Backwardation and Commodity Futures Performance: *Evidence from Evolving Agricultural Markets*

BARRY FELDMAN AND HILARY TILL

BARRY FELDMAN
is a senior research analyst at the Russell Investment Group in Tacoma, WA and the founder of Prism Analytics.
bfeldman@russell.com and **barry@prismanalytics.com**

HILARY TILL
is a research associate at the EDHEC Risk and Asset Management Research Centre and the co-founder of Premia Capital Management, LLC in Chicago, IL.
till@premiacap.com

Commodity investment has often been suggested both as a stand-alone investment as well as an important diversifier to traditional stock and bond portfolios. For instance, Erb and Harvey [2006] 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 over the period December 1969 to May 2004. Erb and Harvey [2005] also show that diversification into commodities would have *historically* improved the performance of equity-dominated portfolios. Gorton and Rouwenhorst [2006] reach similar conclusions using an equally-weighted index of commodities over the period 1959 to 2004.[1]

The recent performance of commodities markets has spurred renewed interest in better understanding the various sources of return to performance of commodity investments (e.g., Anson [1998]; Greer [2000]; Nash and Symk [2003]; Heaney [2006], and Zulauf et al. [2006]). The sources of return to fully-collateralized commodity futures investments have often been broken down into three components: spot return, collateral return, and the roll yield. The *spot return* is generated from changes in the price of the spot (physical) commodity. In a collateralized commodity futures program, the investor sets aside funds in fixed-income instruments in the exact amount of the investor's commodity futures exposure. This results in a *collateral return*, which is generated from interest on the initial margin for a futures contract plus the additional invested capital held in fixed-income instruments. Therefore, commodity-futures-based investments offer gains or losses from changes in commodity values as well as from interest income. The third component of futures returns is often described as *roll yield*. Roll yield is captured when the futures markets are backwardated; that is, when the term structure of futures prices is downward sloping. As futures contracts underlying a commodity mature, they must be sold and further maturity contracts must be purchased. If the commodity futures market is backwardated, the maturing futures contracts will be sold at prices higher than those of the longer-dated contracts purchased, generating roll yield.

In the classical model of commodity futures pricing, which was successively developed by Kaldor [1939]; Working [1948]; Brennan [1958], and Telser [1958]; the return from purchasing a commodity and selling it for future delivery should, in the absence of arbitrage, equal the interest forgone plus the marginal storage cost less the marginal convenience yield for holding an inventory. This pricing model is also known as the theory of storage. For commodity markets to become backwardated, the convenience yield from holding the physical commodity must exceed the cost of physical storage plus the interest forgone.[2] The extent of backwardation existing in various commodities depends both on the actual commodity examined and the changing characteristics of that particular commodity market. In this article 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 study the performance of soybean, corn and wheat futures because of their relatively long available history. 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.

We also provide a detailed examination of backwardation for soybean futures. We provide a detailed analysis of soybeans because of the unique circumstances associated with the production of soybeans.[3] 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. Based on this example, we consider the implications of how a commodity's changing supply-and-demand characteristics affect a commodity futures contract's term structure and therefore, its future returns.

In the next section we provide a brief review of some of the relevant commodities literature as to the source of commodity futures returns, and the role of backwardation as a source of that return. In later sections we detail how our passive long agricultural futures portfolios are constructed; how backwardation is measured; and how the strength of the relationship between backwardation and commodity performance improves over longer time horizons. We also provide a more detailed examination of backwardation for soybean futures contracts. The case study on soybean futures considers two issues: 1) how structural changes in this market's supply-and-demand conditions likely caused corresponding changes in the futures contract's backwardation; and 2) how seasonality has affected the futures contract's term structure. We examine how each of these two issues has impacted the historical return of passive long positions in soybean futures. We then explore the implications of this research for commodity investors. The concluding section of the article summarizes our research.

BACKWARDATION AS A SOURCE OF COMMODITY RETURN

As noted, backwardation describes a term structure for futures prices where a contract closer to expiration trades at a higher price than a further-dated contract. Using the classical commodity futures pricing model, backwardation occurs when the convenience yield is greater than the risk-free rate plus the cost-of-storage. Numerous authors have demonstrated that backwardation occurs when there are insufficient or structurally low inventories for a commodity. More generally, the term is sometimes applied to forward prices other than those of futures contracts, when analogous price patterns arise. For example, if it costs more to lease silver for 30 days than for 60 days, it might be said that the silver lease rates are "in backwardation." The opposite market condition to backwardation is known as contango (see Appendix 2).

Extensive literature exists concerning the drivers of commodity returns and backwardation in particular. Keynes [1930] developed the classical theory of backwardation-driven commodities futures prices, wherein backwardation arises because of the risk aversion of commodity inventory holders. Kaldor [1939] expands this framework to include long hedgers; i.e., he also includes the case of commodity purchasers who need to reduce price risk. Hicks [1946] agreed with Keynes that hedgers were more 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.[4] This leads to a "congenital weakness" on the demand side of many commodity future contracts.

The modern theory of commodity pricing could be considered to start with Working [1948], who considered risk aversion to be a minor 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.

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 factors can prevent the risk premium from being bid to zero, including the magnitude of impediments to common participation in the futures 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] qualitatively consider difficult storage situations as a common factor in the historically positive performance of the gasoline, copper, and live cattle futures contracts.

Fama and French [1988], and Schneeweis, Spurgin, and Georgiev [2000] also identified a strong business cycle component in the variation of spot and futures prices of industrial metals. Fama and French [1987, 1988] perform tests of the theory of storage and present empirical evidence that in periods of increasing volatility and risk, convenience yields increase for a wide variety of metals prices (e.g., aluminum, copper, nickel and lead). The theory of storage splits the difference between the futures price and the spot price into the forgone interest from purchasing and storing the commodity, storage costs and the convenience yield on the inventory. Convenience yield is now seen as an embedded consumption timing option in holding a storable commodity. Further, the theory predicts an inverse relationship between the level of inventories and convenience yield: at low inventory levels convenience yields are high and vice versa. A related implication is that the term structure of forward price volatility generally declines with time to expiration of the futures contract—the so-called "Samuelson effect." While at shorter horizons mismatched supply-and-demand in the commodity will increase the volatility of cash prices, these forces should fall into equilibrium at longer horizons.

Litzenberger and Rabinowitz [1995] observe that oil futures prices are often backwardated. They explain the phenomenon with the existence of "real options" under uncertainty. They specifically model oil reserves as a "call option whose exercise price corresponds to the extraction cost." As uncertainty about the future price of oil increases, the (call option) value of reserves increases, motivating producers to leave oil in the ground. Strong backwardation occurs when futures prices are below current spot prices. In weak backwardation, discounted futures prices are below spot prices. The authors show that production occurs only if discounted futures prices are below spot prices, overcoming the option value of leaving oil in the ground. Strong backwardation emerges if the volatility of oil prices (and therefore the call option value of reserves) is sufficiently high. A major consequence of a declining term structure of forward prices for investment in commodity futures is the opportunity to capture a positive roll return as investment in expiring contracts is moved to cheaper new outstanding contracts.

More recent studies on oil futures, such as Milonas and Henker [2001], have directly linked the supply of storage to stocks and convenience yield. Similarly, Sorenson [2002] addressed the effect of the supply of storage on convenience yields for the same commodities studied here. These studies find a negative relationship between stocks and convenience yield, consistent with earlier theories (e.g., Working [1948]) of the impact of the supply of storage. The actual impact is, of course, commodity specific, as recently shown in Zulauf et al. [2006]. Zulauf et al. showed that for soybeans, issues with supply affect price variability, which in turn may have a direct impact on the expected returns associated with convenience yield.

Another line of research has been pursued by Liu [2005], who uses a cointegration framework to identify systematic interaction effects between prices for hogs, corn and soy meal futures contracts. Liu demonstrates systematic spill-over effects between these related markets.

THE CONSTRUCTION AND PERFORMANCE OF PASSIVE LONG FUTURES POSITIONS

We concentrate on estimating the extent of backwardation in three commodities for which an extensive history exists. In this study, commodity return indices are constructed 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 December 31, 1949 and ending on December 31, 2004. 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 soybean contracts in the roll order. We include September but exclude August contracts in order to obtain a regular pattern of semi-monthly contract rolls.[5]

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 contracts in the reported return.

We compare our commodity futures excess returns with those of the S&P 500. The S&P 500 total-return series was obtained from Ibbotson Associates. 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 excess returns are calculated in the familiar fashion as the equity series' total return minus the risk-free rate.

Exhibit 1 reports monthly excess return statistics for our indexes and S&P 500 excess returns from the period starting December 31, 1949.

Exhibit 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. Over the same period, the S&P 500 averaged 0.66% per month. Soybean performance is considerably stronger than either corn or wheat over the entire history of the study.

Exhibit 2 reports correlations, calculated using monthly data, between these excess-return indexes. All crop futures indexes have low correlations with the S&P 500. The returns to rolled long commodity futures positions can be seen to have almost zero correlation with equity markets and moderate mutual correlation.

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 then 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 the relevant investment reference point and therefore is used as the denominator in forming the percentage.

We calculate the average backwardation over an interval such as a year as the average of that year's monthly percentage-of-backwardation ratios.

Exhibit 3 shows aggregate backwardation statistics for soybean, corn and wheat contracts. 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 Exhibit 1.

EXHIBIT 1
Excess Returns: 1950–2004

	Soybeans	Corn	Wheat	S&P 500
Average monthly excess return	0.51%	-0.20%	-0.07%	0.66%
Annualized geometric excess return	3.41%	-4.35%	-2.91%	6.80%
Monthly std. dev	7.05%	5.92%	6.04%	4.14%
Skewness	1.86	1.80	0.98	-0.39
Kurtosis	13.23	12.41	5.79	1.71

EXHIBIT 2
Correlations: 1950–2004

Correlations	Soybeans	Corn	Wheat	S&P 500
Soybeans	100%			
Corn	67%	100%		
Wheat	43%	59%	100%	
S&P 500	-3%	2%	3%	100%

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 the price change in 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. Exhibit 4 shows aggregate statistics for the roll returns. There is a roll return only on the months when contracts are rolled. In our procedure, soybean futures are rolled six times a year while corn and wheat futures are rolled five times per year.

EXHIBIT 3
Backwardation Statistics 1950–2004

	Soybeans	Corn	Wheat
Average backwardation	0.46%	-1.24%	-0.59%
Standard deviation	4.74%	3.35%	4.15%
Skewness	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%

EXHIBIT 4
Roll returns 1950–2004

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

Note the approximate one-to-one correspondence between average roll returns and the average backwardations shown in Exhibit 3. Both statistics for each crop futures contract are measured over the same time intervals. For example, all soybean roll returns and backwardations are measured over two-month intervals. Over long periods of time, the levels of roll return and backwardation converge. Roll return is generated by backwardation. Appendix 1 presents annualized price and roll returns by five-year periods and over the complete history of this study.

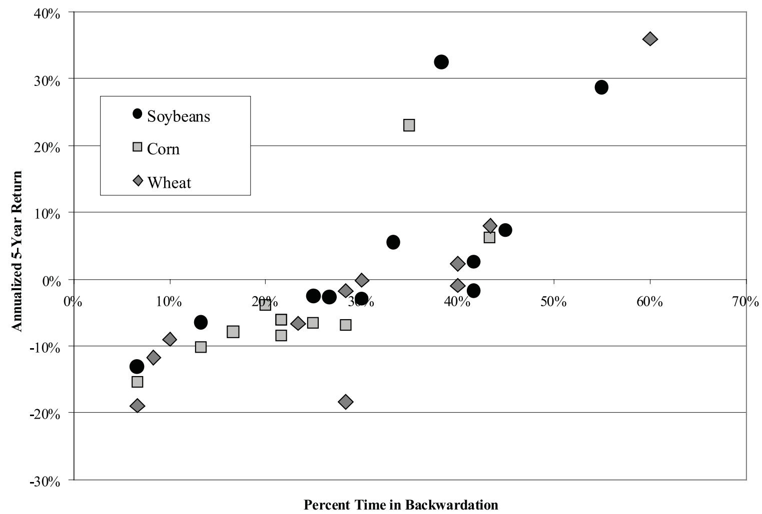
INVESTMENT HORIZON EFFECTS ON BACKWARDATION AND RETURN

Nash and Smyk [2003]; Gorton and Rouwenhorst [2006], and Erb and Harvey [2006] observe that the correlation between backwardation or roll return and the returns to a passive long position is high over long time horizons. Nash and Smyk [2003], and Erb and Harvey [2006] examine time periods beginning in the early 1980s running about 20 years. Gorton and Rouwenhorst [2006] analyze the period from 1959 to 2004. Exhibit 5 shows five-year soybean, corn and wheat annualized excess returns as a function of percentage-of-time in backwardation for five-year periods between 1950 and 2004. Percent time in backwardation is the fraction of time that a commodity's near-month futures contract price exceeds the deferred-contract's futures price. A strong positive correlation between backwardation and return at the five-year horizon is apparent.

The foregoing suggests that there is a gradual increase in the fraction of price variability explained by backwardation with increasing time horizon. Two of the outlier observations with large excess returns relative to their time-in-backwardation are from the period 1970–1974. This period saw unusually strong advances in spot prices

EXHIBIT 5

Five-Year Annualized Returns as a Function of Percentage-of-Time in Backwardation



due to a combination of short- and long-term factors including rising energy prices, monetary instability, U.S. grain sales to the U.S.S.R., and negative supply shocks such as corn blight.

We further study the effect of horizon on the relationship between excess return and backwardation and roll return by examining the percentage of return variance explained by these measures over increasing time intervals. Exhibit 6 presents the R-squared values of univariate regressions modeling excess returns as a function of percent-of-time in backwardation, average backwardation and roll 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.[6] The corresponding numbers for the single-crop regressions are 55, 27, 18, 11 and 7 observations. The resulting precision

EXHIBIT 6

Percentage of Excess-return Variance Explained as a Function of Time Horizon

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%

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 each of these factors increases greatly, if unevenly, with the length of the investment horizon. 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 five years, the percentages of explained variance are 64%, 64% and 67%, respectively. The power of backwardation to explain returns increases greatly with time horizon.

TRENDS OVER TIME

We have shown that the importance of backwardation increases with the investment horizon. Exhibit 7 shows how soybean backwardation changed over time. Soybean average backwardation is 2.28% over the 1950–1959 period and strongly statistically significant ($p < 0.005$). This is consistent with an explanation that inadequate inventories were a factor in soybean price dynamics during this period. The next section shows that inventories were indeed exceptionally low at the time. A generally downward trend in backwardation is then visible through the 1980–1989 period, with 1970–1979 an exception to the trend. Soybean backwardation then increases for 1990–1999 and 2000–2004. Over the entire period, 1950–2004, soybean backwardation is positive and strongly statistically significant ($p = 0.001$). The overall trend in backwardation will be seen to parallel inventory trends, as would be predicted by the theory of storage.

Corn is in contango during each period. This result is statistically significant overall and in every period except for 1950–1959. 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.

Exhibit 8 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, but only the 1.11% average excess return in 1950–1959 is statistically significant ($p = 0.022$). Soybean average excess return over the entire history, 0.51%, is statistically significant ($p = 0.062$). Overall these results suggest that the development of soybean production and storage facilities has not matched demand to nearly the same degree as have corn and wheat, as will be briefly touched upon in the next section.

SOYBEANS: A CASE STUDY

Changing Characteristics of Soybean Production and Consumption: Implications for Commodity Backwardation

Exhibit 9 graphically displays the relationship between backwardation and remaining days-of-inventory for soybeans over the period 1950 to 2004. This graph is consistent with what would be predicted by the theory-of-storage.

EXHIBIT 7

Average Backwardation by Time Period

Period	Soybeans	Corn	Wheat
1950 -1959	2.28% +	-0.20%	0.27%
1960 -1969	0.59% o	-1.40%*	-0.65%
1970 -1979	0.88% o	-0.98%*	0.00%
1980 -1989	-1.18%*	-1.41%*	-0.98% o
1990 -1999	-0.41% o	-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%, *: < 0.1%.

EXHIBIT 8

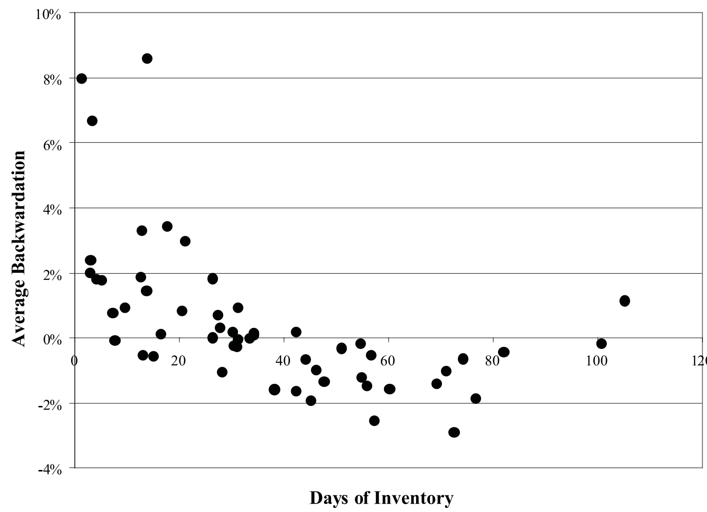
Average Monthly Excess Returns by Time Period

Period	Soybeans	Corn	Wheat
1950 -1959	1.11% o	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%, *: < 0.1%.

EXHIBIT 9

Soybean Backwardation as a Function of Remaining days of Inventory, 1950–2004



The observed trend in soybean backwardation and investment performance over time has been closely related to clearly visible aspects of the production and distribution of soybeans.

Soybean cultivation in the U.S. was initiated chiefly as a replacement for oats in crop-rotation schemes. Soybean oil was the first soy product of commercial value. 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.[7] In general, soybean demand was highly variable. One of the most important reasons was that the production of soymeal substitutes such as cottonseed and linseed meals was not price-sensitive. 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 from early in our sample demonstrate that soybean supply was more vulnerable than corn and wheat supplies. Exhibit 10 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.

Soybean inventories are tracked by U.S. Department of Agriculture statistics. The average stocks-to-use ratio for soybeans[8] is 2.9% over the period 1950 to 1959, and it increases to 11.3% over the period 1960 to 2004. For the

EXHIBIT 10

Ratio of Minimum to Peak Visible Supply 1950–1960

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.

period 1995 to 2004, the average stocks-to-use ratios for soybeans, corn and wheat were 8.6%, 14.4% and 30.3%, respectively.[9] Soybean inventories are relatively much higher now than during the 1950s but remain considerably lower as a fraction of consumption than stocks for corn and wheat.

Regarding recent trends, soybean exports—first from Brazil and then from Argentina—have become 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 for 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 have tracked together very closely. The availability of South American soybeans appears to have indirectly been reflected in U.S. stock levels.

It is perhaps surprising that rising exports from Brazil and Argentina have not been 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 that 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.[10]

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.

Seasonality

The previous section illustrates the relationship between backwardation and changing structural factors. In addition, the underlying price process must be considered. Agricultural prices are seasonal. Fama and French [1987] and other authors have noted that futures prices tend to increase for expiration dates before harvests and to fall across harvests. They 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.

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. Backwardation during these months is due to the tendency of the July contract to trade at a premium relative to the September contract. If prices were expected to be stable, this is a signal of expected return on 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.[11] 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 apparent over a span of years.[12]

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. Exhibit 11 presents soybean backwardation, return, and price changes over the period 1951 to 2004, but excluding 1970 to 1974. The first row presents

EXHIBIT 11

Seasonal Backwardation, Returns and Prices for Soybean Contracts: 1951–2004 Without 1970–1974

Measure	Dec-Jan	Feb-Mar	Apr.-May	Jun-Jul	Aug-Sep	Oct-Nov
Backwardation	-1.27%*	-1.08%*	-0.72%+	4.61%*	1.00%*	-1.63%*
Contract return	-1.52%	2.03% o	0.47%	-1.51%	0.20%	1.20%
Spot return	-0.84%	2.59%	1.21%	-5.48%+	-0.77%	3.35%*

Statistical significance levels: o: < 10%, +: < 1%, *: < 0.1%.

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. The contract is always the next 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 over the same period.

The average backwardation over the 49 years covered in Exhibit 11 is 0.153%. The average contract return is 0.146%. The average spot price return is 0.01%. Thus, the 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.

Exhibit 11 suggests that seasonality leads to a reordering of the incidence of backwardation and return over the crop cycle. The 2.03% average return on the May contract over February to March is statistically significant ($p = 0.063$).[13] This return is most likely associated with the conditions that generate June backwardation. The correlation between February to March returns and June backwardation over the period covered in Exhibit 11 is 50%, while the correlation of June backwardation and the June-to-July returns of the September contract is 1%. This suggests that the May contract over March to April reflects changes in market expectations due to supply shocks later reflected in July price rises. These expectations are not reflected in September prices due to the new harvest, generating backwardation.

Thus, high levels of backwardation near the end of the crop cycle 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 annual backwardation is still an important determinant of annual return. Short-term price variability leads to considerable differences between average return and average backwardation over short periods of time. But as the time horizon increases, this relationship becomes increasingly clear.

IMPLICATIONS FOR INVESTORS

In their research on commodity futures, Erb and Harvey [2006] emphasize that it is important not to simply extrapolate past returns into the future. 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 merely 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? Investors need 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 our historical results is that while normally over five-year periods an agricultural futures contract's curve shape[14] has been the driver of returns, there is one exception: the 1970 to 1974 period was a time of extraordinary changes in spot commodity prices. What this means for an investor is that there can be an additional, fundamental rationale for a long-term, passive investment in individual commodity futures contracts *besides* predicting structural backwardation in a futures contract.

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 frequently in contango, negative returns were realized. The trend in spot prices has been a secondary 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 contracts 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 percentage-of-time-in-backwardation rises from 19% at a one-year horizon to 64% using five-year time periods.

While average annual backwardation is a good, if noisy, predictor of return, we find that backwardation is a much less reliable short-term predictor because of 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 likely 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, as has been noted by previous authors. 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 returns.

We also find that the unusually high levels of backwardation and return for soybeans in the 1950s were concurrent with tight inventories. Hieronymus [1949] documents that existing storage was not adequate for soybeans in his time. Also, we compile visible inventory statistics for this period showing that soybean supplies were effectively exhausted before the new harvest until the late 1950s.

In brief, an understanding of potential returns to various commodity futures contracts requires a more detailed understanding of both the underlying dynamics of the futures contract itself as well as the conditional factors driving the markets in which it trades.

APPENDIX 1

Annualized Geometric Price and Roll Returns, Five-Year Periods and Overall, 1950–2004

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%

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%

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%

APPENDIX 2

[A] Cost of Carry Arbitrage Models and [B] Convenience Yield Estimation

[A] Cost-of-Carry Arbitrage Model

Convenience yield can be presented as an extension of the simple cost-of-carry model. In this model, the futures price equals the spot price plus the cost of financing the spot position to the maturity of the futures contract minus any yield missed from holding the futures (vs. spot) position over this same time period.

$$F_{0-T} = S_0 e^{rT} - De^{r(T-t)}$$

The current time (when a futures contract can be bought or sold for future delivery) is defined as time = 0. The expiration date on the contract is defined as time = T. So the price today on the futures contract with an expiration term of T is defined as F_{0-T}. The spot price of the asset underlying this contract when it is bought or sold is defined as S_0. Time in between today (0) and expiration (T) is defined by t, where $0 < t < T$. At expiration of the contract, the market price of the underlying asset is defined as S_T.

This equation is identical to that for a single-stock futures contract on a stock that pays a dividend at time T-t. But commodities, unlike stocks, does not pay a dividend D at time t. Instead, there is a storage cost associated with the commodity. So the futures price equals the spot price plus the cost of financing the spot position plus the storage costs (W) of holding the commodity due at time T-t.

$$F_{0-T} = S_0 e^{rT} + We^{r(T-t)}$$

Storage costs are often treated like the dividend yield on a stock index—paid continuously over the life of the contract (T) as a percent of the value of the inventory (S_0)—allowing us to express the futures price as:

$$F_{0-T} = S_0 e^{(r+w)T}$$

With the exception of a sign change in the exponent (+w instead of –q), this equation is identical to the one for pricing futures on stock indexes with a continuous dividend yield of q.

[B] Futures Pricing With Convenience Yield

The simple cost-of-carry model may not apply a) when markets are not easily arbitraged; or b) if the costs of storage and transport are important; or c) when pricing is regional. Also, certain participants have to hold inventory for production processes independent of any financial-arbitrage considerations. The result is the following inequality for pricing consumption commodity futures contracts that are not held strictly for investment purposes:

$$F_{0-T} < S_0 e^{(r+w)T}$$

The concept of a "convenience yield," y, is the yield that coverts the above inequality into an equality:

$$F_{0-T} = S_0 e^{(r+w-y)T}$$

ENDNOTES

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

[2]This can be stated mathematically as $F(t,T) = S(t) + S(t)R(t, T) + C(t, T) - Y(t, T)$ where F(t, T) is the futures price at time t for delivery of the commodity at time T, S(t) is the spot price of the commodity, S(t)R(t, T) is the interest income forgone by purchasing the commodity, C(t, T) is the storage cost, and Y(t, T) is the convenience yield.

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

[4]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.

5Our 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.

6Time 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.

7Hieronymous [1949] wrote: "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."

8More specifically, the ratio is of September 1 inventories of the current year divided by the sum of total production and September 1 last-year inventory minus September 1 current-year inventory.

9Soybean 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*.

10Cronin (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.

11The year 1950 is not included because the September 1950 soybean contract was not traded.

12Let 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 $E_i(F_{jj})/F_{ij}-1 = E_i(P_j)/F_{ij}-1$, where E_i is the expectation at month i. The difference between backwardation and expected return is then $(E_i(F_{jj}) - P_i)/F_{ij}$. 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 $E(P_1) = E(P_{13})$. 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.

13Note that these returns do not agree exactly with the returns generated by the rolling procedure because rolling takes place during the fifth to ninth trading days at the beginning of these bimonthly periods.

14By 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."

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