SIMULTANEITY, FORECASTING AND EFFICIENCY IN THE U.S. OATS MARKET

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6.1 INTRODUCTION

Oats are the fourth most important crop in the United States, after corn, wheat and soybeans, according to area planted. The U.S. is an important world producer of oats, ranking second only to the U.S.S.R., although West Germany, Poland and Canada are important producers. In 1975-76 U.S. production of oats was 639 m.bush. (458 m.bush. in 1980-81), while production of corn in 1975-76 was nine times that of oats (14.5 times in 1980-81) and production of soybeans in 1975-76 was 2.4 times that of oats (3.9 times in 1980-81). Yet in terms of the volume of futures contracts traded on the Chicago Board of Trade, corn and soybeans are proportionately far more important. In 1975 oats futures contracts representing 772 bil.bush. were traded (1604 bil.bush. in 1980), while the volume of corn futures contracts was 31 times that of oats in 1975 (37 times in 1980), and the volume of soybeans futures contracts traded was 25 times that of oats in 1975 (36 times in 1980). This minor status of the oats market is reflected in research on U.S. grains, with most studies concentrating on wheat, corn and soybeans.

The comparative neglect of the oats market may have arisen, in part, because a large proportion of the oats crop is consumed on the farm (38.2% in 1975-76, 34.9% in 1980-81), and this in turn may be due to the high bulk:weight ratio and the relative lack of profitability of oats, compared, for example, with corn. Another contributing factor to the lack of interest in the oats market may be the low speculative ratio which the oats crop has attracted (see Appendix 1), probably due largely to its relatively smaller price fluctuations compared with soybeans and corn (Inkeles (1972), pp.129-30).

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Oats are an important feed component for horses, dairy cattle, poultry and hogs, being high in protein and in fibre content, compared with other grains on a weight basis. They also play an important role in crop rotation programs. In the U.S. in 1975-76 86% of the oats crop was fed to livestock (94% in 1980-81), while food uses comprise typically 7% to 9%, seed comprises about 6% to 7% and exports account for around 2% to 3% of the crop. In the milling of oats for feed, white oats are preferred. The major oats producing states in the U.S. are Minnesota, South Dakota, Iowa, Wisconsin and North Dakota. These states produce essentially white oats, which are grown on a spring planting cycle, being harvested in the summer, some 100 to 120 days later.

In the preparation of animal feeds, the degree of substitutability between oats and corn is higher than that between oats and any other grain. In practice the price of corn has a strong influence on the price of oats, and given that the weight of a bushel of oats is only 57.14% of that of a bushel of corn, and that corn has a higher feed value on a volume basis, the price of corn is usually significantly higher than that of oats. Indeed, in the period 1972-73 to 1980-81 the average ratio of the annual average cash price of oats to the annual average cash price of corn was 58.0%.

The main trading location for oats futures contracts is the Chicago Board of Trade (CBOT), although such contracts are traded also on the Winnipeg Commodity Exchange in Canada, and on the Mid-America Commodity Exchange in Chicago. Oats have traded on the CBOT since 1877, where the contract calls for delivery of 5,000 bushels in March, May, July, September and December.

The issue of informational efficiency in futures markets is discussed in the Introduction to this volume. In this chapter it is proposed simply to summarize the results according to the main methodologies employed to explore this question in the area of futures markets. The issue of weak form efficiency has been studied by many writers including Larson (1960), Stevenson and Bear (1970), Leuthold (1972), Cargill and Rausser (1975) and Praetz 1975), using research methodologies essentially the same as those employed in the equities area (see Fama (1970)).

While some departures from the strict random walk model have been found, it is not clear that these could have been used to generate returns in excess of transaction costs.

The question of semi-strong form efficiency in futures markets, that is efficiency with respect to publicly available information, has been studied using three different approaches. Hansen and Hodrick (1980) investigated whether a relationship existed between the current forecast error for a particular currency and immediately prior forecast errors for related currencies. This approach, which exploits the "predictive" quality of futures prices, is based upon the idea that the information contained in forecast errors will be immediately exploited in an efficient market, so that there will be no systematic relationship between the current forecast error for a futures contract and the elements assumed to comprise the information set. This method has been applied to a group of non-ferrous metals by Goss (1986, pp. 168-71) and to the Australian wool market by Goss (1987).

Another method used to investigate this question, which also exploits the predictive qualities of futures prices, requires the employment of a quantitative model of the market to forecast the cash price at future dates. If the futures price does not predict at least as well as the model, this suggests that the model contains information not reflected in the futures price. This method has been used by Leuthold and Hartmann (1979) and Leuthold and Garcia (see Chapter 3 of this volume) for U.S. livestock, Rausser and Carter (1983) for the U.S. soybeans complex and Brasse (1986) for the London tin market, all of whom discovered some inefficiencies in the markets studied.

Failure to reject the hypothesis of semi-strong form efficiency, under either of these approaches, is not proof that the market is efficient. There remains the possibility that an alternative model may lead to rejection. More recently Chance (1985a, 1985b) has studied the response of the U.S. Treasury Bond and GNMA futures markets to "news" (in this case the unanticipated component of inflation rate announcements). The results are generally consistent with the hypothesis of semi-strong form efficiency. In this chapter the second method is employed to examine whether U.S. oats futures prices reflect publicly available information as fully as possible. A simultaneous model of the U.S. oats market is developed in Section 6.2, while in Section 6.3 the data are discussed and tests of the hypothesis of a single unit root in oats futures prices are reported. Estimates of the parameters of the simultaneous model are reported and evaluated in Section 6.4, while post sample forecasts of the cash price and tests of the efficient markets hypothesis are discussed in Section 6.5. Some conclusions are presented in Section 6.6.

The model presented in this paper draws on the approach of Peston and Yamey (1960) and Giles, Goss and Chin (1985) and extends the work of Goss and Giles (1986a, 1986b) in the analysis of intertemporal price relationships in commodity markets with futures trading. The model presented here comprises separate functional relationships for long and short hedgers, long and short speculators in futures, consumers and holders of unhedged inventories.

It is assumed that there are three submarkets for oats: a storage submarket, a futures submarket and a submarket for present consumption. Within each submarket appropriate demand and supply relationships may be distinguished. In the storage submarket, the supply of hedged storage is provided by short hedgers, who hold inventories and sell futures contracts as a hedge against the risk of a fall in the cash price. The demand for hedged storage comes from long hedgers, who require the commodity at a later date for processing or to fulfil a forward commitment, and who hedge the risk that the price of the commodity will rise by buying futures contracts.[1]

Storage is held unhedged by agents who anticipate a rise in the cash price. Their price expectations are assumed to involve them in a reciprocal demand for and supply of unhedged storage, so that the quantity of unhedged inventories held by these agents is added equally to the hedged components of demand and supply in the storage submarket, to obtain total demand for and supply of storage.

The futures submarket partially overlaps the storage submarket, but the two are not synonymous. In the submarket for futures contracts, supply is provided by short hedgers and by short speculators. Short speculators expect the price to fall and sell futures contracts in pursuit of an uncertain gain. Demand for futures is provided by long hedgers and long speculators. Long speculators buy futures because they expect the price to rise and employ risk capital in support of their expectations.

In periods when hedgers are net short, the demand for hedged storage is assumed to be provided by long hedgers and sufficient long speculative positions in futures to balance the hedged storage submarket. Similarly, in periods when hedgers are net long, the supply of hedged storage is assumed to be provided by short hedgers and sufficient short speculative positions in futures to balance the hedged storage submarket.

In the submarket for present consumption, demand is provided by consumers or processors of oats, whose demand is a derived demand. It is further assumed that in each period there is a given amount of the commodity for allocation between current consumption and storage. This amount is the available supply. The supply in the consumption submarket is that part of the available supply which is not allocated to storage. Note that the submarket for present consumption is not the same as the spot market for the commodity because a spot purchase may be made either for consumption or for storage purposes.

6.2 SPECIFICATION OF THE EQUATIONS

6.2.1 Supply of Hedged Storage

Hedgers are assumed not only to pursue risk reduction but also to seek gains from their hedging activities. If the forward premium declines, gains will be realised for short hedgers. Hence the volume of hedged storage that is supplied by short hedgers is assumed to be an increasing function of the forward premium and of the volume of inventories eligible for hedging. The supply of hedged storage also varies inversely with the marginal net cost of storage, represented here by the marginal interest cost (m_t) (the dominant component of storage cost) because warehousing costs of oats are not available to us.

Since hedging is usually done in the expectation of a favourable change in the price spread (Working (1953) p.325) we expect the supply of hedged storage to be inversely related to the expected price spread. The specification of the short hedging equation therefore is:

$$SH_t = \alpha_0 + \alpha_1(P_t - A_t) + \alpha_2 CK_t + \alpha_3(P_{t+1} - A_{t+1})^* + \alpha_4 m_t + e_{1t} \quad \text{(1a)}$$

where α_1 , $\alpha_2 > 0$; α_3 , $\alpha_4 < 0$

SH_t = supply of storage (and futures) by short hedgers;

P_t = current futures price of oats;

A_t = current cash price of oats;

CK_t = indicator of the quantity of oats eligible for hedging;

$(P_{t+1} - A_{t+1})^*$ = expected price spread for period (t+1).

The oats market has a lower speculation ratio than the soybeans market (see Appendix 1), so that expectations in the oats market are likely to respond less rapidly to new information; hence price expectations are assumed here to be represented by the adaptive expectations hypothesis (Nerlove (1958)). This hypothesis assumes that the current revision of expectations is a proportion of the immediately prior expectational error:

$$(P_{t+1} - A_{t+1})^* - (P_t - A_t)^* = \alpha[(P_t - A_t) - (P_t - A_t)^*]$$

where $0<\alpha<1$.

Hence
$$(P_{t+1} - A_{t+1})^* = \frac{(1-\beta)(P_t - A_t)}{(1 - \beta L)} \quad \text{(1b)}$$

where $\beta = 1 - \alpha$, and L is the lag operator. This hypothesis implies that the current expectation is a geometrically weighted average of the post actual values, with backwardly declining weights, and will under-predict on a rising market and over-predict on a falling market. Substitution from (1b) into (1a) yields the following:

$$SH_t = \phi_1 + \phi_2(P_t - A_t) + \phi_3(P_{t-1} - A_{t-1}) + \phi_4 CK_t + \phi_5 CK_{t-1} + \phi_6 m_t + \phi_7 m_{t-1} + \phi_8 SH_{t-1} + u_{1t} \quad \text{(1c)}$$

While inclusion of the price spread yields parameter estimates of the expected signs, the significance of these estimates improves, as does simulation by the model generally, when cash and futures prices are included, in both current and lagged form, as separate variables, thus supporting an alternative hypothesis. The marginal net cost of storage was deleted from the equation for the same reason.[2] The final specification, therefore, is based on the hypothesis that short hedging varies directly with the current futures price and the volume of inventories eligible for hedging, and inversely with the expected futures price and the current cash price:

$$SH_t = \alpha_0 + \alpha_1 P_t + \alpha_2 P^*_{t-1} + \alpha_3 A_t + \alpha_4 CK_t + e_{1t} \tag{1d}$$

where α_1 , $\alpha_4 > 0$; α_2 , $\alpha_3 < 0$;

$$P^*_{t+1} = \frac{(1 - \beta)P_t}{(1 - \beta L)} \tag{1e}$$

Substitution from (1e) into (1d) yields the final specification:

$$SH_t = \phi_1 + \phi_2 P_t + \phi_3 A_t + \phi_4 P_{t-1} + \phi_5 A_{t-1} + \phi_6 CK_t + \phi_7 CK_{t-1} + \phi_8 SH_{t-1} + u_{1t} \tag{1}$$

where $\phi_2 > 0$ if $\alpha_1 > |\alpha_2(1 - \beta)|$, otherwise $\phi_2 < 0$;

ϕ_3 , ϕ_4 , $\phi_7 < 0$; ϕ_5 , $\phi_6 > 0$; $0 < \phi_8 < 1$.

If e_{1t} is independently and identically distributed (i.i.d.) then u_{1t} follows a first order moving average process (MA1).

6.2.2 Demand for Hedged Storage

Long hedgers will suffer a loss if the price spread narrows; i.e. if the forward premium at the time a hedge is lifted is less than the difference between the futures price and the forward actuals price at the time the hedge is opened, the long hedger will incur a loss. The cash price has been used as a proxy for the forward actuals price, which is generally unobservable. So it is expected that the demand for hedged storage by long hedgers (LH) will be inversely related to the current price spread and directly related to the expected price spread. Forward actuals commitments of long hedgers are measured by planned exports (X_{t+1}) and planned consumption (C_{t+1}) in period (t+1), where the plans are assumed to be realized. Hence the long hedging equation is:

$$LH_t = \alpha_5 + \alpha_6(P_t - A_t) + \alpha_7(P_{t+1} - A_{t+1})^{**} + \alpha_8 C_{t+1} + \alpha_9 X_{t+1} + e_{2t} \tag{2a}$$

where $\alpha_6 < 0$; α_7 , α_8 , $\alpha_9 > 0$.

Adaptive expectations implies that

$$(P_{t+1} - A_{t+1})^{**} = \frac{(1-\lambda)(P_t - A_t)}{(1-\lambda L)} \text{ , } 0 < \lambda < 1 \text{ .}$$

Substitution of this expected price spread expression into (2a) gives

$$LH_t = \phi_9 + \phi_{10}(P_t - A_t) + \phi_{11}(P_{t-1} - A_{t-1}) + \phi_{12}C_{t+1} + \phi_{13}C_t$$
$$+ \phi_{14}X_{t+1} + \phi_{15}X_t + \phi_{16}LH_{t-1} + u_{2t} \tag{2b}$$

Again, inclusion of the price spread led to deterioration of the parameter estimates and model simulation, so that the price spread was replaced by the ratio of the futures price to the cash price (P_t/A_t). The variables representing planned exports and planned consumption were deleted from the relationship for the same reason. The long hedging equation is therefore

$$LH_t = \alpha_5 + \alpha_6(P_t/A_t) + \alpha_7(P_{t+1}/A_{t+1})^* + e_{2t} \tag{2c}$$

where $\alpha_6 < 0$; $\alpha_7 > 0$, and $(P_{t+1}/A_{t+1})^* = \dfrac{(1-\lambda)(P_t/A_t)}{(1-\lambda L)}$.

Substitution for $(P_{t+1}/A_{t+1})^*$ in (2c) gives

$$LH_t = \phi_9 + \phi_{10}(P_t/A_t) + \phi_{11}(P_{t-1}/A_{t-1}) + \phi_{12}LH_{t-1} + u_{2t} \tag{2}$$

where $\phi_{10} < 0$ if $|\alpha_6| > \alpha_7(1-\lambda)$, otherwise $\phi_{10} > 0$; $\phi_{11} < 0$; $0 < \phi_{12} < 1$.

6.2.3 Unhedged Storage

Unhedged storage is held by agents who purchase stocks spot in the expectation of a rise in the spot price. Following Brennan (1958) and Telser (1958), the demand for unhedged storage (U_t) is related directly to the expected spot price A^*_{t+1}, and inversely to the current spot price (A_t), the marginal risk premium (r_t) and the marginal net cost of storage (m_t).
The specification of this equation is

$$U_t = \alpha_{10} + \alpha_{11}A_t + \alpha_{12}A^*_{t+1} + \alpha_{13}m_t + \alpha_{14}r_t + e_{3t} \tag{3a}$$

where α_{11} , α_{13} , $\alpha_{14} < 0$; $\alpha_{12} > 0$; and $A^*_{t+1} = \dfrac{(1-\gamma)A_t}{(1-\gamma L)}$

where $0<\gamma<1$. Inclusion of the marginal net cost of storage had a detrimental impact on the significance of the estimated coefficients and on the model simulation, and so m_t was deleted, although this is not a cause for concern.[2]

Substituting for A^*_{t+1} into (3a) gives:

$$U_t = \phi_{13} + \phi_{14}A_t + \phi_{15}A_{t-1} + \phi_{16}r_t + \phi_{17}r_{t-1} + \phi_{18}U_{t-1} + u_{3t} \quad (3)$$

where ϕ_{15}, $\phi_{17} > 0$; $\phi_{16} < 0$; $0 < \phi_{18} < 1$; $\phi_{14} < 0$

if $|\alpha_{11}| > \alpha_{12}(1 - \gamma)$ otherwise $\phi_{14} > 0$.

6.2.4 Demand for Futures by Long Speculators

Long speculators purchase futures contracts expecting the futures price to rise. Their demand for futures (LS) is assumed to vary inversely with the current futures price and marginal risk premium, and directly with their expected futures price. Such speculators, however, are likely to take into account the relative profitability of speculating in oats and other grain futures such as corn. Account was taken of this substitution through the spread between the oats futures price (P_t) and the corn futures price (P^c_t); this spread performed better in preliminary estimation than a ratio of these prices, in that the latter had a detrimental effect on signs and significance in the model generally. Hence the specification of this relationship is:

$$LS_t = \alpha_{15} + \alpha_{16}(P_t - P^c_t) + \alpha_{17}(P_{t+1} - P^c_{t+1})^* + \alpha_{18}r_t + e_{4t} \quad (4a)$$

where α_{16}, $\alpha_{18} < 0$; $\alpha_{17} > 0$; and $(P_{t+1} - P^c_{t+1})^*$ is the expected spread between oats and corn futures prices for next period formed in the current period.

Adaptive expectations implies that

$$(P_{t+1} - P^c_{t+1})^* = \frac{(1-\delta)(P_t - P^c_t)}{1 - \delta L}, \; 0 < \delta < 1 \; . \quad (4b)$$

Inclusion of the marginal risk premium, however, adversely affects the signs of the parameter estimates of the model, and this variable was deleted, although again this is not a cause for concern.[2]

Substituting from (4b) into (4a) for $(P_{t+1} - P^c_{t+1})^*$ yields

$$LS_t = \phi_{19} + \phi_{20}(P_t - P^c_t) + \phi_{21}(P_{t-1} - P^c_{t-1}) + \phi_{22}LS_{t-1} + u_{4t} \quad (4)$$

where $\phi_{21} > 0$; $0 < \phi_{22} < 1$; $\phi_{20} < 0$ if $|\alpha_{16}| > \alpha_{17}(1 - \delta)$, otherwise $\phi_{20} > 0$.

6.2.5 Supply of Futures by Short Speculators

Futures contracts are also supplied by speculators, i.e. economic agents without actuals commitments who expect the futures price to fall. Again, to take account of the relative profitability of speculating in oats futures and corn futures, the spread between these two futures prices is included in the relationship. These agents may be seen as extending their holdings of short positions to the point where the current oats-corn futures price spread does not exceed their expected oats-corn futures price spread plus marginal risk premium, i.e. until $P_t - P^c_t = (P_{t+1} - P^c_{t+1})^{**} + r_t$, where $(P_{t+1} - P^c_{t+1})^{**}$ is the expected oats-corn futures price spread of short speculators.

The supply of futures (SS) is assumed to vary directly with the current oats-corn futures price spread and inversely with their expected futures price spread and marginal risk premium, so that

$$SS_t = \alpha_{19} + \alpha_{20}(P_t - P^c_t) + \alpha_{21}(P_{t+1} - P^c_{t+1})^{**} + \alpha_{22}r_t + e_{5t} \qquad (5a)$$

where $\alpha_{20} > 0$, α_{21} , $\alpha_{22} < 0$;

$$\text{and } (P_{t+1} - P^c_{t+1})^{**} = \frac{(1-\tau)(P_t - P^c_t)}{1 - \tau L} \text{ , } 0 < \tau < 1 \text{ .} \qquad (5b)$$

Again, inclusion of the marginal risk premium has an adverse effect on the signs of parameter estimates, and this variable was deleted, although this is not disadvantageous.

Substituting from (5b) into (5a) for $(P_{t+1} - P^c_{t+1})^{**}$ yields

$$SS_t = \phi_{23} + \phi_{24}(P_t - P^c_t) + \phi_{25}(P_{t-1} - P^c_{t-1}) + \phi_{26}SS_{t-1} + u_{5t} \qquad (5)$$

where $\phi_{25} < 0$; $0 < \phi_{26} < 1$; $\phi_{24} > 0$ if $\alpha_{20} > |\alpha_{21}(1-\tau)|$ otherwise $\phi_{24} < 0$.

6.2.6 Consumption Submarket

The demand for the consumption of oats (C) by processors is derived from the use of this crop as a feed for dairy cattle, livestock and horses. Hence the consumption demand for oats is assumed to be dependent upon the parameters of demand for the end-products, the parameters of the supply of other factors employed in making these final products, and the cash price of oats. Dairy cattle consume about 34% of oats used for animal feed, and oats make up

35% of all grains fed to dairy cattle (Inkeles (1972) p.31). The profitability of feeding oats to dairy cattle may be represented by the oats/milk cash price ratio. Inclusion of the cash price of milk, however, detrimentally affected the signs and significance of the parameter estimates of the model, and so this variable was omitted from the relationship.

Corn is also used with oats in preparing livestock feed, and the cash price of corn (A^c) is included as a parameter of the supply of other inputs. Whether corn is a complement to or substitute for oats will be inferred from the sign of its coefficient (a negative coefficient implies complementarity while a positive coefficient indicates the grain is a substitute for oats). U.S. real personal income is assumed to be a parameter of end-product demand.

In order to place the anticipations of all agents on the same theoretical footing, the adaptive hypothesis has been extended to income in the consumption equation, so that the relationship is

$$C_t = \alpha_{23} + \alpha_{24}A_t + \alpha_{25}A_t^c + \alpha_{26}Y^*_{t+1} + e_{6t} \tag{6a}$$

where $\alpha_{24} < 0$, $\alpha_{25} \leq 0$, $\alpha_{26} > 0$; Y^*_{t+1} is anticipated U.S. real personal income for period $(t+1)$ and $Y^*_{t+1} = \left(\frac{1-\omega}{1-\omega L}\right) Y_t$, $0 < \omega < 1$.

Substituting for Y^*_{t+1} in (6a) gives

$$C_t = \phi_{27} + \phi_{28}A_t + \phi_{29}A_t^c + \phi_{30}A_{t-1} + \phi_{31}A_{t-1}^c + \phi_{32}Y_t + \phi_{33}C_{t-1} + u_{6t} \tag{6}$$

where $\phi_{28} < 0$; ϕ_{29} , $\phi_{31} \leq 0$; ϕ_{30} , $\phi_{32} > 0$; $0 < \phi_{33} < 1$.

6.2.7 Identities

The model is completed with the following identities:

$$K_t = U_t + HH_t \tag{7}$$

where $HH_t = \max[SH_t , LH_t]$

and K_t = total inventories of oats and is exogenous;

$$SH_t + SS_t = LH_t + LS_t \tag{8}$$

The first identity states that the total quantity of stocks equals the demand for unhedged storage plus the demand for hedged storage. It is written in this form because this identity is employed to generate observations on the variable U_t (see Section 6.3, below).

The second identity states that total supply of futures contracts equals total demand for futures contracts. These are identities of observed values and it is assumed that the storage and futures markets clear every trading period so that only equilibrium values are observed in monthly data. There are 8 endogenous variables (SH, LH, U, SS, LS, C, P, A) together with six behavioural relationships and two identities in this model.

6.3. DATA

This section provides details of the collection and generation of data employed in the estimation of the model. The sample period dates from 1972(10) to 1978(9): after allowing for lags up to four periods in the selection of instruments for estimation purposes (see below), this results in 72 observations.

6.3.1 Endogenous Variables

Oats futures prices (P_t) are the closing prices in U.S. dollars per bushel for a six-month future[3] on the median trading day of each month. These prices are quotations from the Chicago Board of Trade *Statistical Annual*, 1972-1981.

Spot price data (A_t) are daily cash prices for oats on the median trading day of each month in U.S. dollars per bushel (No.2 Extra Heavy White) at Minneapolis, as published in the CBOT *Statistical Annual*, 1972-81.

The demand for and supply of hedged storage (LH_t and SH_t respectively) of oats are assumed to be measured by the end-of-month open interest of hedgers at the Chicago Board of Trade. These open interest data (in thousands of bushels) are reported in the *Commitments of Traders* for the years 1972-1981 and published by the U.S. Commodity Futures Trading Commission (CFTC). The reporting level for oats was 200,000 bushels for the sample and forecast periods. The CFTC reports open positions data, both long and short, for large (reporting) hedgers, large (reporting) speculators and for non-reporting traders, i.e. the distribution of the positions of these non-reporting traders between hedging and speculation is unknown. How the positions of small traders should be distributed has been the subject of analysis by Peck (1982) who argued that 'virtually all' of the 'small traders' in corn and possibly soybeans were speculators for most of the 1970s. The oats market, however, was not discussed in that paper and we assume that the distribution (between speculation and hedging) for non-reporting traders is the same as that for reporting traders. Allocation of the positions of non-reporting traders was carried out based on this assumption using open position data. These open position data were used to measure the supply of and demand for oats futures contracts by hedgers, because a corresponding classification by type of transaction is not available for turnover. This last procedure is unsatisfactory to the extent that some of these open positions may have been instituted prior to the current month. The demand for and supply of oats futures contracts by long and short speculators (LS_t and SS_t) are also measured by the end-of-month open interest for speculators calculated from the figures reported by the CFTC. Again this procedure is not optimal insofar as some of these positions may have been opened prior to the current month.

Data on the demand for unhedged storage (U_t) are unobservable, and U_t is generated by subtracting LH_t or SH_t whichever is larger, from K_t . In some periods negative U_t values[4] are generated by this procedure. Negative U_t values are not consistent with this model, and so the following procedure is used to adjust these values: in periods when U_t is negative, LH_t or SH_t whichever is larger,[5] has been reduced by the absolute value of U_t , and this absolute value has been added to LS_t (if LH_t is decreased) or to SS_t (if SH_t is decreased). In this procedure, it is assumed that excess hedging is speculation rather than hedging. The signs and significance of the estimates of the structural parameters of the model are improved if commercial stocks (CK) rather than total stocks (K) are employed in the calculation of unhedged storage (see Section 6.4 below).

Oats consumption data (C_t) are quarterly observations, in thousands of bushels, on the total domestic use of oats published in the *Commodity Yearbook*, 1978 and 1983. These quarterly observations are interpolated to monthly data using the program TRANSF (Wymer (1977)).

6.3.2 Exogenous Variables

Data on U.S. total stocks of oats (K_t) are total stocks (in thousands of bushels) at end of month from the Chicago Board of Trade *Statistical Annual*, 1982, while data on U.S. commercial stocks of oats (CK_t) are in thousands of bushels at end of month, also from the Chicago Board of Trade *Statistical Annual*, 1982. The latter do not include stocks on farms.

The marginal risk premium r_t is defined as the (90-day) Commercial Paper rate less the (90-day) Treasury Bill rate in per cent per annum, as published in the U.S. *Federal Reserve Bulletin*, 1972-1981.

The marginal interest cost is the U.S. prime rate in per cent per annum divided by twelve and multiplied by A_t ; the U.S. prime rate is published in the U.S. *Federal Reserve Bulletin*, 1972-1981.

The income variable Y_t is U.S. total nominal personal income in billion U.S. dollars, from the *Federal Reserve Bulletin*, 1972-1981, divided by the Consumer Price Index (CPI) (base year = 1963) from the *International Financial Statistics*, 1972-1981. While Y_t data for the period 1972-1975 are monthly observations, data for total personal income for the years 1976-1981 are quarterly observations interpolated to monthly data using the program TRANSF (Wymer (1977)). Cash prices of corn (A_t^c) are daily prices in U.S. dollars per bushel, on the median trading day of each month, as published in the CBOT *Statistical Annual*, 1972-82.

Corn futures prices (P_t^c) are the closing prices on the median trading day of each month for a corn futures contract approximately six months prior to delivery, where that contract is selected according to the rule in footnote 3. These prices are in U.S. dollars per bushel as published in the Chicago Board of Trade *Statistical Annual*, 1972-1982.

6.3.3 Tests for Unit Roots

Tests for unit roots have been of interest in recent research on financial time series, partly because a time series which has an autoregressive representation with a single unit root, can be approximated by a random walk, which is of special interest in the study of efficient markets. Moreover, rational expectations models of financial markets require stationarity in order that conditional expectations of prices in such models are time invariant.

Tests for unit roots have been studied by Fuller (1976), Dickey and Fuller (1979, 1981), Evans and Savin (1981, 1984) and Doukas and Rahman (1987). In this chapter tests are reported for a single unit root in oats futures prices, using the test statistics developed by Dickey and Fuller (1979, 1981). This hypothesis is of interest here, given the focus of this paper on the informational efficiency of the oats market.

In the autoregressive representation of the futures price series,

$$P_t = \rho P_{t-1} + e_t \qquad \text{(Model A)}$$

it is assumed that ρ is a real number and e_t is NID $(0,\sigma^2)$. If

(a) $|\rho| < 1$, P_t converges to a stationary series as $t \to \infty$.

(b) $|\rho| > 1$, the series is non-stationary, and the variance of P_t grows exponentially as $t \to \infty$.

(c) $|\rho| = 1$, there is borderline non-stationarity. If $\rho = 1$, there is a single unit root.

The models used to test the hypothesis of a single unit root are (A) as well as the following representations:

$$P_t = \mu + \rho P_{t-1} + e_t \qquad \text{(Model B)}$$

$$P_t = \mu + \beta t + \rho P_{t-1} + e_t \qquad \text{(Model C)}$$

In these models, P_1 is assumed fixed, (B) contains an intercept, while (C) contains an intercept and time trend. The tests employed are the Wald test and the likelihood ratio test developed by Dickey and Fuller (1979, 1981). The Wald test requires estimation of the unconstrained model, while the likelihood ratio test requires that the model be re-estimated according to the constraint of the null hypothesis.

The least squares estimator $\hat{\rho}$ is consistent for all values of ρ (Dickey and Fuller (1979) p. 427). The estimates of the parameters for the models in (A), (B), (C) are presented in Table 6.1 for oats futures prices, for 119 observations, together with the relevant Wald test statistics as developed by Dickey and Fuller (1979), which are used to test the hypothesis $H(\rho = 1)$. These calculated statistics are compared with the tabulated 10% critical values, given in Fuller (1976) Tables 8.5.1 and 8.5.2 (pp. 371, 373), which are reproduced in Table 6.1 for sample size $n = 100$. It will be seen that the hypothesis of one unit root $H(\rho = 1)$ cannot be rejected at the 10% level in any of the versions formulated in (A), (B) or (C). This statement applies whether the test statistic $n(\hat{\rho} - 1)$ or the statistic $\hat{\tau} = (\hat{\rho} - 1)/SD\hat{\rho}$ is employed (where $SD\hat{\rho}$ is the sample standard deviation of $\hat{\rho}$).

In Dickey and Fuller (1979, p. 430) the powers of these various tests in a Monte Carlo study are given, using the model A, for different sample sizes and different values of ρ. For a sample of $n = 100$ with $\rho = 0.95$, the powers of the test statistics $n(\hat{\rho} - 1)$ and $\hat{\tau}$ are identical, and both are more powerful than the statistics $n(\hat{\rho}_\mu - 1)$ and $\hat{\tau}_\mu$. When the sample value of $\rho = 1.02$, the power of $\hat{\tau}$ slightly exceeds that of $n(\hat{\rho} - 1)$, and again both these test statistics are more powerful than $n(\hat{\rho}_\mu - 1)$ and $\hat{\tau}_\mu$.

Likelihood ratio tests are employed also to test for the presence of a single unit root in oats futures prices, and these tests, as noted below, can under some circumstances be more powerful than the Wald tests reported in Table 6.1. Three likelihood ratio tests are reported here. The first hypothesis considered is $H(\alpha,\rho) = (0,1)$, in which the alternative model (B), is tested against the null model $P_t = P_{t-1} + e_t$, and the test statistic is ϕ_1. The second hypothesis is that $H(\alpha,\beta,\rho) = (0,0,1)$; that is, model (C) is tested against the same null as above, and the test statistic is ϕ_2. The third hypothesis tested is $H(\alpha,\beta,\rho) = (\alpha,0,1)$; here the alternative model (C) is tested against the slightly wider null $P_t = \alpha + P_{t-1} + e_t$, and the test statistic is ϕ_3. Table 6.2 gives the calculated values of the relevant statistics for these various hypothesis tests, according to the formulae in Dickey and Fuller (1981, p. 1059). Empirical distributions of the test statistics ϕ_1, ϕ_2, ϕ_3 are given for various sample sizes in Tables IV, V, VI of Dickey and

Fuller (1981, p. 1063). Tabulated values for 0.9 probability of a smaller value (thus giving 0.1 rejection region) for a sample size n = 100, from Dickey and Fuller (1981, p. 1063) are given in Table 6.2. Comparing the critical values with the calculated values of the test statistics in Table 6.2, supports the view that in none of the three cases is it possible to reject the hypothesis of a single unit root. This result is consistent with the outcome of the Wald tests in Table 6.1.

It is observed by Dickey and Fuller (1981, p. 1069) that the statistics $n(\hat{\rho}_\mu - 1)$ and $\hat{\tau}_\mu$ display poor power when ρ is close to unity and $\alpha \neq 0$, as in some of the models estimated here. Moreover, these authors note (p. 1068) that the test statistic ϕ_1 has more power than ϕ_2, because the alternative model for ϕ_2 is wider.

These tests were executed also for oats cash price data for the same sample period, and again in no case could the hypothesis of a single unit root be rejected (these latter tests are not reported here for reasons of space).

6.4 ESTIMATION AND RESULTS: SAMPLE PERIOD

The model is linear in the parameters, but non-linear in the endogenous variables P, A. Each of the six structural equations is over-identified. Prior to the estimation of the simultaneous system, the initial values of the parameters of the structural equations were estimated by two stage least squares (2SLS) for each equation. The 2SLS procedure obtains instrumental variable (IV) estimates, and the instrument set used to obtain initial values for equations (1) to (6) comprised lagged endogenous variables and current and lagged exogenous variables from the model as a whole. Only in the demand for unhedged storage (equation (3)), a spot market relationship, was there evidence of serial correlation among the residuals. In this equation a correction was made for first order autocorrelation. The signs of the estimates of all parameters in all equations, except for ϕ_{11} in equation (2), were as expected. In equation (2), the long hedging relationship, the sign of the estimated coefficient of (P_{t-1}/A_{t-1}) was contrary to expectations. This may have arisen because the cash price of oats is an imperfect proxy for the forward actuals price of stock feed products, or it may be due to an inadequate understanding of the behaviour of long hedgers.

These 2SLS estimates were employed as initial values for the simultaneous estimation of the structural parameters by three stage least squares (3SLS) using the program TSP 4.1B (Hall and Hall (1986)). The 3SLS procedure obtains IV estimates, and the instrument set employed here is as follows:

$$CK_t,\ CK_{t-1},\ r_{t-1},\ r_{t-2},\ Y_{t-1},\ SH_{t-2},\ P^c_{t-1},\ A^c_{t-1},\ LH_{t-2},\ SS_{t-2},\ LS_{t-2},$$
$$U_{t-2},\ C_{t-3},\ (P_{t-2} - A_{t-2})\ .$$

The correction for first order autocorrelation made in the estimation of the initial values for equation (3) was extended to the estimation of the simultaneous system. This was done by means of an autoregressive transformation, obtained by taking equation (3), lagging it one period, multiplying by ρ_3 (the autocorrelation coefficient) and subtracting the result from (3), which gives:

$$\begin{aligned} U_t - \rho_3 U_{t-1} &= \phi_{13}(1 - \rho_3) + \phi_{14}(A_t - \rho_3 A_{t-1}) + \phi_{15}(A_{t-1} - \rho_3 A_{t-2}) \\ &+ \phi_{16}(r_t - \rho_3 r_{t-1}) + \phi_{17}(r_{t-1} - \rho_3 r_{t-2}) + \phi_{18}(U_{t-1} - \rho_3 U_{t-2}) \\ &+ u_{3t} - \rho_3 u_{3t-1} \end{aligned} \tag{3.1}$$

The 3SLS procedure was employed to estimate the structural parameters of the model and the autocorrelation coefficient. The 3SLS estimates are consistent and asymptotically efficient (Hall (1986) p.270). These estimates for the sample period 1972(10) to 1978(9) (72 observations) are presented in Table 6.3, together with asymptotic t-values.

The main features of these estimates are as follows. First, all adaptive expectations adjustment coefficients are between zero and unity, as economic theory requires. The adaptive hypothesis is evidently an appropriate representation of expectations revision in this market, including anticipations of income. In equation (3), for example, the adaptive adjustment coefficient (which is $(1 - \hat{\phi}_{20})$) implies that only seven and a half per cent of expectational error is taken into account in revision of expectations of the spot price, and hence implies that expectations of holders of unhedged inventories are somewhat static. While one may be sceptical of such an estimate, the simulation performance of this equation (see below) tends to support this estimate.

Second, the two spot market relationships, (3) and (6), have the signs of all parameter estimates as expected, and the majority of these estimates are significant. These relationships are important, because oats inventories are mostly held unhedged, and most oats are consumed domestically. It should be noted that the definition of U as the residual of CK over the volume of hedging [max SH, LH] is more satisfactory from the viewpoint of signs and significance of parameter estimates, than as the surplus of total stocks (K) over the volume of hedging, notwithstanding that U is sometimes negative. Hence the variable U here should be interpreted as unhedged commercial inventories, which are evidently more sensitive to market signals than unhedged total inventories. Moreover, the estimated autocorrelation coefficient in (3) is not significant, although omission of the correction for autocorrelation is not warranted. In the consumption equation, the estimate of ϕ_{32} suggests that oats are a normal good, as expected, while the hypothesis of interdependence with the corn market is supported, and the two grains are evidently substitutes (see $\hat{\phi}_{29}$).

Thirdly, in the short hedging equation, which is an important futures market relationship, the hypothesis that the volume of short hedging varies directly with the futures price and inversely with the cash price and expected futures price is supported. The hypothesis that short hedging varies directly with the price spread (P-A) and inversely with the expected price spread, is also supported with alternative estimates (not reported), but this alternative hypothesis results in inferior simulation by the model generally.[6] It is noted that the volume of commercial stocks (CK) performs well as an indicator of the commitments of short hedgers (see $\hat{\phi}_6$). The estimates of the coefficients of the long hedging equation provide some support for the hypothesis that long hedgers respond to the ratio of futures to spot prices, although the sign of the estimate of ϕ_{11} is contrary to expectations (equations (2c) and (2) predict that $\phi_{10}>0$ if $|\alpha_6| < \alpha_7(1 - \lambda)$). It should be noted that there is a comparable degree of support for the hypothesis that long hedgers respond to the price spread, although substitution of $(P_t - A_t)$ for

(P_t/A_t) in (2) results in the sign of $\hat{\phi}_5$ in (1) being contrary to expectations and leads to a slight deterioration in the simulation performance of the model.

Fourth, the general lack of significance in the long and short speculation equations is disappointing, although not fatal to model performance in view of the low speculative ratio in the oats market. The hypothesis of interdependence with the corn market receives weak support, rather than the strong support observed in the estimates of the coefficients of the consumption equation.

Notwithstanding these deficiencies in the estimation of the structural parameters, an important test of the appropriateness of a simultaneous model with an expectations function, is the ability of the model to simulate values of the endogenous variables both within and outside the sample period. A summary evaluation of intra-sample simulation by this model is presented in Table 6.4, which comprises correlation coefficients between simulated and actual values, as well as Theil's Inequality Coefficient (IC) and per cent root mean squared error of forecast (%RMSE). The intra-sample simulation is illustrated also in Figures 6.1 to 6.8. It will be seen that the unhedged inventory relationship is the best performing equation, with virtually perfect simulation throughout. This is an important result because, as seen above, most stocks are held unhedged. The short hedging function also performs quite well, except for some slight under-prediction on a rising market, as expected with the adaptive hypothesis. This under-prediction leads to a delay of around one month in the prediction of peaks, and of course there is a tendency to over-predict on a falling market. The long hedging function, although exhibiting a relatively high Theil's IC, performs tolerably well after December 1974, and not as poorly as the parameter estimates for equation (2) would lead one to expect. It may be appropriate to infer that there was some significant change in the behaviour of long hedgers after 1974(12), which renders the present model more relevant after that date.

The tracking of consumption reveals a tendency to exaggerate all peaks and troughs, and this is reflected to some extent in the correlation coefficient and Theil's IC for equation (6). This deficiency of the model may be due partly to the substantial proportion of the oats crop which is consumed on the farm (see Section 1 above), and is therefore not the subject of any market transaction.

The simulation of the long and short speculation functions in futures is moderately good, except for the adaptive characteristic of under-(over-) prediction on a rising (falling) market noted above, which is reflected especially in the Theil's IC and %RMSE statistics. While the simulation of the futures and cash prices improves after June 1975, prior to that date there is notable exaggeration of the amplitude of fluctuations. Again, the present model would seem to be more appropriate in explaining these variables after 1975.

Simulation of the oats cash price is better than that of the soybeans cash price in the study reported in Giles, Goss and Chin (1985), although it is inferior to that of the corn cash price reported in the same paper. Simulation of the oats futures price however, is inferior to that of both corn and soybeans futures prices in the earlier paper, a feature which may be due to the more successful representation of the (greater) speculative interest in the latter two markets. Of the various structural equations, only the unhedged storage relationship for the oats market clearly outperforms any corresponding function for the corn and soybeans markets, although the performance of the oats short hedging equation may be comparable (no per cent RMSEs were reported in the earlier paper).

In any case, the results reported here are sufficiently encouraging to warrant the generation of post-sample forecasts of the cash price, and the use of these forecasts to test the semi-strong form of the efficient markets hypothesis.

6.5 POST SAMPLE FORECASTS AND MARKET EFFICIENCY

The model analysed above in Section 6.4 was employed to provide forecasts of the cash price of oats six months ahead, during a post-sample forecast period 1979(3) to 1981(9) comprising 31 observations. In order to place the model on the same informational footing as the oats futures price, the model was continuously updated by re-estimating the parameters for each successive forecast during the post-sample period. A test of the efficient markets hypothesis requires that these model-derived forecasts of the cash price (AS) be compared with the six month ahead forecasts of the cash price implicit in the futures price (P). The performance of these two predictors is compared in Table 6.5, and it will be seen that the model predictor AS clearly outperforms the futures price P, although the difference between the two according to the %RMSE criterion is not statistically significant (see Appendix 2). Incidentally, the hypothesis that each of these two predictors is unbiased cannot be rejected (see Appendix 2).

Each of these predictors, however, contains information which the other does not (see Figure 6.9), and so the proportionate contribution of each to an assumed composite predictor was estimated from the relationship

$$CP_{t-6,t} = \alpha AS_{t-6,t} + \beta P_{t-6,t} + e_t \tag{9}$$

where $CP_{t-6,t}$ is a composite predictor formed at time t-6 for the cash price at time t. Equation (9) was estimated by OLS for 31 observations in the forecast period, $\hat{\alpha}$ and $\hat{\beta}$ were not constrained to add to unity, and there is no evidence of serial correlation among the residuals. The results of this estimation are given in Table 6.6, and while multicollineary would normally be expected to qualify the interpretation of such estimates, the relative magnitudes of the estimated coefficients do confirm the view that the model predictor outperforms the futures price as an anticipation of the cash price.

The estimated weights $\hat{\alpha}$ and $\hat{\beta}$ were used to form the composite predictor of the cash price $CP_{t-6,t}$ the performance of which is evaluated in Table 6.5. It will be seen that, as expected, CP outperforms the other two predictors, and moreover that the difference in performance between CP and the model predictor, according to the %RMSE criterion, is statistically significant at the five per cent level, but not at the one per cent level (see Appendix 2).

In this case it would seem more appropriate to reduce the probability of a Type 1 error (i.e. reduce the chance of rejecting the EMH when it is true), and so select the one per cent level of significance. This is so because the EMH is not a purely static concept, but also raises the question whether there is evidence that agents are learning to use the information contained in the model. Convergence of the two predictors, CP and P, for example, would constitute such evidence, although in Figure 6.9 it is not clear that these two series do converge. In any case, selection of the one per cent level and hence non-rejection of the EMH, simply has the consequence of calling for further evidence on this market, and in view of the ambiguous results in this Section, that is the decision made here. Non-rejection of the EMH at this level of significance is consistent with the outcome in Section 6.3.3 above, in which the hypothesis of a single unit root could not be rejected.

A speculative trading program also was employed to investigate whether significant profits could be made in the oats futures market, using the information contained in the model. For each month of the forecast period a futures contract, as defined in footnote 3, was sold if the futures price P exceeded the model predictor AS, while the futures contract was purchased if $P \leq AS$. There were 17 sell and 14 buy transactions in this program, each position being reversed after six months (or one month prior to the delivery date, whichever was the earlier). This program resulted in mean gross profits which are significant at the one per cent level (two tail test), but which ceased to be significant when the expense ratio reached 25% of profits. This result suggests a possible inefficiency in the oats futures market, but in the absence of information about actual expenses, and confirmation from repeated samples, cannot be used to reject the EMH.

6.6 CONCLUSIONS

Although the area planted to oats in the U.S. is the fourth largest after wheat, corn and soybeans, oats have been comparatively neglected in grain market studies. This may be because a significant proportion of the crop is consumed on the farm, due possibly to the high bulk:weight ratio. Moreover, the oats market has attracted a relatively low speculative ratio and this may have made it a less interesting subject of economic investigation.

This paper develops a simultaneous model of the oats market, distinguishing functional relationships for holders of unhedged inventories and consumers (mainly stock feed processors), as well as for short and long hedgers and short and long speculators in futures. In 3SLS estimation of the parameters of the simultaneous system and in intra-sample simulation, the best performing equation, with virtually perfect simulation, is the unhedged inventory function. This is an important result because most inventories are held unhedged. The short hedging equation performs better when specified in terms of current cash and futures prices and the expected futures price, rather than as a function of the current and expected price spread. Better results are obtained when the long hedging equation is specified in terms of the current and expected ratio of the futures price to the spot price, rather than the price spread, although this relationship does not perform as well as its short hedging counterpart. Simulation of long and short speculative positions is acceptable given the low speculative ratio. The adaptive hypothesis, employed throughout, is an appropriate representation of expectations, including anticipated income in the consumption relationship. There is no evidence of serial correlation except in the unhedged inventory function, in which a correction is made for first order autocorrelation.

This model is employed to forecast the cash price of oats six months ahead during a post-sample forecast period, and for each monthly forecast the model is updated by extending the sample period one month and re-estimating the parameters. The semi-strong form EMH is tested by comparing the model prediction of the cash price with the prediction implicit in the futures price for six months ahead delivery. The model is a superior predictor to the futures price, although the difference between the two is not significant. A composite predictor, with OLS estimated weights, also outperforms the futures price as a predictor of the cash price, and in this case the difference in performance, while significant at the five per cent level, is not significant at the one per cent level at which the test is conducted. The outcome of this test, therefore, is that the EMH is not rejected. This result is consistent with the outcome of Wald and likelihood ratio tests for a single unit root in futures prices, reported in the data section, an hypothesis which also is not rejected.

A speculative trading program, in which the future was sold if priced at a premium to the model predictor, and bought if priced at a discount, resulted in significant gross profits in the forecast period, although this is insufficient evidence to reject the EMH.

TABLE 6.1

PARAMETER ESTIMATES AND WALD TEST STATISTICS FOR UNIT ROOTS: FUTURES PRICES*

MODEL	$\hat{\mu}$	$\hat{\beta}$	$\hat{\rho}$	$n(\hat{\rho} - 1)$	$\hat{\tau}$
A	-	-	1.0018 (0.0072)	0.2142	0.2500
Critical Value (0.1)				-5.6	-1.61
				$n(\hat{\rho}_\mu - 1)$	$\hat{\tau}_\mu$
B	0.1067 (0.0442)	-	0.9358 (0.0283)	-7.6398	-2.2686
Critical Value (0.1)				-11.0	-2.58
				$n(\hat{\rho}_\tau - 1)$	$\hat{\tau}_\tau$
C	0.1509 (0.0497)	0.00097 (0.00052)	0.8680 (0.0457)	-15.7080	-2.8884
Critical Value (0.1)				-17.5	-3.15

* Numbers in parentheses are standard errors.

TABLE 6.2

LIKELIHOOD RATIO TESTS FOR UNIT ROOTS : FUTURES PRICES

Hypothesis	Null Model	Alternative Model	Test Statistic (Calc. Value)	Critical Value*
$H(\alpha,\rho) = (0,1)$	$A_t = A_{t-1} + e_t$	B	$\phi_1 = 2.9170$	3.86
$H(\alpha,\beta,\rho) = (0,0,1)$	$A_t = A_{t-1} + e_t$	C	$\phi_2 = 3.1761$	4.16
$H(\alpha,\beta,\rho) = (\alpha,0,1)$	$A_t = \alpha + A_{t-1} + e_t$	C	$\phi_3 = 4.3955$	5.47

* These are tabulated values for 0.9 probability of a smaller value, from Dickey and Fuller (1981), p. 1063, tables IV, V, and VI (see text).

TABLE 6.3

OATS MODEL : 3SLS PARAMETER ESTIMATES

Coefficient	Variable	Estimate	Asymp-t value	Equation
ϕ_1	Const.	4631.2	2.010	1
ϕ_2	P_t	11084.0	2.698	
ϕ_3	A_t	-7829.1	-1.921	
ϕ_4	P_{t-1}	-10603.0	-3.036	
ϕ_5	A_{t-1}	5191.3	1.232	
ϕ_6	CK_t	0.298	4.716	
ϕ_7	CK_{t-1}	-0.300	-4.844	
ϕ_8	SH_{t-1}	0.914	11.306	
ϕ_9	Const.	-6917.2	-1.807	2
ϕ_{10}	P_t/A_t	28550.0	4.499	
ϕ_{11}	P_{t-1}/A_{t-1}	-20670.0	-3.183	
ϕ_{12}	LH_{t-1}	0.935	11.676	
ϕ_{13}	Const.	4058.5	1.025	3
ϕ_{14}	A_t	-14041.0	-2.647	
ϕ_{15}	A_{t-1}	10971.0	2.232	
ϕ_{16}	r_t	-389.1	-0.252	
ϕ_{17}	r_{t-1}	1505.2	1.215	
ϕ_{18}	U_{t-1}	0.925	28.921	
ρ_3		0.235	1.680	
ϕ_{19}	Const.	3048.1	2.248	4
ϕ_{20}	$P_t - P_t^c$	1603.4	0.504	
ϕ_{21}	$P_{t-1} - P_t^c$	232.8	0.076	
ϕ_{22}	LS_{t-1}	0.916	14.681	

TABLE 6.3 (Continued)

Coefficient	Variable	Estimate	Asymp-t value	Equation
ϕ_{23}	Const.	498.4	0.449	5
ϕ_{24}	$P_t - P_t^c$	3434.4	1.267	
ϕ_{25}	$P_{t-1} - P_{t-1}^c$	-3366.1	-1.295	
ϕ_{26}	SS_{t-1}	0.991	17.386	
ϕ_{27}	Const.	-84585.0	-1.488	6
ϕ_{28}	A_t	-120.37×10^3	-3.464	
ϕ_{29}	A_t^c	55383.0	3.120	
ϕ_{30}	A_{t-1}	54376.0	1.612	
ϕ_{31}	A_{t-1}^c	-19915.0	-1.082	
ϕ_{32}	Y_t	15891.0	2.184	
ϕ_{33}	C_{t-1}	0.346	2.024	

TABLE 6.4

INTRA-SAMPLE SIMULATION ASSESSMENT

Variable	Correlation Coeff.	THEIL'S IC	%RMSE
SH	0.9356	0.1445	23.378
LH	0.7034	0.3534	34.417*
U	1.0000	0.0000	0.0000
LS	0.7707	0.4132	82.463*
SS	0.8771	0.3365	81.707*
C	0.5966	0.4666	50.328
P	0.5570	0.2131	22.815
A	0.7406	0.1542	17.308

* Values of per cent root mean squared error are calculated for LH with observation 1974(07) deleted, for LS with observations 1973(12), 1974(08), 1977(08), 1977(12) deleted, and for SS with observations 1975(03), 1975(08), 1977(08) deleted. The reason for these deletions is that this statistic can be greatly distorted by the presence of a few outliers.

TABLE 6.5

POST SAMPLE PREDICTION OF CASH PRICE*

Predictor	Corr. Coeff.	Theil's I.C.	%RMSE
AS	0.8663	0.0880	9.541
P	0.7922	0.1086	10.257
CP	0.8774	0.0829	8.625

* AS is the model predictor with continuous updating during the 31 observations of the forecast period; P is the futures price; CP is a composite predictor constructed as 0.71AS + 0.30 P, where the weights are estimated by OLS (see Section 6.5).

TABLE 6.6

ESTIMATION OF WEIGHTS FOR COMPOSITE PREDICTOR*

Equation	$\hat{\alpha}$	$\hat{\beta}$	DW
9	0.713 (4.283)	0.307 (1.815)	1.587

* Estimation is by OLS for 31 observations. Asymptotic t values are in parentheses.

FOOTNOTES

1. They are said to demand storage because they plan to acquire the physical commodity in the next period, although they do not necessarily plan to take delivery under the futures contract. These traders are using the futures contract as a substitute for a merchandising contract (see Working (1953)).

2. This is not necessarily a cause for concern. Since the equilibrium condition for profit-maximizing short hedgers can be written

$$(P_t - A_t) - (P_{t+1}^* - A_{t+1}^*) = m_t$$

the influence of m_t is taken into account through the variables on the left hand side of this condition. Similarly in (3a), if the equilibrium condition for holders of unhedged inventories is

$$A_{t+1}^* - A_t - r_t = m_t$$

then the effect of m_t is taken into account by the presence in (3) of the variables on the left side of this equilibrium condition. A similar statement can be made about the marginal risk premium in (4a).

3. A six-month future is defined as follows:
when the month is January/February, the future is July;
when the month is March/April, the future is September;
when the month is May/June/July, the future is December;
when the month is August/September, the future is March;
when the month is October/November, the future is May;
when the month is December, the future is July.

4. A total of 22 such negative values are generated, of which 3 are in periods when LH>SH, 18 are in periods when LH<SH and 1 is in a period when LH=SH.

5. When $LH_t = SH_t$, both LH_t and SH_t are decreased by half of the absolute value of U_t, while LS_t and SS_t are each increased by half the absolute value of U_t.

6. It will be recalled that the specification of equation (1) does not include the expected cash price: this would have led to a two period lag of all variables in (1), and to an excessive number of parameters.

REFERENCES

Brasse, V. (1986), "Testing the Efficiency of the Tin Futures Market on the LME", Chapter 2 in K. Tucker and C. Baden Fuller (eds), *Firms and Markets: Essays in Honour of Basil Yamey*, London: Croom Helm.

Brennan, M.J. (1958), "The Supply of Storage", *American Economic Review*, 48, 50-72.

Cargill, T.F. and G.C. Rausser (1975), "Temporal Price Behaviour in Commodity Futures Markets", *Journal of Finance*, 30(4), 1043-53.

Chance, D.M. (1985a), "A Semi Strong Form Test of the Efficiency of the Treasury Bond Futures Market", *Journal of Futures Markets*, Vol. 5(3), 385-405.

Chance, D.M. (1985b), "The Reaction of the Chicago Board of Trade GNMA Futures Contract to the Announcement of Inflation Rates: A Study of Market Efficiency", *Review of Research in Futures Markets*, Vol. 4(1), 132-54, Chicago Board of Trade.

Chicago Board of Trade (1977), *Grains: Production, Processing and Marketing*, Chicago.

Commodity Year Book (1979-82), New York, Commodity Research Bureau.

Dickey, D.A. and W.A. Fuller (1979), "Distribution of the Estimators for Autoregressive Time Series with a Unit Root", *Journal of the American Statistical Association*, 74, pp. 327-31.

Dickey, D.A. and W.A. Fuller (1981), "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root", *Econometrica*, 49, pp. 1057-1072.

Doukas, J. and A. Rahman (1987), "Unit Roots Tests: Evidence from the Foreign Exchange Futures Market", *Journal of Financial and Quantitative Analysis*, 22, pp. 101-108.

Evans, G.B.A. and N.E. Savin (1981), "Testing for Unit Roots: 1", *Econometrica*, 49, pp. 753-779.

Evans, G.B.A. and N.E. Savin (1984), "Testing for Unit Roots: 2", *Econometrica*, 52, pp. 1241-68.

Fama, E.F. (1970), "Efficient Capital Markets: A Review of Theory and Empirical Work", *Journal of Finance*, Vol. 25, 383-417.

Fuller, W.A. (1976), *Introduction to Statistical Time Series*, New York: Wiley.

Giles, D.E.A., B.A. Goss and O.P.L. Chin (1985), "Intertemporal Allocation in the Corn and Soybeans Markets with Rational Expectations", *American Journal of Agricultural Economics*, 67, 749-760.

Goss, B.A. and D.E.A. Giles (1986a), "Price Determination and Storage in Commodity Markets: Soybeans and Wool", Chapter 1 in K.A. Tucker and C. Baden Fuller (eds), *Firms and Markets: Essays in Honour of Basil Yamey*, London, Croom Helm, 3-41.

Goss, B.A. and D.E.A. Giles (1986b), "Intertemporal Allocation in the Australian Wool Market", Chapter 4 in B.A. Goss (ed.), *Futures Markets: Their Establishment and Performance*, London: Croom Helm, 93-118.

Goss, B.A. (ed.) (1986), *Futures Markets: Their Establishment and Performance*, London: Croom Helm.

Goss, B.A. (1987), "Wool Prices and Publicly Available Information", *Australian Economic Papers*, Vol. 26(49), December, pp.225-36.

Granger, C.W.J. and P. Newbold (1986), *Forecasting Economic Time Series*, second ed., London: Academic Press.

Hall, B.H. (1986), *Time Series Processor Version 4.1B Reference Manual*, California, Stanford.

Hansen, L.P. and R.J. Hodrick (1980), "Forward Exchange Rates as Optimal Predictors of Future Spot Rates: An Econometric Analysis", *Journal of Political Economy*, 88, 829-53.

Inkeles, D.M. (1972), "Understanding the Oats Futures Market", *Commodity Yearbook*, New York.

Larson, A.B. (1960), "Measurement of a Random Process in Futures Prices", *Food Research Institute Studies*, 1, 313-24.

Leuthold, R.M. (1972), "Random Walks and Price Trends: The Live Cattle Futures Market", *Journal of Finance*, 27, 879-89.

Leuthold, R.M. and P.A. Hartmann (1979), "A Semi-strong Form Evaluation of the Efficiency of the Hog Futures Market", *American Journal of Agricultural Economics*, 61(3), 482-89.

Nerlove, M. (1958), "Adaptive Expectations and Cobweb Phenomena", *Quarterly Journal of Economics*, 72, 227-240.

Peck, A.E. (1982), "Estimations of Hedging and Speculative Positions in Futures Markets Revisited", *Food Research Institute Studies*, 18, 181-195.

Peston, M.H. and B.S. Yamey (1960), "Intertemporal Price Relationships with Forward Markets: A Method of Analysis", *Economica*, 27, 355-367.

Praetz, P.D. (1975), "Testing the Efficient Markets Theory on the Sydney Wool Futures Exchange", *Australian Economic Papers*, 14(25), 240-9.

Rausser, G.C. and C. Carter (1983), "Futures Market Efficiency in the Soybean Complex", *Review of Economics and Statistics*, 65, 469-78.

Stevenson, R.A. and R.M. Bear (1970), "Commodity Futures: Trends or Random Walks?", *Journal of Finance*, 25, 65-81.

Telser, L. (1958), "Futures Trading and the Storage of Cotton and Wheat", *Journal of Political Economy*, 66, 233-255.

Working, H. (1953), "Futures Trading and Hedging", *American Economic Review*, 43, 313-343.

Wymer, C.R. (1977), "Computer Programs: TRANSF Manual", Washington DC: International Monetary Fund, mimeo.

APPENDIX 1

AVERAGE MONTH-END RATIO OF LARGE SPECULATORS TO TOTAL OPEN POSITIONS (%)

	OATS		CORN		SOYBEANS		WHEAT	
	Long	Short	Long	Short	Long	Short	Long	Short
1970	24.5	17.3	28.7	27.1	31.2	33.5	37.9	31.2
1974	12.3	8.2	18.8	15.0	27.2	29.2	20.6	20.6
1975	13.1	9.1	18.5	15.2	30.0	33.8	16.7	20.6
1976	11.7	10.4	14.2	14.9	41.5	39.6	22.1	21.1
1977	4.3	4.1	13.9	16.3	41.2	35.6	24.4	22.8
1978	13.4	11.5	12.5	9.5	29.7	26.5	24.6	21.1

Source: CFTC, *Commitments of Traders* 1970-79.

APPENDIX 2

COMPARATIVE PERFORMANCE OF THE FUTURES PRICE, THE MODEL AND COMPOSITE PREDICTOR AS ANTICIPATIONS OF THE CASH PRICE

(1) Comparison of P and AS

Define $e_1 = A\text{-}AS$

$e_2 = A\text{-}P$

where A is the cash price, P is the futures price, AS is the model predictor of the cash price, all at time t as defined in Sections 6.2 and 6.5. For the post-sample forecast period 1979(3) to 1981(9) (31 observations)

$\bar{e}_1 = 0.03116$ $\quad$ $S.D._{e_1} = 0.16442$

$\bar{e}_2 = 0.05307$ $\quad$ $SD_{e_2} = 0.19937$

Hence neither of the hypotheses $H(\mu_{e_1} = 0)$ and $H(\mu_{e_2} = 0)$ can be rejected; i.e. the separate hypotheses that the futures price and the model are each unbiased predictors of the cash price cannot be rejected.

Now define $S = e_1 + e_2$ and $D = e_1 - e_2$. Since it is reasonable to assume that both predictors are unbiased the formula for the coefficient of correlation between S and D is given in Granger and Newbold (1986, p. 279), and its value is $r = -0.2505$. On the argument in Granger and Newbold (1986, pp. 278-79), if r is significantly different from zero, then it can be inferred that the %RMSEs of P and AS, as forecasts of A, are significantly different. The hypothesis $H(\mu_r = 0)$ can be tested by the statistic

$$t = r/S_r \text{, where } S_r = \sqrt{\frac{(1 - r^2)}{n - 2}}$$

and n is the number of observations.

In this case t = -1.3936, and the hypothesis $H(\mu_r = 0)$ cannot be rejected. Hence it sho be inferred that the model does not significantly outperform P as a predictor of A.

(2) Comparison of P and CP

Define e_3 = A-CP, where CP is a composite predictor as defined in Section 6.5. For post-sample period 1979(3) to 1981(9)

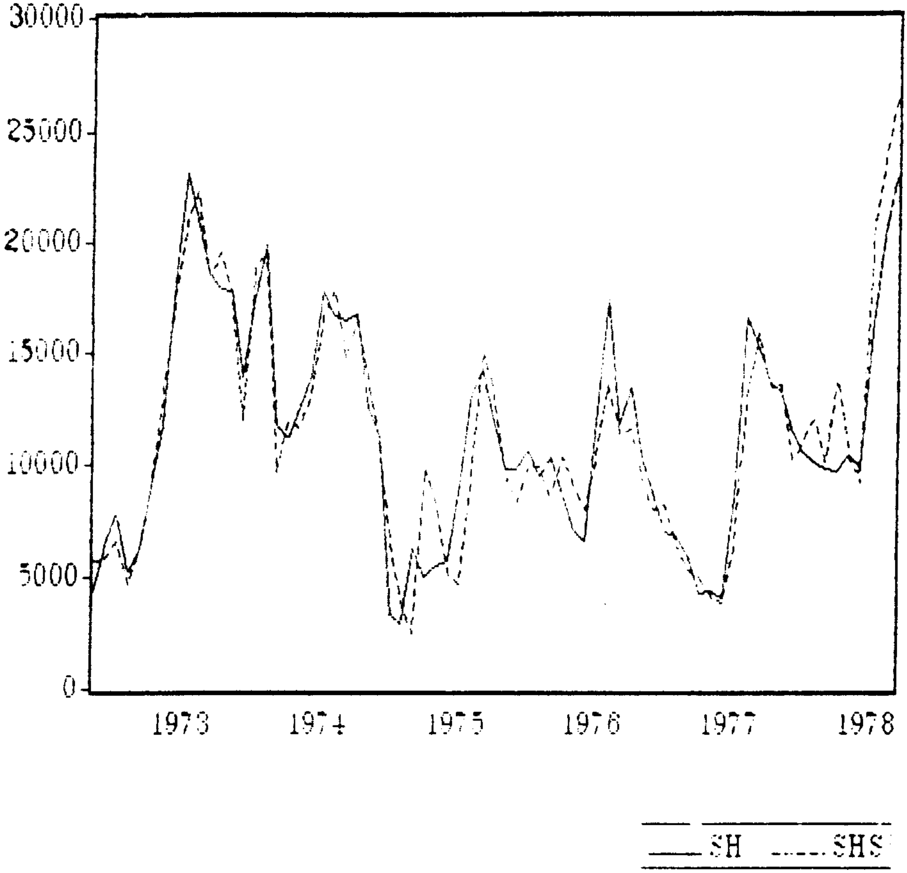
$$\bar{e}_3 = 0.01961 \qquad S.D_{e_3} = 0.15646$$

and the hypothesis $H(\mu_{e_3} = 0)$ cannot be rejected.

Now define $S_1 = e_2 + e_3$ and $D_1 = e_2 - e_3$. Since it is reasonable to assume that P and are each unbiased predictors of A, the formula for the correlation coefficient between and D_1 is as employed above, and its value is $r_1 = -0.40338$.

The question of the significance of the difference between the %RMSEs of P and CP, be addressed by testing the hypothesis $H(\mu_{r_1} = 0)$.

This latter hypothesis can be tested by the statistic $t = r_1/S_{r_1}$. In this case t = -2.3742 that the hypothesis $H(\mu_{r_1} = 0)$ is rejected at the 5% level of significance but is not rejec at the 1% level (two tail test). If the test is conducted at the 1% level for the reasons gi in Section 6.5, $H(\mu_{r_1} = 0)$ is not rejected, and it is inferred that CP does not significa outperform P as a predictor of A.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5000
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1973
1974
1975
1976
1977
1978
SH
SHS

Figure 6.1

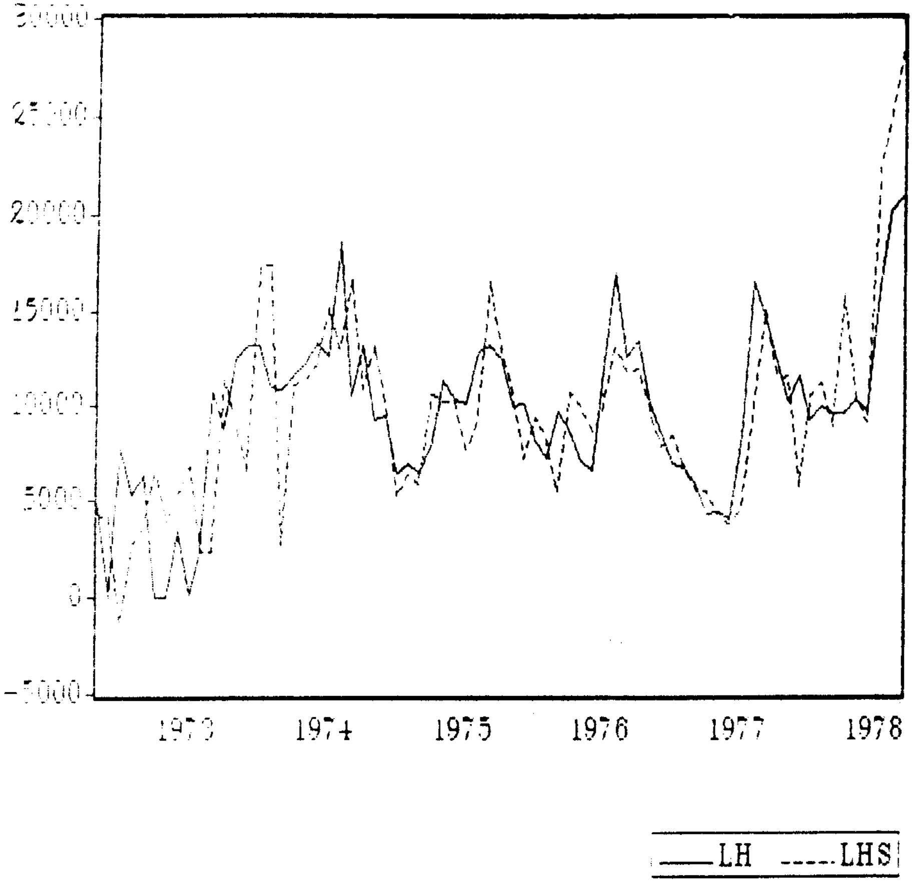
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Figure 6.2

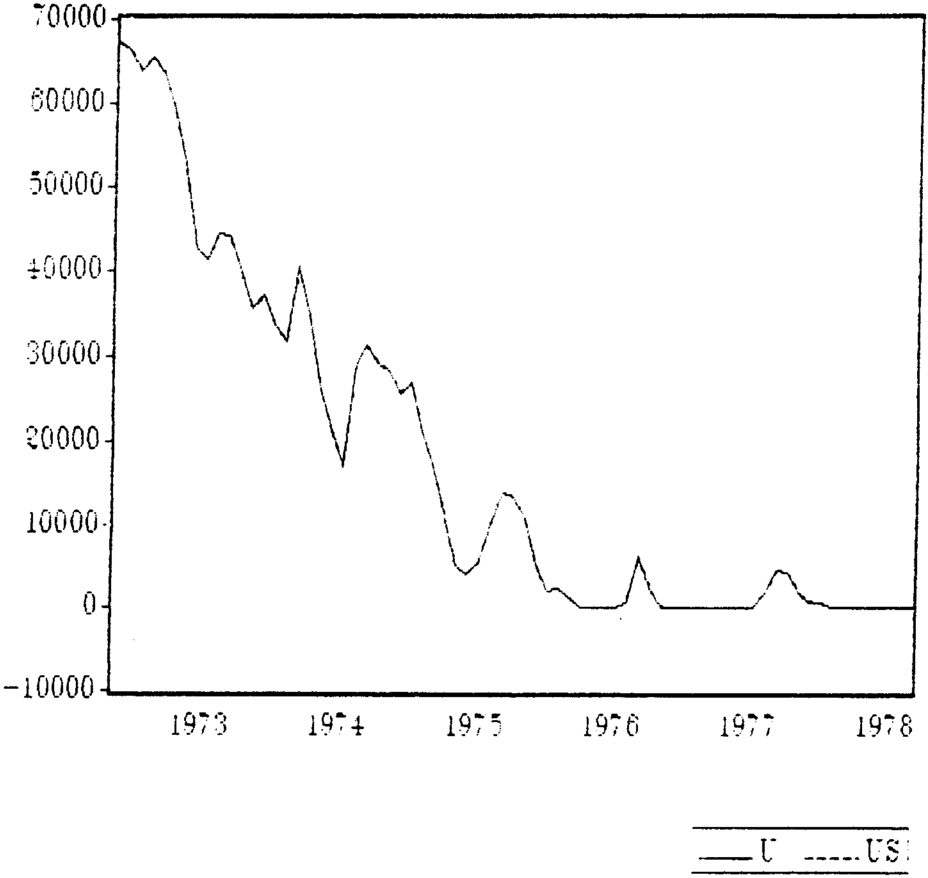
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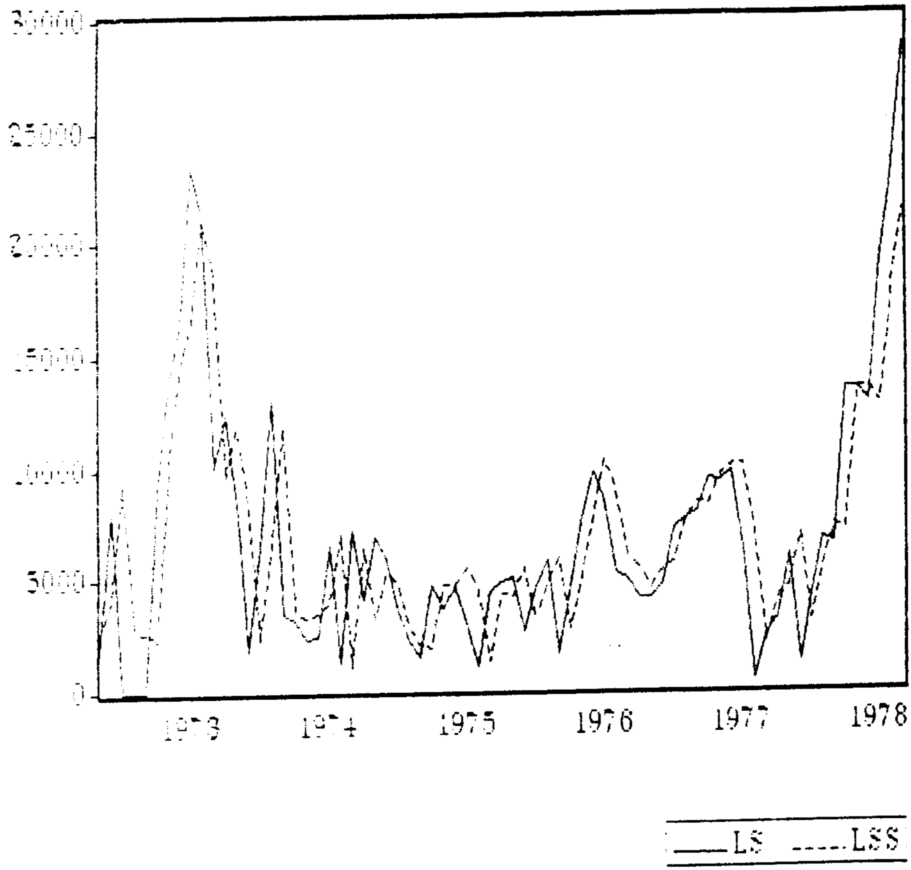
Figure 6.3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1973
1974
1975
1976
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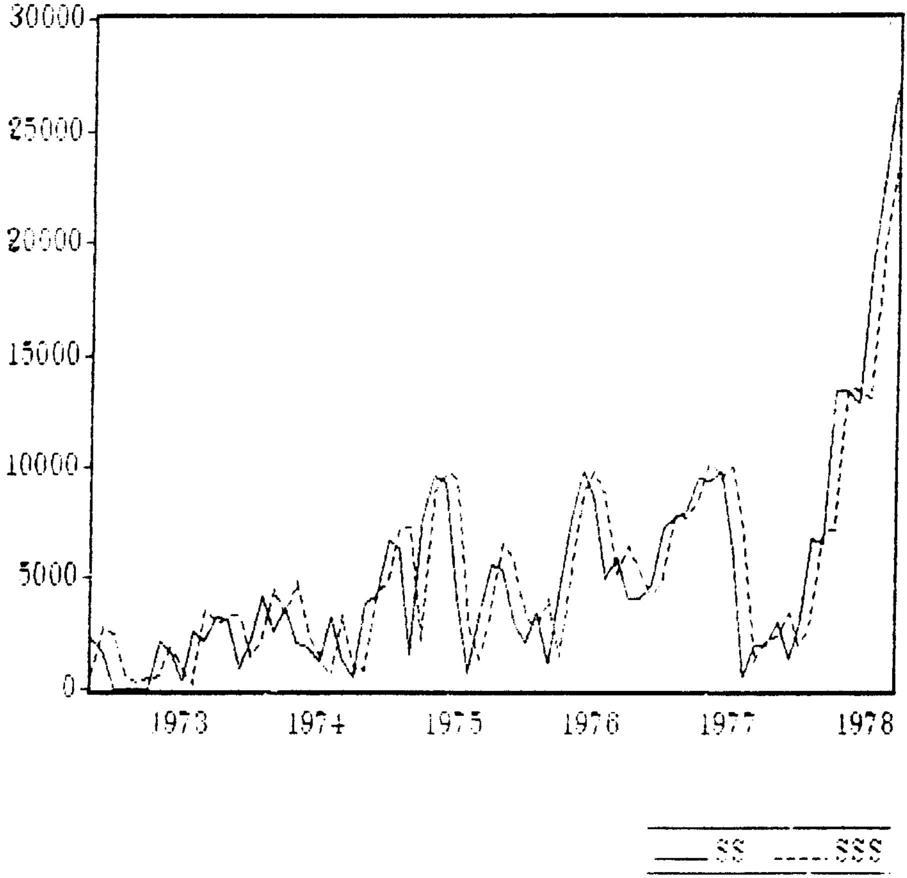
1978
LS
LSS

Figure 6.4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5000
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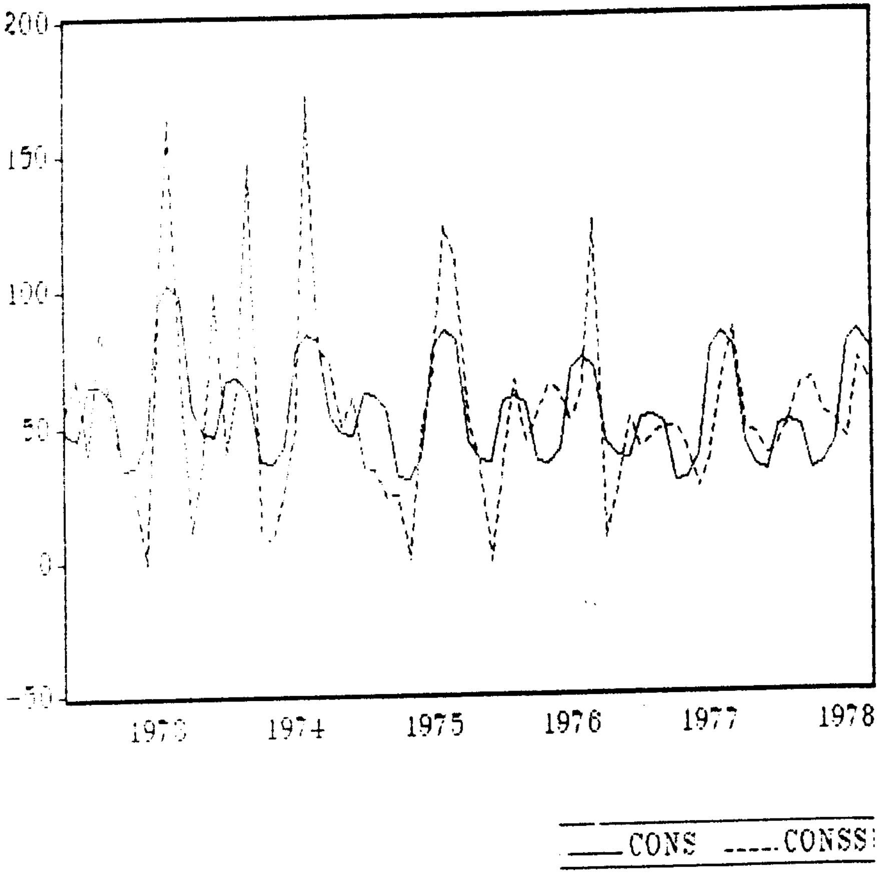
1973
1974
1975
1976
1977
1978
SS
SSS

Figure 6.5



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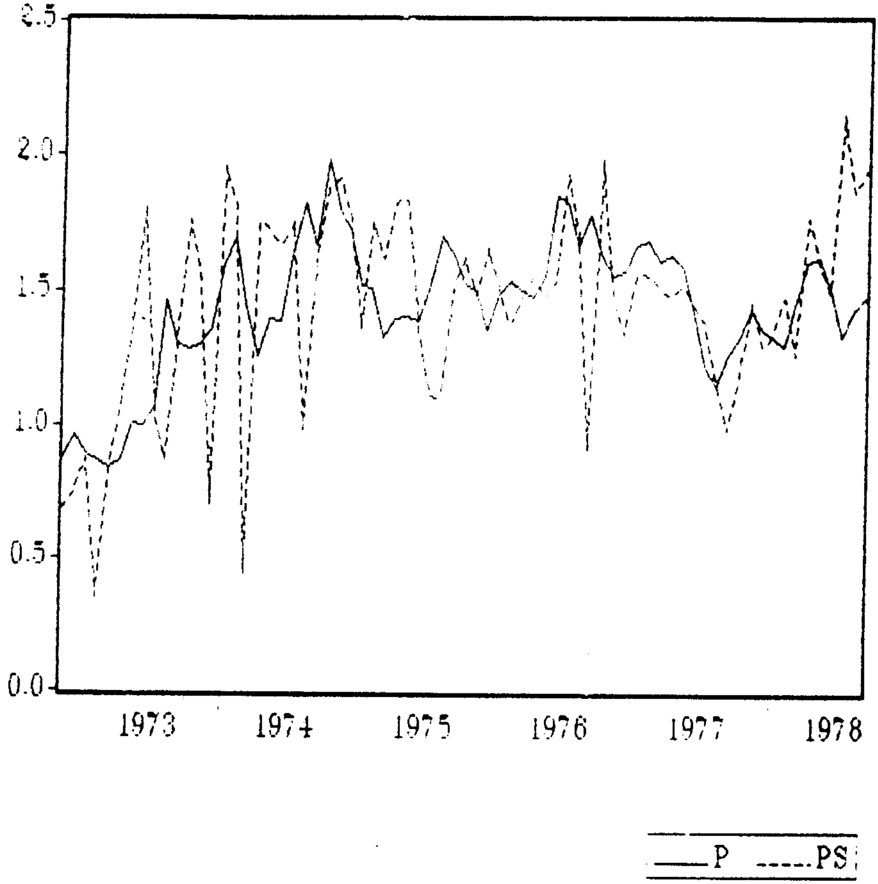

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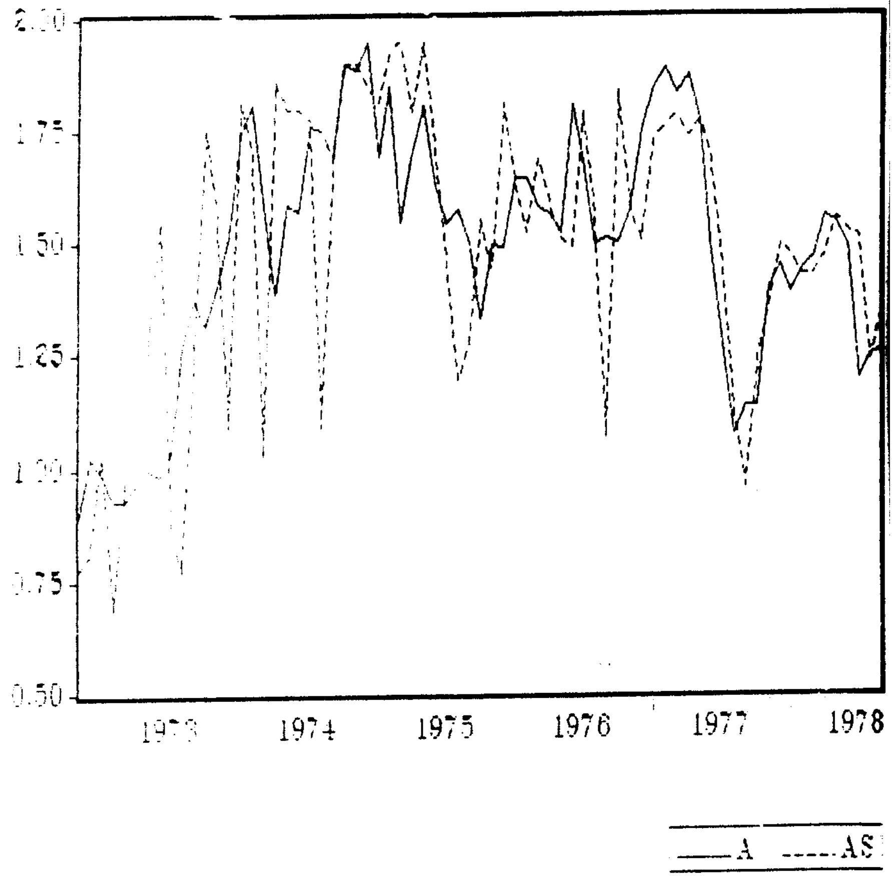

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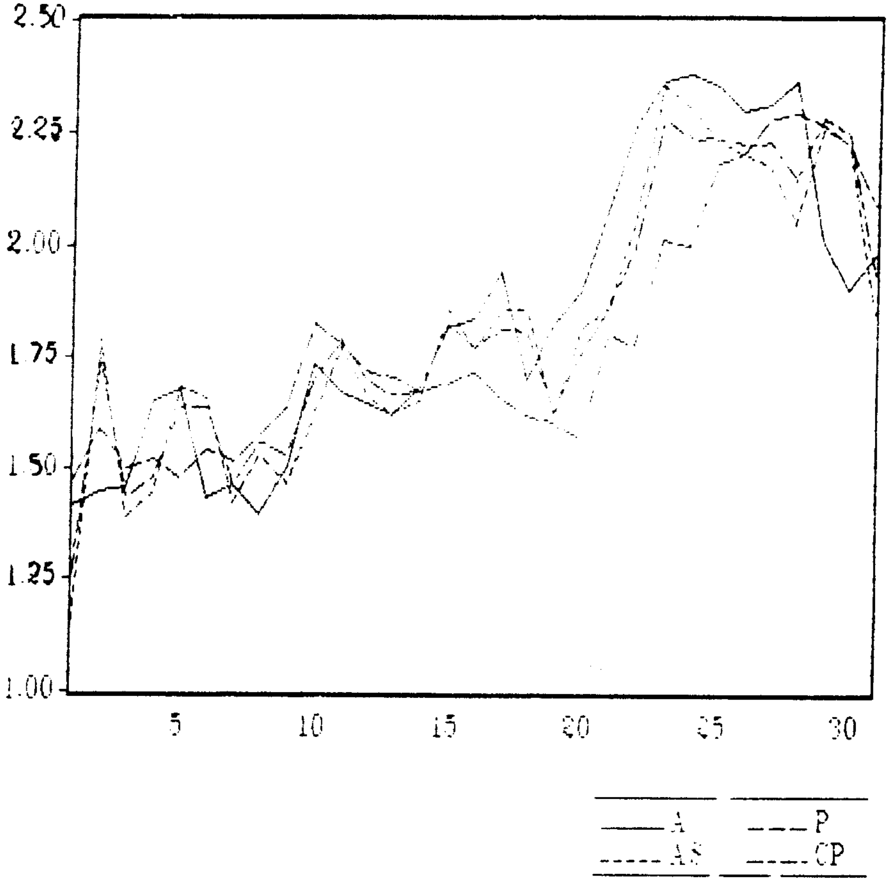

Figure 6.9

Post Sample Simulation