AN EVALUATION OF THE *RICE OUTLOOK AND SITUATION* PRICE FORECASTS

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Abstract

The *Rice Outlook and Situation* (RO&S) forecasts were compared to the forecasts of a univariate Box-Jenkins (BJ) model. On balance, the RO&S forecasts had lower mean square forecast errors and lower mean absolute forecast errors than the BJ model forecasts. The differences in the squared and absolute forecast errors were not significant, however. Based on the concept of conditional efficiency as set forth by Granger and Newbold, it was found that the BJ forecasts did not add any information that might improve forecast accuracy beyond what was already incorporated in the RO&S forecasts.

Key words: rice price, forecast evaluation, univariate time series.

The *Rice Outlook and Situation* (RO&S) is published in September and March by the Economic Research Service, United States Department of Agriculture (USDA). Each issue includes a price forecast for the rice marketing year, August 1 through July 31. The first objective of this paper was to evaluate the accuracy of the RO&S price forecasts. This was accomplished in two steps. First, using data for the 11 marketing years 1972-82, the accuracy of the RO&S price forecasts was compared to the accuracy of forecasts from a univariate autoregressive-integrated-moving-average (ARIMA) model. An ARIMA model was chosen for comparison because of its simplicity and, furthermore, because ARIMA models have been shown to provide accurate forecasts for agricultural prices (e.g., Bessler and Brandt; Harris and Leuthold). Second, the "conditional efficiency" of the RO&S price forecasts was examined. A test for conditional efficiency determines whether the information in the series of past prices has been utilized in making the RO&S price forecasts. Moreover, the failure to reject the null hypothesis of conditional efficiency implies that a composite forecast (i.e., a linear combination of the RO&S and ARIMA forecasts) will not be significantly more accurate than the RO&S forecasts alone.

Price forecasts are important to the rice sector because there currently is no active rice futures market that can provide price forecasts. An industry without an active futures market lacks a very important source of information useful in decisionmaking under risk. According to a recent study by Just and Rausser, futures prices have exhibited "surprising accuracy" compared to price forecasts from large-scale econometric models. While rice is an important U. S. field crop, only recently has there been futures trading in rice.[1] Until trading is well established, there is a question of whether the conclusion of Just and Rausser applies to the rice futures market. Thin markets, as Gray has shown, are noticeably biased in their projections of subsequent cash prices. Consequently, in the absence of a long established futures market that has been shown to provide accurate price forecasts, there remains a need for alternative rice price forecasts.

The second objective of this analysis was to determine the advantage of using the RO&S price forecasts in a selective storage program. Price forecasts are useful to producers only if they help them make better marketing decisions. Whether to sell at harvest or store and sell later in the season is an important decision for a rice producer. If the price received can be increased or its variability reduced by using the RO&S price forecasts, the forecast information is useful in making storage decisions.

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[1]The most extended period of trading in rice futures lasted only 26 months before it was temporarily suspended in New Orleans in June 1983. Trading was restarted in Chicago in September 1983 and by January 1985 the open interest had fallen to virtually zero.

RO&S Forecasts

The September issue of the RO&S is published early in the rice marketing year (August 1-July 31) and the March release is available a little beyond the halfway point of the marketing year. As the title suggests, the RO&S is a report of the current outlook and situation in the rice sector. The report provides information relative to supply and demand, and also forecasts of the near future. Of widespread interest is a forecast of the U.S. average price received by farmers (PRBF) for rough rice for the marketing year. The series forecasted is a weighted seasonal average of the monthly PRBF's published in *Agricultural Prices* (USDA). The weighting factors are the estimated volumes of farmer sales during each month. Also, incorporated in the weighted average price are commodity credit corporation purchases and unredeemed loans included at the average loan rate.

The projections in the RO&S are developed by the Interagency Rice Estimates Committee of the World Agricultural Outlook Board. The committee is composed of members from various USDA agencies such as the Economic Research Service, Foreign Agricultural Service, Agricultural Marketing Service, and the Agricultural Stabilization and Conservation Service. The forecasting methods used by the committee have ranged over time from judgmental forecasting based on market fundamentals to formal econometric modeling. A combination of judgment and econometric modeling, as suggested by Thomsen and Foote (pp. 341-42) and Crowder, might best characterize the committee effort over the 11-year period used for the analysis.

ARIMA Price Forecasts

A univariate ARIMA model was used to evaluate the accuracy of the RO&S price forecasts. The iterative technique of identification, estimation, and diagnostic checking, as popularized by Box and Jenkins, was used in developing the ARIMA model.[2] Although the Box-Jenkins technique can be quickly and inexpensively applied, it is a powerful alternative to traditional forecasting techniques. For example, Granger and Newbold report the results of three studies which show that the ARIMA model was superior to large scale, macro-econometric models. For cattle and hog prices, Bessler and Brandt found that the ARIMA model exhibited lower mean square error forecasts than econometric models or the expert opinion of Purdue University outlook specialists. Recently, Harris and Leuthold reported that ARIMA models forecasted more accurately than several variations of livestock price forecasting equations used by outlook specialists at the University of Illinois.

The first step in developing the ARIMA model was to examine the autocorrelation function for the PRBF series. Estimates of the autocorrelation coefficients were obtained using 132 monthly observations for the period August 1972 through July 1983. The slow decline exhibited by the autocorrelations indicated that differencing was needed in order to produce stationarity. The autocorrelations of the first differences clearly exhibited stationarity. None of the individual autocorrelation coefficients were significantly different from zero.[3] Surprisingly, there was no evidence of correlation at the seasonal lags of 12, 24, and 36 months. The Ljung-Box Q statistics for 6, 12, 24, and 36 lags did not reject the null hypothesis of randomness. These results suggests that the random walk (RW) model,

$$(1)\quad PRBF_t = PRBF_{t-1} + e_t,$$

is an appropriate characterization of the monthly PRBF series.[4] The disturbance (e_t) is nonautocorrelated with a finite variance. A constant term was not included in the model because the mean of the first differences was not significantly different from zero.

The RW model implies that the best estimate of any future price is nothing more than the most recent past price. When the RO&S price forecast is made in September, the latest

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[2]Abbreviated discussions of the Box-Jenkins methodology are found in texts by Pindyck and Rubinfeld and by Nelson.

[3]The 0.05 level of significance was used throughout the analysis.

[4]Support for the random walk model is found in the conclusions of financial economists who have shown that stock prices are essentially a random walk (Fama). Labys and Granger found that both cash and futures prices are well approximated by a random walk also.

available PRBF is for the month of August.[5] Hence, the RW forecast in September for the marketing year is simply the August price. In March, the price forecast for the marketing year based on the RW model is a weighted average of the PRBF's for the first half of the marketing year and the RW forecast for the second half. The average of the prices during the first 6 months of the marketing year (i.e., August through January) is known in March. The RW model forecast for the second half of the marketing year is the February PRBF.[6] The season average price forecast in March was formed by multiplying the average price during the first half of the marketing year by 0.75 and the February price by 0.25, and then summing these products. These weights represent the approximate percentage of producer sales made during each half of the marketing year.[7] Weighted average price forecasts were needed for the RW model in order for comparisons to be made with the weighted average price forecasts published in the RO&S.

Accuracy of RO&S and RW Price Forecasts

A comparison of the RO&S and RW price forecasts is found in Table 1. For the September RO&S forecasts, the bias was $.88 per hundredweight and for the RW forecasts the bias was $.48 per hundredweight. Since the bias measures the average difference between actual and forecasted prices, these results indicate that both the RO&S and RW forecasts underestimated the final weighted season average price. Using a t-test, neither bias was found to be significantly different from zero.

A primary concern in forecasting is accuracy for an individual year, rather than on a long term basis, as measured by the bias. Two measures of forecast accuracy on an individual year basis were tabulated: (1) mean absolute error (MAE)—the average absolute difference between actual and forecasted prices and (2) root mean square error (RMSE)—the square root of the average squared difference between actual and forecasted prices. For September, the results for the individual year accuracy of the RO&S and RW price forecasts were mixed. The MAE for the RW forecasts was $1.34 per hundredweight compared to $1.41 per hundredweight for the RO&S price forecasts, Table 1. On the basis of RMSE, however, the RO&S

TABLE 1. FORECAST ACCURACY OF THE *RICE OUTLOOK AND SITUATION* RANDOM WALK PRICE FORECASTS FOR THE U. S. AVERAGE PRICE RECEIVED BY FARMERS FOR ROUGH RICE, 1972-82

Month and measure of forecast accuracy	Forecast[a] *Rice Outlook and Situation*	Random walk
	——Dollars per cwt.——	
September		
Bias[b]	0.88	0.48
MAE[c]	1.41	1.34
RMSE[d]	1.48	1.58
March		
Bias[b]	0.16	−0.10
MAE[c]	0.42	0.50
RMSE[d]	0.47	0.61

[a] For the marketing year August 1 through July 31.

[b] Bias $= 1/n \sum_{t=1}^{n} (A_t - F_t)$. n = number of forecasts—for September n = 7 (i.e., forecasts were not published in the *Rice Outlook and Situation* (RO&S) for the marketing years 1973-76); for March n = 11. A_t is the U. S. average price received by farmers for rough rice for the marketing year (PRBF) and F_t is either the September or March RO&S or random walk (RW) model forecast for the marketing year.

[c] MAE $= 1/n \sum_{t=1}^{n} |A_t - F_t|$ with A_t and F_t as defined in b.

[d] RMSE $= \{1/n [\sum_{t=1}^{n} (A_t - F_t)^2]\}^{1/2}$ with A_t and F_t as defined in b.

[5]The September RO&S forecast is developed during the second week of September and released during the last week of the month. The Interagency Rice Estimates Committee has available an estimate of PRBF in August for use in making their September projections. Recently, the PRBF estimate has been a first half of the month average but formerly it was a mid-month price. By using this estimate in conjunction with the cash prices published in the *Weekly Rice Market News* (USDA), a very accurate reading of PRBF can be derived for the month of August.

[6]The March issue of the RO&S is developed during the second week of March and released during the last week of the month. When developing the forecast found in this issue, the Interagency Rice Estimates Committee has available an estimate of the February PRBF.

[7]Weighting factors were developed by regressing the weighted average price for the marketing year, as published in *Agricultural Prices* (USDA), on the average price for the first and second halves of the year. That is, the weights that v_t was uncorrelated.
received by farmers in the marketing year t; $U1_t$ and $U2_t$ = simple average of the prices, respectively, for the first and second halves of marketing year t; and v_t = random error. The sum of the two weights (a, (1−a)) was assumed to equal one because, by definition, the weighting factors in a weighted average sum to one. The above weighting factor estimates used in making the RO&S price forecasts. Any attempt to derive a partial year forecast 82, it was estimated using least squares regression: $PRBF_t - U2_t = 0.75 \cdot (U1_t - U2_t)$ with the standard error of $\hat{a}$ being 0.15 and $r^2 = 0.72$. The estimated Durbin-Watson statistic (2.04) did not reject the null hypothesis that v_t was uncorrelated.

price forecasts were more accurate than the RW model forecasts. The RMSE for the RO&S price forecasts was $1.48 per hundredweight, while the RMSE for the RW model was $1.58 per hundredweight.

For the March forecasts, the bias was $0.16 per hundredweight for the RO&S forecasts and −$0.10 per hundredweight for the RW model forecasts, Table 1.[8] Again, neither bias was significantly different from zero. On the basis of individual year accuracy, the RO&S price forecasts were noticeably better than the RW model forecasts. Contrary to what was found for the September forecasts, the MAE for the RO&S forecasts of $0.42 per hundredweight was $.08 per hundredweight less than the MAE for the RW model forecasts of $0.50 per hundredweight. On the basis of RMSE, the RO&S forecasts were again more accurate than the RW forecasts. The RMSE for the RO&S forecasts was $0.47 per hundredweight compared to $0.61 per hundredweight for the RW model forecasts.

A procedure for determining if the squared errors for the RW and RO&S price forecasts were significantly different was suggested by Ashley et al.[9] For September, the squared errors for the RO&S forecasts were not significantly different from the squared errors for the RW forecasts at any reasonable level of significance. This finding was not expected since the RO&S price forecasts were developed from supply and demand information, which presumably is useful in improving forecast accuracy. For March, however, the squared errors for the RO&S price forecasts were significantly smaller than the squared errors for the RW forecasts.

Efficiency of the RO&S Price Forecasts

Additional insight into forecast quality can be gleaned through the concept of conditional efficiency as presented by Granger and Newbold. The concept involves the combination of two sets of competitive forecasts. One set is the RO&S price forecasts while the other set is the RW forecasts. The objective is to determine if there is information in the RW forecasts that has not been utilized in making the RO&S forecasts.

As suggested by Nelson, a practical test for conditional efficiency can be derived from the relationship,

$$(2)\ A_t = k_1 \cdot RO\&S_t + k_2 \cdot RW_t + u_t,$$

where A_t is the actual price for marketing year t; $RO\&S_t$ and RW_t are the price projections for marketing year t made by the Interagency Rice Estimates Committee and the RW model, respectively; k_1 and k_2 are fixed coefficients; and u_t is the composite predictor error. If the RO&S and RW forecasts are unbiased, as the empirical results in Table 1 suggest, $k_1 + k_2$ should equal one. Thus, equation (2) can be written as:

$$(3)\ A_t = k_1 \cdot RO\&S_t + (1-k_1) \cdot RW_t + u_t$$

or

$$(4)\ A_t - RW_t = k_1 \cdot (RO\&S_t - RW_t) + u_t.$$

A test of the null hypothesis that $k_1=1$ is a test for conditional efficiency. If the least squares estimate of k_1 is significantly different from one, a weight of $(1-\hat{k}_1)$ would be given to the RW forecast. This would mean that the RO&S squared error forecast of A_t could be improved and thus the RO&S forecasts should not be considered conditionally efficient. On the other hand, if $\hat{k}_1$ is not significantly different from one, the RO&S forecasts are considered conditionally efficient. The forecasts are termed conditionally efficient because they are efficient only in regard to a limited information set, namely, all past prices.

The tests for conditional efficiency of the RO&S forecasts are shown in Table 2. For both the September and March RO&S forecasts, the difference between the $\hat{k}_1$'s and one was less than their respective standard errors and thus neither $\hat{k}_1$ was significantly different from one at any reasonable level of significance. Hence, the conclusion is that the RO&S forecasts are conditionally efficient, or in other words, in developing their forecasts over the 11-year period, the Interagency Rice Estimates Committee made efficient use of the information in the series of past prices. This may seem to be a trivial finding but forecasts from macro-econometric models (Nelson) and an econometric hog price equation (Bes-

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[8]Comparisons based on forecasts for the entire marketing year were made even though seven of the monthly prices for the year were known at the time the forecasts were being developed. This was unavoidable because it was not possible to derive a partial year forecast from the RO&S marketing year forecasts without knowing the weighting factor estimates used in making the RO&S price forecasts. Any attempt to derive a partial year forecast in the absence of the estimated weighting factors could substantially lessen the quality of the RO&S price forecasts.

[9]A discussion and application of the procedure is found in Brandt and Bessler (1982 and 1983).

sler and Brandt) have been shown not to be conditionally efficient.

These findings are based on regression results that constrain the weights in the composite regression equation (2) to equal one. The rationale for the constraint is based on the earlier findings that both the RO&S and RW forecasts were unbiased. An additional test of unbiasedness can be made, while at the same time determining the effect of the constraint on the conditional efficiency weights, by relaxing the constraint. The unconstrained weight estimates are shown on the right-hand-side of Table 2. Again, there was no evidence suggesting rejection of the null hypothesis of conditional efficiency since neither $\hat{k}_2$ was significantly different from zero. The negative value for $\hat{k}_2$ for the March regression is clear evidence that no information was available in the series of past prices that was not utilized in developing the RO&S price forecasts. Finally, it should be noted that the null hypothesis that the RO&S and RW forecasts are unbiased (i.e., $k_1 + k_2 = 1$) was not rejected for either the September or March forecasts.

Conditional efficiency implies that a combination of the RO&S and RW forecasts will not provide significantly more accurate price forecasts than the RO&S price forecasts alone. To empirically verify this, a composite forecast was developed based on a weighted combination of the RO&S and RW price forecasts. The weights were taken from the conditional efficiency regressions in Table 2. For the September composite forecast, the weights were 0.60 for the RO&S forecasts and 0.40 for the RW forecasts. The MAE and RMSE for the September composite forecasts were $1.27 and $1.40 per hundredweight, respectively. Both were lower than the MAE ($1.41) and RMSE ($1.48) for the RO&S price forecasts. Based on the test of squared errors developed by Ashley et al., there was no significant difference in forecast accuracy of the RO&S and composite price forecasts. As already noted, this is consistent with the conclusion based on the conditional efficiency regression results in Table 2. For the March composite forecasts, the weights were 0.93 for the RO&S forecasts and 0.07 for the RW price forecasts. The MAE for the composite forecasts ($0.41) was lower than the MAE ($0.42) for the RO&S price forecasts. The RMSE for the composite forecasts ($0.47) was the same, however, as the RMSE for the RO&S price forecasts. Because the weight attached to the March RO&S forecasts in the composite forecast equation was so close to one, there was virtually no difference in the composite and RO&S price forecasts and, thus, there was little to no difference in forecast accuracy.

TABLE 2. CONDITIONAL EFFICIENCY REGRESSIONS FOR *RICE OUTLOOK AND SITUATION* FORECASTS OF THE U. S. AVERAGE PRICE RECEIVED BY FARMERS FOR ROUGH RICE, 1972-82

	Constrained weights		Unconstrained weights			F-test for null hyp.
Month	$\hat{k}_1$	DW[a,b]	$\hat{k}_1$	$\hat{k}_2$	DW[a]	$k_1+k_2=1$
Sept. (n=7)[c]	0.60	1.79	0.90	0.19	1.46	1.64
	(0.48)[d]		(0.44)	(0.43)		
March (n=11)	0.93	2.15	1.28	−0.26	2.23	1.27
	(0.35)		(0.46)	(0.45)		

[a] Durbin-Watson statistic. None of the DW's show evidence of autocorrelation in the residuals.

[b] See Farebrother and Koerts and Abrahamse for DW critical values when there is no intercept in the regression.

[c] n = number of forecasts.

[d] Standard errors of the regression coefficients are shown in parentheses.

Storage Decision Based on the RO&S Price Forecasts

A simple test was designed to determine if a producer, who owned a rice storage facility, could increase the price received compared to selling at harvest by using the RO&S price forecasts. To conduct the test, it was necessary to convert the RO&S price forecasts for the marketing year to monthly forecasts based on the average seasonal pattern of prices in previous years. These monthly price forecasts were reduced by the variable cost of storage to the forecast month. Using T-bill interest rates (Board of Governors of the Federal Reserve System), the price forecasts, net of the variable cost of storage, were discounted to a harvest (September) basis. This set of monthly discounted net prices for the marketing season was compared to the cash price available at harvest. If the cash price at harvest was greater than any of the discounted net RO&S price forecasts, rice was sold at the harvest price. If any of the discounted net RO&S price forecasts were greater than the harvest price, rice was stored to the month which offered the highest expected net discounted price. While this test is simple, it should suggest reasonable conclusions concerning the benefit of using the RO&S price forecasts in making storage decisions.

The result of basing storage decisions on the RO&S price forecasts was calculated for the 7 marketing years 1972 and 1977-82. (Note: September price forecasts were not published in the RO&S for the marketing years 1973-76.) The average net price from storage past harvest based on the RO&S price forecasts was $8.80 per hundredweight.[10] This was $.16 per hundredweight greater than the harvest price of $8.64 per hundredweight. There was, however, greater uncertainty involved in storing past harvest. The standard deviation of the net price received—a measure of this uncertainty—was $1.85 per hundredweight when rice was stored beyond harvest compared to $1.60 per hundredweight for the harvest price. The difference in the standard deviations was $.25 per hundredweight. Even though there was greater variability in the net price received from storage beyond harvest, some producers would undoubtedly find the added return attractive. Conversely, more risk averse producers might choose to sell at harvest and be subject to less price variability ($1.60 vs. $1.85) at the cost of a somewhat lower net price received ($8.64 vs. $8.80).

Summary and Conclusions

The forecast accuracy of the RO&S and RW (i.e., univariate ARIMA) models was compared. Based on RMSE, the RO&S price forecasts were more accurate. The results were mixed based on MAE. For September, the MAE for the RW price forecasts was less than the MAE for the RO&S price forecasts. However, for March, the RO&S price forecasts had a lower MAE than the RW forecasts. The fact that the RO&S price forecasts were only marginally better than the RW model forecasts implies that the supply and demand information utilized in making the RO&S price forecasts, for the most part, had already been discounted in cash prices. This was likely the result of the activity of cash rice traders who were aware of the same supply and demand information. Their trading activity in the cash market imparted the supply and demand information to cash prices. Hence, the RW model forecasts, which were based on the latest available cash price, provided almost as accurate forecasts as the RO&S price forecasts.

A test was designed to determine the advantage of using the RO&S price forecasts to selectively store rice beyond harvest. The results showed that the average net price received was increased $.16 per hundredweight over the harvest price by selectively storing rice past harvest. However, the variance in the net price received from storage was increased $.25 per hundredweight compared to the variance of the harvest price. Hence, a tradeoff between return and risk is offered by the two marketing approaches.

Finally, the results—namely, the surprising accuracy of the cash price compared to the RO&S price forecasts—suggest an important policy question: Should public monies be spent for developing the forecasts in the RO&S? To partially answer this question, the impact on rice producers' income of marketing rice using the RO&S price forecasts was estimated. For example, if one-tenth of the rice production in the United States for the 6 marketing years 1977-82 had been sold based on the RO&S price forecasts, the net annual income of rice producers would have increased $2.3 million. The cost of developing the RO&S price forecasts could be determined from the salaries paid the economists and support staff (plus equipment and overhead) that have been involved in developing the RO&S price forecasts. These costs of several hundred thousand dollars would not be greater than the increased returns achieved if only 10 percent of the rice production had been sold using the simple marketing strategy outlined in the previous section.

The benefits to society of improved price forecasts extend beyond this, however. An increase in rice producers' income as a result of improved marketing would benefit not only rice producers but business in general, since most of the additional income would be spent. Consequently, the total annual income in the United States would increase more than $2.3 million because of the multiplier effect. Better forecasts should also improve the allocation of rice inventories over time and thus reduce price variability and improve consumer satisfaction (Hayami and Peterson). Even slightly improved price forecasts are important to rice producers, business in general, and consumers alike. The results indicate that the RO&S price forecasts

[10] For no year was storage called for beyond March. Hence, the March forecasts were not used in the evaluation of the selective storage strategy.

were only marginally better than the RW forecasts. This suggests a need for the USDA to strengthen its methods of forecasting rice prices.

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