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by

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I. Introduction

The accurate forecasting of soybean complex (soybeans, soybean meal, soybean oil) prices is an important component of economic decision making in the soybean industry. Accurate forecasts allow a processor to establish profitable processing (or crush) margins. By being able to lock in profitable future crush margins, a high level of plant utilization can be maintained, thus, reducing per unit processing costs. Accurate forecasts are also a requisite to effective hedging by soybean producers, as well as soybean oil and meal users, such as vegetable oil processors and livestock feed manufacturers. In addition, individual speculators also require accurate soybean complex forecasts to achieve trading success.

There have been several recent studies of price forecasting within the soybean complex using econometric models, time-series models, and technical trading systems. Just and Rausser compared the accuracy of large scale econometric forecasts with soybean, soybean meal, and soybean oil futures market prices, finding neither outperforms the other. Rausser and Carter investigated the forecasting accuracy of multivariate and univariate time-series models of soybean, soybean meal, and soybean oil prices. They found univariate models to be more accurate than futures prices for predicting soybean and soybean meal prices, but not soybean oil prices. Wendland found univariate time-series models to be deficient in detecting market turning points for all three soybean complex prices. Finally, Lukac, Brorsen, and Irwin reported negative average trading returns to using twelve technical trading systems in the soybean futures market.

Comparison of these disparate results is difficult because the models were developed and evaluated over different time periods. A two year time frame (1976-1978) was used by Just and Rausser to evaluate the econometric models. Rausser and Carter used the time period 1966-1976 to develop their models. This is a period in which structural change took place within the soybean complex. This makes the use of univariate time series analysis somewhat suspect since it violates a basic assumption underlying such methodologies. Wendland developed his models over the decade 1976-1986. He did not report out-of-sample results. Lukac, Brorsen, and Irwin's results were based on out-of-sample trading over 1975-1984.

A second problem is the selection of an appropriate measure of forecast effectiveness. The studies of econometric and time series models used statistical criteria such as root mean squared error or mean absolute error.

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These measures can be suspect in an economic decision-making framework. The concern with the statistical criteria is their inability to account for the crucial element of market timing. The Lukac, Brorsen, and Irwin study did evaluate trading systems based on economic returns, but they used the Capital Asset Pricing Model as a benchmark. The problems associated with its application to futures markets are well-documented (i.e. Stein).

In this study, univariate and multivariate time-series models and technical trading systems are used to forecast soybean, soybean meal, and soybean oil prices. Univariate models are represented by Autoregressive Integrated Moving Average (ARIMA) time-series models. Multivariate models are represented by Vector Autoregressive (VAR) multivariate time-series models. Technical trading systems are represented by a channel system.

The ARIMA and VAR models are developed over the time period January 1974 through December 1983 and then used to forecast out-of-sample from January, 1984 through July, 1988. The Channel Rule trading signals are used as directional forecasts over the same out-of-sample period. The Cumby-Modest test is used to evalute the out-of-sample forecasts for all models. This test provides a method of determining a forecasting model's market timing ability, or economic value.

II. Models

ARIMA

To obtain an accurate univariate time-series specification of each series (prices of soybeans, soybean meal, and soybean oil), the familiar Box-Jenkins methodology was employed. This entailed establishing that each series was stationary (devoid of trend) over the study period 1974-1983. Time plots of each series confirmed earlier findings by Wendland, that each series has been stationary since the period 1972-1973.

Given stationarity, the Autocorrelation Function (ACF) and the Partial Autocorrelation Function (PACF) were computed. The behavior of these functions for each series tentatively suggested that an AR(2) specification may be an appropriate specification for each series. Further diagnostic testing confirmed that the AR(2) specification was appropriate for the soybean price series. However, model overfitting indicated that a mixed ARMA(1,1) model was a more suitable specification of the soybean meal and oil price series. The accepted models along with their associted statistics can be found in Table 1.

VAR

Carter and Rausser proposed a monthly econometric model of the U.S. soybean complex. Their model was used as a guide to develop the VAR model used in this study. The variables in their model include:

SBP = price of soybeans
SOP = price of soybean oil
SMP = price of soybean meal
SBS = stocks of soybeans
CSH = soybean crushings
SBE = soybean exports
SOE = soybean oil exports
SME = soybean meal exports

SOS = stocks of soybean oil	CP = corn price
SMS = stocks of soybean meal	OI = crude vegetable oil index

Data on monthly average soybean prices at Chicago, IL and monthly average soybean oil and meal prices at Decatur, IL are the same as those used in the specification and estimation of the univariate models. Month end stocks of soybean oil and soybean meal at mills, total monthly U.S. soybean crushings, total monthly U.S. soybean oil and meal exports, and the monthly average cash price of corn at Chicago, IL are taken from the Chicago Board of Trade Annuals and various issues of the Market News. The stocks of soybeans are imputed by taking U.S. quarterly stocks subtracting soybean crushings and exports and adding harvested production (from USDA harvest progress reports). The monthly average crude vegetable price index was obtained from the Bureau of Labor Statistics.

In order to develop a parsimonious VAR specification, the exclusion of variables approach, outlined by Hsiao is used. As a result, only six of the original variables specified by Carter and Rausser entered into the VAR model: prices of soybeans, soybean oil, soybean meal, stocks of soybean oil and meal, and corn prices. Parameter estimates were computed by estimating the equations simultaneously as seemingly unrelated regressions. The fitted VAR model may be found in Table 2.

Parameters for the VAR were recomputed and tested each month in the out-of-sample forecast period. Throughout the test period, none of the previously excluded variables became significant in the later months. The updated model was then used to forecast one, three, and six months ahead.

Technical Trading System

The methodical buying and selling of futures contracts based on some pre-specified trading rule without regard to underlying fundamentals constitutes a traditional technical trading system. Numerous trading systems have been developed. After a review of recent studies comparing technical trading systems (Irwin and Uhrig, Lukac, Brorsen, and Irwin, Lukac and Brorsen) the Close Channel (CHL) system was selected to represent the traditional technical trading system. Previous results have shown that the CHL system is one of the most successful trading systems and is widely used by traders. In Lukac, Brorsen, and Irwin's study the CHL system's gross and mean monthly returns were significantly different from zero and were also the highest of twelve systems investigated using a portfolio of commodities. The CHL system also provided positive returns using soybeans as an individual investment.

The CHL system is a member of the price channel family of technical systems. A price channel is a time interval which is L days in length, present day included. The CHL system generates a buy signal anytime the current futures price is higher than the highest price during the specified time interval (L) and generates a sell signal anytime the current futures price is lower than the lowest price over the same interval. The trade occurs at the opening price the day after a signal is generated. A trader using this system is always in the market: a short (long) position is replaced with a long (short) position whenever a trading signal is triggered.

The simulation model is intended to replicate how actual traders use trading systems. Traders usually hold positions only in the nearby contract because of liquidity costs. Therefore, the simulation model only places trades in the dominant, or nearby, contract (Lukac, Brorsen, and Irwin). The parameters for the CHL system must also be selected. Lukac and Brorsen in their study of trading system parameter optimization suggest that longer channel lengths (40 to 60 days) tended to preform better than those of shorter lengths. Based on Lukac and Brorsen's results the channel length used in this study is set arbitrarily at forty days.

III. The Market Timing Value of Forecasts

Merton recently proposed an equilibrium model of the value of price forecasts that explicitly accounts for market-timing ability. Merton's model is an improvement over earlier models in that it does not require specification of an equilibrium theory of asset pricing. His fundamental insight is that a forecast has value if it causes rational investors to modify their prior beliefs about the probability distribution of future asset returns.

Cumby and Modest, adopting Merton's criteria of changing expectations due to forecast information, proposed a general regression test of market timing ability. They hypothesize a linear relationship between a forecast signal and a benchmark measure of economic returns. In the case of price forecasts for a commodity, Cumby and Modest suggest the use of a naive long positon in the appropriate futures market as the benchmark measure of returns. Based on this assumption, the model for testing market timing ability is:

$$(1) \quad R_t = \alpha + \beta X_{ti} + \epsilon_{ti}$$

where R_t equals the percentage rate of return to a naive long position for time period t, X_{ti} equals one for a buy signal and zero otherwise for time period t and model i, and ϵ_{ti} is a standard normal error term. Market timing ability is found under the Cumby-Modest test if β in (1) is significantly different from zero. In other words, market timing ability is found if the fractional increase in average holding period returns, conditional on a buy signal, is significantly different from zero.

If additional assumptions are made, the Cumby-Modest test provides evidence of market efficiency as (defined by Fama). In order for the rejection of the null hypothesis to imply that the markets are inefficient, risk premiums must be constant across time. Alternatively, if it can be assumed that all publicly available information is included in the model, then the test results also provide evidence of market inefficiences (Cumby and Modest).

IV. Market Timing Test Procedures

For the ARIMA and VAR models, buy and sell signals were generated for each set of forecasts by a decision rule similar to that employed in previous economic evaluations of forecasting models (i.e., Gerlow and Irwin). Under the decision rule, buy and sell signals are generated in the following manner:

Buy Signal:

$$FSP_{ti} \geq SP_k$$

Sell Signal:

$$FSP_{ti} < SP_k$$

where FSP_{ti} is the forecasted soybean complex price for time period t and model i and SP_k is the actual soybean complex price on the last trading day, k, of time period t-1. Buy and sell signals for the channel trading system correspond to the directional signals generated by the system.

Following the procedure used by Cumby and Modest in their study of exchange rate advisory services, the investment benchmark is assumed to be a naive long position in the appropriate soybean complex futures market. Positions are initiated on the first trading day of the forecast period. For comparisons to ARIMA and VAR model forecasts, it is assumed that long positions are initiated at the opening price in the nearest maturity contract that does expire in the forecast month. All positions are offset at the closing futures price on the last day of the appropriate month. For comparisons to channel system forecasts, it is assumed that positions are initiated in nearest to maturity contracts. If a position is held beyond the expiration of the initial contract, channel positions are rolled to the next nearest contract. The contract is rolled on the first day of the second week of the month in which the initial contract expires. Channel positions are assumed to be offset at the close of the day following a signal change.

Because margin requirements can be satisfied by pledging U.S. Treasury Bills that continue to earn interest, the profits and losses from following the naive long positions may be calculated as the change in futures prices over the holding period. Hence, the percentage gross return for naive positions comparable to ARIMA and VAR positions is:

$$(2) \quad R_t = [\ln(SFP_{n)} - \ln(SFP_{m)}] * 100$$

where R_t is the percentage gross return realized over time period t, and SFP_n and SFP_m are the appropriate soybean complex futures prices on the first and last trading days of the time period, respectively. The calculation of the percentage gross return for naive long positions comparable to channel positions differs slightly. Specifically, returns must be summed over more than one contract if it was necessary to roll the initial position to one or more additional contracts.

Since the forecasts are predetermined, consistent estimates of the parameters of (1) can be obtained by ordinary least squares (OLS) [Cumby and Modest]. With respect to the market-timing tests of the ARIMA and VAR models, it is questionable whether the error term in the equation will have a constant variance due to the heteroskedasticity of futures price changes (i.e. Hall, Brorsen, and Irwin). Therefore, White's test statistic is computed to determine if significant heteroskedasticity exists.[1] If the White test indicates significant heteroskedasticity, estimates of (1) will be obtained using White's heteroskedastic-consistent covariance estimator. Since, the Channel Rule's forecast length varies due to the nature of the system, the parameters of (1) for market-timing tests of the channel system must be estimated using White's heteroskedastic-consistent covariance matrix estimator.

V. Forecast Evaluation Results

Market timing results for ARIMA, VAR and CHL forecast are presented in Tables 3, 4, and 5, respectively. In the original OLS regressions for the three and six month forecasts, the ARIMA and VAR model Durbin Watson test statistics suggested serial correlation was present in the error termss. The Cochrane-Orcutt correction for serial correlation was performed and the parameters in the tables reflect this correction. No evidence was found to indicate the presence of heteroskedasticity in any of the estimations.

The t-ratios in the tables are tests of the null hypothesis of no market timing value. With respect to the ARIMA models, only the six month forecast for soybean meal exhibited significant market timing value (Table 3). The VAR model was slightly more successful, with significant market timing value indicated for the six month forecasts for soybeans and soybean meal (Table 4). Only CHL forecasts of soybean meal prices exhibited significant market timing value (Table 5).

These results have two interesting implications with regard to forecasting soybean complex prices. First, none of the models exhibited consistent market timing value across the three commodities or forecasting horizons. Thus, it does not appear that a single forecasting technique is

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[1]The White Statistic is,

$$nR^2 \sim X^2_{k(k+1)/2}$$

where n is the number of observations in the original sample and k is the number of independent variables in the OLS estimation equation.

R^2 is the (constant-adjusted) squared multiple correlation coefficient from the following regression:

$$\epsilon^2_i = \alpha_0 + \sum_{j=1}^{K} \sum_{k=1}^{K} \alpha_s X_{ij} X_{ik} \qquad (i=1,\ldots,n)$$

where ϵ_i is the error of the ith observation from the OLS estimation and X_{ij} and X_{ik} are the ith observation of the jth and kth independent variable, respectively.

best when forecasting soybean complex prices. Second, market timing value did differ by commodity. Significant market timing value was evident in forecasting soybeans for only one of the seven models tested (ARIMA model: six months). In contrast, market timing value was indicated for forecasting soybean meal prices for three out of the seven models tested. Further, significant value for forecasting soybean meal prices was indicated for each model at one forecasting horizon (ARIMA model: three months; VAR model: six months; CHL system). No model exhibited significant market timing value for forecasting soybean oil prices.

The results also provide interesting efficiency implications with in the soybean complex. Note that the ARIMA model and CHL system results provide a test of weak form efficiency, while the VAR model results provide a test of semi-strong form efficiency.[2] The soybean oil market appears to be both weak and semi-strong form efficient as no model exhibited significant market timing value. The soybean market appears to be nearly as efficient, with only the ARIMA six month forecast providing any evidence of weak form inefficiency. The soybean meal market appears to be the least efficient of the soybean complex. Weak form inefficiency is indicated by the significant market timing value of the ARIMA model at three months and the CHL system (approximately a one month horizon). Semi-strong form inefficiency is indicated by the significant market timing value of the VAR model at six months.

It should be noted that the efficiency conclusions were based on an assumption of zero transaction costs (Fama) The inefficiencies may disappear with the inclusion of transactions costs.

VI. Summary

The accurate forecasting of soybean complex (soybeans, soybean meal, soybean oil) prices is an important component of economic decision making in the soybean industry. Accurate forecasts are inherent in a processor's ability to establish profitable processing (or crush) margins. Accurate forecasts are also a requisite to effective hedging by soybean producers, as well as soybean oil and meal users, such as vegetable oil processors and livestock feed manufacturers. In addition, commodity futures fund managers and individual speculators also require accurate soybean complex forecasts as correct forecasts are essential to a speculator's trading success.

There have been several recent studies of price forecasting within the soybean complex using econometric models (Just and Rausser), time-series models (Carter and Rausser; Wendland), and technical trading systems (Lukac, Brorsen, and Irwin). Firm conclusions are difficult to reach based on the results of these studies. The first problem is that the models were developed and evaluated over different time periods. The second problem is the selection of an appropriate measure of forecast effectiveness.

In this study, univariate and multivariate time-series models and

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[2]Both weak-form and semi-strong form efficiency are defined in the Fama sense.

technical trading systems were used to forecast soybean, soybean meal, and soybean oil prices. Univariate models were represented by Autoregressive Integrated Moving Average (ARIMA) time-series models. Multi-variate models were represented by Vector Autoregressive (VAR) multivariate time-series models. Technical trading systems were represented by a channel system.

The ARIMA and VAR models were developed over the time period January 1974 through December 1983 and then used to forecast out-of-sample from January, 1984 through July, 1988. One month, three month, and six month forecasts were generated. The Channel Rule trading signals were used as forecasts over the same out-of-sample period. The out-of-sample forecasts for all models were evaluated via the Cumby-Modest market-timing test. This test provides a method of determining a forecasting model's market timing ability, or economic value, within the soybean complex.

None of the models exhibited consistent market timing value across the three commodities or forecasting horizons. Thus, it does not appear that a single forecasting technique is best when forecasting soybean complex prices. Market timing value did differ by commodity. Significant market timing value was evident in forecasting soybeans for only one of the seven models tested (ARIMA model: six months). In contrast, market timing value was indicated for forecasting soybean meal prices for three out of the seven models tested (ARIMA model: three months; VAR model: six months; CHL system). No model exhibited significant market timing value for forecasting soybean oil prices.

Table 1. Final Univariate ARIMA Models: Soybeans(2,0,0), Soybean Meal(1,0,1), and Soybean Oil(1,0,1)[a]

Estimated Structure[b]	R^2	Q-stat[c,d]
SOYBEANS (SBP):		
$SBP_t + 1.37SBP_{t-1} - .379SBP_{t-2} = a_t$ (16.12) (-4.456)	0.81	19.94
SOYBEAN MEAL (SMP):		
$SMP_t + .994SMP_{t-1} = a_t + .299a_t$ (106.22) (3.379)	0.83	22.98
SOYBEAN OIL (SOP):		
$SOP_t + .993SOP_{t-1} = a_t + .345a_t$ (88.03) (3.972)	0.78	15.96

[a] Estimated over January, 1974 through December, 1983 using the RATS BOXJENK command.

[b] Figures in paranthesis are t-statistics.

[c] $$Q = N(N + 2)\left[\sum_{j=1}^{M} \frac{1}{N-j} r_j^2\right]$$

where r_j^2 is the jth lag autocorrelation of the residuals. M is the number of autocorrelations used and is selected according to the formula

$$M = \min(N/2 : 3N^{1/2})$$

(Doan and Litterman).

[d] Follows a X^2 distribution, Critical value at 5% significance level and 30 degrees of freedom = 43.8.

Table 2. Vector Autoregressive Model Equations for Soybean (SBP), Soybean Meal (SMP), and Soybean Oil Prices (SOP), Soybean Meal Stocks (SMS), Soybean Oil Stocks (SOS), and Corn Prices (CP), U.S., January, 1974 through December, 1983.

Dependent Variable		Independent Variables[a]	R^2
(1) SBP(t)	=	1.3SBP(t-1) - .47SBP(t-2)	0.83
		(15.32) (-5.50)	
(2) SMP(t)	=	.73SMP(t-1) + .20SMP(t-2)	0.88
		(4.13) (1.15)	
		+ .06SMS(t-1) - .03SMS(t-2) - .48SMS(t-3) + .95SMS(t-4)	
		(3.08) (-1.29) (-2.04) (.479)	
		+ 13SBP(t-1) - 16SBP(t-2)	
		(2.47) (-3.14)	
(3) SOP(t)	=	1.2SOP(t-1) - .36SOP(t-2) + .12SOP(t-7)	0.84
		(13.09) (-3.93) (.328)	
(4) SMS(t)	=	.58SMS(t-1)	0.60
		(8.02)	
		- .11SOS(t-1)	
		(-.437)	
		+ 39CP(t-1)	
		(2.20	
		- .91SMP(t-1)	
		(-2.36)	
		+ 20.44SBP(t-1)	
		(1.70)	
(5) SOS(t)	=	.93SOS(t-1)	0.89
		(26.41)	
		+ .32SMS(t-1)	
		(2.81)	
		- 4.4SOP(t-1)	
		(-1.67)	
(6) CP(t)	=	1.4CP(t-1) - .44CP(t-2) - .46CP(t-11)	0.93
		(16.50) (-5.23) (-1.54)	
		- .29SBP(t-1)	
		(-2.22)	

[a] Figures in parenthesis are t-statistics.

Table 3. Market Timing Tests of Soybean, Soybean Meal, and Soybean Oil ARIMA Models, U.S., January 1984 through July 1988[a]

MODEL	FORECAST HORIZON[b]	OLS ESTIMATES[c] β_0	β_1[d]
SOYBEANS	1	0.30 (0.241)	-2.10 (-1.028)
	3	0.60 (0.182)	-1.50 (-0.618)
	6	5.20 (0.451)	-4.40 (-1.499)
SOYBEAN MEAL	1	1.00 (0.663)	-1.80 (-0.857)
	3	1.80 (0.299)	3.10 (1.427)*
	6	12.20 (0.590)	-3.60 (-1.278)
SOYBEAN OIL	1	0.60 (0.451)	-2.30 (-0.933)
	3	0.90 (0.187)	-1.50 (-0.573)
	6	-0.90 (-0.895)	1.10 (0.329)

[a] Figures in parentheses are t-statistics. A star indicates statistical significance at the ten percent level, two stars indicates significance at the five percent level.

[b] in months.

[c] The Cochrane-Orcutt correction for autocorrelation was performed for three and six month forecast horizons.

[d] The ß coefficient is the percentage increase in mean holding period returns to a long futures position when a buy signal is given.

Table 4. *Market Timing Tests of Soybeans, Soybean Meal, and Soybean* Oil for VAR model, U.S., January 1984 through July 1988[a].

		OLS ESTIMATES[c]	
MODEL	HORIZON[b]	β_0	β_1[d]
SOYBEANS	1	-0.10 (-0.074)	-0.50 (-0.226)
	3	6.00 (0.827)	-4.50 (-0.904)
	6	-17.90 (-1.760)	20.10 (2.644)**
SOYBEAN MEAL	1	2.50 (1.531)	-4.10 (-1.930)
	3	3.20 (0.473)	-1.00 (-0.233)
	6	-2.30 (-0.138)	10.80 (2.020)**
SOYBEAN OIL	1	1.20 (0.796)	-3.00 (-1.306)
	3	1.40 (0.233)	-1.50 (-0.222)
	6	3.40 (0.262)	-5.50 (-0.584)

[a] Figures in parentheses are t-statistics. A star indicates statistical significance at the ten percent level, two stars indicates significance at the five percent level.

[b] in months.

[c] The Cochrane-Orcutt correction for autocorrelation was performed for three and six month forecast horizons.

[d] The ß coefficient is the percentage increase in mean holding period returns to a long futures position when a buy signal is given.

Table 5. Market Timing Tests of Soybeans, Soybean Meal, and Soybean Oil for Channel Rule Technical Trading System, U.S., January 1984 through July 1988[a].

	OLS ESTIMATES[c]	
MODEL	β_0	β_1[d]
SOYBEANS	-0.20 (-0.269)	-0.30 (-0.143)
SOYBEAN MEAL	-1.50 (-1.375)	4.00 (1.547)*
SOYBEAN OIL	-1.20 (-0.879)	2.00 (0.866)

[a] Figures in parentheses are t-statistics. A star indicates statistical significance at the ten percent level, two stars indicates significance at the five percent level.

[b] in months.

[c] Using Whites's Heteroskedastistic-consistent covariance estimator.

[d] The β_1 coefficient is the percentage increase in mean holding period returns to a long futures position when a buy signal is given.

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