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IN SEARCH OF HUNT'S SHORT-RUN PRICE CYCLES IN THE SYDNEY WOOL FUTURES MARKET*

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The structure of prices of Sydney wool futures contracts is examined with the aid of spectral analysis. Although the series studied are not strictly random walks, it is shown that there is little useful information for forecasting contained in the historical price data. It is concluded that the behaviour of prices on the Sydney wool futures market is essentially the same as that observed for the majority of stock and futures price series from other markets.

Most studies of the behaviour of prices on overseas stock and futures markets have found evidence that such series follow a random walk. For example, after examining futures and cash prices for a wide range of commodities in the United States, Labys and Granger concluded that 'This hypothesis was largely confirmed, despite some evidence of seasonal components in monthly series' [8, p. 259]. For another comprehensive study of various price series, see Granger and Morgenstern [5]. However, Hunt [7], in a study published in 1974, found evidence of systematic short-run price movements in some Sydney wool futures prices and concluded that the market was not efficient.[1] In an attempt to resolve the conflict between Hunt's findings and those reported elsewhere, the propositions advanced by Hunt in support of his statistical findings are examined. Prices of Sydney wool futures contracts for a more recent period are then analysed as a further test of Hunt's hypothesis.

Cycles in Futures Prices

Hunt's study of the behaviour of wool futures prices was based on historical data. He tested the hypothesis that futures prices follow a random walk; that is, that prices may be described by the equation

$$(1) \qquad P_t = P_{t-1} + a_t,$$

where P_t is price and a_t a random disturbance in period t.[2] The random walk model is a special case of the 'fair game' efficient markets model; a market is considered a 'fair game' if excess profits cannot be generated solely on the basis of information contained in past prices.[3]

Using spectral analysis and cyclical indices to examine daily and seven times daily price series, Hunt concluded that a strong weekly cycle existed [7, p. 139]. Prices of wool futures contracts were, on

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[1] In the efficient markets literature, a market in which prices always fully reflect all available information is called efficient. For a review of the efficient markets model see Fama [4]. An alternative view of the way in which competitive markets behave has been presented by Grossman and Stiglitz [6].

[2] The model describes a random walk if $E[a_t] = 0$, a_t has a stationary distribution, and a_t, a_{t-s} are independent. A model for which only the conditions $E[a_t] = 0$ and Cov $[a_t, a_{t-s}] = 0$, $s \neq 0$, hold is known as a martingale.

[3] See Fama [4, pp. 384-7] for a discussion of 'fair game' models.

average, high at the beginning and end of the week and low for the three mid-week days. Hunt claimed that the magnitude of the weekly cycle was such that it could be traded against profitably. He further argued that the existence of a weekly price cycle indicated that the market was inefficient, especially given that hedgers could profitably trade against the cycle as they enter and leave the market [7, pp. 142-3].

Hunt suggested that the weekly cycle resulted from speculators (who were apparently net short in the market) liquidating their open positions at the end of the week rather than taking the risk of maintaining open positions over the weekend [7, p. 141]. In other words, according to Hunt, speculators enter the market as buyers at the end of the week and thereby force prices to rise. This explanation is incomplete in that it fails to indicate who would act as sellers immediately before a period of high risk. For Hunt's proposition to be useful, it is necessary to hypothesize that a number of hedgers are willing to close out their positions, regularly, at the end of each week, or that there are two classes of speculators, one group being far less risk averse than the other. Further, Hunt has suggested that the high prices on Mondays are again the result of risk averse speculators liquidating their position in the market in response to the uncertainty which exists on Mondays before wool sales commence on Tuesdays, the usual day on which wool auctions begin in Australia. This hypothesis suffers from the same deficiency as the previous one, that the rationale of the sellers remains unexplained.

Methodology

To test the proposition that wool futures prices contain systematic components, series of average daily prices, average twice-daily prices and daily closing prices for seven wool futures contracts for the period from 6 December 1976 to 30 September 1977 were analysed using spectral analysis. Prices for days on which the market was closed or during which no trading occurred for a particular contract were computed by linear interpolation. To determine whether each price series was a random walk, the null hypothesis that the first difference of each series was a white noise process was tested.[4] Both the first differences of the original series and the first differences of the logarithms of the series were analysed.

Results

For the contracts analysed there was no evidence to suggest the existence of any weekly cycle in either the differences of the original series or the differences of the logarithms. There was some evidence that a cycle with a period of six half-days existed in the series observed twice daily. This cycle tended to be less pronounced in the more distant contracts and to become stronger as contracts approached maturity. These cycles accounted for, at the most, 13 per cent of the variance of the series, and in most cases accounted for between 2 and 5 per cent of the total variance. There was no evidence of systematic movements in any of the daily price series. While for most series the

[4] A sequence of random variables with zero mean and finite variance is often referred to as a white noise process.

spectra transgressed the 90 per cent confidence limits at frequencies corresponding to periods of approximately 3·0, 4·5 and 20·0 days in length, the variance accounted for by these cycles was in all cases less than 10 per cent. In general, it appeared that there was little or no information in the innovations that might be used for the purpose of short-term forecasting.

As an illustration, detailed results of an analysis of the daily closing prices for the contract that matured on 21 October 1977 are given below. The spectrum of the October price series is presented in Figure 1. The spectrum was estimated using the finite fourier transform estimator. (For a full discussion of the properties of this estimator and listings of the Fortran routines used, see de Jong [3]). Sets of five adjacent periodogram points were smoothed to obtain the estimate of the spectrum presented in Figure 1. The spectrum of the October price series transgresses the upper bound of the 90 per cent confidence band at frequencies which correspond to periods of approximately 19·0, 7·0, 4·5 and 3·2 days. These cycles account for approximately 3·5, 1·7, 6·9 and 5·5 per cent of the variance of the series respectively. In other words, very little of the variance of this series can be accounted for by systematic movements in the prices.

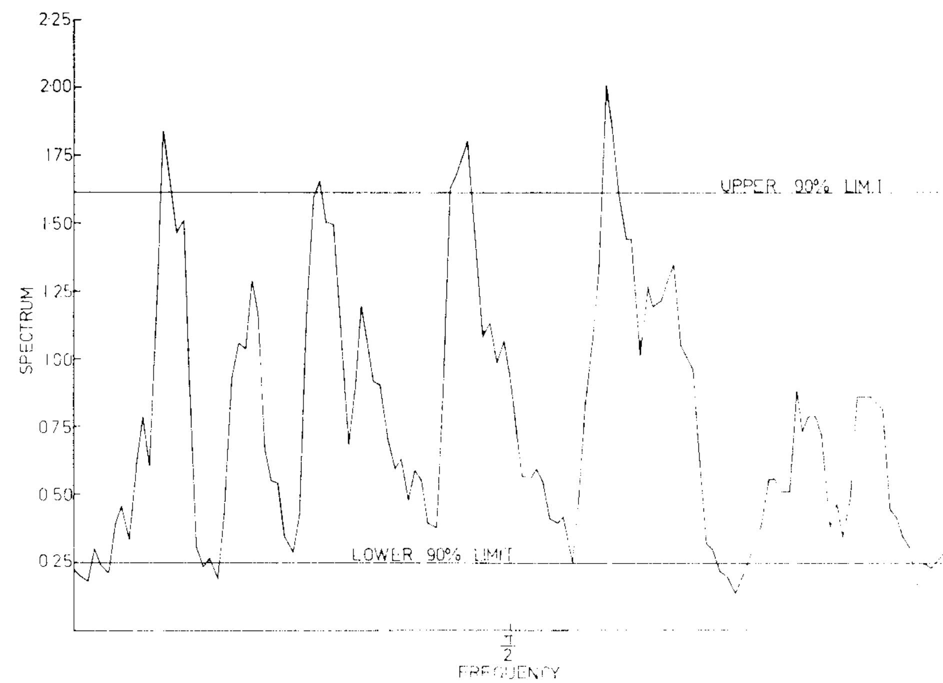

FIGURE 1—The estimated spectrum of the first differences of the October price series.

Two tests may be used to check whether the random walk model provides an adequate representation of the price series. If equation (1) represents the model to be fitted, then the first difference of the price series represents the resultant sequence of errors. If there is evidence that this sequence of errors is not a white noise process, then it can be concluded that the random walk model is inadequate. Two relevant tests of model adequacy are described in Box and Jenkins [2, pp. 290-8]. The first is based on the autocorrelation function and tests whether, say, the first 10 or the first 20 autocorrelations of the $\hat{a}$s, taken as a whole, indicate inadequacy of the model. The first 20 autocorrelations of the first difference series are given in Table 1. The approximate standard error of the autocorrelations given in Table 1 is 0·08. (Box and Jenkins [2, pp. 34-5] show that the standard error is approximately equal to $N^{-\frac{1}{2}}$ where N is the sample size.) An inspection of the table shows that the autocorrelations at lags 2 and 11 are large relative to their respective standard errors. However, the general or portmanteau test on the residual autocorrelations indicates that the model is adequate. For example, the test statistic, Q, has values of 8·37 and 17·11 over 10 and 20 lags of the correlogram respectively. The values of the test statistic should be compared with the χ^2 statistic with 10 and 20 degrees of freedom respectively.

TABLE 1

The Estimated Autocorrelation Function of the First Differences of the October Price Series[a]

Lag	Autocorrelation	Lag	Autocorrelation
1	0·05	11	—0·16
2	—0·13	12	0·01
3	0·01	13	0·07
4	—0·03	14	—0·02
5	—0·05	15	—0·04
6	0·02	16	—0·04
7	—0·02	17	0·05
8	—0·11	18	0·02
9	0·07	19	0·07
10	—0·09	20	0·09

[a] The series consisted of 174 observations.

A second test described by Box and Jenkins, namely the cumulative periodogram check, is designed to detect periodic patterns in a series of residuals. When the normalized cumulative periodogram was computed, it was found that none of its values fell above or below the 10 per cent limit lines, indicating that there were no strong periodic components in the first difference series.

Taken together, these tests indicate that the first difference series provides a good approximation of a white noise process. However, the magnitude of individual autocorrelations at lags 2 and 11 indicate that a suitable univariate time-series model may provide an improved representation of the series which may be useful for forecasting.

Inspection of the correlogram of the first difference series presented in Table 1 suggests that a moving average model of the following form would provide an adequate representation of the series.[5]

(2) $$P_t - P_{t-1} = (1 - \theta_1 B^2 - \theta_2 B^{11})\, a_t,$$

where B is the backward-shift operator such that $B^m a_t = a_{t-m}$. When

[5] For a discussion of the methods employed in identifying a univariate time-series model see Box and Jenkins [2, pp. 173-86].

a model of this form was estimated it was found that the coefficient θ_2 was not significantly different from zero at the 5 per cent level of significance. As a consequence, the variable was excluded from the model and the equation re-estimated. The results for the re-estimated equation are given below.

$$P_t - P_{t-1} = (1 - \underset{(0{\cdot}09)}{0{\cdot}18}B^2)\, a_t$$

$$R^2 = 0{\cdot}21$$

$$Q_{(24)} = 33{\cdot}03$$

The number below the coefficient is its estimated standard error. The re-estimated equation adequately modelled the structure of the series.

The equation presented above contains little additional information beyond that contained in a random walk model. As an illustration, one series of forecasts, including confidence limits, is presented in Table 2. The forecasting model is of the form:

$$\hat{P}_{t+1} = P_t - 0{\cdot}18a_{t-1}.$$

As a consequence of the structure of this model, the forecast values of the series are constant beyond a lead-time of two periods. In the case of a wool futures contract, a favourable price movement of three cents is sufficient to cover all transaction costs. However, the width of the 90 per cent confidence interval for a one-step-ahead forecast from the moving average model is six cents. The model would have to forecast a price change of greater than three cents before a speculator (who accepted the 90 per cent confidence limits) could be confident in acting on a one-step-ahead forecast. It is unlikely, however, that a model of this kind would result in forecasts of price changes of this order of magnitude because the coefficient of P_t in the forecasting equation is unity and the other coefficient is small. In other words, the series is a good approximation of a random walk.

TABLE 2

Forecasts of Futures Prices from a Moving Average Model

Periods ahead	Lower bound of the 90 per cent confidence interval	Forecast price	Upper bound of the 90 per cent confidence interval	Actual price
	c/kg	c/kg	c/kg	c/kg
1	329·9	333·0	336·0	333·5
2	328·9	333·2	337·5	334·5
3	328·2	333·2	338·2	334·6
4	327·6	333·2	338·8	334·5
5	327·1	333·2	339·3	333·5

Conclusion

The futures prices analysed in this study did not exhibit any strong systematic movements. However, the series were strictly not random walks. These results are not inconsistent with other studies of futures and stock markets which have found that minor deviations from a random walk do sometimes occur in daily data. For example, Labys and Granger [8, pp. 77-81] found that, of the ten daily futures price series investigated, two were non-random.[6] Although the estimated spectra of the first differences of the wool futures price series indicated that those series were not white noise processes, the series contained little information useful for forecasting. The apparent systematic movements observed by Hunt in wool prices on the Sydney futures exchange are no longer sufficient to allow the generation of excess profits merely from a knowledge of past prices.

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[6] See Allingham [1] for a possible explanation of this behaviour.