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Facts and Fantasies about Commodity Futures

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For this study of the simple properties of commodity futures as an asset class, an equally weighted index of monthly returns of commodity futures was constructed for the July 1959 through December 2004 period. Fully collateralized commodity futures historically have offered the same return and Sharpe ratio as U.S. equities. Although the risk premium on commodity futures is essentially the same as that on equities for the study period, commodity futures returns are negatively correlated with equity returns and bond returns. The negative correlation is the result, primarily, of commodity futures' different behavior over a business cycle. Commodity futures are positively correlated with inflation, unexpected inflation, and changes in expected inflation.

Commodity futures are still a relatively unknown asset class, despite being traded in the United States for more than 100 years—and elsewhere for even longer.[1] The reason may be that commodity futures are strikingly different from stocks, bonds, and other conventional assets. Among these differences are the following: (1) commodity futures are derivative securities, not claims on long-lived corporations; (2) they are short-maturity claims on real assets; and (3) unlike financial assets, many commodities have pronounced seasonality in price levels and volatilities. Another reason that commodity futures are relatively unknown may be more prosaic—namely, the paucity of commodity futures return data.[2]

The economic function of such corporate securities as stocks and bonds—that is, liabilities of companies—is to raise external resources for the company. Investors in these securities are bearing the risk that the future cash flows of the company may be low and may not occur during bad times, such as recessions. Investors expect to be compensated for taking these risks. These claims represent the discounted value of cash flows over long horizons. Their value depends on the decisions of corporate managers.

Commodity futures are quite different; they do not raise resources for companies to invest. Rather, commodity futures allow companies to obtain insurance for the future value of their outputs (or inputs). Investors in commodity futures receive compensation for bearing the risk of short-term commodity price fluctuations.

Commodity futures do not represent direct exposure to actual commodities. Futures prices represent bets on the expected future spot price. Inventory decisions link current and future scarcity of the commodity and, consequently, provide a connection between the spot price and the expected future spot price. But commodities themselves, and hence commodity futures, display many differences. Some commodities are storable and some are not; some are input goods and some are intermediate goods.

We provide here some stylized facts about commodity futures and address some commonly raised questions: Can an investment in commodity futures earn a positive return when spot commodity prices are falling? How do spot and futures returns compare? What are the returns to investing in commodity futures, and how do these returns compare with the returns to investing in stocks and bonds? Are commodity futures riskier than stocks? Do commodity futures provide a hedge against inflation? Can commodity futures provide diversification?

Many of these questions have been investigated by others, but largely with the use of short data series applying to a small number of commodities.[3] For this study, we constructed a monthly time series starting in 1959 of an equally weighted index of commodity futures. We focused on an index because we wanted to address the questions with respect to the asset class as a whole rather than with respect to individual commodity futures.

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Investing in Commodity Futures

A commodity futures contract is an agreement to buy (or sell) a specified quantity of a commodity at a future date at a price agreed upon when the parties entered into the contract—the futures price. The futures price is different from the value of a futures contract. When the buyers and sellers enter into a futures contract, no cash changes hands between them; hence, the value of the contract is zero at its inception.[4]

How, then, is the futures price determined? To obtain the commodity in the future, the alternative to buying a futures contract is to simply wait and purchase the commodity in the future spot market. Because the future spot price is unknown today, a futures contract is a way to lock in the terms of trade for future transactions. In determining the fair futures price, market participants compare the current futures price with the spot price that can be expected to prevail at the maturity of the futures contract. In other words, futures markets are forward looking and the futures price embeds expectations about the future spot price. If spot prices are expected to be much higher at the maturity of the futures contract than they are today, the current futures price will be set at a high level relative to the current spot price. Lower expected spot prices in the future will be reflected in a low current futures price (see Black 1976).

Because foreseeable trends in spot markets are taken into account when futures prices are set, expected movements in the spot price are not a source of return to an investor in futures. Futures investors benefit when the spot price at maturity turns out to be higher than expected when they entered into the contract, and they lose when the spot price is lower than anticipated. A futures contract is thus a bet on the future spot price, and by entering into a futures contract, an investor assumes the risk of unexpected movements in the future spot price. Unexpected deviations from the expected future spot price are by definition unpredictable; for an investor in futures, the deviations should average out to zero over time—unless the investor has an ability to correctly time the market.

What return can investors in futures expect to earn if they do not benefit from expected spot price movements and are unable to outsmart the market? The answer is the risk premium: the difference between the current futures price and the expected future spot price. If today's futures price is set below the expected future spot price, a purchaser of futures will, on average, earn money. If the futures price is set above the expected future spot price, a seller of futures will earn a risk premium.

Theoretical reasons have been developed for the risk premium to accrue to either buyers or sellers of futures contracts. Keynes (1930) and Hicks (1939) postulated the theory of *normal backwardation*, which states that the risk premium will, on average, accrue to the buyers. They envisioned a world in which producers of commodities seek to hedge the price risk of their output. For example, a producer of grain sells grain futures to lock in the future price of the crops and obtain insurance against the price risk of grain at harvest time. Speculators provide this insurance and buy futures, but they demand a futures price that is below the spot price expected to prevail at the maturity of the futures contract. By "backwardating" the futures price relative to the expected future spot price, speculators receive a risk premium from producers for assuming the risk of future price fluctuations.[5]

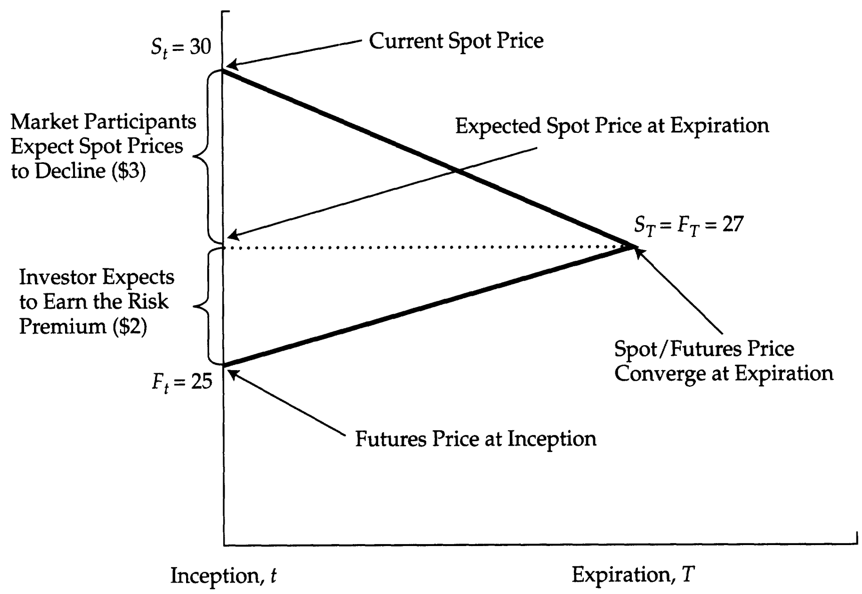
Speculators do not have to hold the futures contract until expiration to earn the risk premium. Over time, as the maturity date of the commodity futures contract draws close, the futures price will start to approach the spot price. At maturity, the futures contract will become equivalent to a spot contract and the futures price will equal the spot price. If a futures price was initially set below the expected future spot price, the futures price will gradually increase over time, thereby rewarding the long position.

Whether the theory of normal backwardation is an accurate theory of the determination of the futures price is an empirical matter, and much of this article will be devoted to examining the existence of a risk premium in commodity futures.[6] The preceding discussion of the mechanics of futures markets, however, underlines the following important points about an investment in futures:

- The expected payoff to a futures position is the risk premium. The realized payoff is the risk premium plus any unexpected deviation of the future spot price from the expected future spot price.
- A long position in futures is expected to earn positive (excess) returns as long as the futures price is set below the expected future spot price.
- If the futures price is set below the expected future spot price, the futures prices will tend to rise over time, providing a return to investors in futures.
- Expected trends in spot prices are not a source of return to an investor in futures.

Consider this hypothetical example (adapted from Weiser 2003), which is illustrated in **Figure 1**. Assume that the spot price of oil, S_t, is \$30 a barrel and that market participants expect the price of oil

Figure 1. Futures Returns and Spot Returns



to be $27 in three months. To entice investors into the market, the futures price, F_t, is set at $25, which is a discount to the expected future spot price. The difference between the futures price and the expected future spot price, or $2, is the risk premium that the investor expects to earn for assuming short-term price risk.

Now, suppose that at the time the contract expires, oil is trading at the expected price of $27. An investor in physical commodities, who cares about the direction of spot prices, has just lost $3 (i.e., $30 – $27). An investor in the futures contract, however, has gained the difference between the final spot price of $27 and the initial futures price of $25, or $2.

This example and Figure 1 show the case in which the expected future spot price of $27 is, in fact, realized. But suppose the expectation of a price of $27 is *not* realized and, instead, the final spot price turns out to be $26. Then, the realized return to the investor is $1. This realized return can be broken down into the risk premium ($27 – $25 = $2) plus the difference between the final spot price and the expected price ($26 – $27 = –$1).

Before we examine the empirical evidence for the historical performance of commodity futures as an asset class, we need to make one final remark about the calculation of futures returns. At the beginning of this section, we explained that the value of a futures contract is zero at origination and does not require any cash outlays for either the long or the short position. In practice, both the long and short positions will have to post collateral that can be used to settle gains and losses on the futures position over time. The collateral is typically only a fraction of the notional value of the futures position, which implies that a futures position can involve substantial leverage.

Therefore, to draw a meaningful comparison between the performance of futures and other asset classes, we need to control for leverage when calculating futures returns. We make the assumption that futures positions will be fully collateralized. For example, when an investor buys a contract with a futures price of $25, we assume that the investor simultaneously invests $25 in U.S. T-bills. The total return earned by the investor over a given time period will thus be the change in the futures price and the interest on the $25 (calculated daily), scaled by the $25 initial investment.

Commodity Futures Index

To investigate the long-term return to commodity futures, we constructed an equally weighted performance index of commodity futures. The source of our data is a database maintained by the Commodity Research Bureau (CRB), which has daily prices for individual futures contracts (covering, among other exchanges, the Chicago Board of Trade and Chicago Mercantile Exchange) since 1959.[7] We augmented this database with data from the London Metal Exchange (LME). A detailed description of these data is given in Appendix A, but a few general comments are in order.

Our index potentially suffers from a variety of selection and survivor biases. First, the CRB database contains data primarily for futures contracts that have survived until today or were in existence for extended periods during the 1959–2004 period. Many contracts that were introduced during this period but failed to survive are not included. How survivor bias affects the computed returns to a futures investment is not clear. Futures contracts fail for lack of interest by market participants—that is, lack of trading volume (see Black 1986; Carlton 1984). Although this lack of interest may be correlated with the presence of a risk premium, the direction of the bias is not as clear-cut as it would be in the calculation of an equity index.[8] Second, to avoid double counting commodities, we selected contracts for the index from a single exchange, even though a commodity might have been traded on multiple exchanges (we based our selection on the liquidity of the contract). So, the index is subject to a selection bias that may or may not be correlated with the computed returns. Finally, for each commodity, multiple contracts are listed that differ by maturity. For each day, we selected for the index the contract with the nearest expiration date (the shortest contract) unless the contract expired in that month, in which case we rolled into the next contract. For each month, therefore, we held the shortest futures contract that would not expire in that month.[9]

The performance index was computed as follows: At the beginning of each month, we held $1 in each commodity futures contract. (If the futures price was $25, we held 1/25th of a contract). At the same time, we purchased $1 in T-bills for every contract that the index invested in. The index was thus fully collateralized by a position in T-bills. The contracts were held until the end of the month, at which time we rebalanced the index to equal weights (for details, see Appendix A).

We are not the first to construct an index to study commodities at the portfolio level. Bodie and Rosansky (1980) constructed an equally weighted index from quarterly data for 1950 to 1976. Greer (1978) studied an index built for the 1960–74 period. And Fama and French (1987) reported average monthly excess returns for 21 commodities as well as for an equally weighted portfolio of commodity futures for 1966–1984. The advantage of studying commodities at the portfolio level is that diversification helps reduce the noise inherent in individual commodity data. Among other things, this noise may obscure the detection of a risk premium.

We could have weighted individual commodity futures in our index in many different ways.[10] By analyzing the returns of an equally weighted index of commodity futures, we can draw conclusions about how the "average" commodity futures contract behaves during the "average time period." Monthly rebalancing to equal weights embeds a trading strategy that might influence the performance of the index. We discuss this influence in the next section.

Historical Returns on Commodities

We now turn to the empirical evidence on the average return to commodity futures and whether the collateralized futures position outperforms the spot return for the "average" commodity futures contract. Panel A of **Figure 2** compares the price of the equally weighted total return index of commodity futures with the price of an equally weighted portfolio of spot commodity prices between 1959 and 2004.[11] Both indices were adjusted for inflation by deflating each series by the U.S. Consumer Price Index (CPI). The index of commodity spot prices simply tracks the evolution of the spot prices and ignores all costs associated with the holding of physical commodities (storage, insurance, etc). It is thus an upper bound on the return that an investor in spot commodities would have earned in the period.

The main conclusions from Panel A of Figure 2 are as follows:

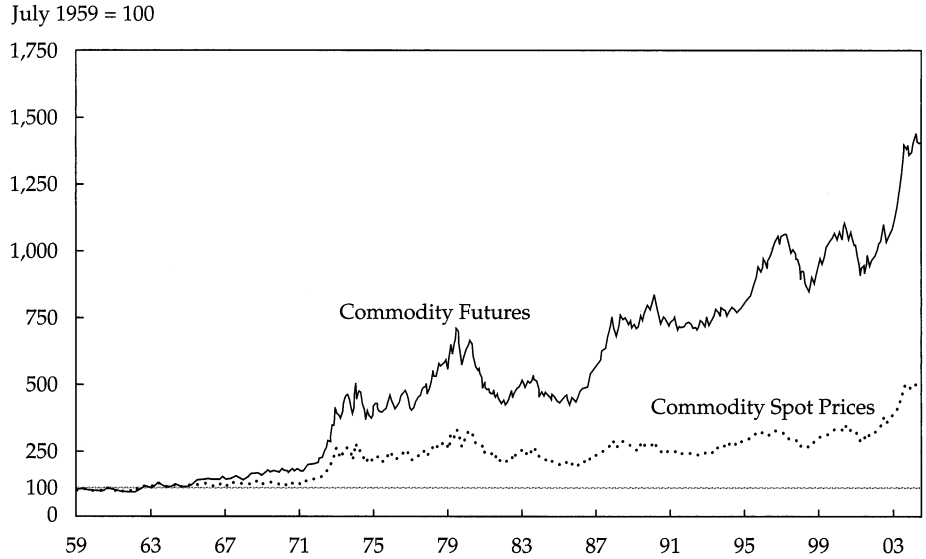
- The historical performances of spot commodity prices and collateralized commodity futures returns exhibit large differences. The historical return to an investment in commodity futures has far exceeded the return to a holder of spot commodities.
- The equal-weighted indices of both commodity spot and commodity futures prices have outpaced inflation.

What is perhaps not directly apparent from Panel A is that the return on the futures position is highly correlated with movements in the spot price. As explained, an investment in commodity futures benefits from unexpected increases in spot prices. The close correlation, especially in times of high spot market volatility, is illustrated in Panel B of Figure 2, which is built on the same data as Panel A but the scale is in logs (which facilitates identification of proportional changes in series that differ in levels). Clearly, these two series are highly correlated but diverge because of differing trends. Expected trends in the spot price are excluded from the futures index, which rises with the risk-free rate plus any risk premium earned by the futures position.

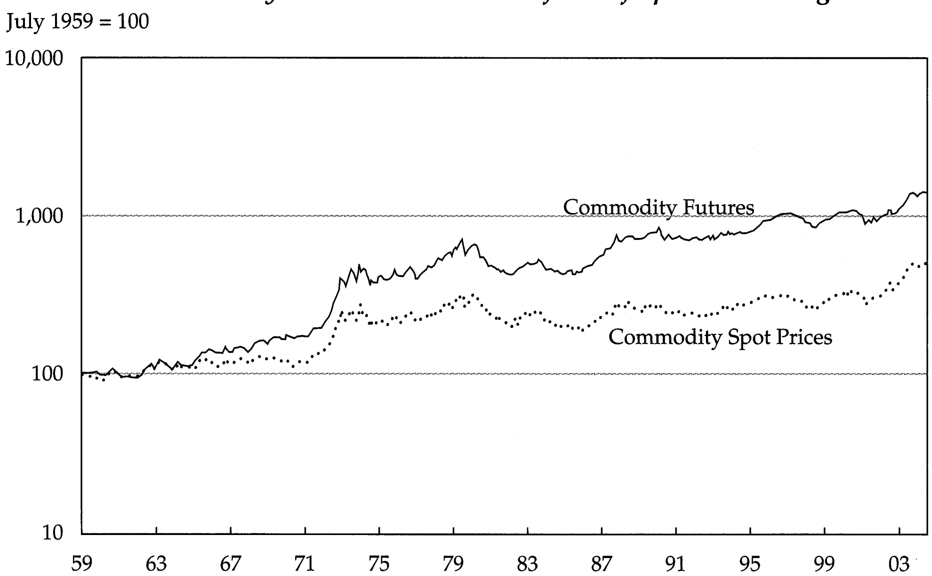
Panel A of Figure 2 also provides a clue about the magnitude of the risk premium of commodity futures. Part of the return to collateralized futures is the return on the collateral (T-bills). Because the historical return to T-bills is about the rate of inflation, the real (i.e., inflation-adjusted) return to collateralized commodity futures is an indication of

Figure 2. Inflation-Adjusted Commodity Futures Performance, July 1959–December 2004

A. Commodity Futures Index vs. Portfolio of Spot Prices



B. Commodity Futures Index vs. Portfolio of Spot Prices: Log Scale



the risk premium earned by investors. (We return to the risk premium in the next section.)

How robust are our conclusions about spot and futures prices to our method of index construction? The return of a frequently rebalanced index will differ from the return to a buy-and-hold strategy if returns are not independently distributed over time.[12] Our equal-weighted index has an embedded trading strategy that, in effect, bought at the end of each month a portion of those commodities that went down in price and sold a portion of those commodities that went up in price. If temporary spikes occurred in commodity prices that partially reverted during the next month, rebalancing to equal weights had the effect of buying future winners and selling future losers. This strategy would cause a rebalanced index to outperform a buy-and-hold index.

Temporary price movements can be pronounced in spot markets because many spot commodity prices exhibit seasonal price fluctuations. For example, heating oil prices are, on average, higher during the winter months, and gasoline prices increase during the summer driving season. Seasonality in spot prices is not likely to influence futures returns, however, because seasonality is a foreseeable fluctuation that is taken into account when market participants set futures prices. Other factors may drive temporary price movements in futures returns, but their analysis is beyond the scope of this article.

Table 1 summarizes the average annualized returns—arithmetic and geometric—of our commodity index under different assumptions about rebalancing. (Appendix A provides the formulas corresponding to the return calculations in Table 1.) The column "Annual Rebalancing" reports results for an index rebalanced annually to equal weights.[13] The last column reports results for a portfolio that weighted commodities equally when they entered the index but did not subsequently rebalance.[14] Table 1 shows the following:

- The average returns of a futures index rebalanced monthly and an index that was not rebalanced are similar and somewhat lower than returns to an index rebalanced annually to equal weights.[15]
- Consistent with our previous conjecture, the frequency of rebalancing has a larger influence on the spot index returns than it does on the futures returns, and its effect is to lower the spot returns. The influence is especially large for the buy-and-hold portfolio that was not rebalanced.
- The geometric average buy-and-hold spot return of 3.47 percent a year is lower than the average inflation of 4.13 percent over the sample period, which is consistent with conventional wisdom that over the long term, commodity prices have not kept pace with inflation.[16]

We conclude that our estimate of the average return on commodity futures is robust to different assumptions about rebalancing. Rebalancing matters—particularly for the calculation of average spot returns. In the remainder of the article, we focus our reporting on the equal-weighted index that was rebalanced monthly.

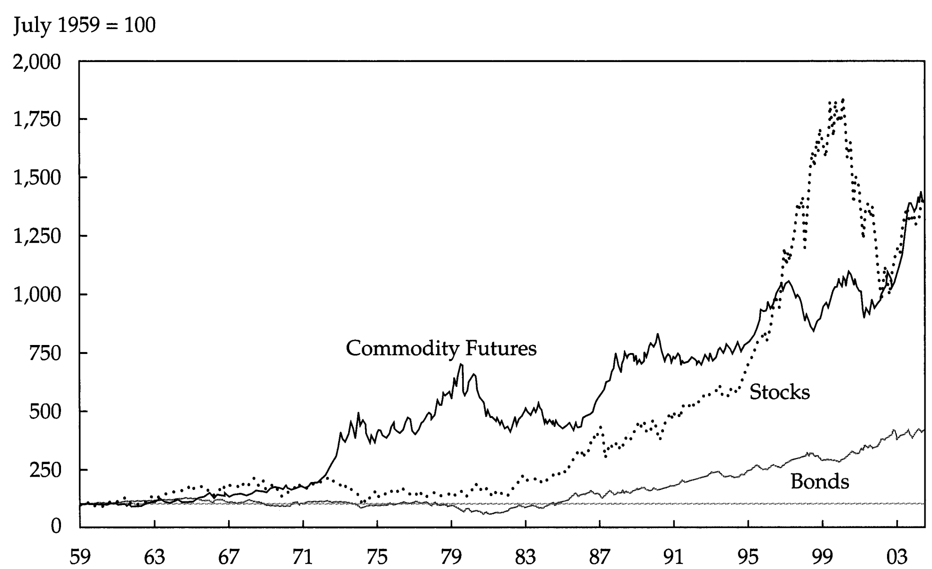
Table 1. Average Annualized Returns, July 1959–December 2004

Index	Monthly Rebalancing	Annual Rebalancing	Buy and Hold
Arithmetic return			
Futures	10.69%	11.97%	11.46%
Spot	8.42	7.51	4.64
Inflation	4.14	—	—
Geometric return			
Futures	9.98%	11.18%	10.31%
Spot	7.66	6.66	3.47
Inflation	4.13	—	—

Risk and Return

The cumulative performances of the Ibbotson corporate bond total return index for U.S. bonds, the S&P 500 total return index for U.S. stocks, and the equally weighted commodity futures index are compared for the period July 1959 through 2004 in **Figure 3**. All the series were deflated by the U.S.

Figure 3. Inflation-Adjusted Performance of Stocks, Bonds, and Commodity Futures, July 1959–December 2004



CPI and, therefore, measure inflation-adjusted performance. Figure 3 shows the following:

- In the past 45 years, the average annualized return to a collateralized investment in commodity futures has been comparable to the return on the S&P 500. Both outperformed corporate bonds.
- Stocks and commodity futures have experienced higher volatility than bonds.
- Commodity futures outperformed stocks during the 1970s, but this performance reversed during the 1990s.

Table 2 summarizes the historical risk premiums (not adjusted for inflation) for the three asset classes. The following observations stand out:

- The average historical risk premium of commodity futures was about 5 percent a year during the period from 1959 to 2004. The average premium is significant in a statistical sense (*t*-statistic = 2.92).
- The historical risk premium of commodity futures is about equal to the risk premium of stocks and is more than double the risk premium of bonds.

Table 2. Risk Premiums for Annualized Monthly Returns, July 1959–December 2004

	Commodity Futures	Stocks	Bonds
Average (%)	5.23	5.65	2.22
Standard deviation (%)	12.10	14.85	8.47
t-Statistic	2.92	2.57	1.77
Sharpe ratio	0.43	0.38	0.26
Percent returns > 0	55	57	54

Notes: The *t*-statistic measures the confidence that the average risk premium is different from zero. The Sharpe ratio is the average excess return divided by its standard deviation.

As pointed out previously, much debate has been going on among economists about the existence of a risk premium in commodity futures. Keynes and Hicks assumed for the theory of normal backwardation that hedgers outnumber speculators in the futures markets. The estimate of the risk premium in Table 2 is consistent with this theory and is in line with previous studies that estimated the risk premium at the portfolio level.[17] Most importantly, Table 2 shows that the risk premium has been economically large and statistically significant.[18]

Our commodity futures total return index covers a period of more than 45 years and is diversified across many commodities. Therefore, it provides a unique opportunity to examine the risk premium across a variety of commodities and time periods.

Note that the risk premium is measured as the arithmetic average of the commodity futures' excess returns. It measures the average rate at which the futures price rose over the life of the average contract. This measure of the risk premium is consistent with the definition of risk aversion in the finance literature (see also Gorton and Rouwenhorst 2005).

Table 3 summarizes the distribution of monthly returns of stocks, bonds, and commodity futures. The "Standard deviation" row shows that the historical volatility of the commodity futures total return has been below the volatility of the S&P 500, which explains the slightly higher historical Sharpe ratio of commodity futures in Table 2. The "Skewness" and "Kurtosis" rows illustrate that financial returns are not completely characterized by the mean and standard deviation of returns. (Appendix B contains similar summary statistics for the individual commodities.)

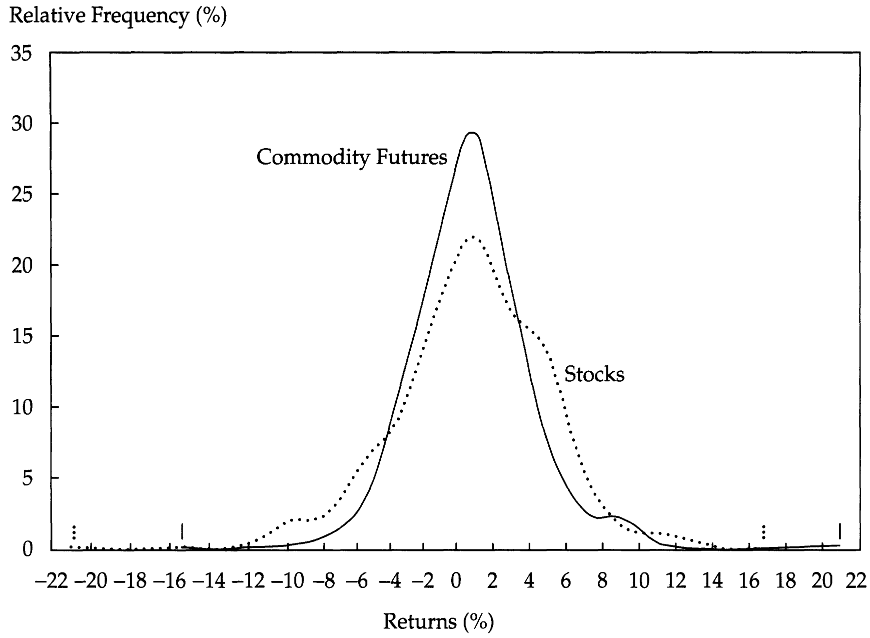
Table 3. Distribution of Percentage Returns, July 1959–December 2004

	Commodity Futures	Stocks	Bonds
Average return	0.89	0.93	0.64
Standard deviation	3.47	4.27	2.45
Skewness	0.71	–0.34	0.37
Kurtosis	4.53	1.81	3.56

As investment practitioners are well aware, the returns on financial assets often deviate from a normal distribution; they display skewness and have "fat tails." The pattern is illustrated in **Figure 4**, which compares the historical distribution of monthly returns for the S&P 500 with that of our equally weighted commodity futures index. From Table 3 and Figure 4, the following observations stand out:[19]

- Commodity futures and stocks have about the same average return, but the standard deviation of stock returns is slightly higher.
- The return distribution of equities has negative skewness, whereas the distribution of commodity futures returns has positive skewness. Therefore, proportionally, equities have more weight in the left tail of the return distribution and commodity futures have more weight in the right tail.
- Both distributions have positive excess kurtosis, indicating more realizations in the tails than would be expected based on a normal distribution. They are fat tailed relative to the normal distribution.

Figure 4. Empirical Distributions of Monthly Returns: Stocks and Commodity Futures, July 1959–December 2004



The slightly higher variance and negative skewness of equities implies that equities have more downside risk than commodity futures have. For example, the 5 percent tail of the empirical distribution of equities occurs at –6.34 percent whereas it occurs at –4.10 percent for commodity futures. In terms of value at risk, the maximum loss on equity is substantially exceeded by the maximum loss on a commodity futures investment. From the perspective of risk management, an important question is whether these tail events occur simultaneously for these asset classes or in isolation.

Correlations

In this discussion of the correlation of commodity futures returns with stocks and bonds, we report monthly returns and correlations computed by using overlapping returns for quarterly, annual, and five-year intervals. Because asset returns are volatile, by examining correlations over long holding periods, we could discover any patterns in the data that are obscured by short-term price fluctuations.

Table 4 presents the correlations of commodity futures returns with stocks, bonds, and inflation over the 1959–2004 period. Table 4 shows the following:

- Over all horizons except the monthly horizon, the equally weighted commodity futures total return was negatively correlated with the return on the S&P 500 and the return on long-term bonds. Although the hypothesis that the correlation of commodity futures with stocks is zero at short horizons cannot be rejected, these findings suggest that commodity futures are effective in diversifying equity and bond portfolios.
- The negative correlation of commodity futures with stocks and bonds tends to increase with the holding period. This pattern suggests that the diversification benefits of commodity futures are larger at longer horizons.
- Commodity futures returns are positively correlated with inflation, and the correlation increases with lengthening horizons. Because commodity futures returns are volatile relative to inflation, the long-term correlations better capture the inflation properties of a commodity investment.

Figure 4 shows that equities contain more downside risk than commodity futures. So, an

Table 4. Correlations of Commodity Futures Returns with Stocks, Bonds, and Inflation, July 1959–December 2004

Holding Period	Stocks	Bonds	Inflation
Monthly	0.05	–0.14*	0.01
Quarterly	–0.06	–0.27*	0.14
One year	–0.10	–0.30*	0.29*
Five years	–0.42*	–0.25*	0.45*

Note: Overlapping return data.

*Significant at the 5 percent level in a Newey–West corrected test of standard errors.

important question is whether the negative correlation between equities and commodity futures holds up when equity returns are low—a time when diversification is especially valuable. We addressed this question by examining the returns to commodity futures during the months of lowest equity returns. During the 5 percent of the months of worst performance of equity markets, when stocks fell by 8.98 percent a month, on average, commodity futures experienced a positive return of 1.03 percent, which is slightly above the full sample's average return of 0.89 percent a month. During the 1 percent of months of lowest performance of equity markets, when equities fell, on average, by 13.87 percent a month, commodity futures returned an average of 2.38 percent.[20] Apparently, the diversification benefits of commodity futures were at work just when they were needed most.

For symmetry, we also examined the return to equities in months when the commodity markets had their poorest performance. The average return to equity in the bottom 5 percent (1 percent) of months in terms of commodity market performance was –0.99 percent (–4.10 percent) a month.

Commodity Futures Returns and Inflation

Investors ultimately care about the *real* purchasing power of their returns, so the threat of inflation is a concern for investors. Many traditional asset classes are a poor hedge against inflation—at least over short- and medium-term horizons.

For example, bonds are nominally denominated assets, and their yields are set to compensate investors for expected inflation over the life of the bond. When inflation is unexpectedly higher than the level investors contracted for, the real purchasing power of the bond's cash flows falls short of expectations. If unexpected inflation leads to revisions of future expected inflation, this loss of real purchasing power can be significant.

Equities provide a better hedge than bonds against inflation—at least in theory. After all, stocks represent claims against real assets—such as factories, equipment, inventories—whose value can be expected to keep pace with the general price level. Companies also, however, have contracts with suppliers of inputs, labor, and capital that are fixed in nominal terms, and therefore, these contracts act much like nominal bonds. In addition, (unexpected) inflation is often not neutral for the real economy. Unexpected inflation is associated with negative shocks to aggregate output, which is generally bad news for equities (see Fama 1981). In short, the extent to which stocks provide a hedge against inflation is an empirical matter.

Table 4 suggests that commodity futures might be a better inflation hedge than stocks or bonds. First, because commodity futures represent a bet on commodity prices, they are directly linked to the components of inflation. Second, because futures prices include information about foreseeable trends in commodity prices, they rise and fall with unexpected deviations from components of inflation.

Table 5 presents the correlations of stocks, bonds, and commodity futures with inflation. As in Table 4, correlations were computed for various investment horizons. Several observations stand out from Table 5.

- Stocks and bonds are negatively correlated with inflation, but the correlation of commodity futures with inflation is positive at all horizons and statistically significant at the longer horizons. Commodity futures' opposite exposure to (unexpected) inflation may help to explain why futures do well when stocks and bonds perform poorly.
- In absolute magnitude, inflation correlations tend to increase with the holding period. The negative correlation of stocks and bonds with inflation and the positive correlation of commodity futures with inflation are larger at return intervals of one and five years than they are at the monthly or quarterly frequency.

Table 5. Correlations of Assets with Inflation, July 1959–December 2004

Holding Period	Stocks	Bonds	Commodity Futures
Monthly	–0.15*	–0.12*	0.01
Quarterly	–0.19*	–0.22*	0.14
One year	–0.19	–0.32*	0.29*
Five years	–0.25	–0.22	0.45*

*Significant at the 5 percent level in a Newey–West corrected test of standard errors.

Our previous discussion suggested that stocks, and especially bonds, can be sensitive to *unexpected* inflation. To measure such sensitivity, a model of expected inflation is needed. For this purpose, we chose a simple method that has been used by others (e.g., Fama and Schwert 1977; Schwert 1981). We used the 90-day T-bill yield as our measure of expected inflation for the next quarter. The short-term T-bill rate is a proxy for the market's expectation of inflation *if the expected real rate of interest is constant over time.* Consequently, *unexpected* inflation can be measured as the actual inflation rate minus the nominal interest rate (which is known *ex ante*).

Because inflation is persistent over time, unexpected inflation often causes market participants to revise their estimates of future expected inflation. Therefore, we report both correlations with unexpected inflation and correlations with changes in expected inflation, which can be measured by the change in the nominal interest rate.

Table 6 illustrates the correlations, measured quarterly, of the returns to stocks, bonds, and commodity futures with the components of inflation. These observations stand out:

- The negative sensitivities of stocks and bonds to inflation stem mainly from sensitivities to *unexpected* inflation.
- Commodity futures are also more sensitive to unexpected than expected inflation but (again) in the opposite direction of stock and bond sensitivities.
- Stock returns and (especially) bond returns are negatively influenced by revisions about future expected inflation. Revisions about future inflationary expectations are positively correlated with commodity futures returns.

Table 6. Quarterly Correlations of Assets with Components of Inflation, July 1959–December 2004

Asset Class	Inflation	Change in Expected Inflation	Unexpected Inflation
Stocks	–0.19*	–0.10*	–0.23*
Bonds	–0.22*	–0.51*	–0.35*
Commodity futures	0.14	0.22*	0.25*

*Significant at the 5 percent level in a Newey–West corrected test of standard errors.

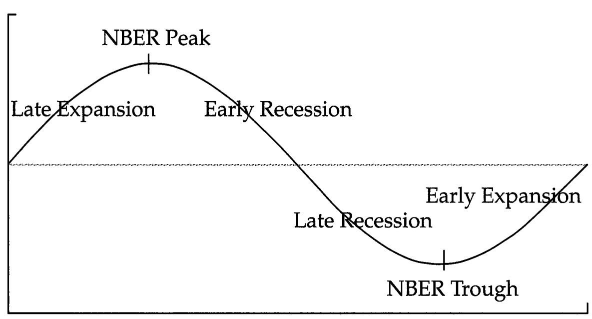
Commodity futures returns are negatively correlated with stock returns. Commodity futures' exposures to unexpected inflation are opposite to the exposures of stocks and bonds to unexpected inflation. It is tempting to put both together and ask: Does the opposite exposure to unexpected inflation account for the negative correlation between commodity futures and stocks and bonds? Preliminary findings suggest that this combination is only part of the story. If one isolates the portion of the returns of commodity futures, stocks, and bonds that is unrelated to unexpected inflation (that is, one examines the correlation of regression residuals from regressions of each asset class's returns on unexpected inflation) and examines the correlations again, one finds that the correlations of the residual variation of commodity futures with stocks or bonds continue to be negative. At the quarterly horizon, the correlation between futures and stocks increases from –0.06 to 0 and the correlation between futures and bonds increases from –0.27 to –0.20. In other words, additional factors are apparently driving the negative correlation between futures returns and stock and bond returns. One of those sources is business cycle variation.

Returns over the Business Cycle

Commodity futures are useful in diversifying traditional portfolios containing stocks and bonds because commodity futures returns are negatively correlated with stocks and bonds at quarterly, annual, and five-year horizons. Part of the negative correlation is attributable to the opposite exposures of commodity futures and stocks/bonds to inflation, but Weiser provided an alternative perspective on the diversification potential of commodity futures returns—especially at longer horizons. He showed that commodity futures returns vary with the stage of the business cycle: In a relative sense, commodity futures perform well in the early stages of a recession, a time when stock returns are generally disappointing. In the later stages of a recession, commodity futures returns are low while bonds and equities generally have their best performance.[21]

Figure 5 displays peaks and troughs of a business cycle based on phases identified by the National Bureau of Economic Research.[22] The NBER identifies peaks and troughs, and we added phases by dividing the number of months from peak to trough (trough to peak) into equal halves to indicate early recession and late recession (early expansion and late expansion). Clearly, the early and late expansion phases correspond to an economic expansion whereas the early and late recession phases correspond to a recession. We analyzed the performance of commodity futures, stocks, and bonds according to these phases for our sample

Figure 5. Business Cycle Phases



Sources: Based on Vrugt (2003) and NBER.

period. Starting in 1959 allowed us to analyze seven full business cycles, more than Weiser or Vrugt could analyze. **Table 7** shows the results:

- On average, stocks and commodity futures behave similarly during expansions and recessions. In expansions, our proxy for stocks (the S&P 500) averaged a return 1.45 percentage points (pps) higher than the return to the equally weighted index of commodity futures. In recessions, the return to the S&P 500 was 0.54 pps lower than the return to the commodity futures index. Therefore, although the returns to stocks and the commodity futures index appear to be similar, the similarity falls apart when business cycles are broken into phases.
- During an early recession phase, the returns to both stocks and bonds are negative, but the return to commodity futures is positive. During a late recession phase, the signs of the returns reverse.
- The diversification effect is not limited to the early stages of recessions. Whenever stock and bond returns are below their overall average, in the late expansion and early recession phases, commodity returns are positive and commodity futures outperform both stocks and bonds.

Table 7. Average Returns by Stage of the Business Cycle, July 1959–December 2004

Cycle Type	Stocks	Bonds	Commodity Futures
Expansion	13.29%	6.74%	11.84%
Early	16.30	9.98	6.76
Late	10.40	3.63	16.71
Recession	0.51%	12.59%	1.05%
Early	–18.64	–3.88	3.74
Late	19.69	29.07	–1.63

These results are purely descriptive and do not imply a trading strategy because business cycles are dated "after the fact," but the *ex post* returns do illustrate how commodity futures can help to diversify traditional portfolios of stocks and bonds.

Information Content of Futures Prices

The empirical evidence presented in this article is consistent with Keynes' theory of normal backwardation. The notion of normal backwardation involves a comparison of the futures price with the *expected spot price in the future*, which is unobservable when the futures price is set. In the practice of commodity trading, the term "backwardation" is commonly used to refer to the *basis* of a futures position, which is defined as the difference between the futures price and the *current* spot price. Commodities for which the current spot price exceeds the futures price are said to be in backwardation, whereas commodity futures with a positive basis are referred to as being in "contango." Note that a negative basis is different from Keynesian normal backwardation, which relates the futures price to the expected future spot price. Commodities can be in contango (have a positive basis) yet be in normal backwardation.

For example, assume (as in the example in Figure 1) that the current spot price of oil is $30. But for this example, market participants expect the future spot price to be $34 and speculators and hedgers agree to set the futures price at $32, offering a $2 risk premium to speculators for assuming price risk. The market is in normal backwardation (futures price is below expected spot price) but not backwardated in the second sense because the futures price is above the current spot (that is, the market is in contango). To avoid confusion, we will refer to the basis when comparing the futures price with the current spot price.

Why would a commodity have a negative basis? Figure 1 illustrated that, by construction, the basis is the difference between the expected spot return and the risk premium that buyers of futures expect to earn. So, variation in the basis must be the result of either variation in expectations about the future spot price or variation in the expected risk premium. For example, a decline of the futures price relative to the current spot price will occur when market participants believe the future spot price to be lower or when buyers of futures require a higher risk premium. The basis of a futures position is thus not a source of return in itself, but movements in the basis may contain information about future expected returns.

In the absence of variation in required risk premiums either over time or across commodities, variation in the basis will simply reflect variation in market expectations about the future spot price. In this scenario, a futures trading strategy that selects commodities conditional on their basis will not be profitable because, in an efficient market, expected spot price movements are incorporated in the futures price. In contrast, if variation in the basis mirrors differences in required risk premiums across commodities or the changing risk of a given commodity over time, a trading strategy that selects commodities according to the size of their basis can be expected to earn positive profits.[23]

To examine the information content of the basis for future returns, we implemented the following trading strategy. We calculated the basis of a futures position as the slope of the futures curve between the contract in our index and the next available expiration.[24] At the end of each month in our sample, we ranked all available commodity futures by their basis and divided them into two equally weighted portfolios (high basis and low basis). As the ranking of each commodity changed over time, commodities could migrate between the low- and high-basis portfolios. Either way, the high-basis (low-basis) portfolio was constructed so as to rebalance each month toward the half of the commodity universe with the highest (lowest) basis. The annualized monthly return deviations from the equally weighted index are summarized in **Table 8**. Three observations stand out:

- The low-basis portfolio has historically outperformed the high-basis portfolio by about 10 pps a year. Relative to the equally weighted index, the outperformance of the low-basis portfolio is about equal to the underperformance of the high-basis portfolio. These performance differences are highly significant in a statistical sense.
- The low-basis portfolio, on average, beat both the equally weighted portfolio and the high-basis portfolio in three of every five months in the sample period.
- The historical standard deviation of the low–high excess return is similar to the standard deviation of investing in the equally weighted index itself. The Sharpe ratio of a diversified long–short bet on the futures basis is twice the Sharpe ratio of the equally weighted index.

The conclusion from this section is that the futures basis seems to hold important information about the risk premium of individual commodities.

Table 8. Performance of Low- and High-Basis Portfolios: Annualized Return Deviations from Equally Weighted Index and Each Other, July 1959–December 2004

	Low-Basis Portfolio – Index	High-Basis Portfolio – Index	Low – High
Average return (%)	4.87	–5.17	10.04
Standard deviation (%)	6.64	6.64	13.16
t-Statistic	4.94	–5.26	5.15
Sharpe ratio	0.73	–0.78	0.76
Percent returns > 0	59	39	60

The simple trading strategy we examined potentially exploits differences in risk premiums across commodities as well as time-series variation in the premiums of individual commodities.[25]

International Setting

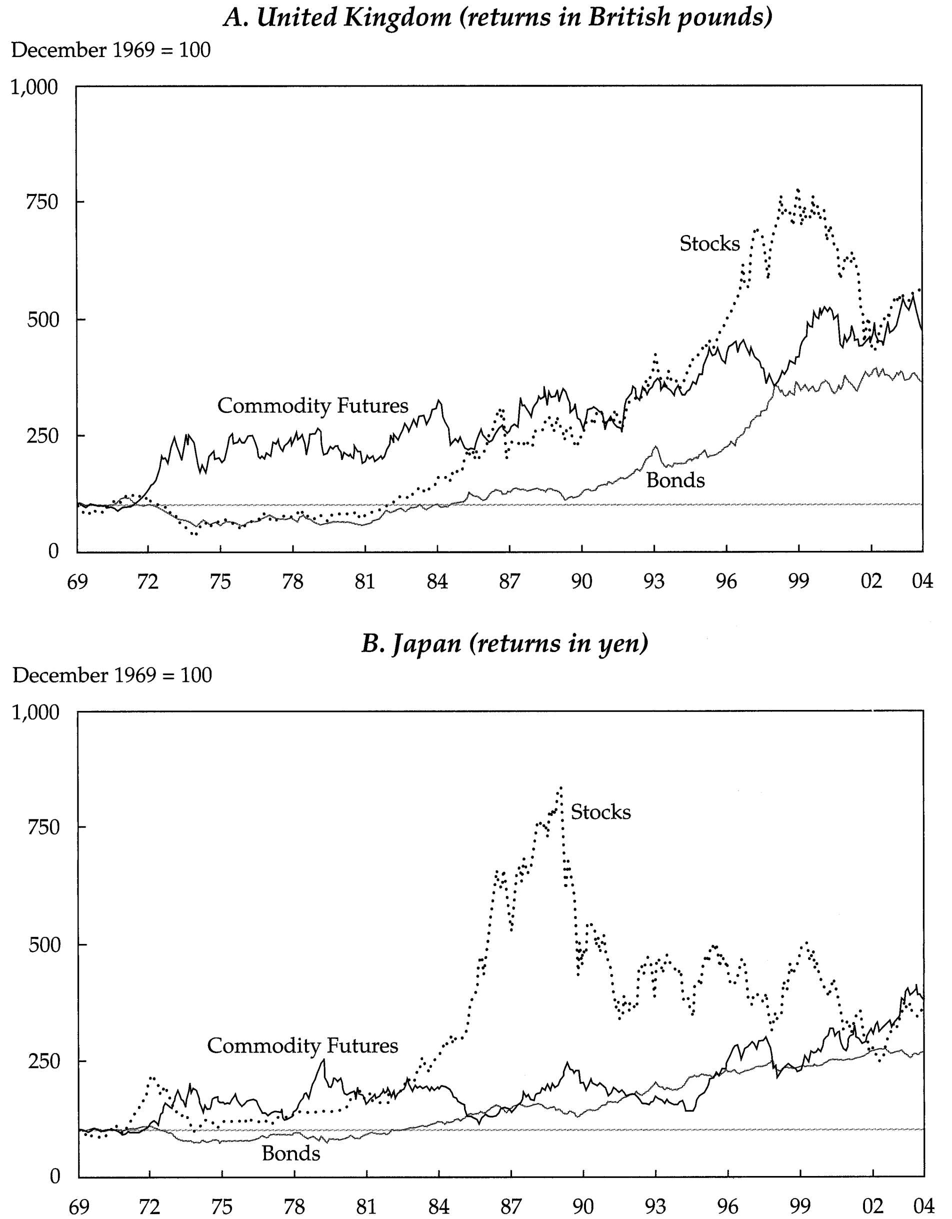
The majority of commodity futures in our index are traded on U.S. exchanges (although some metals are traded in London). Physical delivery takes place at a location within the contiguous 48 states, and settlement is in U.S. dollars. The U.S. markets for some commodity futures (gold, crude oil) are probably integrated with global markets, but prices of other commodities (natural gas, lean hogs) are likely to be influenced by local conditions. A common country-specific U.S. factor may influence both stock and commodity futures returns in the United States. If so, commodity futures may look quite different to a foreign investor from the way they look to a U.S. investor.

Figure 6 illustrates the performance of commodities from the perspective of U.K. investors (Panel A) and Japanese investors (Panel B). The equity benchmarks we used are the total-return indices for equities from Morgan Stanley Capital International for the United Kingdom and Japan and the cumulative performance of long-term government bonds in both countries published by the International Monetary Fund. All the indices were computed in local currency and deflated by the local consumer price index. Similarly, for commodity futures, we computed the performance of the index in British pounds or yen before deflating the data by the local CPI.[26] Three observations stand out from Figure 6:

- Between 1970 and the end of 2004, the average historical performance of commodity futures was similar to equities in the United Kingdom and in Japan. Commodity futures outperformed long-term government bonds.
- Commodity futures outpaced local CPI inflation in the United Kingdom and Japan.
- The relative rankings of the inflation-adjusted performance of stocks, bonds, and commodity futures are similar in Japan, the United Kingdom, and the United States.

Our earlier conclusions about the relative performance of commodity futures are not, therefore, specific to the U.S. experience. Foreign investors—evaluating performance in local currency and relative to local inflation—would have had much the same experience.

Figure 6. Inflation-Adjusted Performance of Commodities in the United Kingdom and Japan, December 1969–December 2004



Commodity Futures vs. Stocks of Commodity Companies

Some have argued that the equities of companies involved in producing commodities are a good way to gain exposure to commodities. In fact, some argue that the stocks of such "pure plays" are a substitute for commodity futures. We examined this argument by constructing an index of the stock returns on such U.S. companies and then comparing the performance of this index with that of an equally weighted index containing the commodity futures for which a pure play exists. To make this comparison, we had to identify companies that most closely matched the commodities of interest. There is no obvious way to match companies involved in commodities because companies are almost never purely commodity producers; they are involved in a number of businesses. We chose to base matches on a simple rule: For each commodity that can be associated with a four-digit SIC code, we used all the companies with that same four-digit SIC code. On this basis, we matched 17 commodities with companies having publicly traded stock. The details are in Appendix D.

Figure 7 presents the return performance of commodity futures versus commodity companies for 1962 through 2003. A significant difference between the average return of commodity futures and of an investment in commodity company stocks is visible. Over the 41-year period, not only did the cumulative performance of futures deviate from the cumulative performance of matched equities, but more interestingly, the correlation between the two investments was only 0.40. In comparison, the correlation of the commodity company stocks with the S&P 500 was 0.57. In other words, commodity company stocks behave more like other stocks than they do like commodity futures. And an investment in commodity company stocks has not been a close substitute for an investment in commodity futures.

Conclusions and Directions for Future Research

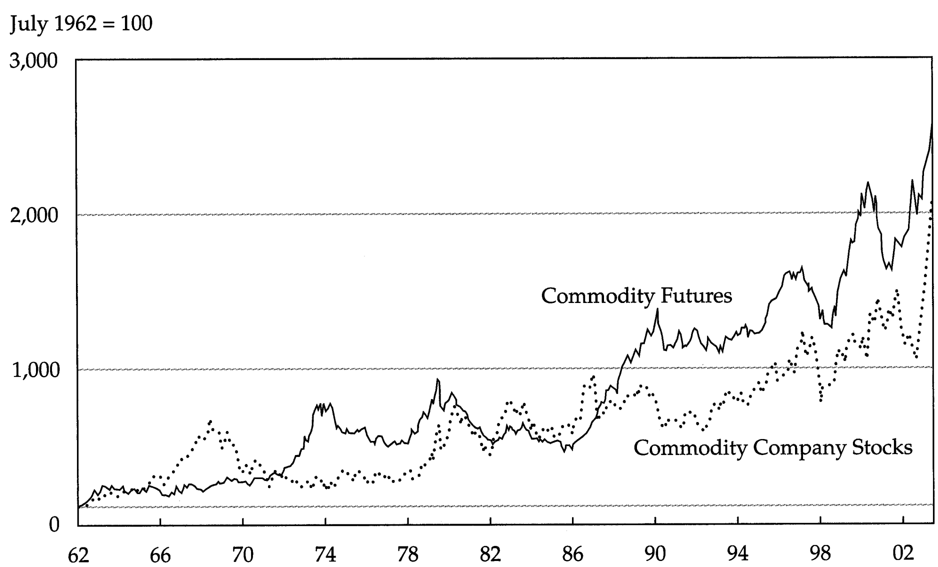
To analyze the long-term properties of an investment in collateralized commodity futures contracts, we constructed an equally weighted index of commodity futures covering the period July 1959 through December 2004. We showed empirically the large difference between the historical performance of commodity futures and the return an investor in spot commodities would have earned. An investor in our index would have earned an excess return over T-bills of about 5 percent a year. During our sample period, this commodity futures risk premium was about equal in size to the historical risk premium of stocks (the equity premium) and exceeded the risk premium of bonds. This evidence of a positive risk premium to a long position in commodity futures is consistent with Keynes' theory of normal backwardation.

In addition, the historical risk of an investment in commodity futures has been relatively low—especially if evaluated in terms of its contribution to a portfolio of stocks and bonds. Our study shows that a diversified investment in commodity futures has slightly lower risk than an investment in stocks (as measured by standard deviation). And because the distribution of commodity returns is positively skewed relative to equity returns, commodity futures have less downside risk.

Commodity futures returns have been especially effective in providing diversification for stock and bond portfolios. The correlation with stocks and bonds was negative over most horizons, and the negative correlation was strongest over the longer holding periods. Possible explanations are (1) commodity futures perform better in periods of unexpected inflation or (2) commodity futures diversify the cyclical variation in stock and bond returns.

The stylized facts documented in this article suggest several avenues for future research. First, what is the source of the documented risk premium? The Keynesian theory of normal backwardation whereby commodity producers pay to obtain insurance from investors may fit the context of undiversified farmers during the 1930s, but it has less appeal in the context of modern multinational companies

Figure 7. Inflation-Adjusted Performance of Commodity Futures vs. Shares of Commodity-Producing Companies, July 1962–December 2003



operating in integrated global capital markets, such as oil companies. Although some evidence supports Keynes' view that supply-and-demand factors determine the risk premium (e.g., Bessembinder 1992), the identities and motives of participants in commodity futures markets are not understood. The Keynesian view predates modern asset-pricing theory, according to which the risk premium should be determined by the covariation of commodity futures returns with systematic risk factors. To explain high average returns in the context of an asset-pricing model requires that commodity futures have substantial exposure to the benchmarks that investors use to measure risk. Although there is no agreement about the best model to measure risk, the traditional capital asset pricing model will fail because of the low correlation of commodity futures with equities (see Dusak 1973).

We documented that many of the return distributions of commodity futures exhibit positive skewness. Therefore, a second question for future research concerns the source of skewness in commodity returns. At the root of commodity futures price behavior are inventory decisions. Deaton and Laroque (1992) suggested that the possibility of stockouts may produce spikes in commodity prices (see also Routledge, Seppi, and Spatt 2000). Spikes would lead to positive skewness in the returns for a long investor in commodity futures. Thus far, relatively few papers have attempted to apply the inventory models empirically to the data.[27]

A third issue for investigation is the reported returns to trading strategies that select commodities by their futures basis. This points to variation in excess returns—both across commodities and over time. Relating these returns to cross-sectional and time-series variation in risk seems a logical next step.

Despite their long history, commodity futures are only recently receiving attention by the investment community as an asset class. This article produces some stylized facts about commodity futures, and it illustrates the benefit of additional research in this field.

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This article qualifies for 1 PD credit.

Appendix A. Index Construction and Return Calculation

We provide details on the construction of the equally weighted commodity futures index and calculation of returns.

Index Construction

The CRB dataset covers all commodity futures that are in existence today. We used the closing prices of the futures contracts for aluminum, nickel, zinc, lead, and tin expiring on the third Wednesday of each month. Since January 1994, these prices have been provided by Reuters (some prices, especially early in the period, may have been linearly interpolated). Prior to January 1994, we linearly interpolated between the official LME closing ask prices for cash and three-month forwards.

Commodity futures contracts that were introduced but later discontinued because of lack of liquidity are not covered by the CRB and were not included in the equally weighted index.

Cash prices from actual transactions in commodities are not widely available for most commodities. Therefore, we constructed daily spot prices by linear interpolation between the futures contract that was in the index and the next-nearest futures contract. For contracts expiring after 31 December 2004 (index end date), we calculated expiration dates by using current rules. Because rules governing expiration dates may have changed over time, for all contracts expiring prior to 31 December 2004, we used the latest date for which there was a price at the contract expiration date. For LME-traded commodity futures, we used the LME official "cash" settlement ask price, which is really a two-business-day forward because physical settlement is in two business days.

We constructed the equally weighted commodity futures index in steps. For each month, we first constructed price (or excess returns) on each commodity futures contract by using the nearest contract that did not expire in that month. In terms of a mechanical trading strategy, on the last business day of the month prior to the expiration date of a futures contract, we rolled into the next nearest futures contract. Then, we computed the total returns under the assumption that the futures position was fully collateralized, was marked to market on a monthly basis, and had earned interest monthly on the basis of the total return of 30-day T-bills provided by Ibbotson Associates.

Second, using monthly returns for each commodity futures contract, we constructed the index by adding the monthly returns together each month and dividing by the number of commodities in the index that month. A commodity entered the index on the last business day of the month following its introduction date, except the first seven commodity futures entered the index on 1 July 1959, not 31 July 1959. This approach corresponds to monthly rebalancing. **Table A1** shows the introduction dates of the commodities.

For hogs, the contract specifications changed in 1996 from "live hogs" to "lean hogs." We constructed a single series by dividing all live hog prices by 0.74 (a constant calculated by CRB from the 1996 contract specification). For pork bellies during the months of August 1962, September 1962, August 1963, and September 1963, gaps occurred during which no prices for any contracts were available. For feeder cattle in March 1973 and rough rice in November 1987, we were unable to roll into the next futures contract because of missing data.

Table A1. Introduction Dates of Commodities in the Index

No.	Commodity	Quotes Start	Index Inclusion Date	First Contract Year	First Contract Month	Sector
1	Copper	1 Jul 1959	1 Jul 1959	1959	Oct	Industrial metals
2	Cotton	1 Jul 1959	1 Jul 1959	1960	Jul	Industrial materials
3	Cocoa	1 Jul 1959	1 Jul 1959	1960	Mar	Softs
4	Wheat	1 Jul 1959	1 Jul 1959	1959	Dec	Grains
5	Corn	1 Jul 1959	1 Jul 1959	1959	Sep	Grains
6	Soybeans	1 Jul 1959	1 Jul 1959	1959	Sep	Grains
7	Soybean oil	1 Jul 1959	1 Jul 1959	1959	Sep	Grains
8	Soybean meal	1 Jul 1959	1 Jul 1959	1959	Dec	Grains
9	Oats	1 Jul 1959	1 Jul 1959	1959	Dec	Grains
10	Sugar	4 Jan 1961	31 Jan 1961	1961	Jul	Softs
11	Pork bellies	18 Sep 1961	30 Sep 1961	1962	Feb	Animal products
12	Silver	12 Jun 1963	30 Jun 1963	1963	Aug	Precious metals
13	Live cattle	30 Nov 1964	30 Nov 1964	1965	Apr	Animal products
14	Lean hogs	28 Feb 1966	28 Feb 1966	1966	Jul	Animal products
15	Orange juice	1 Feb 1967	28 Feb 1967	1967	May	Softs
16	Platinum	4 Mar 1968	31 Mar 1968	1968	Jul	Precious metals
17	Lumber	1 Oct 1969	31 Oct 1969	1970	Mar	Industrial materials
18	Feeder cattle	30 Nov 1971	30 Nov 1971	1972	Mar	Animal products
19	Coffee	16 Aug 1972	31 Aug 1972	1973	Mar	Softs
20	Gold	31 Dec 1974	31 Dec 1974	1975	Jan	Precious metals
21	Palladium	3 Jan 1977	31 Jan 1977	1977	Mar	Precious metals
22	Zinc	3 Jan 1977	31 Jan 1977	1977	May	Industrial metals
23	Lead	1 Feb 1977	28 Feb 1977	1977	Jun	Industrial metals
24	Heating oil	14 Nov 1978	30 Nov 1978	1979	Feb	Energy
25	Nickel	23 Apr 1979	30 Apr 1979	1979	Aug	Industrial metals
26	Crude oil	30 Mar 1983	31 Mar 1983	1983	Jun	Energy
27	Unleaded gas	3 Dec 1984	31 Dec 1984	1985	Feb	Energy
28	Rough rice	20 Aug 1986	31 Aug 1986	1981	May	Grains
29	Aluminum	1 Jun 1987	30 Jun 1987	1987	Oct	Industrial metals
30	Propane	21 Aug 1987	31 Aug 1987	1987	Dec	Energy
31	Tin	3 Jul 1989	31 Jul 1989	1989	Sep	Industrial metals
32	Natural gas	4 Apr 1990	30 Apr 1990	1990	Jun	Energy
33	Milk	11 Jan 1996	31 Jan 1996	1996	Apr	Animal products
34	Butter	5 Sep 1996	30 Sep 1996	1997	Feb	Animal products
35	Coal	12 Jul 2001	31 Jul 2001	2001	Sep	Energy
36	Electricity	11 Apr 2003	30 Apr 2003	2003	Jun	Energy

Finally, for milk in July 1997 and butter in October 1998, no single futures contract was available for the duration of the entire month. For these eight months, we set price (excess) return to zero. In terms of mechanical trading strategy, the index invested the money allocated to these commodities in 30-day T-bills for these months.

Return Calculation

Table 1 in the article body reflects differing calculations of average annualized returns. We briefly explain these here; Roll (1983) provides details. For simplicity, we assume that all commodity futures contracts exist at all times. Suppose N commodity futures each exist for T months and $R_{i,t}$ is 1 plus the return on collateralized commodity future i during month t.

The *arithmetic* average return on a monthly rebalanced portfolio over the T months, $\bar{R}_{AR}^{T}$, is

$$\bar{R}_{AR}^{T} = \frac{1}{NT}\sum_{i}\sum_{t} R_{i,t} = \frac{1}{T}\sum_{t}\left(\frac{1}{N}\sum_{i} R_{i,t}\right). \tag{A1}$$

The *geometric* average return on a monthly rebalanced portfolio over the T months, $\bar{R}_{GR}^{T}$, is given by

$$\bar{R}_{GR}^{T} = \left[\prod_{t}\left(\frac{1}{N}\sum_{i} R_{i,t}\right)\right]^{1/T}. \tag{A2}$$

The *arithmetic* average return on a *buy-and-hold portfolio* over the T months, $\bar{R}_{ABH}^{T}$, is given by

$$\bar{R}_{ABH}^{T} = 1 + \frac{1}{T}\sum_{\tau}\left(\frac{\sum_{i}\prod_{t=1}^{\tau} R_{i,t}}{\sum_{i}\prod_{t=1}^{\tau-1} R_{i,t}} - 1\right),$$

where

$$\prod_{t=1}^{\tau-1=0} R_{i,t} \equiv 1. \tag{A3}$$

The *geometric* average return on a *buy-and-hold portfolio* over the T months, $\bar{R}_{GBH}^{T}$, is given by

$$\bar{R}_{GBH}^{T} = \left[\frac{1}{N}\sum_{i}\left(\prod_{t} R_{i,t}\right)\right]^{1/T}. \tag{A4}$$

We annualized these returns by subtracting 1 and multiplying by 1,200 (i.e., 12 months × 100). The returns in the middle column of Table 1, "Annual Rebalancing," are similar to Equation A1 and Equation A2; these formulas are omitted.

Appendix B. Summary Statistics of Distributions of Individual Commodity Futures Returns

Table B1 summarizes the number of monthly observations and the average annualized arithmetic and geometric average returns for the equally weighted index and for individual commodity futures. It also reports the standard deviation, the skewness, and the kurtosis of returns. The last two columns provide the average pairwise correlations of individual commodity futures with all other commodities and the correlation of a commodity futures contract with the equally weighted index.

Appendix C. Simple Commodity Futures Mathematics

Commodity futures are different from financial assets in several aspects. First, financial assets are held for investment purposes, whereas commodities are produced for use as, and derive their value from, ultimate consumption or inputs into the production of finished goods. Second, although commodities can be stored (to varying degrees), doing so is often costly in comparison with "storing" financial assets. Finally, financial assets have an active borrowing and lending market, but such a market for commodities is limited. As a consequence, spot prices of commodities behave differently from prices of financial assets. Financial asset prices are close to a random walk with drift; commodity prices often fluctuate in a predictable manner because of seasonal patterns in demand and supply.

The close link between futures prices and contemporaneous spot prices that is necessary to prevent arbitrage in the futures markets for financial assets—known as the cost-of-carry model—is not a good description of commodity markets.[28] Specifically, the cost-of-carry model predicts that the futures (forward) price of an asset equals the spot price adjusted for the cost associated with carrying the asset into the future. Intuitively, this link derives from the equivalence between (1) purchasing an asset in the spot market and carrying it into the future and (2) borrowing to finance the purchase of the asset in the futures market. If the

Table B1. Annualized Monthly Returns, July 1959–December 2004

Commodity	Obs.	Average: Arithmetic	Average: Geometric	St. Dev.	Skewness	Kurtosis	Correlation: w/Others	Correlation: w/Index
Equally weighted index	546	10.69%	9.98%	12.04%	0.71	4.54	0.39	1.00
Copper	546	15.83	12.16	27.40	0.46	2.71	0.15	0.42
Cotton	546	8.01	5.38	23.27	0.79	4.03	0.05	0.24
Cocoa	546	8.95	4.18	31.59	0.81	1.70	0.04	0.29
Wheat	546	3.24	0.74	22.73	0.88	4.11	0.14	0.53
Corn	546	2.13	–0.19	22.16	1.73	11.03	0.16	0.58
Soybeans	546	8.99	5.84	26.02	1.86	13.32	0.17	0.65
Soybean oil	546	13.53	9.03	31.28	1.61	7.22	0.12	0.55
Soybean meal	546	13.85	9.38	31.67	2.67	21.18	0.16	0.59
Oats	546	2.63	–1.22	29.24	2.92	28.72	0.09	0.45
Sugar	527	11.28	2.12	44.58	1.23	3.47	0.05	0.37
Pork bellies	519	9.66	3.35	35.98	0.52	1.65	0.10	0.40
Silver	498	7.53	2.83	31.60	1.87	17.98	0.14	0.47
Live cattle	481	13.00	11.39	17.96	–0.24	1.93	0.10	0.35
Lean hogs	466	15.37	11.81	26.78	0.13	1.55	0.13	0.44
Orange juice	454	11.15	6.30	32.76	2.06	10.92	–0.02	0.12
Platinum	441	10.02	6.06	28.49	0.69	4.38	0.15	0.51
Lumber	422	6.26	1.91	29.80	0.46	1.48	0.04	0.20
Feeder cattle	397	9.40	7.90	17.17	–0.55	3.01	0.07	0.26
Coffee	388	15.11	7.68	39.95	1.10	2.75	0.04	0.22
Gold	360	4.48	2.65	19.34	0.72	4.73	0.13	0.47
Palladium	335	13.12	6.67	36.24	0.45	2.65	0.13	0.49
Zinc	335	8.41	5.99	22.11	0.14	0.27	0.13	0.45
Lead	334	7.31	4.78	22.74	0.45	0.46	0.13	0.42
Heating oil	313	18.62	13.62	32.74	1.24	5.54	0.11	0.38
Nickel	308	16.28	10.51	36.83	3.38	28.96	0.10	0.35
Crude oil	261	20.67	15.24	33.59	0.64	3.21	0.11	0.45
Unleaded gas	240	24.29	18.73	34.49	1.00	3.35	0.11	0.49
Rough rice	220	–1.21	–5.59	30.42	1.25	5.17	0.03	0.17
Aluminum	210	6.44	3.72	24.07	1.55	8.19	0.10	0.41
Propane	208	30.25	20.61	49.40	4.07	36.00	0.08	0.42
Tin	185	2.46	0.91	17.77	0.54	2.69	0.11	0.37
Natural gas	176	14.50	1.70	51.93	0.69	1.08	0.07	0.41
Milk	107	5.81	3.93	19.42	–0.11	0.96	–0.01	–0.01
Butter	99	24.73	17.06	40.06	0.50	1.34	0.01	0.12
Coal	41	–2.04	–4.47	22.01	–0.52	0.76	0.16	0.55
Electricity	20	–46.73	–54.56	40.24	0.44	–0.83	0.09	0.44

returns to these strategies differ, an arbitrageur can simultaneously sell the higher priced alternative and buy the cheaper alternative, thereby locking in an arbitrage profit. This strategy is relatively easy in the case of financial assets but is often complicated for commodities, especially when the arbitrage strategy involves selling the asset spot. As a consequence, the link between spot and futures prices is less tight for commodity futures than for financial futures.

Formally, consider an investor who buys an asset in the spot market at time t (at a price S), incurs the net storage cost, w, and finances this transaction with a T-period loan (so the transaction does not require any cash at time t). If the investor simultaneously sells the commodity by using futures for delivery at time T (at a price F), the net proceeds from the combined transaction are $F_{t,T} - e^{r(T-t)}(S_t + w)$, where e is the natural number used to compute continuously compounded returns and r is the interest rate.

The payoff is shown in **Table C1**. This payoff has to be nonpositive to ensure the absence of arbitrage opportunities:

$$F_{t,T} \leq e^{r(T-t)}(S_t + w).$$

Table C1. Relationship between Spot and Futures Prices: Cash Flows of Arbitrage Strategy

Transaction	Date t	Date T
Buy 1 unit of commodity at spot	$-S_t$	S_T
Pay net storage costs	$-w$	0
Borrow	$S_t + w$	$-e^{r(T-t)}(S_t + w)$
Sell 1 commodity in futures	0	$F_{t,T} - S_T$
Net cash flows	0	$F_{t,T} - e^{r(T-t)}(S_t + w)$

Intuitively, the futures price cannot exceed the spot price by more than the cost of carry (storage plus interest) or arbitrage exists. Unlike the case with financial futures, this expression does not hold with equality because it is generally not possible to take advantage of a "low" futures price. Low futures prices (or high spot prices, for that matter) create the incentive to sell the commodity at the spot price and simultaneously buy it back in the futures market. Those who do not own the commodity cannot borrow it, and those who possess an inventory of the commodity will be reluctant to give it up temporarily (either by lending it or selling it to themselves and buying it back forward) because inventory stockouts lead to disruptions in the productive process to which the commodity is an input.

Appendix D. Matching Commodity-Producing Companies to Commodities

As a rule, we matched companies with commodities based on four-digit SIC codes. We identified 17 matching publicly traded companies from the CRSP monthly stock database. For all companies with the same SIC code, we formed equally weighted monthly stock return series, and then, using these series, we formed an equally weighted index of the commodity-producing companies' stock. Commodities entered the futures index during the same months as the corresponding stocks entered the equity index.

There were several exceptions to the general rule. In the case of palladium, SIC codes 1099 and 1090 (i.e., "metal ores, NEC" and "miscellaneous metal ores") include companies mining palladium, but they also include companies mining uranium and other metals.[29] From the list of all these companies, we found two palladium-mining companies—North American Palladium Ltd. and Stillwater Mining Company—which we included. The remaining companies were ruled out.

Silver does not occur in a pure form. It is usually found as a byproduct of gold and copper ores or lead and zinc ores. SIC code 1044 "silver ores" contains few stocks, especially in the recent period. About 200 stocks, however, have SIC code 1040 for "gold and silver ores." Among these stocks, we identified several companies that specifically focus on silver—Pan American Silver Corporation, Silver Standard Resources Inc., Apex Silver Mines Limited, Helca Mining Company, and Coeur d'Alene Mines Corporation. These stocks were used as the silver stock matches. The rest of the stocks in SIC code 1040 were used as gold stocks.

In the case of milk, from SIC code 2020 for "dairy products," we excluded stocks that we could identify as ice cream producers, which are consumers of milk, not producers of milk.

Table D1 provides the number of stocks for each commodity and the period covered. "Zero" stocks means that the commodity was not included because no matching company could be found.

Table D1. Summary of Matches of Companies to Commodities

Commodity	Start	End	Matching SIC Codes	SIC Description	Stocks Start	Stocks End	No. of Stocks	Comparison Start	Comparison End	2nd Range Start	2nd Range End
Natural gas	30 Apr 1990	31 Dec 2003	1310; 1311	Crude petroleum and gas extraction	31 Dec 1925	31 Dec 2003	297	30 Apr 1990	31 Dec 2003		
Crude oil	31 Mar 1983	31 Dec 2003	2910; 2911	Petroleum refining	31 Dec 1925	31 Dec 2003	137	31 Mar 1983	31 Dec 2003		
Unleaded gas	31 Dec 1984	31 Dec 2003	2910; 2911	Petroleum refining	31 Dec 1925	31 Dec 2003	137	30 Nov 1984	31 Dec 2003		
Heating oil	30 Nov 1978	31 Dec 2003	2910; 2911	Petroleum refining	31 Dec 1925	31 Dec 2003	137	30 Nov 1978	31 Dec 2003		
Live cattle	31 Dec 1964	31 Dec 2003	212; 5154	Beef cattle except feedlots; livestock	31 Aug 1983	31 Mar 1986	2	31 Aug 1983	31 Mar 1986	31 Mar 2002	31 Dec 2003
Lean hogs	28 Feb 1966	31 Dec 2003	213	Hogs			0				
Wheat	1 Jul 1959	31 Dec 2003	111	Wheat			0				
Corn	1 Jul 1959	31 Dec 2003	115	Corn	31 Dec 1972	31 Mar 1986	2	31 Dec 1972	31 Mar 1986		
Soybeans	1 Jul 1959	31 Dec 2003	116	Soybeans			0				
Soybean oil	1 Jul 1959	31 Dec 2003	2075	Soybean oil mills	31 Jul 2001	31 Dec 2003	2	31 Jul 2001	31 Dec 2003		
Aluminum	30 Jun 1987	31 Dec 2003	3334	Primary aluminum	31 Aug 1991	31 Dec 2003	6	31 Aug 1991	31 Dec 2003		
Copper	1 Jul 1959	31 Dec 2003	1020; 1021; 3331	Copper ores; primary copper	31 Jul 1962	31 Dec 2003	43	31 Jul 1962	31 Dec 2003		
Zinc	31 Jan 1977	31 Dec 2003	1030; 1031	Lead and zinc ores	31 Jul 1962	31 Jan 2002	22	31 Dec 1976	31 Jan 2002		
Nickel	30 Apr 1979	31 Dec 2003	1061	Ferroalloy ores except vanadium	31 Jul 1962	31 Dec 2003	9	30 Apr 1979	31 Dec 2003		
Lead	28 Feb 1977	31 Dec 2003	1030;1031	Lead and zinc ores	31 Jul 1962	31 Jan 2002	22	31 Jan 1977	31 Jan 2002		
Tin	31 Jul 1989	31 Dec 2003					0				
Gold	31 Dec 1974	31 Dec 2003	1041;1040	Gold ores; gold and silver ores	28 Feb 1986	31 Dec 2003	299	28 Feb 1986	31 Dec 2003		
Silver	30 Jun 1963	31 Dec 2003	1044; 1040	Silver ores	31 Jul 1962	31 Dec 2003	16	30 Jun 1963	31 Dec 2003		
Platinum	31 Mar 1968	31 Dec 2003					0				
Sugar	31 Jan 1961	31 Dec 2003	2061; 2063	Raw cane sugar; beet sugar	31 Jul 1962	31 Dec 2003	15	31 Jul 1962	31 Dec 2003		
Cotton	1 Jul 1959	31 Dec 2003	131	Cotton	31 Oct 1975	31 Aug 1985	1	31 Oct 1975	31 Oct 1977	31 Oct 1981	31 Aug 1985
Coffee	31 Aug 1972	31 Dec 2003					0				
Cocoa	1 Jul 1959	31 Dec 2003					0				
Lumber	31 Oct 1969	31 Dec 2003	2400; 2410; 2411; 810; 811	Lumber and wood products; logging; timber tracts	28 Feb 1927	31 Dec 2003	19	31 Oct 1969	31 Dec 2003		
Propane	31 Aug 1987	31 Dec 2003	1320; 1321	Natural gas liquids	31 May 1991	31 Dec 2003	12	31 May 1991	31 Dec 2003		
Butter	30 Sep 1996	31 Dec 2003	2021	Creamery butter			0				
Milk	31 Jan 1996	31 Dec 2003	240; 241; 2026; 2020	Dairy farms; fluid milk; dairy products	31 Dec 1925	31 Dec 2003	35	31 Jan 1996	31 Dec 2003		
Orange juice	28 Feb 1967	31 Dec 2003	174	Citrus fruits	30 Sep 1970	30 Nov 1999	4	30 Sep 1970	30 Nov 1999		
Oats	1 Jul 1959	31 Dec 2003	119	Cash grains, NEC[a]			0				
Rough rice	31 Aug 1986	31 Dec 2003	112	Rice	31 Jul 1973	31 Jul 1999	1	31 Aug 1986	31 Jul 1999		
Soybean meal	1 Jul 1959	31 Dec 2003	2075	Soybean oil mills	31 Jul 2001	31 Dec 2003	2	31 Jul 2001	31 Dec 2003		
Feeder cattle	30 Nov 1971	31 Dec 2003	211; 5154	Beef cattle, feedlots; livestock	31 Dec 1969	30 Sep 1988	4	30 Nov 1971	30 Sep 1988		
Pork bellies	30 Sep 1961	31 Dec 2003	213	Hogs			0				
Palladium	31 Jan 1977	31 Dec 2003	PAL; SWC	Selected from 1090, 1099 misc. metal ores	30 Nov 1993	31 Dec 2003	2	30 Nov 1993	31 Dec 2003		

[a]NEC = not elsewhere classified.

Notes

1. Financial futures were traded on shares of the Dutch East India Company in the 17th century (see Jonker and Gelderblom 2005), but modern futures markets appear to have their origin in Japanese rice futures, which were traded in Osaka starting in the early 18th century (see Anderson, Hamori, and Hamori 2001).
2. For example, the University of Chicago's Center for Research in Security Prices has no commodity futures data, nor does Ibbotson Associates. In addition, the well-known commodity futures indices either do not extend back very far or cannot be reproduced for various reasons.
3. Exceptions include Bodie and Rosansky (1980), Kolb (1992, 1996), Fama and French (1987), Froot (1995), and Greer (2000).
4. The value of the contract is reset to zero also at the end of each day. Gains and losses during the day are settled by the two parties to the contract via transfers from their margin accounts.
5. Keynes put it this way: "In other words, the quoted forward price, though above the present spot price, must fall below the anticipated future spot price by at least the amount of normal backwardation" (p. 144).
6. Attempts to measure the risk premium empirically have yielded mixed results for individual commodities (for example, Gray 1961; Dusak 1973; Jagannathan 1985; Bessembinder 1992; Kolb 1992). Part of the reason for the lack of success is no doubt the volatility of futures prices, which motivates our focus on the properties of a diversified index (in the spirit of Bodie and Rosansky).
7. For information, see www.crbtrader.com/crbindex/ndefault.asp.
8. Among other reasons, stocks do not survive because of bankruptcy, and excluding bankrupt companies would create a strong upward bias in the computed returns.
9. The rolling itself is not a source of return. Because the futures price adjusts continuously and gains and losses are settled daily, a futures contract has zero value at the end of each day. Even though a distant futures contract may have a different futures price from that of a near contract, the exchange of one for another has no cash flow implications.
10. The popular traded indices of collateralized commodity futures (e.g., the Dow Jones-AIG Commodity Index and the Goldman Sachs Commodity Index) sometimes use (a combination of) production and liquidity data as the basis for calculating weights. At the time of our study, the Reuters–CRB Index used equal weights but did not rebalance as we did for our index.
11. See Appendix A for a discussion of how spot prices were constructed from futures prices. Given the spot prices, we constructed the equally weighted spot commodity prices to exactly mimic the equally weighted index of commodity futures.
12. See, for example, Blume and Stambaugh (1983) and Roll (1983).
13. To avoid the potential sensitivity of our results to the particular month of the year in which the index was rebalanced, we report the average return across 12 indices, each of which was rebalanced annually in a different month of the year. This procedure was suggested by Jegadeesh and Titman (1993) in the context of momentum strategies.
14. At the beginning of the sample, commodities entered the index with equal weights. When a new futures contract became available, we set its weight to the average of the other commodities but did not rebalance the relative positions of the original commodities. For example, if the index had 19 commodities and an additional commodity became available, we sold 1/20 of the index and invested the proceeds in the 20th commodity.
15. Throughout, averages of monthly returns were annualized by multiplying the raw average returns by 1,200.
16. See Prebisch (1950), Singer (1950), and (more recently) Grilli and Yang (1988) and Cashin and McDermott (2002).
17. Bodie and Rosansky reported an average excess return of 9.5 percent a year for an equally weighted portfolio of commodity futures between 1950 and 1976. Fama and French (1987) reported a continuously compounded risk premium of 0.45 percent (t = 1.57) a month on an equally weighted portfolio of 21 commodity futures between 1966 and 1984.
18. Kolb (1992), Erb and Harvey (2006), and others evaluated normal backwardation by the average geometric return (or average log return) on the futures position. This approach is equivalent to asking whether an investor with log utility who invested his or her entire wealth would have been better off faced with the average futures payoffs. Because a log investor is risk averse, using this approach amounts to measuring the premium relative to a log (i.e., risk-averse) investor. We thank Jon Ingersoll for pointing this aspect out to us.
19. To a large extent, the index returns inherit the properties of individual commodity returns, which are skewed to the right and exhibit excess kurtosis (see Appendix C).
20. The average returns during 1 percent of the months in the sample need to be interpreted with caution, as they were computed only over six observations.
21. Weiser analyzed the 1970–2003 period and determined the business cycles in terms of the rate of change of the quarterly GDP growth rate. Vrugt (2003) also analyzed the period 1970–2003 but used National Bureau of Economic Research (NBER) business cycle dating and divided the business cycle into phases. Jensen, Mercer, and Johnson (2002) examined the variation in commodity returns conditional on interest rates.
22. For information on the NBER, see www.nber.org/cycles.html.
23. Nash (2001) presented support for a relationship between average returns and the average basis. Fama and French (1987) showed that between 1966 and 1984, the basis was more informative about future spot rate movements than about the risk premium in a sample of 21 commodities. See also French (1986).
24. If F_1 is the futures price of the contract in our equally weighted index and F_2 is the futures price of the next contract, the basis is calculated as $[(F_2 - F_1)/F_1] \times 365/(T_2 - T_1)$, where T_1 and T_2 refer to the time (in days) to expiration of the two contracts.
25. A detailed decomposition of the relative contribution of these components and the source of the variation of the premiums is beyond the scope of this article and is left for future research.
26. The collateral for the futures position was U.S. T-bills. It is possible to collateralize the futures position by local T-bills.
27. Exceptions include Brennan (1958), Fama and French (1988), and Ng and Pirrong (1994).
28. For a textbook treatment of financial futures and commodity futures, see Hull (2002) or McDonald (2002).
29. NEC stands for "not elsewhere classified.

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