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FACTS AND FANTASIES ABOUT COMMODITY FUTURES

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Abstract

We construct an equally-weighted index of commodity futures monthly returns over the period between July of 1959 and December of 2004 in order to study simple properties of commodity futures as an asset class. Fully-collateralized commodity futures have historically offered the same return and Sharpe ratio as equities. While the risk premium on commodity futures is essentially the same as equities, commodity futures returns are negatively correlated with equity returns and bond returns. The negative correlation between commodity futures and the other asset classes is due, in significant part, to different behavior over the business cycle. In addition, commodity futures are positively correlated with inflation, unexpected inflation, and changes in expected inflation.

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1. Introduction

Commodity futures are still a relatively unknown asset class, despite being traded in the U.S. for over 100 years and elsewhere for even longer.[1] This may be because commodity futures are strikingly different from stocks, bonds, and other conventional assets. Among these differences are: (1) commodity futures are derivative securities; they are not claims on long-lived corporations; (2) they are short maturity claims on real assets; (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, there is a paucity of data.[2]

The economic function of corporate securities such as stocks and bonds, that is, liabilities of firms, is to raise external resources for the firm. Investors are bearing the risk that the future cash flows of the firm may be low and may occur during bad times, like recessions. These claims represent the discounted value of cash flows over very long horizons. Their value depends on decisions of management. Investors are compensated for these risks. Commodity futures are quite different; they do not raise resources for firms to invest. Rather, commodity futures allow firms 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 exposures 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, and hence commodity futures, display many differences. Some commodities are storable and some are not; some are input goods and some are intermediate goods.

In this paper we produce 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 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 to other asset classes? Many of these questions have been investigated by others but in large part with short data series applying to only a small number of commodities.[3] In this paper we construct a monthly time series of an equally-weighted index of commodity futures starting in 1959. We focus on an index because we want to address the above questions with respect to this asset class as a whole, rather than

[1] Financial futures were traded on shares of the Dutch East India Company in the 17th century (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, et al. (2001).

[2] For example, the University of Chicago 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), Fama and French (1987) and Greer (2000).

with respect to individual commodity futures. We produce some stylized facts to characterize commodity futures.

2. The Mechanics of an Investment 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 entering into the contract – the futures price. The futures price is different from the value of a futures contract. Upon entering a futures contract, no cash changes hands between buyers and sellers – and hence the value of the contract is zero at its inception.[4]

How then is the futures price determined? Think of the alternative to obtaining the commodity in the future: 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 will compare the current futures price to 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 will embed 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 the futures prices are set, expected movements in the spot price are not a source of return to an investor in futures. Futures investors will benefit when the spot price at maturity turns out to be higher than expected when they entered into the contract, and lose when the spot price is lower than anticipated. A futures contract is therefore 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, and should average out to zero over time for an investor in futures, unless the investor has an ability to correctly time the market.

What return can an investor in futures expect to earn if he does not benefit from expected spot price movements, and is 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.

Are there any theoretical reasons for the risk premium to accrue to either buyers or sellers of futures contracts? Keynes' (1930) and Hicks' (1939) theory of *normal backwardation* postulated that the risk premium would on average accrue to the buyers of futures. They

[4] This is also true at the end of each day when the value of a futures contract is reset to be zero. Gains and losses during the day are settled by the two parties to the contract via transfers from their margin accounts.

envisioned a world in which producers of commodities would seek to hedge the price risk of their output. For example, a producer of grain would sell grain futures to lock in the future price of his crops and obtain insurance against the price risk of grain at harvest time. Speculators would provide this insurance and buy futures, but demand a futures price which is below the spot price that could be expected to prevail at the maturity of the futures contract. By "backwardating" the futures price relative to the expected future spot price, speculators would receive a risk premium from producers for assuming the risk of future price fluctuations.[5]

How is the risk premium earned? Do speculators have to hold the futures contract until expiration? The answer is no. Over time, as the maturity date of the futures contract draws close, the futures price will start to approach the spot price of a commodity. At maturity, the futures contract will become equivalent to a spot contract, and the futures price will equal the spot price. If futures prices were initially set below the expected future spot price, the futures price will gradually increase over time, 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 paper will be devoted to examining the existence of a risk premium in commodity futures.[6] The above discussion of the mechanics of futures markets, however, serves to make the following important points about an investment in futures:

1. 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

2. 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.

3. 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.

4. Expected trends in spot prices are not a source of return to an investor in futures.

To further illustrate these points, consider a stylized example, adapted from Weiser (2003). The example is displayed in Figure 1 below. Assume that the spot price of oil is \$30 a barrel and that market participants expect the price of oil to be \$27 in three months. In order to entice investors into the market, the futures price is set at \$25, which is a

[5] Keynes (1930, p. 144) 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."

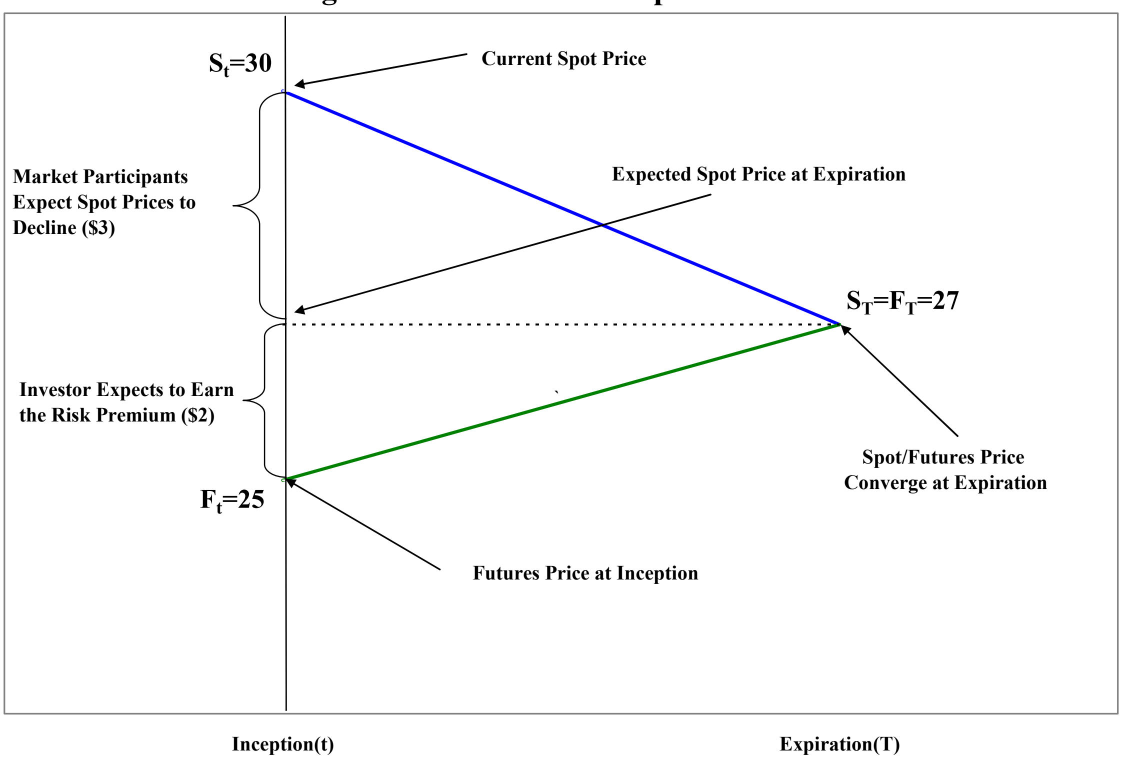
[6] Attempts to empirically measure the risk premium have yielded mixed results for individual commodities (see for example, Gray (1961), Dusak (1973), Jagannathan (1985), Bessembinder (1992), and Kolb (1992)). Part of the reason for the lack of success is no doubt the volatility of futures prices, and motivates our focus on the properties of a diversified index, in the spirit of Bodie and Rosansky (1980).

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, would have gained the difference between the final spot price of \$27 and the initial futures price of \$25, or \$2.

The example above and the figure examine the case where 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 would be \$1. This realized return can be broken down into the risk premium (\$27 - \$25 = \$2), less the difference between the final spot price and the expected price (\$26 - \$25 = \$1).

Figure 1: Futures versus Spot returns



The remainder of the paper will be devoted to empirical evidence on the historical performance of commodity futures as an asset class. One final remark needs to be made regarding 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 position 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.

In order 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. When an investor buys a contract with a futures price of $25, we will assume that the investor simultaneously invests $25 in T-bills. The total return earned by the investor over a given time period, will therefore be the change in the futures price and the interest on the $25 (calculated daily), scaled by the $25 initial investment.

3. An Equally-Weighted Index of Commodity Futures

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 Commodities Research Bureau, which has daily prices for individual futures contracts since 1959. We append this with data from the London Metals Exchange. A detailed description of the data is given in Appendix 1, but a few general comments are in place.

Our index potentially suffers from a variety of selection and survivorship biases. First, the CRB database mostly contains data 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 in the database. It is not clear how survivorship bias affects the computed returns to a futures investment. Futures contracts fail for lack of interest by market participants, i.e. lack of trading volume (Black (1986) and Carlton (1984)). While this may be correlated with the presence of a risk premium, the direction of the bias is not as clear cut as would be the case of the calculation of an equity index. Among other reasons, stocks do not survive because of bankruptcy, and excluding bankrupt firms would create a strong upward bias in the computed returns. Second, in order to avoid double counting of commodities, we selected contracts from a single exchange for inclusion in our index, even though a commodity might be traded on multiple exchanges. We based our selection on the liquidity of the contract, and it is therefore subject to a selection bias that may or may not be correlated with the computed returns. Finally, for each commodity, there are multiple contracts listed that differ by maturity. On each day, we selected the contract with the nearest expiration date (the shortest contract) for our index, unless the contract expired in that month, in which case we would roll into the next contract. In each month, we therefore hold the shortest futures contract that will not expire in that month.[7]

[7] 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 than a near contract, the exchange of one for another has no cash flow implications.

The performance index is computed as follows: at the beginning of each month we hold one dollar in each commodity futures contract. (If the futures price is $25, we hold 1/25th of a contract). At the same time we purchase $1 in T-bills for every contract that the index invests in. The index is therefore "fully collateralized" by a position of T-bills. The contracts are held until the end of the month, at which time we rebalance the index to equal weights. More detail is contained in Appendix 1.

We are not the first to construct an index to study commodities at the portfolio level. Bodie and Rosansky (1980) construct an equally-weighted index using quarterly data between 1950 and 1976. Fama and French (1987) report average monthly excess returns for 21 commodities as well as on an equally-weighted portfolio. Greer (2000) studies a commercially available index between 1970 and 1999. The advantage of studying commodities at the portfolio level is that diversification helps to reduce the noise inherent in individual commodities data. Among other things, this noise may obscure the detection of a risk premium.

There are many different ways in which we could have weighted individual commodity futures in our index.[8] By analyzing the returns of an equally-weighted index of commodity futures we can make statements about "how the average commodity future behaves during the average time period." Monthly re-balancing to equal weights embeds a trading strategy that might influence the performance of the index. Below we provide some evidence on how the index returns are influenced by our re-balancing assumption.

4. The Historical Returns on Commodities: Spot Prices, Collateralized Futures, and Inflation

We now turn to the empirical evidence on spot and future returns. What is the average return to commodity futures? Does the collateralized futures position outperform the spot return for the "average commodity future"? Figure 2a compares the equally-weighted total return index of commodity futures to an equally-weighted portfolio of spot commodities between 1959 and 2004.[9] Both indices have been adjusted for inflation by deflating each series by the 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 therefore an upper bound on the return that an investor in spot commodities would have earned. The main conclusions from examination of the figure are that:

1. There are large differences between the historical performance of spot commodity prices and collateralized commodity futures returns. The historical return to an

[8] The popular traded indices of collateralized commodity futures sometimes use (a combination of) production and liquidity data as the basis for calculating weights (e.g., the Dow Jones AIG Commodity Index and the Goldman Sachs Commodity Index). The Reuters-CRB index uses equal weights, but does not rebalance like our index.

[9] See Appendix 1 for a discussion of how spot prices are constructed from futures prices. Given the spot prices, the equally-weighted spot commodity prices are then constructed to exactly mimic the equally weighted index of commodity futures.

Figure 2a

Commodities Inflation Adjusted Performance 1959/7-2004/12
Spot versus Equally-weighted Collateralized Futures Index 1959/7 = 100

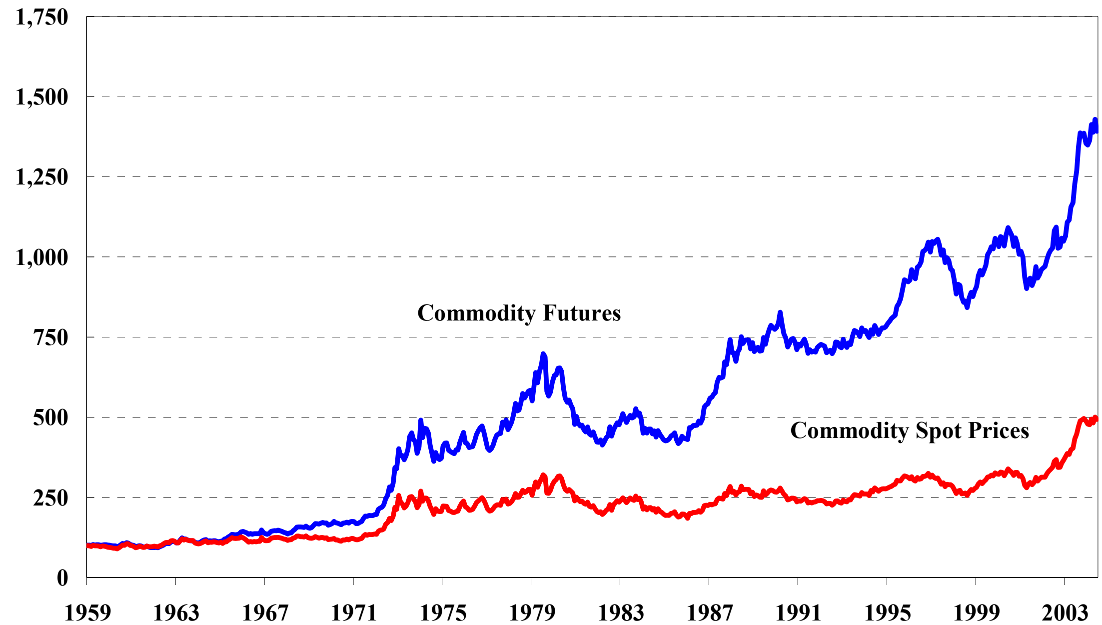
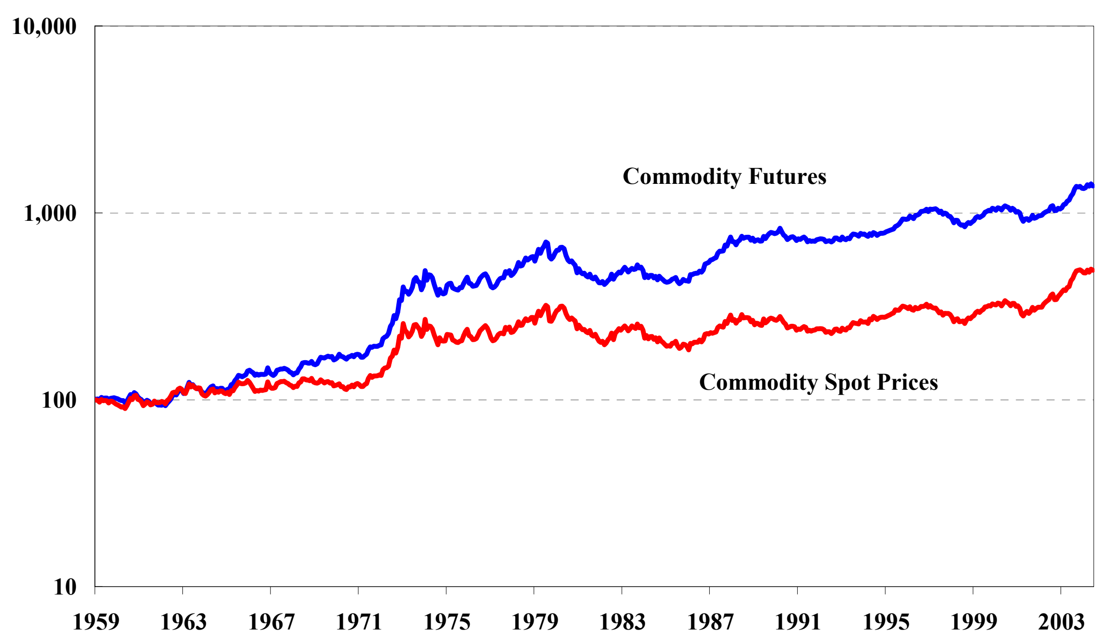


Figure 2b

Commodities Inflation Adjusted Performance 1959/7-2004/12
Spot versus Equally-weighted Collateralized Futures Index 1959/7 = 100



investment in commodity futures has far exceeded the return to a holder of spot commodities.

2. The equal-weighted indices of both commodity spot and commodity futures prices have outpaced inflation.

What is perhaps not directly apparent from Figure 2a is that the return on the futures position is highly correlated with movements in the spot. As explained in Section 2, an investment in commodity futures benefits from unexpected increases in spot prices. Especially in times of high spot market volatility, the returns to spot and futures will be highly correlated. This is illustrated in Figure 2b. It presents the same data as Figure 2a of the graph, but the scale is in logs, which facilitates identification of proportional changes in series that differ in levels. What is clear from Figure 2b is that the 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.

Figure 2a also gives a clue about the magnitude of the risk premium of commodity futures. Part of the return to collateralized futures is the return on collateral (T-bills). Because the historical inflation adjusted return to T-bills is about the rate of inflation, the (inflation adjusted) real return to collateralized commodity futures is an indication of the risk premium earned by investors. We will return to a discussion of 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 re-balanced index will differ from a buy-and-hold strategy if returns are not independently distributed over time.[10] In particular, our equal-weighted index has an embedded trading strategy, which at the end of each month effectively buys a portion of those commodities that went down in price and sells a portion of those commodities that went up in price. If there are temporary spikes in commodity prices that partially revert during the next month, re-balancing to equal weights has the effect of buying future winners and selling future losers. This would lead a re-balanced 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 because they represent foreseeable fluctuations that are taken into account when market participants set futures prices. There may be separate factors that drive temporary price movements in futures returns, but this is a question that is beyond the scope of the current paper.

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[10] See for example Blume and Stambaugh (1983), and Roll (1983).

Table 1 summarizes the annualized average returns – arithmetic and geometric – of our commodity index, under different assumptions about rebalancing. (Appendix 1 provides the formulas corresponding to the return calculations in Table 1.) The second column reports results for an index that rebalances annually to equal weights.[11] The last column studies a portfolio that weights commodities equally when they enter the index, but does not rebalance subsequently.[12]

Table 1: Average Annualized Returns to Spot Commodities and Collateralized Commodity Futures 1959/7 – 2004/12

		Rebalancing		
Average Return % p.a.	Index	Monthly	Annual	Buy and hold
Arithmetic	Futures	10.69	11.97	11.46
	Spot	8.42	7.51	4.64
	Inflation	4.14		
Geometric	Futures	9.98	11.18	10.31
	Spot	7.66	6.66	3.47
	Inflation	4.13		

1. The table shows that the average returns of a monthly re-balanced futures index and an index that does not rebalance are very similar, and somewhat lower than an index that annually rebalances to equal weights.[13]

2. Consistent with our previous conjecture, the frequency of rebalancing has a larger influence on the spot index returns than the futures returns, and has the effect of lowering the spot returns. The influence is especially large for the buy-and-hold index which does not rebalance.

3. The geometric average buy-and-hold spot return of 3.47% per annum is lower than the average inflation of 4.15% over the sample period, which is consistent with the common "wisdom" that over the long-term commodity prices have not kept pace with inflation.[14]

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[11] To avoid the potential sensitivity of our results to the particular month of the year in which this index rebalances, we report the average return across 12 indices, each of which rebalances annually in a different month of the year. This procedure was suggested by Jegadeesh and Titman (1993) in the context of momentum strategies.

[12] At the beginning of the sample, commodities enter the index with equal weight. When a new futures contract becomes available, we set its weight to the average of the other commodities, but the relative positions of the original commodities are not rebalanced. For example, if the index currently has 19 commodities and an additional commodity becomes available, we sell 1/20 of our index and invest the proceeds in the 20th commodity.

[13] Throughout the paper, averages of monthly returns are annualized by multiplying the raw average returns by 1200.

[14] See Prebisch (1950) and Singer (1950), and more recently Grilli and Yang (1988) and Cashin and McDermott (2002).

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 paper we will report results for our monthly re-balanced equal-weighted index.

5. The Risk and Return of Commodity Futures Compared with Other Asset Classes

Figure 3 compares the cumulative performance of the Ibbotson corporate bond total return index ("Bonds"), the SP500 total return index (Stocks), and the equally-weighted commodity futures index total return ("Commodity Futures") for the period July 1959 to the end of 2004. All series have been deflated by the CPI index, and therefore measure the inflation-adjusted performance of the three asset classes.

Figure 3 shows:

1. Over the last 45 years, the average annualized return to a collateralized investment in commodity futures has been comparable to the return on the SP500. Both outperformed corporate bonds.

2. Stocks and Commodity Futures have experienced higher volatility than Bonds.

3. Commodity Futures outperformed stocks during the 1970s, but this performance was reversed during the 1990s

Figure 3

Stocks, Bonds, and Commodity Futures
Inflation Adjusted Performance 1959/7-2004/12

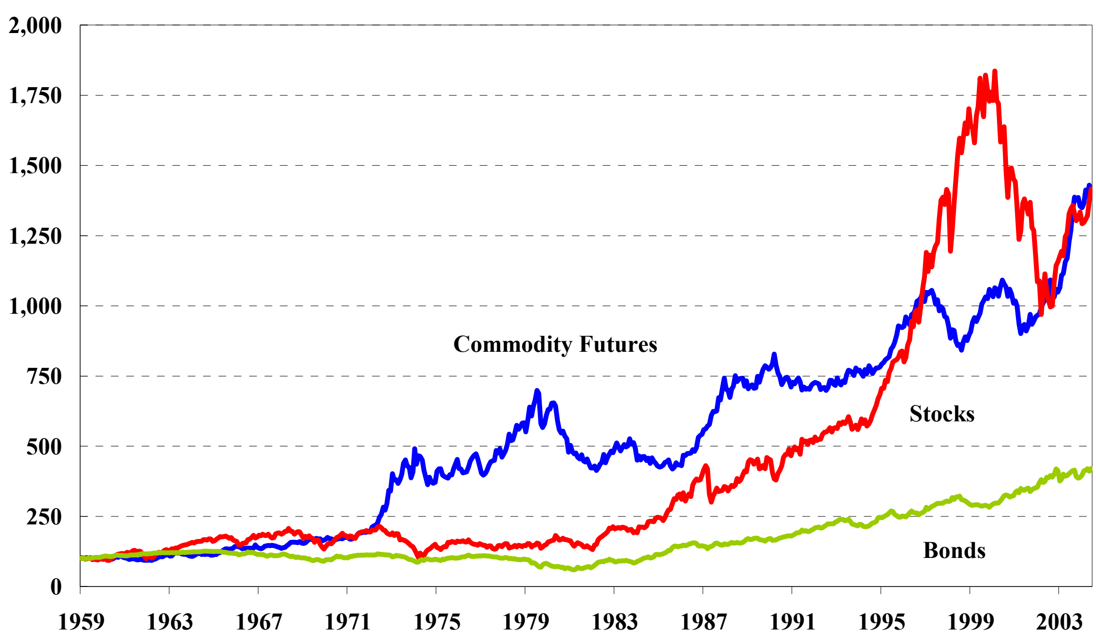


Table 2 summarizes the historical risk premiums (not adjusted for inflation) for the three asset classes. The *t*-statistic measures the confidence that the average risk premium is different from zero.

Table 2: Risk Premium of Commodity Futures, Stocks and Bonds
Annualized Monthly Returns 1959/7 – 2004/12

	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
% returns > 0	55	57	54

Two observations stand out:

1. The average historical risk premium of Commodity Futures has been about 5% per annum during the period from 1959 to 2004. The average premium is significant in a statistical sense (*t*-statistic = 2.92).

2. 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.

As pointed out in Section 2, there has been much debate among economists about the existence of a risk premium in commodity futures. Keynes (1930) and Hicks (1939) assumed that hedgers outnumber speculators in the futures markets, which was the basis for the theory of *normal backwardation*. The estimate of the risk premium in Table 2 is consistent with this theory, and is in line with previous studies that have estimated the risk premium at the portfolio level.[15] Most importantly, Table 2 shows that the risk premium has been economically large and statistically significant. Our commodity futures total return index covers a period of more than 45 years, and is diversified across many commodities. As such it provides a unique opportunity to examine the risk premium across a variety of commodities and time periods.

It is perhaps important to point out that the risk premium is measured as the arithmetic average of the commodity futures excess returns. It measures the average rate at which

[15] Bodie and Rosansky (1980) report an average excess return of 9.5% per annum for an equally weighted portfolio of commodity futures between 1950 and 1976. Fama and French (1987) report a continuously compounded risk premium of 0.45% (*t*=1.57) per month on an equally weighted portfolio of 21 commodity futures between 1966 and 1984.

the futures price rises over the life of the average contract. This measure of the premium is consistent with the definition of risk aversion in the finance literature.[16]

Table 3 summarizes the distribution of monthly returns of stocks, bonds and commodity futures. The second row shows that the historical volatility of the equally-weighted commodity futures total return has been below volatility of the SP500, which explains the slightly higher historical Sharpe Ratio of commodity futures in Table 2. The next two rows illustrate that financial returns are not completely characterized by the mean and standard deviation of returns. (Appendix 3 contains similar summary statistics for the individual commodities.)

Table 3: Monthly Returns of Commodity Futures, Stocks and Bonds
Distribution of Percentage Returns 1959/7-2004/12

	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 is well known, the returns on financial returns often deviate from a normal distribution, display skewness, and have "fat tails." Table 3 shows that this is also true of commodities: commodity futures returns are positively skewed while stock returns are skewed negatively. In addition, commodities display relatively high kurtosis indicating more realizations in the tails than would be expected based on a normal distribution.[17] This is further illustrated in Figure 4, which compares the empirical distribution of monthly returns for the SP500 and our equally-weighted commodity futures index between 1959 and 2004.

Three observations stand out:

1. Commodity Futures and Stocks have about the same average return, but the standard deviation of stock returns is slightly higher.

2. The return distribution of equities has negative skewness, while the distribution of commodity returns has positive skewness. This means that, proportionally,

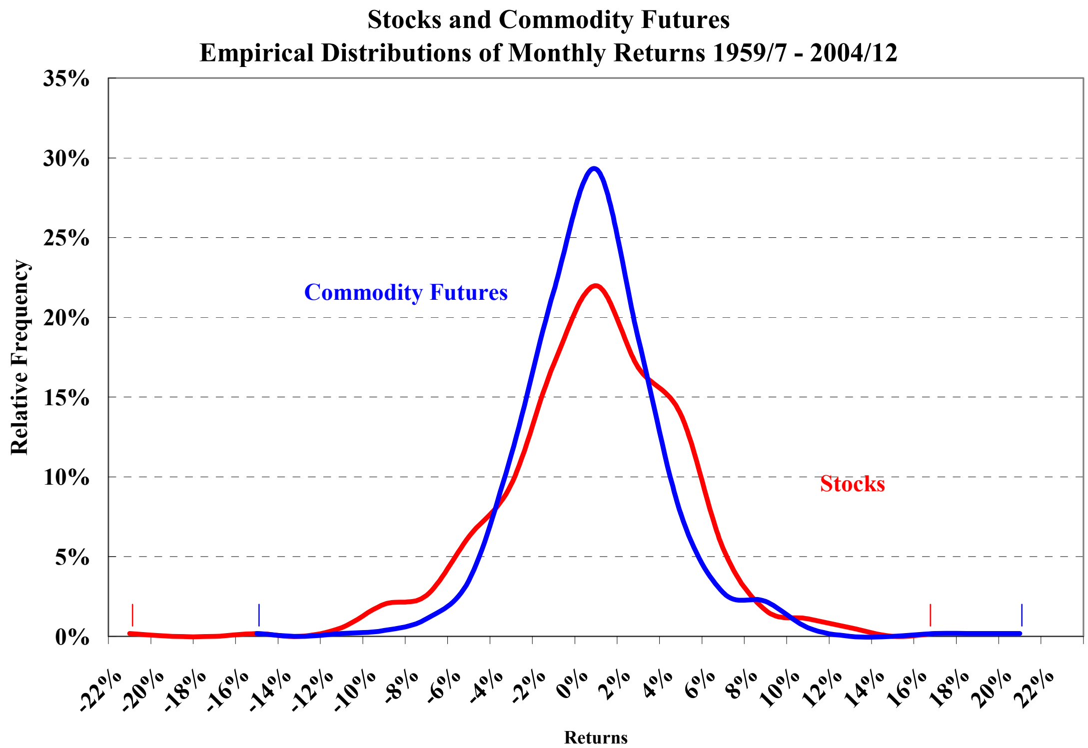
[16] Kolb (1992), Erb and Harvey (2005), and others evaluate normal backwardation by the average geometric or average log return on the futures position. This is equivalent to asking whether an investor with log utility who invested his entire wealth would have been better off faced with the average futures payoffs. Because a log investor is risk averse, this amounts to measuring the premium relative to a log (i.e. risk averse) investor. We thank Jon Ingersoll for pointing this out to us.

[17] To a large extent, the index returns inherit the properties of individual commodity returns which are skewed right and exhibit excess kurtosis. See Appendix 3.

equities have more weight in the left tail of the return distribution while Commodity Futures have more weight in the right tail.

3. Both distributions have positive excess kurtosis, and are "fat-tailed" relative to the normal distribution.

Figure 4



The slightly higher variance and negative skewness of equities implies that equities have more downside risk relative to commodity futures. For example, the 5% tail of the empirical distribution of equities occurs at –6.34% compared to –4.10% for commodity futures. In terms of Value-at-Risk, the maximum loss on equity has been substantially exceeded the loss of a commodity futures investment. From the perspective of risk management, an important question is whether these tail events occur simultaneously for both assets, or in isolation. We will turn to the question of correlation next.

6. The Correlation of Commodity Futures with Other Asset Classes

We examine the correlation of commodity futures returns with stocks and bonds over various investment horizons. In addition to monthly returns, we report correlations computed using overlapping returns over quarterly, annual and 5-year intervals. Because asset returns are volatile, examining correlation over longer holding periods may reveal patterns in the data that are obscured by short-term price fluctuations. Table 4 illustrates the correlations of commodity futures returns with stocks, bonds, and inflation over the period between 1959 and 2004.

Table 4

Correlation of Commodity Futures Returns with Stocks, Bonds, and Inflation Overlapping Return Data 1959/7 – 2004/12

	Stocks	Bonds	Inflation
Monthly	0.05	-0.14*	0.01
Quarterly	-0.06	-0.27*	0.14
1-year	-0.10	-0.30*	0.29*
5-year	-0.42*	-0.25*	0.45*

A "*" next to a coefficient indicates that the correlation is significant at the 5% level using Newey-West corrected standard errors.

Table 4 shows that:

1. Over all horizons – except monthly – the equally-weighted commodity futures total return is negatively correlated with the return on the SP500 and long-term bonds. While it is not possible to reject the hypothesis that the correlation of Commodity Futures with Stocks is zero at short horizons, these findings suggest that Commodity Futures are effective in diversifying equity and bond portfolios.

2. The negative correlation of Commodity Futures with Stocks and Bonds tends to increase with the holding period. This suggests that the diversification benefits of Commodity Futures tend to be larger at longer horizons.

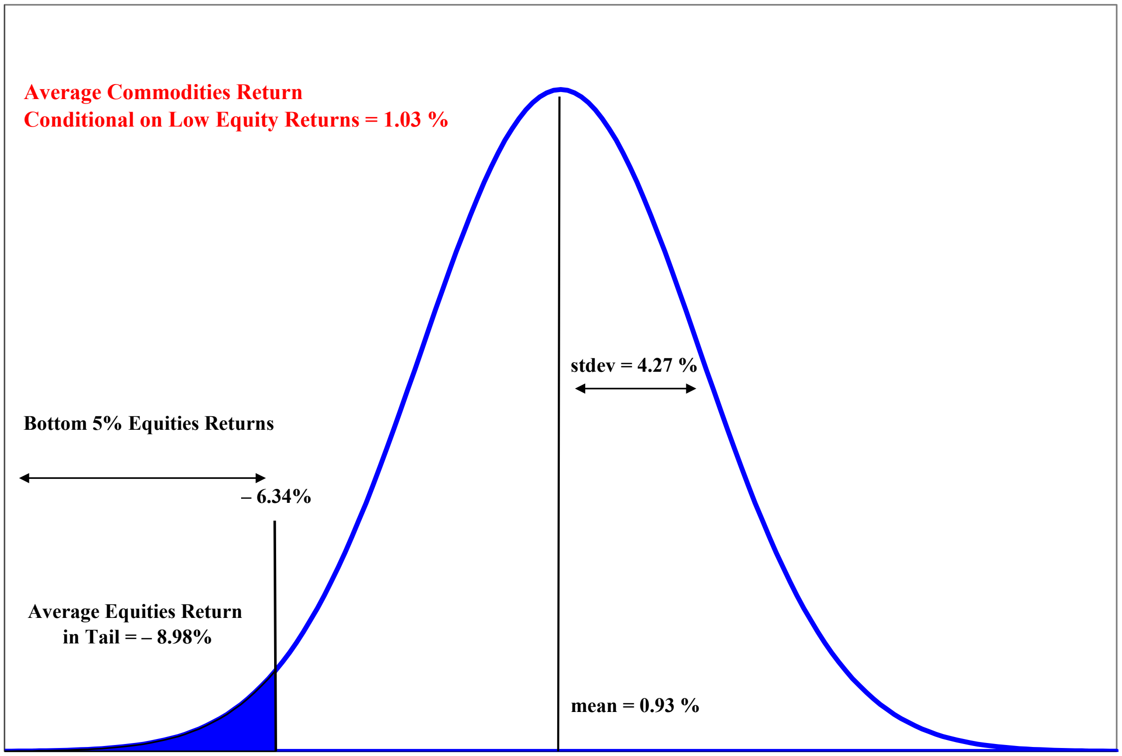
3. Commodity Futures returns are positively correlated with inflation and the correlation is larger at longer horizons. Because Commodity Futures returns are volatile relative to inflation, longer-term correlations better capture the inflation-properties of a commodity investment.

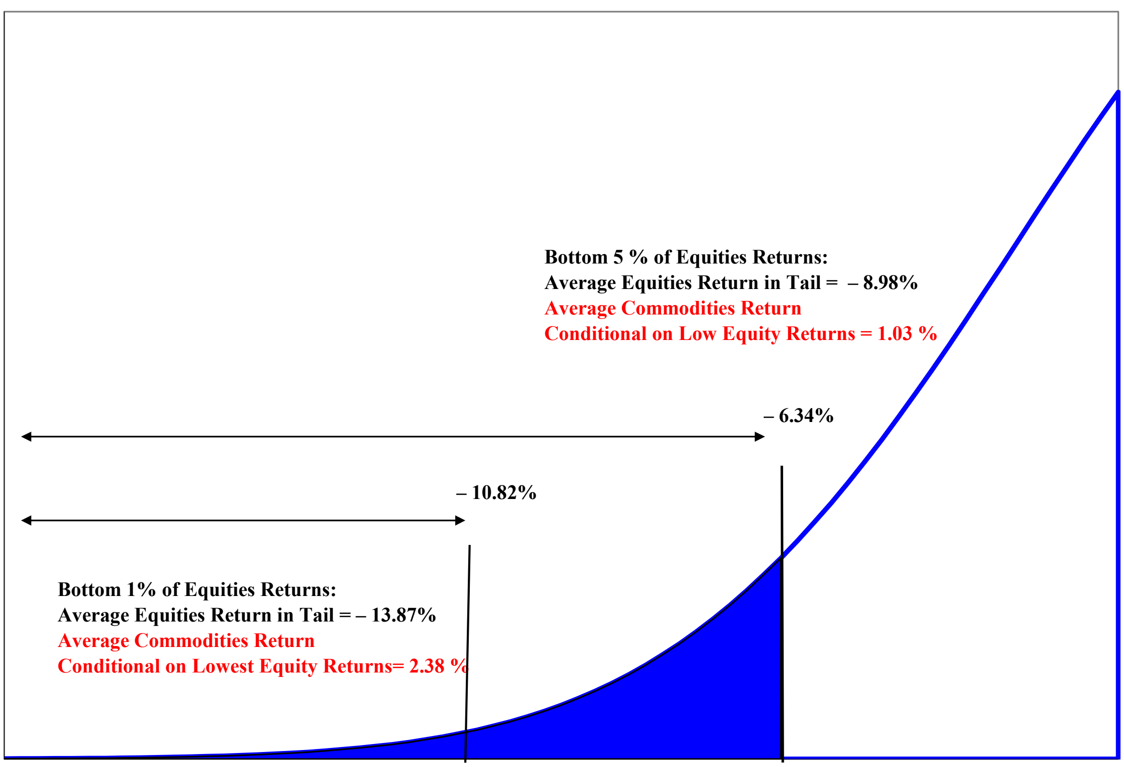
Figure 4 showed that equities contain more downside risk than commodity futures. So it is important to ask whether the negative correlation between equities and commodity futures holds up when equity returns are low – a time when diversification is especially valuable. We examined the returns to commodity futures during the months of lowest equity returns. The results are given in Figure 5a and 5b. Figure 5a shows the equity returns during the 5% of months of poorest performance of equity markets. Figure 8b concentrates on the lowest 1% of realized equity returns.

The figures show the following:

1. During the 5% of the months of worst performance of equity markets, when stocks fell on average by 8.98% per month, commodity futures experienced a positive return of 1.03%, which is slightly above the full sample average return of 0.89% per month.

Figure 5: Conditional Commodity Futures Returns When Stock Returns are Low





2. During the 1% of months of lowest performance of equity markets, when equities fell on average by 13.87% per month, commodity futures returned an average of 2.36%.

It seems that the diversification benefits of commodity futures work well when they are needed most.[18] Consistent with a negative correlation, commodity futures earn above average returns when stocks earn below average returns.

For symmetry, we also examined the situation in which commodity markets have their poorest performance. The average return to equity in the bottom 5% (1%) months in terms of commodity market performance was -0.99 % (-4.10%) per month.

7. Commodity Futures Returns and Inflation

Investors ultimately care about the real purchasing power of their returns, which means that 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.

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 cash flows will fall short of expectations. To the extent that unexpected inflation leads to revisions of future expected inflation, this loss of real purchasing power can be significant.

There are reasons to expect equities to provide a better hedge than bonds against inflation – at least in theory. After all, stocks represent claims against real assets, such as factories, equipment, and inventories, whose value can be expected to hold pace with the general price level. However, firms also have contracts with suppliers of inputs, labor and capital, that are fixed in nominal terms and hence act very 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 sum, the extent to which stocks provide a hedge against inflation is an empirical matter.

Table 4 suggested 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. In summary, the opposite exposure to (unexpected) inflation may help to explain why futures do well when stocks and bonds perform poorly.

[18] The average returns during 1% of the months in the sample need to be interpreted with caution, as they are computed only over six observations.

Table 5 compares the correlations of stocks, bonds, and commodity futures with inflation. As before, correlations are computed over various investment horizons.

Table 5:
Correlation of Assets with Inflation 1959/7 – 2004/12

	Stocks	Bonds	Commodity Futures
Monthly	-0.15*	-0.12*	0.01
Quarterly	-0.19*	-0.22*	0.14
1 – year	-0.19	-0.32*	0.29*
5 – year	-0.25	-0.22	0.45*

A "*" next to a coefficient indicates that the correlation is significant at the 5% level using Newey-West corrected standard errors.

Several observations stand out from Table 5:

1. Commodity Futures have an opposite exposure to inflation compared to Stocks and Bonds. Stocks and Bonds are negatively correlated with inflation, while the correlation of Commodity Futures with inflation is positive at all horizons, and statistically significant at the longer horizons.

2. In absolute magnitude, inflation correlations tend to increase with the holding period. The negative inflation correlation of Stocks and Bonds and the positive inflation correlation of Commodity Futures are larger at return intervals of 1 and 5 years than at the monthly or quarterly frequency.

Our previous discussion suggested that stocks, and especially bonds, can be sensitive to *unexpected* inflation. In order to measure unexpected inflation, a model of expected inflation is needed. For this purpose we choose a very simple method that has been used by others in the past (e.g., see Fama and Schwert (1977) and Schwert (1981)). 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 was known ex ante).

Because inflation is persistent over time, unexpected inflation often causes market participants to revise their estimates of *future* expected inflation. The *change* in expected inflation can be measured by the change in the nominal interest rate. This is not necessarily perfectly correlated with the unexpected inflation rate since investors may use more information than just the current rate of inflation to revise their expectations of future inflation.[19]

[19] Following the large literature on inflationary expectations, we choose the 90-day T-bill yield as our measure of expected inflation for the next quarter. See Fama and Schwert (1977) and Schwert (1981) for discussions

Table 6 illustrates the correlations of Stocks, Bonds, and Commodity Futures returns with the components of inflation. These observations stand out:

1. The negative sensitivities of Stocks and Bonds to inflation stem mainly from sensitivities to *unexpected* inflation. The correlations with unexpected inflation exceed the raw inflation correlations.

2. Commodity Futures are also more sensitive to unexpected inflation, but (again) in the opposite direction.

3. Stock returns and (especially) bond returns are negatively influenced by revisions about *future* expected inflation. Revisions about future inflationary expectations are a positive influence on commodity futures returns.

Table 6:
Quarterly Correlation of Assets with Components of Inflation 1959/7 – 2004/12

	Inflation	Change 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*

A "*" next to a coefficient indicates that the correlation is significant at the 5% level using Newey-West corrected standard errors.

Commodity futures returns are negatively correlated with stock returns. Commodity futures have opposite exposures to unexpected inflation from stocks and bonds. 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 is only part of the story behind the negative correlations. If we isolate the portion of the returns of commodity futures, stocks and bonds that is unrelated to unexpected inflation and examine the correlations again, we find that the residual variation of commodity futures and stocks or bonds continue to be negatively correlated.[20] At the quarterly horizon, the correlation between futures and stocks increases from –0.06 to 0, while for bonds the correlation increases from –0.27 to –0.20. In other words there appear to be additional factors that drive the negative correlation between futures returns and stocks and bonds. The next section describes one of these sources: business cycle variation.

[20] In other words, we examine the correlation of regression residuals from regressions of each asset class' returns on unexpected inflation.

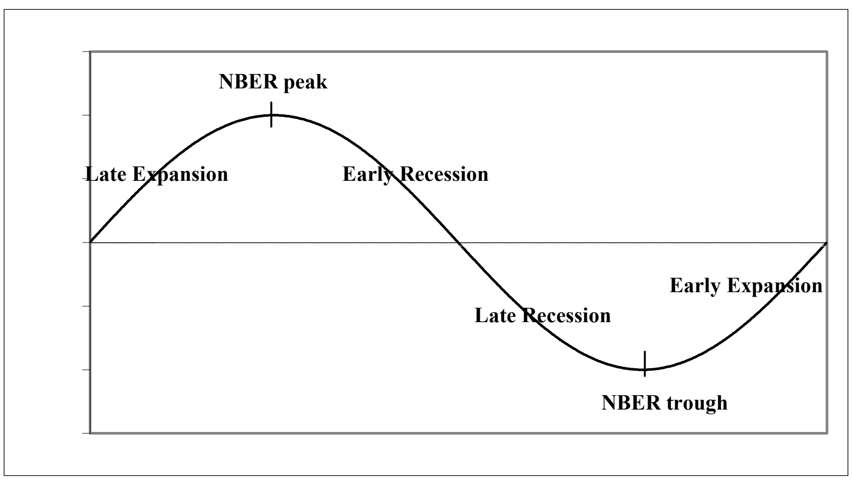
8. Commodity Futures Returns over the Business Cycle.

Modern finance theory identifies two components to asset returns: a systematic component and a nonsystematic, or idiosyncratic, component. Holding a portfolio of many different securities can diversify idiosyncratic components. But, the systematic component corresponds to movements in the market as a whole, and so is viewed as nondiversifiable. The nondiversifiable component, associated with beta in the Capital Asset Pricing Model, also corresponds to the business cycle since business cycle risk is nondiversifiable. Stock and bond returns are negative in (the early phase of) recessions, in particular.

Commodity future returns and equity returns are negatively correlated at quarterly, annual, and five-year horizons. This means that commodity futures are useful in creating diversified portfolios, with respect to the idiosyncratic component of returns.

But, importantly, there is also evidence of another "diversification effect." Commodity futures have a feature quite unique to this asset class, namely, commodity futures have some power at diversifying the systematic component of risk – the part that is not supposed to be diversifiable! Weiser (2003) reports that commodity futures returns vary with the stage of the business cycle.[21] In particular commodity futures perform well in the early stages of a recession, a time when stock returns generally disappoint. In later stages of recessions, commodity returns fall off, but this is generally a very good time for equities.

Figure 6: Business Cycle Phases



[21] Weiser (2003) looks at the period 1970-2003, and determines business cycle dating in terms of the rate of change of the quarterly GDP growth rate. Vrugt (2003) also analyzes the period 1970-2003. He uses National Bureau of Economic Research (NBER) business cycle dating, and divides the business cycle into phases. We have used Vrugt's (2003) figure to show the phases. Jensen et al. (2002) examine variation in commodities returns conditional on interest rates.

Figure 6 displays a business cycle, where the National Bureau of Economic Research (NBER) peak and trough are identified.[22] The NBER identifies peaks and troughs, but the figure further divides the cycle into phases. Phases are identified 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, while the Early and Late Recession phases correspond to a recession. Starting in 1959 allows us to analyze seven full business cycles, more than Weiser (2003) and Vrugt (2003).

Table 7
Average Returns by Stage of the Business Cycle

	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%

Table 7 shows that:

1. On average, Stocks and Commodity Futures behave similar during expansions and recessions. The S&P500 averaged a 13.29% return during expansions, compared to 11.84% for our equally weighted index of commodity futures. Over recessions, the average monthly annualized returns for the S&P and the equally weighted commodity futures are 0.51 % and 1.05%.

Based on this observation, stocks and the commodity futures index appear to be very similar. But, these similarities obscure an important difference when the business cycles are broken in two parts as in Figure 6.

2. During the Early Recession phase the returns on both Stocks and Bonds are negative, –18.64% and –3.88% respectively. But, the return on Commodity Futures is a positive 3.74%. During the Late Recession phase the signs of the returns reverse, stocks and bonds are positive, while commodity futures are negative.

3. 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.

[22] The NBER is a private, nonprofit, economic research consortium, which dates business cycles in the U.S. by identifying business cycle peaks and troughs. See http://www.nber.org/cycles.html .

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

9. The Information Content of Futures Prices

The empirical evidence presented in this paper is consistent with Keynes' theory of normal backwardation. The notion of normal backwardation involves a comparison of the futures price to 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 describe the *basis* of a futures position, which is defined as the difference between the *current* spot price and the futures price. Commodities for which the futures price exceeds the current spot price are said to be in "contango," while commodity futures with a positive basis are referred to as being in backwardation. It is important to note that a positive basis is different from Keynesian "normal backwardation," which relates the futures price to the expected future spot price. Commodities can be in contango (negative basis), yet be in "normal backwardation."

For example, assume as in our earlier example in Figure 1, that the current spot price of oil is $30. But now let's change the example and assume that market participants expect the future spot price to be $34, and that 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 below expected spot), but not backwardated in the second sense because the futures is above the current spot (contango). In order to avoid confusion, we will refer to the basis when comparing the futures price to the current spot price.

What are the reasons for a commodity to have a positive basis? In Figure 1 we showed that by construction the basis is the sum of the expected spot return and the risk premium that buyers of futures investors expect to earn. So variation in the basis must be either due to variation in expectations about the future spot price or to 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 therefore not a source of return in itself, but movements in the basis may contain information about future expected returns.

If there is no 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. 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. By 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]

In order to examine the information content of the basis for future returns, we conduct the following trading strategy. We calculate the basis of a futures position as the slope of the futures curve between in the contract in our index and the next available expiration.[24] At the end of each month in our sample, we rank all available commodity futures by their basis, and divide them into two equally-weighted portfolios (High and Low Basis). As the ranking of each commodity changes over time commodities might migrate between the Low and High Basis portfolios. Either way, the High (Low) Basis portfolio is constructed as to rebalance each month towards the half of the commodity universe with the highest (lowest) basis. The annualized monthly returns in deviation from the equally-weighted index are summarized in the following Table.

Table 8: Performance of High and Low Basis Portfolios
Annualized Returns in Deviation from EW Index 1959/7-2004/12

	High Basis - EW	Low Basis – EW	High - Low
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
% returns > 0	59	39	60

Three observations stand out:

1. The High Basis portfolio has historically outperformed the Low Basis portfolio by about 10% per annum. Relative to the EW index, the out-performance of the High basis portfolio is about equal to the underperformance of the Low basis portfolio. These performance differences are highly significant in a statistical sense.

2. The High Basis portfolio has on average beaten both the EW and the Low Basis portfolio in 3 out of every 5 months since 1959.

3. The historical standard deviation of the High–Low excess return is similar to the standard deviation of investing in the equally-weighted index itself.

[23] Nash (2001) presents support for a relationship between average returns and the average basis. Fama and French (1987) show that between 1966 and 1984, the basis has been more informative about future spot rate movements than for 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 $[(F_1-F_2)/F_1] \times 365/(T_2-T_1)$, where T_1 and T_2 refer to the time (in days) to expiration of the two contracts.

The Sharpe Ratio of a diversified long-short bet on the futures basis has been twice the Sharpe Ratio of the EW index.

The conclusion from this section is that the futures basis seems to carry important information about the risk premium of individual commodities. Our simple trading strategy potentially exploits both differences in risk premiums across commodities as well as time series variation in the premiums of individual commodities. A detailed decomposition of the relative contribution of these components as well as the source of the variation of the premiums is beyond the scope of this paper, and left for future research.

10. Commodity Futures in an International Setting

The majority of commodity futures in our index are traded on US exchanges – with the exception of some metals that are traded in London. Physical delivery takes place at a location within the contiguous 48 states, and settlement is in US dollars. The US markets for some commodity futures (gold, crude oil) are probably integrated with global markets, but prices of others are likely to be influenced by local conditions (natural gas, live hogs). It is conceivable that a common country-specific US factor has positively influenced both stock and commodity futures returns in the US. If that were the case, commodity futures might look quite different from the perspective of a foreign investor. Therefore, it is interesting to ask whether a Japanese or UK investor would draw the same conclusion as a US investor about the relative performance of these asset classes.

Figures 7 and 8 illustrate the performance of commodities from the perspective of UK and Japanese investors. The equity benchmarks we use are the total return indices from Morgan Stanley Capital International (MSCI) for the UK and Japan, and the cumulative performance of long-term government bonds in both countries published by the International Monetary Fund. All indices are computed in local currency (GBP and YEN), and deflated by the local CPI-index. Similarly, for commodity futures we compute the performance of the index measured in GBP and Yen, before deflating it by the local CPI.[25]

Three observations stand out from Figures 7 and 8:

1. Between 1970 and September of 2004 the historical performance of Commodity Futures has been similar to equities in both the UK and Japan. Commodity Futures have outperformed long-term government bonds.[26]

2. Commodity Futures have outpaced local CPI inflation in the UK and Japan.

[25] The collateral for the futures position is US T-bills. It is possible to collateralize the futures position by local T-bills.
[26] Japanese government bond data is only available through February 2004.

Figure 7

Inflation Adjusted Performance of Commodities in the UK
All Returns in Local Currency (GBP), 1969/12 - 2004/9

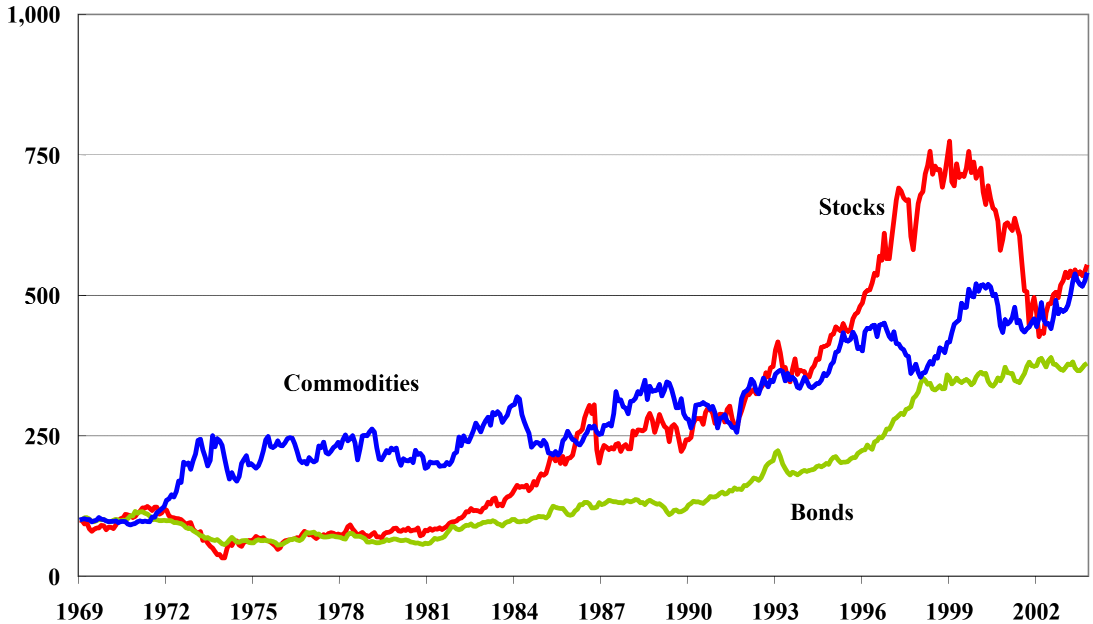
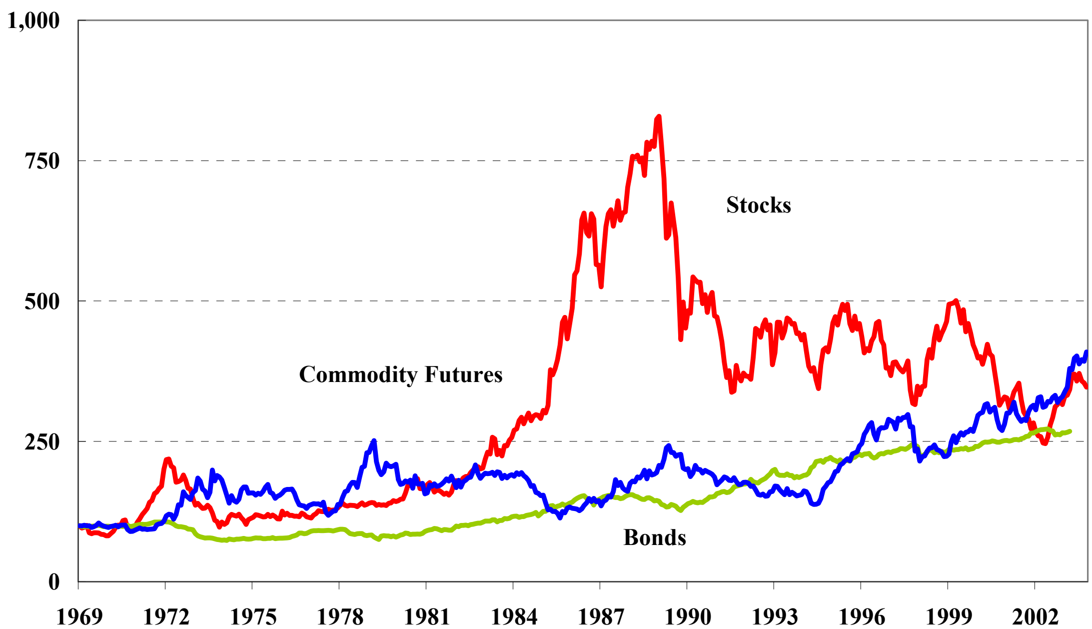


Figure 8

Inflation Adjusted Performance of Commodities in JAPAN
All Returns in Local Currency (YEN), 1969/12-2004/9



3. The relative rankings of inflation-adjusted performance Stocks, Bonds, and Commodity Futures are similar in Japan, the UK, and the US.

Our earlier conclusions about the relative performance of commodity futures have not been specific to the US experience. Foreign investors – evaluating performance in local currency, and relative to local inflation – would have drawn many of the same conclusions.

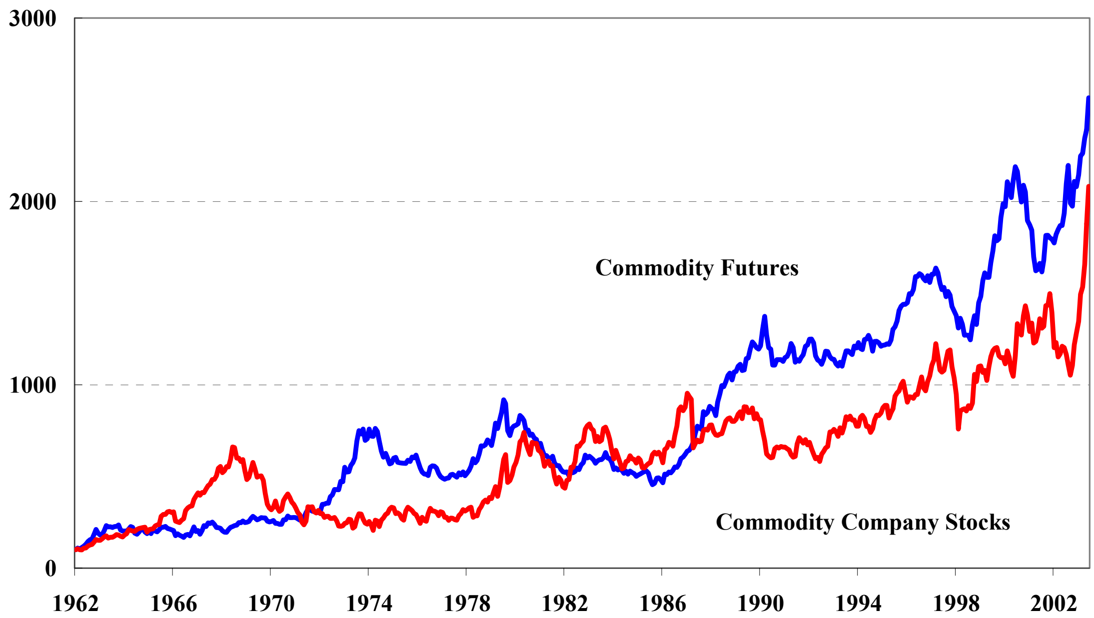
11. Commodity Futures vs. Stocks of Commodity Producing Companies

It is sometimes 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 can examine this argument by constructing an index of the stock returns on such companies and then comparing the performance of this index to an equally weighted commodity futures index. In order to make this comparison we need to identify companies that can be most closely matched with the commodities of interest. There is no obvious way to match companies with commodities since companies are almost never "pure plays," but rather are involved in a number of businesses. We chose to match based on a simple rule, namely, with each commodity that can be associated with a four-digit SIC code, we take all the companies with that same four-digit SIC code. On this basis we can match seventeen commodities with companies having publicly-traded stock. The details are in Appendix 4.

Figure 9 shows a significant difference between the average return of commodity futures and investment in commodity company stocks. Over the 41-year period between 1962 and 2003 the cumulative performance of futures has exceeded the cumulative performance of "matching" equities. More interestingly, the correlation between the two investments has only been 0.40. By comparison, the correlation of the commodity company stocks with the S&P500 was 0.57. In other words, commodity company stocks behave more like other stocks than their counterparts in the commodity futures market. The conclusion of Figure 9 is that an investment in commodity company stocks has not been a close substitute for an investment in commodity futures.

Figure 9

Commodity Futures vs Shares of Commodity Companies
Inflation Adjusted Performance 1962/7 - 2003/12



12. Summary

This paper provides evidence on the long-term properties of an investment in collateralized commodity futures contracts. We construct an equally-weighted index of commodity futures covering the period between July 1959 and December 2004. We show empirically that there is a large difference between the historical performance of commodity futures and the return an investor of spot commodities would have earned. An investor in our index of collateralized commodity futures would have earned an excess return over T-bills of about 5% per annum. During our sample period, this commodity futures risk premium has been about equal in size to the historical risk premium of stocks (the equity premium), and has 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 to offering high returns, 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. A diversified investment in commodity futures has slightly lower risk than 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 of both stock and bond portfolios. The correlation with stocks and bonds is negative over most horizons, and the negative correlation is stronger over longer holding periods. We provide two explanations for the negative correlation of commodity futures with traditional asset classes. First, commodity futures perform better in periods of unexpected inflation, when stock and bond returns generally disappoint. Second, commodity futures diversify the cyclical variation in stock and bond returns.

On the basis of the stylized facts we have produced, two conclusions are suggested. First, from the point of view of investors, the historical performance of collateralized investments in commodity futures suggests that they are an attractive asset class to diversify traditional portfolios of stocks and bonds. Second, from the point of view of researchers, there are clearly challenges for asset pricing theory, which to date has primarily focused on equities.

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Appendix 1: Data and Return Calculation

Construction of the Equally-Weighted Commodity Futures Index

The equally-weighted index is constructed using Commodity Research Bureau (CRB) data (http://www.crbtrader.com/crbindex/ndefault.asp) and data from the London Metals Exchange.[27] The CRB data set covers all commodity futures that are in existence today. Commodity futures contracts that were introduced, but later discontinued – due to lack of liquidity – are not covered by the CRB, and are not included in the equally-weighted index. As discussed in the main text, this omission is a type of survivor bias, but is fundamentally different from survivor bias in other asset classes, like mutual funds and stocks. In other asset classes, assets disappear because they had low returns or failed. Consequently, calculating returns that omit these assets biases the returns upwards. In the case of commodity futures, contract types do not disappear because of failure in the same sense. Rather, there is a lack of liquidity, not low returns. (See Black (1986) and Carlton (1984).) Therefore, this type of survivor bias is less of an issue here.

Cash prices from actual transactions in commodities are not widely available for most commodities. Given this lack of data, we construct daily spot prices by linear interpolation between the futures contract that is in the index and the next nearest futures contract. For contracts expiring after December 31, 2004 (index end date) we calculate expiration dates using current rules. Since rules, governing expiration dates, might have changed over time, for all contracts expiring prior to December 31, 2004 we use the latest date for which there is a price as the contract expiration date. For LME traded commodity futures we use the LME official "Cash" settlement ask price, which is really a two business day forward because physical settlement is in two business days.

We construct the equally-weighted commodity futures index in steps.

For each month we first construct price (or excess) returns on each commodity future using the nearest contract that does 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 roll into the next nearest futures contract. Then we compute the total returns assuming that the futures position is fully collateralized, marked-to-market on the monthly basis and earns interest on the monthly basis based on the total return of 30-day Treasury Bills provided by Ibbotson.

Second, using monthly returns for each commodity futures contract, we construct the index by adding the monthly returns together each month and dividing by the number of commodities in the index that month. A commodity enters the index on the last business day of the month following its introduction date except the first seven commodity futures entered the index on 07/01/59, not 07/31/59. This corresponds to monthly rebalancing.

[27] We use the closing prices of the futures contracts for Aluminum, Nickel, Zinc, Lead and Tin expiring on the third Wednesday of each month. From July 1993 these prices were provided by Reuters (some of these prices, especially early in the period, may have been linearly interpolated). Prior to July 1993 we linearly interpolate between the official LME closing ask prices for cash and three month forward.

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The table below shows the introduction dates of the commodities. For Lean Hogs the contract specifications changed in 1996 from Live Hogs to Lean Hogs. We construct a single series by dividing all Live Hogs prices by 0.74 – the constant was calculated by CRB based on the 1996 contract specification.

For Pork Bellies during the months of 08/62, 09/62, 08/63 and 09/63 there were gaps during which no prices for any contracts were available. For Feeder Cattle on 3/73 and Rough Rice on 11/87 we were unable to roll into the next futures contract due to missing data. Finally, for Milk and 07/97 and Butter and 10/98 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 Treasury Bills for these months.

no	Name	Quotes start	Index inclusion date	First contract year/month		Sector
1	Copper	07/01/59	07/01/59	1959	10	Industrial Metals
2	Cotton	07/01/59	07/01/59	1960	7	Industrial Materials
3	Cocoa	07/01/59	07/01/59	1960	3	Softs
4	Wheat	07/01/59	07/01/59	1959	12	Grains
5	Corn	07/01/59	07/01/59	1959	9	Grains
6	Soybeans	07/01/59	07/01/59	1959	9	Grains
7	Soybean Oil	07/01/59	07/01/59	1959	9	Grains
8	Soybean Meal	07/01/59	07/01/59	1959	12	Grains
9	Oats	07/01/59	07/01/59	1959	12	Grains
10	Sugar	01/04/61	01/31/61	1961	7	Softs
11	Pork Bellies	09/18/61	09/30/61	1962	2	Animal Products
12	Silver	06/12/63	06/30/63	1963	8	Precious Metals
13	Live Cattle	11/30/64	11/30/64	1965	4	Animal Products
14	Lean Hogs	02/28/66	02/28/66	1966	7	Animal Products
15	Orange Juice	02/01/67	02/28/67	1967	5	Softs
16	Platinum	03/04/68	03/31/68	1968	7	Precious Metals
17	Lumber	10/01/69	10/31/69	1970	3	Industrial Materials
18	Feeder Cattle	11/30/71	11/30/71	1972	3	Animal Products
19	Coffee	08/16/72	08/31/72	1973	3	Softs
20	Gold	12/31/74	12/31/74	1975	1	Precious Metals
21	Palladium	01/03/77	01/31/77	1977	3	Precious Metals
22	Zinc	01/03/77	01/31/77	1977	5	Industrial Metals
23	Lead	02/01/77	02/28/77	1977	6	Industrial Metals
24	Heating Oil	11/14/78	11/30/78	1979	2	Energy
25	Nickel	04/23/79	04/30/79	1979	8	Industrial Metals
26	Crude Oil	03/30/83	03/31/83	1983	6	Energy
27	Unleaded Gas	12/03/84	12/31/84	1985	2	Energy
28	Rough Rice	08/20/86	08/31/86	1981	5	Grains
29	Aluminum	06/01/87	06/30/87	1987	10	Industrial Metals
30	Propane	08/21/87	08/31/87	1987	12	Energy
31	Tin	07/03/89	07/31/89	1989	9	Industrial Metals
32	Natural Gas	04/04/90	04/30/90	1990	6	Energy
33	Milk	01/11/96	01/31/96	1996	4	Animal Products
34	Butter	09/05/96	09/30/96	1997	2	Animal Products

35	Coal	07/12/01	7/31/01	2001	9	Energy
36	Electricity	04/11/03	4/30/03	2003	6	Energy

Portfolio Return Calculations

Table 1 contains different average annualized return calculations. We briefly explain these here; for some details see Roll (1983). For simplicity we assume that all commodity futures contracts exist at all times. Suppose N commodity futures each exist for T months, where R_{it} is one plus the return on a collateralized commodity future i during month t.

The arithmetic average return on a monthly rebalanced portfolio over the T months is:

$$\overline{R}_{AR} = \frac{1}{NT}\sum_{i}\sum_{t} R_{it} = \frac{1}{T}\sum_{t}\left[\frac{1}{N}\sum_{i} R_{it}\right]. \qquad (1)$$

The geometric average return on a monthly rebalanced portfolio over the T months is given by:

$$\overline{R}^{T}_{GR} = \left[\prod_{t}\left(\frac{1}{N}\sum_{i} R_{it}\right)\right]^{\frac{1}{T}}. \qquad (2)$$

The arithmetic average return on a buy-and-hold portfolio over the T months is given by:

$$R^{T}_{ABH} = 1 + \frac{1}{T}\sum_{\tau}\left[\frac{\sum_{i}\prod_{t=1}^{\tau} R_{it}}{\sum_{i}\prod_{t=1}^{\tau-1} R_{it}} - 1\right], \text{ where } \prod_{t=1}^{\tau-1=0} R_{it} \equiv 1 \qquad (3)$$

The geometric average on a buy-and-hold portfolio over the T months is given by:

$$\overline{R}^{T}_{GBH} = \left[\frac{1}{N}\sum_{i}\left(\prod_{t} R_{it}\right)\right]^{\frac{1}{T}}. \qquad (4)$$

We annualize these returns subtract one and multiply by 1200 (i.e., 12 months x 100). The returns in the middle column of Table 1, Annual Rebalancing, are similar to formulas (1) and (2); these formulas are omitted.

Appendix 2: Simple Commodity Futures Mathematics

Compared to financial assets, commodity futures are different in several aspects. First, financial assets are held for investment purposes, while commodities are produced, and derive their value from their ultimate consumption or from their use as inputs into the production of finished goods. Second, commodities can be stored (to varying degrees), but this is often costly compared to financial assets. Finally, there is an active borrowing and lending market for financial assets, but less so for commodities. 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, while commodity prices often fluctuate in a predictable manner due to seasonal patterns in demand and supply.

The close link between futures prices and contemporaneous spot prices – known as the cost-of-carry model – that is necessary to prevent arbitrage in financial futures markets is not a good description of commodity markets. 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 the asset in the futures market. If the 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 is relatively easy in the case of financial assets, but is often more 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 than for financial futures.[28]

More 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. As a consequence the transaction does not require any cash at time t. If the investor simultaneously sells the commodity using futures for delivery at time T (at a price F), the net proceeds from the combined transaction are $F_{t,T} - e^{r(T-t)}[S_t + w]$.

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	$F_{t,T} - e^{r(T-t)}[S_t + w]$

This payoff has to be non-positive in order to ensure the absence of arbitrage opportunities:

[28] For a more detailed textbook treatment of financial futures and commodity futures, see Hull (2002) or McDonald (2002).

$$F_{t,T} \le e^{r(T-t)}[S_t + w]\,. \qquad (1)$$

Intuitively, the futures price cannot exceed the spot price by more than the cost of carry (storage plus interest) or there is arbitrage. Unlike the case with financial futures, the above 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 spot and simultaneously buy 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 lend it or to sell it themselves and buy back forward), because inventory stock-outs will lead to disruptions in the productive process to which the commodity is an input.

Appendix 3:
Summary statistics of distributions of individual commodity futures returns.
Annualized monthly returns 1959/7 – 2004/12

	Obs	Average		Stdev	Skewness	Kurtosis	Correlation	
		Arithmetic	Geometric				w/ others	w/ Index
EW 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

This table summarizes the number of monthly observations, and the average annualized arithmetic and geometric average returns for the equally-weighted index and individual commodity futures. The next columns report the standard deviation of returns, the skewness and the kurtosis. The last two columns give the average pair-wise correlations of individual commodity futures with all other commodities and the correlation of a commodity future with the equally-weighted index.

Appendix 4: Matching Commodity-Producing Firms to Commodities

As mentioned in the main text, we chose to match companies with commodities based on associating with each commodity future a four-digit SIC code. We then search the University of Chicago Center for Research in Security Prices monthly stock database for all the companies with that same four-digit SIC code. On this basis we can match 17 commodities with companies having publicly-traded stock. For all companies with same SIC code we form the equally weighted monthly stock return series, and then using these series we form the equally weighted commodity-producing firms stock index. Commodities are included in the futures index during the same months as the corresponding stocks enter the equity index.

There were several exceptions to the general rule. In the case of Palladium, we looked at SIC codes 1099 and 1090, i.e., Misc. Metal Ores. This category includes companies mining palladium, but it also includes companies mining uranium and other metals. From the list of all these companies we found two palladium mining companies, namely, North American Palladium (PAL) and Stillwater Mining (SWC); 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 very few stocks, especially in the recent period. There is, however, an SIC code 1040 – "Gold and Silver Ores". There are about 200 stocks with this SIC code. Among these stocks we were able to identify several companies specifically focusing on silver – Pan American Silver (PAAS), Silver Standard Resources (SSRI), Apex Silver Mines Ord (SIL), Helca Mining (HL), and Coeur d'Alene Mines (CDE). These stocks were added to silver stocks. The rest of the stocks in the 1040 SIC code "Gold and Silver Ores" were added to gold stocks.

In the case of Milk, we looked at SIC code 2020. From the SIC code 2020 "Dairy Products" we excluded all stocks that we could identify as ice cream producers – these are consumers of milk, not producers of milk. The remainder was taken as Milk stocks.

The table below provides the detail on the number of stocks for each commodity and the period covered. If there are zero stocks, then that commodity was not included because no matching company could be found.

Summary of Matches of Companies to Commodities

Commodity	Start	End	Matching SIC Codes	SIC description	Stocks Start	Stocks End	Number of Stocks	Comparison Start	Comparison End	2nd range start	2nd range end
Natural Gas	04/30/90	12/31/03	1310; 1311	Crude Petroleum and Gas Extraction	12/31/25	12/31/03	297	04/30/90	12/31/03		
Crude Oil	03/31/83	12/31/03	2910; 2911	Petroleum Refining	12/31/25	12/31/03	137	03/31/83	12/31/03		
Unleaded Gas	12/31/84	12/31/03	2910; 2911	Petroleum Refining	12/31/25	12/31/03	137	11/30/84	12/31/03		
Heating Oil	11/30/78	12/31/03	2910; 2911	Petroleum Refining	12/31/25	12/31/03	137	11/30/78	12/31/03		
Live Cattle	12/31/64	12/31/03	212; 5154	Beef cattle except feedlots; Livestock	8/31/83	3/31/86	2	08/31/83	03/31/86	3/31/02	12/31/03
Lean Hogs	02/28/66	12/31/03	213	Hogs			0				
Wheat	07/01/59	12/31/03	111	Wheat			0				
Corn	07/01/59	12/31/03	115	Corn	12/31/72	3/31/86	2	12/31/72	03/31/86		
Soybeans	07/01/59	12/31/03	116	Soybeans			0				
Soybean Oil	07/01/59	12/31/03	2075	Soybean Oil Mills	7/31/01	12/31/03	2	07/31/01	12/31/03		
Aluminum	06/30/87	12/31/03	3334	Primary Aluminum	8/31/91	12/31/03	6	8/31/91	12/31/03		
Copper	07/01/59	12/31/03	1020; 1021; 3331	Copper ores; Primary Copper	7/31/62	12/31/03	43	07/31/62	12/31/03		
Zinc	01/31/77	12/31/03	1030;1031	Lead and Zinc Ores	7/31/62	1/31/02	22	12/31/76	01/31/02		
Nickel	04/30/79	12/31/03	1061	Ferroalloy ores except vanadium	7/31/62	12/31/03	9	04/30/79	12/31/03		
Lead	02/28/77	12/31/03	1030;1031	Lead and Zinc Ores	7/31/62	1/31/02	22	01/31/77	01/31/02		
Tin	07/31/89	12/31/03					0				
Gold	12/31/74	12/31/03	1041;1040	Gold ores; Gold and silver ores	2/28/86	12/31/03	299	02/28/86	12/31/03		
Silver	06/30/63	12/31/03	1044; 1040	Silver ores	7/31/62	12/31/03	16	6/30/63	12/31/03		
Platinum	03/31/68	12/31/03					0				
Sugar	01/31/61	12/31/03	2061;2063	Raw cane sugar; Beet sugar	7/31/62	12/31/03	15	07/31/62	12/31/03		
Cotton	07/01/59	12/31/03	131	Cotton	10/31/75	8/31/85	1	10/31/75	10/31/77	10/31/81	8/31/85
Coffee	08/31/72	12/31/03					0				
Cocoa	07/01/59	12/31/03					0				

Lumber	10/31/69	12/31/03	2400; 2410; 2411; 810; 811	Lumber and Wood Products; Logging; Timber tracts	2/28/27	12/31/03	19	10/31/69	12/31/03
Propane	08/31/87	12/31/03	1320; 1321	Natural gas liquids	5/31/91	12/31/03	12	05/31/91	12/31/03
Butter	09/30/96	12/31/03	2021	Creamery butter			0		
Milk	01/31/96	12/31/03	240; 241; 2026; 2020	Dairy farms; Fluid milk; Dairy products	12/31/25	12/31/03	35	01/31/96	12/31/03
Orange Juice	02/28/67	12/31/03	174	Citrus fruits	9/30/70	11/30/99	4	09/30/70	11/30/99
Oats	07/01/59	12/31/03	119	Cash grains, n.e.c.			0		
Rough Rice	08/31/86	12/31/03	112	Rice	7/31/73	7/31/99	1	08/31/86	07/31/99
Soybean Meal	07/01/59	12/31/03	2075	Soybean Oil Mills	7/31/01	12/31/03	2	07/31/01	12/31/03
Feeder Cattle	11/30/71	12/31/03	211; 5154	Beef cattle, feedlots; Livestock	12/31/69	9/30/88	4	11/30/71	09/30/88
Pork Bellies	09/30/61	12/31/03	213	Hogs			0		
Palladium	01/31/77	12/31/03	PAL; SWC	Selected from 1090, 1099 Misc Metal Ores	11/30/93	12/31/03	2	11/30/93	12/31/03