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The Strategic and Tactical Value of Commodity Futures

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Investors face numerous 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 the average individual commodity futures has been approximately zero and commodity futures returns have been largely uncorrelated with one another. The prospective annualized excess return of a rebalanced portfolio of commodity futures, however, can be "equity-like." Some security characteristics (such as the term structure of futures prices) and some portfolio strategies have historically been rewarded with above-average returns. It is important to avoid naive extrapolation of historical returns and to strike a balance between dependable sources of return and possible sources of return.

Previous research suggests that long-only portfolios of commodity futures have had average returns similar to the S&P 500 Index. Examples of such research are Bodie and Rosansky's (1980) analysis of an equally weighted paper portfolio of commodity futures from 1949 to 1976 and Gorton and Rouwenhorst's (2006; see pp. 47–68 of this issue) study of an equally weighted paper portfolio of commodity futures from 1959 to 2004. Both studies found equity-like average returns. **Table 1** reinforces the possibility of equity-like returns by highlighting the performance of a widely used commodity futures index. The 12.2 percent compound annualized return of the Goldman Sachs Commodity Index (GSCI) since 1969 compares favorably with the return for the S&P 500. Given this evidence, should investors have the same long-term return expectations for portfolios of commodity futures as they have for equities?

The idea that past performance is a good forecast of future performance is an example of naive extrapolation. Recent research suggests that naively extrapolating past performance into the future is dangerous. For instance, Arnott and Bernstein (2002) pointed out that the past high excess returns for U.S. equities do not prove that the forward-looking equity risk premium is high. They argued that forward-looking returns should be based on an understanding of the fundamental drivers of equity returns, such as earnings growth, dividend yield, and the change in valuation levels. Past returns will be a guide to the future only if the future return drivers are the same as in the past. More recently, Dimson, Marsh, and Staunton (2004) presented a similar cautionary argument for global equities and suggested reasons that future equity returns in many countries may be lower than those observed in the past.

A common message of these analyses is that historical returns are an incomplete guide to investment prospects. The challenge for investors contemplating a long-only investment in commodity futures is to develop a framework for thinking about prospective returns.[1] There are at least two steps in developing a forward-looking framework. The first step is an examination of the historical returns of both individual commodity futures and portfolios of commodity futures. This analysis of historical returns provides a sense of the drivers, the building blocks, of historical returns. The second step focuses on estimating possible future values for these return drivers. The reward of this two step process is an appreciation of the potential return and risk of a commodity futures investment.

Historical Returns

The jumping-off point for a consideration of prospective commodity futures returns is an examination of historical returns. In this section, the goal is to answer a number of questions: What have been the historical excess returns of individual commodity futures and commodity futures portfolios? How comparable are the returns of commodity futures portfolios with returns of broad-based indices of

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Table 1. Return and Risk, December 1969–May 2004

Entity	Annualized Compound Return	Annualized Standard Deviation	*t*-Statistic[a]
U.S. inflation	4.79%	1.15%	—
Three-month U.S. T-bill return	6.33	0.83	—
Intermediate-term government bond return	8.55	5.82	2.23
S&P 500 return	11.20	15.64	1.83
GSCI return	12.24	18.35	1.89
50% S&P 500/50% GSCI return	12.54	11.86	3.07

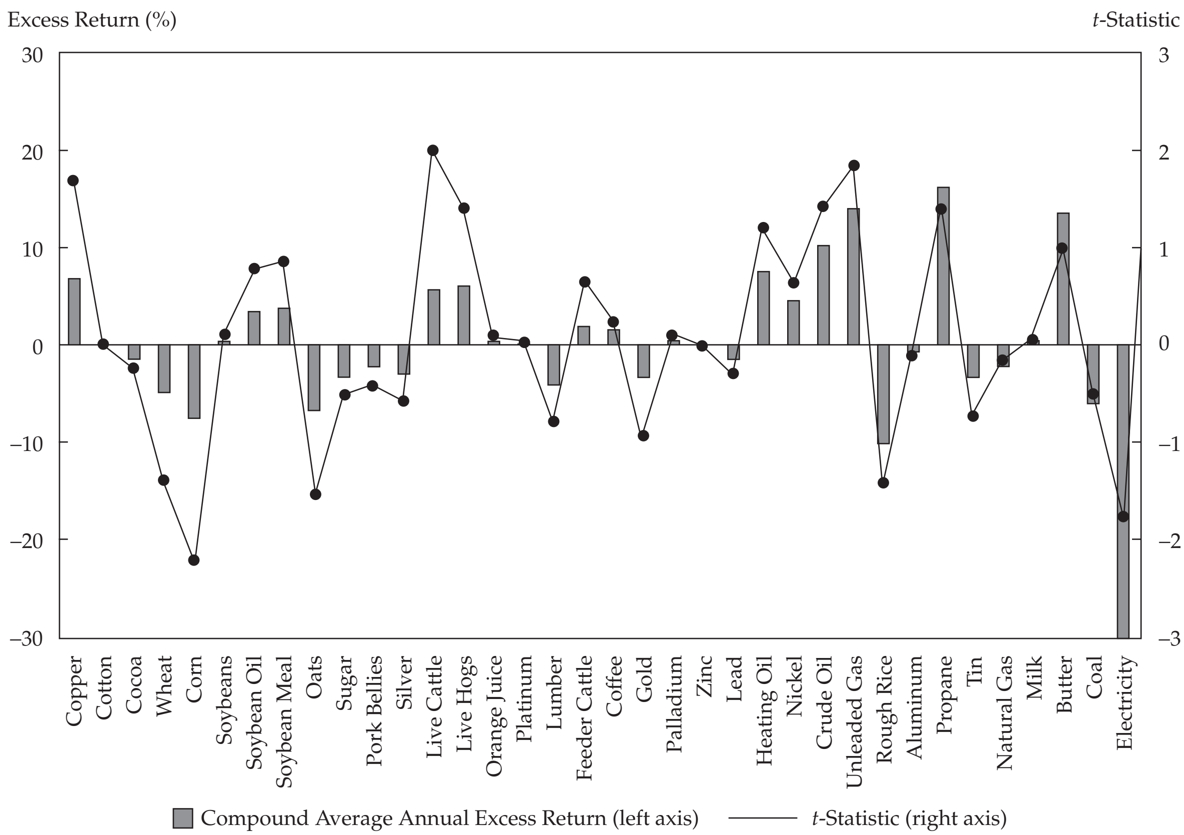
Notes: The GSCI inception date is December 1969. The GSCI return is a total return that includes the return on collateral (the T-bill return). During this time period, the S&P 500 and the GSCI had a monthly return correlation of –0.03. This low correlation drives the lower standard deviation for a rebalanced portfolio.

[a]Test of whether excess return is different from zero.

stocks and bonds? And what is a meaningful time period for assessing the correlations of individual commodities with one another?

Individual Commodity Returns and a Portfolio Return Conundrum. Historically, the average and median compound (geometric) annual excess return of individual commodity futures has been close to zero.[2] Of the 36 individual commodity futures that Gorton and Rouwenhorst studied over the 1959–2004 period, 18 had geometric excess returns that were greater than zero and 18 had geometric excess returns that were less than zero. **Figure 1** shows that only a single commodity, corn, had a "statistically significant" return.[3] An equally weighted average of the 36 individual compound excess returns was –0.51 percent (with a standard deviation of 30.10 percent), and the average

Figure 1. Compound Average Annual Excess Return of Individual Commodity Futures, 1959–2004



Note: The return for "Electricity" falls below the graph, to –55.65 percent.

absolute *t*-statistic was 0.8. The median of individual compound excess returns was 0.03 percent.

The bottom line is that in this sample, the average return of the average commodity futures contract is not statistically different from zero or, stated differently, the average commodity futures has an average geometric "risk premium" of zero. It is intriguing, however, that a rebalanced and equally weighted portfolio of these commodity futures had an average excess return of 4.5 percent—which is significantly greater than zero. Thus, an important question for investors considering a long-only investment in commodity futures is: How can a portfolio have equity-like returns when the average and median returns of the portfolio's constituents are zero?

The geometric return of a rebalanced portfolio can significantly exceed the weighted-average geometric return of its constituents if the securities in the portfolio have low correlations with one another and the securities have high average standard deviations. For investors used to investing in unrebalanced bond and stock portfolios, the significance of this observation may or may not seem obvious. An investor investing in an *unrebalanced* bond portfolio, such as the Lehman Aggregate Bond Index, can reasonably expect that the return of the bond portfolio should be close to the weighted-average return of the portfolio's constituents. For instance, if an unrebalanced bond portfolio consists of two bonds, each of which has a return of zero, the portfolio is unlikely to have a positive rate of return. This intuition can also hold for an unrebalanced equity portfolio. Siegel (2005; see also Siegel and Schwartz 2006) presented data indicating that the weighted-average geometric return of the original constituents of the S&P 500 was about 11.0 percent over the period March 1957 through December 2003, similar to the performance of the actual, updated, S&P 500 and what Siegel called the "total descendants portfolio" (125 original companies that remained intact plus shares issued by companies that acquired an original S&P 500 company plus all the spin-offs and other stocks distributed by these companies). As illustrated later, this intuition does not seem to hold, however, for the returns of *rebalanced* portfolios of commodity futures.[4]

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 such a 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 may be a guide to the average return of the aggregate commodity futures "market."

Bodie and Rosansky calculated the returns for an equally weighted cash-collateralized portfolio of commodity futures over the 1949–1976 period. Their equally weighted portfolio started with 10 futures contracts and ended with 23. They found that their portfolio had statistically significant excess returns that were similar in magnitude to those of the S&P 500. Fama and French (1987) calculated the performance of an equally weighted portfolio of up to 21 commodity futures over the 1967–84 period and found only marginal evidence of statistically significant portfolio returns. Gorton and Rouwenhorst investigated the performance of an equally weighted cash-collateralized commodity futures portfolio for 1959–2004. Their portfolio initially consisted of 9 commodity futures and ended with 36. They found that their equally weighted portfolio of commodity futures had statistically significant returns similar to those 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. An important and obvious question is: How relevant are equally weighted portfolios for investors seeking to assess the attractiveness of an asset class?

Inferring the long-term performance of any asset class from the performance of an equally weighted portfolio is unusual. For example, Arnott, Hsu, and Moore (2005) pointed out that equally weighted equity portfolios lack the liquidity and capacity found in traditional market cap–weighted equity indices and, importantly, have return characteristics that are not representative of the aggregate equity market.[5]

The difference in return between the market cap–weighted Wilshire 5000 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. From December 1970 through May 2004, the market cap–weighted Wilshire 5000 had a compound annualized return of 11.4 percent and the equally weighted Wilshire 5000 had a return of 20.3 percent. In this case, the return of the equally weighted equity portfolio was almost twice as high as the return of the aggregate stock market.

Most investors would not consider an equally weighted equity portfolio to be representative of the equity market because it is dominated by small-cap securities.[6] 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 the answer to this question is yes, perhaps an equally weighted commodity futures portfolio should not be used to measure the return of a "commodity asset class," nor should the returns of an equally weighted commodity portfolio be used to make return comparisons with other asset classes.[7]

Do Commodity Indices Measure Asset-Class Returns? Even if the message of equally weighted paper portfolios may be difficult to decipher, an examination of commodity futures indices may provide some insight. The three most commonly used commodity futures indices are the GSCI, traded on the Chicago Mercantile Exchange; the Dow Jones-AIG Commodity Index (DJ-AIGCI), traded on the Chicago Board of Trade; and what used to be the Reuters-CRB Futures Price Index (CRB), traded on the New York Board of Trade.[8] As of May 2004, the GSCI represented 86 percent of the combined open interest of the three indices, the DJ-AIGCI accounted for 10 percent, and the CRB made up the remaining 4 percent of open interest.[9]

Each of these indices is intended to be a broad representation of investment opportunities in the aggregate commodity futures market. An investor might expect the return and risk of broad-based indices to be similar. Interestingly, however, **Table 2** shows that the three commodity indices experienced different levels of return and volatility when measured over a common time period.[10] The GSCI had twice the volatility of the CRB during the period. The DJ-AIGCI and the GSCI had average returns similar to that of the Lehman Aggregate, and the CRB had a return similar to that of the T-bill return, underperforming the Lehman Aggregate by about 4 percentage points a year. What might explain the return and risk differences among these indices?

Commodity Indices as Strategies. Asset weights and asset returns drive portfolio returns. The return and risk differences among these three commodity indices can be partially explained by the differing weights of individual commodity futures contracts in the indices. The use of different portfolio weights implies that each index defines the aggregate commodity futures market differently.

Table 3 shows that the unrebalanced GSCI, which has a portfolio weighting scheme based on the level of worldwide production for each commodity, is heavily skewed toward energy exposure. The annually rebalanced DJ-AIGCI focuses primarily on contract liquidity, supplemented by production data, to determine portfolio weights. The monthly rebalanced CRB was historically a geometrically averaged and equally weighted index, but a recent change in calculation methodology makes the index fairly similar to the DJ-AIGCI.

The comparatively higher returns of the GSCI and the DJ-AIGCI shown in Table 2 can be viewed as a payoff to overweighting individual commodity futures that turned out to have above-average returns. The compositions 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. The compositions of the aggregate stock and bond markets are 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 outstanding value of long and short futures contracts is exactly offsetting. As a result, there is no commodity futures market capitalization.[11] Lacking a market capitalization–based portfolio weighting scheme, commodity indices can best be thought of as commodity portfolio *strategies*.

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.[12] For example, the GSCI initially consisted of only four commodity

Table 2. Return and Risk over a Common Time Period, January 1991–May 2004

Index	Compound Total Return	Standard Deviation	Correlation: GSCI	DJ-AIGCI	CRB	Wilshire 5000	EAFE
GSCI	6.81%	17.53%					
DJ-AIGCI	7.83	11.71	0.89				
CRB	3.64	8.30	0.66	0.83			
Wilshire 5000	11.60	14.77	0.06	0.13	0.18		
EAFE	5.68	15.53	0.14	0.22	0.27	0.70	
Lehman Aggregate	7.53	3.92	0.07	0.03	–0.02	0.07	0.03

Notes: The comparison of annualized index returns starts in 1991 because this is the earliest common time period for all three commodity indices. EAFE is the MSCI Europe/Australasia/Far East Index. The T-bill return was 4.14 percent over this period.

Table 3. Composition of Commodity Indices, May 2004

	Portfolio Weight		
Commodity	CRB	GSCI	DJ-AIGCI
Aluminum	—	2.9%	7.1%
Cocoa	5.9%	0.3	2.0
Coffee	5.9	0.6	2.8
Copper	5.9	2.3	6.7
Corn	5.9	3.1	5.1
Cotton	5.9	1.1	1.8
Crude oil	5.9	28.4	16.7
Brent crude oil	—	13.1	—
Feeder cattle	—	0.8	—
Gas oil	—	4.5	—
Gold	5.9	1.9	5.3
Heating oil	5.9	8.1	4.7
Lead	—	0.3	—
Hogs	5.9	2.1	5.1
Live cattle	5.9	3.6	6.7
Natural gas	5.9	9.5	9.9
Nickel	—	0.8	1.9
Orange juice	5.9	—	—
Platinum	5.9	0.0	—
Silver	5.9	0.2	2.2
Soybeans	5.9	1.9	5.1
Soybean oil	—	0.0	1.7
Sugar	5.9	1.4	3.8
Unleaded gas	—	8.5	5.4
Wheat	5.9	2.9	3.8
Red wheat	—	1.3	0.0
Zinc	—	0.5	2.3
Total	100.0%	100.0%	100.0%
Number of futures	17	24	20

Note: Columns do not sum to 100 because of rounding.

futures: cattle, corn, soybeans, and wheat. For the first decade of the index's return history, cattle represented the largest portfolio exposure—more than 50 percent in the early 1970s. Over time, new commodity futures contracts have been added. Recently, cattle represented less than 5 percent of the GSCI, and crude oil, at about 29 percent, had become the single largest portfolio constituent. If returns differ from one commodity futures to another and if portfolio composition and weights change over time, historical index performance is at best a murky guide to prospective index returns.

Comparing Returns in 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.

A comparison of the returns of individual commodities with one another in a common time period, however, is also useful. Dimson et al. (2002), focusing on the question of how similar or dissimilar national equity market returns have been, argued that a desirable characteristic of a good index is an ability to allow comparisons among the constituents of the index over a common time period. The same argument suggests that a common time period can be useful when investigating the returns of individual commodity futures and commodity futures portfolios.

The challenge 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 investment 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 DJ-AIGCI, 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, and because the GSCI antedates the DJ-AIGCI, December 1982 is a plausible start date for the cross-sectional comparison of individual commodity futures returns.[13] Given that the GSCI has a greater number of individual constituents than either the DJ-AIGCI or the CRB, and because 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 yielded the 12 individual commodities listed in **Table 4**.

Table 4 presents the historical excess returns of the overall GSCI, six GSCI sectors, and 12 individual constituents of the GSCI that have been available since December 1982. Over the December 1982 through May 2004 period, the GSCI's compound annualized excess return was higher than the Lehman excess return and lower than the excess return for the S&P 500. The performance of the GSCI was boosted by the performance of the energy sector and negatively affected by the performance of the nonenergy sector.[14] Among the 12 individual commodities listed, only four individual commodity futures had positive excess returns.

Combining the substantial differences in the returns of individual commodity futures shown in Table 4 with the weight differences of the various commodity futures in the indices shown in Table 3 suggests a reason for differences in the returns of indices. Of course, the fact that individual returns

Table 4. Historical Excess Returns, December 1982–May 2004

Index/Sector/ Commodity/ Portfolio	Geometric Mean	Arithmetic Mean	Standard Deviation	*t*-Statistic	Skewness	Kurtosis	Sharpe Ratio	Auto-correlation	Difficult Storage
GSCI	4.49%	5.81%	16.97%	1.22	0.51	1.98	0.26	0.11	
Sectors									
Nonenergy	–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	
Commodity									
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									
Initially EW; buy-and-hold	0.70	1.26	10.61	0.31	0.05	0.69	0.07	0.01	
EW rebalanced	1.01	1.51	10.05	0.46	0.01	0.37	0.10	–0.04	
Average of 12 commodities	–1.71	1.51	25.16	–0.31	0.60	3.06	–0.07	–0.01	
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	
EAFE	5.84	7.18	17.29	1.56	–0.22	0.38	0.34	0.05	

within a universe of commodity futures have differed in the past does not guarantee that they will differ in the future. The return dispersion (and lack of statistical significance) in these data, however, is consistent with the data presented by Bodie and Rosansky and by Gorton and Rouwenhorst.

Table 4 also reports the average annual geometric excess return of an initially equally weighted (EW) buy-and-hold portfolio, of an EW portfolio rebalanced monthly, and of the 12 individual commodities in the EW portfolio. The differences in return between the GSCI and these three averages reflect the significant energy exposure of the GSCI.

Till (2000) suggested that an important determinant of an individual commodity future's return comes from the difficulty of storing that commodity. Till identified four of the commodity futures in Table 4 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 was 3.5 percent for the period, and the average geometric excess return of the other (not difficult to store) commodity futures was –4.3 percent.

Calculating Correlations. Focusing on a common time period makes it possible to explore the correlations of a universe of individual commodity futures. Observing historical correlations makes it possible to ask: Is the investment universe a "homogeneous commodity futures market" or a "heterogeneous market of commodity futures"? Or, alternatively, is the market a collection of securities that behave in a similar way, or is the market a collection of dissimilar securities? Average correlations in **Table 5** are low, particularly between commodities in different sectors. For example, heating oil and silver excess returns are essentially uncorrelated (0.02). The average return correlation of the 12 commodity futures with the GSCI is 0.20. The average correlation of individual commodities with one another is only 0.09.[15] Heating oil's average correlation with the other 11 commodities, for instance, is 0.03; its highest correlation is with gold, and its lowest correlation is with coffee. The average correlation of the commodity sectors (energy, livestock, agriculture, industrial metals, and precious metals) with the GSCI is 0.33. This relatively high correlation is driven by the 0.91 correlation between the overall GSCI and the energy sector.

Because commodity futures are largely uncorrelated with one another, thinking of them as a market of individual dissimilar assets is more meaningful than thinking of them as a homogeneous market of similar assets.

Table 5. Excess Return Correlations, December 1982–May 2004 (monthly observations)

A. Correlation of sectors and commodities

	GSCI	Nonenergy	Energy	Livestock	Agriculture	Industrial Metals	Precious Metals
Sector							
Nonenergy	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	
Commodity							
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
Hogs	0.21	0.52	0.06	0.81	0.13	–0.06	0.05
Wheat	0.25	0.66	0.06	0.18	0.79	0.05	0.06
Corn	0.14	0.58	–0.03	0.10	0.78	0.12	–0.01
Soybeans	0.20	0.58	0.02	0.11	0.72	0.18	0.14
Sugar	0.03	0.21	–0.06	–0.05	0.35	0.14	0.05
Coffee	–0.01	0.15	–0.04	–0.07	0.23	0.07	0.01
Cotton	0.11	0.25	0.06	0.00	0.27	0.17	0.04
Gold	0.20	0.16	0.16	0.01	0.07	0.18	0.97
Silver	0.08	0.19	0.02	0.02	0.10	0.19	0.77
Copper	0.15	0.36	0.04	0.01	0.22	0.94	0.20

B. Correlation of commodities continued

	Heating Oil	Cattle	Hogs	Wheat	Corn	Soybeans	Sugar	Coffee	Cotton	Gold	Silver
Heating oil											
Cattle	0.00										
Hogs	0.06	0.37									
Wheat	0.06	0.12	0.17								
Corn	–0.04	0.05	0.11	0.52							
Soybeans	0.05	0.03	0.14	0.43	0.70						
Sugar	–0.04	0.02	–0.10	0.11	0.12	0.09					
Coffee	–0.07	–0.06	–0.06	0.00	0.03	0.07	–0.01				
Cotton	0.05	–0.06	0.06	0.05	0.11	0.18	–0.02	–0.01			
Gold	0.15	–0.02	0.04	0.07	–0.01	0.14	0.02	0.00	0.03		
Silver	0.02	–0.01	0.05	0.03	0.09	0.13	0.07	0.04	0.04	0.66	
Copper	0.07	0.03	–0.02	0.08	0.16	0.23	0.14	0.11	0.19	0.18	0.21

Note: Average correlation: GSCI with commodity sectors, 0.34; GSCI with individual commodities, 0.20; heating oil with other commodities, 0.03; and individual commodities, 0.09.

Return Decomposition and Expectations

What drives the returns of individual commodity futures and of portfolios of commodity futures? Decomposing returns into building blocks can provide some insight. An examination of four theories of commodity price determination provides perspective on earlier attempts to make sense of commodity futures as well as a framework for the cross-sectional and time-series examination of commodity futures returns.

Decomposition of Commodity Futures Returns. The annualized total 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 is 1 percent.

Similarly, the annualized total return of a diversified cash-collateralized commodity futures portfolio can be decomposed into three components:

Commodity portfolio total
return = Cash return
+ Weighted-average excess return
+ Diversification return.

The diversification return is a synergistic benefit of combining two or more assets (to reduce variance) *with portfolio rebalancing*.[16] A positive diversification return means that the compound return of the portfolio will be greater than the weighted-average compound return of the individual portfolio constituents. The geometric average return of a portfolio will be positively affected by the reduction in variance. As we will discuss later, the diversification return is enhanced by rebalancing but will typically suffer if the portfolio is not rebalanced.[17]

Understanding Expected Returns. A number of theoretical frameworks have been proposed for understanding the source of commodity futures excess returns: the capital asset pricing model (CAPM), 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 prospective returns from investing in commodity futures, but they are part of the evolution of thought about commodity futures investing.

■ *The CAPM.* Lummer and Siegel (1993) and Kaplan and Lummer (1998) argued that the long-run expected return of an investment in the cash-collateralized GSCI should be similar to that of T-bills. This argument is equivalent to saying that the expected excess return should be zero for the cash-collateralized GSCI. 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 Sharpe (1964) and Lintner (1965) CAPM. Finding that the stock market beta does not drive the returns of a commodity futures index, or the returns of individual commodity futures, does not necessarily imply, however, that expected commodity futures excess returns should be zero. As Fama and French (1992b) pointed out, the empirical relation between realized returns and beta is weak. This finding does not mean that expected excess returns are zero; it simply highlights the limitations of using beta to estimate expected return.

There is another good reason to question a CAPM explanation of commodity futures returns. The CAPM is supposed to explain the expected returns of capital assets, but commodity futures are not capital assets. Black (1976) pointed out that commodity futures are similar to sports bets, and neither bets on college football games nor commodity futures are included in the market portfolio. If commodity futures are not included in the market portfolio, why would the CAPM explain commodity futures returns?

■ *The insurance perspective.* Gorton and Rouwenhorst 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, returns could be similar to those of equities.[18] In Keynes' theory of normal backwardation, 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 toward the spot price at maturity, excess returns should be positive. Keynes' insight was that commodity futures allow operating companies to hedge their commodity price exposures, and because hedging is a form of insurance, hedgers must offer investors in long-only commodity futures an insurance premium.

Normal backwardation suggests that in a world with risk-averse hedgers and investors, the excess return from a long commodity futures investment should be viewed as an insurance risk premium. Under normal backwardation, investors who go long commodity futures should receive a positive risk premium; therefore, 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 futures contract should have a higher return than a relatively less normally backwardated commodity futures contract. Because the expected future spot price is impossible to know, however, 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. Therefore, historical evidence of positive excess returns for individual commodity futures could be a good indicator of the existence of normal backwardation.

To test for the presence of normal backwardation risk premiums in individual commodity futures, Kolb (1992) looked at 29 futures contracts and concluded that "normal backwardation is not normal." Specifically, he noted that 9 commodities exhibited statistically significant positive returns, 4 had statistically significant negative returns, and the remaining 16 returns were not statistically significant. Kolb looked at individual commodity futures; hence, he missed the potential increase in the power of statistical inference that may come from forming portfolios of commodity futures. His work shows, however, that some commodity futures have positive returns and some commodity futures have negative returns. Because normal backwardation suggests that all commodity futures should have positive returns, Kolb's work indicates the challenge in proving the existence of normal backwardation.

Bodie and Rosansky, Fama and French (1987), and Gorton and Rouwenhorst report the performance of individual commodity futures and the performance of equally weighted portfolios of commodity futures. Their evidence on individual futures' returns supports Kolb's finding that proving the existence of normal backwardation for the average individual commodity futures is difficult. Bodie and Rosansky and Gorton and Rouwenhorst do report statistically significant returns for an equally weighted portfolio, which they concluded supports a finding of normal backwardation for a periodically rebalanced equally weighted portfolio. However, these statistically significant portfolio returns do not prove the existence of normal backwardation because, as illustrated later, simply rebalancing alone can be a source of statistically significant returns.

■ *The hedging pressure hypothesis.* This 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) noted 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 selling commodity futures short. As a result, the futures price is expected to rise over time, which provides an inducement for investors to go long commodity futures. They suggested 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, may have risk premiums if backwardation holds when hedgers are net short futures and contango holds when hedgers are net long futures. Bessembinder (1992) found substantial evidence for the period 1967 to 1989 that average returns for 16 nonfinancial futures were influenced by the degree of net hedging.[19] In other words, commodities in which hedgers were net short had positive excess returns on average and commodities in which hedgers were net long had negative excess returns on average.

De Roon, Nijman, and Veld (2000) analyzed 20 futures markets over the 1986–94 period and concluded that hedging pressure plays an important role in explaining futures returns. Anson (2002) distinguished between markets that provide a hedge for producers (backwardated markets) and markets that provide a hedge for consumers (contangoed markets). He pointed 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. A manufacturer such as Boeing is a consumer of aluminum, so it is short aluminum and 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. As a result, 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 is 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, without a reliable measure of hedging pressure, investors will find this concept to be of limited practical value.

■ *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 is 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, having a level of inventories that will reduce the impact of production disruptions is beneficial. Kaldor (1939) and Brennan (1991) dubbed this benefit the "convenience yield." The convenience yield is high when desired inventories are low and 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, the difference between the spot price of a commodity and the futures price will be the interest cost until the maturity of the contract. If the spot price of a commodity is 100 and the one-year interest rate is 10 percent, the one-year commodity futures price should be 110. If desired inventories are in short supply, however, the convenience yield may be high; if inventories are low, the convenience yield may be low. If the convenience yield is 5 percent, the one-year commodity futures price will be 105. If the convenience yield is 15 percent, the commodity futures price will be 95.

The convenience yield conceptually links desired inventories with commodity futures prices. By observing, or estimating, a high convenience yield, one can 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.

The convenience yield suggests that inventories may be low for difficult-to-store commodities; as a result, those commodities may have high convenience yields. Conversely, inventories should be plentiful for easy-to-store commodities, and they should have low convenience yields.

Imagine an investor who is contemplating investing in commodity futures for the next 10 years. What the investor needs to know is how high the convenience yield will be over the 10 years for difficult-to-store commodities and how low the convenience yield will be for easy-to-store commodities. Unfortunately, the theory of storage does not provide an answer to this question, nor is any definitive answer likely.

Drivers of Commodity Futures Returns. In this section, we turn from theories of how prices should behave to an examination of actual price behavior.

■ *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. The literature contains competing theories of how commodity prices should behave, but the term structure of futures prices is a market reality that investors face every day, and it is an indication of actual commodity price behavior. **Figure 2** illustrates the term structure of futures prices for crude oil and gold at the end of May 2004.

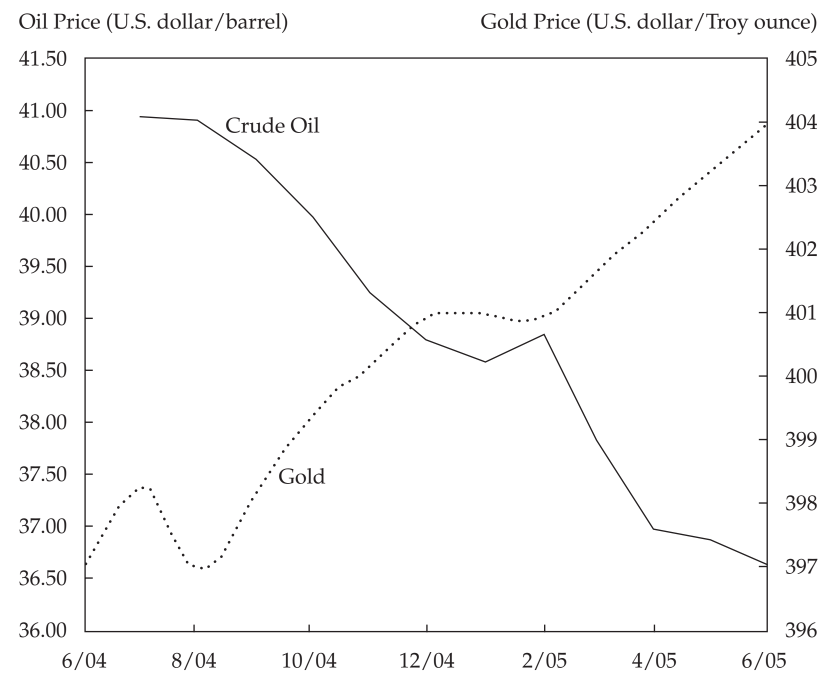
In Figure 2, the futures price for crude oil declines as the time horizon increases—from $40.95 a barrel for the July 2004 futures contract to $36.65 for the June 2005 futures contract. This is an example of *market* (not normal) backwardation:[20] The futures price is lower than the current spot price. Typically, the current spot price is the futures contract with the shortest time to maturity, the nearby futures contract.

For gold, Figure 2 shows the futures price increasing as the time horizon increases. This relationship is known as contango.

Crude oil commodity futures are backwardated in Figure 2 but are not always backwardated. Historically, crude oil futures have been backwardated about 66 percent of the time.[21] Gold is in contango in Figure 2, and gold has always been in contango. Interestingly, although gold is a standard component of many commodity futures indices, some theorists have argued that gold is really a currency, not a commodity, and that gold futures are best thought of as financial futures.

An upward- or downward-sloping term structure of futures prices creates the possibility of the futures price roll return. In fixed-income parlance,

Figure 2. Term Structure of Commodity Prices: Crude Oil and Gold, 30 May 2004



Note: Gold futures prices were interpolated for the months of September 2004, November 2004, January 2005, and March 2005.

an upward-sloping yield curve produces a return attributable to the passage of time known as "rolling down the yield curve."[22]

In the crude oil futures example, the futures price for July 2005 was $36.65 and the July 2004 price was $40.95. If the term structure of oil remained unchanged between July 2004 and July 2005, the roll return from buying the July 2005 oil contract and holding the position for one year was 11.7 percent ($40.95/$36.65 – 1). For gold, assuming no change in the term structure of gold futures prices, the roll return was –1.4 percent ($398.30/$404.00 – 1).

Investors should beware of the fallacy of composition and resist extrapolating the roll return of an individual commodity futures to all other commodity futures. This point is worth remembering because marketers of long-only commodity strategies commonly highlight in their presentation materials only the excess returns of backwardated commodity futures.[23]

■ *Historical importance of roll returns*. **Table 6** shows how important roll returns have been in explaining the cross-section of individual commodity futures' excess returns from December 1982 through May 2004. The R^2 indicates that the roll returns explained 91.6 percent of the long-run cross-sectional variation of commodity futures returns over the period. Four commodities had positive roll returns, on average, and positive excess returns. Eight had negative roll returns, on average, and negative excess returns. The difference between the average excess returns for the commodities with positive roll returns and those with negative roll returns is almost 9 percentage points, consisting of a 7.5 percentage point difference in roll returns and a 1.4 percentage point difference in spot returns.

Table 6 is inconsistent with the idea of normal backwardation. Long-only normal backwardation suggests that the average excess returns of individual commodity futures should be positive for contangoed as well as backwardated commodity futures. Of course, just as the existence of that which is unobservable cannot be disproved, Table 6 does not disprove the existence of normal backwardation. Nevertheless, Table 6 and the individual commodity futures return data of Bodie and Rosansky and Gorton and Rouwenhorst provide little support for the idea that normal backwardation is an explanation of actual individual commodity futures returns.

Table 6 highlights that when substantial differences in roll returns among various commodity futures persist for a long time, investing in com-

Table 6. Commodity Excess Returns and Roll Returns, December 1982–May 2004

Commodity	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

Note: Compound annualized excess return: intercept = 0.89 percent; intercept t-statistic = 1.84; roll coefficient = 1.20; roll t-statistic = 10.97; adjusted R^2 = 91.57 percent.

modity futures with relatively high roll returns may be rewarding. Conversely, if roll return differences were insignificant, security selection might not be rewarding.

For investors thinking about how to invest in the future, Table 6 must be viewed with some caution. It does not suggest that roll returns explained 91.6 percent of the daily, weekly, monthly, quarterly, or annual cross-section of returns for the 12 commodity futures during the time period studied. More importantly, it does not suggest that roll returns will explain 91.6 percent of the cross-sectional variation of commodity futures returns over any particular future time horizon.

Naive extrapolation of historical roll returns might be convenient, but there is no reason that they will be important in the future. For a broadly diversified portfolio of commodity futures, a risk-averse investor might well want to assume a future roll return of zero (or less).

Time-Series Variation in Individual Commodity Futures Returns. The analysis so far has focused on the cross-section of average returns from December 1982 through May 2004. During this period, the roll return was the dominant driver of performance differences among individual commodity futures. The variation of individual commodity futures returns over time reveals a different story. We have shown (Erb and Harvey 2005a) that most of the time-series variation of commodity futures excess returns is driven by *spot return variation*. The standard deviation of average excess return for the 12 individual commodity futures in the period studied was 25.16 percent, the average spot return standard deviation was 26.76 percent, the average roll return standard deviation was 9.14 percent, and the average correlation between spot and roll returns was –0.29. Clearly, spot returns have been more important than roll returns in explaining the excess return volatility of individual commodity futures.[24]

Also, from December 1982 through 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. The high volatility of spot returns, however, converted even the most significant roll return into an insignificant excess return. As a result, given the nature of this sort of statistical test, one cannot 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 reported in the work of Bodie and Rosansky and Gorton and Rouwenhorst.[25]

Risk Factors and Commodity Returns. Because spot returns are highly volatile, a sensible question is whether this volatility can be explained. Can measures proposed in the empirical finance literature for explaining the variation over time of stock and bond returns be applied to explain commodity futures price volatility? The low return correlations between individual commodities suggest, unfortunately, that a hunt for such an explanation will not be rewarding. Nevertheless, inflation, the most often mentioned driver of commodity prices, provides a good starting point for the exploration of the drivers of return volatility.

■ *Inflation and returns.* Greer (2000) showed that over the 1970–99 period, 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) found that the GSCI does well (especially relative to stocks and nominal bonds) during periods of rising inflation. As a result, an exploration of the relationship between the U.S. Consumer Price

Index (CPI) and the constituents of commodity futures indices makes sense.

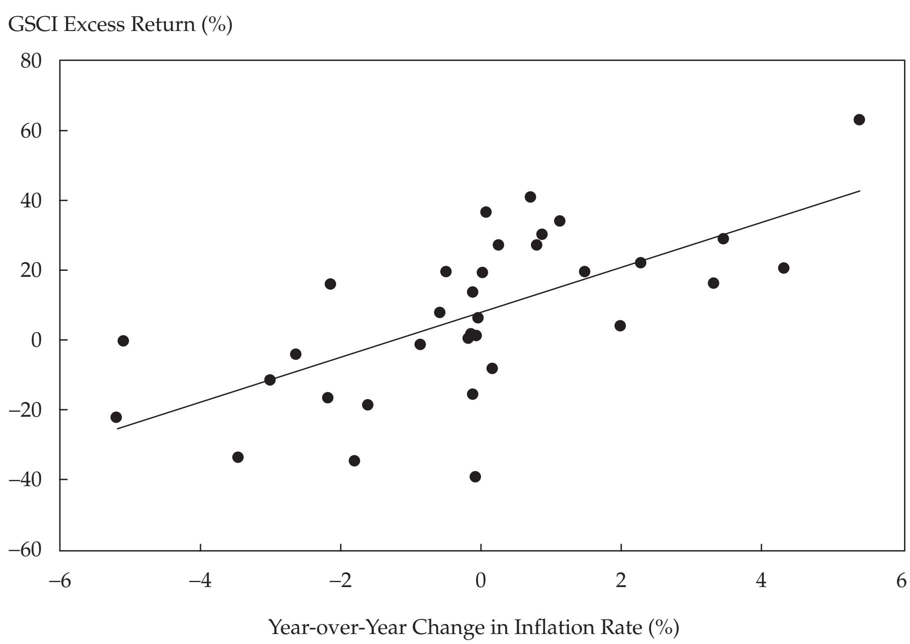
The components of the CPI can be categorized in two ways. Commodities have about a 40 percent weight in the CPI, and services have a 60 percent weight. Energy commodities make up only about 4 percent of the CPI, food commodities constitute about 14 percent, and other commodities account for the remaining commodity exposure of the CPI. Clearly, a broad-based commodity futures index excludes many items measured in the CPI. For instance, the single largest component of the CPI is the owner's equivalent rent of a primary residence. This mismatch between the composition of a commodity futures index and the CPI limits the ability of commodity futures to be an effective CPI inflation hedge.

■ *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.[26] **Figure 3** shows the relationship between excess returns of the GSCI and year-over-year change in inflation from 1969 through 2003. Since 1969, contemporaneous changes in the annual rate of inflation have seemingly explained 43 percent of the time-series variation in the GSCI's annual excess returns.[27] That is, average GSCI excess returns have been positive when year-over-year unexpected inflation rose and the GSCI excess return has been negative when year-over-year inflation fell.

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, what does this overall unexpected inflation correlation mean? Because the inflation beta of a commodity futures portfolio is simply 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.

Table 5 showed that individual commodity futures' excess returns are largely uncorrelated with one another, which suggests that commodity inflation sensitivity should vary from one commodity futures to another. **Table 7** shows the historical sensitivity of commodity excess returns (index, sector, and the individual index components) to actual prior annual inflation and actual

Figure 3. GSCI Excess Return and Unexpected Inflation, 1969–2003 (annual observations)



Notes: The GSCI excess return = 0.083 + 6.50ΔInflation rate; the R^2 is 0.43.

Table 7. Commodity Excess Return and Change in Annual Inflation, 1982–2003 (annual observations)

Index/Sector/ Commodity	Intercept	Intercept *t*-Statistic	Coefficient	Inflation *t*-Statistic	ΔInflation Coefficient	ΔInflation *t*-Statistic	Adjusted R^2
GSCI	–5.27%	–0.38	3.92	0.93	10.88	**2.98**	28.0%
Sector							
Nonenergy	–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
Commodity							
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 12 commodities	1.16	0.14	0.15	0.06	3.88	1.74	10.3

Note: Significance is indicated by boldface.

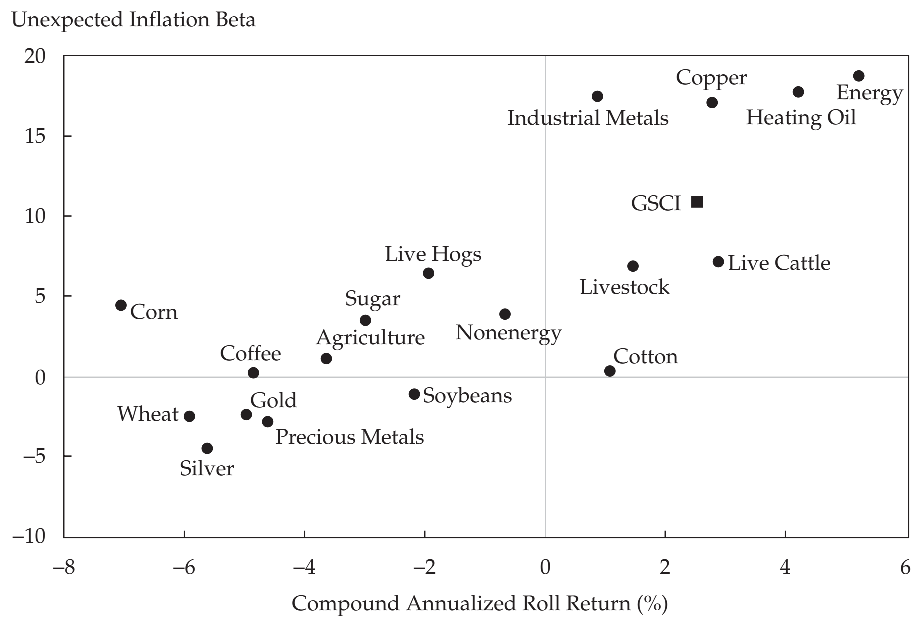
changes in the annual rate of inflation over the 1982–2003 period. The GSCI has a positive (but statistically insignificant) actual inflation beta and a positive (and significant) unexpected inflation beta. Three sectors (energy, livestock, and industrial metals) and three individual commodity futures (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 inflation betas. Although some commodities apparently respond positively to changes in the rate of inflation, others have negative or insignificant inflation change betas. Indeed, the equally weighted average of the 12 commodities has a positive (but insignificant) inflation beta.[28]

The inflation betas in Table 7 are a measure of the sensitivity of commodity futures returns to changes in the rate of inflation during a specific time period. Neither the magnitude nor the sign of the inflation coefficients is guaranteed to remain constant in the future. For instance, gold is often thought of as an inflation hedge, but the 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 period-specific return dynamics of gold.

The regression R^2s suggest that inflation can explain some of the return variation of individual commodity futures. At best, however, inflation "explains" only a modest portion of return variability. Some commodity futures may be good inflation hedges, but empirical evidence is lacking that all commodity futures are good inflation hedges or that the average commodity futures investment is a good inflation hedge.

Why might some commodity futures be better inflation hedges than others? With the usual caveat that these results describe a specific time period, **Figure 4** shows that average roll returns are highly correlated with unexpected inflation betas. Average roll returns explain 67 percent of the cross-sectional variation of commodity futures unexpected inflation betas. Some commodities (e.g., copper, heating oil, and live cattle) had positive roll returns for the period and high unexpected inflation betas. Other commodities (e.g., wheat) had negative roll returns and negative unexpected inflation betas.

Figure 4. Unexpected Inflation Betas and Roll Returns, December 1982–December 2003



What explains the historical link between roll returns and inflation betas? The commodities that Till identified as difficult to store—namely, heating oil, copper, live cattle, and live hogs—had both high roll returns and positive unexpected inflation betas. The difficulty of storage could, therefore, be a general, or time-specific, link between roll returns and unexpected inflation betas.

This period-specific analysis leads to the following conclusions. First, individual commodity futures have experienced varying exposures to unexpected inflation. Second, the efficacy of an individual commodity futures contract in hedging unexpected inflation 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.

■ *Are commodity futures returns sensitive to risk factors other than inflation?* Even though commodity futures returns seem to be largely uncorrelated with one another, perhaps they exhibit some common connection to pervasive risk factors other than inflation. Research by Bailey and Chan (1993) found a connection between the commodity futures *basis* (the spread between spot commodity prices and futures prices) for 22 commodities and a number of factors over the 1966–87 period, with various start dates.

We chose to carry out a multifactor examination of commodity futures returns using the five-factor model of Fama and French (1992a). This model contains three equity market risk factors (market excess return, book value to market value, and size) plus a term premium (the long-term bond excess return) and a default premium (the corporate bond return minus the government bond return). Although Fama and French found that these last two factors are influential for bonds but not for stocks, these factors may be important for commodity futures. In addition, following Ferson and Harvey (1993) and Dumas and Solnik (1995), we considered 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 market risk factors. Absence of significant exposure to these factors is not, however, an indication that the expected excess return of commodity futures is zero. It is simply a sign of lack of correlation with certain risk factors that have been widely studied in the literature.

We examined the unconditional (i.e., assumed constant) monthly betas of commodity excess returns relative to the common set of risk factors for 1982–2004 and found (see Erb and Harvey 2005a) none of the Fama and French (1992a) factors to be significant in regression results. The GSCI had a statistically significant negative beta with regard to the change in the trade-weighted dollar.[29] The nonenergy sector had a statistically significant, but small, equity market beta, and energy had a statistically significant negative dollar beta. We found no uniformly positive or negative sensitivities to these risk factors across individual commodities, which is not surprising in light of the low correlations commodities have with one another. Nor did we find any risk factors that seemed to be more important than others in explaining the time-series variation of individual commodity futures returns.

If inflation and other well-known risk factors cannot explain the time series of commodity futures returns, should an investor simply give up and assume that the excess return from investing in a portfolio of commodity futures will be zero? The answer is no.

Turning Water into Wine: The Diversification Return. One of the potential compound-return drivers for a commodity futures portfolio is the diversification return—the difference between a portfolio's geometric return and the weighted-average geometric return of the portfolio's constituents.[30] Under certain circumstances, the diversification return can appreciably raise the geometric return of a fixed-weight, rebalanced, commodity futures portfolio. As we have shown (Erb and Harvey 2005b), with some minor and technical qualifications, unrebalanced portfolios, however, such as market cap–weighted portfolios, are unlikely to benefit from a diversification return to the same extent as fixed-weight or rebalanced portfolios.

Using historical annual excess returns, **Table 8** illustrates the mechanics of portfolio diversification returns. It shows returns to the GSCI heating oil index and the S&P 500 for 1993 to 2003 as well as returns to a rebalanced portfolio and an unrebalanced, buy-and-hold portfolio. Heating oil had a geometric annual excess return of 8.21 percent, and the S&P 500 had a geometric annual excess return of 6.76 percent. The equally weighted average of these two returns [i.e., (8.21 + 6.76)/2] is 7.49 percent, but the geometric excess return of an equally weighted, annually rebalanced portfolio is 10.95 percent. The so-called diversification return is simply the difference between 10.95 percent and 7.49 percent, or 3.46 percentage points. In this example of "turning water into wine," 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.[31] Whereas for an individual security variance measures the volatility of the security, a portfolio's variance is simply the weighted average of the covariances of individual securities within a portfolio. The equally weighted average variance of heating oil and stocks is 11.44 percent, and the variance of the equally weighted and rebalanced portfolio is 4.52 percent, a difference in variance of 6.92 percentage points. Half of 6.92 is 3.46 percent, which is the variance reduction benefit (and the diversification return) of the equally weighted portfolio.

For an initially equally weighted but *unrebalanced* (or "let it run") portfolio, the diversification return has two components: the variance reduction and the impact of not rebalancing. First, 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 percent and the unrebalanced portfolio variance of 3.53 percent, or 3.57 percent. The let-it-run portfolio has a *lower* variance and a *larger* variance reduction than the equally weighted portfolio. But the second component of the unrebalanced portfolio's diversification return is the impact of not rebalancing. This driver of portfolio return is simply the covariance between an asset's weight in a portfolio and the asset's return. The impact of not rebalancing heating oil is –2.51 percentage points, the covariance between the portfolio weights of heating oil in the unrebalanced portfolio and the returns of heating oil. The impact of not rebalancing the S&P 500 position is –0.97 percentage points, the covariance between the portfolio weights of the S&P 500 in the unrebalanced portfolio and the returns of the S&P 500. The sum of these two values is –3.48 percentage points, the total impact of not rebalancing.

In this example, 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 percent, is simply the portfolio's weighted-average arithmetic return, 12.75 percent, less the covariance drag of –3.48 percent. The –3.48 percent covariance drag almost completely offsets the 3.57 percent variance reduction benefit of the unrebalanced portfolio. We found (Erb and Harvey 2005b) that the geometric return of an unrebalanced portfolio, on average, approximates the weighted-average geometric return of the portfolio's constituents.

The example in Table 8 has 10 annual observations and rebalances annually. What happens if a portfolio is rebalanced monthly rather than annually? **Table 9** illustrates the diversification return with two commodity futures, heating oil and copper, and is based on monthly data from December 1982 through May 2004. The equally weighted portfolio that rebalanced monthly had a geometric excess average return of 7.86 percent

Table 8. Mechanics of the Diversification Return: S&P 500 and Heating Oil, 1993–2003

	Excess Return				Fixed Portfolio Weights (rebalanced)		Let-It-Run Portfolio Weights (not rebalanced)	
Year/Measure	Heating Oil	S&P 500	Equally Weighted	Initially Equally Weighted	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 arithmetic return			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				

Table 9. Diversification Return with Two Commodity Futures, December 1982–May 2004

Statistic	Heating Oil	Copper	EW 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

Note: The weighted-average return is calculated by first multiplying each asset's geometric excess return by the average weight of an asset in a portfolio and then summing these products across all assets in a portfolio.

and a diversification return of 2.01 percent, whereas the portfolio that did not rebalance had a return of 5.86 percent and a diversification return of –0.03 percent. The diversification return of the unrebalanced portfolio is negative because the covariance drag is greater than the benefit of variance reduction.[32]

A fairly simple formula establishes the diversification return of an equally weighted, rebalanced portfolio:

$$\text{Expected EW rebalanced portfolio diversification return} = \frac{1}{2}\left(1-\frac{1}{K}\right)\overline{\sigma}^2\left(1-\overline{\rho}\right).$$

This equation simply says 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.[33]

Table 10 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 *individual* security standard deviations of 30 percent a year and average security correlations ranging from 0.0 to 0.3, the diversification return ranges from 3.05 percent to 4.35 percent.

The diversification return is a payoff to one of the few high-confidence ways an investor can boost portfolio geometric return—that is, by rebalancing a portfolio. When asset variances are high and correlations are low, the diversification return can be high. For example, Bodie and Rosansky reported an equally weighted portfolio geometric excess return of 8.52 percent for their equally weighted

Table 10. Diversification Return Drivers

Average Correlation	Average Standard Deviation	Number of Securities in Portfolio: 10	15	20	25	30
0.0	10%	0.45%	0.47%	0.48%	0.48%	0.48%
0.1	10	0.41	0.42	0.43	0.43	0.44
0.2	10	0.36	0.37	0.38	0.38	0.39
0.3	10	0.32	0.33	0.33	0.34	0.34
0.0	20%	1.80%	1.87%	1.90%	1.92%	1.93%
0.1	20	1.62	1.68	1.71	1.73	1.74
0.2	20	1.44	1.49	1.52	1.54	1.55
0.3	20	1.26	1.31	1.33	1.34	1.35
0.0	30%	4.05%	4.20%	4.28%	4.32%	4.35%
0.1	30	3.65	3.78	3.85	3.89	3.92
0.2	30	3.24	3.36	3.42	3.46	3.48
0.3	30	2.84	2.94	2.99	3.02	3.05
0.0	40%	7.20%	7.47%	7.60%	7.68%	7.73%
0.1	40	6.48	6.72	6.84	6.91	6.96
0.2	40	5.76	5.97	6.08	6.14	6.19
0.3	40	5.04	5.23	5.32	5.38	5.41

and rebalanced commodity futures portfolio. The average standard deviation of the securities in their portfolio was about 40 percent a year. If the average commodity futures correlation was 0.10, in line with the evidence of Table 5, then the expected diversification return of their portfolio was close to 7 percent—almost all of the return of their equally weighted portfolio. Gorton and Rouwenhorst report a 4.52 percent excess return for their equally weighted and rebalanced portfolio, and the average standard deviation of the securities in their portfolio is about 30 percent. Depending on assumed average correlations, these data suggest a diversification return in the range of 3.0–4.5 percent, almost all of the excess return of the Gorton–Rouwenhorst commodity futures portfolio. Finally, de Chiara and Raab (2002) documented a 2.8 percent diversification return for the rebalanced DJ-AIGCI during the time period 1991 to 2001.

Thoughtful investors quickly learn to be skeptical of stories suggesting easy ways to boost investment returns. Two circumstances could result in the elimination of a portfolio's diversification return. The return would be zero if all the assets in the portfolio had standard deviations of zero. A portfolio's diversification return would also be zero if the correlations of all assets in the portfolio were exactly 1. Unless these conditions hold, however, the diversification return is likely to be a valuable source of portfolio return.

Two last points merit attention. First, an investor can more easily calculate the forward-looking return of a rebalanced portfolio than the forward-looking return of an unrebalanced portfolio. For a rebalanced portfolio, all an investor needs are difficult-to-obtain estimates of expected returns, volatilities, and correlations. The return of an unrebalanced portfolio is more complex because it requires the calculation of the return of a rebalanced portfolio plus 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 may be higher than that of a rebalanced portfolio. If so, determining the source of the higher return is important—whether it is greater capital efficiency, a higher Sharpe ratio, or greater risk. Some have pointed out (Erb and Harvey 2005b; also Plaxco and Arnott 2002) that rebalanced portfolios typically have higher Sharpe ratios than unrebalanced portfolios, which suggests that the possible outperformance of a buy-and-hold portfolio may be the result of greater risk.

Long-Term Expectations and Strategic Allocation

Why does an investor have to bother with a forecast of expected return for a commodity futures portfolio? Can't historical returns simply be extrapolated? Table 2 showed that, historically, the long-only GSCI has had an excess return of about 6 percent a year, but this excess return is for the performance of a commodity futures portfolio that has dramatically changed in composition over time. As a result, what the 6 percent return measures is hard to determine. Our analysis of rolling one-year GSCI excess and roll returns showed a declining return trend over time (Erb and Harvey 2005a). Although this trend does not guarantee that returns will be lower in the future, it highlights that excess returns have not been a constant 6 percent a year.

The reason for the observed decline in excess and roll returns is not clear. It might be simply 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 it might be the result of some other unknown or unknowable explanation.

Additionally, even though the term structure of commodity prices may have been an important driver of realized commodity futures' excess returns historically, 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 have often, although not always, been backwardated, but whether they will continue to be backwardated in the future is not obvious. There is also the possibility that the futures term structure of an individual commodity might, on average, be backwardated yet the *particular* contract that an index mechanically rolls into might be in contango.

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 the investor rebalances a commodity futures portfolio, the investor might achieve a diversification return of, say, 3 percent, similar to the historical diversification return of the rebalanced DJ-AIGCI. (Depending on the actual composition of the portfolio and the average volatilities and correlations of the portfolio constituents, the diversification return could be higher or lower than 3 percent.) If the portfolio is not rebalanced, the diversification return will probably be close to zero—perhaps, negative.

The challenge investors face when estimating future spot and roll returns based on historical data is that, historically, individual commodity futures' excess and spot returns have not been statistically significant. Essentially, any long-term forecast of positive excess return or positive spot return for an individual commodity futures contract is unlikely to be statistically supported by historical experience.

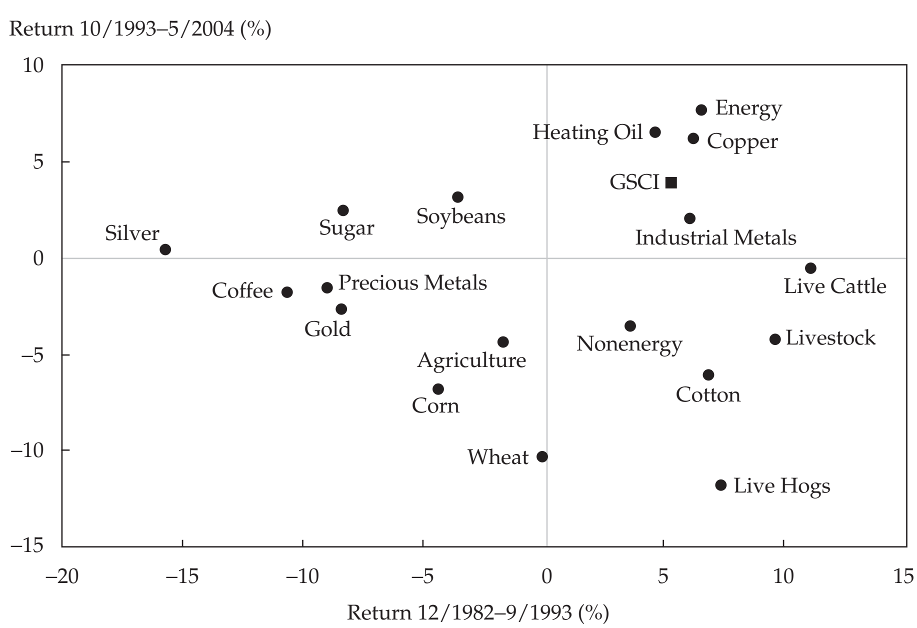
As a result, there is no one best estimate of the expected return of a commodity futures portfolio, although the diversification return is the easiest return driver to estimate.

Persistence of Returns. One way some have tried to salvage the case for naive historical extrapolation of past returns is to look at return persistence over long periods of time. **Figure 5** shows the excess return persistence of the GSCI, GSCI sectors, and individual commodity futures. It plots returns from December 1982 through September 1993 against returns from October 1993 through May 2004. The correlation between these periods' returns is 0.03. Each return quadrant has nearly the same number of observations. The quadrant of positive first-period and positive second-period return is populated by the energy and industrial metals sectors, and these two sectors drove the positive returns of the GSCI during both time periods. Thus, in this specific universe of futures and specific time period, one finds little evidence of long-term return persistence among commodity futures.

The Strategic Asset Allocation Bet. Previous researchers have thought about the role of commodity futures in strategic, or long-term, asset allocation in at least two ways—as an asset-only exercise and as an asset/liability exercise. From an asset-only perspective, Anson (1999) examined the performance of indices of stocks, bonds, and cash-collateralized commodity futures for 1974–1997 and found 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 percent in commodities. Jensen, Johnson, and Mercer (2000) examined portfolios that could invest in stocks, corporate bonds, T-bills, real estate investment trusts, and the cash-collateralized GSCI over the period 1973–1997. They found that, depending on risk tolerance, commodities should represent 5–36 percent of investors' portfolios.

Nijman and Swinkels (2003) investigated the appeal of commodity futures in the 1972–2001 period for pension plans with nominal and real liabilities. The authors found that pension plans that seek to hedge nominal liabilities and that already invest in long-term bonds and global equity are unlikely to improve risk-adjusted

Figure 5. Long-Term Commodity Futures Excess Return Persistence



Note: Returns measured as compound annualized excess return.

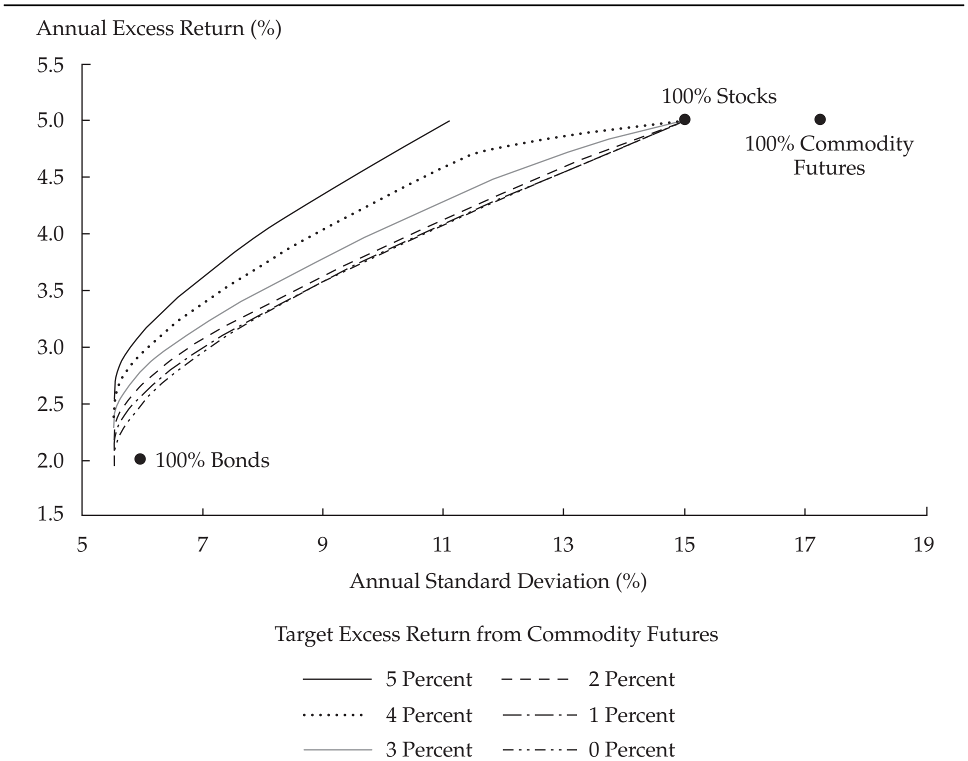
returns through commodity futures investment. They also found, however, that pension plans with liabilities indexed to inflation can significantly increase the return–risk trade-off through commodity futures investment.

A drawback of all these analyses is that they used historical returns. Optimization exercises using historical data tell an investor what the investor should have done in the past. When undertaking a forward-looking asset allocation analysis, forward-looking expected returns should be used. **Figure 6** shows six forward-looking efficient frontiers for stocks, bonds, commodity futures, and combination portfolios. The assumptions underlying the efficient frontiers are that bonds have expected excess returns of 2 percent (where "excess return" refers to an asset's annualized return in excess of the risk-free rate), stocks have expected excess returns of 5 percent, and the expected return of a commodity futures portfolio ranges from 0 percent to 5 percent. Because there is no economic theory of expected future asset correlations and volatilities, historical correlations and variances for the 1969–2004 period were used.

Given these 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. The efficient frontiers do not rise appreciably until the excess return for commodity futures rises to at least 3 percent. Conceptually, a 3 percent excess return is consistent with a commodity futures portfolio that has an expected diversification return of 3 percent, which is similar to the historical experience of the DJ-AIGCI, and expected spot and roll returns of 0 percent. Other combinations of expected diversification, spot, and roll returns are, of course, possible. Starting with a hypothetical diversification return of 3 percent, a 5 percent excess return could be achieved by assuming a 1 percent spot return and a 1 percent roll return, or other combinations of spot and roll returns that add up to 2 percent. The forward-looking expected returns for commodity futures (as well as for stocks, bonds, hedge funds, and other assets) are simply bets. The commodity futures bet has one high-confidence element—namely, the diversification return—and two uncertain elements—namely, spot and roll returns.

Suppose an investor is willing to bet that stocks have a forward-looking excess return of 5 percent, bonds have a forward-looking excess return of 2 percent, and a portfolio of commodity futures has a forward-looking excess return of 3 percent. How much should the investor allocate to commodity futures? The answer depends on the investor's risk tolerance. If the investor is comfortable with the

Figure 6. Efficient Frontiers for Portfolios with Commodity Futures



volatility of a 60 percent stocks/40 percent bonds portfolio (in this example a volatility of about 10.1 percent), a portfolio with 18 percent in a commodity futures portfolio, 60 percent in stocks, and 22 percent in bonds would maximize expected excess return. The primary drivers of these mean–variance allocations are expected returns and correlations.

Table 2 showed that stock and commodity returns have been uncorrelated historically, so a portfolio that invested 50 percent in the S&P 500 and 50 percent in the GSCI would have a lower level of volatility than either stocks or commodity futures alone. As a result, a mixed portfolio of stocks and commodity futures may be more efficient (have a higher ratio of return to risk) than a stand-alone stock portfolio.

Suppose that, instead of a 3 percent excess return to the commodity futures portfolio, an investor expected only a 1 percent excess return. The optimal allocation to commodity futures would then fall to 3 percent. Not surprisingly, the ideal allocation to commodity futures is largely a function of excess return expectations. And the expected return is simply a bet.

For investors who are managing an asset portfolio relative to liabilities, Sharpe and Tint (1990) suggested the "liability-hedging credit" as a way to measure the return benefit of various assets. The Sharpe–Tint liability-hedging credit is approximately twice the risk tolerance–adjusted 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 arithmetic expected return. Waring (2004) pointed out that liabilities can be nominal (not adjusted for inflation) or real (adjusted for inflation). **Figure 7** illustrates the ambiguity involved in estimating the value of commodity futures in a liability-focused setting.

For the creation of Figure 7, nominal liabilities were proxied by the returns of the 10-year T–bond and real liabilities were proxied by the returns of the Citigroup Inflation-Linked Bond Index. Over the period December 1982 through May 2004, few of the commodity futures had positive nominal liability-hedging credits. But since the inception of TIPS (Treasury Inflation-Indexed Securities) in the United States in 1997, many commodity futures have had positive nominal and real liability-hedging credits.

Figure 7. Liability-Hedging Credit, December 1982–May 2004

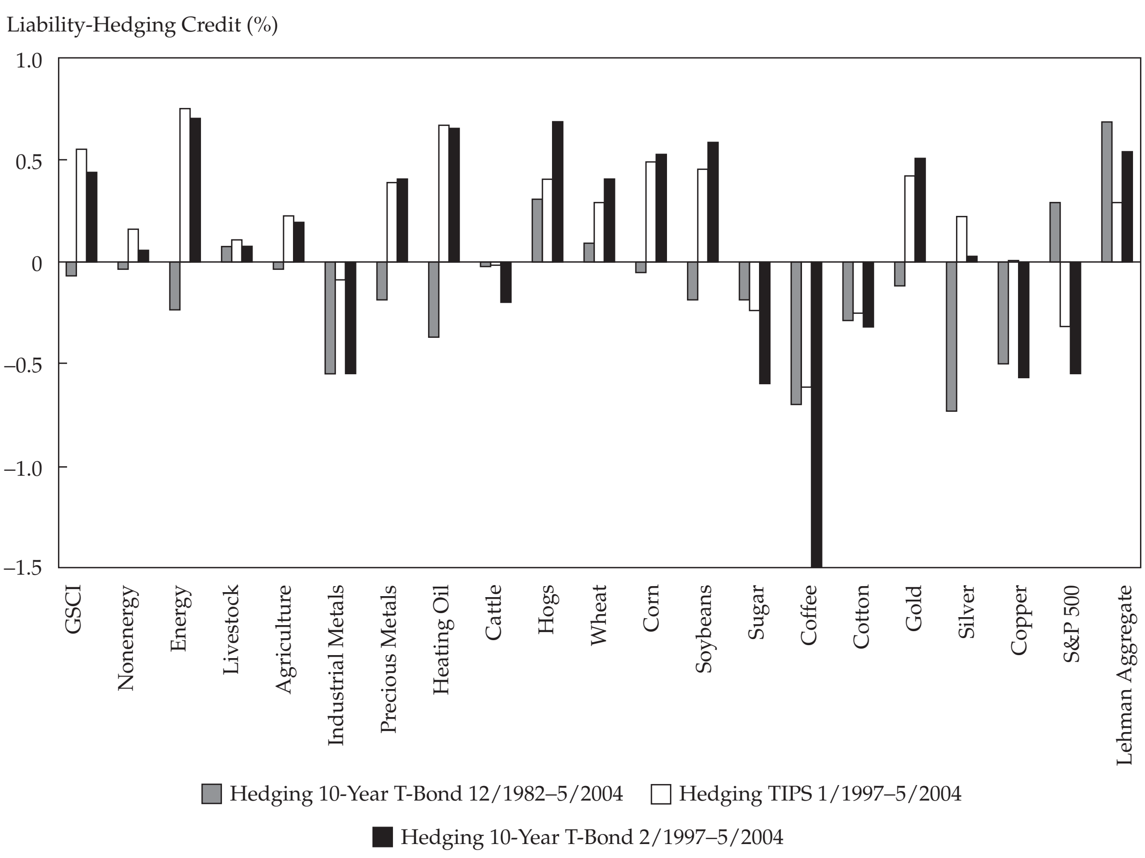


Figure 7 illustrates that, although calculating a historical liability-hedging credit is technically easy, estimating prospective liability-hedging credits is difficult. As a result, no clear evidence exists for or against the ability of commodity futures to hedge liabilities.

Predictable Returns and Tactical Asset Allocation

To illustrate the opportunities and pitfalls of active management to enhance the return of a commodity futures portfolio, we explore two possibilities. One approach aims to capitalize on return momentum. The rationale for exploring this idea is the finding of Fung and Hsieh (2001) that most active managers of commodity futures portfolios (that is, commodity trading advisors) are trend followers. As Spurgin (1999) pointed out, trend followers pursue price momentum strategies that rely on the presumption that past price moves predict future price moves.

The other approach focuses on the idea that the term structure of commodity futures explains a significant portion of the long-run cross-section of commodity futures returns.

The possibility of both time-series and cross-sectional return predictability may make tactical asset allocation (TAA) with commodity futures attractive to some investors. Cochrane (1999) referred to findings of stock, bond, and foreign exchange return predictability as "new facts in finance," and given a belief in asset return predictability, there is no reason that the returns of commodity futures should be any more or less predictable than the returns of other assets.

There is, of course, reason to doubt how broad based the demand for commodity TAA might be. Many, if not most, investors interested in investing in commodities are interested only in a long-only exposure to commodity futures. A TAA approach is unacceptable to these investors because they want to know that they will always have a well-defined long exposure to the commodities market. Tactical strategies that allocate among 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.

Previous research has put forward a tantalizing case for commodity futures return predictability. Jensen et al. (2000, 2002) found that the GSCI outperformed stocks and bonds when their measure (now discontinued) of U.S. Federal Reserve monetary policy rose. Strongin and Petsch found that GSCI returns were tied to current economic conditions; when inflation rose, the GSCI had above-average returns and performed well relative to stocks and bonds. Nijman and Swinkels found 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) found that GSCI 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 suggests that these systematic influences have, at best, a weak ability to explain the time-series variation of individual commodity futures excess returns.

Momentum and TAA. Although the literature on momentum in equity markets is considerable, no simple explanation of why momentum works is available. Barberis, Shleifer, and Vishny (1998) suggested that momentum is a behavioral artifact resulting from investor underreaction to news. Johnson (2002) argued that momentum returns are simply payoffs for taking risk. Keim (2003) suggested that, whatever the reason for a momentum return in paper portfolios created by researchers, in reality, the high turnover of momentum strategies will generate transaction costs that will consume most of the return from following a momentum strategy. In other words, investors can find a pro or con momentum argument to fit their individual beliefs.

A momentum strategy may go long an asset after prior returns have been positive and go short an asset after prior returns have been negative. **Table 11** shows the payoffs to a strategy of going long the GSCI for one month if the previous one-year excess return was positive and going short the GSCI if the previous one-year excess return was negative. (The choice of a one-month investment period and a one-year look-back period is arbitrary.) The

Table 11. GSCI Momentum Returns
(*t*-statistics in parentheses)

Trailing Annual Excess Return	12/1969–5/2004	12/1969–12/1982	12/1982–5/2004
Greater than 0	13.47%	17.49%	11.34%
	(2.98)	(2.12)	(2.10)
Less than 0	–5.49	–9.89	–4.07
	(–1.31)	(–1.26)	(–0.68)

momentum effect is strongest in the first 13 years of the sample period, but the effect is still evident in the more recent period. Of course, the historical stability of this result says little about the future.

Many analyses of momentum strategies focus on the value added by the strategy within an asset class, such as going long the best-performing stocks and going short the worst-performing stocks. **Figure 8** shows the payoff to investing in a long-only equally weighted portfolio of the four commodity futures with the highest prior 12-month returns, a long-only portfolio of the worst-performing commodity futures, and a long–short portfolio based on these two performance-based portfolios. Consistent with many prior momentum studies, the "winner" portfolio had a high excess return (7.0 percent), the "loser" portfolio had a negative excess return (–3.4 percent), and the long–short portfolio achieved the highest excess return (10.8 percent) and a higher Sharpe ratio (0.55) than either the winner or the loser portfolios (ratios of, respectively, 0.45 and –0.21). The long–short portfolio Sharpe ratio is more than twice as high as the Sharpe ratio of the long-only GSCI (0.25).

An alternative momentum strategy would be to go long those individual commodity futures that had positive returns over the past 12 months and go short those that had negative returns. In any particular month, all past returns may be positive or negative; as a result, all portfolio positions may be long or short. **Figure 9** shows the growth of $1 invested in this trend-following strategy (rebalanced monthly) as compared with the payoff to an equally weighted portfolio of the 12 components of the GSCI and the GSCI itself. The trend-following portfolio had higher returns (6.54 percent) and a much higher Sharpe ratio (0.85) than the long-only GSCI (4.39 percent and 0.25) or equally weighted portfolio (1.01 percent and 0.10). And the volatility of the trend-following portfolio was lower than the volatility of the other two portfolios. These results are reassuring *if* one believes in momentum as a reliable source of return.

TAA Based on the Term Structure of Futures Prices. The previous analysis examined the historical payoff to timing exposures to the GSCI and to individual commodity futures based on momentum. The historical payoff to timing based on the term structure of futures prices can also be examined.

GSCI term structure and TAA. 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), an investor can gamble that the prospective long-only excess return will, on average, be positive. Nash and Smyk (2003), for instance, found 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), an investor can speculate that the long-only excess return will, on average, be negative.

Since the inception of GSCI futures trading in 1992, the GSCI has been backwardated as often as

Figure 8. Momentum Portfolios, December 1982–May 2004

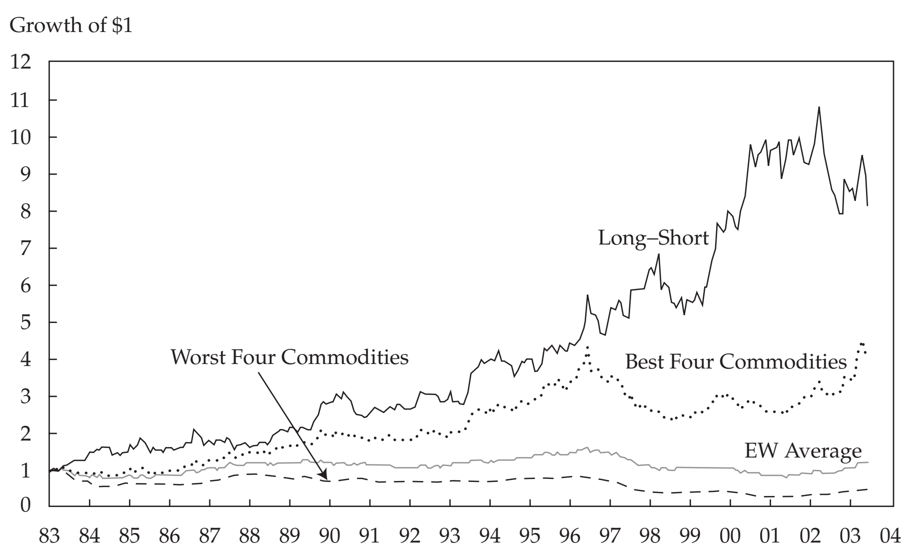
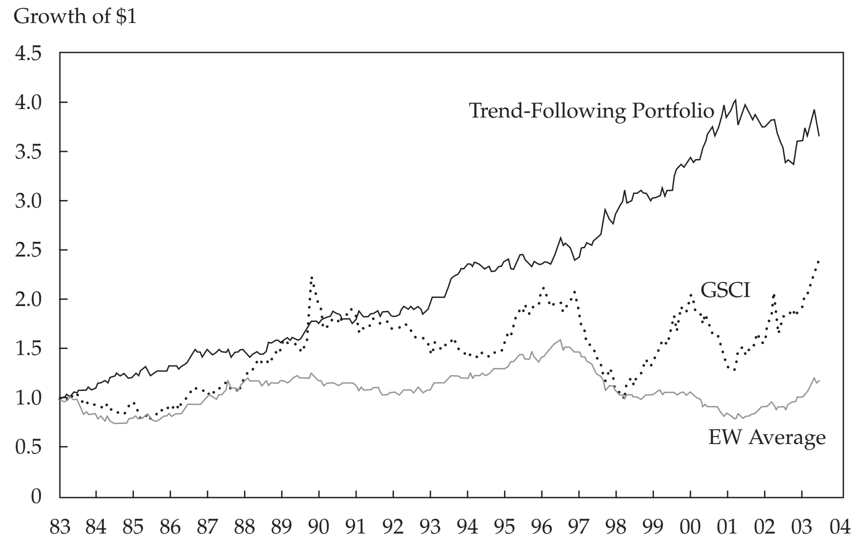


Figure 9. Individual-Commodity Momentum Portfolio, December 1982–May 2004



it has been in contango. From the inception of GSCI futures trading until May 2004, the annualized payoff from buying the GSCI when the term structure was backwardated was 11.2 percent. When the term structure was contangoed, however, the annualized excess return was –5.0 percent. The payoffs to these two term-structure strategies are shown in **Table 12**. A strategy of going long the GSCI when backwardated and short when contangoed and, therefore, always having an exposure to the GSCI, generated an excess return of 8.2 percent a year compared with the average long-only excess return of 2.68 percent, and the strategy had a much higher Sharpe ratio. Historically, the term structure seems to have been an effective tactical indicator of when to go long or go short a broadly diversified commodity futures portfolio.

Individual-commodity futures term structure and TAA. **Table 13** provides the results of a trading strategy based on the term structure of individual commodity futures. Starting with 12 constituents of the GSCI, the long–short portfolio went long the six commodities that each month had the highest ratio of nearby futures price to next-nearby futures price and went short the six commodities with the lowest ratio of nearby futures price to next-nearby futures

Table 12. Using the Information in the GSCI Term Structure for TAA, July 1992–May 2004

Portfolio Strategy	Compound Annualized Excess Return	Annualized Standard Deviation	Sharpe Ratio
Long if GSCI backwardated	11.25%	18.71%	0.60
Long if GSCI contangoed	–5.01	17.57	–0.29
Long if GSCI backwardated; short if GSCI contangoed	8.18	18.12	0.45
Long cash-collateralized GSCI	2.68	18.23	0.15

Table 13. TAA Based on Individual Commodities' Term Structures, December 1982–May 2004

Portfolio Strategy	Compound Annualized Excess Return	Annualized Standard Deviation	Sharpe Ratio
Long backwardated commodities and short contangoed commodities	3.65%	7.79%	0.47
Long EW portfolio	1.01	10.05	0.10
Long GSCI	4.49	16.97	0.26

price. The Sharpe ratio of this long–short portfolio is almost twice as high as the Sharpe ratio of the long-only GSCI and more than four times higher than the ratio for the equally weighted portfolio.

The term structure of commodity prices seems to have been a valuable tool for allocations among individual commodity futures. Of course, the historical success of a strategy does not mean that the strategy will be successful in the future.

Conclusions

Although some commodity futures have been trading for hundreds of years, only recently has the debate begun about including these assets in mainstream portfolios. The goal of this article was to explore 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 have earned a return similar to that of equities. Focusing on the dangers of naive historical extrapolation raises a question, however, about what this historical evidence means. Does the average commodity futures contract have an equity-like return? Our research suggests it does not: The average excess 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 maybe. A commodity futures portfolio can have equity-like returns if it can 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 toward commodity futures that are likely to have positive roll or spot returns in the future. The challenge for investors is that, although spot and roll returns may be high in the future, nothing in the historical record gives 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 TAA using commodity futures. Historical evidence suggests that momentum-based strategies and strategies based on information in the term structure of futures prices have achieved attractive returns. There is no guarantee, however, that the historically observed payoff 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, the empirical TAA results suggest a way to dynamically vary commodity futures allocations.

We benefited from conversations with Gary Gorton, Geert Rouwenhorst, Tadas Viskanta, Hilary Till, Lisa Plaxco, and participants at the 2005 Q-Group meeting and the 2005 Society of Quantitative Analysts meeting. We appreciate the research assistance of Jie Yang and Paul Borochin.

This article qualifies for 1 PD credit.

Notes

1. The usual way to compare the total return of commodity futures with that of 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 will typically go long $1 of a commodity futures contract and invest $1 of "collateral" in a "safe" asset. The safe asset could be a U.S. T-bill, as is customary for commodity index construction, or it could be a nominal or real bond portfolio, as is common in practice. Although 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 is referred to as "rolling" a futures position.
2. Focusing on the annualized geometric excess return is consistent with the approach used by Ibbotson and Chen (2003) and Dimson et al. (2002) 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.
3. Corn had a significantly negative return with a *t*-statistic of –2.25.
4. It is common to approximate the geometric return of a portfolio as: Portfolio geometric return = Weighted-average arithmetic return – Variance/2. As we point out later, however, this formulation works only for rebalanced portfolios. For either rebalanced or unrebalanced portfolios, the correct formula to use is: Portfolio geometric return = Weighted-average arithmetic return + Impact of not rebalancing – Variance/2. The impact of not rebalancing for an individual asset is simply the covariance between an asset's return and its weight in an unrebalanced portfolio. The overall portfolio impact of not rebalancing is simply the sum of each asset's impact of not rebalancing. Ignoring the impact of not rebalancing can lead to erroneous conclusions in attempts to understand the building blocks of portfolio return.
5. An equally weighted portfolio requires the same investment in every portfolio security regardless of how large or small the investment opportunity is. But consider, for instance, a market with two securities in which one security has a value of 1 and the other security has a value of 100. The aggregate market value is 101, but the equally weighted portfolio has a value of only 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 market. As a result, although the return of an equally weighted equity portfolio may be higher or lower than the market, the portfolio is not the market.

6. Small- and micro-cap securities represent about 12 percent of the market capitalization of, and about 72 percent of the number of securities in, the Wilshire 5000.
7. Another fundamental question is: 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 the return of the average portfolio constituent. Imagine a portfolio that invests equally in two assets over four time periods and suppose that one asset has a return of 20 percent and the other asset has a return of 5 percent. The equally weighted average return of these two securities is 12.5 percent, the same as the average return of the equally weighted portfolio. A characteristic of equally weighted commodity futures portfolios in the early literature on commodity futures portfolios, however, seems to be that their composition changes over time. So, what happens when the portfolio invests in the asset with a 20 percent return for each of the four time periods but invests in the asset with a 5 percent return only for the last two time periods? When the composition of an equally weighted portfolio changes over time, the average return of the portfolio—in this case, 16.25 percent—does not equal the return of the average portfolio constituent, 12.5 percent. As a result, an equally weighted portfolio may not convey the information an investor seeks.
8. On 20 June 2005, the CRB composition and name 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 the tradition of geometric equal weighting. The new weights reflect the relative significance and liquidity of the contracts. The weights are rebalanced every month.
9. Total futures open interest of these three indices amounted to about $1.5 billion. The PIMCO Commodity Real Return Fund alone had more than a $4 billion exposure to the DJ-AIGCI at the end of May 2004, which illustrates how many investors use swaps, rather than exchange-traded futures, to gain access to commodity index returns.
10. The performance histories of commodity futures indices are longer than the trading histories of the indices. In making strategic asset allocation decisions, however, many investors use the complete history of returns—even if some of the history is backfilled. For the commodity indices with subjective choices of weights, one needs to exercise caution. For instance, the GSCI has been traded since 1992, but its performance history was backfilled to 1969. From 1969 to 1991, the GSCI had a compound annual return of 15.3 percent, beating the 11.6 percent return for the S&P 500. From 1991 to May 2004, the compound annualized return of the GSCI was 7.0 percent and that of the S&P 500 was 10.4 percent. The historical performance of the DJ-AIGCI potentially suffers from similar construction bias because it has been traded since 1998 but its history goes back to 1991. From the inception of the performance history of the DJ-AIGCI to its first trade date in July 1998, the DJ-AIGCI had a compound annualized return of 4.1 percent whereas the GSCI had a return of only 0.5 percent. The CRB's performance history commences in 1982, and the futures contracts first started trading in 1986. For each index, the returns since trading actually started have been tangible whereas the pretrading returns are to some degree hypothetical.
11. As Black (1976) pointed out, because every long futures position always has a short futures position, the market capitalization of commodity futures is always zero.
12. The CRB referred to at the time we were writing this article used equal weights and was geometrically weighted. Since the redesign of the Reuters/Jefferies CRB, the weights can be broadly characterized as "between" those of the DJ-AIGCI and the GSCI (see www.crbtrader.com/crbindex/futures_current.asp). The unrebalanced GSCI uses "production" weights determined annually by calculating the annual production for each commodity, averaging the production values over five years, and weighting each commodity relative to the sum of all the production values (see www.gs.com/gsci for details). Portfolio weights for the DJ-AIGCI are rebalanced every year on the basis of a combination of production weights and liquidity considerations (see www.djindexes.com). Liquidity-based portfolio weights emphasize storable commodities, such as gold, whereas production-based portfolio weights emphasize nonstorable commodities, such as live cattle and oil. The differing approaches to weighting complicate historical analysis.
13. Crude oil futures were added in 1987; Brent crude oil in 1999; unleaded gasoline in 1988; gasoline in 1999; and natural gas in 1994.
14. The GSCI sector returns reflect the performance of the commodity futures listed in Table 4 as well as the returns of commodity futures that were added to the GSCI subsequent to December 1982.
15. The average absolute correlation between individual commodities is 0.11.
16. The label "diversification return" may seem somewhat novel or confusing. Some who read Booth and Fama (1992) may not realize that there is more to the diversification return than simply a variance reduction. Diversification return includes both a variance reduction and the impact of balancing or not rebalancing. Fernholz and Shay (1982) also provide details on the diversification return.
17. See also Greer (2000); De Chiara and Raab (2002).
18. The presence of a backwardation return was also the focus of work by Bodie and Rosansky and by Fama and French (1987).
19. Bessembinder obtained data on net hedging from the Commodity Futures Trading Commission's "Commitments of Traders in Commodity Futures" report. These data can be found at www.cftc.gov/cftc/cftccotreports.htm.
20. Market backwardation can be observed, whereas normal backwardation cannot. The two components of market backwardation are the market consensus expected future spot price and a possible risk premium.
21. Goldman Sachs "The Case for Commodities as an Asset Class," presentation (June 2004).
22. 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. Because futures contracts have an expiration date, investors who want to maintain a commodity futures position must periodically sell an expiring futures contract and buy the next-to-expire contract—that is, roll the 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. The implication is that the term structure of futures prices drives the roll return.
23. Such was the case of a PowerPoint marketing presentation by Goldman Sachs titled "The Case for Commodities as an Asset Class."
24. We benefited from a discussion with Lisa Plaxco on this point.
25. The conclusion "lack of statistical significance" is difficult to interpret. One interpretation is 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. This line of thought, however, is problematic. Given

the return and risk of the energy sector, for instance, about 78 years would be needed for the excess returns to pass conventional tests of statistical significance. Given the return and risk of the GSCI, about 57 years of data would be needed to inspire confidence that the excess returns of the GSCI were significant. These 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. At the moment, however, the data suggest that excess returns, on average, have not been statistically significant.

26. In fact, from 1969 to 2003 the first-order autocorrelation of the annual rate of change of the CPI inflation rate was 0.13.
27. Figure 3 shows a univariate regression of excess return on the year-over-year change in the rate of inflation.
28. Using overlapping data (and correcting for the induced autocorrelation) did not change the overall results of the regression analysis.
29. Because consensus as to the existence of an average foreign exchange risk premium is lacking, exposure of the GSCI to the foreign exchange rate helps explain return volatility but does nothing for a traditional risk-based explanation of average return.
30. Campbell (2000) called 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.
31. De la Grandville (1998) showed why this approximation can be misleading and provided exact analytical formulas.
32. In a simulation example with 40 securities and 10,000 uncorrelated 45-year simulated return histories for each security, the equally weighted, rebalanced portfolio had an average geometric return of 4.3 percent and the initially equally weighted (not rebalanced) portfolio had a geometric return of 3.8 percent (each simulated security had a 0 continuous average return). Do the positive returns for both rebalanced and unrebalanced portfolios pose a problem for this analysis of the diversification return? The answer is no because the geometric excess returns of the rebalanced portfolios in our simulation are entirely driven by the return to variance reduction. The geometric excess returns of unrebalanced portfolios are driven by changing portfolio asset mixes. On average and over a long enough time period, unrebalanced portfolios can 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. The implication is that, on average, it is best to assume that the diversification return of an unrebalanced portfolio will be close to zero. Furthermore, our simulation showed that 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.
33. Some investors may be skeptical and assert that historical demonstration of the diversification return is simply the result of a period-specific mean-reverting strategy in which one "sells winners and buys losers." The equation shows how an investor can calculate the expected, *base-case* diversification return when asset returns are serially uncorrelated. Negative serial correlation of returns might increase this base-case diversification return, and positive serial correlation might decrease the base-case diversification return.

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