backwardated in the future.

Figure 13
One-Year Moving Average GSCI Excess and Roll Returns
December 1969 to May 2004



Another way to try to salvage the case for naïve historical extrapolation of past returns is to look at return persistence over long periods of time. Figure 14 looks at the excess return persistence of the GSCI, GSCI sectors and individual commodity futures from December 1982 to September 1993 and from October 1993 to May 2004. The correlation between first period and second period returns is 0.03. The positive first period return-positive second return quadrant is populated by the energy and industrial metals sectors, and these two sectors drive the positive returns of the GSCI during both time periods. Each of the return quadrants has approximately the same number of observations. Given the specific universe of securities and the specific time period, there seems to be little evidence of long-term return persistence across commodity futures.

Figure 14
Long-Term Excess Return Persistence
December 1982 to May 2004



3.12 Making the strategic asset allocation bet

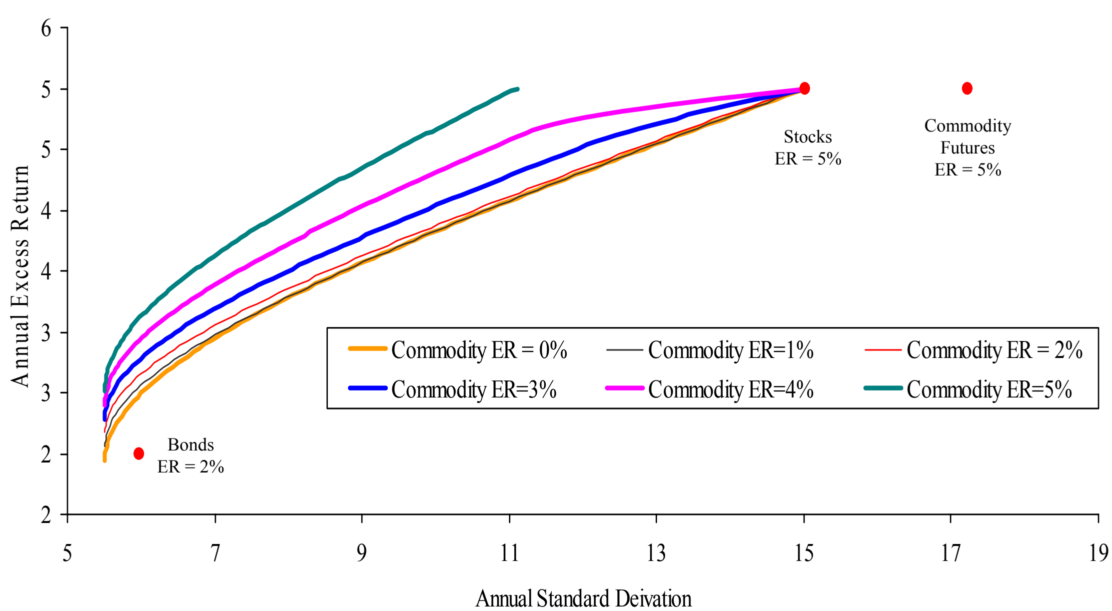
There are at least two ways that previous researchers have thought about the role of commodity futures in a strategic, or long-term, asset allocation: an asset only exercise and an asset-liability exercise. From an asset only perspective, Anson (1999) looks at the performance of stocks, bonds and cash collateralized commodity futures indices from 1974 to 1997, and finds that the demand for commodity futures rises as an investor's risk aversion rises and that an investor with high risk aversion should invest about 20% in commodities. Jensen, Johnson and Mercer (2000) examine portfolios that can invest in stocks, corporate bonds, Treasury-bills, real estate investment trusts and the cash collateralized GSCI over the period 1973 to 1997. They find that, depending upon risk tolerance, commodities should represent anywhere from 5-36% of investors' portfolios. Over the 1972 to 2001 period, Nijman and Swinkels (2003) address the issue from the standpoint of pension plans with nominal and real liabilities. They find that pension plans seeking to hedge nominal liabilities that already invest in long-term bonds and global equity are unlikely to improve risk adjusted returns through commodity investment. They find, though, that pension plans with liabilities indexed to inflation can significantly increase the return-risk trade off through commodity futures investment. A drawback of each of these analyses is that they all use historical returns. When undertaking a forward-looking asset allocation analysis, it is important to use forward-looking expected returns rather than historical returns.

Exhibit 15 shows six forward-looking asset only efficient frontiers. The assumptions underlying the efficient frontiers are that bonds have expected excess returns of 2% (where excess return simply refers to an asset's return in excess of the "risk-free rate"), that stocks have expected excess returns of 5% and that the expected return of a commodity futures portfolio ranges from 0% to 5%. Correlations and variances over the period 1969 to 2004 are used.

Given the expected excess returns for stocks and bonds, as the expected excess return for the commodity futures portfolio increases, the stock/bond/commodity futures efficient frontier rises. It is apparent that the efficient frontiers do not rise appreciably until the excess return for commodity futures rises to at least 3%. Conceptually, a 3% excess return is consistent with a commodity futures portfolio that has an expected diversification return of 3%, similar to the historical experience of the Dow Jones AIG index, and expected spot and roll returns of 0%. Other combinations of expected diversification, spot and roll returns are, of course, possible. Starting with a hypothetical diversification return of 3%, a 5% excess return could be achieved by assuming a 1% spot return and a 1% roll return, a 2% spot return and a 0% roll return, a 0% spot return and a 2% roll return, or any other combination of spot and roll returns that adds up to 2%. Bottom line, forward looking expected returns for commodity futures (as well as for stocks, bonds, hedge funds, anything) are just bets. The commodity futures bet has one really high confidence element, the diversification return, and two very uncertain elements, spot and roll returns.

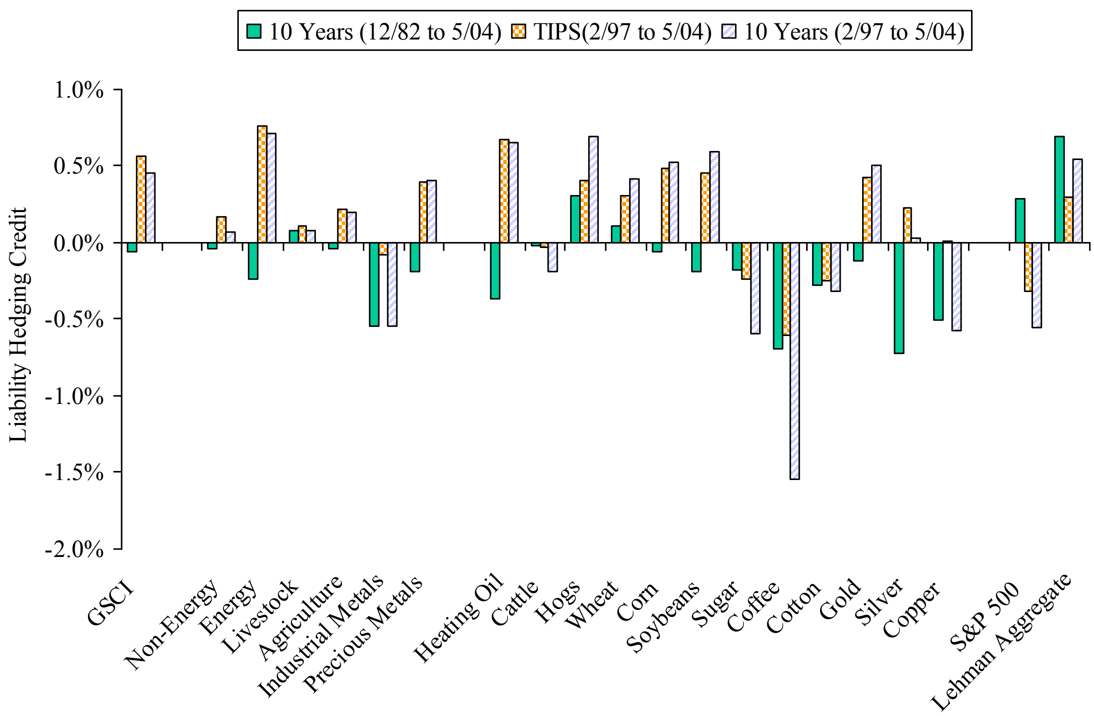
Say an investor is willing to bet that stocks have a forward looking excess return of 5%, bonds have a forward looking excess return of 2% and commodity futures portfolio will have a forward looking excess return of 3%. How much should an investor allocate to commodity futures? Obviously the answer depends upon an investor's risk tolerance. Perhaps an investor is comfortable with the volatility of a 60% stocks/40% bonds portfolio (in this example a volatility of about 10.1%). Given these assumptions, then, a portfolio with 18% in a commodity futures portfolio, 60% in stocks and 22% in bonds maximizes expected excess return for a targeted volatility of 10.1%. What drives these allocation changes? Returns and correlations. Figure 1 shows that historically stock and commodity returns were uncorrelated and that a portfolio that invested 50% in the S&P 500 and 50% in the GSCI had a lower level of volatility than either stocks or commodity futures. As a result, a mixed portfolio of stocks and commodity futures can possibly be more efficient, have a higher ratio of return to risk, than a stand alone stock portfolio. In Figure 15, assuming stock and bond returns are uncorrelated with commodity futures returns, commodity futures become a compelling portfolio asset when the expected excess return of commodity futures rises to 3%. Say, instead, that an investor only expected a 1% excess return from a commodity futures portfolio. The "optimal" allocation to commodity futures falls to 3%. With a 0% expected excess return, the recommended strategic asset allocation is 0%. Not surprisingly, the ideal allocation to commodity futures is largely a function of excess return expectations. And the expected return is just a bet.

Figure 15
Efficient Frontiers and Commodity Portfolio Excess Returns



What about investors who try to manage an asset portfolio relative to a liability? Sharpe and Tint (1990) suggested the "liability hedging credit" as a way to measure the return benefit of various assets for a liability centric investor. The Sharpe and Tint liability hedging credit is approximately twice the covariance of an asset's return with the return of the liability. In a forward looking optimization, the liability hedging credit should be added to an asset's forward looking expected return. Waring (2004) points out that liabilities can be nominal, not adjusted for inflation, or real, adjusted for inflation. Figure 16 illustrates the ambiguity involved in estimating the value of commodity futures in a liability focused setting. In this example, nominal liabilities are proxied by the returns of the ten year Treasury bond and real liabilities are proxied by the returns of the Citigroup inflation-linked bond index. Over the time period December 1982 to May 2004, few commodity futures had positive nominal liability hedging credits. Since the inception of the TIPS market in the U.S. in 1997, many commodity futures have had positive nominal and real liability hedging credits. Figure 16 illustrates that while it is easy to calculate a historical liability hedging credit, it is difficult to estimate prospective liability hedging credits. As a result, there is no clear evidence for or against the ability of commodity futures to hedge liabilities.

Figure 16
Liability Hedging Credit
December 1982 to May 2004



4. The search for predictable returns and tactical asset allocation

How might investors try to actively enhance the return of a commodity futures portfolio? To illustrate the opportunities and pitfalls of active management it might be useful to explore two possibilities. One possibility focuses on the earlier analysis indicating that the term structure of commodity futures historically explained a significant portion of the long run cross-section of commodity futures returns. Another possibility is to examine a simple momentum based trading strategy. The rationale for exploring this second possibility is the finding of Fung and Hsieh (2001) that most active managers of commodity futures portfolios, commodity trading advisors, are trend followers. As Spurgin (1999) points out, trend followers pursue price momentum strategies that rely upon the presumption that past price moves predict future price moves. Inherent in any active strategy is the controversial idea that asset returns are to some degree predictable. However, historical evidence of return predictability will only be useful for forward looking investment if the current predictability is sustained in the future.

Of course for many investors interested in a long-only exposure to commodity futures, a tactical approach will be unacceptable. The reason is that many long-only investors want to know that they always have a well defined long exposure to the "commodities market". Tactical strategies which can allocate amongst commodities, or go long or short commodity futures, will naturally leave these investors wondering about what sort of portfolio exposure they happen to have at any point in time.

4.1 Momentum and tactical asset allocation of a commodity index

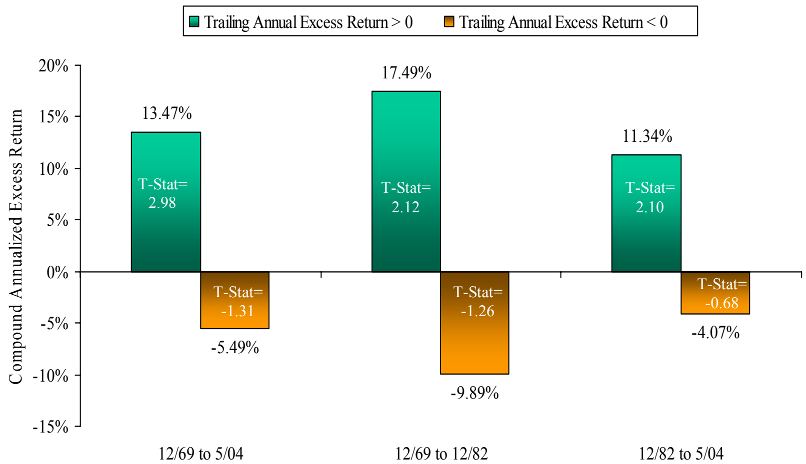
The possibility of both time-series and cross-sectional return predictability might make tactical allocation into commodity futures as well as among individual commodity futures attractive. Cochrane (1999) refers to findings of stock, bond and foreign exchange return predictability as "new facts in finance", and there is no reason why predictability should not extend to commodity futures returns.

Previous research has suggested a tactical role for commodity futures. Jensen, Johnson and Mercer (2000, 2002) found that the GSCI outperformed stocks and bonds when their (now discontinued) measure of Federal Reserve monetary policy rose. Strongin and Petsch (1996) found that GSCI returns were tied to current economic conditions and, when inflation rose, had above average returns and performed well relative to stocks and bonds. Nijman and Swinkels (2003) find that nominal and real portfolio efficient frontiers can be improved by timing allocation to the GSCI in response to variation in a number of macroeconomic variables (bond yield, the rate of inflation, the term spread and the default spread). Vrugt, Bauer, Molenaar and Steenkamp (2004) find that GSCI commodity index return variation is affected by measures of the business cycle, the monetary environment and market sentiment. These analyses suggest that commodity futures returns respond systematically to changes in state variables. Yet the low crosscorrelation of commodity returns with one another and the message of Tables 4, 5 and 6 suggest that these systematic influences have at best a weak ability to explain the time series variation of commodity excess returns.

While there is a considerable literature on momentum in equity markets (e.g. Jegadeesh and Titman (1993), Carhart (1997), Conrad and Kaul (1998)), there is no simple explanation as to why momentum works. Barberis, Shleifer and Vishny (1998) suggest that momentum is a behavioral artifact due to investor underreaction to news. Johnson (2004) argues that momentum returns are just payoffs for taking risk. Keim (2003) suggests that whatever the reason for the existence of a momentum return in paper portfolios created by researchers in reality the high turnover of momentum strategies will generate transactions costs that will consume most of the return from following a momentum strategy. Bottom line, investors can find a pro or con momentum argument to fit their individual beliefs.

A momentum strategy typically goes long an asset after prior returns have been positive and goes short an asset after prior returns have been negative. Figure 17 shows the pay-off to a strategy of going long the GSCI for one month if the previous one year excess return has been positive or going short the GSCI if the previous one year excess return has been negative. The choice of a one month investment period and a one year lookback period is arbitrary, as are all investment and lookback periods for momentum strategies. While the momentum effect is strongest in the first 13 years of the sample, the effect is robust in the more recent period. Of course, the observed historical stability of this result says little about the prospective stability of this result.

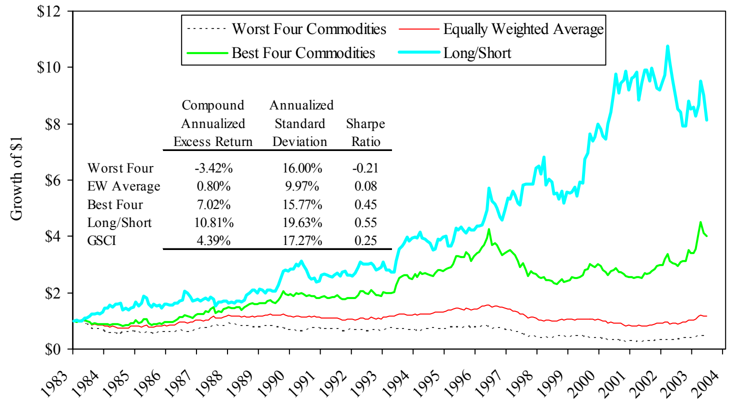
Figure 17
GSCI Momentum Returns
December 1982 to May 2004



4.3 Active allocation of the constituents of a commodity index

Many momentum strategy analyses look at the value-added of the strategy within an asset class, such as going long the best performing stocks and going short the worst performing stocks. Figure 18 examines the long only pay-off to investing in an equally-weighted portfolio of the four commodity futures with the highest prior twelve month returns, a long only portfolio of the worst performing commodity futures, and a long/short portfolio fashioned from these two portfolios. Consistent with many prior momentum studies, the winner portfolio has a high excess return (7.0%), the loser portfolio has low excess returns (-3.4%) and the long/short portfolio achieves higher excess returns (10.8%) and an even higher Sharpe (0.55) ratio than either the winner or the loser portfolios. The long/short portfolio Sharpe ratio is more than twice as high as the Sharpe ratio of the long-only GSCI.

Figure 18
Individual Commodity Momentum Portfolios
December 1982 to May 2004

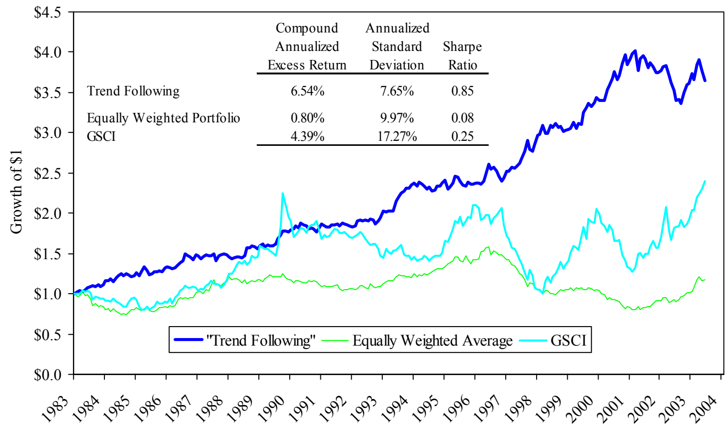


Trading strategy sorts each month the 12 categories of GSCI based on previous 12-month return. We then track the four GSCI components with the highest ('best four') and lowest ('worst four') previous returns. The portfolios are rebalanced monthly.

An alternative momentum strategy might be to go long those commodities that have had positive returns over the past 12 months and to go short those that have had negative returns. It is possible that in any particular month that all past returns are positive or negative and as a result all portfolio positions might be long or short. Figure 19 shows that this trend following portfolio had an excess return of 6.5% and a Sharpe ratio of 0.85. Note the trend following portfolio had higher returns and a higher Sharpe ratio than the long-only GSCI.

This result makes sense conceptually if one believes in momentum as a reliable source of return. This result is of absolutely no use if one harbors any doubt about the future pay-off to following a trend following strategy.

Figure 19
Individual Commodity Momentum Portfolio Based on the Sign of the Previous Return
December 1982 to May 2004



Trading strategy is an equally weighted portfolio of twelve components of the GSCI. The portfolio is rebalanced monthly. The 'trend following' portfolio goes long those components that have had positive returns over the previous 12 months and short those components that had negative returns over the previous period.

4.4 Tactical asset allocation using the term structure of futures prices

The previous analysis examined the historical pay-off to timing exposures to the GSCI and to individual commodity futures using momentum. It is also possible to examine the historical pay-off to time exposure to the GSCI and to individual commodity futures using the term structure of futures prices.

4.4.1 Term Structure and GSCI Tactical Asset Allocation

When the price of the nearby GSCI futures contract is greater than the price of the next nearby futures contract (when the GSCI is backwardated), one can gamble that the long only excess return should, on average, be positive. Nash (2003), for instance, finds that GSCI total returns are positive when the GSCI is backwardated. Furthermore, when the price of the nearby GSCI futures contract is less than the price of the next nearby futures contract (when the GSCI is in contango), one can speculate that the long only excess return should, on average, be negative. Since inception of GSCI futures trading, the GSCI has been backwardated as often as it has been in contango. The annualized payoff from buying the GSCI[xxviii] when the term structure has been backwardated is 11.2%. However, when the term structure is contagoed, the annualized excess return has been -5.0%. The payoffs are illustrated in Table 10. A strategy of going long the GSCI when backwardated and short when contangoed, and therefore always having an exposure to the GSCI, generates an excess return of 8.2% per annum compared to the average long-only excess return of 2.6% and a much higher Sharpe ratio. The term structure seems to have been an effective tactical indicator.

Table 9
Using the Information in the GSCI Term Structure for a Tactical Strategy
July 1992 to May 2004

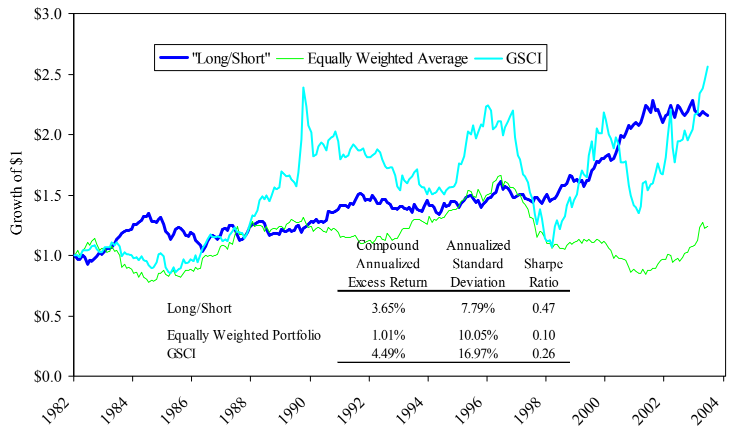
	Compound Annualized Excess Return	Annualized Standard Deviation	Sharpe Ratio
GSCI Backwardated	11.25%	18.71%	0.60
GSCI Contangoed	-5.01%	17.57%	-0.29
Long if Backwardated, Short if Contangoed	8.18%	18.12%	0.45
Cash Collateralized GSCI	2.68%	18.23%	0.15

4.4.2 Active Allocation of GSCI components

Exhibit 20 shows the results of a trading strategy based on the term structure of individual commodity futures.[xxix] Two portfolios are created: a long portfolio consisting of the six commodities with the highest ratio of nearby futures price to next nearby futures price, and a short portfolio consisting of the six commodities with the lowest ratio of nearby futures price to next nearby futures price. The Sharpe ratio of this long/short portfolio was 0.47, almost twice as high as the Sharpe ratio of the long-only GSCI and over four times higher than the equally weighted portfolio of twelve individual commodity futures. The term structure of commodity prices seems to have been a valuable tool for allocation across individual commodity futures. Of course, in all of these cases, it is important to remember the uncertain relationship between "has been" and "will be".

.

Figure 20
Individual Commodity Term Structure Portfolio
December 1982 to May 2004



Trading strategy is an equally weighted portfolio of twelve components of the GSCI. The portfolio is rebalanced monthly. The 'Long/Short' portfolio goes long those six components that each month have the highest ratio of nearby future price to next nearby futures price, and the short portfolio goes short those six components that each month have the lowest ratio of nearby futures price to next nearby futures price.

5. Conclusions

While commodity futures have been trading for hundreds of years, it is only recently that the debate has begun about including these assets in mainstream portfolios. The goal of this paper is to explore both the strategic and tactical opportunities that these assets present to investors.

A number of studies have argued that commodity futures are an appealing long-only investment class because they earn a risk premium similar to equities. Our paper argues that there are reasons to wonder what this is supposed to mean. Does the average commodity futures have 'equity-like' returns? Our research suggests that this has not been the case: the average returns of individual commodity futures contracts have been indistinguishable from zero. Might portfolios of commodity futures have "equity-like" returns? Here the answer seems to be a definitive "maybe". A commodity futures portfolio might have "equity-like" returns if it is able to achieve a high enough diversification return. The diversification return is a reasonably reliable source of return. Or a commodity futures portfolio can have "equity-like" returns by skewing portfolio exposures towards commodity futures that are highly certain to have positive roll or spot returns in the future. The challenge for investors, though, is that while spot and roll returns might be high in the future, there is really nothing in the historical record to give investors comfort that future spot and roll returns will be substantially positive.

The nuanced case for strategic allocation to long-only commodity futures extends to the case for commodity futures tactical allocation. Historical evidence suggests that momentum-based strategies, as well as strategies that use the information in the term structure of futures prices, have achieved attractive returns. However, there is no way to guarantee that the historically observed pay-off to momentum or term structure signals will persist in the future. If an investor wishes to bet on the persistence of historical patterns of return, then our empirical tactical asset allocation results suggest a way to allocate across asset classes as well as within a portfolio of commodity futures.

References

Ankrim, Ernest M., and Chris R. Hensel. 1993. "Commodities in Asset Allocation: A Real-Asset Alternative to Real Estate?" *Financial Analysts Journal*, vol. 49, no.3 (May/June): 20-29.

Anson, Mark J. P.. 1999. "Maximizing Utility with Commodity Futures Diversification", *Journal of Portfolio Management*, (Summer): 86-94.

Anson, Mark J. P..2002. *Handbook of Alternative Assets*, Wiley Finance.

Anson, Mark J. P and Ho Ho. 2004. "Measuring the Long Volatilty Strategies of Managded Futures", a chapter in *Commodity Trading Advisors* (edited by Greg N. Gregoriou, Vassilios N. Karavas, Francois-Serge Lhabitant and Fabrice Rouah) Wiley, New Jersey, 2004.

Arnott, Robert D. 2004. "Blinded by Theory", Journal of Portfolio Management, 30th Anniversary issue: 113-123.

Arnott, Robert D., and Peter L. Bernstein. 2002. "What Risk Premium Is Normal." *Financial Analysts Journal*, vol. 58, no.2 (March/April): 64-85.

Arnott, Robert D., Jason Hsu, and Philip Moore. 2005. "Fundamental Indexation" *Financial Analysts Journal*, vol. 61, no.2 (March/April): 64-85.

Bailey, Warren, and K. C. Chan. 1993. "Macroeconomic Influences and the Variability of the Commodity Future Basis", *Journal of Finance*, (June):555-573.

Barberis, N., A. Shleifer, and R. Vishny, 1998. "A Model of Investor Sentiment," *Journal of Financial Economics*, 49, 307-343

Bessembinder, Hendrik. 1992."Systematic Risk, Hedging Pressure and Risk Premiums in Futures Markets", *Review of Financial Studies*, vol. 5, no. 4: 637-667.

Black, Fischer. 1976. "The pricing of commodity contracts", *Journal of Financial Economics*, vol. 3, 167-179.

Bodie, Zvi and Victor Rosansky. 1980. "Diversification Returns And Asset Contributions", *Financial Analysts Journal*, (May/June): 26-32.

Booth, David G., and Eugene F. Fama. 1992. "Diversification Returns And Asset Contributions", *Financial Analysts Journal*, (May/June): 26-32.

Brennan, Michael J. 1991. "The Price of Convenience and the Valuation of Commodity Contingent Claims", on D. Land, B. Oeksendal, (Eds.), *Stochastic Models and Options Value*s, Elsevier Science Publications.

Campbell, John Y. 2000. "Diversification: A Bigger Free Lunch", Canadaian Investment Review, vol. 13: 14-15.

Carhart, Mark M. 1997. "On Persistence in Mutual Fund Performance", Journal of Finance, (March): 57-82.

Chiara, Adam de, and Daniel M. Raab, "The Benefits of Real Asset Portfolio Diversification", AIG Trading Group.

Clarke, Roger, Harinda de Silva and Steven Thorley. 2002. "Portfolio Constraints and the Fundamental Law of Active Management." *Financial Analysts Journal*, vol. 58, no.5 (September/October): 48-67.

Cochrane, John H. 1999. “New Facts in Finance”, NBER working paper 7169.

Cootner, Paul H. 1960. *Journal of Political Economy*, vol. 68., 396-404

De la Grandville, Olivier. 1998. “The Long-Term Expected Rate of Return: Setting it Right, *Financial Analysts Journal*, vol.54, no. 6: 75-80.

Deaves, Richard, and Itzhak Krinsky. 1995. “Do Futures Prices For Commodities Embody Risk Premiums”, *Journal of Futures Markets*, (September): 637-648.

Dimson, Elroy, Paul Marsh, and Mike Staunton. 2002. "Global Evidence on the Equity Risk Premium”, London Business School working paper: 1-15

Dimson, Elroy, Paul Marsh, and Mike Staunton. 2004. "Irrational Optimism", *Financial Analysts Journal*, vol. 60, no. 1 (January/February): 15-25.

Dimson, Elroy, Paul Marsh, and Mike Staunton. 2001. *Triumph of the Optimists*. Princeton University Press.

Dusak, Katherine. 1973. *Journal of Political Economy*, vol. 81, no. 6: 1387-1406

Elton, Edwin J., Martin J. Gruber and Joel C. Rentzler. 1987. “Professionally Managed, Publicly Traded Commodity Funds”, *Journal of Business*, vol.60, no. 2: 175-199.

Erb, Claude and Campbell R. Harvey, 2006a, “Unconditional Alpha,”,Working paper, Duke University.

Erb, Claude and Campbell R. Harvey, 2006b, “The Tactical and Strategic Value of Commodity Futures,” *Financial Analysts Journal,* March/April.

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

Fama, Eugene F., and Kenneth R. French. 1992. "Common Risk Factors in the Returns on Stocks and Bonds", *Journal of Financial Economics*, vol. 33: 3-56.

Fama, Eugene F., and Kenneth R. French. 1992. "The Cross-Section of Expected Stock Returns”, *Journal of Finance*, vol. 47: 427-465.

Fernholz, Robert, and Brian Shay. 1982. “Stochastic Portfolio Theory and Stock Market Equilibrium”, *Journal of Finance*, vol. 37: 615-624.

Froot, Kenneth A. 1995. “Hedging Portfolios with Real Assets”, Journal of Portfolio Management, Summer: 60-77.

Fung, William and David A. Hsieh. 2001. “The Risk in Hedge Fund Strategies: Theory and Evidence from Trend Followers”, *Review of Financial Studies*, vol/ 14, no. 2: 313-341

Gorton, Gary, and Geert Rouwenhorst. 2005. “Facts and Fantasies about Commodity Futures.” *Financial Analysts Journal*, forthcoming.

Greer, Robert J. 2000. "The Nature of Commodity Index Returns." *Journal of Alternative Investments*, (Summer): 45-52.

Grinold, Richard C and Ronald N. Kahn. 2000. “The Efficiency Gains of Long-Short Investing.” *Financial Analysts Journal*, vol. 56, no.6 (November/December): 40-53.

Grossman, Sanford J. and Joseph E. Stiglitz.1980. “On the Impossibility of Infomrationally Efficient Markets”, American Economic Review, vol. 70, no. 3: 393-408.

Ibbotson, Roger G., and Paul D. Kaplan. 2000. "Does Asset Allocation Policy Explain 40, 90 or 100% of Performance?", *Financial Analysts Journal*, (January/February): 26-33.

Jacquier, Eric, Alex Kane and Alan J. Marcus. 2003. “Geometric or Arithmetic Mean: A Reconsideration”, *Financial Analysts Journal,* vol. 59, no. 6: 48-53

Jensen, Gerald R., Robert R. Johnson, and Jeffrey M. Mercer. 2002. "Tactical Asset Allocation and Commodity Futures", *Journal of Portfolio Management*, (Summer): 100- 111.

Jensen, Gerald R., Robert R. Johnson, and Jeffrey M. Mercer. 2000."Efficient Use of Commodity Futures in Diversified Portfolios", *Journal of Futures Markets*, (May): 489-506.

Johnson, Timothy C. 2004."Rational Momentum Effects", *Journal of Finance*, vol.57: 585-608.

Kaldor, Nicholas. 1939-40, “Speculation and Economic Theory,” *Review of Economic Studies*, vol. 7: 1-27

Kaplan, Paul D., and Scott L. Lummer. 1998. "Update: GSCI Collateralized Futures as a Hedging and Diversification Tool for Institutional Portfolios." *Journal of Investing*, vol. 7, no. 4 (Winter): 11-17.

Keim, Donald B. 2003. "The Cost of Trend Chasing and the Illusion of Momentum Profits", working paper, Wharton.

Keynes, John M. 1930. A Treatise on Money, volume 2. London: Macmillan.

Kolb, Robert W. 1992. "Is Normal Backwardation Normal?" *Journal of Futures Markets*, volume 12, iss. 1 (February): 75-90.

Lamm, R. McFall. 2003."Asymmetric Returns and Optimal Hedge Fund Portfolios", *Journal of Alternative Investments*, (Fall): 9- 21.

Litterman, Robert. 2004."The Active Risk Puzzle: Implications for the Asset Management Industry", Goldman Sachs, (March).

Lummer, Scott L., and Laurence B. Siegel. 1993. "GSCI Collateralized Futures: A Hedging and Diversification Tool for Institutional Portfolios." *Journal of Investing*, (Summer): 75-82.

Nash, Daniel and Yuliya Smyk. 2003. "Backwardation of Commodities and Returns on a GSCI Investment", Morgan Stanley Global Pensions Group.

Nijman, Theo, and Laurens Swinkels. 2003. "Strategic and Tactical Allocation to Commodities for Retirement Savings Schemes", Tilburg University: 1-36.

Plaxco, Lisa M. and Robert D. Arnott. 2002. "Rebalancing a Global Policy Benchmark", *Journal of Portfolio Management*, (Winter): 9-220.

Roll, Richard. 1977. "A Critique of the Asset Pricing Theory's Tests; Part I. On Past and Potential Testability of the Theory*", Journal of Financial Economics*, vol. 4, no. 2: 129-176.

Roll, Richard. 1994. "What Every CFO Should Know About Scientific Progress In Financial Economics: What is Known and What Remains to be Resolved", *Financial Management*, vol. 23, no. 2: 69.75

Roon, Frans de, Theo E. Nijman, and Chris Veld. 2000."Hedging Pressure Effects in Futures Markets", *Journal of Finance*, vol. 55, no. 3: 1437-1456.

Sharpe, William F., and Lawrence G. Tint. 1990. "Liabilities-A New Approach", *Journal of Portfolio Management*, (Winter): 5 - 10.

Siegel, Jeremy J. 2005. *The Future for Investors,* Crown Business.

Spurgin, Richard. 2001. "A Benchmark for Commodity Trading Adivosrs", Journal of Alternative Investments. Summer 1999.

Strongin, Steve, and Melanie Petsch. 1996. "Asset Returns and the Economic Environment", Goldman Sachs research report.

Till, Hilary. 2000. "Two Types of Systematic Return Available in the Futures Markets", *Commodities Now*, (September).

Till, Hilary and Joseph Eageleye. 2003. "The Risks of Commodity Investing", a chapter in *The New Generation of risk Management for Hedge Fund and Private Equity Investments* (edited by Lars Jaeger), Euromoney Books, London, 2003.

Treynor, Jack L. and Fischer Black. 1973. "How to Use Security Analysis to Improve Portfolio Selection", *Journal of Finance*, vol. 46, no. 1: 66-86.

Vrugt, Evert B., Rob Bauer, Roderick Molenaar, and Tom Steenkamp. 2004. "Dynamic Commodity Trading Strategies", working paper, (July).

Waring, M Barton. 2004. "Liability Relative Investing", *Journal of Portfolio Management*,*. Vol. 30, no. 4*

Notes

[i] The usual way to compare the total return of commodity futures to other assets is to examine the performance of a fully collateralized, unlevered, long only diversified commodity futures portfolio. In making a fully collateralized commodity futures investment, an investor desiring $1 of collateralized commodity futures exposure would typically go long $1 of a commodity futures contract and invest $1 of "collateral" in a "safe" asset. The "safe" asset could be a Treasury bill, as is customary for commodity index construction, or it could be a nominal or real bond portfolio, as is common in practice. Though the underlying collateral might be T-bills or some other asset, the excess return of the commodity futures investment will not include the collateral return. Because futures contracts

mature, an investor must sell a maturing contract and buy a yet to mature contract. This process of selling a maturing contract and buying a yet to mature contract is referred to as "rolling" a futures position.

[ii] There is another fundamental question: what is the return of an equally-weighted portfolio supposed to measure? As a measure of historical performance, for a constant universe of securities in which each security has the same number of return observations, an equally-weighted portfolio is equal to return of the average portfolio constituent. Imagine a portfolio that invests equally in two assets over four time periods and that one asset has a return of 20% and another asset has a return of 5%. The equally-weighted average return of the two illustrative securities is 12.5%, the same as the average return of the equally-weighted portfolio. A characteristic of equally-weighted commodity futures portfolios in the earlier commodity futures portfolio literature, though, seems to be that their composition changes over time. What happens, though, when the portfolio invests in the asset with a 20% return for each of the four time periods but only invests in the asset with a 5% return for the last two time periods? When the composition of an equally-weighted portfolio changes over time, the average return of the equally weighted portfolio, 16.25%, does not equal the return of the average portfolio constituent, 12.5%. As a result, an equally weighted portfolio might not convey the information an investor seeks when the composition of a portfolio changes over time.

[iii] On June 20, 2005 the CRB Index index composition was changed. Three commodities were added (unleaded gasoline, aluminum and nickel) and one commodity was dropped (platinum). Most importantly, the new Reuters/Jefferies CRB Index abandons its tradition of geometric equal weighting. The new weights reflect the relative significance and liquidity of the contracts. The weights are rebalanced every month.

[iv] The total futures open interest of these three indices amounted to about $1.5 billion. The PIMCO Commodity Real Return mutual fund alone had more than a $4 billion exposure to the Dow Jones AIG commodity index at the end of May 2004. This illustrates how many investors use swaps, rather than exchange traded futures, to gain access to commodity index returns.

[v] See www.gs.com/gsci/ for a brief explanation of the GSCI's portfolio weighting scheme.

[vi] See djindexes.com/html/aig/aigabout.html for a brief explanation of the Dow Jones-AIG Commodity index weighting scheme.

[vii] See www.crbtrader.com/crbindex/futures_current.asp for a description of the historical CRB commodity index. The CRB was reconfigured in mid-2005 and renamed the Reuter-Jefferies CRB index. Importantly, the performance of the index is no longer calculated using geometric averaging.

[viii] There is an important difference between the weighting schemes of commodity indices versus stock and bond indices. Most stock and bond market indices use seemingly objective market capitalization weights. However, there is no market capitalization for commodity futures. In fact, as Black (1976) pointed out, since there is always a short futures position for every long futures position, the market capitalization of commodity futures is always zero. The CRB index referred to at the time this paper was written used equal weights and was geometrically weighted. More recently the Reuters- Jefferies CRB index has been redesigned as a monthly arithmetically rebalanced portfolio with weights that can broadly be characterized as "between" those of the Dow Jones-AIG and the GSCI. In contrast, the GSCI uses "production" weights. These weights are determined annually by calculating the annual production for each commodity, averaging the production values over five years and then weighting each commodity relative to the sum of all the production values. Portfolio weights for the DJ AIG index are rebalanced every year using a combination of production weights and liquidity considerations. Liquidity-based portfolio weights emphasize storable commodities, such as gold, and production based portfolio weights emphasize non-storable commodities, such as live cattle and oil.

The differing approaches to weighting complicate the historical analysis. In addition, it is also the case that the performance histories of commodity futures indices are longer than the trading histories of the indices. However, in making strategic asset allocation decisions, many investors will use the complete history of returns – even if some of the history is backfilled. For these commodity indices with subjective choices of weights, one needs to exercise caution. For instance, the GSCI has been traded since 1992, yet its performance history was backfilled to 1969. From 1969 to 1991, the GSCI had a compound annual return of 15.3%, beating the 11.6% return for the S&P 500. From 1991 to May 2004, the compound annualized return of the GSCI was 7.0% and the S&P 500 had a return of 10.4%. The historical performance of the DJ AIG index potentially suffers from similar construction bias since it has been traded since 1998 but its history goes back to 1991. From the inception of the performance history of the DJ AIG Commodity Index to its first trade date in July of 1998, the AIG index had a compound annualized return of 4.1% while the GSCI only had a return of 0.5%. The CRB index's performance history commences in 1982 and the futures contracts first started trading in 1986. For each of these indices, the returns since trading actually started are tangible while the pre-trading returns are to some degree hypothetical.

[ix] Heating oil was added in December 1982; crude oil futures were added in 1987; Brent crude oil in 1999, unleaded gasoline in 1988, gasoline in 1999 and natural gas in 1994. Currently, there are 24 commodities in the GSCI.

[x] The average absolute correlation is 0.11.

[xi] See Booth and Fama (1992) and Fernholz and Shay (1982). Our appendix details the different formulas for the diversification return.

[xii] See Greer (2000) and de Chiara and Raab (2002).

[xiii] Some have argued that only a select number of commodities should have a risk premium. Kaldor (1939) introduced the concept of the convenience yield as a way to explain normal backwardation. The convenience yield is a function of inventory and it reflects the market's expectation about the future availability of a commodity. Generally, the lower the level of inventory the higher the convenience yield, and the higher the level of inventory the lower the convenience yield. A commodity perceived to have abundant inventory would have a convenience yield of zero. A convenience yield might be a risk premium. However, since not all commodities face the same inventory situation at all times, not all commodities should have the same risk premium. Till (2000) suggests that crude

oil, gasoline, live cattle, soymeal and copper are commodities that are difficult to store. Assuming that commodities that are difficult to store are those with relatively low inventories, Table 2 shows that difficult to store commodities have on average had high historical excess returns. The presence of a convenience yield is usually indicated by a futures price that is lower than the spot price for a commodity. However, a convenience yield is only a risk premium when the futures price is lower than the expected future spot price. Unfortunately, while the current spot price is always observable the expected future spot price is never observable.

If the convenience yield is viewed as an inventory insurance premium, there is some appeal to this approach. It is possible to view a crude oil future as supplying crude oil inventory insurance and a live cattle future as supplying live cattle inventory insurance. Because these are separate lines of business, the risk of each line of business should determine the price of insurance for each line of business

[xiv] Bessembinder obtained data on net hedging from the Commodity Futures Trading Commission's "Commitments of Traders in Commodity Futures" report. This data can be found at: www.cftc.gov/cftc/cftccotreports.htm.

[xv] Gold futures prices have been interpolated for the months of September 2004, November 2004, January 2005 and March 2005.

[xvi] There are two components of market backwardation: the market consensus expected future spot price and a possible risk premium. While it is possible to observe market backwardation, it is impossible to observe normal backwardation because neither the expected future spot price nor the potential risk premium is observable.

[xvii] Goldman Sachs "The Case for Commodities as an Asset Class", presentation, June 2004

[xviii] See for instance "The Case for Commodities as an Asset Class" by Goldman Sachs

[xix] We benefited from a discussion with Lisa Plaxco on this point.

[xx] In fact from 1969 to 2003 the first order autocorrelation of the annual rate of change of the CPI inflation rate was 0.13.

[xxi] This is an univariate regression of excess return on the year-over-year change in the rate of inflation

[xxii] Using overlapping data (and correcting for the induced autocorrelation) did not change the overall results of the regression analysis.

[xxiii] They studied twenty-two commodities, with various start dates, over the time period 1966 to 1987.

[xxiv] Erb and Harvey (2005) point out that the diversification return actually has two return drivers: a variance reduction benefit and the impact of not rebalancing. The impact of not rebalancing can also be viewed as a "covariance drag". All portfolios have the potential for a variance reduction benefit. The variance reduction benefit is relatively easy to understand. The variance of a portfolio, such as the S&P 500, will generally be lower than the weighted average variance of the constituents of the S&P 500. This reduction in variance translates directly into an increase in the geometric return of the S&P 500. However, on average the portfolio weights of individual assets in an unrebalanced portfolio covary negatively with the returns of the individual assets. This results in a negative impact of not rebalancing. In many cases the negative impact of not rebalancing can exceed the variance reduction benefit of an unrebalanced portfolio. As a result, the diversification return of an unrebalanced portfolio can be very small or negative. The impact of not rebalancing for a rebalanced portfolio is, of course, zero.

[xxv] De la Grandville (1998) takes thoughtful exception to this rule of thumb. As a result, this is not an endorsement of the idea that the geometric return is equivalent to the arithmetic return minus one half the variance of return, rather it is simply an expedient and pedagogic acceptance of a rule of thumb.

[xxvi] There are two ways to think of the diversification return for an equally weighted and rebalanced portfolio: the difference between the geometric return of the portfolio and the weighted average geometric return of the portfolio's constituents or half of the difference between the weighted average variance of the constituents of a portfolio and the variance of the portfolio. The stand alone geometric return of an asset is equal to its average arithmetic return minus one half the asset's variance (Geometric return = Average Return – Variance/2). However, the geometric return of a portfolio is equal to the weighted average arithmetic return of the portfolio constituents minus one half the portfolio's variance (Portfolio Geometric Mean Return = Portfolio Arithmetic Average Return – Portfolio Variance/2). The portfolio's variance is simply the weighted average covariance of the portfolio's assets.

An asset's geometric return is equal to the asset's arithmetic return minus one half the asset's variance. An asset's geometric return in a portfolio context is equal to the asset's arithmetic return minus one half the asset's *covariance* (Average Return – Covariance/2= Ri – $\beta i\ \sigma^2_{Portfolio}$ /2). The variance of an equally weighted portfolio consisting of N securities is: Portfolio Variance = Average Variance/N + (1-1/N) Average Covariance = Average Variance/N + (1-1/N) Average Correlation * Average Variance. For an equally weighted portfolio the diversification return is:(Weighted Average Asset Variance – Portfolio Variance)/2 = (Average Variance – (Average Variance/N + (1-1/N) Average Covariance))/2 = (1-1/N) *(Average Variance - Average Covariance)/2 = ((1-1/N) *(Average Variance) - (1-1/N) Average Correlation * Average Variance)/2 = (1-1/N) * Average Variance * (1- Average Correlation)/2. As the number of securities, N, becomes large, this reduces to: (Average Variance – Average Correlation * Average Variance)/2 = Average Diversifiable Variance/2

[xxvii] At the margin, negative autocorrelation of returns might boost the base case diversification return and positive autocorrelation of returns might lower the base case diversification return.

[xxviii] Since the inception of actual trading of the GSCI futures in 1992.

[xxix] Till and Eagleeye (2003) quotes Nash and Smyk (2003) in which they find that the term structure of commodity prices is a predictor of total returns.