United States Department of Agriculture

National Agricultural Statistics Service

Research and Applications Division

SRB Staff Report Number SRB-88-07

December 1988

An Alternative Method to Produce Prices Received Estimates

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AN ALTERNATIVE METHOD TO PRODUCE PRICES RECEIVED ESTIMATES, W. W. Donaldson and B. F. Klugh, Jr., National Agricultural Statistics Service, U.S. Department of Agriculture, Washington, D.C. 20250, December 1988, Staff Report No. SRB 88-07.

ABSTRACT

The United States Department of Agriculture has issued statistics on prices received by farmers since 1866. Beginning in 1924, prices received were collected as of the middle of the month instead of the first of the month. In this research analysis both univariate and transfer function Box-Jenkins time series modeling techniques are applied to nine prices received series: four national crop price series, four national livestock price series, and the Wisconsin-Minnesota manufacturing milk price series. When a Box-Jenkins transfer function forecast is composited with the preliminary midmonth price survey estimate, midmonth price estimates are generated that are more reliable than the current preliminary survey estimate alone. We recommend that the Agency adopt this composite forecasting method, that uses time series analysis and current National Agricultural Statistics Service (NASS) survey data, to estimate all national midmonth prices.

KEYWORDS: Transfer function, time series

ACKNOWLEDGMENTS

The authors wish to express their appreciation to John Buche, Doug Kleweno, Carol Harris, Jennifer Kotch, Patsy Nelson, and those NASS employees who collect and process the NASS data series of prices received by farmers.

CONTENTS

AN ALTERNATIVE METHOD TO PRODUCE PRICES RECEIVED ESTIMATES

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SUMMARY

Time series structure was discovered in the prices received data for four national crop price series, four national livestock price series, and the Wisconsin-Minnesota manufacturing milk price series. Box-Jenkins transfer function models outperformed univariate Box-Jenkins time series models of the data. A composite forecast consisting of the preliminary midmonth price estimate and a forecast from a Box-Jenkins transfer function model outperformed the current preliminary midmonth price estimates from January 1987 to December 1987. We recommend that the Agency adopt this composite forecasting method, that uses times series analysis and current NASS survey data, to estimate midmonth prices.

INTRODUCTION

The introductory paragraphs below, describing the prices received program of the National Agricultural Statistics Service (NASS), were quoted or paraphrased from Miscellaneous Publication Number 1308, Scope and Methods of the Statistical Reporting Service (1983).

> The United States Department of Agriculture started collecting prices received by farmers in 1866; early reports covered December 1 prices for 10 crops. Collection of 'farm values' as of January 1 for six species of livestock began in 1867. Collection of prices as of the first of each month began in 1908 for eight crops, and during the next 2 years monthly prices received for livestock, poultry, and their products were added. . . . Beginning in 1924, prices received were collected as of the middle of the month instead of the first. The series for the earlier years were converted to a midmonth basis to preserve continuity.(p. 95)
>
> The concept used to estimate prices received by farmers is that of a price which, if multiplied by the total quantity of the commodity sold, would give

> the total amount received by all farmers for that commodity. . . . the estimated price reflects prices received by farmers for all classes and grades of the commodity being sold, including quality premiums or discounts. Estimates generally relate to prices farmers receive for their products at the point of first sale, usually a local market, or the point to which farmers deliver their products. . . . NASS estimates prices received by farmers monthly for about 60 of the more important crop and livestock items, and on an annual or season-average basis for some 30 additional items.(p. 96)

Estimates are calculated for most items using voluntary responses from probability survey samples of independent local buyers, such as, elevators, produce dealers, livestock yards, processors, canneries, slaughter plants, auctions, etc.

> NASS publishes preliminary monthly prices received by farmers on the last working day of each month in 'Agricultural Prices'. These [preliminary] prices [Y^{P}_{T}] are based on data reported for the first 2 weeks of the month or at the middle of the month (from the 13th through the 17th). Preliminary monthly prices are subject to revision the following month when data for the entire month [Y_T] become available. Entire-month prices generally are associated with reported marketings or purchases which are used to arrive at a weighted price.(Material within the brackets did not appear in the original quote.)(p. 96)

These entire-month prices are subject to one annual revision and a possible revision once every five years due to census results.

The purpose of this paper is to determine if Box-Jenkins time series techniques could be applied to historical price series to provide preliminary midmonth price estimates that would be closer to the final entire-month price estimates. Previous work by Klugh and Markham (1985) demonstrated that one step ahead forecasts from univariate Box-Jenkins models applied to prices received for fluid and manufacturing milk outperformed current preliminary midmonth price estimates. Rao, Srinath, and Quenneneville (1986) suggested that the current preliminary midmonth price estimate could be used with previous entire-month estimates in a Kalman filter modeling approach to improve performance of the midmonth estimate. Finally, Brandt and Bressler (1983) demonstrated for hog prices that simple composite forecasts of several comparable prediction methods outperformed any one method.

In this paper we will evaluate the application of univariate Box-Jenkins time series models, transfer function models, and composite forecasting techniques on eight national price series: Cotton, rice, wheat, corn, steers, cows, sows, and barrows-gilts. We will also apply the same techniques to the Wisconsin-Minnesota manufacturing milk price series, for which the preliminary price is published on the fifth of the succeeding month.

THE DATA

Monthly U.S. price estimates used in the analysis for cotton, rice, cows, and steers covered the period 1973 through 1987 for all models. For wheat and corn we used 1973 through 1987 for the univariate models and 1977 to 1987 for the transfer function models. For sows and barrows-gilts we used 1981 through 1987 for all models. Finally, we used 1978 through 1987 for all models for the manufacturing milk series.

Following the notation of Rao, et al. (1986), two different price estimates were considered for each crop for a given survey month: (1) the preliminary midmonth price estimate (Y^p_T) for the current month T and (2) the entire-month price estimate (Y_{T-1}) for the previous month T-1.

Six months of preliminary midmonth price data for rice were missing. To replace the missing data value for time period i, an unweighted average was calculated using the entire-month prices for time periods i and i-1.

METHODOLOGY

This section will define terms, present methods used to fit the data, and describe statistics that compare the performances of the models. The theory used in the decision making process will not be presented. Final model forms will be demonstrated.

The automated time series package AUTOBOX was used in all modeling steps. The AUTOBOX package was run on a Compaq 386 with a 16 Mhz processor and math coprocessor. Four minutes of computer time were required to fit a model and 15 seconds were needed to produce a forecast from a fitted model. An IBM/AT with a math coprocessor will take three times longer. The cost of the AUTOBOX software package is $1195.

The options that were chosen in modeling used standard Box-Jenkins criteria for all decision making. Tc evaluate the models, one month ahead forecasts for all the commodities for 1987 were computed and compared to final entire-month price values.

Univariate and transfer function models were fit to each commodity to make one month ahead forecasts ($\hat{Y}_T$). Univariate models use only previous values of the modeled variable (Y_T) or errors in previous forecasts of the modeled variable

$(Y_{T-1}-\hat{Y}_{T-1})$ to predict future values. Transfer function models use the same information about the modeled series as do univariate models, as well as, current and historic values of at least one other variable (Y^{P}_{T}). The significant issue in using a transfer function to predict the unknown variable (Y_T) at time T-1 is that the value of the ancillary variable (Y^{P}_{T}) is known at time T-1.

The general form of a univariate time series model is given by:

$$Y_T = \mu + \phi_1 Y_{T-1} + \ldots + \phi_p Y_{T-p} - \theta_1(Y_{T-1} - \hat{Y}_{T-1}) - \ldots - \theta_q(Y_{T-q} - \hat{Y}_{T-q}) + \epsilon_T,$$

where:

Y_T = the current value of the time series to be predicted at time T,

μ = the mean of the time series,

Y_{T-i} = a previous value of the time series at time T-i,

$(Y_{T-i} - \hat{Y}_{T-i})$ = ϵ_{T-i} - the difference between the actual and predicted values at time period T-i,

ϕ_i, θ_j = parameters of the time series calculated for time periods T-i and T-j, and

ϵ_T = a normally distributed error with mean zero and standard deviation equal to σ.

This model is also represented in functional notation by:

$$f(Y_T) = g(\epsilon_T),$$

where:

$$f(Y_T) = \mu + Y_T - \phi_1 Y_{T-1} - \ldots - \phi_p Y_{T-p}, \text{ and}$$

$$g(\epsilon_T) = \epsilon_T - \theta_1 \epsilon_{T-1} - \ldots - \theta_q \epsilon_{T-q}.$$

The general functional form of a transfer function model is:

$$f(Y_T) = h(Y^{P}_{T}) + g(\epsilon_T),$$

where:

$$h(Y^{P}_{T}) = \mu^{P} + w_0 Y^{P}_{T-b} - \ldots - w_s Y^{P}_{T-b-s},$$

Y^{P}_{T} = the current value of the time series used in prediction at time T,

μ^{P} = the mean of the time series for Y^{P}_{T},

Y^P_{T-b} = a previous value of the time series at time T-b,

w_j = a parameter of the time series calculated for time period T-b-j,

and

$f(Y_T)$ and $g(\epsilon_T)$ are as above.

Another forecast that was considered was constructed by using a composite estimation procedure. The preliminary midmonth price estimate and the forecast from the transfer function model were composited. Forecasts from each method are weighted by the inverse of the method's historical mean square error divided by the sum of the inverse historical mean square errors for both forecast methods. The sum of the weights used in compositing is 1.

To compare the performances of the models and methods, let Y_T be the entire-month price at time T and let F_T be the forecast from a model or method at time T; then the forecast error can be defined as:

$$e_T = Y_T - F_T \ .$$

The following standard statistical measures to describe model performance are calculated:

Mean Error $= \sum_t e_t / n,$

Mean Absolute Error (MAE) $= \sum_t |e_t| / n,$

Mean Percent Error (MPE) $= [\sum_t (e_t / Y_t)/n] \times 100,$

Mean Absolute Percent Error (MAPE) $= [\sum_t |e_t / Y_t|/n] \times 100,$

Root Mean Squared Error (RMSE) $= \sqrt{\sum_t e^2_t / n},$

Theil's U-Statistic $= \sqrt{\dfrac{\sum_{t=1}^{n-1} (e_{t+1} / Y_t)^2/n}{\sum_{t=1}^{n-1} ((Y_{t+1}-Y_t) / Y_t)^2/n}}\ .$

The mean error, the mean absolute error, and the root mean square error are three statistics that provide measures of forecast error in terms of the units of the originally measured data. The mean error when calculated over many samples provides an estimate of the bias of the forecast. The mean absolute error provides a measure of the size of the average miss in the forecast. The root mean square error provides a measure of the expected variability in the forecast and permits comparisons across forecasts. The root mean square error penalizes forecast procedures that miss by a large deviation, since the magnitude of the miss is squared.

The mean percent error and the mean absolute percent error are relative measures of forecast performance and could be used to compare forecast procedures across items as well as within an item. Each statistic expresses performance on a percentage basis. Therefore a procedure that misses by 1% is better than a procedure that misses by 2%. Finally, Theil's U-statistic [see Makridakis, <u>et al</u>. (1983)] is a measure that compares a forecast procedure to a naive method which assumes that the current value in the series could be predicted by the previous value of the series.

The ranges of the U-statistic can be summarized as follows:

U = 1: the naive method is as good as the forecasting technique being evaluated;

U > 1: there is no point in using a formal forecasting method, since using a naive method is better; and

U < 1: the forecasting technique being used is better than the naive method. The smaller the U-statistic the better the forecast relative to the naive method.

More refined naive methods could be used as a benchmark by modifying the statistic.

RESULTS

Tables A1 and A2 of the Appendix contain price forecasts and estimates for the nine price series evaluated. One step ahead forecasts were created for January 1987 to December 1987. The univariate time series model used the final entire-month price as the modeled variable. The transfer function model used both the preliminary midmonth price estimate and the final entire-month price as modeled variables. The general forms of the models are found in Exhibit 1 of the Appendix. Tables 1 and 1a contain evaluation statistics of the forecasts from the different models and methods. Table 2 contains counts of the number of times a forecast method was better than the current preliminary midmonth price estimating procedure. Table 3 contains counts of the number of times that a method was best or second best among all procedures. Ties were counted in Table 3 as many times as they occurred.

The following results apply to each of the nine prices received estimate series examined and highlight the information found in Tables 1, 1a, 2, and 3. All univariate models possess U-statistics with values less than 1, indicating that there is some structural information in the data that can be used to produce a forecast. However, the U-statistics for three of the univariate price series are very close to 1 indicating weak structure. When four evaluation criteria: Mean absolute error, mean absolute percent error, root mean square error, and Theil's U statistic, are examined, forecasts from transfer function models outperformed forecasts from univariate models for all nine price series. For the other two criteria, transfer function model forecasts were better in seven of the nine price series. Forecasts produced from the composite estimating technique, employing the preliminary midmonth price and the forecast from the transfer function model, outperformed the preliminary midmonth price estimate. The composite estimate had smaller mean errors and mean percent errors for all nine commodities, mean absolute errors and mean absolute percent errors five times, and root mean square errors and Theil's U-statistics seven times.

The composite method was the best or second best method for all nine price series when examining root mean square error and Theil's U-statistic. When the composite method was second best for the previous two evaluation statistics, the magnitude of difference between evaluation statistics for the best and second best procedures was small. Sometimes the current midmonth price estimate method or the transfer function model outperformed the composite method; however, the composite method performed more reliably across all series.

Table 1: Evaluation statistics for rice, wheat, cotton, corn, steers, cows, barrows, and sows national price forecasts listed in Appendix Table A1.

Commodity / Statistic	Mid Month Price	One step ahead forecasts: Univ.	Transfer	Composite
Rice				
Mean Error	0.338	0.245	0.276	0.300
Mean % Error	5.607	4.128	4.755	5.076
Mean Abs. Error	0.394	0.356	0.338	0.353
Mean Abs. % Error	7.195	7.296	6.484	6.573
RMSE	0.591	0.530	0.491	0.527
Theil's U	0.899	0.900	0.781	0.821
Wheat				
Mean Error	0.026	-0.046	0.007	0.015
Mean % Error	1.020	-1.852	0.295	0.704
Mean Abs. Error	0.034	0.066	0.040	0.036
Mean Abs. % Error	1.332	2.645	1.576	1.401
RMSE	0.047	0.099	0.049	0.044
Theil's U	0.402	0.981	0.474	0.399
Cotton				
Mean Error	-0.004	0.010	0.010	0.002
Mean % Error	-0.696	1.289	1.313	0.214
Mean Abs. Error	0.019	0.028	0.025	0.017
Mean Abs. % Error	3.262	4.888	4.283	2.991
RMSE	0.027	0.040	0.030	0.022
Theil's U	0.585	0.963	0.697	0.504

Table 1: Evaluation statistics for rice, wheat, cotton, corn,
Cont'd: steers, cows, barrows, and sows national price forecasts listed in Appendix Table A1.

Commodity / Statistic	Mid Month Price	One step ahead forecasts		
		Univ.	Transfer	Composite
Corn				
Mean Error	0.009	-0.018	-0.002	0.001
Mean % Error	0.676	-1.250	-0.174	0.071
Mean Abs. Error	0.028	0.060	0.019	0.016
Mean Abs. % Error	1.812	3.903	1.227	1.009
RMSE	0.035	0.140	0.051	0.017
Theil's U	0.425	0.781	0.278	0.216
Steers				
Mean Error	-0.333	0.500	-0.058	-0.200
Mean % Error	-0.495	0.774	-0.086	-0.295
Mean Abs. Error	0.417	1.150	0.408	0.366
Mean Abs. % Error	0.630	1.759	0.613	0.555
RMSE	0.657	1.611	0.542	0.596
Theil's U	0.382	0.988	0.364	0.347
Cows				
Mean Error	0.208	0.592	0.167	0.200
Mean % Error	0.493	1.404	0.340	0.471
Mean Abs. Error	0.658	1.125	0.700	0.683
Mean Abs. % Error	1.528	2.631	1.617	1.583
RMSE	0.746	1.453	0.831	0.785
Theil's U	0.506	0.811	0.567	0.532

Table 1: Evaluation statistics for rice, wheat, cotton, corn,
Cont'd: steers, cows, barrows, and sows national price forecasts listed in Appendix Table A1.

Commodity / Statistic	Mid Month Price	One step ahead forecasts		
		Univ.	Transfer	Composite
Barrows & Gilts				
Mean Error	-0.058	0.467	0.050	0.017
Mean % Error	-0.152	0.589	0.041	-0.018
Mean Abs. Error	0.475	2.667	0.500	0.483
Mean Abs. % Error	0.968	5.385	1.005	0.980
RMSE	0.577	3.021	0.554	0.551
Theil's U	0.145	0.779	0.137	0.137
Sows				
Mean Error	-0.275	-0.142	-0.067	-0.200
Mean % Error	-0.478	-0.733	0.031	-0.290
Mean Abs. Error	0.958	1.892	0.967	0.983
Mean Abs. % Error	2.288	4.745	2.360	2.373
RMSE	1.409	2.728	1.447	1.420
Theil's U	0.396	0.773	0.417	0.403

Table 1a: Evaluation statistics for Wisconsin-Minnesota manufacturing milk price forecasts listed in Appendix Table A2.

Commodity / Statistic	Fifth of Month Price	One step ahead forecasts		
		Univ.	Transfer	Composite
Manufacturing Milk				
Mean Error	0.034	-0.022	-0.004	0.012
Mean % Error	0.294	-0.176	-0.035	0.101
Mean Abs. Error	0.054	0.111	0.042	0.043
Mean Abs. % Error	0.466	0.949	0.366	0.374
RMSE	0.065	0.140	0.051	0.051
Theil's U	0.269	0.519	0.208	0.210

Table 2: Numbers of times for each evaluation statistic that a forecast method was superior to the current midmonth price estimate for the nine price series examined.

Statistic	Count of number times better		
	Univ.	Transfer	Composite
Mean Error	3	8	9
Mean % Error	2	8	9
Mean Abs. Error	1	4	5
Mean Abs. % Error	0	4	5
RMSE	1	4	7
Theil's U	0	5	7

Table 3: Numbers of times for each evaluation statistic that a forecast method was best or second best for the nine price series examined.

Statistic	Best / Second Best Count			
	Mid Month Price	Univ.	Transfer	Composite
Mean Error	0/1	1/1	5/4	3/3
Mean % Error	0/1	1/0	4/3	4/5
Mean Abs. Error	4/1	0/0	2/3	3/5
Mean Abs. % Error	4/1	0/0	2/3	3/5
RMSE	2/3	0/0	3/1	5/4
Theil's U	2/3	0/0	3/2	5/4

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are based on the nine series examined.

- Time series structure exists within price data so that transfer function models using preliminary midmonth price perform quite well.

- Transfer function models perform everywhere better than univariate models for these nine price series (except for cotton and rice when using the mean error and the mean percent error for comparative purposes).

- A composite forecast that uses the current preliminary midmonth price and the forecast from a transfer function model, when compared to the other types of forecasts, performs more reliably across all series.

- The technique for creating a composite forecast as examined in this paper should be adopted by the Agency to produce the preliminary price estimate for prices received items.

- Additional research : Evaluate the benefit of current Market News information in the transfer function model. Consider the same approach for price estimates at the state level.

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APPENDIX

Table A1: Rice, wheat, cotton, corn, steers, cows, barrows, and sows national price forecasts and estimates for the period January 1987 to December 1987 from models fit to all available data from January 1973 or later to month before forecast.

Commodity / Month	Mid Month Price	One step ahead forecasts			Entire Month Price
		Univ.	Transfer	Composite	
Rice					
January	3.72	3.71	3.76	3.74	3.55
February	3.72	3.52	3.70	3.71	3.84
March	3.71	3.91	3.51	3.60	3.62
April	3.52	3.57	3.47	3.49	3.63
May	3.54	3.64	3.64	3.60	3.71
June	3.66	3.72	3.74	3.71	3.62
July	3.53	3.62	3.53	3.53	3.49
August	3.65	3.47	3.63	3.64	3.74
September	3.73	3.79	3.80	3.77	4.32
October	4.58	4.43	4.69	4.65	5.88
November	5.95	6.27	6.15	6.07	7.08
December	6.49	7.29	6.92	6.74	7.37
Wheat					
January	2.44	2.57	2.48	2.46	2.53
February	2.53	2.60	2.59	2.56	2.58
March	2.57	2.65	2.61	2.59	2.57
April	2.59	2.62	2.64	2.61	2.63
May	2.70	2.70	2.67	2.69	2.66
June	2.44	2.72	2.48	2.46	2.44
July	2.30	2.44	2.24	2.27	2.32
August	2.31	2.35	2.33	2.32	2.36
September	2.52	2.43	2.50	2.51	2.53
October	2.62	2.64	2.63	2.62	2.62
November	2.59	2.70	2.60	2.59	2.69
December	2.71	2.76	2.78	2.74	2.70
Cotton					
January	0.492	0.532	0.504	0.497	0.521
February	0.468	0.526	0.499	0.482	0.464
March	0.513	0.473	0.504	0.509	0.475
April	0.508	0.483	0.489	0.499	0.504
May	0.589	0.510	0.541	0.567	0.600
June	0.722	0.599	0.643	0.687	0.662
July	0.711	0.656	0.642	0.680	0.683
August	0.591	0.673	0.589	0.590	0.637
September	0.653	0.633	0.661	0.657	0.649
October	0.639	0.644	0.655	0.646	0.644
November	0.650	0.640	0.654	0.652	0.650
December	0.644	0.645	0.635	0.640	0.642

Table A1: Rice, wheat, cotton, corn, steers, cows, barrows, and sows
Cont'd: national price forecasts and estimates for the period January 1987 to December 1987 from models fit to all available data from January 1973 or later to month before forecast.

Commodity / Month	Mid Month Price	One step ahead forecasts			Entire Month Price
		Univ.	Transfer	Composite	
Corn					
January	1.43	1.57	1.49	1.47	1.48
February	1.36	1.51	1.43	1.41	1.42
March	1.41	1.43	1.46	1.45	1.47
April	1.49	1.55	1.55	1.53	1.52
May	1.70	1.60	1.66	1.67	1.66
June	1.72	1.75	1.72	1.72	1.69
July	1.59	1.68	1.59	1.59	1.60
August	1.47	1.56	1.50	1.49	1.47
September	1.52	1.40	1.47	1.48	1.49
October	1.55	1.55	1.53	1.54	1.56
November	1.63	1.65	1.64	1.64	1.62
December	1.72	1.67	1.69	1.70	1.72
Steers					
January	59.50	59.00	59.60	59.50	59.70
February	62.20	59.90	62.20	62.20	62.40
March	62.60	63.00	62.70	62.60	62.70
April	66.90	62.60	66.90	66.90	66.60
May	69.20	67.60	69.00	69.10	67.40
June	67.30	67.40	66.60	67.00	67.20
July	66.60	67.20	66.20	66.40	65.40
August	66.20	65.00	65.80	66.00	65.90
September	68.00	66.10	67.30	67.70	67.90
October	67.80	68.30	67.50	67.70	67.40
November	67.00	67.20	66.60	66.80	66.90
December	66.80	66.80	66.40	66.60	66.90
Cows					
January	38.10	35.90	38.10	38.10	39.00
February	40.70	41.30	40.80	40.70	41.70
March	42.40	42.10	43.10	42.70	43.30
April	43.90	42.80	44.50	44.20	43.30
May	43.50	44.40	43.30	43.40	43.10
June	43.70	42.60	43.50	43.60	43.60
July	44.00	43.30	43.80	43.90	43.40
August	43.80	43.70	43.30	43.60	43.80
September	44.60	44.10	44.20	44.40	45.60
October	44.70	45.60	45.10	44.90	43.70
November	42.60	42.90	42.60	42.60	43.00
December	44.10	42.80	44.20	44.10	45.10

Table A1: Rice, wheat, cotton, corn, steers, cows, barrows, and sows
Cont'd: national price forecasts and estimates for the period January 1987 to December 1987 from models fit to all available data from January 1973 or later to month before forecast.

Commodity / Month	Mid Month Price	One step ahead forecasts: Univ.	Transfer	Composite	Entire Month Price
Barrows					
January	47.00	50.20	47.00	47.00	47.60
February	49.50	45.80	49.50	49.50	48.80
March	47.20	49.30	47.40	47.30	47.90
April	51.10	47.60	50.80	50.90	51.30
May	55.10	52.30	55.00	55.00	55.20
June	61.00	55.60	60.90	60.90	60.70
July	61.00	60.70	60.90	60.90	61.20
August	59.90	58.80	59.50	59.70	59.80
September	54.20	56.90	54.00	54.10	54.90
October	50.50	51.20	50.20	50.30	49.30
November	41.30	46.40	41.40	41.40	41.10
December	41.70	38.40	41.60	41.60	41.00
Sows					
January	42.20	39.80	42.20	42.40	42.00
February	41.50	42.30	41.50	41.50	41.40
March	40.60	41.10	40.80	40.70	41.50
April	45.30	41.60	45.20	45.30	44.70
May	45.60	45.70	45.60	45.60	45.30
June	45.70	45.00	45.20	45.50	45.10
July	45.10	44.50	44.40	44.80	46.50
August	49.10	46.40	48.90	49.00	48.10
September	48.60	47.80	48.40	48.50	48.10
October	47.60	47.10	47.40	47.50	43.50
November	33.50	41.20	33.10	33.30	33.90
December	29.70	30.40	29.30	29.50	31.10

Table A2: Wisconsin-Minnesota manufacturing milk price forecasts and estimates for the period January 1987 to December 1987 from models fit to all available data from January 1978 to month before forecast.

Commodity / Month	Fifth of Month Price	One step ahead forecasts			Entire Month Price
		Univ.	Transfer	Composite	
Manufacturing Milk					
January	12.16	12.38	12.20	12.18	12.19
February	11.68	11.98	11.72	11.70	11.65
March	11.39	11.31	11.42	11.41	11.48
April	11.33	11.28	11.34	11.34	11.37
May	11.22	11.23	11.24	11.23	11.25
June	11.16	11.06	11.21	11.19	11.14
July	11.13	11.08	11.15	11.14	11.15
August	11.25	11.40	11.31	11.29	11.37
September	11.72	11.71	11.83	11.79	11.81
October	11.87	12.09	11.91	11.89	11.98
November	11.94	12.04	11.99	11.97	11.91
December	11.67	11.64	11.66	11.66	11.63

Exhibit 1: Univariate and transfer function time series model forms for prices received.

<u>Univariate model</u>

Rice : $(1-B)(\ln Y_T) = (1-\Theta_1 B)\epsilon_T$

Wheat : $(1-\phi_1 B-\phi_2 B^2)(Y_T^{-.5}-\mu) = \epsilon_T$

Cotton: $(1-\phi_1 B)(Y_T^{.5}-\mu) = \epsilon_T$

Corn: $(1-\phi_1 B-\phi_2 B^2)(1-\phi_{12}B^{12})(Y_T^{.5}-\mu) = \epsilon_T$

Milk: $(1-B)(1-B^{12})(1-\phi_1 B)Y_t = \Theta_0 + (1-\Theta_{12}B^{12})\epsilon_t$

Barrows-Gilts: $(1-\phi_1 B-\phi_2 B^2)(Y_T-\mu) = \epsilon_T$

Cows: $(1-B)(1-\phi_{12}B^{12})(Y_t^{.5}) = (1-\Theta_1 B-\Theta_2 B^2)(1-\Theta_{24}B^{24})\epsilon_t$

Sows: $(1-\phi_1 B-\phi_2 B^2)(Y_T-\mu) = \epsilon_T$

Steers: $(1-B)(Y_T) = (1-\Theta_1 B)\epsilon_T$

<u>Transfer function model</u>

Rice : $(1-B)Y_T= ((1-B)(w_o-w_2B^2-w_8B^8)/(1-\delta_2B^2))Y^P{}_T$
$+((1-\Theta_2B^2)/(1-\phi_1B))\epsilon_T$

Wheat : $(1-B)Y_T= ((1-B)(w_o-w_1B-w_{11}B^{11})/(1-\delta_1B))Y^P{}_T$
$+((1-\Theta_2B^2)(1-\Theta_1B)/(1-\phi_6B^6))\epsilon_T$

Cotton: $(1-B)Y_T= (1-B)(w_o-w_{13}B^{13}-w_{16}B^{16})Y^P{}_T + (1-\Theta_1B)\epsilon_T$

Transfer function model

Corn: $(1-B)Y_T = ((1-B)(w_0 - w_1 B - w_{18}B^{18})Y^P{}_T$

$+((1-\theta_2 B^2)(1-\theta_{24}B^{24})\epsilon_T$

Milk: $(1-B)(1-B^{12})Y_T = (1-B)(1-B^{12})w_0 Y^P{}_T$

$+((1-\theta_2 B^2)(1-\theta_{12}B^{12})/(1-\phi_1 B))\epsilon_T$

Barrows: $(Y_T-\mu) = ((w_0 - w_1 B)/(1-\delta_1 B - \delta_2 B^2))(Y^P{}_T - \mu^P) + \epsilon_T$
-Gilts

Cows: $(1-B)Y_T = ((1-B)(w_0 - w_{10}B^{10} - w_{14}B^{14}))Y^P{}_T$

$+ \epsilon_T/(1-\phi_1 B)$

Sows: $(Y_T-\mu) = w_0(Y^P{}_T - \mu^P) + \epsilon_T$

Steers: $(1-B)Y_T = (1-B)w_0 Y^P{}_T + (1-\theta_1 B)(1-\theta_3 B^3)\epsilon_T$

Notes : 1) $(1-B^n)Y_t = Y_t - Y_{t-n}$

2) The transfer function model form for the sows data frequently was used to model the barrows-gilts data.