Is the Australian Wool Futures Market Efficient as a Predictor of Spot Prices?

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Giles and Goss (1980) have suggested that, if a futures market provides a forward pricing function, then it is an efficient market. In this article a simple test for whether the Australian Wool Futures market is efficient is proposed. The test is based on applying cointegration techniques to test the Law of One Price over a three, six, nine, and twelve month spread of futures prices. We found that the futures market is efficient for up to a six-month spread, but no further into the future. Because futures market prices can be used to predict spot prices up to six months in advance, woolgrowers can use the futures price to assess when they market their clip, but not for longer-term

The authors wish to acknowledge the helpful comments of two anonymous reviewers. The first author undertook this project as a student of the Department of Agricultural and Resource Economics (UNE). Any remaining errors are our responsibility.
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The Journal of Futures Markets, Vol. 19, No. 5, 565–582 (1999)

CCC 0270-7314/99/050565-18

production planning decisions. Jrl Fut Mark 19: 565–582, 1999

INTRODUCTION

Giles and Goss (1981, p. 2) suggest the four main functions that futures markets perform:

1. To facilitate risk management, because they provide a hedging facility.
2. To facilitate stock-holding, because the difference between the futures price and the spot price is a guide for inventory control and may be interpreted as a price of storage.
3. To act as a center for the collection and dissemination of information.
4. To perform a forward pricing function, because futures prices can be interpreted as an indication of what the market can anticipate to be the subsequent cash price.

The first two functions lead to the appraisal of the futures market as performing the role of an insurer, whereas the last two suggested functions would lead to conclusions regarding the market's role in providing information. In this study, the forward pricing function of the wool futures market is considered. The importance of this function resides in its role as an assessment of whether the market is efficient.[1] Market efficiency is an important concept in futures markets, because inefficiencies lead to speculators entering the market and extracting more than normal rent.

Giles and Goss (1980, 1981—GG hereafter) studied the forward pricing function of Australian wool futures and found that wool futures price was an unbiased predictor of the spot price up to a period of 12 months in advance. However, as the Reserve Price Scheme operated then (which stabilized the spot price for wool), their assessment of the predictive ability of the futures market could be called into question. In addition, since their study was undertaken time series techniques have improved.

In this study, the period under assessment does not include the operation of the Reserve Price Scheme. Further, new techniques of time-series, particularly cointegration, are employed to gain results that can then be used to check the validity of GG's findings. They used ordinary least squares techniques to undertake their analysis, which creates prob-

[1]Market efficiency in this case is defined as the futures market price adequately reflecting the spot price.

lems if cointegration exists—as the distributions of the calculated F-statistics and t-ratios are not standard.

It should be noted that the intention of this article is not to assess the problems wool producers experience in accounting for basis risk. Growers experience basis risk when they attempt to compare futures prices with spot prices of wool that are not the same as those specified in the futures contract. The problems of basis risk and that of price differentials in the wool industry have been assessed in Cunningham (1995) and Lubulwa et al. (1997). Although this is an important problem, Australian wool producers are just beginning to have full and readily available access to data on specific contracts. Currently, the easily available information relates to the "eastern indicator." This issue is central to the data set used in this study and is discussed in greater detail later in the article.

FUTURES MARKET EFFICIENCY

Conceptual framework

According to Tomek and Gray (1970), because the wool market is a continuous inventory commodity market, it should adequately perform a forward pricing function. If the market is efficient, then the futures price can be used to predict the spot price. This phenomenon can be seen by considering the following model:

$$P_{s,t+1} = \beta_0 + \beta_1 P_{f,t} + e_{t+1} \tag{1}$$

where

$P_{s,t+1}$ is the wool spot price at time period $t + 1$;

$P_{f,t}$ is the wool futures price at time period t of period $t + 1$;

e_{t+1} is the error term with $E(e_t) = 0$ and $E(e_t^2) = \sigma^2$;

β_0 is the intercept term; and β_1 is the slope coefficient.

If β_0 equals zero and β_1 equals one, this model will satisfy the Law of One Price. If results vary slightly from the Law of One Price, the futures price can be said to be reflective of the spot price. Enders (1995, p.6) argues that ". . . the unbiased forward rate hypothesis asserts that expected profits from speculative behaviour should be zero. . ." The relationship between forward and spot exchange rates is similar to that specified in eq. (1). Thus, in theory, the futures price at time t is an unbiased estimate of the spot price in the following time period, t + 1.[2]

Using time-series techniques, it is possible to estimate an equilibrium correction model of the relationship between the wool futures and spot prices. An equilibrium correction model provides not only the long-run relationship parameters (as estimated in GG study), it also provides speed of adjustment coefficients, which are the short-run parameters. Within this model, if the futures and spot prices are in disequilibrium in the short run, the speed of adjustment coefficient provides an estimate of the path needed to return to equilibrium as well as an insight into the causal relationship (in the Granger sense) between futures and spot prices. In summary, using equilibrium correction techniques, both a test for efficiency and a forecasting model are provided.

In order to conclude that the Australian wool futures market is efficient as a predictor of spot prices, the data must support the propositions within eq. (1):

1. $\hat{e}_t$ is "well behaved" because e_t is a stationary zero mean process by assumption, which translates to a test that the futures and spot prices are cointegrated[3].

2. The joint hypothesis that $\beta_0 = 0$ and $\beta_1 = 1$.

If propositions 1 and 2 hold, then there is evidence that, for a given time spread, the futures price is an unbiased predictor of the spot price. That is, the evidence indicates that, on average in the long-run,

$$P_{s,t+1} = P_{f,t} \tag{2}$$

This study's approach to testing market efficiency is based on an equilibrium correction model of the wool market. Through this approach we assess propositions 1 and 2 for different horizons as well as for Granger causality.

In financial economics the normal usage of market efficiency follows the definition of Fama (1971, 1991), and is concerned with the speed with which various information sets are impounded in prices and whether or not excess returns are available after controlling for risk and transac-

[2]It should be noted that the forward rate hypothesis, the Law of One Price, and the tests for boarder price state the same principle within different economic contexts.

[3]Note that a cointegrating relationship is expected to be found only when the theoretical relationship indicates the existence of equilibrium. Finding of cointegration has several potentially beneficial results for estimation (see McCallum 1993, for instance). The empirical finding of cointegration in this study is not only an empirical test for the Law of One Price, but also allows the use of an Equilibrium Correction Model for estimation and prediction.

tion costs. Fama's usage is different from the usage intended by GG and this article. In the context of this study, the futures market is efficient if the spot price can be predicted by the futures price. This causality relationship seems to contravene Fama's definition of efficiency. This is because the assumption in this context is of no adjustment for either risk or transaction costs. Both would be crucially important if the focus of the study were on hedging activity.[4]

Baillie and Myers (1991) have claimed that Spot and Futures prices cannot be cointegrated. Their argument is based on the following arbitrage condition:

$$P_{f,t} - P_{s,t+1} = r_t + \delta \tag{3}$$

where

r_t: is the yield of holding a riskless bond between t and t + 1; and

δ: is a risk premium.

If r_t is integrated, then $P_{f,t} - P_{s,t+1}$ cannot be a cointegrating relationship. This view of the world might hold for some time spreads. That is, it is possible that the expected return on holding the cash commodity equals the return on holding the bond plus a risk premium when the time spread between spot and futures becomes wider.

Testing for Futures Market Efficiency

Formally, we can model the futures and spot prices as follows:

$$\Delta P_{st} = -\alpha_s (P_{s,t-1} - \beta_0 - \beta_1 P_{f,t-1}) + \varepsilon_{st} \tag{4}$$

$$\Delta P_{ft} = \alpha_f (P_{s,t-1} - \beta_0 - \beta_1 P_{f,t-1}) + \varepsilon_{ft} \tag{5}$$

where

$P_{s,t-1}$ = spot price at time $t-1$;

$P_{f,t-1}$ = futures price for time $t - 1$ (at time $t - 2$)[5];

$\Delta P_{st} = P_{st} - P_{s,t-1}$;

$\Delta P_{ft} = P_{ft} - P_{f,t-1}$;

$\alpha_i > 0$ are the speed of adjustment coefficients; i = s,f; and

ε_{st} and ε_{ft} are white noise.

Once eqs. (4) and (5) are estimated it is possible to obtain:

[4]We thank one of the anonymous referees for pointing this out.

[5]Note that the notation has been changed slightly from eq. (1) for easier exposition. The futures price's subscript now denotes the time period that it is predicting.

1. Estimates of the long-run elasticities [β_o and β_1 in eq. (1)], which are the cointegrating parameters if they exist.
2. Test for efficiency, as described in the immediately preceding section.
3. An assessment of causality between futures and spot prices.

Following Granger (1988), if futures and spot prices are cointegrated, then there is causality in at least one direction. Further, if one of the α_i equals zero (where $i = f,s$), then the direction of the causality in a two variable system is established. Suppose that α_s is equal to zero, then (4) and (5) would equal:

$$\Delta P_{st} = \varepsilon_{st}; \text{ and} \tag{6}$$

$$\Delta P_{ft} = \alpha_f \, (P_{s,t-1} - \beta_0 - \beta_1 \, P_{f,t-1}) + \varepsilon_{ft} \tag{7}$$

Then, if $P_{s,t-1} - \beta_0 - \beta_1 \, P_{f,t-1}$ is not equal to zero, the adjustment of the futures price will respond to this disequilibrium, whereas the time path of the spot price would not. In this case, it is said that the spot price "Granger causes" the futures price, whereas the converse is not true.

Data Requirements

At least two alternative 'types' of data might be perceived as useful for this study. The first are data by specific contracts including micron and other characteristics such as strength length vegetable matter content and color. The second are data based on 21 micron wool or the "eastern indicator." Both have relative merits. The first type is not readily available to producers, and on some days the price for the specific type in the futures contract is not reported because that particular type of wool is not available for sale. Thus some interpolation would be necessary in order to use the prices of 21-micron wool. The second is readily available to producers and available from the Sydney Futures Exchange (SFE) Web Page (www.sfe.com.au, 1997). Although only an indicator, it is still the only widely available information for producers. This situation is changing, and it is expected that many producers will have access to the specific contracts via the Internet in the near future. The main objective of this article is to assess whether the producer can use the futures price as a predictor for the spot price, and, therefore, it is believed that producers use the information that is readily available—namely, the eastern indicator.[6]

[6]As one of the referees correctly indicated, it is expected that basis risk exists in futures trading; the question is whether the growers can assess risk associated with the type of wool they produce and how far ahead they can do this assessment.

All futures price data used in this analysis were downloaded from the SFE Web Page. Historical data on wool futures prices and their settlement prices for trading days dating back to December 1991 were obtained. The SFE defines the settlement price as: "the midpoint of the closing bid and offer. If only one is available, then the closing bid (or offer) is used. If there is no closing bid (or offer) then the previous day's settlement is adjusted to maintain the differential to the spot month contract."

The settlement price is used in this study as it is a consistent series of data going back as far as December 1991. Other data series that could have been chosen suffer from reporting breaks that limit the number of observations. Choosing any earlier series would involve accounting for the effects of the Reserve Price Scheme, which reduced trading volumes and created too much volatility when the scheme was being phased out. Furthermore, choosing such a data set would lead to some of the bias thought to exist in GG's work. Data on the spot price for wool, which fitted the specification by the futures contract, were obtained from Wool International (1997 and earlier issues) and its predecessor the Australian Wool Corporation (1993 and earlier issues). The last day of trading for a wool futures contract is noon on the third Thursday of the contract month. Thus the choice of the contract spot price is relatively straightforward. The indicator price from the week containing the third Thursday of the month was taken as the spot price that is used to compare the corresponding futures prices. Although this is not the exact day's price for the end of trading, it is the best available indicator of the spot price for wool at that point in time. Prior to the greasy wool futures listing in mid-1995, when the wool (cash settlement) futures were traded, trading ceased on the business day following the last day of wool auction sales in the month in question. Despite this convention, the same method for determining the spot price was applied to the wool (cash settlement) futures as outlined above because, in all but the rarest of cases, this turned out to be the third Thursday of the trading month.

The spot price used in this analysis was obtained from contract months, given in the contract specifications for wool futures traded on the SFE. To align the futures price data with the spot price data, it was necessary to take the futures price three, six, nine, and twelve months prior to the spot price. This allowed the aligning of the two data series (futures and spot) for each spread (three, six, nine, and twelve months).

Taking futures price data on a daily basis is not desirable, because the futures price in many cases does not change from one day to the next. Therefore the futures price data were aggregated into weekly averages.

Following the practice used in past studies, notably by GG, it was decided that the three, six, nine, and twelve month price spreads would be analyzed. This involves taking futures price data and matching it to spot price data with a spread of three, six, nine, and twelve months between each series' corresponding observation. Consequently, four different spot price series were obtained, each corresponding to the one futures price series.

A further problem arose because the data contained a structural break in all the time spreads—when the change was made to a tradeable futures contract. The cash settled wool futures were delisted on 4 September 1995 and replaced by the new, and currently traded, deliverable wool futures contract. The contract was changed from a 22-micron wool to a 21-micron wool. In addition, there were other changes to the contract including the physical delivery of the settlement requirement for *outstanding contracts* on maturity and a change in the specification of the end of trading day. To assess the problem associated with a structural break in the data, a pulse dummy was included in the analysis. The structural breaks occurred at different points in each of the time spreads, with the break occurring at observation number 100 for the three-month spread, observation number 98 for the six-month spread, observation number 93 for the nine months spread, and observation number 88 for the twelve months spread.

Graphical representations of all the series used in the three, six, nine, and twelve month time spreads are presented in Figures 1, 2, 3, and 4. In both the three-month and six-month spread, the comovement does seem apparent and yet is not apparent in the other two price spreads, though tests are needed to prove whether unit roots and cointegration exist for each of the time spreads.[7]

RESULTS

The first step in conducting a cointegration analysis is to analyze the spot price and futures price data series to determine whether a unit root exists. Detection of a unit root indicates the series is following a nonstationary process. If both the spot price and the futures price are integrated of order one, then the two series must be cointegrated for a stationary linear combination to exist.

Using Perron's Model A to test for a unit root under a structural break (Perron, 1989) provided confirmation of the structural breaks in the data. The results of the unit root tests indicated that the dummy

[7]All the tests and analysis were conducted using the Regression Analysis of Time-Series (RATS) and the Cointegration Analysis of Time-Series (CATS) packages.

FIGURE 1
Three-month futures and spot price series.

FIGURE 2
Six-month futures and spot price series.

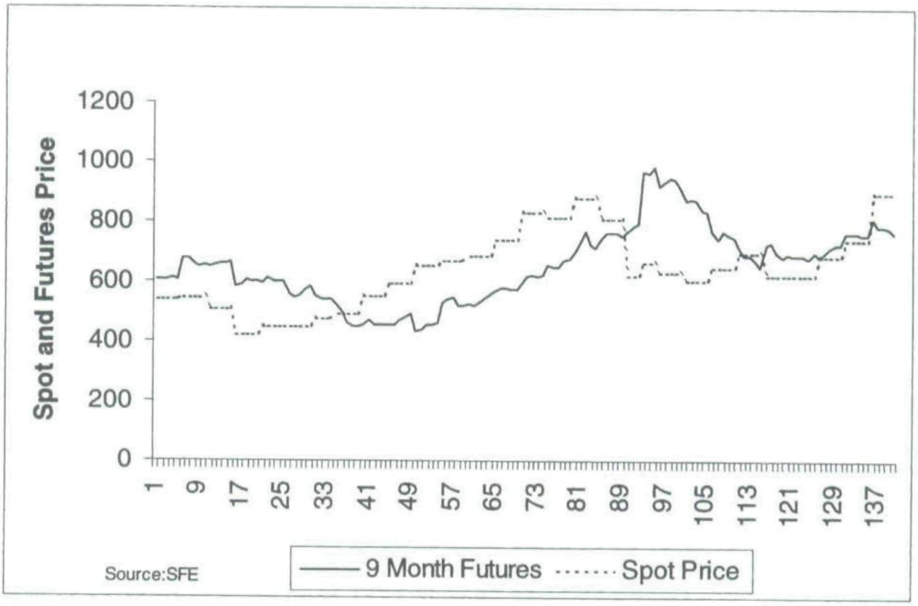

FIGURE 3
Nine-month futures and spot price series.

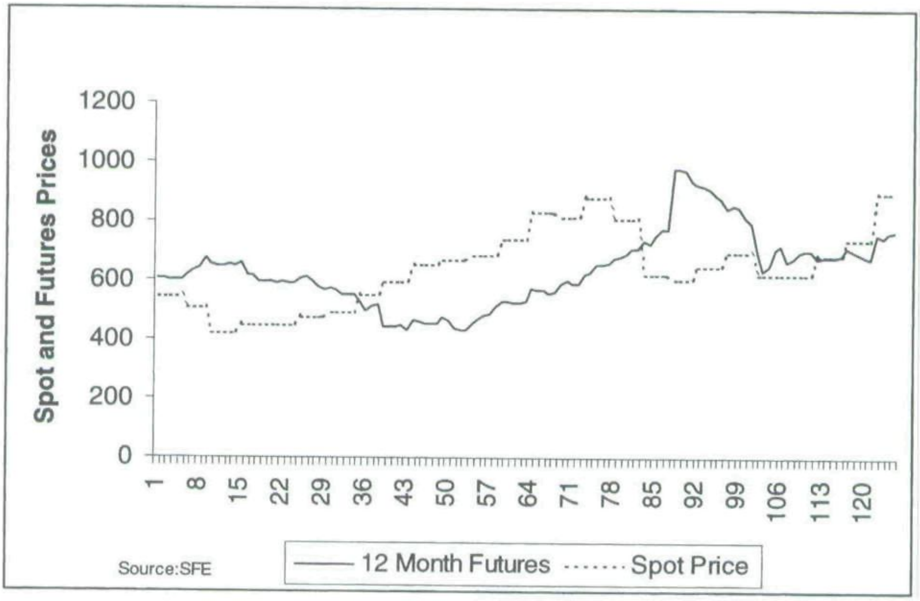

FIGURE 4
Twelve-month futures and spot price series.

TABLE I

Unit Root Test Results

	Lags			
Dickey-Fuller Test	*0*	*1*	*3*	*5*
Futures Price Series				
12 month	−1.342	−1.623	−1.474	−2.109
9 month	−1.451	−1.485	−1.399	−1.843
6 month	−1.474	−1.678	−1.488	−1.881
3 month	−1.474	−1.569	−1.544	−1.984
Spot Price Series				
12 month	−2.939	−2.987	−3.115	−3.047
9 month	−3.335	−3.422	−2.583	−3.005
6 month	−2.305	−2.288	−2.249	−2.284
3 month	−2.179	−2.186	−2.203	−2.011

Notes: The critical values obtained were at the 5% level with $\lambda_3 = 100/158 \approx 0.6$, the critical value is − 3.76, with $\lambda_6 = 98/150 \approx 0.7$, the critical value is −3.80, with $\lambda_9 = 93/140 \approx 0.7$, the critical value is −3.80 and with $\lambda_{12} = 88/125 \approx 0.7$, the critical value is −3.80, (Perron 1989).

variable representing the structural break was significant at the 5% level. This indicates the dummy variable should be included in the testing procedure. The results for the null hypothesis that a unit root does exist are presented in Table I.

The relevant critical values for the statistic to test for a unit root in this model depend on the proportion $\lambda = \tau/T$, where T is the total number of observations and τ is the observation number at which the break occurs. There are four different values for λ, one for each different spread of futures. The λ values are presented with subscripts denoting to which spread each critical value applies.

As all the t_{calc} values are greater than the critical values, the null hypothesis that a unit root exists can not be rejected at the 95% confidence level. Such a result would indicate that both the wool futures price and spot price series follow a random walk process. The Law of One Price requires a stationary linear combination of the two series to exist. This stationary linear combination of two nonstationary series is known as cointegration. If a stationary linear combination of the two series does not exist, then eq. (1) is not an equilibrium relationship. This could lead to speculators gaining pure profits from trade, and indicate market inefficiency arising from poor price prediction.

The next step in a cointegration analysis is to use vector autoregression (VAR) analysis to test for the number of lags in the model. Cointegration tests are seriously biased if too few lags are used in the model

TABLE II

Lag Length Test Results

	AIC Tests		*SBC Tests*		
No of Lags	*Unrestricted*	*Restricted*	*Unrestricted*	*Restricted*	*Result*
3 Month Spread					
24 vs 12	2547.229	2310.703	2831.218	2455.595	12 lags best
10 vs 5	2438.000	2245.456	2563.883	2311.395	5 lags best
6 vs 3	2351.536	2228.044	2430.157	2270.378	3 lags best
4 vs 2	2304.191	2164.758	2358.856	2195.127	2 lags best
2 vs 1	2188.783	1981.947	2219.282	2000.246	1 lag best
6 Month Spread					
24 vs 12	2474.759	2212.273	2752.715	2354.087	12 lags best
10 vs 5	2409.984	2263.126	2533.533	2327.842	5 lags best
6 vs 3	2370.615	2201.707	2447.831	2243.284	3 lags best
4 vs 2	2295.997	2127.473	2349.702	2157.309	2 lags best
2 vs 1	2152.408	1942.752	2182.380	1960.735	1 lag best
9 Month Spread					
24 vs 12	2216.140	2086.771	2485.992	2224.450	12 lags best
10 vs 5	2309.154	2138.219	2429.591	2201.305	5 lags best
6 vs 3	2253.063	2096.447	2328.407	2137.016	3 lags best
4 vs 2	2187.951	2019.134	2240.378	2048.260	2 lags best
2 vs 1	2044.634	1851.802	2073.906	1869.366	1 lag best
12 Month Spread					
24 vs 12	1952.235	1895.538	2208.517	2026.294	12 lags best
10 vs 5	2133.495	1962.464	2248.782	2022.852	5 lags best
6 vs 3	2084.769	1912.849	2157.026	1951.757	3 lags best
4 vs 2	2012.765	1836.564	2063.089	1864.522	2 lags best
2 vs 1	1862.654	1677.408	1890.776	1694.281	1 lag best

Note: Decision rule for test is the best model has the smaller AIC and SBC value.

(Gonzalo, 1994). Similarly, too many lags introduce inefficiencies in the estimation of the model that may result in low power of the tests. Therefore care must be taken to estimate the correct number of lags for the model. Testing for the correct lag length was performed with the Akaike Information Criterion (AIC) and Schwartz Bayesian criterion (SBC) for various possible lag lengths that could apply to the model. For the entire range of futures and spot price spreads, the AIC and SBC values were lowest for the model that was lagged only one period (see Table II).

Further lag length checks were conducted using several multivariate statistics. These tests again involve calculating AIC and SBC values and comparing the calculated values as above, and using autocorrelation tests to ensure the residuals display white noise characteristics. In all cases the information criteria tests were ambiguous (see Table III). The AIC

TABLE III

Further Lag Length Test Results

	AIC		*SBC*		
Spread	*1 Lag*	*2 Lags*	*1 Lag*	*2 Lags*	*Result*
3 Month	1993.762	1986.421	12.816	12.929	Inconclusive
6 Month	1954.742	1949.534	13.240	13.375	Inconclusive
9 Month	1861.809	1855.023	13.521	13.654	Inconclusive
12 Month	1681.941	1676.563	13.778	13.937	Inconclusive

Note: Decision rule for test is the best model has the smaller AIC and SBC value.

TABLE IV

Residual Autocorrelation Test Results

	Ljung-Box Test		*Lagrange Multiplier Test (first order autocorrelation)*		*Lagrange Multiplier Test (four order autocorrelation)*	
Spread	*1 Lag*	*2 Lags*	*1 Lag*	*2 Lags*	*1 Lag*	*2 Lags*
3 Months	0.91	0.89	0.34	0.73	0.86	0.85
6 Months	0.12	0.12	0.74	0.03	0.57	0.46
9 Months	0.04	0.02	0.57	0.04	0.76	0.85
12 Months	0.03	0.02	0.77	0.00	0.70	0.60

Note: Values in the table are p-values. Rejection Rule: reject the null of no autocorrelation if the p-value is smaller than 0.05.

test supported the two-lag model as best, and the SBC test supported the one-lag model as best. It was decided that one lag was best on the grounds of efficiency and that two of the three tests supported the one-lag model.

The three tests conducted for residual autocorrelation were a Ljung-Box (L-B) test and two Lagrange Multiplier (LM)–type tests for first order and fourth order autocorrelation. The tests indicate a white noise process in the error term if the p-value is greater than 0.05, at the 95% confidence level. A value of less than 0.05 could indicate an incorrect choice of lag length. Autocorrelation test results were favourable for all the one-lag models, with p-values being greater than 0.05 (see Table IV). For a six-month spread the two-lag models had one of the three p-values less than 0.05, which seems to be an outlier. The twelve-month spread performed poorly with both one-lag and two-lag models showing p-values less than 0.05. This may be indicative of the problems with the twelve-month spread that will be dealt with shortly.

TABLE V

Lambda Max and Lambda Trace Tests for Three-Month Spread

	H_0	λ_{calc}	λ_{crit}	*Reject* H_0
Lambda Max				
	$r = 0$	24.29	15.752	Yes
	$r = 1$	2.14	9.094	No
Trace Test				
	$r = 0$	26.43	20.168	Yes
	$r \leq 1$	2.14	9.094	No

Note: Reject Ho if $\lambda_{calc} > \lambda_{crit}$.

TABLE VI

Lambda Max and Lambda Trace Tests for Six-Month Spread

	H_0	λ_{calc}	λ_{crit}	*Reject* H_0
Lambda Max				
	$r = 0$	18.53	15.752	Yes
	$r = 1$	1.82	9.094	No
Trace Test				
	$r = 0$	20.34	20.168	Yes
	$r \leq 1$	1.82	9.094	No

Note: Reject Ho if $\lambda_{calc} > \lambda_{crit}$.

Following the determination of the number of lags required in the model, the tests for cointegration can be undertaken. The model estimated was of the form specified in eqs. (4) and (5) with the inclusion of the pulse dummy as an exogenous variable. The Johansen procedure can be used to test for the existence of cointegration and the number of independent cointegrating vectors, also known as the cointegrating rank. The tests are likelihood ratio tests known as the Lambda Max and the Lambda Trace tests. A calculated Lambda greater than the critical Lambda value leads to rejection of the null hypotheses of the rank equal to zero or one under the Lambda Max and the rank equal to zero, or less than or equal to one, under the Lambda Trace test (see Tables V, VI, VII, and VIII).

From the results of these tests, it would appear that cointegration, with rank equal to one, exists between the futures and spot prices for spreads of three months and six months. So the three-month and six-month spread models are cointegrated with one cointegrating vector (visual inspection of Figures 1 and 2 also seems to indicate this comove-

TABLE VII

Lambda Max and Lambda Trace Tests for Nine-Month Spread

	H_0	λ_{calc}	λ_{crit}	*Reject H_0*
Lambda Max				
	$r = 0$	7.66	15.752	No
	$r = 1$	4.45	9.094	
Trace Test				
	$r = 0$	12.11	20.168	No
	$r \leq 1$	4.45	9.094	

Note: Reject Ho if $\lambda_{calc} > \lambda_{crit}$.

ment). There is no evidence to suggest that cointegration exists between the futures and spot price series with a nine month or twelve month spread (visual inspection of Figures 3 and 4 seems to support this finding). As a consequence the nine month and twelve month spreads were not included in the cointegration modeling from this point on. Estimates of the model are presented in Table IX. The estimated cointegrating vector parameters (β_i) and speed of adjustment coefficients (α_i), along with the t-values for the speed of adjustment coefficients, are reported. The cointegrating vectors were normalized with respect to the spot price parameter during the estimation of both the three-month and six-month spread. Furthermore, it is expected that the spot price will affect the futures price and the futures price will not affect the spot price. Thus, in this analysis, an attempt is made to measure the effect a change in the spot price has upon the futures price. Another way of stating this question is to ask whether the spot price does "Granger cause" the futures price and/or whether the futures price does "Granger cause" the spot price.

In both the three-month and six-month spreads the results yield a t-value of less than 1.96 for the α_s values. Thus α_s values are not significantly different from zero, giving support to the spot price model of the form indicated in eq. (6). Note that the estimated futures price cointegrating vector parameters ($\beta_{3f} = -1.023$, $\beta_{6f} = -1.009$) are close to one. As stated previously in this article, if the futures and spot prices are cointegrated, then the wool futures market is efficient for the given time spread if there is evidence to support the null hypothesis that:

$$H_0\text{: } \beta_0 = 0 \text{ and } \beta_1 = 1$$

$$H_1\text{: at least one does not}$$

The likelihood ratio test yielded a value of 0.30 (p-value $= 0.86$) for the

TABLE VIII

Lambda Max and Lambda Trace Tests for Twelve-Month Spread

	H_0	λ_{calc}	λ_{crit}	Reject H_0
Lambda Max				
	r = 0	7.27	15.752	No
	r = 1	3.56	9.094	
Trace Test				
	r = 0	10.83	20.168	No
	r ≤ 1	3.56	9.094	

Note: Reject Ho if $\lambda_{calc} > \lambda_{crit}$.

TABLE IX

Estimated Cointegrating Vector Parameters and Speed of Adjustment Coefficients for Three- and Six-Month Spreads[a]

	$\hat{\beta}_f$	$\hat{\beta}_s$	$\hat{\alpha}_f$	$\hat{\alpha}_s$
Three-Month Spread	−1.023	1.000	0.116[a]	0.037
			(5.125)	(1.118)
Six-Month Spread	−1.009	1.000	0.072[b]	0.012
			(4.080)	(0.571)

[a]Subscript 'f' indicates futures price coefficient and subscript 's' indicates spot price coefficient.
[b]Values in brackets are t-values, significant at the 1% level.

three-month spread, whereas for the six-month spread the likelihood ratio test yielded a value of 0.14 (p-value = 0.93). Thus, for the three-month and six-month spreads, using likelihood ratio tests, the null hypothesis that the cointegrating vector between spot and futures prices β' is equal to $[1\ -1]$ could not be rejected. That is, in the notation of eqs. (4) and (5), and (6) and (7), $P_{s,t} - P_{f,t} = 0$.

These results suggest that the adjustment of futures price depends on the long-run disequilibrium between spot and futures prices, whereas the adjustment of the spot price is independent of the long-run disequilibrium. Thus the empirical evidence supports Granger causality from the spot to the futures price, but not the reverse. This is the expected result, in accordance with the Law of One Price.

DISCUSSION OF RESULTS—THE SPEED OF ADJUSTMENT

The results of this analysis (with all the restrictions imposed) indicate that the following models are supported by the data:

For the three-month spread:

$$\Delta\hat{P}_{f3,t} = 0.118\ (P_{s3,t-1} - P_{f3,t-1}) \tag{8}$$

$$\hat{P}_{f3,t} = P_{f3,t-1} \tag{9}$$

For the six-month spread:

$$\Delta\hat{P}_{f6,t} = 0.074\ (P_{s6,t-1} - P_{f6,t-1}) \tag{10}$$

$$\hat{P}_{f6,t} = P_{f6,t-1} \tag{11}$$

These results are encouraging, for they imply a futures market that is working in an efficient manner and one that is providing a forward pricing function, for the three-month and six-month spreads. The estimated model reported above indicates that a movement in the spot price is causing a correction to the futures price.

It was also found that the futures respond faster to a change in the spot price in the three-month futures than in the six-month futures. This is shown by the smaller speed of adjustment value in the six-month futures model. Because three-month futures are closer to their expiration of contract than six-month futures, it seems reasonable to find a faster response to disequilibrium.

The results estimated in this study confirm some of those concluded by GG. The results also add to our knowledge by finding that cointegration does exist and by providing estimates of the short-run effect of spot price movements on the futures price.

In the case of the nine-month and twelve-month futures, no cointegration was found. This raises the question of whether the arbitrage condition proposed by eq. (3) might be valid for these time spreads. However, this question cannot be answered without further analysis.

Finally, the recent introduction of more wool futures contracts to cover a broader range of microns in the wool market by the SFE (January 1998) will provide more data to answer questions associated with basis risk that have not been assessed in this study.

CONCLUSIONS

In summary, in this study an improved technique was used to assess whether wool futures prices are a good predictor of wool spot prices. A similar study was conducted by GG using ordinary least squares techniques. To properly test market efficiency, an error correction model was estimated in this study. Market efficiency was established to exist for the three-month and six-month spreads. This technique also made it possible to estimate the path of adjustment futures prices will follow when they move from a position of disequilibrium to equilibrium. In addition, Granger causality from spot to futures prices was found.

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