Rollover Hedging

B. Sam Yoon

and

B. Wade Brorsen *

Paper presented at the NCR-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management

Chicago, Illinois, April 17-18, 2000

* Graduate research assistant (*yoon@okstate.edu*) and regents professor (*brorsen@okstate.edu*), Department of Agricultural Economics, Oklahoma State University.

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Practitioner's Abstract

Both market advisors and researchers have often suggested rollover hedging as a way of increasing producer returns. This study tests whether rollover hedging can increase expected returns for producers. For rollover hedging to increase expected returns, futures prices must follow a mean-reverting process. Using both the return predictability test based on long-horizon regression and the variance ratio test, we find that mean reversion does not exist in futures prices for corn, wheat, soybeans, soybean oil and soybean meal. The findings are consistent with the weak form of market efficiency. The results of the study imply that rollover hedging should not be seriously considered as a marketing alternative. As long as the commodity markets are efficient, the efforts of producers to improve returns through market timing strategies will meet limited success over time.

Keywords

Rollover hedging, mean reversion, market efficiency

Introduction

When agricultural commodity prices are unusually high, it is tempting for producers to try to lock in prices for several years of production at the high levels. Some have argued that producers can capture the benefits of higher prices over an extended period of time by rollover hedging (Gardner, 1989; Kenyon and Beckman, 1997). Rollover hedging recommendations were also made in the popular press and extension literature when crop prices were high as recently as 3-4 years ago. For example, *Farm Journal* economist, Bob Utterback, recommended the following strategy in the "Outlook" (*Farm Journal,* 1996).

> The trigger for selling multiple years' crops is a close in the lead-month futures below the 18-day moving average; we'll buy September put options two strikes in the money. My plan is to price 100% of expected 1997 production when the trigger is tripped, and the '98 and '99 crops if the trigger occurs above $4. Then we'll convert the put options to futures when weather scares are past, and just keep rolling them forward.

The price changes of agricultural commodities in recent years have been dramatic and major crops recorded historical highs in mid-1996 and prices are now quite low. The price variability of agricultural commodities is expected to increase since the 1996 farm bill is more market-oriented and removes target prices for wheat, feedgrains and cotton. With larger price volatility, the interest in rollover hedging is likely to increase.

The available empirical literature (Gardner, 1989; Huang, Turner, and Houston, 1994; Kenyon and Beckman, 1997; Conley and Almonte-Alvarez, 1998) suggests that rollover hedging is poorly understood. This literature has used sample sizes that are too small to be conclusive and also generally fails to recognize the connections between rollover hedging, market efficiency, and the underlying stochastic process.

A recent survey of extension marketing economists found that a majority of extension economists did not disagree with the statement that rollover hedging can increase expected returns (Brorsen and Anderson, 1999). Given the widespread failure of hedge-to-arrive contracts, the survey result is very surprising. Lence and Hayenga (1998) argues that it is infeasible for hedge-to arrive contracts involving interyear rollover hedging to lock in high current prices for crops to be harvested one or more years in the future. Yet, their results still leave open the possibility of a small increase in returns.

For rollover hedging to increase expected returns, price movements in agricultural markets should follow a mean reversion process, where price is expected to change in a direction toward its underlying fundamental value whenever it deviates from the underlying value (Ross, 1997). A mean reversion price process violates the efficient market hypothesis that is associated with the assertion that future price changes are unpredictable. As long as prices have any tendency to gravitate back to their fundamental values, they will be mean reverting over long horizons, which in turn suggests that prices are somewhat predictable and not a random walk. If markets are efficient, futures prices should follow a random walk, but cash prices should be mean reverting.

Time-varying risk premium (Fama and French, 1987) and investor overreactions (De Bondt and Thaler, 1989) are widely viewed as a potential source of mean reversion. The risk premium which varies over time is the difference between the expected spot price and the prevailing futures price. The existence of a risk premium is the result of a net hedging imbalance. The larger the risk premium, the greater are the speculative demand for futures contracts and the magnitude of the expected price change. However, Kolb (1992) shows that futures markets for grains such as wheat, corn and oats exhibit no risk premium.

This paper primarily aims to determine whether rollover hedging can be used to increase mean returns for producers. Specifically, this study will determine if agricultural cash and futures prices are mean reverting. Futures prices must be mean reverting for rollover hedging to increase expected returns.

Theory

The rationale for hedging is to trade a greater price risk for a lesser basis risk. This simply means that hedgers choose to assume basis risk as a trade-off for eliminating the price risk they would have if they did not hedge, presumably because the basis risk is less than the price risk (Edwards and Ma, 1992).

Typical hedges are performed using nearby futures contracts. The most common reasons for using nearby futures contracts are that liquidity is much better in nearby contracts than in distant contracts, and that more distant futures contracts may not be available on reasonable terms.

Rollover hedging is different from standard hedging in that it involves continuously switching from a nearby futures contract to a more distant futures contract. In rollover hedging, the hedger first opens a position in a nearby futures contract and later closes it while simultaneously opening the same position using a more distant futures contract.

Economic theory suggests that the underlying value of the product traded in a competitive market such as agricultural commodities should be equal to the total economic cost of production. A price that is relatively higher (lower) than the cost of production sends an economic signal to increase (decrease) production. Consequently, price should return to its cost of production over time, even though there may exist lagged adjustments of supply and demand in response to price changes. Thus, cost of production should equal the long-term equilibrium price.

With the relationship between the cash and futures prices, the concept of cointegration suggests that prices from two efficient markets for the same asset are cointegrated, whereas, prices from two efficient markets for different assets can not be cointegrated (Schroeder and Goodwin, 1991; Chowdhury, 1991; Lai and Lai, 1991; Krehbiel and Adkins, 1993). Cointegration suggests that price changes in one market are reflected by equilibrating changes in the other market. Although significant short-run deviations may be observed, economic forces should prohibit persistent long-run deviations from equilibrium. Since cash and futures prices do not represent the same asset except during the delivery period, cash and futures prices should not be cointegrated.

Data and Procedures

The agricultural commodities chosen for the analysis of mean reversion in futures prices are corn, wheat, soybeans, soybean oil, and soybean meal. Futures prices from the Chicago Board of Trade are obtained from Annual Report of the Board of Trade of the City of Chicago and from a computer database compiled by Technical Tools, Inc. The data period for corn and wheat begins in January 1891 and ends in December 1999. The data period for soybeans runs from January 1951 to December 1999. The data period for soybean oil and soybean meal runs from January 1959 to December 1999.[1]

To test for mean reversion in agricultural futures prices, return horizons of 1, 3, and 6 months are examined. For each return horizon, the closing price of the corresponding nearby futures contract observed on the first trading day of the beginning month of the *k*-month horizon is used as the beginning price. The closing price of the corresponding nearby futures contract observed on the first trading day of the end month of the *k*-month horizon is used as the ending price. For example, for 3 month return horizon from January through April, the closing price of the May futures contract observed on the first trading day in January is used as the beginning price, and the closing price of the May futures contract observed on the first trading day in April is used as the ending price. The *k*-month returns are defined as the natural logarithmic difference between the beginning price and the ending price of the *k*-month horizon.

The agricultural commodities chosen for the analysis of mean reversion in cash prices are corn, soybeans, and wheat. For cash grain prices, monthly data from 1908 to 1999 were obtained from National Agricultural Statistics Service (NASS) of the U.S. Department of Agriculture. The cash prices are U.S. average prices received by farmers and denoted in dollars per bushel. Return horizons of 1, 3, 6, 12, 24, and 36 months are examined.

The seasonal factors in cash prices may affect the slope coefficient of the long-horizon regression that will be used in the following return predictability test. The seasonality is removed by including a set of monthly dummies as regressors.

In order to test for mean reversion, the underlying mean value of the commodities must be estimated. In this study, 5-year moving averages are used to estimate the mean value of each commodity. A 5-year moving average is often used in the literature as a reasonable proxy for underlying value since it averages prices across a variety of supply and demand conditions and thus smoothes out the effect of weather on yield in any one crop year. The futures prices used to calculate the 5-year moving averages are closing prices for the futures contract nearest to

[1] This study planned to extend the data period of each commodity to the launch date of each futures contract. But, in early years after the introduction of futures contracts, the trading volume was extremely low and prices of only a few nearby contracts were irregularly reported. These years might be considered as a learning period during which markets learn how to price new contracts, and thus, were excluded from the price series. The launch dates of futures contracts are as follows: corn and wheat, January 2, 1877; soybeans, October 5, 1936; soybean oil, July 17, 1950; soybean meal, August 19, 1951.

maturity on the first trading day of each calendar month. For example, the 5-year moving average for January 1999 is the sum of the nearby closing futures prices on the first trading day of each month from January 1994 through December 1998 divided by sixty.

In previous studies, three general approaches are employed to test for mean reversion. The first approach uses autocorrelation coefficients and involves regressing multiperiod returns on lagged multiperiod returns (Fama and French, 1988; Kim, Nelson, and Startz, 1991). That is, the cumulative return from period t to period t + T is regressed on the return from t - T to t. If prices are a random walk, then the slope coefficient in the regression should be zero. If prices are mean reverting, then the regression slope should be negative.

The second approach is a return predictability test using information on fundamentals (Cutler, Poterba, and Summers, 1991; Irwin, Zulauf, and Jackson, 1996). This approach regresses observed market price movements over various return horizons on the deviation of current price from an estimate of fundamental value. A significant regression slope coefficient is considered evidence of return predictability, and implies mean reverting price behavior.

The third approach uses variance ratios (Poterba and Summers, 1988; Cochrane, 1988; Lo and Mackinlay, 1988; Kim, Nelson, and Startz, 1991). This approach exploits the fact that if the logarithm of prices follows a random walk, then the return variance should be proportional to the return horizon. That is, the return variance of a random walk is a linear function of the length of the time interval. The variance ratios are scaled so that if returns are uncorrelated through time, the ratios converge to 1 (random walk). While a variance ratio of less than one implies negative serial correlation (mean reversion), a ratio greater than one implies positive serial correlation.

The variance ratio test is closely related to the regression test based on estimated autocorrelations. Lo and Mackinlay (1988) show that the variance ratio is equal to a linear combination of autocorrelation coefficients. Poterba and Summers (1988) show that the variance ratio tests are more powerful than regression tests based on autocorrelation coefficients. In this context, this study employs the return predictability test and the variance ratio test for mean reversion.

Return Predictability Test

This test examines whether the information on the deviation of current market prices from estimates of underlying mean value has forecast power for returns over various horizons. We study returns over different horizons by estimating the following form of regression equations:

$$(\ln P_{t+k} - \ln P_t) = \alpha_k + \beta_k(\ln M_t - \ln P_t) + \varepsilon_{t+k} \qquad (1)$$

where P_{t+k} is the market price (cash, futures) at the end of the return horizon, P_t is the market price (cash, futures) at the beginning of the return horizon, and M_t is an estimated mean value at the beginning of the return horizon. The logarithmic price relative $\left(\ln P_{t+k} - \ln P_t\right)$ is the continuously compounded return over the period of k-months.

The estimated coefficient $\boldsymbol{b}_k$ is interpreted as the rate of mean reversion, meaning the fraction of the price deviation from the underlying mean value that is adjusted over a k-month horizon. If the current price is one percent below (above) the mean value, then returns will be increased (decreased) by $0.01\boldsymbol{b}$ over the next k months.

Overlapping sample periods are used in this study. Ordinary least squares (OLS) can produce consistent parameter estimates in this case, but the usual standard errors estimated are biased due to serial correlation in the error terms (Harri and Brorsen, 1998). In this study, the standard errors of regression coefficients are bias-adjusted using Newey-West (1987) correction method. The Newey-West method is consistent, but tends to underestimate standard errors in small samples.[2]

Another caution is that since the underlying mean value of commodities is estimated imprecisely by using proxy variables, that is, 5-year moving averages, measurement error may be present. This measurement error causes a bias towards zero in the estimate of the regression coefficient $\boldsymbol{b}_k$.

Variance Ratio Test

The variance ratio approach of Lo and MacKinlay (1988) uses the fact that if the natural logarithm of a price series P_t follows a random walk process, then the variance of k-period returns should equal k times the variance of one-period returns. The general k-period variance ratio statistic VR(k) is defined as:

(2) $$VR(k) = \frac{Var[r_t(k)]}{k \cdot Var[r_t(1)]} = \frac{\boldsymbol{s}^2(k)}{k \cdot \boldsymbol{s}^2(1)} = 1 + 2\sum_{t=1}^{k-1}\left(1 - \frac{t}{k}\right)\boldsymbol{r}(t),$$

where $r_t(k) = r_t + r_{t-1} + \cdots r_{t-k+1}$, that is, k-period continuously compounded return, $r_t(1)$ is a one-period return, and $\rho(t)$ is the tth-order autocorrelation coefficient of return series r_t. Equation (2) shows that VR(k) is a particular linear combination of the first t-1 autocorrelation coefficients of return series r_t, with linearly declining weights.

Lo and MacKinlay show that the variance ratio estimator can be calculated as follows:

[2] Harri and Brorsen (1998) showed that when dealing with the overlapping data problem, generalized least squares (GLS) estimator is often superior to the conventional Newey-West estimator. But, since lagged dependent variables are used as explanatory variables, GLS is not the preferred estimator here.

(3) $$\sigma^2(k) = \frac{1}{m}\sum_{t=k}^{nk}\left(P_t - P_{t-k} - k\hat{\mu}\right)^2,$$

where $$m = k\left(nk - k + 1\right)\left(1 - \frac{k}{nk}\right).$$

and

(4) $$\sigma^2(1) = \frac{1}{\left(nk-1\right)}\sum_{t=1}^{nk}\left(P_t - P_{t-1} - \hat{\mu}\right)$$

in which $$\hat{\mu} = \frac{1}{nk}\sum_{t=1}^{nk}\left(P_t - P_{t-1}\right) = \frac{1}{nk}\left(P_{nk} - P_0\right),$$

where P_0 and P_{nk} are the first and last observation of the price series. The asymptotic variance of the variance ratio under homoscedasticity, $\psi(k)$, is:

(5) $$\psi(k) = \frac{2(2k-1)(k-1)}{3k(nk)}.$$

The standard Z test statistic under the assumption of homoscedasticity, $Z(k)$, is:

(6) $$Z(k) = \frac{VR(k) - 1}{\left[\psi(k)\right]^{\frac{1}{2}}} \stackrel{a}{\rightarrow} N(0,1),$$

where $\stackrel{a}{\rightarrow}$ indicates that the standardized test statistic is asymptotically normally distributed.

Results

In this section, the results of mean reversion tests on agricultural futures and cash prices are reported. The results of both return predictability tests and variance ratio tests are presented.

Mean Reversion Tests of Futures Prices

The evidence on the forecast power of the difference between fundamental mean value and current futures price is presented in Table 1. The estimated β coefficients are not statistically significant at the 5 percent level except for corn with a one-month return horizon. But, the negative β coefficient of –0.02 is not interpreted as the evidence of mean reversion, since it suggests mean aversion rather than mean reversion. Overall, the regression R^2 values are extremely low. R^2 value represents the percentage of the observed change over the return horizon that is explained by the difference between futures price and the mean value at the beginning of the return horizon. Thus, the deviation of futures price from its estimated mean value explains at most 1.0 percent of the observed change in futures price.

The evidence presented in Table 2 suggests that we generally fail to reject the null hypothesis of random walk for every return horizon across all commodities, except for corn with a 3-month return horizon. Under the random walk null hypothesis, the value of the variance ratio is 1.0. To find mean reversion in futures prices, the variance ratio should be less than 1.0, meaning negative serial correlation, and the *Z*-statistic should be statistically significant.

Compared with the conventional critical value, which is 1.96 for the 5% level, all the *Z*-statistics, except for corn with a 3-month return horizon, indicate that the variance ratios, VR(*k*), are not significantly different from 1.0. The variance ratio for corn with a 3-month return horizon is 1.10, implying that there is a positive serial correlation. The variance ratio of 1.10 implies that 3-month returns for corn have an autocorrelation coefficient of 10%. These results provide no evidence for mean reversion in agricultural futures prices. The results are consistent with those of return predictability tests.

Table 1. Results of Return Predictability Tests Using Futures Prices

Commodity	Return Horizon (*k* months)	Data Period	Number of Observations	$\boldsymbol{b}_k$	*t*-statistic	R^2
Corn	1	1891-1999	1,200	-0.02	-2.06*	0.01
	3	1891-1999	1,198	-0.04	-1.65	0.01
	6	1948-1999	618	0.06	1.23	0.01
Wheat	1	1891-1999	1,193	-0.00	-0.34	0.00
	3	1891-1999	1,191	-0.01	-0.24	0.00
	6	1948-1999	618	0.06	0.93	0.01
Soybeans	1	1951-1999	526	0.02	0.81	0.00
	3	1951-1999	524	0.07	1.04	0.01
	6	1957-1999	509	0.07	0.88	0.01
Soybean Oil	1	1959-1999	431	-0.01	-0.26	0.00
	3	1959-1999	429	0.02	0.26	0.00
	6	1959-1999	426	0.08	0.80	0.01
Soybean Meal	1	1959-1999	431	0.02	0.56	0.00
	3	1959-1999	429	0.05	0.66	0.01
	6	1959-1999	426	0.06	0.56	0.00

Note: The estimated regression equation is $(\ln P_{t+k} - \ln P_t) = \boldsymbol{a}_k + \boldsymbol{b}_k (\ln M_t - \ln P_t) + \boldsymbol{e}_{t+k}$ where $(\ln P_{t+k} - \ln P_t)$ is the continuously compounded return in futures prices from month *t* to month *t*+*k*, and $(\ln M_t - \ln P_t)$ is the natural logarithmic difference between the estimated mean value on the first trading day of month *t* and the closing futures price on the first trading day of month *t*. The *t*-statistics are bias-corrected using the Newey-West procedure.

Table 2. Results of Variance Ratio Tests Using Nearby Futures Price Series

Commodity	Return Horizon (*k* months)	Data Period	Number of Observations	Variance Ratio [VR(*k*)]	*Z*-statistic
Corn	3	1891-1999	1,257	1.10	2.28*
	6		1,254	1.12	1.66
Wheat	3	1891-1999	1,250	1.06	1.45
	6		1,247	1.03	0.47
Soybeans	3	1951-1999	583	1.11	1.78
	6		580	1.04	0.41
Soybean Oil	3	1959-1999	488	0.98	-0.28
	6		485	0.96	-0.39
Soybean Meal	3	1959-1999	488	1.09	1.41
	6		485	1.04	0.34

Note: The variance ratio is $VR(k) = \frac{\sigma^2(k)}{k \cdot \sigma^2(1)}$ where $\sigma^2(k)$ is the variance of k-month returns and $\sigma^2(1)$ is the variance of one-month returns. The null hypothesis is that VR(k)=1, meaning that futures prices follow a random walk process. The *Z*-statistic marked with asterisk indicates that the corresponding variance ratio is statistically different from 1.0 at the 5% level of significance.

Mean Reversion Tests of Cash Prices

The evidence on the forecast power of the difference between fundamental mean value and current cash price is presented in Table 3. The results show that we generally find mean reversions across commodities when the return horizons are over 6 months. The estimated β coefficients for all commodities over 6-month return horizon are greater than zero at the 5 percent level. The β coefficient of corn for 6-month return horizon suggests that 11 percent of a price deviation from the mean value is adjusted over the subsequent 6 months.

When only the regression coefficients of statistical significant are considered, there is a tendency for β to increase as the return horizon grows. This finding that β increases as the return horizon increases is consistent with studies in stock markets which also tend to find more evidence of mean reversion at longer horizons (Fama and French, 1988; Porterba and Summers, 1988).

Table 3. Results of Return Predictability Tests Using Cash Prices

Commodity	Return Horizon (k months)	Data Period	Number Of Observations	b_k	t-statistic	R^2
Corn	1	1908-99	1,043	0.00	0.06	0.21
	3		1,041	0.03	1.43	0.23
	6		1,038	0.11	2.72*	0.20
	12		1,032	0.25	5.36*	0.07
	24		1,020	0.53	9.74*	0.17
	36		1,008	0.69	14.98*	0.23
Wheat	1	1908-99	1,043	-0.00	-0.28	0.07
	3		1,041	0.01	0.59	0.08
	6		1,038	0.04	2.12*	0.06
	12		1,032	0.11	2.55*	0.02
	24		1,020	0.33	5.82*	0.07
	36		1,008	0.52	9.96*	0.13
Soybeans	1	1824-99	851	0.01	0.55	0.11
	3		849	0.05	1.58	0.17
	6		846	0.12	2.50*	0.16
	12		840	0.24	4.08*	0.06
	24		828	0.38	6.39*	0.09
	36		816	0.37	7.39*	0.08

Note: The estimated regression equation is $(\ln P_{t+k} - \ln P_t) = a_k + b_k(\ln M_t - \ln P_t) + e_{t+k}$ where $(\ln P_{t+k} - \ln P_t)$ is the continuously compounded return in futures prices from month t to month $t+k$, and $(\ln M_t - \ln P_t)$ is the natural logarithmic difference between the estimated mean value on the first trading day of month t and the closing futures price on the first trading day of month t. The t-statistics are bias-corrected using the Newey-West procedure. The test statistics marked with asterisks indicates that the corresponding regression coefficients are statistically significant at 5% level.

Table 4 presents the results of variance ratio tests for deseasonalized cash prices. The variance ratios for corn are all greater than 1.0, ranging from 1.62 with k=3 to 2.03 with k=12. The variance ratios for corn imply that there exists a positive serial correlation in multiperiod returns. The variance ratios for wheat and soybeans show that multiperiod returns are uncorrelated when return horizons are over 24 months. The results provide little evidence for mean reversion in cash prices.

Table 4. Results of Variance Ratio Tests Using Deseasonalized Cash Prices

Commodity	Return Horizon (k months)	Data Period	Number Of Observations	Variance Ratio [VR(k)]	Z-statistic
Corn	3	1908-99	1,101	1.62	13.73*
	6		1,098	1.92	12.40*
	12		1,092	2.03	9.11*
	24		1,080	1.93	5.59*
	36		1,068	1.68	3.34*
Wheat	3	1908-99	1,101	1.35	6.86*
	6		1,098	1.36	4.29*
	12		1,092	1.48	3.69*
	24		1,080	1.32	1.70
	36		1,068	1.10	0.44
Soybeans	3	1924-99	909	1.35	7.14*
	6		906	1.41	5.07*
	12		900	1.37	2.98*
	24		888	1.19	1.07
	36		876	0.98	-0.09

Note: The variance ratio is $VR(k) = \frac{s^2(k)}{k \cdot s^2(1)}$ where $\sigma^2(k)$ is the variance of k-month returns and $\sigma^2(1)$ is the variance of one-month returns. The null hypothesis is that $VR(k)$=1, meaning that cash prices follow a random walk process. The Z-statistics marked with asterisks indicate that the corresponding variance ratios are different from 1.0 at the 5% level of significance.

Conclusions

In this study, the existence of mean reversion in agricultural cash and futures prices was tested to determine whether rollover hedging can increase mean returns. This study used the longest set of price data ever evaluated. A long data set enhances the statistical power of the analysis, in part because it contains a more diverse set of market and weather conditions.

Using both return predictability test and variance ratio test, we found that mean reversion does not exist in futures prices for corn, wheat, and soybean complex, but we found conflicting results for cash prices for corn, soybeans, and wheat. The findings on futures prices are consistent with the weak form of market efficiency suggested by Fama (1970), because information available at the beginning of the forecast period does not help to predict subsequent market price changes.

The results in this study imply that it is very likely that the use of rollover hedging as a marketing alternative may end up in a total waste of time. Zulauf and Irwin (1998) also show that for most field crop producers, marketing strategies have limited ability to enhance income. As far as the commodity markets are efficient, the efforts of producers to improve returns through market timing strategies will meet limited success over time.

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