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The Tactical and Strategic Value of Commodity Futures

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ABSTRACT

Historically, commodity futures have had excess returns similar to those of equities. But what should we expect in the future? The usual risk factors are unable to explain the time-series variation in excess returns. In addition, our evidence suggests that commodity futures are an inconsistent, if not tenuous, hedge against unexpected inflation. Further, the historically high average returns to a commodity futures portfolio are largely driven by the choice of weighting schemes. Indeed, an equally weighted portfolio of commodity futures returns has approximately a zero excess return over the past 25 years. Our portfolio analysis suggests that the a long-only strategic allocation to commodities as a general asset class is a bet on the future term structure of commodity prices, in general, and on specific portfolio weighting schemes, in particular. In contrast, we provide evidence that there are distinct benefits to an asset allocation overlay that tactically allocates using commodity futures exposures. We examine three trading strategies that use both momentum and the term structure of futures prices. We find that the tactical strategies provide higher average returns and lower risk than a long-only commodity futures exposure.

Keywords: Strategic asset allocation; Tactical asset allocation; Diversification return; 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.

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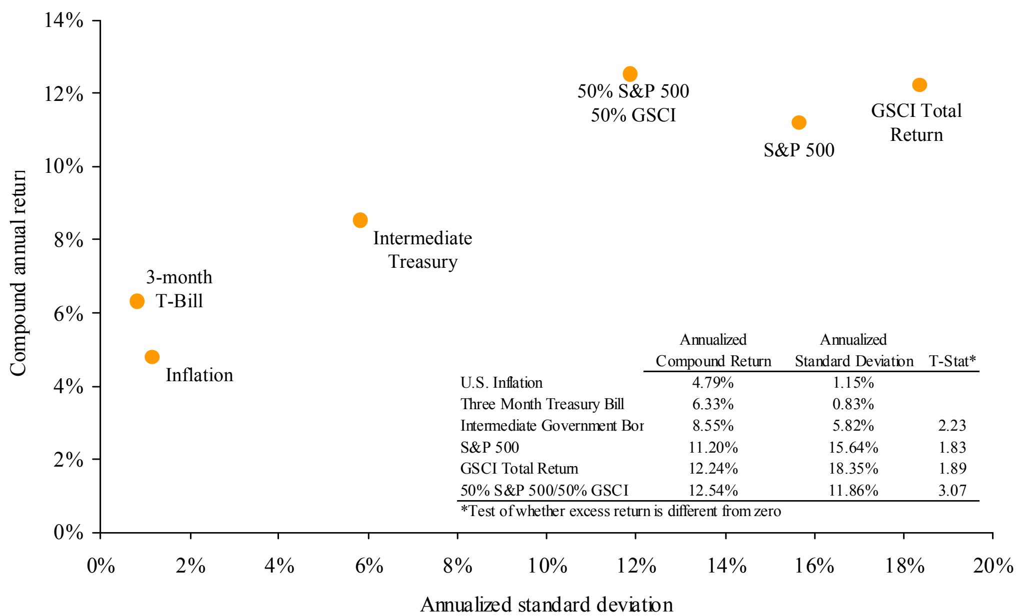
1. Introduction

Historically, investing in commodity futures appears to have been as rewarding as investing in equities. Figure 1 shows that, 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 fact, the compound return on a rebalanced portfolio of 50% stocks and 50% commodity futures has historically outperformed both stocks and commodity futures with a significantly lower standard deviation of return.[i] However, it is often dangerous to extrapolate past performance into the future.[ii] Arnott and Bernstein (2002) point out that the past high excess returns for U.S. equities do not make the case that the forward looking equity risk premium is high.[iii] Dimson, Marsh and Staunton (2004) present a similar case for global equities, and challenge the value of conclusions based on the performance of any single country. If history is an incomplete guide to investment prospects, what is the benefit to investing in commodity futures? To answer this question, it is necessary to create a framework for thinking about the prospective return from a commodity futures investment and analyze the role that commodity futures play in strategic and tactical asset allocation.

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 Bor	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.

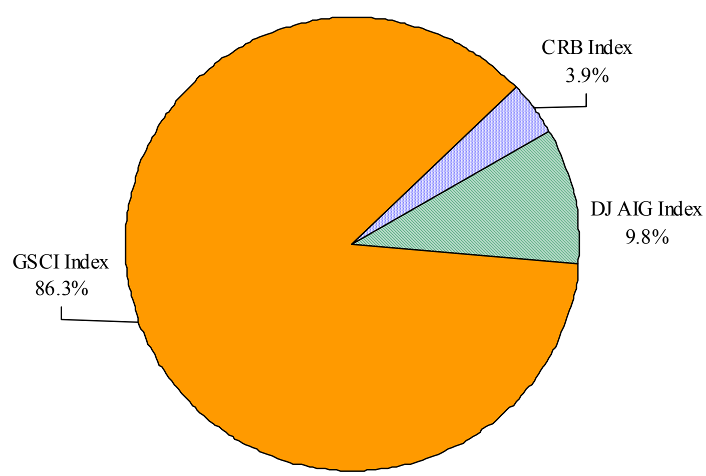
2. Commodity indices and constituents

2.1 Three benchmark commodity indices

The usual way to compare the performance of commodity futures to other assets is to examine the performance of a fully collateralized, unlevered, diversified commodity futures index. A collateralized index provides the return of a passive long-only investment in commodity futures contracts such as wheat, gold, oil and copper. In making a fully collateralized commodity futures investment, an investor desiring $1 of commodity futures exposure would typically go long a commodity futures contract and invest $1 of "collateral" in a "safe" asset such as a Treasury bill.

The three most commonly used commodity futures indices are the Goldman Sachs Commodity Index (GSCI)[iv], the Dow Jones-AIG Commodity Index (DJ AIG)[v], and the Reuters-CRB Futures Price Index (CRB).[vi] Figure 2 shows that the GSCI represents 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.

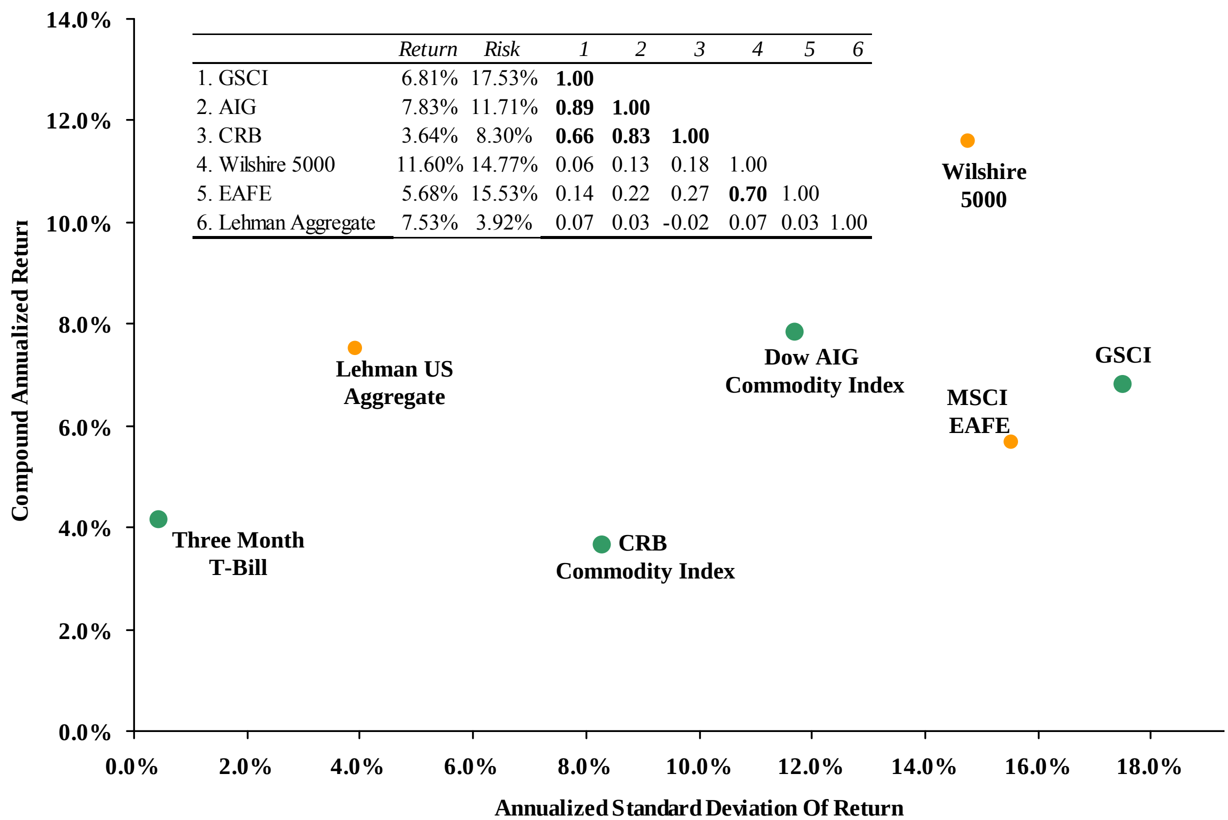
Figure 2
Market Value of Long Open Interest
As May, 2004



Data Source: Bloomberg

Figure 3 shows that the three commodity indices have experienced different levels of return and volatility. The GSCI has twice the volatility of the CRB commodity index during the common time period for all three indices.[vii] The DJ AIG Commodity Index and the GSCI have average returns similar to the Lehman Aggregate Bond Index and the CRB has a return similar to three-month Treasury bills, underperforming the Lehman Aggregate by 4% per annum. Surprisingly, the CRB index has a lower correlation with the GSCI (0.66) than the Wilshire 5000 has with the Morgan Stanley Capital International EAFE index (0.70). The low correlation of U.S. equity returns and non-U.S. equity returns can be explained by the generally nonoverlapping composition of these equity portfolios. But this is not the case for commodity futures.

Figure 3
Return And Risk
January 1991 to May 2004



	Return	*Risk*	*1*	*2*	*3*	*4*	*5*	*6*
1. GSCI	6.81%	17.53%	**1.00**					
2. AIG	7.83%	11.71%	**0.89**	**1.00**				
3. CRB	3.64%	8.30%	**0.66**	**0.83**	**1.00**			
4. Wilshire 5000	11.60%	14.77%	0.06	0.13	0.18	1.00		
5. EAFE	5.68%	15.53%	0.14	0.22	0.27	**0.70**	1.00	
6. Lehman Aggregate	7.53%	3.92%	0.07	0.03	-0.02	0.07	0.03	1.00

January 1991 is the inception date for the Dow AIG Commodity Index

2.2 Benchmark constituents and weighting

The relatively low correlation can be explained by the different weighting of individual commodity futures contracts in each of the indices. 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.[viii] The DJ AIG Commodity Index focuses primarily on futures contract liquidity data, supplemented with production data, as well as limits on maximum exposures to determine portfolio weights.[ix] The CRB index is an equally weighted index.[x]

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 Contracts	17	24	20
Gini coefficient	0.00	0.65	0.32

Data Source: Goldman Sachs, Dow Jones AIG

There is an important difference between the weighting schemes of commodity indices versus stock and bond indices. Most stock and bond market indices use market capitalization weights. While there may be a debate as to what measure of stock or bond market capitalization to use (total market capitalization or some float or liquidity adjusted measure), market capitalization weights are seemingly objective. 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 employs equal weights. 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.

2.3 Interpreting the historical performance

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%. Is it possible that the GSCI weights were determined with an eye towards creating an index that outperformed stocks and to enhance the ability of Goldman Sachs to convince investors of the appeal of commodity futures investment? 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%. Is it possible that the DJ AIG index was created with an emphasis on demonstrating hypothetical historical outperformance relative to the GSCI? 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.

Table 2 looks at the historical excess returns of the overall GSCI, five GSCI sectors, and twelve individual constituents of the GSCI. We begin the analysis in 1982 because (a) the GSCI is currently an energy oriented commodity index, (b) energy futures are a large part of all futures open interest, and (c) the first energy futures contract entered the GSCI in January of 1983.[xi] Over this sample, the GSCI has 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 provides a return of 7.06% and the non-energy sector had a return of -0.12%. Among the twelve individual commodities, heating oil has an annual return of 5.53% and silver has a return of -8.09%. An initially equally weighted buy-and-hold portfolio experiences an average annual return of 0.70%, an equally weighted, monthly rebalanced, portfolio has an average annual return of 1.01% and the equally weighted average of the twelve individual commodity returns is -1.71%. The difference in return between the GSCI and these three averages reflects the significant energy exposure of the GSCI.

Table 2
Historical Excess Return
December 1982 to May 2004

	Geometric Mean	Arithmetic Mean	Standard Deviation	T-Statistic	Skew	Kurtosis	Sharpe Ratio	Auto-correlation	Difficult Storage
GSCI Index	4.49%	5.81%	16.97%	1.22	0.51	1.98	0.26	0.11	
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	
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
Twelve Commodities									
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	
Rebalancing Impact	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	

2.4 The correlation of constituents

Our initial analysis of the data raises an interesting point: the average commodity futures contract has a return that is close to zero (-1.71%) yet there is substantial dispersion of individual commodity futures returns about this average.

Table 3 shows that the average level of commodity return correlations is low. Heating oil and silver excess returns are essentially uncorrelated (0.02). The average correlation of the twelve commodity futures returns with the GSCI is 0.13. The average correlation of individual commodities with one another is only 0.09. 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.

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	0.33
GSCI with individual commodities	0.13
Heating oil with other commodities	0.03
Individual commodities	-0.09

3. Models of expected returns

Most previous research has focused on the expected returns of a commodity index, without considering the expected returns for the portfolio constituents. We will consider both.

3.1 Decomposition of the index return

The total return on a diversified cash collateralized commodity futures portfolio can be decomposed into three components:

Commodity Portfolio Total Return = Cash Return + Excess Return + Diversification 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 diversification return simply means that the compound return of a fixed weight portfolio will be greater than the weighted average of the compound returns of the individual investments. The diversification return is due to the reduction in variance as investors form diversified portfolios.[xii]

Regardless of the model for expected excess returns of the components, Greer (2000) and de Chiara and Raab (2002) show that commodity futures indices might have expected returns similar to equities. The ongoing process of rebalancing investments in a commodity futures index can be a significant source of return. We explore the diversification return in more detail in section 3.5.

3.2 The CAPM perspective

Lummer and Siegel (1993) and Kaplan and Lummer (1998) argue that the long-run expected return of an investment in the 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 analysis of Dusak (1973) who documents low betas and low expected returns in the context of the Capital Asset Pricing Model of Sharpe (1964) and Lintner (1965).

There is considerable evidence that a multifactor model is needed to explain the cross-section and time-series of asset returns. In section 3.5, we explore the role of unexpected inflation as well as a five factor model.

3.3 The insurance perspective

Gorton and Rouwenhorst (2004) 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.

Keynes (1930) advanced the theory of normal backwardation in which he suggested that the futures price should be less than the expected future spot price. If today's future prices is below the future spot price, 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 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, a positive excess return, and it is for this reason than 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 more normally backwardated commodity future should have a higher return than a 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. In spite of the ex ante nonobservability of normal backwardation, positive excess returns should be a good ex post indicator of the existence of normal backwardation. To test for a normal backwardation risk premium, 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. Table 2 seems to support Kolb's earlier finding. However, as Ibbotson and Kaplan (2000) show, a satisfactory understanding of asset returns requires an examination of the cross-section of returns, the time series of returns and the level of returns.

3.4 The cross-section of commodity returns

3.4.1 Hedging pressure

Is there an explanation for the lack of 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 contango 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 contago 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 causes 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 suggests that a portfolio that goes long backwardated futures and short contangoed 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 of these examples highlight a view that commodity futures are a means of risk transfer and that the providers of risk capital charge an insurance premium.

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

The term structure of futures prices depicts the relationship between futures prices and the maturity of futures contracts. Figure 4 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 in 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. An upward or downward sloping term structure of futures prices creates the possibility of a futures price "roll return"[xvii]. For instance, in this example, the futures price of oil in July 2005 was $36.65 and the July 2004 price was $40.95. If the term structure of oil remained unchanged, then the roll return from buying the July 2005 oil contract would be 13% ($40.95/$36.65 -1 = 13.1%). For gold, assuming no change in the term structure of gold futures prices, the roll return would have been -1.4% ($398.3/404-1 = -1.4%). Another way of looking at this is as follows: the term structure of commodity futures prices may provide hedgers with a convenient way to determine the expected price of commodity price insurance.

Figure 4
Term Structure of Commodity Prices
May 30, 2004

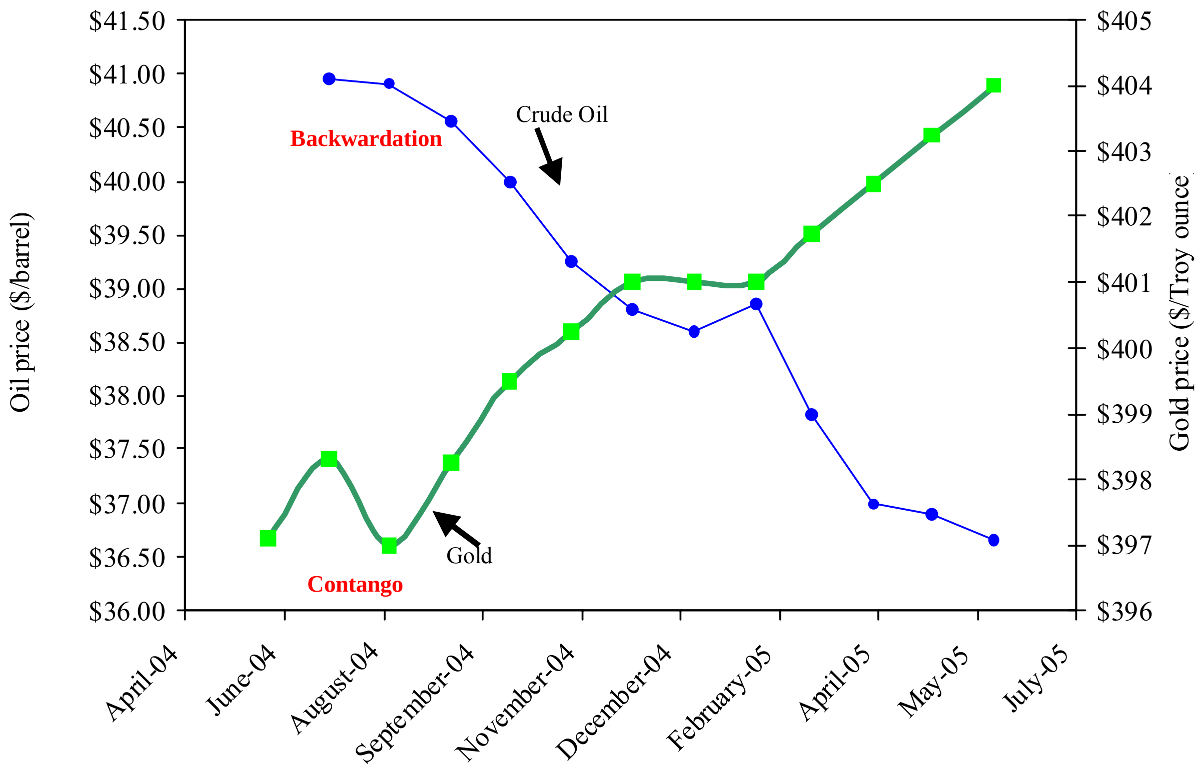
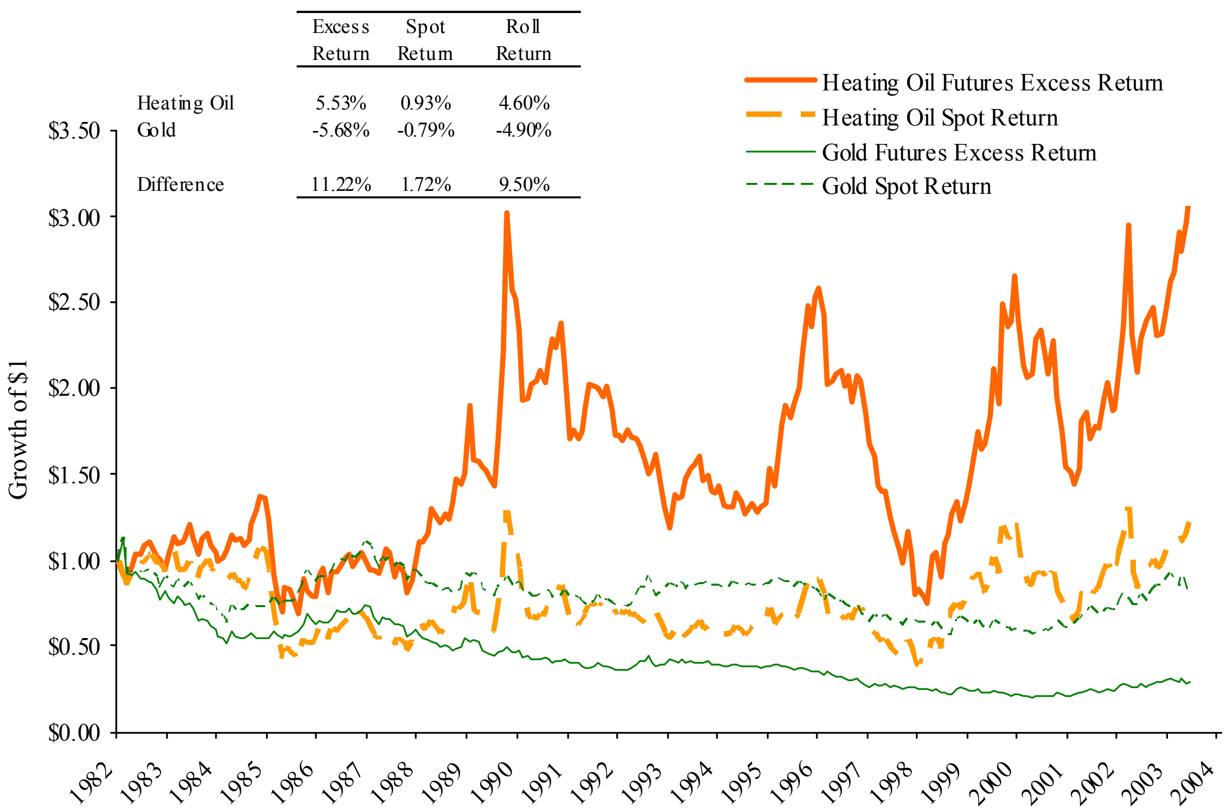


Figure 5 shows that, since 1982, the excess return for heating oil futures was 5.5% per annum. The excess return consists of a spot return and a roll return. The spot return is the change in the price of the nearby futures contract. Since futures contracts have an expiration date investors who want to 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 upward sloping, an investor rolls from a lower priced expiring contract into a higher priced next nearest futures contract. If the term structure of futures prices is downward sloping, an investor rolls from a higher priced expiring contract into a lower priced next nearest 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 4.9%. The roll return was positive because the energy markets are 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 is almost always in contango. The average spot return of heating oil and gold futures was close to zero. The 11.2% 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 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[xviii].

Figure 5
Excess and Spot Returns
December 1982 to May 2004

	Excess Return	Spot Return	Roll Return
Heating Oil	5.53%	0.93%	4.60%
Gold	-5.68%	-0.79%	-4.90%
Difference	11.22%	1.72%	9.50%



3.4.3 Implications for asset allocation

How important have roll returns been in explaining the cross-section of individual commodity futures excess returns? Figure 6 shows the historical relationship between excess returns and roll returns for individual commodities. 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[xix]. Roll returns explain 91% of the cross-sectional variation of commodity futures returns in Figure 6.

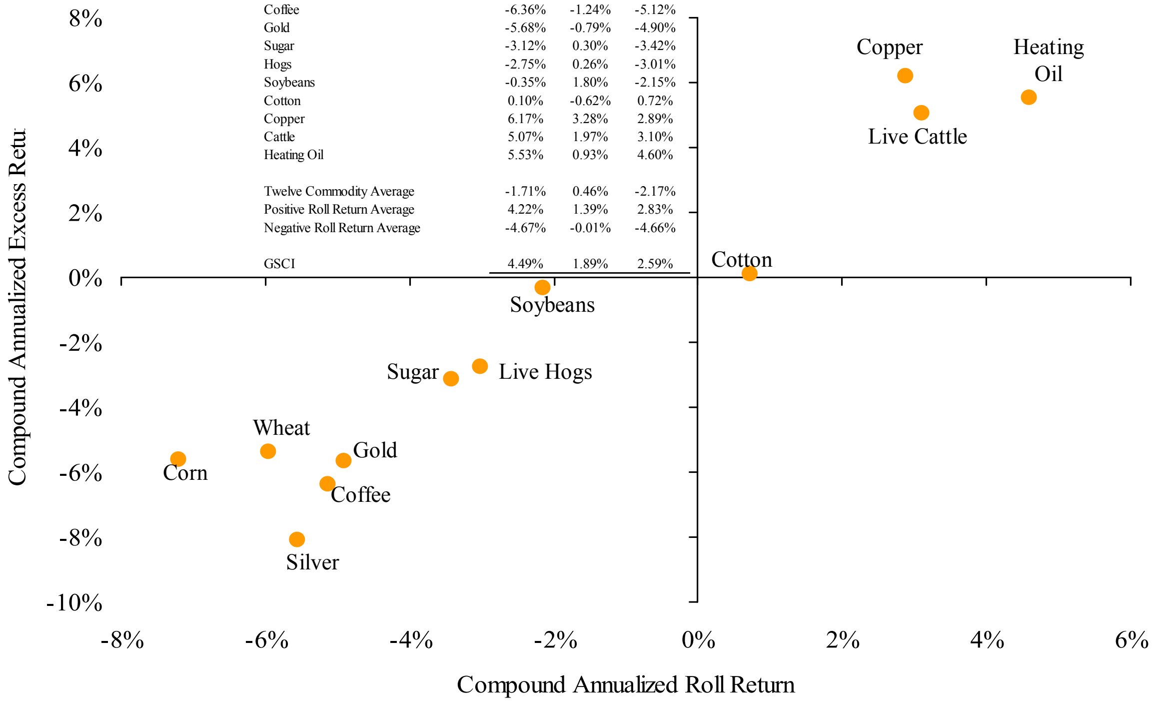
Long-only normal backwardation suggests that commodity futures excess returns should be positive, for both backwardated and contangoed commodity futures. In fact, Gorton and Rouwenhorst (2004) suggest that under normal backwardation there should be no relationship between the term structure of commodity futures prices and the returns from investing in commodity futures. Under normal backwardation, what matters is the degree of normal backwardation, which, unfortunately, is unobservable ex ante. Normal backwardation suggests that all of the observations in Figure 6 should lie in the northeast and the northwest quadrants. The hedging pressure hypothesis is consistent with the observation that excess returns are positively correlated with roll returns and that backwardated commodity futures should have positive returns and contangoed commodity futures should have negative returns. Figure 6 does not, therefore, empirically provide any support for long only normal backwardation. Figure 6 challenges the relevance of normal backwardation as an explanation of actual commodity futures returns.

Roll returns are a major driver of the cross-section of realized commodity futures excess returns. Realized commodity futures returns have two components: the expected price of insurance and the unexpected price of insurance. Roll returns represent the expected price of insurance. As Gorton and Rouwenhorst (2004) note, unexpected price deviations, which represent the unexpected price of insurance, are unpredictable and should average out to zero over time. It is interesting that over a very long time period, the expected price of insurance has been the dominant driver of long-term commodity futures returns and that unexpected returns have played a secondary role. The regression intercept of 0.89% in Figure 6 seems to suggest that if the term structure of commodity prices was flat, that is if prices were the same for each futures maturity, then roll returns and excess returns would be close to zero. Further examination of the data also reveals that the roll return accounts for more than half of the excess return level of the GSCI (2.59% of the 4.49% excess return) and more than three quarters of the equally weighted twelve commodity average excess return.

Figure 6
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%
Twelve Commodity Average	-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%



The term structure of futures prices may reveal information about whether suppliers of commodity price insurance should expect a positive rate of return. If unexpected price changes average to zero over time, then going long a commodity futures in a backwardated market supplies price insurance and going short a commodity futures in a contagoed market supplies commodity price insurance. Similarly, going short a backwardated commodity futures, or going long a contangoed commodity futures, is similar to buying insurance. If there is a long-term return from investing in commodity futures, it will be from providing insurance, not from buying insurance. If positive returns only accrue to buyers of insurance ultimately there will be no providers of insurance. In the context of the insurance explanation, it is not surprising that the term structure of futures prices is a significant driver of the cross-section of commodity futures returns. This insight will be important for both strategic and tactical asset allocation.

3.5 Time-series variation in commodity futures returns

We now consider multifactor models of commodity futures returns. However, first we explore the conventional wisdom that commodity futures provide good inflation hedges.

3.5.1 <u>Inflation hedges – but what component of inflation?</u>

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). First, we need to explore the relation between the components of the Consumer Price Index (CPI) and the components of commodity futures indices.

Figure 7
Consumer Price Index Composition, 2003

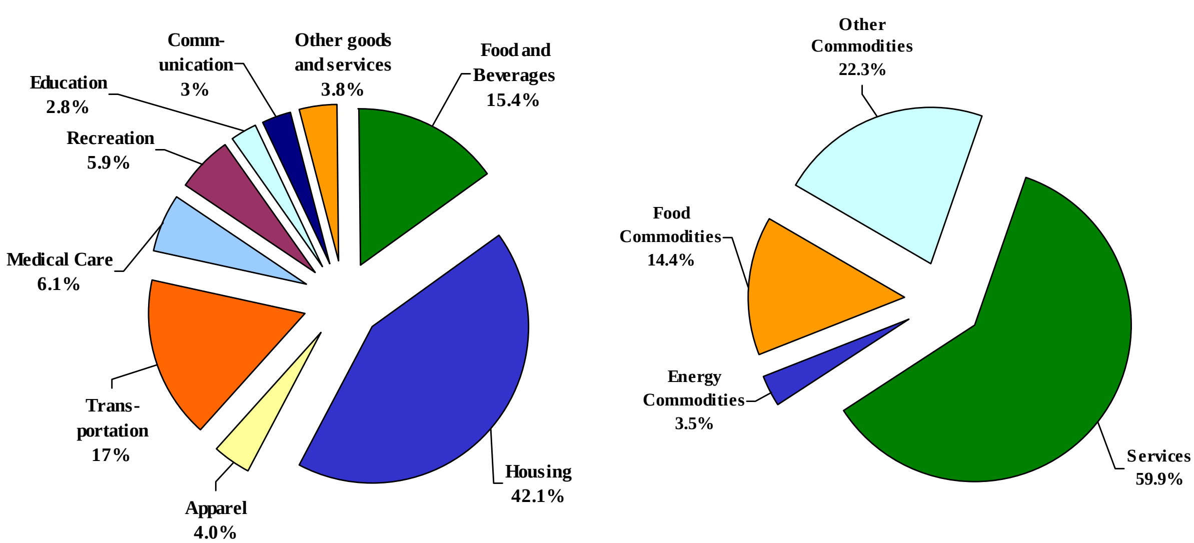


Figure 7 shows two ways of categorizing the components of the CPI. Commodities have about a 40% weight in the CPI and services have a 60% weight. Energy commodities make up only about 4% of the CPI, food commodities constitute about 14% of the CPI and other commodities account for the remaining commodity 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 inflation hedge.

3.5.2 Expected and unexpected inflation

Actual inflation can be decomposed into two components: expected inflation and unexpected inflation, the difference between actual and expected inflation. Gorton and Rouwenhorst (2004) point out that absent any systematic errors in the market's forecast of future spot prices, expected trends in spot prices should not be a source of return for futures investors. This suggests that the expected inflation beta of commodity futures should be zero. 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]. Figure 8 shows that, historically, contemporaneous changes in the annual rate of inflation have explained 43% of GSCI annual excess return time series variation[xxi]. That is, average GSCI excess returns have been positive (+24.5%) and above average (+4.9%) when year-over-year unexpected inflation rises, and the GSCI excess return has been negative (-8.4%) and below average when year-over-year inflation falls.

Figure 8
GSCI Excess Return and Unexpected Inflation
Annual Observations, 1969 to 2003

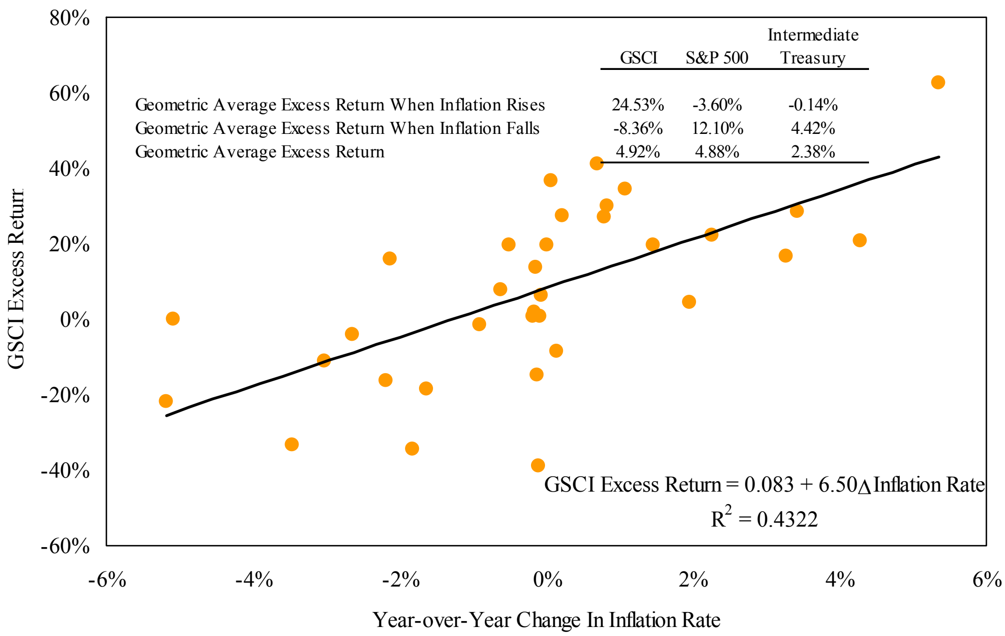


Table 3 shows that individual commodity futures excess returns are largely uncorrelated with one another. This suggests that the sensitivity to inflation varies across the commodity futures components. Table 4 shows the historical sensitivity of commodity returns (index, sector and components) to actual 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 betas. Indeed, the equally weighted average of the twelve commodities has positive, but insignificant, inflation betas[xxii]. Clearly, not all commodity futures are good inflation hedges.

Table 4
Commodity Excess Return And Change in Annual Inflation
Annual Observations, 1982 to 2003

	Intercept	Intercept T-Stat	Inflation Coefficient	Inflation T-Stat	□Inflation Coefficient	□Inflation T-Stat	Adjusted R Square
GSCI	-5.27%	-0.38	3.92	0.93	10.88	**2.98**	27.96%
Non-Energy	-5.37%	-0.64	1.84	0.71	3.94	1.77	5.95%
Energy	-9.02%	-0.36	7.50	0.97	18.80	**2.81**	24.54%
Livestock	-11.90%	-1.15	4.73	1.49	6.88	**2.51**	17.64%
Agriculture	-7.60%	-0.67	1.68	0.48	1.06	0.35	-9.64%
Industrial Metals	6.71%	0.26	1.20	0.15	17.44	**2.59**	26.73%
Precious Metals	20.93%	2.36	-8.02	**-2.95**	-2.78	-1.19	26.19%
Heating Oil	-6.40%	-0.26	6.07	0.81	17.76	**2.73**	23.89%
Cattle	-7.07%	-0.75	4.00	1.38	7.19	**2.87**	24.02%
Hog	-20.39%	-1.23	6.32	1.24	6.47	1.48	2.04%
Wheat	-13.24%	-0.87	3.09	0.67	-2.58	-0.64	-0.05%
Corn	-23.02%	-1.37	5.91	1.15	4.44	1.00	-2.57%
Soybeans	20.50%	1.17	-5.95	-1.11	-1.10	-0.24	-2.77%
Sugar	1.39%	0.06	-0.06	-0.01	3.56	0.61	-7.75%
Coffee	4.25%	0.11	-0.81	-0.07	0.24	0.02	-11.05%
Cotton	6.74%	0.31	-0.51	-0.08	0.30	0.05	-10.99%
Gold	19.16%	2.02	-7.50	**-2.58**	-2.38	-0.95	20.27%
Silver	24.83%	2.16	-10.18	**-2.89**	-4.45	**-1.46**	24.33%
Copper	7.15%	0.27	1.43	0.18	17.08	2.45	23.77%
EW Twelve Commodities	1.16%	0.14	0.15	0.06	3.88	1.74	10.30%

The wide variation in individual commodity futures unexpected inflation betas is explained by the roll returns. Figure 9 shows that average roll returns have been highly correlated with unexpected inflation betas. Average roll returns explained 67% of the cross-sectional variation of commodity futures unexpected inflation betas. In other words, the realized return for supplying commodity price insurance has been highly correlated with realized 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.

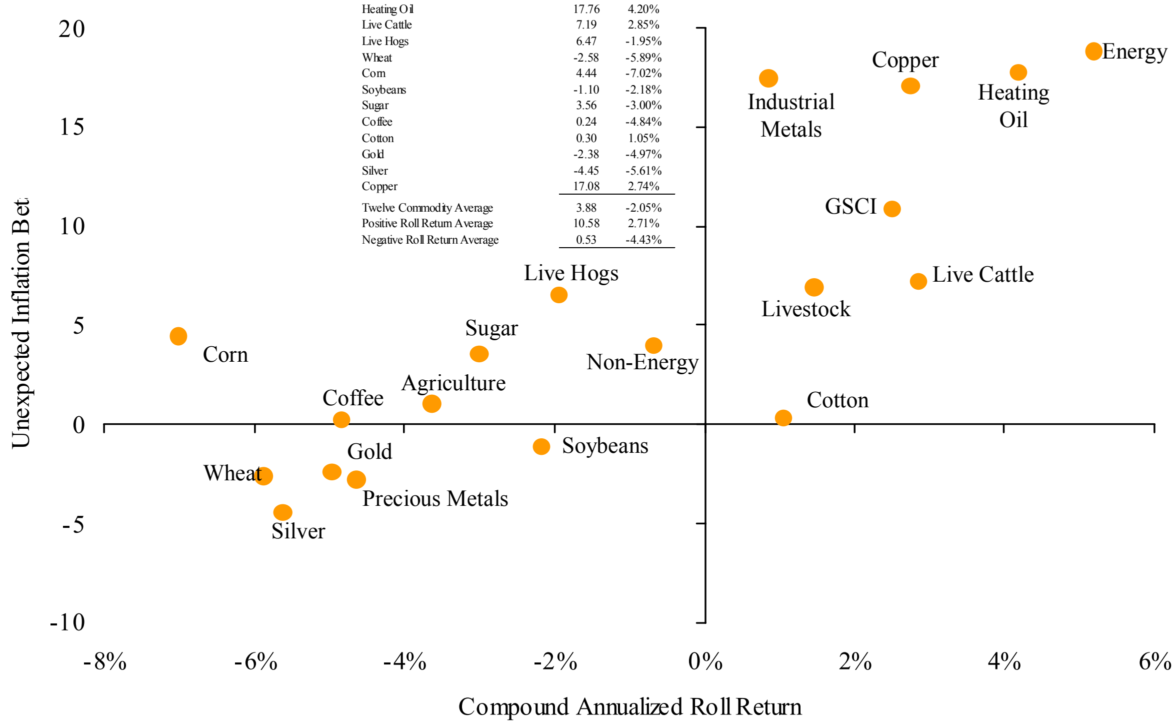
What explains the linkage between roll returns and inflation betas? Table 2 shows that some commodities are difficult to store, and it is these commodities that seem to have had high roll returns and positive inflation betas. Storability, then, could be the link between roll returns and inflation betas.

Figure 9

Unexpected Inflation Betas and Roll Returns

December 1982 to December 2003

	Unexpected Inflation Beta	Roll Return
GSCI	10.88	2.52%
Non-Energy	3.94	-0.67%
Energy	18.80	5.19%
Livestock	6.88	1.46%
Agriculture	1.06	-3.64%
Industrial Metals	17.44	0.84%
Precious Metals	-2.78	-4.64%
Heating Oil	17.76	4.20%
Live Cattle	7.19	2.85%
Live Hogs	6.47	-1.95%
Wheat	-2.58	-5.89%
Corn	4.44	-7.02%
Soybeans	-1.10	-2.18%
Sugar	3.56	-3.00%
Coffee	0.24	-4.84%
Cotton	0.30	1.05%
Gold	-2.38	-4.97%
Silver	-4.45	-5.61%
Copper	17.08	2.74%
Twelve Commodity Average	3.88	-2.05%
Positive Roll Return Average	10.58	2.71%
Negative Roll Return Average	0.53	-4.43%



3.5.3 Sensitivity 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. Early research by Bailey and Chan (1993) empirically estimates 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. We consider the five-factor model of Fama and French (1993). In addition to the popular three factors (market excess return, a high minus low book to market return (HML) and a small minus large cap return (SML)), they also consider a term spread return (long-term bond excess return) and a default spread (corporate bond return minus government bond return). While they find no evidence that these last two factors are priced for stocks, they might be important for commodity futures. Finally, following Ferson and Harvey (1993) and Dumas and Solnik (1995), we consider the foreign exchange rate exposure of the commodity futures. If the return to investing in individual commodity futures is the return from supplying individual commodity price insurance, a multifactor explanation is equivalent to saying that the price of individual commodity price insurance is driven by various common risk factors.

Table 5 presents the unconditional (i.e. assumed constant) monthly betas of commodity excess returns relative to a common set of "risk factors". The GSCI has a statistically significant negative beta with regard to the change in trade weighted dollar and no statistically significant betas with regard to other risk factors. 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 5
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.

3.5 The diversification return

The diversification return provides another reason to simultaneously analyze the performance of a commodity index and its constituents. The diversification return can lead to significant differences between the compound return of a commodity index and the weighted average compound return of the index's constituents. For instance in Table 1, the compound return of an equally weighted and monthly-rebalanced portfolio of twelve commodities was 1.01%. Yet the average geometric return of the twelve individual commodity was -1.71%. In other words, rebalancing a portfolio added 2.72% per annum to the performance of the portfolio. Hence, it would be a mistake when measuring the performance of an equally weighted portfolio to ascribe the return of 2.72% to a risk premium. Booth and Fama (1992) show that rebalancing a portfolio to predetermined fixed weights results in a diversification return[xxiv]. They showed that the stand alone geometric return of an asset can be approximated as its arithmetic average return minus one half its variance. However, the geometric return of an asset in a portfolio can be approximated as its arithmetic average return minus one half its covariance with the portfolio. The diversification return is roughly one half the difference between an asset's variance and its covariance.

Table 6 illustrates the mechanics of the portfolio diversification return using the historical annual excess returns for the GSCI Heating Oil index and the S&P 500. From 1993 to 2003, heating oil had a geometric annual excess return of 8.2%, the S&P 500 had a geometric annual excess return of 6.8%, the average of these two returns was 7.5% and the geometric excess return of an equally weighted annually rebalanced portfolio was 10.9%. The diversification return in this instance is simply the difference between 10.9% and 7.5%, or about 3.4%.

Whether or not the 8.2% excess return of heating oil is a risk premium, it is certainly obvious that the 3.5% diversification return is not a risk premium. The average of the individual variances was 12.8% (the average of the heating oil variance of 21.2% and the S&P 500 variance of 4.4%) and the average of the asset covariances with the equally weighted portfolio was 5.3% (the average of the heating oil covariance of 9.5% and the S&P 500 covariance of 1.1%). One half of the difference of these two averages is about 3.5%, the diversification return.

Table 6
The mechanics of the diversification return

	Heating Oil Excess Return	S&P 500 Excess Return		Equally Weighted Portfolio Excess Return
1994	19.96%	-2.92%		8.52%
1995	7.73%	31.82%		19.78%
1996	67.37%	17.71%		42.54%
1997	-35.06%	28.11%		-3.48%
1998	-50.51%	23.51%		-13.50%
1999	73.92%	16.30%		45.11%
2000	66.71%	-15.06%		25.82%
2001	-36.62%	-15.97%		-26.30%
2002	41.40%	-23.80%		8.80%
2003	21.90%	27.62%		24.76%
			Weighted Average	
Portfolio Weight	50%	50%		
Geometric Return	8.21%	6.76%	**7.49%**	**10.95%**
Variance	21.22%	4.44%	**12.83%**	**5.34%**
Beta (EW Portfolio)	1.79	0.21	1.00	1.00
Covariance	9.54%	1.14%	5.34%	5.34%

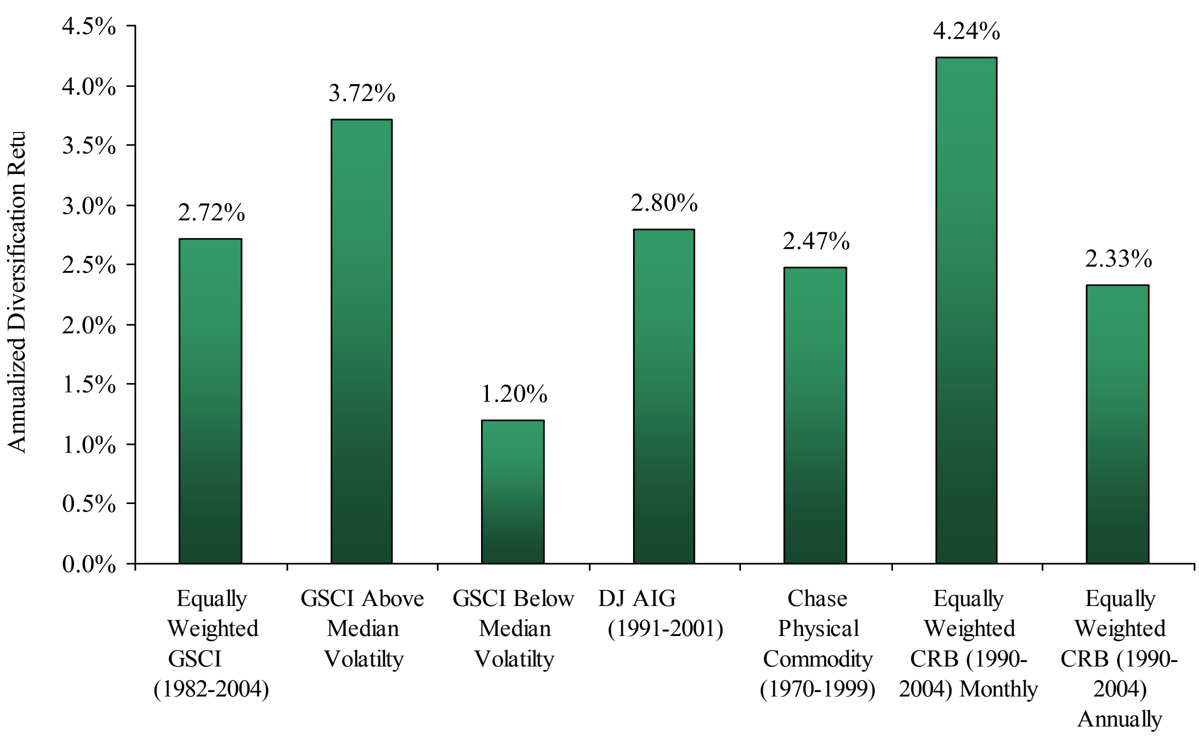
Diversification Return = EW Portfolio Return - Weighted Average Return = **10.95%** - **7.49%** = 3.46%

Approximate Diversification Return = (Average Variance - Average Covariance)/2 = (**12.83%** - **5.34%**)/2 = 3.74%

Figure 10 shows that the diversification return can vary substantially. For an equally weighted, monthly rebalanced portfolio of the twelve individual GSCI commodities, the diversification return has been 2.72% over the December 1982 to May 2004 period. The size of the diversification return is influenced by the average variance of a portfolio's constituents. Separating the twelve individual commodities into two portfolios of above median volatility commodities and below median volatility commodities, shows that the above median volatility portfolio had a diversification return almost three times larger than the low volatility portfolio. De Chiara and Raab document a diversification return of 2.8% for the DJ AIG index, over the 1991 to 2001 time period, and Greer estimates a 2.5% diversification return for the Chase Physical Commodities index over the 1970 to 1999 time period. An equally weighted portfolio consisting of the seventeen individual commodities currently in the CRB index, rebalanced monthly, had a diversification return of 4.24% since 1990. Additionally, the frequency of rebalancing can impact the size of the diversification returns. For the seventeen individual commodities currently in the CRB index, if the portfolio weights were only rebalanced annually, the diversification return would have been 2.33%.

It is important to distinguish between a return caused by portfolio variance reduction and a return that might otherwise be credited to a risk premium. For a risk premium, expected returns increase as risk rises. For a diversification return, returns rise while portfolio variance falls. Gorton and Rouwenhorst (2004) analyze the performance of an equally weighted portfolio of commodity futures over the time period 1959 to 2004. They find that the historical risk premium of this monthly rebalanced portfolio was about 5%. However, Figure 10 shows that the diversification return for a sample of seventeen equally weighted commodities over the time period 1990 to 2004 was over 4%. This raises the possibility that the risk premium they infer from their data is actually a diversification return.

Figure 10
Commodity Futures Index Diversification Returns



4. Asset allocation with commodity futures

Our historical analysis has revealed the following facts. First, the average return to commodity futures is close to zero. Second, the correlation of the index constituents is low. Third, the diversification return is an important contributor to the average performance. One can think of the diversification return as the return to a mechanical active strategy. Fourth, the term structure of commodity futures is a strong explanatory driver of the cross-section of returns. The setting we have described is one that invites active asset allocation.

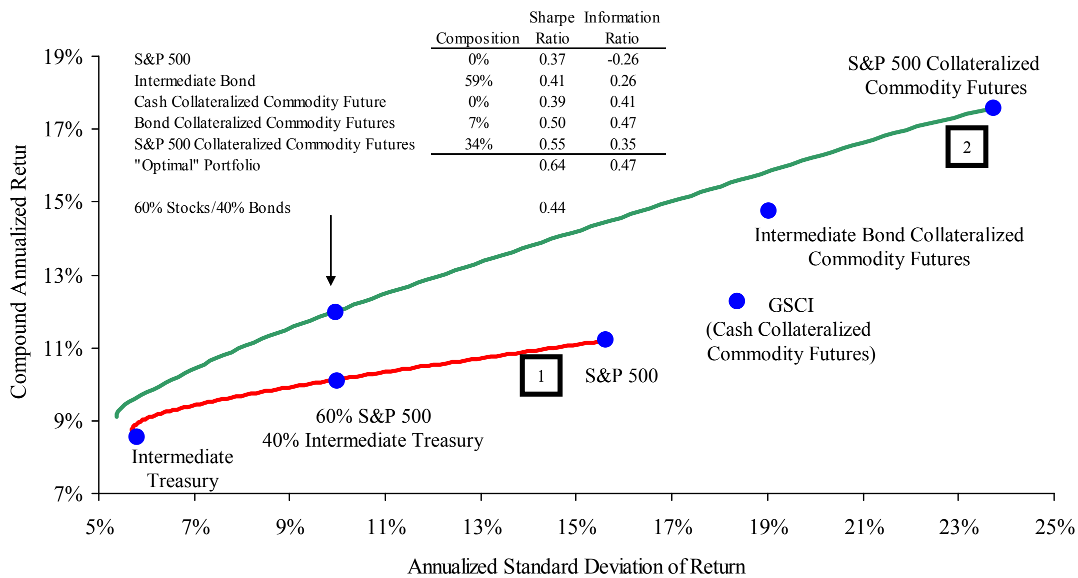
4.1 Strategic asset allocation

There are two ways that investors usually think about forming portfolios: 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, finds that the demand for commodities 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. For many investors commodity futures investment remains a curiosity. Harvard University's endowment is an example of an organization that has acted on its curiosity and currently has a 13% strategic asset allocation to commodities[xxv].

Imagine an investor with a strategic asset allocation of 60% stocks and 40% bonds. This strategic asset allocation reflects the level of risk the hypothetical investor is willing to tolerate. How should this investor go about investing in commodity futures? One possibility is to make a cash collateralized commodity futures investment producing the total return of the GSCI index. Since there are a number of commodity futures vehicles using bonds as the underlying collateral, bond collateralized commodity futures are another investment possibility. Recognizing that collateralized commodity futures are overlaid on another asset, yet another possibility would be to invest in an equity collateralized commodity futures vehicle.

Figure 11 illustrates the historical return and risk of five possible investments: bonds, stocks, cash collateralized commodity futures, bond collateralized commodity futures and stock collateralized commodity futures. Figure 11 also makes clear that no matter which collateral is used, a standalone long-only GSCI commodity futures investment has volatility most comparable to stocks. Efficient frontier 1 represents optimal mixes of stocks and bonds. Efficient frontier 2 traces out optimal mixes of the five assets: bonds, stocks, cash collateralized commodity futures, bond collateralized commodity futures and equity collateralized commodity futures. These long-only portfolio positions are constrained to add up to 100% of portfolios assets.

Figure 11
Strategic Asset Allocation
December 1969 to May 2004



	Composition	Sharpe Ratio	Information Ratio
S&P 500	0%	0.37	-0.26
Intermediate Bond	59%	0.41	0.26
Cash Collateralized Commodity Future	0%	0.39	0.41
Bond Collateralized Commodity Futures	7%	0.50	0.47
S&P 500 Collateralized Commodity Futures	34%	0.55	0.35
"Optimal" Portfolio		0.64	0.47
60% Stocks/40% Bonds		0.44	

Historically, for the risk level of the 60/40 stock-bond portfolio, adding commodity futures enhanced return by about 2% (from roughly 10% to 12%). This volatility matching portfolio consists of a 59% allocation to bonds, a 7% allocation to bond collateralized commodity futures and a 34% allocation to stock collateralized commodity futures. The portfolio Sharpe ratio rises to 0.64 from the 0.44 Sharpe ratio of the 60% stock and 40% bond portfolio.[xxvi] Equity collateralized commodity futures have a higher Sharpe ratio and information ratio than equities and this drives the allocation shift from stocks into equity collateralized commodity futures. The portfolio constraint requiring that volatility equal the volatility of a 60% stock and 40% bond portfolio drives the increased bond allocation. The message of this exercise is that commodity futures should be thought of as an asset allocation overlay, and that there is no natural underlying asset to attach the overlay returns to. The strategic rationale for commodity futures exposure is to optimally combine commodity futures with other portfolio assets in order to achieve the highest possible portfolio Sharpe ratio. Long-only commodity futures can be useful portfolio diversifiers as long as they provide a positive source of uncorrelated return (alpha). This conclusion holds for both an asset-only framework and an asset-liability framework.

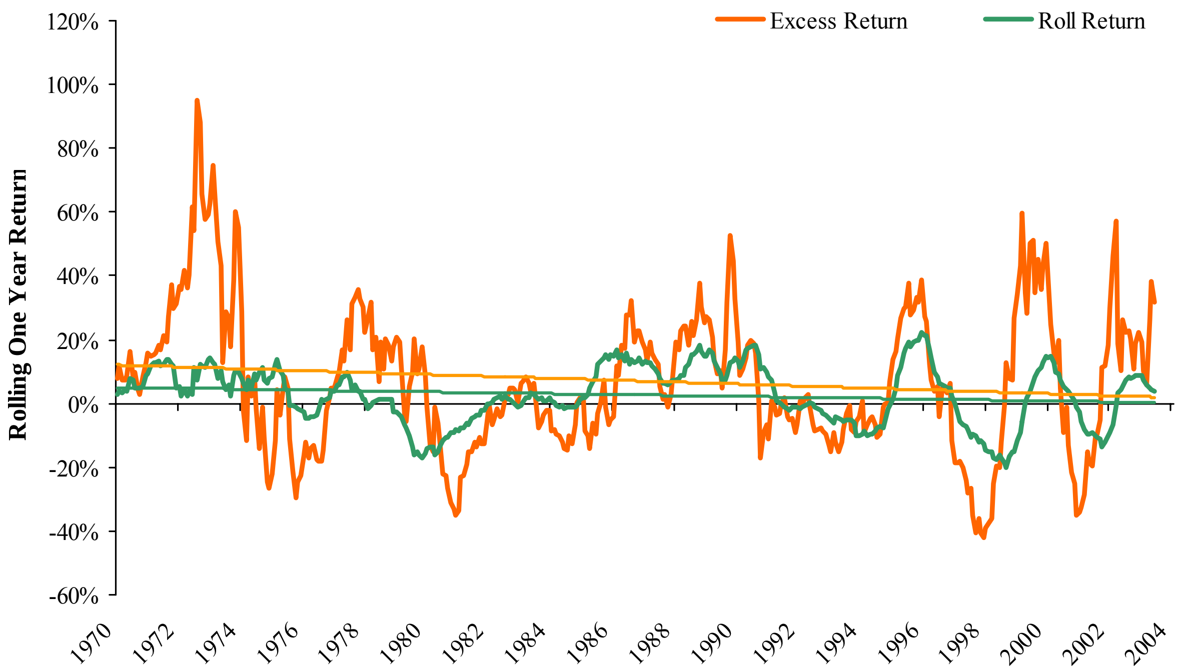
Is exposure to a long-only commodity futures index such as the GSCI the best way to improve a portfolio's Sharpe ratio with commodity futures? Treynor and Black (1973) showed that an asset's information ratio is a guide to the potential improvement in a portfolio's Sharpe ratio. Table 7 shows that, from December 1982 to May 2004, the long-only GSCI had an information ratio of about 0.36 relative to stocks, bonds and a balanced portfolio consisting of 60% stocks and 40% bonds. Energy has the highest information ratio relative to stocks and the balanced portfolio. Industrial metals and energy have the highest information ratios relative to bonds. However, the highest information ratio portfolio is formed by going long assets with positive information ratios and going short assets with negative information ratios. "Optimal" long-short commodity futures portfolios had information ratios of 0.75 relative to stocks, 0.86 relative to bonds and 0.75 relative to the balanced portfolio. The fact that these long-short commodity futures portfolios have information ratios twice as high as the long-only GSCI is consistent with the work of Grinold and Kahn (2000) and Clarke, de Silva and Thorley (2002) on the portfolio efficiency gains of long-short investing.

Table 7
Marginal Contribution To Portfolio Sharpe Ratio
Monthly Observations, December 1982 to May 2004

	Stock			Bond			60/40		
	Alpha	Residual Risk	Information Ratio	Alpha	Residual Risk	Information Ratio	Alpha	Residual Risk	Information Ratio
GSCI	6.19%	16.99%	0.36	6.04%	17.00%	0.36	6.30%	16.99%	0.37
Non-Energy	-0.49%	9.77%	-0.05	0.60%	9.88%	0.06	-0.56%	9.79%	-0.06
Energy	12.67%	31.22%	0.41	12.21%	31.28%	0.39	12.99%	31.21%	0.42
Livestock	2.93%	14.50%	0.20	3.10%	14.52%	0.21	2.77%	14.50%	0.19
Agriculture	-2.87%	14.32%	-0.20	-1.68%	14.36%	-0.12	-2.89%	14.34%	-0.20
Industrial Metals	5.08%	22.74%	0.22	8.70%	22.60%	0.39	5.35%	22.81%	0.23
Precious Metals	-3.77%	14.86%	-0.25	-3.87%	14.88%	-0.26	-3.54%	14.84%	-0.24
Heating Oil	11.64%	32.54%	0.36	11.70%	32.56%	0.36	12.06%	32.53%	0.37
Live Cattle	5.32%	13.96%	0.38	5.98%	14.01%	0.43	5.23%	13.97%	0.37
Live Hogs	-0.05%	24.25%	0.00	-1.22%	24.16%	-0.05	-0.36%	24.24%	-0.01
Wheat	-4.20%	21.03%	-0.20	-3.72%	21.08%	-0.18	-4.42%	21.02%	-0.21
Corn	-4.21%	22.63%	-0.19	-2.61%	22.66%	-0.12	-4.19%	22.65%	-0.19
Soybeans	1.60%	21.53%	0.07	2.99%	21.47%	0.14	1.78%	21.53%	0.08
Sugar	3.25%	38.72%	0.08	4.97%	38.68%	0.13	3.45%	38.73%	0.09
Coffee	-0.69%	39.67%	-0.02	4.91%	39.28%	0.12	-0.08%	39.75%	0.00
Cotton	1.46%	22.59%	0.06	3.88%	22.59%	0.17	1.55%	22.62%	0.07
Gold	-3.57%	14.21%	-0.25	-4.48%	14.38%	-0.31	-3.32%	14.21%	-0.23
Silver	-5.97%	25.05%	-0.24	-2.71%	24.77%	-0.11	-5.54%	25.08%	-0.22
Copper	7.35%	25.53%	0.29	11.25%	25.54%	0.44	7.52%	25.62%	0.29
"Optimal"			0.75			0.86			0.75

In our sample, the long-only GSCI had a historical excess return of about 6% per annum. But Figure 12 shows that the rolling one-year GSCI excess and roll returns exhibit a declining return trend over time. While this trend do not tells us whether returns will be higher or lower in the future, however, it does raise some doubts as to whether commodity futures investment will average 6% in the future. The reason is simple. Though the term structure of commodity prices may be an important long-run driver of realized commodity futures returns, there is no way to determine what the term structure of futures prices will look like in the future. For instance, energy futures are often, though not always, backwardated, but it is not obvious that the degree of future backwardation or even that these markets remain backwardated. Gold futures are seemingly always in contango. Will the future return from going long gold futures continue to be as negative as it has been in the past?

Figure 12
Rolling One Year GSCI Excess and Roll Returns
December 1969 to May 2004



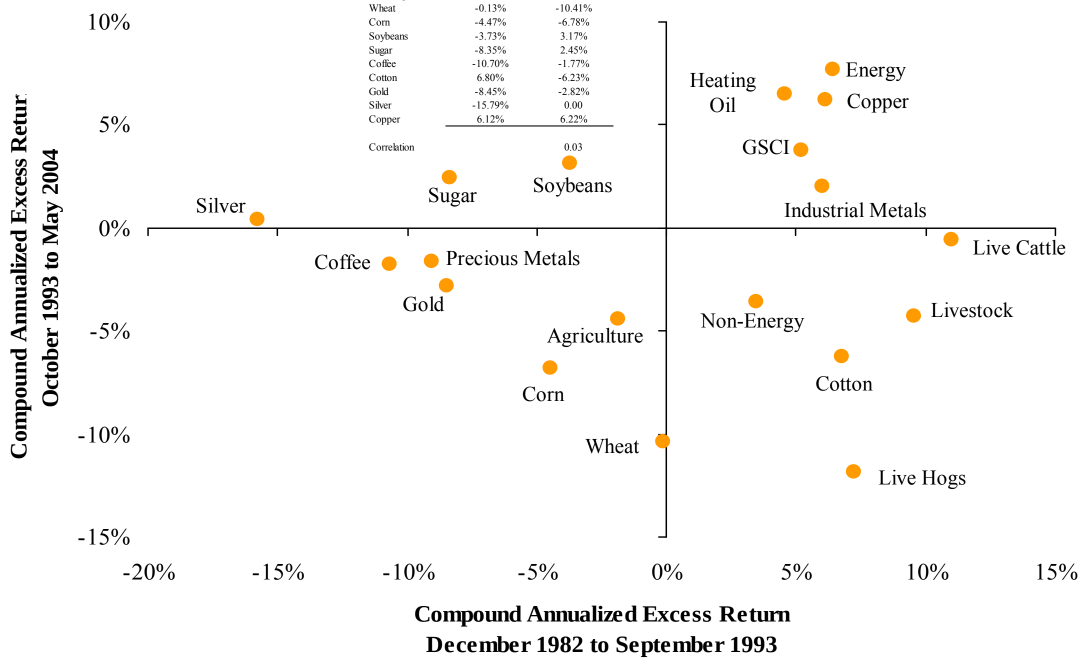
Another way of thinking about the value of historical returns as an indicator of future returns is to look at return persistence over long periods of time. Figure 13 looks at the excess return persistence of the GSCI, GSCI sectors and individual commodity futures from December 1982 to September 1993 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. There seems to be little evidence of long-term return persistence across commodity futures.

Figure 13

Long-Term Excess Return Persistence

December 1982 to May 2004

	Excess Return December 1982 to September 1993	Excess Return October 1993 to May 2004
GSCI	5.20%	3.77%
Non-Energy	3.45%	-3.59%
Energy	6.43%	7.70%
Livestock	9.57%	-4.26%
Agriculture	-1.86%	-4.40%
Industrial Metals	5.99%	2.04%
Precious Metals	-9.05%	-1.61%
Heating Oil	4.55%	6.53%
Live Cattle	11.00%	-0.59%
Live Hogs	7.25%	-11.88%
Wheat	-0.13%	-10.41%
Corn	-4.47%	-6.78%
Soybeans	-3.73%	3.17%
Sugar	-8.35%	2.45%
Coffee	-10.70%	-1.77%
Cotton	6.80%	-6.23%
Gold	-8.45%	-2.82%
Silver	-15.79%	0.00
Copper	6.12%	6.22%
Correlation		0.03



Even though commodity futures provide price insurance, it is reasonable that the price of commodity price insurance will dynamically fluctuate over time in response to the supply of and demand for insurance. If too much capital is supplied for a finite insurance need, it makes sense that returns should decline. Obviously, a shortage of capital should increase returns. If investors respond to research identifying the ability of commodity futures investment to raise portfolio Sharpe ratios, the supply of capital increases. It is certainly possible that the trend decline in the excess and roll return exhibited in Figure 12 is a reflection of too much capital chasing too few opportunities. Extrapolating past long-term term structure returns into the future might be convenient, but it is no more revealing than asserting that future stock returns will be high because past long-term stock returns have been high. Ultimately, a long-term strategic asset allocation to long-only commodity futures makes sense for investors with a subjective view that future excess returns will be high enough to increase a portfolio's Sharpe ratio. Without a defensible expectation for the excess return of a long only commodity futures investment it is hard to argue for a strategic allocation to long only commodity futures.

4.2 Tactical asset allocation for commodity indices

Though it may be hard to justify a long-run long-only strategic asset allocation to commodity futures, it is more natural to see a role for active allocation among individual commodity futures and tactical allocation into commodity futures[xxvii].There is substantial evidence that shorter-horizon expected returns for assets may vary with the state of the economy. Furthermore, commodity futures are an overlay strategy, and, as Litterman (2004) points out, tactical overlay strategies are the most capital efficient way to produce alpha.

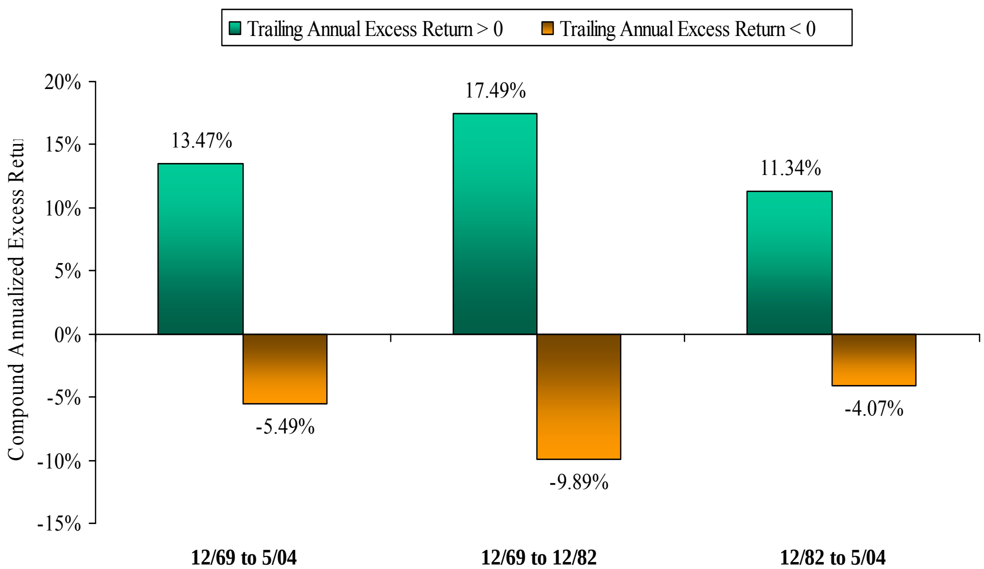
Previous research has suggested a tactical role for commodity futures. Jensen, Johnson and Mercer (2000, 2002) found that the GSCI commodity index outperformed stocks and bonds when their (now discontinued) measure of Federal Reserve monetary policy rose. Strongin and Petsch (1996) found that GSCI commodity index 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 commodity index 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 cross-correlation 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.

One alternative might be to consider a short-term momentum based strategy. The economic interpretation is as follows. We expect a positive average return for commodities that provide insurance. The "insurance providing" role is probably persistent in the short-term. Hence, a momentum based strategy says: 'if the commodity has provided insurance in the past period, it is likely to provide insurance in the next period.

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. However, for commodity futures, momentum could be a simple result of the short-term persistence of the realized pay-off to providing insurance.

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 14 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 long the GSCI if the previous one year excess return has been negative. This result is stable over time. While the momentum effect is strongest in the first 13 years of the sample, the effect is robust in the more recent period.

Figure 14
GSCI Momentum Returns
December 1982 to May 2004



We also consider some portfolio strategies. One commodity futures momentum strategy might be to invest in either cash collateralized commodity futures or cash, depending upon which strategy had the highest prior return for some time period. Alternatively, the strategy could be to invest in equity collateralized commodity futures or stocks, or bond collateralized commodity futures or bonds.

Table 8 illustrates the pay-off to an investment strategy that invests 100% of portfolio assets in one of four strategies: cash, bonds, cash collateralized commodity futures or bond collateralized commodity futures. The decision rule is to invest in the strategy that has the highest previous twelve month return. During this time period, bond collateralized commodity futures outperformed cash collateralized commodity futures by over 2.3% per annum. In turn, the momentum portfolio outperformed bond collateralized commodity futures by over 2.9% per annum. In this case, tactical allocation raises portfolio efficiency as reflected by the momentum portfolio's Sharpe ratio of 0.70.

There is no reason to limit the momentum exercise to just commodity futures, bonds and cash. Table 8 shows that historically equity collateralized commodity futures outperformed bond and cash collateralized commodity futures. The simple momentum portfolio had a return of 20.5% per annum, over 3% higher than the commodity futures, bond and cash momentum portfolio. The Sharpe ratio of this strategy is 0.72.

Table 8
Momentum strategies based on: GSCI, bonds, cash, and equity
December 1969- May 2004

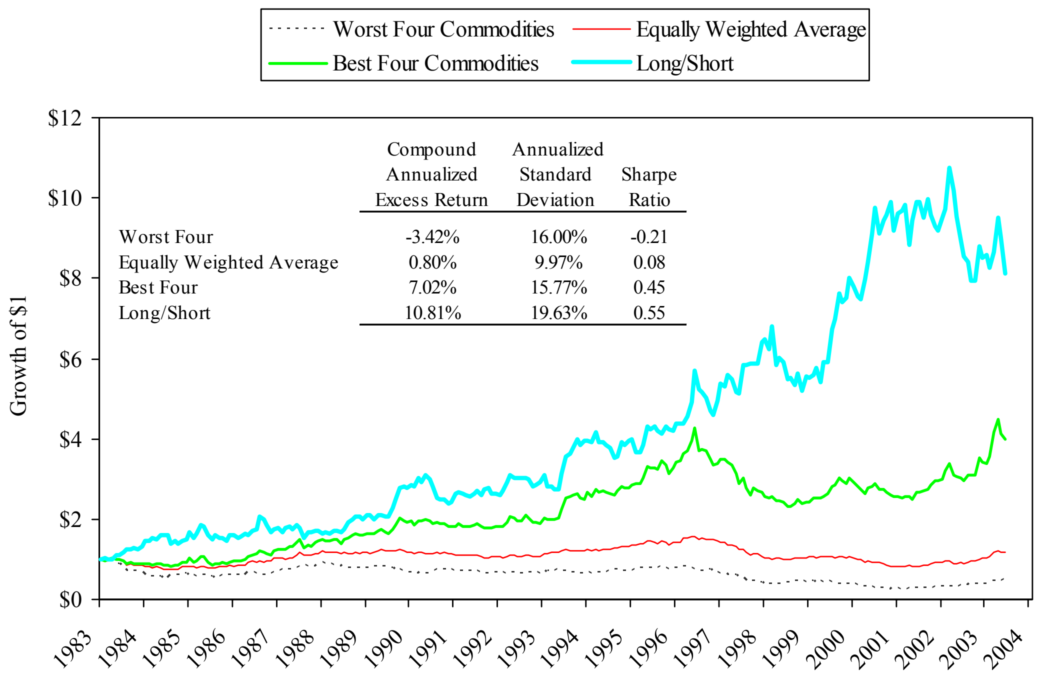
	A. Cash, Bonds, GSCI			B. Cash, bonds, stocks, GSCI		
	Compound Annualized Return	Annualized Standard Deviation	Sharpe Ratio	Compound Annualized Return	Annualized Standard Deviation	Sharpe Ratio
Momentum Portfolio	17.32%	16.01%	0.70	20.55%	20.04%	0.72
Asset class returns						
Cash + GSCI	12.16%	18.55%	0.32	12.16%	18.55%	0.32
Bond + GSCI	14.43%	19.19%	0.43	14.43%	19.19%	0.43
Stocks + GSCI				17.74%	23.83%	0.48
Cash	6.19%	0.83%	0.00	6.19%	0.83%	0.00
Bond	8.31%	5.81%	0.36	8.31%	5.81%	0.36
S&P 500				11.42%	15.51%	0.34

Trading strategy is to invest in the asset class with the highest previous 12-month return. In panel A, we consider Cash collateralized GSCI, bond collateralized GSCI, bonds, and cash. In panel B, we add stock collateralized GSCI and stocks.

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 15 examines the pay-off to investing in an equally-weighted portfolio of the four commodity futures with the highest prior twelve month returns, a 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.

Figure 15
Individual Commodity Momentum Portfolios
December 1982 to May 2004

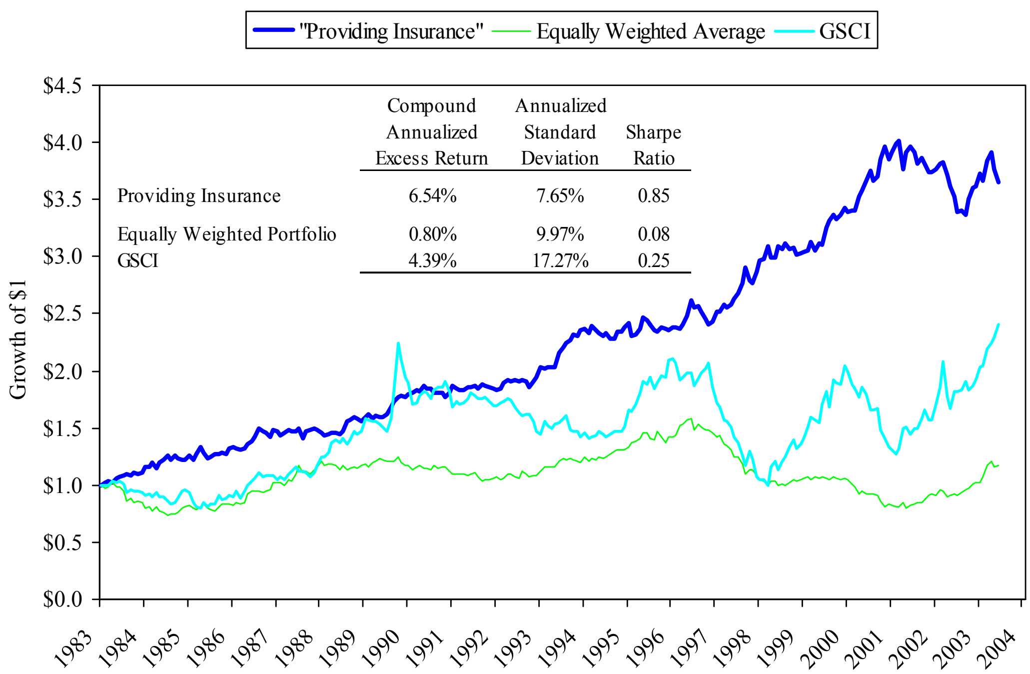


Trading strategy sorts each month the 12 categories of GSCI based on previous 12-month return. We then track the four GSCI components with the highest ('best four') and lowest ('worst four') previous returns. The portfolios are rebalanced monthly.

The tactical strategy in Figure 15 is a pure momentum strategy. We now consider a variation of the strategy that uses the sign of the previous 12-month's return. We create an "insurance providing" proxy portfolio by buying commodities that have had a positive return over the past 12 months and selling those that have had a negative return. We use the insurance term because going long a backwardated commodity provides price insurance as does going short a contangoed commodity. It is possible that in a particular month that all past returns are positive or negative.

Figure 16 shows that an “insurance providing” portfolio had an excess return of 6.5% and a Sharpe ratio of 0.85. Note the pure “insurance providing” portfolio had higher returns and a higher Sharpe ratio than the GSCI. Conceptually this makes sense. The GSCI is a long only portfolio that is a mix of “insurance providing” and “insurance buying” portfolio positions. A long only commodity futures index ends up providing insurance for backwardated commodity futures, a potential source of positive return, and buying insurance for contangoed commodity futures, a potential source of negative return.

Figure 16
Individual Commodity Momentum Portfolio Based on the Sign of the Previous Return
December 1982 to May 2004



	Compound Annualized Excess Return	Annualized Standard Deviation	Sharpe Ratio
Providing Insurance	6.54%	7.65%	0.85
Equally Weighted Portfolio	0.80%	9.97%	0.08
GSCI	4.39%	17.27%	0.25

Trading strategy is an equally weighted portfolio of twelve components of the GSCI. The portfolio is rebalanced monthly. The ‘Providing Insurance’ 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

We now consider an investable strategy that considers the term structures of futures prices as a tactical input for a trading strategy. We examine the overall GSCI as well as the components of the GSCI.

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), we expect that the long only excess return should, on average, be positive. Nash (2003) 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), we expect 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 is backwardated is 11.2%. However, when the term structure is contagoed, the annualized excess return is -5.0%. The payoffs are illustrated in Table 9. A strategy 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%. The term structure seems to be an effective tactical indicator. The economic interpretation is that today's commodity term structure gives an indication of the future price for commodity insurance.

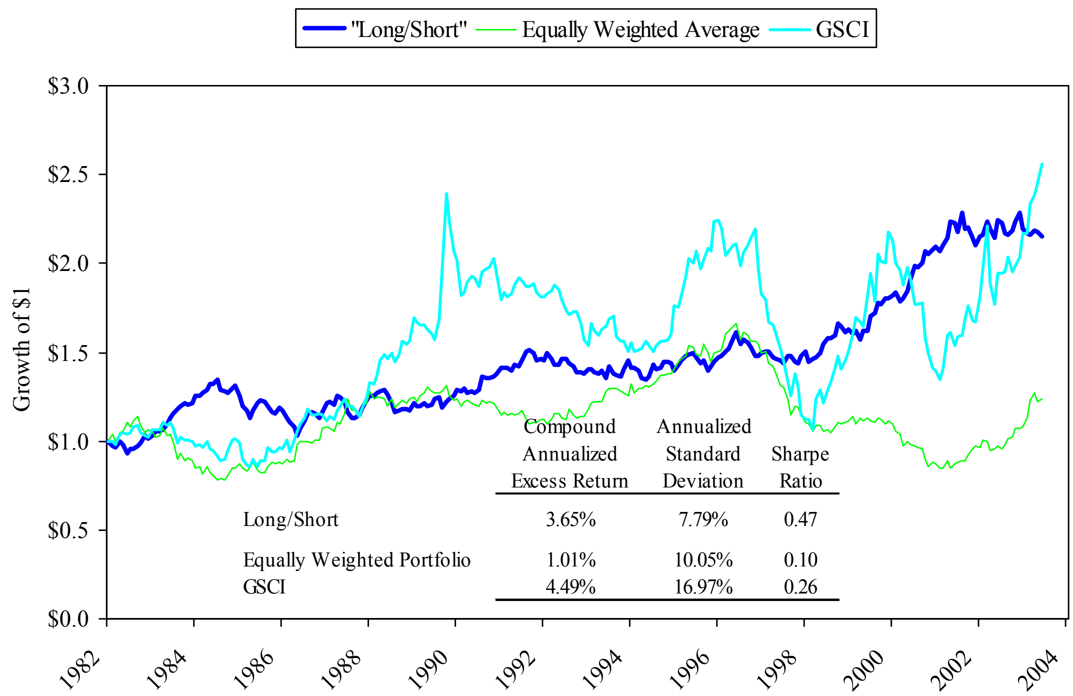
Table 9
Using the Information in the GSCI Term Structure for a Tactical Strategy
July 1992 to May 2004

	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 17 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 be a valuable tool for allocation across individual commodity futures.

Figure 17
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

Historically, a long-only investment in cash collateralized commodity futures has produced impressive average returns – somewhat like equity returns. Our paper analyzes the case for a long only commodity futures position in asset allocation. Central to the case for long-only commodity futures investment is a belief in normal backwardation. Normal backwardation suggests that all long positions in commodity futures should provide a positive excess return, i.e. there is a risk premium. Historical experience casts doubts on this belief.

The term structure of commodity prices provides valuable information about how investors should allocate capital to commodity futures. Going long backwardated commodity futures and short contangoed commodity futures seems more likely to provide positive excess returns than going long both backwardated and contangoed commodity futures.

Understanding what drives commodity futures returns provides a subjective framework with which to assess the prospective long-run pay-off from commodity futures investment. Roll returns should vary over time as the supply of and demand for commodity futures "price insurance" capital varies. The diversification return should vary as commodity futures volatilities and correlations change over time. It is an open question as to whether historical roll returns and diversification returns are a guide to the future.

We analyze both the time-series and cross-sectional properties of individual commodity futures. We find that the conventional wisdom that commodities are a good inflation hedge garners only modest support in the data. We also analyze commodity futures within the context of a multifactor risk model.

Our analysis of tactical asset allocation suggests three results. First, we show that adding a collateralized commodity futures index to a momentum strategy across asset classes improves the risk-reward profile. Second, using two active strategies, we provide evidence that momentum applied to the 12 components of the GSCI leads to a portfolio return that dominates the overall GSCI. Third, we show that the term structure of commodity prices provides a valuable signal for tactical allocation at the aggregate GSCI level as well as active allocation among the components.

Overall, it is our sense that the strategic case for long only commodity futures depends upon subjective beliefs about the long-term return potential of select commodity futures and the appropriate portfolio weighting scheme to apply to these commodity futures. Our results suggest that the traditional rationales for passively including these assets as a long-only holding in a diversified portfolio are suspect. Focusing on the role that commodity futures play in providing commodity price insurance, our research suggests that commodity futures are an important tactical source of alpha in the investment manager's arsenal.

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Notes

[i] During this time period, the correlation of returns between the S&P 500 and the GSCI was -0.03. This low correlation drives the lower standard deviation for a rebalanced portfolio. The standard deviation is: $(0.5^2 *0.1564^2 + 0.5^2 *0.1835^2 + 2*0.5*0.5 * 0.1564* 0.1835)^{1/2}$ which equals 0.1180.

[ii] Keynes (1925) stated "it is dangerous…to apply to the future inductive arguments based on past experience, unless one can distinguish the broad reasons why past experience was what it was." Carol Loomis, "Warren Buffett on the Stock Market", Fortune, December 10, 2001, volume 144, issue 12, pages 80-87.

[iii] Fama and French (1993) present evidence that stock and bond returns vary over time in response to changing levels for five risk factors: the term premium, the default premium, an equity market book-to-price measure, a measure of equity market capitalization and the equity risk premium.

[iv] Traded on the Chicago Mercantile Exchange

[v] Traded on the Chicago Board of Trade

[vi] Traded on the New York Board of Trade

[vii] Figure 2 starts in January 1991 because that is the inception date for the Dow Jones-AIG Commodity index.

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

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

[x] See www.crbtrader.com/crbindex/futures_current.asp for a description of the CRB commodity index.

[xi] Crude oil futures were added to the GSCI in 1987, Brent crude oil in 1999, unleaded gasoline in 1988, gasoil in 1999 and natural gas in 1994.

[xii] In "Diversification Returns and Asset Contributions" (1992), David Booth and Eugene Fama define the diversification return as:

$$D_j = \frac{E(R_j)\ \ln[1+E(R_p)]}{E(R_p)} - \frac{b_{jp} s_p^2}{2[1+E(R_p)]^2}$$

where

$E(R_j)$ = the expected (average) return on asset j,

$E(R_p)$ = the expected (average) return on portfolio p,

$\ln[1+E(R_p)]$ = the average return on p, expressed as a continuously compounded return,

b_{jp} = the covariance of asset j with portfolio p, and

s_p^2 = the variance of the simple returns on j and p.

Alternatively, in "Stochastic Portfolio Theory and Stock Market Equilibrium" (1982), Robert Fernholz and Brian Shay describe excess growth as:

$$\frac{1}{2} \left(\Sigma \pi_i \sigma^2_i - \Sigma_{i,j} \pi_i \pi_j \sigma_{i,j} \right.$$

where

π = weight given to asset i ($\Sigma\pi = 1.00$),

σ^2 = variance of asset i, and

$\sigma_{i,j}$ = covariance of i and j.

This is also similar to the Sharpe and Tint (1990) liability hedging concept where they find that the risk-adjusted return for a security is Expected return - risk penalty + liability hedging credit = Expected return - (variance - covariance)/2.

[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) suggested 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 possible risk premium are observable.

[xvii] In fixed income, an upward sloping yield curve produces a return attributable to the passage of time known as rolling down the yield curve.

[xviii] The roll return is the difference between a commodity future's spot return and excess return, and the term structure of commodity futures prices is the driver of the roll return. If futures prices are the same as spot prices, that is the term structure of futures prices is completely flat, then excess and spot returns should be the same. If futures prices are higher than spot prices, then excess returns should be lower than spot returns. If futures prices are below spot prices, then excess returns should be above spot returns.

[xix] The GSCI had an excess return of 4.5% driven by a significant exposure to the mostly backwardated energy sector.

[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] See endnote ix.

[xxv] This position includes exposure to timberland. Details can be found at http://vpf-web.harvard.edu/annualfinancial/pdfs/2003discussion.pdf

[xxvi] The commodity futures information ratio drives the increase in the portfolio Sharpe ratio. The original portfolio Sharpe ratio is .44 and with the addition of the commodity futures investment this becomes $(.44^2 + .47^2)^{1/2} = .64$

[xxvii] An investor's strategic asset allocation is driven by static expectations about average future returns. However, there are few investors whose expectations for future returns do not change over time The nineteenth century German tactician Moltke is purported to have said "no battle plan survives its first contact with the enemy". In a similar vein, it is possible to say that no strategic asset allocation plan ever survives its first contact with reality.

[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.