Testing for weak-form efficiency in South African futures markets for wheat and sunflower seeds

MP Phukubje & MB Moholwa[1]

Abstract

The deregulation of agricultural markets in South Africa led to the establishment of a futures market for agricultural products, which was opened in January 1995. Commodity futures markets should be efficient to play the most effective role in price risk management. This paper tests for weak-form efficiency in the South African Futures markets for wheat and sunflower seeds by examining the predictability of daily futures price changes. The results suggest that futures price changes for both wheat and sunflower seeds are partially predictable from past price information. The implication is that past price information does contain additional information that could be used to forecast the future price once the current future price is known. But when taking into account the brokerage costs and the time value of money, out-of-sample predictive performance of the model indicates that trading decisions based on the direction of predicted futures price changes do not lead to profitable trades for either crop. Hence, the evidence suggests that there is no strong support for weak-form inefficiency in South African futures markets for wheat and sunflower seeds. The results further suggest that there is no trend in market efficiency over time for wheat and sunflower seeds, except for the wheat December contract.

1. Introduction

South African agriculture has a long history of government intervention with a series of laws, ordinances, statutes and regulations affecting all aspects of agriculture (Kristen and Van Zyl, 1996). Agricultural policy has been characterized by deregulation and market liberalization since the mid-1980s. Further, the Marketing of Agricultural Products Act No 47 of 1996 was passed at the end of 1996. Agricultural marketing policy is now operating in more open and transparent system. For example, in the past the Wheat Board determined producer prices and acted as a single channel marketer. But from 1996 the wheat market has been free from statutory intervention. Prices are now determined by the interaction of supply and demand. The deregulation of agricultural markets in South Africa implies that farmers now compete in a

---

[1] *Postgraduate student and Lecturer respectively, Department of Agricultural Economics, University of Limpopo, Private Bag X1106, Sovenga, 0727. E-mail: Bmoholwa@thedti.gov.za.*

more open global trading environment. While this implies better access to export opportunities, it also implies that farmers have to be competitive in domestic, regional and international markets.

The deregulation of agricultural markets has created the need for South African producers to give more individual attention to managing price risk. While producers may feel they have some influence on yields through their decisions, prices are beyond their control. It has been argued that prices of primary products are often highly volatile, particularly in comparison to manufactured goods (Newbery and Stiglitz, 1981). This implies price risk because agricultural production decisions are generally made on the basis of expected prices and costs six months or more before harvest, allowing time for substantial changes in prices. Agricultural futures markets serve several important functions, such as price risk management for farmers, traders and food processors, price discovery, and forward pricing (Sheldon, 1987). Futures trading is one mechanism for managing the effects of price instability resulting from the production, marketing and purchase of a commodity. The deregulation of agricultural markets in South Africa led to the establishment of a futures market for agricultural products, which was opened in January 1995. The Marketing of Agricultural Products Act No 47 of 1996 in South Africa has created an environment in which farmers, traders and processors are able to react positively to transparent prices which are market related (SAFEX, 2004).

The study of market efficiency in agricultural commodity futures is important to both the government and to producers in South Africa. From the government policy perspective, an efficient market implies an efficient alternative to market interventions such as price stabilization policies. For producers, it provides a reliable forecast of spot prices in the future and allows them to effectively manage their risks in the production and marketing process. Futures markets should be efficient to play the most effective role in risk management and price stabilization (Aulton *et al*, 1997). The informational content of futures prices has important implications for the resource allocation decision of agents in the food chain (Sheldon, 1987). The determination of the nature of the relationship between futures price movements over time becomes critical in understanding and managing market price risk for a given commodity (Fortenbury and Zapata, 1993).

There is a dearth of published research in South Africa on the efficiency of agricultural commodity futures, probably because the Agricultural Marketing Division began trading futures only in mid-1996. Agricultural commodities currently being traded at the South African Futures Exchange (SAFEX) markets are white and yellow maize, wheat, sunflower seed and soybean, and were introduced in 1996, 1997, 1999, and 2002, respectively (SAFEX, 2004).

Wiseman *et al* (1999) tested the efficiency of South African futures market for white maize using cointegration tests for the periods 1997 and 1998. The results suggested that the white maize futures market was not efficient in 1997, but that market efficiency improved in 1998, which could be evidence of a market learning process and a progression towards efficiency. Moholwa (2005) tested the efficiency of South African futures markets for white and yellow maize by examining the predictability of daily futures price changes over the period 1999-2003. The results suggested that there is no strong support for weak-form inefficiency in South African futures markets for white and yellow maize.

It is not yet known whether wheat and sunflower seeds futures markets in South Africa are efficient or not. This study aims at providing essential knowledge still lacking in this area. The goal of this study is, therefore, to test for efficiency in South African futures markets for wheat and sunflower seeds by examining the predictability of daily futures price changes over the period 2000-2003. The specific objectives are: (a) to determine whether daily futures price changes for wheat and sunflower seeds are predictable from past price information; (b) if they are predictable, then to determine whether trading a decision based on the direction of predicted futures price changes could lead to profitable trades; (c) and to determine whether these markets exhibit a trend towards increased efficiency over time.

The remainder of the paper proceeds as follows: Section 2 discusses the concept of market efficiency. Section 3 outlines the methodology of the study. Empirical results of the study are presented in Section 4. Section 5 summarizes the results of the study and draws relevant conclusions, as well as provides a discussion of limitations and suggestions for future research.

2. Market efficiency

According to Fama (1970) the Efficient Market Hypothesis (EMH) postulates that an asset price reflects all known information so that it is impossible to make speculative trading gains using publicly available information. It has been conventional to assume that market equilibrium can be expressed in terms of zero expected returns on assets such as futures contracts (Aulton *et al*, 1997). Given returns Y_{t+1} conditional on the information set I_t reflected in current prices, then this implies,

$$E(Y_{t+1}|I_t) = 0 \tag{1}$$

A sequence of returns is then a "fair game" with respect to a sequence of information. Equation (1) could be described as no arbitrage condition because it implies no unexploited profit opportunities for informed traders.

It is common in practice to distinguish between weak, semi-strong and strong-form efficiency, with the distinction based on the definition of information. Tests for weak-form efficiency rely on information embodied in past prices and tests for semi-strong efficiency typically use publicly available information on prices and other relevant market information (Hansen and Hodrick, 1980; Garcia *et al,* 1988). Tests for strong form efficiency are based on all types of information, including private insider information. Weak-form efficiency is the most widely tested, and will be the basis of the analysis in this study.

Tests of futures market efficiency have traditionally been based on regressions of the observed spot price at time *t* on the futures price maturing at time *t* but observed *i* periods before contract maturity. The goal is to test how well futures price at *t-i* predicts spot (cash) price at *t*. There is lack of spot price data on most agricultural commodities in South Africa, even though there are hundreds of spot prices negotiated every day throughout the country (Gravelet-Blondin, 2004). This is because there is no established price reporting system in the country. In the past SAFEX used to phone around and calculated the so-called “spot prices” but have not done so for the past five years. Due to this lack of data, only futures prices are used to test market efficiency in this study. The rationale here is that if the futures market is efficient, then past futures price changes should have no significant information for predicting current futures price changes.

3. Methodology

3.1 The model

Tests for weak-form efficiency have been based on the so-called “random-walk” model, a special extension of the “fair game” process generating expected returns (Aulton *et al*, 1997). One might argue that the expected value of any futures price $F_t(T)$ quoted at *t* for delivery at T will be conditional upon past realised prices $F_{t-1}(T)$, ………., $F_{t-n}(T)$, where T represents the contract month. Denote this conditional expectation:

$$E[F_t(T)|F_{t-n}(T), n > 0] = g[F_{t-1}(T), F_{t-2}(T), ...] \tag{2}$$

$F_t(T)$ will be a Martingle series if the function $g(......) = F_{t-1}(T)$,

$$E[F_t(T) \,|\, F_{t-n}(T), n>0] = F_{t-1}(T) \tag{3}$$

Equation (3) states that the expected value of a futures price, based on the information set $F_{t-n}(T)$ for n > 0, is equal to the last period price $F_{t-1}(T)$. Granger and Morgenstern (1970) and Sheldon (1987) indicate that such a martingale will obey the model,

$$\ln F_t(T) = \mu + \ln F_{t-1}(T) + u_t \tag{4}$$

where $\ln F_t(T)$ = logarithm of daily futures price observed at day *t* for maturity in period T, $\ln F_{t-1}(T)$ = logarithm of daily futures price observed a day prior to *t*, but again with identical maturity date T, $\mu =$ a constant, and u_t = an error term.

It is common in the statistical analysis of the prices of financial securities, including futures contracts, to apply a logarithmic transformation to the data (Fortenbury and Zapata, 1993). Aulton *et al* (1997) give a number of reasons why it is desirable to use the logarithmic transformation of the futures price series: Firstly, a logarithmic transformation will often succeed in stabilizing the variance of the observed series. Secondly, futures prices are positive valued and a lognormal futures price process cannot have a negative realization for future prices. Thirdly, a typical futures price is non-stationary and requires a logarithmic transformation if it is to conform closely to an integrated of order one, I(1), process. Lastly, by applying the logarithmic transformation to the two series we are more likely to find cointegration when it exists than by analyzing the untransformed data series.

The efficiency test involves first testing the futures price series in equation (4) for a unit root. If the series is I (1), then it is logical to impose differencing in equation (4) and test the joint hypothesis that $\delta_1 = ...\delta_k = 0$ in:

$$\Delta[\ln F_t(T)] = \lambda + \sum_{i=1}^{k} \delta_i \, \Delta[\ln F_{t-i}(T)] + \varepsilon_t \tag{5}$$

where $\Delta[\ln F_t(T)]$ = daily changes in the logarithm of futures price observed at day *t* for maturity in period T, $\Delta[\ln F_{t-i}(T)]$ = lagged daily changes in logarithm of futures price observed *i* periods prior to *t*, but again with identical maturity date T, γ and δ_s = coefficients, and ε_t = an error term.

If $\ln F_t(T)$ series is integrated of order one, I(1), then $\Delta[\ln F_t(T)]$ and $\Delta[\ln F_{t-i}(T)]$ are I(0) (Pindyck and Rubinfeld,1981; Baillie, 1989). Additional lagged differenced terms are included in equation (5) to make sure that the error term is white noise, rather than autocorrelated. A process is said to be a white noise if its elements have zero mean, constant variance and uncorrelated errors across time (Hamilton, 1994). The standard distributional assumptions would then apply to the parameter estimators obtained by applying OLS to (5).

The notion of an unbiased or weak-form efficient futures market, under rational expectations and risk neutrality, is consistent with the null hypothesis that $\delta_1 = ...\delta_k = 0$, ε_t uncorrelated in equation (5). This ensures that past price information does not contain information that could be used to forecast future price changes. It embodies the notion that the market instantaneously and fully reflects available information in past prices and that agents are efficient information processors.

3.2 Data

Daily wheat and sunflower seeds settlement futures prices for March, May, July, September and December contracts were collected directly from SAFEX. These are the five main hedging months on SAFEX. Settlement price is the last price for a futures contract on any trading day. Wheat July and September contract months were excluded from the analysis in this study due to incomplete data provided by SAFEX. Each contract month is introduced a year in advance and expires on the eighth last business day of that contract month. For example, July 2003 contract expired on July 21, 2003. Data is collected over the period 2000-2003. The Data set for each contract month was from the first business day of the month, immediately after the introduction of that contract until the last business day of the month prior to the month of expiry. For example, in a July 2000 contract, the data series is taken from the first business day in August 1999 to the last business day of June 2000.

Data sets were pooled over the period of study according to each specific contract month. For example, July contract data were pooled over the period 2000-2003. But testing for weak-form market efficiency for the July contract (for example) using equation (5) requires first differencing of the data set. It was, therefore, necessary to compute first differences as well as a given number of lagged difference terms for each year's July contract prior to pooling of the data over the period of study to maintain data matching. This ensures that all price differences are computed using prices for the same contract, and lagged difference terms of a specific contract will always be associated with the same contract.

The number of lagged differenced terms computed is fifteen. This number was chosen to ensure that more than enough lagged difference terms would be available to implement the efficiency test with a very flexible lag structure. The natural logarithmic differences for each commodity were rescaled by multiplying them by 100 in order to avoid computational errors from small values. The contract months of March, September and December were pooled in a similar way. In summary, we have eight data sets in this study, three for wheat and five for sunflower seeds.

4. Empirical results

4.1 Efficiency tests

Many commodity prices, at least when sampled at high frequencies, have a tendency to contain stochastic trends or unit roots (Ardeni, 1989; Baillie and Myers, 1991; Goodwin and Schroeder, 1991; Goodwin, 1992). The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are common methods for testing unit roots, and are used here. A detailed explanation of ADF and PP tests is given in Hamilton (1994). So, as expected, all logarithms of daily futures price series have unit roots. This is the characteristic property of many futures price series, especially when sampled at high frequencies because futures prices are speculative and should not be mean reverting. Given that all logarithm of daily futures price series are integrated of order one, I(1), it is then logical to impose differencing and test for predictability of futures price changes using equation (5).

For each crop, equation (5) was estimated for each of the hedging months. The number of lagged difference terms was included in equation (5) to ensure that there was no significant autocorrelation in the error term. The lag length was chosen for each equation separately by starting with the first lagged difference term and then testing for autocorrelation in the error term. If there is significant autocorrelation in the error term, then the second lagged difference term is added. The process of including the additional lagged difference term is continued until there was no significant autocorrelation in the error terms. In order to test whether additional lagged difference terms are needed, the Ljung-Box Q-statistic is used and is formulated as follows:

$$Q = N(N+2)\sum_{k=1}^{m}\left(\frac{\hat{r}_k^{\,2}}{N - k}\right) \tag{6}$$

where $\hat{r}_k$ is the estimated autocorrelation coefficient, k is a given lag, m is the total number of lags and N is the sample size. Q is asymptotically Chi-squared (χ^2) distributed with m degrees of freedom. If the value of Q-statistic exceeds the value in $\chi^2(m)$ table, we can reject the null hypothesis of no significant autocorrelation at the appropriate significance level. The Q test results indicate that there is no significant autocorrelation in the error terms at the 5% level of significance. F-test statistics were used to test the joint null hypothesis of no predictability for both crops and the results are presented in Table 1.

Table 1: Efficiency tests

Contract	Sunflower seeds		Wheat	
	F statistic	Q-statistic	F statistic	Q-statistic
March	$F_{(1,516)} = 54.68$ (0.000)	Q (1) = 0.06 Q (3) = 1.02 Q (6) = 5.04 Q (12) = 13.06 Q (25) = 35.28	$F_{(7,345)} = 10.52$ (0.000)	Q (1) = 0.08 Q (3) = 0.11 Q (6) = 0.66 Q (12) = 12.06 Q (25) = 35.37
May	$F_{(2,844)} = 63.91$ (0.000)	Q (1) = 0.00 Q (3) = 0.00 Q (6) = 1.61 Q (12) = 7.89 Q (25) = 33.51	$F_{(7,252)} = 3.88$ (0.000)	Q (1) = 0.03 Q (3) = 0.27 Q (6) = 0.65 Q (12) = 7.76 Q (25) = 30.63
July	$F_{(8,959)} = 12.89$ (0.000)	Q (1) = 0.01 Q (3) = 0.03 Q (6) = 0.09 Q (12) = 3.89 Q (25) = 36.94	–	–
September	$F_{(1,434)} = 17.11$ (0.000)	Q (1) = 0.47 Q (3) = 4.65 Q (6) = 10.49 Q (12) = 13.55 Q (25) = 25.66	–	–
December	$F_{(2,605)} = 19.24$ (0.000)	Q (1) = 0.08 Q (3) = 1.59 Q (6) = 5.11 Q (12) = 6.96 Q (25) = 31.48	$F_{(1,607)} = 21.49$ (0.000)	Q (1) = 0.15 Q (3) = 4.23 Q (6) = 6.95 Q (12) = 12.73 Q (25) = 29.84

Notes: (1) The estimated model for each contract month is $\Delta[\ln F_t(T)] = \lambda + \sum_{i=1}^{k} \delta_i \, \Delta[\ln F_{t-i}(T)] + \varepsilon_t$ and the joint null hypothesis being tested is $\delta_1 = \ldots = \delta_k = 0$

(2) Figures in the parenthesis are P-values

(3) Q-statistic critical Values: χ^2 (1) = 3.84, χ^2 (3) = 7.81, χ^2 (6) = 12.59, χ^2 (12) = 21.0, χ^2 (25) = 37.65 at the 5% level of probability

All of the estimated F statistics for wheat and sunflower seeds for all contract months are very high with very low p-values. Hence, the joint null hypothesis of market efficiency is rejected in all cases at almost any significance level. The implication is that past price information can be used to forecast futures daily price changes. Hence, the results consistently suggest that South African futures price changes for wheat and sunflower seeds are predictable.

4.2 Out of sample forecasting evaluation

While the statistical significance of weak-form market inefficiency in the South African futures markets for wheat and sunflower seeds have been investigated using in-sample testing, an important additional issue is to determine whether the prediction model has strong out-of-sample predictive performance. In each case, one-third of the sample is withheld for out-of-sample forecasting (approximately one year in advance for all cases) because forecast errors are likely to be higher at longer forecast horizons (Irwin *at al*, 1994).

Out-of-sample forecasts are computed updating with new data as it becomes available but without model re-estimation. Computing forecasts with a once off estimated model is more convenient than re-estimating the data every time another observation becomes available. To determine whether the prediction model has strong out-of-sample predictive performance that can be turned into profitable trades we need a trading rule. A trading rule in this case is defined as follows: If the prediction model predicts a negative futures price change over the next day then a contract will be sold, otherwise a contract will be bought. This implies that if the prediction model predicts a negative futures price change and the actual futures price change is, say negative R10/ton, and then R10/ton will be recorded as a trading gain. And if the futures price change is positive R5/ton then R5/ton will be recorded as a trading loss. All trades are held for one day. Then the position is liquidated and a new position is taken out based on the updated one-day forecast.

The Client brokerage or trading costs for wheat and sunflower seeds at SAFEX for the forecasting period was 0.25 Rand/ton and 0.15 Rand/ton respectively. Round trip brokerage fees of 0.50 Rand and 0.30 Rand were then subtracted off every trade taken out on wheat and sunflower seeds respectively. To take into account the time value of money, trading gains and losses were discounted using 13% per annum as opportunity cost of capital (OCC). The choice of this discount rate was informed by the fact that the average interest rate during the forecasting period was 13% as reported by South African Reserve Bank (SARB).

Discounted trading gains and losses are summed over the forecasting horizon for each of the contract months, for wheat and sunflower seeds, to determine whether trading decisions based on the direction of predicted futures price changes could lead to profitable trades. If the sum of trading gains and losses over the forecasting horizon for each of the contract month is positive, then trading decisions based on the direction of predicted futures price changes could lead to profitable trades. The implication will be that the prediction model has strong out-of-sample predictive performance and that this predictive performance can be turned into a profitable trading rule.

Table 2 presents out-of-sample predictive performance results for each of the contract months, for wheat and sunflower seeds. In all cases the sum of trading gains and losses over the forecasting horizon is negative. The implication of the results is that trading decisions based on the direction of predicted futures price changes would not lead to profitable trades out of sample. Hence, the prediction model does not have a strong out of sample predictive performance and this is consistent with weak-form efficiency in South African futures market for wheat and sunflower seeds.

Table 2: Out-of-sample forecasting evaluation

Contract	Sunflower Seeds Trading Gain/Loss (Rand/ton)		Wheat Trading Gain/Loss (Rand/ton)	
	Without Brokerage fee	With Brokerage fee	Without Brokerage fee	With Brokerage fee
March	24.56	-17.43	13.47	-39.40
May	51.15	-16.22	9.18	-31.27
July	36.86	-39.73	-	-
September	18.25	-15.04	-	-
December	16.41	-29.50	19.29	-71.86

4.3 Trend towards efficiency

New agricultural futures markets may be weak-form inefficient in their early stages of development and exhibit a process of adjustment towards efficiency over time. Statistical evidence of predictability of futures price changes in this study have been established using pooled data from 2000 through 2003. The process of determining whether wheat and sunflower seeds futures markets in South Africa exhibit a trend towards improved efficiency over time involves first testing for the stability of parameter estimates across years. If there were parameter stability, then there would be no trend in market efficiency.

By pooling data, it is assumed that the model parameter estimates are stable from one period to the other. An important issue now is to test for the validity of this assumption. The stability of regression parameter estimates is tested using the standard likelihood ratio F-test, which uses the sum of squared errors with and without imposing restrictions being tested. To test the assumption that the model parameter estimates are stable from one period to the other, we start with the null hypothesis that the regressions are identical and see whether or not we can reject this. Consider the regression models

$$\Delta[\ln F_t(T)] = a_0 + \sum_{i=1}^{k} a_i \, \Delta[\ln F_{t-i}(T)] + m_t \text{ for period 1} \tag{7}$$

$$\Delta[\ln F_t(T)] = b_0 + \sum_{i=1}^{k} b_i \, \Delta[\ln F_{t-i}(T)] + n_t \text{ for period 2} \tag{8}$$

where a_s, and b_s are coefficients, and m_t and n_t are error terms.

We then estimate equations (7) and (8) using ordinary least squares separately. There are no restrictions imposed on the parameters. The unrestricted sum of squared residuals (ESS_{UR}) is obtained by adding the error sums of squares of the individual equations. The number of degrees of freedom is the sum of the numbers of degrees of freedom in each equation, that is $(N_1 - k) + (N_2 - k) = N_1 + N_2 – 2k$. N_1 and N_2 are sample sizes for period 1 and period 2 respectively, and k is the number of parameters in each equation. The joint null hypothesis is $a_0 = b_0$ and $a_i = b_i$. Assuming that the null hypothesis is true, then equations (7) and (8) reduce to

$$\Delta[\ln F_t(T)] = a_0 + \sum_{i=1}^{k} a_i \, \Delta[\ln F_{t-i}(T)] + m_t \text{ for both periods} \tag{9}$$

We then estimate equation (9) using ordinary least squares. Since there are restrictions imposed on the parameters, error sum of squares obtained here is the restricted error sum of squares (ESS_R). The appropriate F statistic with k restrictions and $N_1 + N_2 – 2k$ degrees of freedom is

$$F_{(k,N_1+N_2-2k)} = \frac{(ESS_R - ESS_{UR})/k}{ESS_{UR}/\left(N_1 + N_2 - 2k\right)} \tag{10}$$

If the value of the F statistic exceeds the theoretical value of F at the given level of significance and degrees of freedom, then we reject the null hypothesis of stability of regression parameter estimates. Pooling of the data will be appropriate if the null hypothesis is true, otherwise the results obtained earlier will need to be re-evaluated on a contract-by-contract basis. F-test statistics obtained from testing the joint null hypothesis of the stability of regression parameter estimates across years for wheat and sunflower seeds are presented in Tables 3 and 4 respectively. In the case of sunflower seeds the joint null hypothesis is accepted for all five main hedging months. In the case of wheat, the null hypothesis is rejected only for the December contract. The results indicate that there is parameter stability for the period 2000-2003 for all contract months for sunflower seeds. In the case of the wheat December contract there is parameter stability for the period 2000-2001, but parameter instability for the period 2001-2003.

Table 3: Test for stability of regression parameters across years 2000-2003 for sunflower seeds

Contract	2000 & 2001	2001 & 2002	2002 & 2003
March	$F_{(2, 281)} = 1.99$	$F_{(2, 282)} = 0.01$	$F_{(2, 281)} = 3.80$
May	$F_{(3, 416)} = 1.90$	$F_{(3, 457)} = 0.39$	$F_{(3, 467)} = 2.75$
July	$F_{(9, 498)} = 1.41$	$F_{(9, 525)} = 1.05$	$F_{(9, 458)} = 1.65$
September	$F_{(2, 241)} = 1.59$	$F_{(2, 241)} = 0.48$	$F_{(2, 239)} = 0.64$
December	$F_{(3, 321)} = 3.02$	$F_{(3, 323)} = 1.75$	$F_{(3, 323)} = 3.01$

Notes: The estimated models for each column are $\Delta[\ln F_t(T)] = a_0 + \sum_{i=1}^{k} a_i \, \Delta[\ln F_{t-i}(T)] + m_t$ for period 1 and $\Delta[\ln F_t(T)] = b_0 + \sum_{i=1}^{k} b_i \, \Delta[\ln F_{t-i}(T)] + n_t$ for period 2, and the joint null hypothesis being tested is $a_0 = b_0$ and $a_i = b_i$

Table 4: Test for stability of regression parameters across years 2000-2003 for wheat

Contract	2000 & 2001	2001 & 2002	2002 & 2003
March	$F_{(8, 173)} = 0.06$	$F_{(8, 175)} = 0.43$	$F_{(8, 766)} = 1.77$
May	$F_{(8, 127)} = 0.08$	$F_{(8, 129)} = 0.29$	$F_{(8, 129)} = 0.42$
December	$F_{(2, 325)} = 1.56$	$F_{(2, 328)} = 5.07$*	$F_{(2, 328)} = 7.01$*

Notes: (1) The estimated models for each column are $\Delta[\ln F_t(T)] = a_0 + \sum_{i=1}^{k} a_i \, \Delta[\ln F_{t-i}(T)] + m_t$ for period 1 and $\Delta[\ln F_t(T)] = b_0 + \sum_{i=1}^{k} b_i \, \Delta[\ln F_{t-i}(T)] + n_t$ for period 2, and the joint null hypothesis being tested is $a_0 = b_0$ and $a_i = b_i$

(2) *denotes significant at the 1% level of probability

The implication of these results is that there is no trend in market efficiency over time for sunflower seeds futures market, and wheat March and May contracts (because there is no parameter instability). However, we also found that there is some evidence of parameter instability over time for the wheat December contract. So it is natural to ask whether this contract has become more efficient in the latter part of the sample. Efficiency tests are conducted for the wheat December contract to determine whether there is a trend towards increased market efficiency over time. The results are presented in Table 5.

Efficiency tests for wheat December contract indicate statistical evidence of predictability of futures price changes from the periods 2000-2001 and 2002, but no statistical evidence of predictability for the period 2003. The results suggest that there is trend toward reduced predictability of price changes over time for wheat the December contract.

Table 5: Testing for trend towards efficiency for wheat December contract

Contract	2000-2001		2002		2003	
	F statistic	**Q statistic**	**F statistic**	**Q statistic**	**F statistic**	**Q statistic**
December	$F_{(2,302)}$=9.45 (0.000)	Q (1) = 0.05 Q (3) = 2.82 Q (6) = 5.72 Q (12) = 13.49 Q (25) = 30.42	$F_{(1,167)}$=27.06 (0.000)	Q (1) = 0.00 Q (3) = 0.73 Q (6) = 2.81 Q (12) = 16.72 Q (25) = 22.64	$F_{(1,165)}$=0.09 (0.767)	Q (1) = 0.00 Q (3) = 1.99 Q (6) = 2.28 Q (12) = 3.96 Q (25) = 12.09

Notes: (1) The estimated model for each contract month is $\Delta[\ln F_t(T)] = \lambda + \sum_{i=1}^{k} \delta_i \, \Delta[\ln F_{t-i}(T)] + \varepsilon_t$ and the joint null hypothesis being tested is $\delta_1 = \ldots = \delta_k = 0$

(2) Figures in the parenthesis are P-values

(3) Q-statistic critical Values: χ^2 (1) = 3.84, χ^2 (3) = 7.81, χ^2 (6) = 12.59, χ^2 (12) = 21.0, χ^2 (25) = 37.65 at the 5% level of probability

5. Summary and conclusions

Agricultural marketing policy in South Africa has moved from a highly regulated marketing environment to a more open and transparent system. The demise of Marketing Boards in South Africa in 1996 has created a need for producers to give more individual attention to managing price risk. Commodity futures markets should be efficient to play the most effective role in price risk management. The Agricultural Market Division (AMD) was established in January 1995 as a division of the South African Futures Exchange. Wheat and sunflower seeds were listed in 1997 and 1999 respectively. Given that there is no published research in South Africa on the efficiency of wheat and sunflower seeds futures markets, this study has examined the predictability of daily futures price changes for wheat and sunflower seeds for the period 2000-2003.

The empirical results suggest that daily futures price changes for both wheat and sunflower seeds are partially predictable from past price information. The implication is that past price information does contain additional information that could be used to forecast future price, once the current futures price has been included. But when taking into account brokerage costs and the time value of money, out-of-sample predictive performance of the model indicates that trading decisions based on the direction of predicted futures price changes would not lead to profitable trades for wheat and sunflower seeds. This is consistent with market efficiency in South African futures markets for wheat and sunflower seeds. The results further suggest that there is no indication of change in market efficiency over time for wheat and sunflower seeds, except for wheat December contract.

The implication of these results is that agents in the South African futures markets for wheat and sunflower seeds have not been able to profit from information embodied in past prices. The results also suggest that South African commercial producers of wheat and sunflower seeds can use nationally quoted SAFEX futures contract prices to predict the likely direction and level of future cash prices and manage price risk. Price information derived from wheat and sunflower seeds futures contracts can also be used by producers for price discovery when negotiating with traders and food processors.

The most serious limitation of this study is the unavailability of spot price data on wheat and sunflower seeds. There is a need for the establishment of price reporting agency in South Africa. This agency should be responsible for spot price data collection for agricultural commodities in various local markets in the country. This will facilitate efficiency tests for agricultural commodities futures markets with respect to various local markets in the country, as well as provide a range of other benefits. Daily wheat settlement futures price data for July and September contract months were excluded from the analysis in this study due to incomplete data provided by SAFEX. It must also be noted that the trading rule evaluated for out-of-sample predictive performance of the model is arbitrary, and the results are only for one year (and without parameter updating). Extending to longer forecasting horizon might change the results of no trading gains. Another limitation of this study is the assumption that market participants are risk neutral in testing the weak-form efficiency hypothesis. Given the results from this study, one may try an alternative empirical test of market efficiency that allows for a non-zero risk premium.

Past studies tested the efficiency of South African futures market for white and yellow maize. With the introduction of Soybean futures contracts in 2002, research opportunity exists for testing the efficiency of South African futures market for soybean. Agricultural commodities currently traded on SAFEX, with the exception of wheat and sunflower seeds, are white and yellow maize and Soybean. The South African currency has been highly volatile, especially in the past five years. Hence, another area of research might be to determine the impact of exchange rate volatility on the performance of futures markets for agricultural commodities in South Africa.

References

Ardeni PG (1989). Does the law of one price really hold? *American Journal of Agricultural Economics* 71(3):661-669.

Aulton AJ, Ennew CT & Rayner AJ (1997). Efficiency tests of futures markets for UK agricultural commodities. *Journal of Agricultural Economics* 48:498-524.

Baillie RT (1989). Econometric tests of rationality and markets efficiency. *Econometric Reviews* 8:151-186.

Baillie RT & Myers RJ (1991). Bivariate GARCH estimation of the optimal commodity future hedge. *Journal of Applied Econometrics* 6(2):109-124.

Fama EF (1970). Efficient capital markets: A review of theory and empirical work. *The Journal of Finance* 25:383-417.

Fortenbury TR & Zapata HO (1993). An examination of cointegration relation between futures and local grain markets. *Journal of Futures Markets* 13:921-932.

Garcia P, Leuthold RM, Fortenbury TR & Sarassoro GF (1988). Pricing efficiency in the live cattle futures market: Further interpretation and measurement. *American Journal of Agricultural Economics* 2:162-169.

Goodwin BK (1992). Multivariate cointegration and the law of one price in international wheat markets. *Review of Agricultural Economics* 14(1):117-124.

Goodwin BK & Schroeder TC (1991). Cointegration tests and spatial price linkages in regional cattle markets. *American Journal of Agricultural Economics* 73(2):452-464.

Granger CWJ & Morgenstern O (1970). *Predictability of stock market prices.* Massachusetts: Heath Lexington.

Gravelet-Blondin R (2004). *Personal communication.* The Agricultural Markets Division, South African Futures Exchange.

Hamilton JD (1994). *Time Series Analysis.* Princeton: Princenton University Press.

Hansen LP & Hodrick RJ (1980). Forward exchange rates as optimal predictors of future spot rates: An economic analysis. *Journal on Political Economy* 88:829-853.

Irwin SH, Gerlow ME & Liu T (1994). The forecasting performance of livestock futures prices: A comparison to USDA expert predictions. *Journal of Futures Markets* 14:197-208.

Kristen J & Van Zyl J (1996). *The contemporary agricultural policy enviroment: Undoing the legacy of the past*. In Van Zyl J, Kirsten J & Binswanger HP (eds*),* Agricultural land reform in South Africa: Policies, markets and mechanisms. Cape Town: Oxford University Press.

Moholwa MB (2005). *Testing for weak-form efficiency in South African futures markets for white and yellow maize*. Unpublished Plan B Paper, Department of Agricultural Economics, Michigan State University, East Lansing, USA.

Newbery DMG & Stiglitz JE (1981). *Theory of commodity price stabilisation.* Oxford: Oxford University Press.

Pindyck RS & Robinfeld DL (1981). *Econometric models and economic forecasts.* New York: McGraw Hill.

SAFEX (2004). *The home page of the South African Futures Exchange*. Available online at: http://www.safex.co.za.

Sheldon IM (1987). Testing for weak-form efficiency in new agricultural futures markets. Some UK evidence. *Journal of Agricultural Economics* 38:51-64.

Wiseman JA, Darroch MAG & Ortmann GF (1999). Testing the efficiency of the South African futures market for white maize. *Agrekon* 38(3):321-335.