A MARKETING STRATEGY FOR COTTON PRODUCERS BASED ON MEAN REVERSION IN COTTON FUTURES PRICES

Emmett Elam
Texas Tech University
Lubbock, TX

Abstract

This study found that when the planting time price of December cotton futures was high relative to the long-term average, the harvest price would tend to be lower; and vice versa. This process is called mean reversion. Hedging/speculation strategies, devised to take advantage of mean reversion, showed significant returns in a 19-year simulation.

Introduction

The cotton futures market provides the cotton industry with a mechanism for establishing (discovering) prices. In addition, it complements the cash market by informing market participants of anticipated cotton prices for a year (or more) into the future. Prices provided by the futures market are used by industry participants (including, producers, textile mills, etc.) in making production and manufacturing decisions. Thus, it is important to decision makers to have information on the prediction accuracy of futures prices.

Pricing efficiency of the futures market is a theoretical concept. A futures market is pricing efficient if the price at a given point in time fully embodies all available information that is useful in predicting the subsequent price level of the commodity (Samuelson; Fama). The futures traders who adjust their market positions to new information that could affect the delivery price establish pricing efficiency. This adjustment causes the current futures price to equal the combined market's expectation of the cash price level at contract maturity time (at the delivery point).

An efficient futures price, in time series terminology, follows a random walk process where the day-to-day price change is unpredictable. The randomness of price changes is due to the fact that all fundamental supply-demand information that is available is reflected in the current futures price, and thus any change in price level is the result of unpredictable changes in supply-demand factors. In a random walk market, there is an equal probability that prices will go up or down from the current level.

An extensive literature has developed on pricing efficiency, and, in general, the empirical tests are mostly supportive of efficiency (Kamara; LeRoy). Nevertheless, there are a few studies that report findings that refute this concept. One particular finding argues that if the series of futures prices does not follow a random walk, then it will most likely follow a mean reversion process, where prices revert to the mean in a systematic fashion.

Research has shown that the current futures price is an unbiased predictor of the contract maturity price over a short time interval; however, the predictive power declines as time to maturity increases (Bigman, et al.; Leuthold). This decline could conceivably result from a mean reversion process in futures prices. A study by Firch provides evidence that the planting time price of a futures contract is an "inverse forecaster" of the subsequently realized price at harvest (for cotton, soybeans, and corn). The term inverse forecaster means that when the price is high at planting time, there is a tendency for prices to decline over the growing season to a lower level by harvest (and vice versa). This finding suggests that when prices are high or low that market participants can potentially take advantage of the long-term pricing inaccuracies in futures markets by exercising hedging/speculation strategies that profit from the inverse bias in pricing.

Evidence of mean reversion is reported for the soybean futures market (Elam and Fryar, 1986a,b). In these studies, the authors devised a speculative trading strategy to take advantage of mean reversion by assuming positions in the market when the price was away from the historical mean--i.e., selling when the futures price was above the mean, and buying at a price below the mean. The trading strategy produced highly significant returns over the 11-year period 1974-85, with the highest average return equaling $1.22/bu., or $6,122 per 5,000-bushel contract. In the trading strategy, futures positions were established when contracts were 2 to 12 months from maturity (in 2-month intervals). The results indicate that trading returns were highest for the longer horizons. This is consistent with results from studies of securities markets, where mean reversion has been found for longer horizons (LeRoy).

Jackson, et al, conducted the most comprehensive analysis of mean reversion in agricultural futures markets (to date). In the study, the authors tested for mean reversion in futures prices of corn, soybeans, soyoil, soymeal, fed and feeder cattle, and hogs. Mean reversion was rejected for feeder cattle only. The authors found much stronger evidence for mean reversion at long (3- and 6-month) horizons than at the 1-month horizon.

The overall objectives of this study are to examine pricing inefficiency in the cotton futures market, and to determine if hedging/speculation profits can be made over the long run. We realize the challenge in finding pricing inefficiency because of the widespread and voluminous evidence that supports pricing efficiency in futures markets. This evidence,

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:310-313 (2000)
National Cotton Council, Memphis TN

however, comes largely from studies using daily prices, and thus applies to short-run horizons (Kamara). By contrast, over longer horizons (say months) there is evidence of mean reversion (non-randomness) in futures prices. The best chance to develop hedging/speculation strategies is over the long horizon.

The paper from here includes a second section on the procedures and data used in the study. The third section presents the empirical results. The main results show that cotton futures prices are subject to mean reversion, and that hedging/speculation strategies, devised to take advantage of inefficiencies in cotton futures pricing, are profitable. The final section provides a summary and additional conclusions.

Procedures and Data

The hypothesis that the futures market is pricing efficient can be statistically tested. Suppose that P_t is the actual realized cotton futures price at harvest on December 1 for the December contract, and P_{t-j} is the price for the contract at planting on March 1. P_{t-j} at planting represents the market's expectation for the harvest (December 1) price. If futures pricing is efficient, then the planting price should be a reasonable prediction of the realized harvest price. The efficiency of cotton futures pricing can be tested with the following regression model:

(1) $P_t = \alpha_0 + \alpha_1 P_{t-j} + \varepsilon_t$,

where ε_t is a random (non-autocorrelated) error term. The determination of whether or not the futures market is pricing efficient requires a test of the joint hypothesis that $\alpha_0=0$ and $\alpha_1=1$. If this holds, the futures price follows a random walk and pricing efficiency exists. If $\alpha_0>0$ and $\alpha_1=1$, the futures price follows a random walk with an upward drift over time (referred to as normal backwardation). If the hypothesis that $\alpha_0=0$ and $\alpha_1=1$ is rejected, then the futures price follows a mean reversion process.

Eq. 1 can be reconfigured in terms of the difference between the actual realized price on December 1 and the planting price on March 1:

(2) $P_t - P_{t-j} = \alpha_0 + \beta P_{t-j} + \varepsilon_t$,

where $\beta=(\alpha_1-1)$. The test for pricing efficiency is to determine whether $\alpha_0=0$ and $\beta=0$ (or $\alpha_1=1$ in eq. 1) according to the Dickey-Fuller unit root test (Fuller). Since the estimates generated by OLS in eq. 2 are biased toward zero when the price is (or nearly is) a random walk (Maddala), a standard t-test or F-test is not valid. If the null hypothesis of $\alpha_0=0$ and $\beta=0$ is rejected, the price follows a mean reversion process.

Taking the mathematical expectation of both sides of eq. 2 derives the unbiased price (used in the hedging strategies discussed below):

(3) $E(P_t-P_{t-j}) = E(\alpha_0) + E(\beta P_{t-j}) + E(\varepsilon_t)$.

$E(P_t-P_{t-j})$ equals zero under perfect pricing efficiency, and $E(\varepsilon_t)$ equals zero due to the usual OLS regression assumption. The unbiased price is found by solving eq. 3 for $E(P_{t-j})$:

(4) Unbiased Price = $-\alpha_0/\beta$.

A futures contract purchased or sold at this price would result in a zero profit in the long run (i.e., on average). If the futures price follows a mean reversion process, then the unbiased price is a key element in an effective cotton hedging strategy.

An inefficient futures market creates difficulties for market participants because the distant futures cannot be used to formulate long-term price expectations. It does, however, create opportunities to hedge/speculate for above normal profits. Various hedging strategies were developed and simulated to analyze profit opportunities for market participants, given the pricing inefficiency in the futures market. One-sided hedging was allowed for producers and textile mills since their objectives were to protect against price changes in only one direction. For the cotton producer, the objective was to secure protection from price declines over the growing season. The hedging strategy was to sell December cotton futures when the futures price at planting was above the unbiased price, and then offset the short position at harvest. For the textile mill, the objective was to protect against price increases, which calls for buying futures. Two-sided trading was allowed for speculators because their objective was to profit from price changes in either direction. The trading strategy for a speculator was to take a short (long) position in the market when the futures price on March 1 is above (below) the unbiased price, and then offset the position on December 1.

Simulations based on these hedging/speculation strategies were conducted to estimate the net returns for a producer, textile mill, and speculator for the period 1981-99. Calculations of the unbiased prices were based on estimates of α_0 and β available at the time the hedging/speculation decision was made. For example, a decision made on March 1, 1990, was based on the unbiased price derived from eq. 2 estimated for the period 1973-89. All futures positions were taken on March 1 and held until December 1 regardless of the course of prices. Futures prices were obtained from Technical Tools. Each cotton futures contract is for 50,000 pounds. The futures transaction cost (including commission and execution cost) was set at $100 per contract, or .20 cents/lb.

Mean Reversion Test and Hedge Strategy Simulation

Eq. 2 was estimated using OLS for 19 subperiods, 1973-1980, 1973-1981, and so on (Table 1). A Durbin Watson test for the regressions provided no evidence of autocorrelation. The null hypothesis that futures prices for the December contract follow a random walk was rejected at the 5 percent significance level for all subperiods ending with the year 1987 and later. The results indicate that December cotton futures prices follow a mean reversion process, which implies that the market is pricing inefficient over the long run (9-month horizon from March 1 to December 1).

The results for the hedging simulations are shown in Table 2. For a cotton producer, there were 10 years in which the mean reversion strategy signaled a sell position, with 7 years showing a net profit. The average futures return for the 10 years was 4.69 cents/lb. (p=.080, where p=probability of a sample mean greater than 4.69). When calculating the net price received from the strategy, the futures return (if any) is added to the harvest cash price. If the strategy did not call for a futures sale during a particular year, then the price received by the producer was simply the harvest price. For the 19-year period 1981-99, a cotton producer using the mean reversion selling strategy would have received an average price of 68.17 cents/lb. By comparison, a producer who strictly sold on the cash market at harvest would have received an average price of 65.70 cents/lb. Based on a paired t-test, the prices received are different at the α=.155 significance level. The economic risk involved in the two strategies was measured using the variance in net prices received. Based on an F-test, there was no significant difference in the variances (calculated F=1.02).

The hedge simulation results for a textile mill are shown in col. 7-8 of Table 2. There were nine years in which a buy position was signaled by the mean reversion buying strategy, with four years showing a net profit. The average futures return for the nine trades was 2.49 cents/lb. (p=.195).

The trading results for a speculator are a combination of the sell results for a producer and the buy results for a textile mill (col. 9-10, Table 2). Of the 19 years in the simulation, the speculator earned a net profit in 11 years. The average net profit was 3.65 cents/lb. (p=.044), or $1,825 for a 50,000 pound cotton futures contract.

Interpretation of the statistical results indicates that there is mean reversion in December cotton futures prices. This conclusion is reached despite the fact that the t-tests for the simulation results are significant at higher than the usual .05 level. In a statistical test, the significance level represents the probability of rejecting a true null hypothesis (referred to as a Type I error). The choice of a low significance level (.05 or .01) goes back to early experimental statistics, where there was concern about rejecting an established hypothesis without substantial evidence. In the case at hand, the need for a low significance level may not be called for because the potential loss from rejecting a true null hypothesis (randomness in prices) is not very costly to users of the strategy. For example, consider the case of a cotton producer who implements a mean reversion selling strategy. If cotton futures prices do in fact follow a random walk, the net price received by a producer under the strategy would be approximately equal on average to that from selling on the cash market at harvest. The two prices would differ only slightly due to trading costs from the futures hedge. By contrast, if the alternative hypothesis holds and futures prices follow a mean reversion process, there is substantial monetary benefit to using the strategy.

A similar situation exists for a speculator who trades cotton futures using a mean reversion strategy. If the strategy is ineffective (due to randomness in prices), there is little cost to the speculator. The total trading costs are minimal, because there is only one trade made over a 9-month period (March 1 to December 1). By comparison, if futures prices follow a mean reversion process, the potential profits that can be made from the strategy are substantial (estimated at $1,825 per contract).

Summary and Conclusions

The price established in the competitive cotton futures market is conventionally regarded as an accurate prediction of the harvest price for cotton (Just and Rausser). This study, using historical futures price information for the December cotton contract at planting and at harvest, found that the cotton futures price follows a mean reversion process, with the price at planting representing a biased prediction of the harvest price. When the planting time price was high (relative to the long-term average), the harvest time price would tend to be lower, and vice versa.

Hedging and speculation strategies for cotton producers, textile mills, and speculators were developed and simulated for the years 1981-99. The strategies allowed producers, textile mills, and speculators to obtain significant profits on futures positions. The reader is cautioned that considerable variations occurred in the simulated returns from year to year.

A word of caution is warranted about using the strategies developed in this study. The findings were based on only 29 years of information from the December contract (and 19 years for the simulation results). A more comprehensive study is needed to obtain a more detailed and complete picture for other contracts at other seasons of the year, and to determine the persistence of the historical bias that provides the essential element in a successful futures market strategy.

References

Bigman, D., D. Goldfarb, and E. Schechtman. 1983. Futures market efficiency and the time content of the information sets. J. of Fut. Mkts. 321-34.

Elam, Emmett, and Ed Fryar. 1986a. Pricing inefficiency and long term profits in soybean futures. Selected paper presented at the Southern Agr. Econ. Assoc. annual meeting, Orlando, FL, Feb. 1986. Abstract in So. J. of Agr. Econ. 195-96.

Elam, E. W. and E. O. Fryar. 1986b. Profits from long term pricing inaccuracy in soybean futures. J. of Bus. and Econ. Persp. 5-12.

Fama, Eugene F. 1976. Foundations of Finance. New York: Basic Books, Inc.

Firch, R. S. 1981. Futures markets as inverse forecasters of postharvest prices for storable agricultural commodities. Rev. of Res. in Fut. Mkts. 63-73.

Fuller, W. A. 1976. Intr. to Stat. Time Series. New York: Wiley.

Jackson, Thomas E., C.R. Zulauf, and Scott H. Irwin. 1991. Mean reversion in agricultural futures prices. Staff paper ESO-1841, Dept. of Agr. Econ., Ohio State Univ., 22 pp.

Just, Richard E., and Gordon Rausser. 1981. Commodity price forecasting with large-scale econometric models and the futures market. Am. J. of Agr. Econ. 197-208.

Kamara, Avraham 1982. Issues in futures markets. J. of Fut. Mkts. 261-94.

LeRoy, Stephen F. 1989. Efficient capital markets and martingales. J. of Econ. Lit. 1583-1621.

Leuthold, R. M. 1974. The price performance on the futures market of a nonstorable commodity: live beef cattle. Am. J. of Agr. Econ. 271-79.

Maddala, G. S. 1992. Intr. to Econometrics (2nd ed.) New York: Macmillan.

Samuelson, P.A. 1965. Proof that properly anticipated prices fluctuate randomly. Indus. Manag. Rev. 41-49.

Table 1. Results for Dickey-Fuller test for mean reversion in December cotton futures prices (i.e., $P_t - P_{t-j} = \alpha + \beta P_{t-j}$)[a]

Estimation Period	Intercept α-hat	Slope β-hat	R^2
1973-80	62.1	-0.93 (-1.91)[b]	0.38
1973-81	65.9	-1.00 (-2.58)	0.49
1973-82	66.5	-1.02 (-2.86)	0.51
1973-83	65.6	-0.99 (-2.88)	0.48
1973-84	65.9	-1.00 (-3.14)	0.50
1973-85	65.7	-1.00 (-3.28)	0.50
1973-86	58.8	-0.90 (-3.28)	0.47
1973-87	59.8	-0.92 (-3.52)*	0.49
1973-88	58.7	-0.90 (-3.58)*	0.48
1973-89	59.0	-0.90 (-3.70)*	0.48
1973-90	58.8	-0.89 (-3.68)*	0.46
1973-91	59.8	-0.92 (-3.86)*	0.47
1973-92	59.4	-0.91 (-3.94)*	0.46
1973-93	59.2	-0.91 (-4.03)*	0.46
1973-94	56.4	-0.86 (-3.81)*	0.42
1973-95	50.4	-0.75 (-3.38)*	0.35
1973-96	48.9	-0.72 (-3.48)*	0.36
1973-97	49.1	-0.73 (-3.68)*	0.37
1973-98	50.0	-0.75 (-3.85)*	0.38

[a]A Durbin Watson test on the residuals provided no evidence of autocorrelation. [b]Calculated t-values. * indicates significance at 5% level based on critical values for the Dickey-Fuller unit root test.

Table 2. Hedging results for a cotton producer and textile mill, and trading results for a speculator, 1981-1999.

	Un-Biased Price[a]	Mar. Fut. Price	Dec. Fut. Price	Producer Hdg. Dec.	Producer Net Ret.	Textile Mill Hdg. Dec.	Textile Mill Net Ret.	Speculator Trade Dec.	Speculator Net Ret.
Year	-------cents/lb---------				cents/lb		cents/lb		cents/lb
1981	66.69	81.43	61.45	Sell	19.78	--	--	Sell	19.78
1982	65.59	71.40	62.65	Sell	8.55	--	--	Sell	8.55
1983	65.30	68.07	76.50	Sell	- 8.63	--	--	Sell	- 8.63
1984	66.38	73.85	65.17	Sell	8.48	--	--	Sell	8.48
1985	66.24	65.15	60.59	--	--	Buy	- 4.76	Buy	- 4.76
1986	65.81	44.56	53.83	--	--	Buy	9.07	Buy	9.07
1987	65.22	53.02	67.30	--	--	Buy	14.08	Buy	14.08
1988	65.39	57.76	57.90	--	--	Buy	- .06	Buy	- .06
1989	64.99	60.63	68.60	--	--	Buy	7.77	Buy	7.77
1990	65.24	64.68	75.88	--	--	Buy	11.00	Buy	11.00
1991	65.97	68.37	57.35	Sell	10.82	--	--	Sell	10.82
1992	65.34	61.77	58.52	--	--	Buy	- 3.45	Buy	- 3.45
1993	64.98	62.12	61.00	--	--	Buy	- 1.32	Buy	- 1.32
1994	64.78	72.32	79.80	Sell	- 7.68	--	--	Sell	- 7.68
1995	65.65	78.93	86.78	Sell	- 8.05	--	--	Sell	- 8.05
1996	67.17	80.05	75.25	Sell	4.60	--	--	Sell	4.60
1997	67.58	77.30	69.45	Sell	7.65	--	--	Sell	7.65
1998	67.44	72.85	61.30	Sell	11.35	--	--	Sell	11.35
1999	67.04	58.66	48.95	--	--	Buy	- 9.91	Buy	- 9.91
Mean					4.69		2.49		3.65
Std. Dev.					9.66		8.22		8.83
P-value (one-tail test)					.080		.195		.044

[a]Based on exact values of α_0-hat and β-hat (rather than the rounded values reported in Table 1).