Separating the Wheat from the Chaff: Backwardation as the Long-Term Driver of Commodity Futures Performance; Evidence from Soy, Corn and Wheat Futures from 1950 to 2004

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Separating the Wheat from the Chaff: Backwardation as the Long-Term Driver of Commodity Futures Performance; Evidence from Soy, Corn and Wheat Futures from 1950 to 2004

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Abstract

We examine the role of backwardation in the performance of passive long positions in soybeans, corn and wheat futures over the period, 1950 to 2004. We find that over this period, backwardation has been highly predictive of the return of a passive long futures position when measured over long investment horizons. The share of return variance explained by backwardation rises from 24% at a one-year horizon to 64% using five-year time periods. A historical examination of soybean production and trading suggests that the profitability of a passive long soybean position during the early part of our sample may have resulted from inadequate inventories and storage facilities at the time. These conditions created the conditions for demand-driven price spikes. Further, the thin margins of soybean processors likely increased hedging demand. The implications for commodity investing are considered.

1. Introduction

Rogers (2004) and others have proclaimed the beginning of a new commodities bull market. Recent studies point out the past profitability of commodity investing. Erb and Harvey (2005) note that the annualized return of the Goldman Sachs Commodity Index (GSCI), a passive long investment in commodity futures markets, outperformed the S&P 500 total return with returns of 12.2% for the GSCI compared to 11.2% for the S&P 500 over the period, December 1969 to May 2004. Erb and Harvey (2005) also show that diversification into commodities would have improved the performance of equity-dominated portfolios. Gorton and Rouwenhorst (2004) reach similar conclusions using an equally weighted index of commodities over the period, 1959 to 2004. Erb and Harvey, however, also question whether similar passive commodity investment strategies will be equally successful in the future.[2]

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[2] CISDM (2005) provides a survey of recent work regarding commodity investment and adding commodity exposure to conventional asset portfolios.

We are interested in the determinants of profitability in long-term commodity investing. Our main hypothesis is that difficulty in maintaining adequate stores of a commodity is a fundamental driver of futures returns. This is a natural extension of the theory of storage, which was successively developed by Kaldor (1939), Working (1948), Brennan (1958), and Telser (1958). Lack of adequate inventory leads to upward price pressure and higher volatility, which increases the risk faced by commodity producers and processors. Futures markets can be used to hedge this risk. If hedging demand is driven net-short by commodity inventory holders, futures prices may reflect a discount to the expected expiration price as an inducement for speculative participation to take the long side of these contracts.

We study the performance of soybean, corn and wheat futures because of their relatively long available history and because of the unique circumstances associated with the production of soybeans.[3] Soybeans were still a new crop in the 1950s. Facilities for storage were relatively undeveloped, and production and demand were growing very quickly. These circumstances provide a natural test of our hypothesis.

Geman and Nguyen (2005) show that soybean futures volatility is inversely related to inventory levels over the period, 1974 to 1999. This link between inventories and price volatility provides partial support for our hypothesis, but does not directly address the profitability of commodity investments.

A sustained long position in a futures market is achieved by "rolling" contracts: continually selling contracts before expiration and replacing them with longer-dated contracts. Accordingly, the return to a passive long position is not determined simply by the purchase price of the first contract and the sale price of the last contract. Additionally, the price difference between purchase and sale of all rolled contracts must also be taken into account.

Backwardation is the state in which the price of a futures contract is below the spot price. Contango is the opposite: the futures price is above the spot price.[4] If futures prices are unbiased predictors of future spot prices then backwardation and contango would be equally likely. If futures prices also reflect the cost of financing and storing the commodity, then prices would be more often in contango. Keynes (1930) first proposed that backwardation could result from commodity producers accepting a discounted futures price in order to hedge their positions.

The potential importance of backwardation in commodity investing is easiest to see when it is assumed that prices for a commodity are stable within a range. Stable prices imply that a contract in backwardation will tend to increase in value over time and that a

[3] In contrast, other commodity futures contracts have much shorter trading histories. For example, natural gas futures only began trading in 1990, and gasoline futures only began in 1985.

[4] In agricultural futures markets, a market that has a backwardated futures curve is more frequently referred to as an *inverse-carry* market. Conversely, a market that has a futures curve which is in contango is more frequently referred to as a *carry* market. In the latter case, the futures market is providing a return for *carrying* inventories forward because the futures price is trading at a premium to the spot price.

contract in contango will tend to fall in value. Then, in spite of price stability, if the commodity trades most often in backwardation, a passive long position will systematically gain value. Conversely, if it trades mostly in contango, a passive long position will lose in value. A trend in spot prices is a separate source of profit or loss.

The cumulative result of backwardation and contango over time is roll return. Erb and Harvey (2006) find that roll return explains 92% of the cross-sectional variance in the performance of different commodity futures investments over a single 21-year horizon. Nash and Smyk (2003) present similar results graphically based on the percentage of time a commodity trades in backwardation.

Our first result is that we find high levels of explanatory power for backwardation and roll return in describing the performance of soybean, corn and wheat futures. Considering all crops together, over the period, 1950 to 2004, the share of return variance explained by backwardation rises from 24% at a one-year horizon to 64% using five-year time periods and 72% at eight years. Excluding 1970-1974, a period of sharp spot price increases, the share of excess return variance explained at the five-year horizon increases to 84%. The results for individual crops are similar.

While average annual backwardation is a good, if noisy, predictor of return we find that monthly backwardation is a much less reliable predictor because of the seasonality in prices. Most dramatically, the contract with the highest levels of backwardation in our roll strategy does not produce high levels of subsequent return. This is the September soybean contract. The explanation for high levels of September soybean contract backwardation is that abnormally low inventories just before the harvest cause price spikes in the July contract.

Such observations suggest a seasonal model of backwardation for agricultural commodities, which is consistent with previous authors' work on this class of futures contracts, including Sorensen (2002). Ideally, futures prices would be considered relative to expected expiration prices rather than current spot prices. However even in a seasonal price model, average backwardation over the course of a year is still a good predictor of annual return.

The final step in our quantitative analysis is to examine trends over time. An investment in soybean futures contracts would have been extremely profitable in the early 1950s and show continued profitability until after a large price spike in the early 1970s. A long-term decrease in profitability ensues. Soybean backwardation is positive on average by decade until the 1980s and 1990s, when contango predominates. Corn and wheat positions show only small declines in value from 1950 to 1970. Then, following the price spike of the early 1970s, they show a sharp decline in profitability. These crops are persistently in contango. Over the period 1950-2004, the passive long soybean position generated an annualized excess return of 3.41%. Corn returned –4.35% and wheat –2.91%. These returns are all statistically different from zero.

Corn and wheat show a more or less continual trend of increasing structural contango over time. We see at least three stages in soybean performance at this high level of aggregation. The first stage, from 1950 to 1959, is a period of very high backwardation and return. The second stage, from 1960 to 1989, is one of generally decreasing backwardation and, after the early 1970s, is also one of generally decreasing return. This stage appears to reflect the maturing of soybean production and the increasing globalization of production. The third stage, from 1990 onward, is apparently again one of increasing backwardation and return.

The last piece of our study is to present information about the production and distribution of soybeans that provide a contextual understanding for our results. Soybeans are not native to the United States. According to Windish (1981) soybeans first made their way to the U.S. from China in 1804 as a reserve food supply. Missionaries then started bringing soybeans home with them. Forrestal (1981) reports that, as a boy in rural North Carolina in the 1880s, A. E. Staley cultivated soybeans his father received from a missionary. Staley eventually became one of the largest corn and soybean processors in the country. But before that could happen, agronomists worked for decades adapting soybean varieties to U.S. conditions, soybean promoters had to convince farmers to grow the crop, the infrastructure for storing and trading had to be developed, and the demand for soybean products had to be realized as well.

By the 1950s soybeans had become a staple crop, but the supporting infrastructure for soybean production was still inadequate. We propose that the high levels of backwardation and return of the 1950s are primarily the result of inadequate storage facilities. Hieronymus (1949) documents that existing storage was not adequate for soybeans. Also, we compile visible inventory statistics for this period that show soybean supplies were effectively exhausted before the new harvest until the late 1950s.

In contrast, soybean performance over the period, 1960-1989, suggests that supply was increasing more quickly than demand. By the 1980s soybean contracts were, on average, in contango and average excess returns were negative. The average ratio of stocks-to-use in the U.S. increases from 2.9% over the period, 1950 to 1959, to 17.2% over the period, 1980 to 1989.

It is not clear, however, that the soybean is on its way to becoming a mature crop that will always trade in contango from here on out. The average U.S. stocks-to-use ratio declines to 11.4% over the period, 1990 to 1999, and 7.5% over the period, 2000 to 2004. This suggests that the supply-demand balance could be shifting with demand increasing more quickly than supply, which is creating pressure on inventories. This demand may be the result of expanding global demand by Asian countries and other industrializing countries expanding livestock production.

Section 2 of this paper provides a brief review of some of the relevant commodities literature. Section 3 shows how we construct passive long portfolios and measure backwardation. Section 4 studies the relationship between backwardation and portfolio performance over long time horizons. Section 5 examines the effects of seasonality in prices. Section 6 examines trends over time. Section 7 provides background on the development of soybean production. Section 8 notes the implications of this research for commodity investors. The conclusion follows.

2. Background Literature

There is a huge literature concerning the drivers of commodity returns. Carter (1999) provides an excellent survey of academic futures markets research.[5] Carter reflects the dominant modern academic view of commodity hedging from a portfolio perspective rather than the risk-shifting perspective adopted here. In the portfolio perspective, the hedger seeks both to diversify risks and to find an optimal balance between risk and expected return.

Keynes (1930) developed the classical theory of backwardation-driven commodities futures prices, wherein commodities producers are willing to pay speculators a risk premium to take the long side of commodities futures contracts. Hicks (1939) agreed with Keynes that hedgers were most likely to be short because commodity inventory holders would be in a more vulnerable position than consumers and so will be under more pressure to hedge than consumers. This leads to a "congenital weakness" on the demand side of many commodity future contracts. Modern hedging theory provides a more rigorous model of hedging demand but does not address the central point of the classical model; that is, that net hedging demand generates a risk premium to induce speculative market participation.

The modern theory of commodity pricing could be considered to start with Kaldor (1939) and Working (1948). Kaldor reasoned that there are actually two types of yields for a commodity inventory holder. One is the *cost* of financing and storing inventories (or stocks); and the other is the *benefit* of being able to use the inventories the moment that they are commercially needed. The latter benefit became known as the "convenience yield."

Working considered risk avoidance to be only one source of hedging demand. Working explained the difference between spot and futures prices by the cost of storage. Working believed that the risk-premia explanation for commodity-futures-price relationships had been overemphasized. Instead, he considered backwardation to be the result of a "convenience yield" that accrues to the holder of a commodity during periods of low inventory. Working illustrated the existence of convenience yields through long-term studies on the wheat markets. Brennan (1958) generalized the concept of convenience yields across commodity markets; and his contribution became known as the theory of storage.

[5] In particular, section 4.1 of Carter (1999) reviews the literature on backwardation.

Telser (1958) challenged the existence of risk premia in futures prices with a model in which the premium is driven to zero through speculative competition and with empirical data that seems to show a lack of backwardation in wheat prices. Cootner (1960, 1967) disputed the interpretation of Telser's model and offered empirical counterexamples of profitable trading strategies.

Much later, Hirshleifer (1988) developed an equilibrium model that allows speculators to earn a risk premium from short hedgers. In this model, several structural factors prevent the risk premium from being driven to zero. Hirshleifer proposed that the futures risk premium is equal to a systematic risk factor plus or minus a remaining component due solely to residual risk. The systematic risk factor measures how correlated the futures returns are to the stock market while the residual risk factor is exactly the standard deviation of the risk premium times a market-specific factor. The market-specific factor depends on risk aversion and on the magnitude of impediments to futures trading. The residual risk factor adds to (as opposed to subtracts from) the risk premium as long as hedgers are net short.

Dusak (1973) completed one of the first systematic empirical studies of futures markets. Dusak found both no risk premium in soybean, corn or wheat futures over the period, 1952 to 1967, and no correlation with capital markets. Dusak concluded that commodity market performance is consistent with the CAPM. However, Dusak's results are based on "trimmed means." In this procedure, outliers, such as large positive price spikes are eliminated from the sample. Dusak justifies this step because of the non-normality of commodity future returns. As soybean returns have a strong positive skew (see Table 1), excluding large positive returns obviously biases expected returns downward. The annualized excess return for a soybean position based on our data is 3.6% over the same time period.

Bodie and Rosansky (1980) first examined the performance of a portfolio of passive futures positions by constructing a historical equally-weighted portfolio based on 27 years of data starting in 1950. This portfolio contained 10 commodities in 1950 and 23 in 1976. Bodie and Rosansky found that their portfolio outperformed the equity market over the same period, though with more volatility and also that the performance of their portfolio could not be explained by its beta against equity markets.

Kolb (1992) studied 29 commodities and found that feeder cattle, live cattle, hogs and orange juice futures pass three tests for backwardation: positive returns to long positions, contract prices tending to rise over time, and backwardation increasing with time to expiration. Copper, cotton, soybeans, soy meal and soy oil pass one or two of these tests. Kolb does not consider the causes of backwardation. A common feature of most of the strongly backwardated commodities is that they are difficult to store. Till and Eagleeye (2003) consider difficult storage situations as a common factor in the historically positive performance of the gasoline, copper, and live cattle futures contracts.

A number of studies use position data provided to the Commodities Futures Trading Commission by large market participants to determine the net position of commercial hedgers. These studies support the hypotheses that agricultural hedgers tend to be short and that speculators can earn a risk premium by taking a position opposite to that of net hedging pressure. Chang (1985) uses nonparametric statistics to study hedging and speculative positions in soybean, corn and wheat markets over the period, 1951 to 1980, and finds hedgers net short most of the time. Bessembinder (1992) finds that average futures returns are larger when hedgers are net short than when they are net long. De Roon, Nijman and Veld (2000) examine the period, 1986 to 1994. They find that the net percentage of short hedging positions has a positive and strongly statistically significant relationship to futures returns for a broad range of futures contracts and that agricultural hedgers are, on average, net short.

3. The Construction and Performance of Passive Long Futures Positions

3a. The construction and performance of long futures positions

We construct return indices based on continuously maintaining a long position in the "near" or "front-month" contract. This is the contract nearest to expiration. The month before near-contract maturity, the position is rolled to the next nearest contract. The rolling procedure is that used in the construction of the Goldman Sachs Commodity Index (GSCI), as documented in Goldman Sachs (2004). During the fifth to ninth trading days of the roll month, 20% of the position is rolled each day. Closing prices are used. Transaction costs and execution slippage are ignored.

This study is based on soy, corn and wheat futures prices starting in December 31, 1949 for contracts with maturities from January 1950 to May 2005. Prices for contracts up to the year 1960 were obtained from Commodity Systems Incorporated. Commodity Research Board data is used for subsequent prices. Corn and wheat contracts mature in March, May, July, September and December. All maturities are used. Soy contracts mature in January, March, May, July, August, September and November. The GSCI does not utilize August or September contracts. Our results are based on including the September contracts in the roll order. We include September but exclude August contracts in order to obtain a regular pattern of semi-monthly contract rolls for soybeans.[6]

The reported returns are based on the notional value of the futures contracts. They are equivalent to excess returns above the risk-free rate for a fully collateralized position. Our returns thus do not include the return on funds used to collateralize the futures position. This differs from most commodities index returns, which typically assume that the positions are fully collateralized and include the short-rate return on the notional value of

[6] Our method of constructing soybean returns is equivalent to that of the GSCI for the months, September through May. Our June return is based on rolling into the September future while the GSCI rolls into November at this time. The returns differ during June, July and August. The August roll is into the November future and thus returns again correspond in September. Differences over the months of June to August can be substantial when comparing our soybean index to the GSCI's soybean index.

contracts in the reported return. Table 1 reports monthly return statistics for our indexes and S&P 500 excess returns from the period starting December 31, 1949. The Ibbotson Associates U.S. Treasury 30-Day T-Bill rate is used as a proxy for the risk-free rate. The S&P 500 total-return series was obtained from Ibbotson Associates.

Table 1 shows that soybean excess returns over the 55-year period from 1950 to 2004 average 0.51% per month while corn and wheat excess returns average –0.20% and –0.07%, respectively. Soybean excess returns are statistically greater than zero (p = .062). Over the same period, the S&P 500 averaged 0.66% per month. Using Sharpe ratios as a measure of risk-adjusted performance, Table 1 shows that the S&P 500 considerably outperformed soybeans.[7] Soybean performance, however, is considerably stronger than either corn or wheat over the entire history of the study.

Correlations between commodities futures positions range from 43% to 67% over the course of the study. Correlations between futures positions and the S&P 500 range from –3% for soybeans to 3% for wheat. Betas against the S&P are approximately equal to the correlations (the soybean beta is –0.05).

	Soybeans	Corn	Wheat	S&P 500
Average monthly excess return	0.51%	-0.20%	-0.07%	0.66%
Std. Dev	7.05%	5.92%	6.04%	4.14%
Skew	1.86	1.80	0.98	-0.39
Kurtosis	13.23	12.41	5.79	1.71
Annualized geometric return	3.41%	-4.35%	-2.91%	6.80%
Sharpe ratio	0.07	-0.03	-0.01	0.16
Number of observations	660	660	660	660

Table 1: Excess returns 1950 - 2004.

3b. Backwardation and roll return

The near contract is taken to represent the spot price. The percentage of backwardation is based on the difference between the spot price S_t and the price F_t of the next further contract in the roll order. The percentage of backwardation in month t is the ratio:

$$\frac{S_t - F_t}{F_t}.$$

Spot and futures prices are taken as the average price of the near contact and next further contract in the roll order on the first five trading days of the month. The futures price is

[7] The Sharpe ratio is, in fact, a conservative measure of the degree of equity outperformance due to the high levels of kurtosis in the soybean excess returns. This is because the Sharpe ratio does not properly penalize performance for large drawdowns that are more frequent than the level expected for normally distributed returns. Both the Stutzer index and Sortino ratio take better account of downside risk.

the relevant investment reference point and, so, is used as the denominator in forming the percentage. Backwardation is positive when the next nearest contract is lower in price than the spot price. The average backwardation over an interval such as a year is the average of backwardations measured at monthly intervals. The percentage of time in backwardation is the percentage of months with positive backwardation.

Table 2 shows average backwardation statistics for soybean, corn and wheat contracts. Both roll and non-rolling months are included in these measures. Mean soybean backwardation is greatest, followed by wheat and then corn. This order corresponds to the long-term profitability of long passive positions shown in Table 1. The ordering by percentage of time in backwardation is the same. Note, also, the high levels of skew and kurtosis for backwardation, and that these levels are highest for soybeans. The high kurtosis indicates unexpectedly large backwardations or contangos. The positive skew indicates large backwardations are considerably more frequent than large contangos.

	Soybeans	Corn	Wheat
Average backwardation	0.46%	-1.24%	-0.59%
Standard deviation	4.74%	3.35%	4.15%
Skew	5.15	2.67	2.62
Kurtosis	34.45	15.33	12.02
Minimum	-4.1%	-7.5%	-7.2%
Maximum	42.8%	30.4%	31.4%
Median	-0.9%	-2.1%	-1.6%
Percent time in backwardation	33%	23%	29%
Observations	660	660	660

Table 2: Average backwardation 1950-2004.

The total excess return is the return of the portfolio over any period of time. Again, it is an excess return because the return of any funds used to collateralize the futures positions is not included. Excess return may be broken down into two components. The first is the *spot* or *price* return, which is defined as the proportional change in price of the near contract over the time period:

$$\text{Price return}_t = (\text{near price}_t - \text{near price}_{t-1}) / \text{near price}_{t-1}.$$

Note that the near price at the start of the time period may correspond to a futures contract with a different expiration date than the near price at the end of the time period.

The roll return – also known as roll yield – is the return on the portfolio in excess of the return generated by price change of the near contract. Practitioners often define the roll return as the arithmetic difference between the excess and spot price returns (see, e.g., J.

P. Morgan (1994)). Instead, we define the roll return as the geometric difference between excess and price returns:

$$\text{Roll return}_t = (1 + \text{total excess return}_t) / (1 + \text{price return}_t) - 1.$$

By using the geometric difference, spot and roll returns may be aggregated consistently over any time period. Table 3 shows aggregate statistics for monthly roll returns. There is a roll return only on months when contracts are rolled. The appendix presents annualized price and roll returns by five-year periods and over the complete history of this study.

	Soybeans	Corn	Wheat
Average roll return	0.44%	-0.94%	-0.55%
Standard deviation	4.57%	3.45%	4.49%
Observations	331	278	278

Table 3: Roll returns 1950-2004.

4. The Aggregate Relationship Between Backwardation and Return

Nash and Smyk (2003), Gorton and Rouwenhorst (2004), and Erb and Harvey (2005) observe that the correlation between backwardation or roll return and the returns to a passive long position is high over long time horizons. Nash & Smyk and Erb & Harvey look at time periods beginning in the early 1980s running about 20 years. Gorton and Rouwenhorst look at the period from 1959 to 2004. We use data going back to 1950. First we examine these relationships graphically over five-year time periods cut from our 55-year history. We then study univariate regression R-squared values over varying time horizons. *These results demonstrate the increasing explanatory power of backwardation and roll return with the length of the investment time horizon (at least over the time period of our study.)*

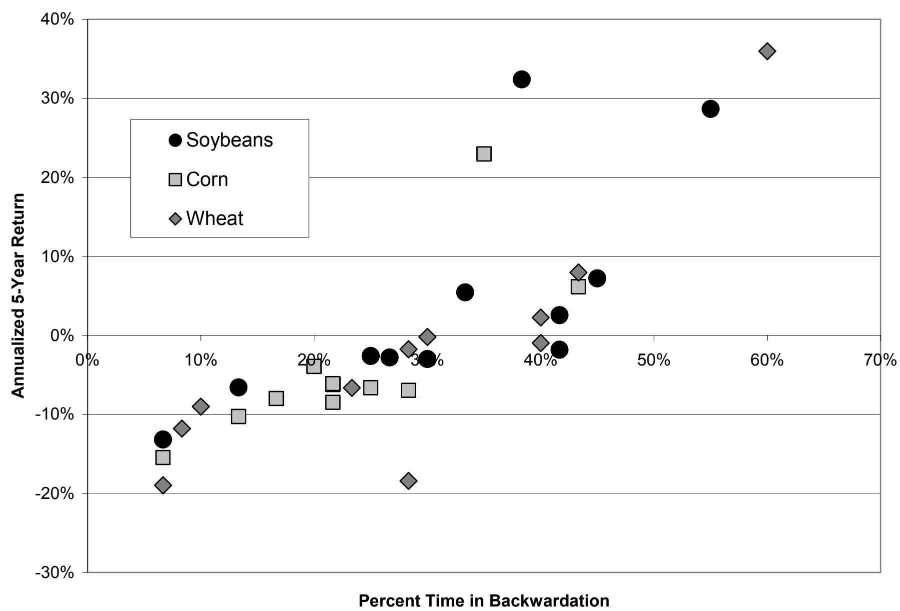


Chart 1: Five year annualized return as a function of percent time in backwardation.

Chart 1 shows five-year soybean, corn and wheat annualized excess returns as a function of percentage of time in backwardation for the five-year periods between 1950 and 2004. There is a clear positive correlation with higher levels of time in backwardation associated with higher returns.

Chart 2 displays five-year soybean, corn and wheat annualized excess returns as a function of average backwardation for the five-year periods between 1950 and 2004. Trend lines for each commodity are shown. The trend lines for each crop have almost identical slopes, indicating similar responses to a change in average backwardation. Three of the outlier observations with 20% or greater annualized returns are from the period, 1970-1974. This period saw unusually strong advances in agricultural prices due to a combination of short- and long-term factors including rising energy prices, excessive monetary stimulus, U.S. grain sales to the U.S.S.R., and negative supply shocks such as corn blight.

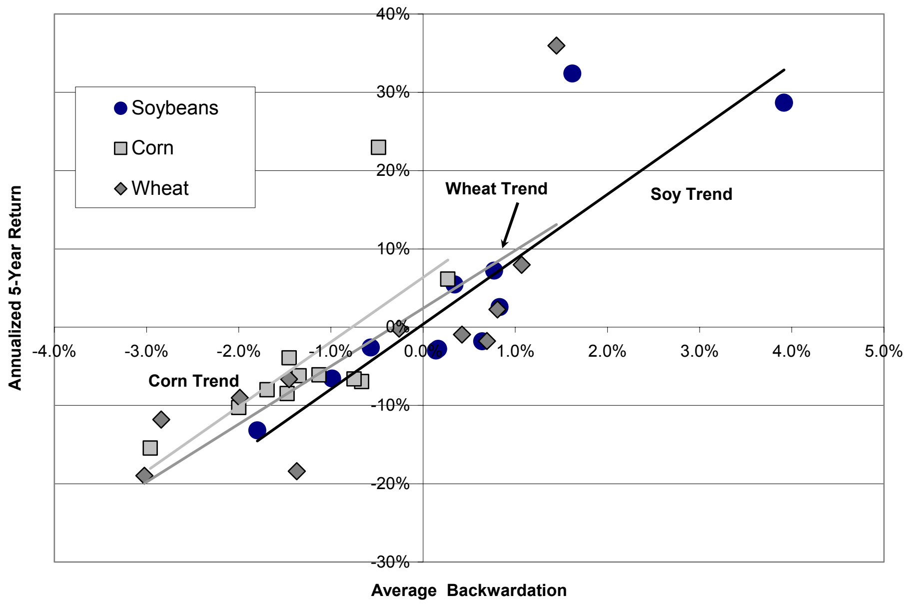


Chart 2: Five-year annualized return as a function of average backwardation.

Short-term variability in commodity prices is high, which should make the spot-price return the dominant factor over shorter horizons. Over longer periods we find that our price series tends to be mean-reverting. This latter point is consistent with the findings of Deaton and Laroque (1992) and Sorensen (2002). Therefore, the importance of the spot return should decline as timeframes increase. However, long-term price shifts, such as those observed for all three crops in the mid-1970s, show that the influence of spot-price changes do not disappear entirely.

The foregoing suggests that there should be a gradual increase in the fraction of price variability explained by backwardation and roll return with increasing time horizon. This relationship is similar in spirit to the increasing importance of dividend yield as a predictor of equity return with the lengthening of the time horizon, which is documented by Cochrane (1999). With a one-year horizon the R-squared value of the regression of dividend yield on excess return is 17%, but at five years the R-squared value becomes 59%. These results are over the sample period, 1947 to 1996. Cochrane explains this as the result of the cumulative effects of the slight short-term predictability of a slow-moving variable.

Regression on total excess return		R-squared by investment horizon				
		1 yr.	2 yr.	3 yr.	5 yr.	8 yr.
All Crops	Percent time in backwardation	19%	40%	62%	64%	75%
	Average backwardation	24%	39%	57%	64%	72%
	Roll return	25%	40%	60%	67%	73%
Soybeans	Percent time in backwardation	10%	36%	57%	52%	85%
	Average backwardation	36%	58%	67%	75%	81%
	Roll return	36%	54%	66%	70%	87%
Corn	Percent time in backwardation	13%	27%	72%	59%	79%
	Average backwardation	10%	20%	63%	47%	76%
	Roll return	10%	20%	63%	50%	49%
Wheat	Percent time in backwardation	31%	48%	63%	73%	66%
	Average backwardation	22%	35%	49%	62%	64%
	Roll return	24%	38%	52%	68%	68%

Table 4: Percentage of excess-return variance explained as a function of time horizon.

We examine the effect of horizon on the relationship between excess return and backwardation and roll return in Table 4. To save space only the R-squared values of univariate regressions are presented. Results for all crops together and then for individual crops are presented. The regressions are of either percentage time in backwardation, average backwardation, or roll return on excess total return. The number of observations for the all-crop regressions is 165, 81, 54, 33 and 21 for, respectively, the 1, 2, 3, 5 and 8-year horizons.[8] The corresponding numbers for the single-crop regressions are 55, 27, 18, 11 and 7 observations. The resulting precision of the single-crop results at higher horizons is lower than might be desired and may account for some of the variability seen in the single-crop results.

Results for the joint analysis of all crops demonstrate that the percentage of excess-return variation explained by all of these factors generally increases with the length of the investment horizon. The effect is most consistent for roll return, but most pronounced for percentage time in backwardation. With a one-year time horizon, percentage-time-in-backwardation explains 19% of total excess-return variance, average backwardation explains 24% of total-excess return variance, and roll return explains 25% of total excess-return variance. At eight years, the percentages of explained variance are 75%, 72% and 73%, respectively.

The pattern for soybeans is very similar, the most important difference being higher levels of R-squared found at most horizons, and, particularly at the eight-year horizon.

[8] Time periods are consecutive periods starting with 1950. Data for 2004 is discarded for two and three-year horizons. For the eight-year horizon the last period is only seven years.

Roll return explains 87% of the variance in soybean total excess returns at the eight-year horizon.

5. Seasonality

Agricultural prices are seasonal. Cootner (1967) considers how seasonality might affect hedging demand. Fama and French (1987) note that futures prices tend to increase for expiration dates before the harvest and to fall across harvests and identify seasonal effects statistically for the crops studied here. However, they do not take seasonality into account when testing for risk premia in agricultural commodities.

The simplest model of backwardation is based on the assumption of stable spot prices. The expected price of a futures contract at expiration is then the current spot price, and backwardation becomes the expected discount on the contract. When prices are seasonal, backwardation also incorporates the expected seasonal price change. Under these circumstances, measured backwardation in any month cannot reliability be used to estimate expected return in the short-term.

Soybeans show considerable seasonality in prices. This seasonality explains an important feature of soybean backwardation. Over the history of this study, the highest levels of backwardation are found in May and June, averaging 5.8% and 5.5%, respectively, over 1950-2004. Backwardation during these months is because of the tendency of the July contract to trade at a premium relative to the September contract. If prices were expected to be stable, this would be a signal of expected return for the September contract. Instead, it signals expected price decline. The average July contract expiration price over the period, 1951 to 2004, is $500.64 while the average for the September contract is $474.18, or 5.3% less. The average return from the beginning of May to expiration of the September contract has been only 0.11% over the period from 1951 to 2004.[9] May and June soybean backwardation is typically the result of low inventories. Low inventories particularly affect the July contract because the July contract expires just before harvest begins. September contract prices are well insulated from July contract price shocks by the replenishment of inventories from the harvest.

Seasonality in prices makes it more difficult to identify the link between backwardation and expected return. However, if prices are stable (or broadly mean-revert), average annual backwardation still determines average annual return. This is because seasonal effects will cancel out. Expected seasonal price increases must then be matched by expected seasonal price decreases. While this cancellation will not be perfect for any single year due to short-term price trends, it becomes increasingly accurate over a span of years.[10]

[9] The year 1950 is not included because the September 1950 soybean contract was not traded.

[10] Let P_i be the spot price for month i, and let F_{ij} be the month i price of the futures contract maturing in month j. Backwardation in any month i is then P_i/F_{ij}-1. The actual expected return is $\mathrm{E_i}(F_{jj})/F_{ij} - 1 = \mathrm{E_i}(P_j)/F_{ij}$-1, where $\mathrm{E_i}$ is the expectation at month i. The difference between backwardation and expected return is then $(\mathrm{E_i}(F_{jj})-P_i)/F_{ij}$. Let P_1 be the price in the first month after harvest and assume a strong model of seasonality such that the month before expectation of the price after harvest is always the same so that

The seasonal relationship between backwardation and return becomes visible for soybeans when data for the early 1970s, a period of sharp spot price rises, is excluded. Table 5 presents soybean backwardation, return, and price changes over the period, 1951 to 2004, but excluding 1970 to 1974.[11] The first row presents average backwardation in the first five trading days of each bimonthly period. Average backwardations are all statistically different from zero. The second row presents two-month returns on the contract held in our roll procedure (*X* is the contract expiration price). This is always the next contract in the roll order. For example, the March contract is held over the December to January period. The last row shows the spot price return.

Measure	Dec-Jan	Feb-Mar	Apr.-May	Jun-Jul	Aug-Sep	Oct-Nov
$(S_0\text{-}F) / F$	-1.27%*	-1.08%*	-0.72%$^+$	4.61%*	1.00%*	-1.63%*
$(X\text{-}F) / F$	-1.52%	2.03%^{o}	0.47%	-1.51%	0.20%	1.20%
$(X\text{-}S_0) / S_0$	-0.84%	2.59%	1.21%	-5.48%$^+$	-0.77%	3.35%*

Statistical significance levels: ^{o}: < 10%, $^+$ < 1%, *: < .1%.

Table 5: Seasonal backwardation, returns and prices for soybean contracts: 1951-2004 without 1970-1974.

The average backwardation over the 49 years covered in Table 5 is 0.153%. The average contract return is 0.146%. The average spot price return is 0.01%. Thus, spot price change is negligible and, as expected, backwardation and return are approximately equal.

Seasonality in prices is most clearly reflected by the large and statistically significant average spot price drop over June to July and rise over October to November. The fact that other price changes are not statistically significant suggests both the high volatility of soybean prices and possible changes in seasonal patterns over time.

High levels of backwardation near the end of the crop cycle most likely reflect a prior price run-up and not the implication of a future run-up in prices. Seasonality in agricultural prices makes it difficult to identify the premium embedded in a futures price without forming an explicit expectation as to the contract price at expiration. Nevertheless, average backwardation is still an important determinant of annual return. Short-term price variability leads to considerable difference between average return and average backwardation over short periods of time. But as the time horizon increases, this relationship becomes increasingly clear.

$E(P_1) = E(P_{13})$. Then the expectation of the average of the difference over the course of a year is approximately zero because the average can be rearranged in the form of a series of differences between prices and their expectations: $\frac{1}{12}\sum_{i=1}^{12}[E(P_i)/F_{i-1,i} - P_i/F_{i,i+1}]$. The expectation in not exact because of the differences in the denominators, but average backwardation is approximately equal to average return in expectation.

[11] The year 1950 is also excluded because of incomplete contract data. This exclusion significantly lowers reported backwardations for the April-May and June-July periods.

6. Trends Over Time

We have shown that the importance of backwardation increases with the investment horizon. We now consider long-term trends in backwardation observable in our data. Table 6 shows average soybean, corn and wheat backwardation by decades except that the last period displayed is only for five years: 2000 to 2004.

Table 6 shows soybean backwardation generally weakened over time. Soybean average backwardation is 2.28% over the 1950-1959 period. This is consistent with our hypothesis that inadequate storage was likely a factor in soybean price dynamics during this period. The next section shows that inventories were exceptionally low as well. A generally downward trend in backwardation then ensues followed by soybean backwardation increasing from 1990 through 2004. Over the entire period, 1950-2004, soybean backwardation is positive and strongly statistically significant ($p = .001$). *The overall trend in backwardation will be seen to parallel inventory trends.*

Corn and wheat are consistently in contango. Corn backwardation is negative (contango) and statistically significant over the entire period. Wheat is also in contango over the entire history and statistically significant. Wheat is in contango in all subperiods except 1950-1959 and 1970-1979. Corn and wheat can be considered to have traded in structural contango. This may be the result of the well-developed storage facilities and greater inventories of these crops.

Period	Soybeans	Corn	Wheat
1950-1959	2.28%	-0.20%	0.27%
1960-1969	0.59%	-1.40%	-0.65%
1970-1979	0.88%	-0.98%	0.00%
1980-1989	-1.18%	-1.41%	-0.98%
1990-1999	-0.41%	-1.37%	-0.47%
2000-2004	0.77%	-2.96%	-2.84%
All Years	0.46% o	-1.24% *	-0.59% *

Statistical significance levels: o: < 10%, + < 1%, *: < .1%.

Table 6: Average backwardation by time period.

Table 7 shows average monthly excess returns for all crops over the same time periods. Excess returns for corn and wheat are generally negative except for the inflationary 1970-1979 period. Soybean excess return is strongest in 1970-1979. Soybean average excess return over the entire history, 0.51%, is statistically significant (p = .062). These results suggest that the development of soybean production and storage facilities have not matched demand to nearly the same degree as have corn and wheat. This may be a function of strong global soybean demand.

Period	Soybeans	Corn	Wheat
1950-1959	1.11%	0.00%	0.12%
1960-1969	0.39%	-0.39%	-0.40%
1970-1979	1.62%	0.81%	1.41%
1980-1989	-0.46%	-0.38%	-0.41%
1990-1999	-0.28%	-0.57%	-0.67%
2000-2004	0.88%	-1.16%	-0.86%
All Years	0.51% o	-0.20%	-0.07%

Statistical significance levels: o: < 10%, + < 1%, *: < .1%.

Table 7: Average monthly excess returns by time period.

7. Soybean Production

The observed trend in soybean backwardation and investment performance over time is closely related to clearly visible aspects of the production and distribution of soybeans. The exceptional performance in the 1950s cannot be properly appreciated without understanding the soybean's status as a new product. In what follows, we also review recent trends in the globalization of the production and consumption of soybeans.

7.1 The 1950s

The beginnings of soybean cultivation in the U.S. are noted in the introduction. Warren (1945) notes the agricultural advantages to soybean cultivation, chiefly as a replacement for oats in crop-rotation schemes. Soybean oil was the first soy product of commercial value. Soybean oil was imported for industrial uses before commercial soybean production developed in the U.S. Disruptions of imported soybean oil during World War I and tariffs on imported oil afterward increased demand for the U.S. soy crop. The arrival of European corn borer also increased interest in soy cultivation. During the 1920s and 1930s, intensive government and university efforts were made to adapt soybean varieties to U.S. conditions. It took time for demand for non-industrial uses for soybean oil to develop and for soy meal, a byproduct of oil extraction, to gain acceptance for use in livestock feeds.

Soybean production increased greatly in the late 1930s and the 1940s. Trading of soybean futures contracts at the Chicago Board of Trade (CBOT) started in 1936. Trading was suspended in 1943 due to World War II price controls, and trading did not resume until 1947. This is the reason that our study did not start any earlier than 1949.

Hieronymus (1949) studied the complex of participants involved in soybean production, storage and processing. He identified soybean processors as the participants with the most risk to hedge and shows that processor's forward prices for soybean oil and meal over the 1947-to-1948 harvest were strongly discounted over time. This is consistent with processors offering increasing discounts over the expected future price as soybean products were sold further into the future. This discounting is equivalent to backwardation in futures markets.

Hieronymus found many factors contributing to the risk faced by the processor. One of the most important was that the production of soy meal substitutes such as cottonseed and linseed meals was not price-sensitive. The result was that soy meal demand was very variable, increasing processor risk. Hieronymus also notes that soybeans store well but must be stored in tight storage bins, which were not economical for farmers, leading to the bulk of the burden of storage provision falling on processors.[12] The result is that farmers sold almost all of their harvest immediately and that processors had to claim a substantial fraction of their annual supplies at that time with the attendant inventory price risk or face the likelihood of shortages and high prices later in the season. Processor risk was not limited to the 1940s. Aronson (1964) finds that price uncertainty in the period up to 1962 was still so great that it was difficult for processors to establish reliable margins even with the help of futures markets. Soybean shortages late in the crop cycle could put processors at great risk.

Inventory statistics demonstrate that soybean supply was more vulnerable than corn and wheat supplies. Table 8 presents the ratio of the minimum visible inventory to peak inventory for soybeans, corn and wheat over the period, 1950 to 1959. We take visible supply as a proxy for storage capability. Visible inventory statistics are estimates of inventories in principal commercial storage sites compiled by the Chicago Board of Trade and reported in CBOT Statistical Annuals. The average minimum visible supply ratio is 6.9% for soybeans, 47.7% for corn and 69.5% for wheat.

[12] "Soybeans are a relatively new crop, and farmers have not yet built storage space for them. In the past farmers have extensively stored corn and oats. These are both feed crops and are needed on the farms throughout the year. … Such a need is not present in the case of soybeans. … In the long run storage will take place where it can be done most economically. … The storage space for soybeans is owned by processors and is located at processing plants. This represents sunk capital and has no feasible alternate use. No other storage can be built cheaply enough to replace it." Hieronymus (1949), p. 91-92.

Year	Soybeans	Corn	Wheat
1950	5.7%	77.0%	64.9%
1951	1.7%	31.8%	63.7%
1952	2.3%	22.1%	36.5%
1953	6.2%	10.7%	68.2%
1954	5.1%	26.0%	86.1%
1955	10.5%	34.1%	82.4%
1956	7.4%	68.3%	75.3%
1957	11.4%	68.5%	62.8%
1958	5.6%	74.8%	73.4%
1959	12.8%	64.1%	81.7%
Average	6.9%	47.7%	69.5%
Source: CBOT Statistical Annuals 1951-1960.			

Table 8: Ratio of minimum to maximum visible supply 1950-1960.

Chart 3 shows weekly soybean visible supplies by week over the period, 1948 to 1960. Supply shortage was chronic until 1959. It also appears that supply shortage was reasonably predictable as visible supply appears to decline approximately linearly in most years. This suggests that demand-driven price spikes might be found relatively early in the crop cycle, as is seen in Table 5. Geman and Nguyen (2005) find that this linear decline in inventories still generally characterizes soybean inventory dynamics over the period of their study, 1974 to 1999.

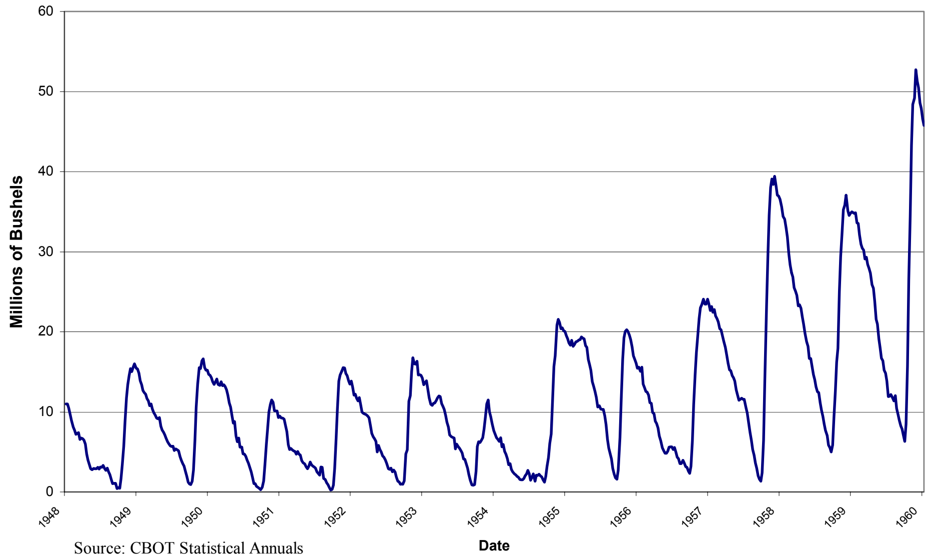
7.2 U.S. soybean production 1950-2004

Soybean inventories are tracked by the U.S. Department of Agriculture. The average stocks-to-use ratio[13] for soybeans is 2.9% over the period, 1950 to 1959, and increases to 11.3% over the period, 1960 to 2004. For the period, 1995 to 2004, the average stocks-to-use ratios for soybeans, corn and wheat were 8.6%, 14.4% and 30.3%, respectively.[14] Soybean storage is much more adequate today than during the 1950s, but remains considerably lower as a fraction of consumption than stocks for corn and wheat.

[13] The stocks-to-use ratio is based on September 1st inventories and is calculated as ending inventories divided by the quantity, total production plus beginning stocks minus ending stocks.

[14] Soybean and corn stocks are as of September 1st. Wheat stocks are as of June 1st, the time of lowest inventory of wheat in the harvest cycle. Data on stocks are from the USDA annual *Agricultural Statistics*.

Chart 3: Soybean Visible Supply 1949-1960



Source: CBOT Statistical Annuals

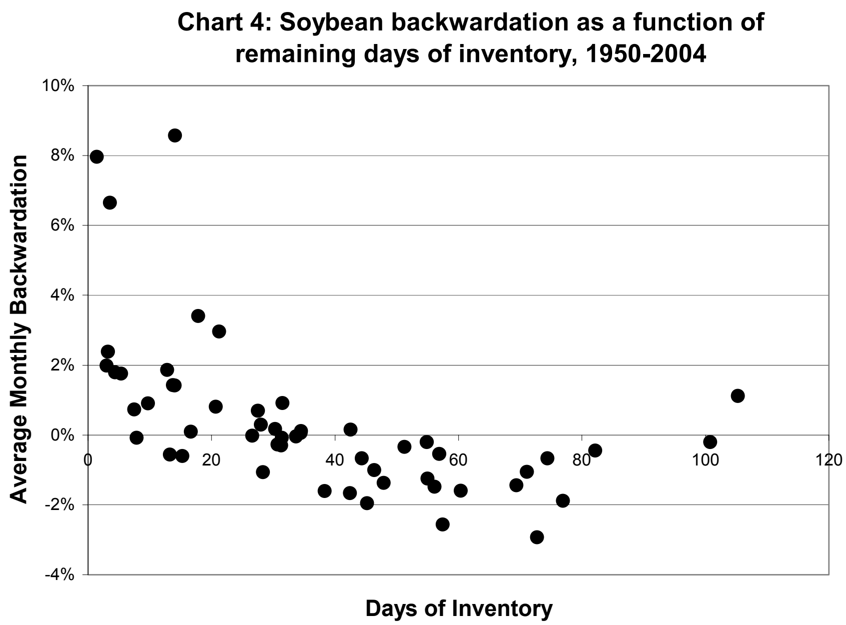
Time Period	Avg.	Std Dev.
1950-1959	2.9%	3.3%
1960-1969	8.1% +	8.4%
1970-1979	10.6% o	5.7%
1980-1989	17.2% *	6.0%
1990-1999	11.4% *	4.1%
2000-2004	7.5% *	2.5%
Overall	9.8%	7.0%

Test based on the Wilcoxon rank sum test.
o: < 10%, + < 5%, *< 1%
Source: U.S.D.A. Agricultural Statistics

Table 9: Stocks-to-use ratios for soybeans 1950-2004.

Table 9 presents the stocks-to-use ratio for U.S. soybeans by decade. The ratio rises decade-by-decade and peaks over the period, 1980 to 1989. It declines thereafter. The reversal of the trend to greater inventories (relative to consumption) parallels the emerging trend toward greater soybean backwardation since 1990 shown in Table 6 and the trend of larger soybean returns visible in Table 7. Period-to-period changes are all statistically significant according to the nonparametric Wilcoxon rank-sum test. This test is appropriate when the data under study are not normally distributed, and particularly in small samples. The test is for the statistical significance of the difference in two samples' averages. These results are consistent with our basic hypothesis that low inventory is a key driver of backwardation and returns in futures markets.

Chart 4 graphically displays the relationship between backwardation and the days of inventory for soybeans over the period, 1950 to 2004. The days of inventory statistic is the stocks-to-use ratio multiplied by 365. The negative relationship between backwardation and inventory is plainly visible.



7.3 The globalization of soybean production and consumption

Soybean exports first from Brazil and then from Argentina became a significant factor in the world market during the 1990s. The globalization of soybean production raises the question of whether it is sound to make inferences regarding the effects of U.S. inventories on U.S. prices. Geman and Nguyen (2005) find that U.S. inventories, in fact, provide better explanatory power of prices when inventories are considered on an annual basis. This relationship changes when quarterly or estimated monthly inventories are used. (This may be because world inventory data at higher frequencies reflects the spring harvest of the southern hemisphere.) However, Geman and Nguyen's annual results are consistent with the general finding that U.S. and world inventories track together very closely. The availability of South American soybeans is indirectly reflected in U.S. stock levels.

It is surprising that rising exports from Brazil and Argentina were not sufficient to keep soybean futures from trending back to trading in backwardation. Vandeputte (2005) notes that the share of world production accounted for by Brazil and Argentina has risen from less than 20% over the 1970s to more than 40% in recent years, greater than the share of the U.S. Vandeputte also finds that Brazil/Argentina production has doubled between the 1994/1995 and the 2002/2003 harvests. Global inventories have risen to historic highs, but, evidently the global expansion in soybean production has been met at least in part by a large increase in global soybean demand.

Many factors will influence the future balance between supply and demand. Brock (2005) reports USDA data estimating Chinese domestic soybean consumption will have increased almost five-fold over the period, 1990-2006. But Brock also reports that demand growth outside of Asia has moderated, and world soybean inventories are projected to rise in the near-term.

Cronin (private communication, 2005) discusses a further consideration. New inexpensive soybean storage technologies being developed in Latin America could lead to meaningful increases in storage capacity and perhaps a significant increase in exports due to reductions in spoilage during storage and the difficult transportation to ports.

A final consideration to weigh, though, is noted by Vandeputte: soybean production in Brazil and Argentina may be reaching the point of diminishing returns due to disease and lower rates of growth in acreage planted.

8. Implications for Investors

We have shown that backwardation has been a driver of returns *over long-time horizons* for three agricultural futures markets. But we have also shown that levels of backwardation have not been static in agricultural markets, particularly for soybeans. What this means for investors is that just identifying a commodity that has frequently traded in backwardation in the past is not a sufficient basis for future passive investment. What if there are structural changes in a market's underlying physical market such that the futures contract no longer typically trades in backwardation as occurred with soybeans during part of our sample? This means an investor needs a fundamental rationale for why a market should continue to trade in backwardation in the future. For example, Till and Eagleeye (2005) discuss why the gasoline and live cattle futures markets might be expected to continue to trade in structural backwardation due to the predominance of short hedging, leading to a systematic downward bias in the value of these markets' futures contracts.

Another noteworthy feature of these historical results is that while normally over five-year periods, an agricultural futures contract's curve shape[15] has been the driver of returns, there is one exception, and that is the 1970-to-1974 period. These are the data points on Chart 2 that do not fit the nearly linear trend-lines of annualized returns as a function of average backwardation. What this means for an investor is that there can be an additional fundamental rationale for a long-term, passive investment in commodity futures contracts *besides* predicting structural backwardation for commodity futures

[15] By futures curve shape, we mean whether a futures market is trading in backwardation or contango. Futures traders frequently refer to the term structure of a futures contract as a "curve:" the futures prices for each maturity are on the y-axis while the maturity of each contract is plotted on the x-axis, which thereby traces out a "futures price curve."

contracts. The second rationale would be to predict that factors are in place to repeat the 1970-to-1974 experience. For example, Howell (2005) points out how excessive monetary stimulus had contributed to the high returns of commodities in the past. Notes Howell, "Negative real interest rates in the 1970's contributed to a commodity boom." And real short-term interest rates had become negative in the United States and in China during early 2005; see Chart 5. Similarly, Roach (2006) discusses the current economic environment as a "super liquidity cycle," which is pushing the "Asset Economy to its limit," of which one manifestation is the boom in prices of certain commodities.

Again, though, the typical historical source of long-term returns in *individual* futures investments has been due to curve shape, at least for the agricultural futures markets that we have studied, rather than because of episodes of excessive monetary stimulus.

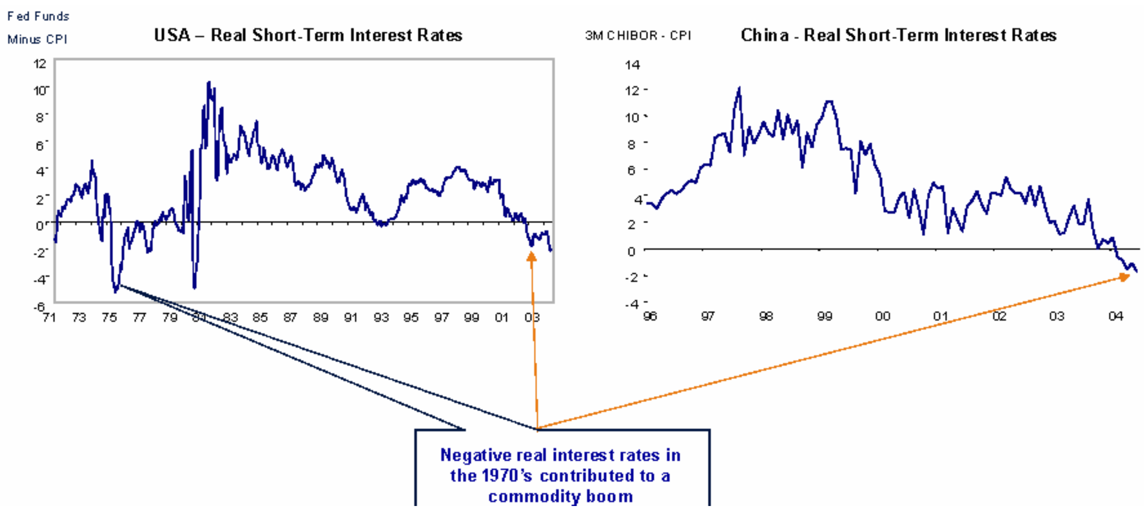
We should emphasize that our work has solely focused on sources of returns for *individual* commodity futures contracts. In contrast, Erb and Harvey (2006) convincingly demonstrate that the most reliable source of returns for an equally-weighted *portfolio* of diverse commodity futures contracts is the "diversification return" that arises from systematically rebalancing volatile instruments with low mutual correlation. Quoting from Erb and Harvey's article: "The diversification return is a pay-off to one of the few high confidence ways, rebalancing a portfolio, that an investor can boost portfolio geometric return. When asset variances are high and correlations are low, the diversification return can be very high." And the commodity "asset class" is precisely one where the correlations amongst individual commodities across sectors are low, and the variance of individual commodities is high. Greer (2000) had also earlier explained the rebalancing effect.

Another issue that we do not consider is how commodity investments may *complement* a traditional portfolio of financial assets. Several authors consider the benefits of adding commodities to the investor's portfolio; Greer (2000), in particular, convincingly discusses how "the real benefits of commodity investment may lie in periods of unexpected rises in inflation." CISDM (2005) also provides a survey of this issue.

9. Conclusion

We show that backwardation is an increasingly important determinant of the historical returns of passive long positions in soybeans, corn and wheat futures contracts as the investment time horizon increases. This relationship is evident in the joint analysis of the three crops and in the analysis of each crop separately. Because soybeans were in backwardation during a large fraction of the period of this study, passive long soybean positions enjoyed positive returns. Because corn and wheat were consistently in contango, negative returns were realized.

Chart 5: Excessive Monetary Stimulus



Source: Howell (2005), which was derived from an analysis by Geoff Blanning of Schroders Alternative Investments.

We also perform a more granular analysis on the relationship of returns to backwardation in timeframes of under a year. We found that the relationship between backwardation and return breaks down for periods less than a year because of the seasonality of crop prices. Average backwardation over the course of a year is still an effective predictor of returns because seasonal price changes cancel out. Annual average backwardation can thus still be considered the average discount on the expected future price and a predictor of the risk premium to passive long speculators. The fact that large backwardations at the end of the crop cycle generally reflect realized rather than expected price rises does not change the overall relationship between backwardation and return. If a monthly backwardation merely reflected prior seasonal price rises, but no risk premium, then average annual backwardation would be zero.

Finally, we examined trends in soybean backwardation and inventories. Both soybean backwardation and returns were very high in the early years of this study and show evidence of an upward trend toward the end. We demonstrate that both of these periods coincide with times of inventory pressure. This is consistent with our contention that tight inventory conditions are a driver of backwardation. Apparently, soybeans are still not produced and stored in sufficient quantity to allow soybeans to trade in structural contango.

The implication for investors in individual commodity markets is that one should consider performing the following analysis: an investor should evaluate what the structural shape of a market's futures curve is expected to be in the future based on trends in inventory pressure, given how important this factor has been (normally) in determining futures investment returns.

Endnotes

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Hilary Till would like to note that some of the ideas on the determinants of commodity futures returns were jointly developed with Joseph Eagleeye, co-founder of Premia Capital Management, LLC.

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Appendix

Annualized geometric price and roll returns, five-year periods and overall, 1950-2004.

1. Soybeans

Five Years Starting	Average Time in Backwardation	Average Backwardation	Annualized Excess Return	Annualized Spot Return	Annualized Roll Yield
1950	55%	3.9%	28.7%	4.3%	23.4%
1955	42%	0.6%	-1.8%	-5.3%	3.6%
1960	33%	0.3%	5.5%	5.7%	-0.2%
1965	42%	0.8%	2.6%	-2.4%	5.1%
1970	38%	1.6%	32.4%	23.2%	7.5%
1975	30%	0.1%	-3.0%	-1.4%	-1.6%
1980	7%	-1.8%	-13.2%	-2.5%	-10.9%
1985	25%	-0.6%	-2.6%	-0.1%	-2.5%
1990	13%	-1.0%	-6.6%	-0.7%	-5.9%
1995	27%	0.2%	-2.8%	-3.5%	0.7%
2000	45%	0.8%	7.2%	3.1%	4.0%
1950-2004	32.4%	0.46%	3.41%	1.59%	1.79%

2. Corn

Five Years Starting	Average Time in Backwardation	Average Backwardation	Annualized Excess Return	Annualized Spot Return	Annualized Roll Yield
1950	43%	0.3%	6.1%	3.4%	2.7%
1955	28%	-0.7%	-7.0%	-6.0%	-1.0%
1960	20%	-1.5%	-3.9%	2.1%	-5.9%
1965	22%	-1.3%	-6.2%	-0.8%	-5.4%
1970	35%	-0.5%	23.0%	23.1%	-0.1%
1975	22%	-1.5%	-8.5%	-3.3%	-5.4%
1980	17%	-1.7%	-8.0%	-1.4%	-6.6%
1985	22%	-1.1%	-6.1%	-2.3%	-3.9%
1990	13%	-2.0%	-10.3%	-0.7%	-9.6%
1995	25%	-0.7%	-6.6%	-2.4%	-4.3%
2000	7%	-3.0%	-15.4%	0.0%	-15.5%
1950-2004	23.03%	-1.24%	-4.35%	0.80%	-5.12%

3. Wheat

Five Years Starting	Average Time in Backwardation	Average Backwardation	Annualized Excess Return	Annualized Spot Return	Annualized Roll Yield
1950	30%	-0.3%	-0.2%	1.4%	-1.6%
1955	40%	0.8%	2.3%	-2.7%	5.1%
1960	28%	0.7%	-1.8%	-6.0%	4.5%
1965	10%	-2.0%	-9.0%	-0.3%	-8.7%
1970	60%	1.4%	36.0%	25.5%	8.4%
1975	23%	-1.5%	-6.6%	-0.2%	-6.5%
1980	7%	-3.0%	-19.0%	-5.2%	-14.5%
1985	43%	1.1%	8.0%	3.3%	4.5%
1990	40%	0.4%	-1.0%	-0.4%	-0.6%
1995	28%	-1.4%	-18.4%	-9.1%	-10.2%
2000	8%	-2.8%	-11.8%	4.4%	-15.5%
1950-2004	28.94%	-0.59%	-2.91%	0.63%	-3.52%