United States
Department of
Agriculture

**Statistical
Reporting
Service**

**Statistical
Research
Division**

**SRS Staff Report
Number YRB-~~85-05~~ 85-14**

July 1985

A Comparison of Box-Jenkins Time Series Forecasts to Preliminary Milk Price Estimates

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A COMPARISON OF BOX-JENKINS TIME SERIES FORECASTS TO PRELIMINARY MILK PRICE ESTIMATES. By Ben Klugh, Jr. and John Markham, Statistical Reporting Service, U.S. Department of Agriculture, Washington, D.C. 20250, August 1985. Staff Report No. YRB-85-05.

ABSTRACT

Forecasts for 1979 through 1983 from Box-Jenkins time series models outperformed the preliminary milk price estimation procedure in five States and was competitive at the national level. One-month-ahead forecasts for the 60-month period possessed average absolute forecast errors of less than 1 percent. The model forecasts were closer to the final estimate or the same as the preliminary estimate 650 times out of 900 State forecasts. This modeling technique could be used to replace or supplement the current preliminary milk price estimation procedure.

ACKNOWLEDGMENTS The authors wish to thank Bob Battaglia for his many useful suggestions and Bessie Johnson for typing the paper.

Washington, D.C. 20250 August 1985

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INTRODUCTION

Box-Jenkins time series models are developed for all-, fluid-, and manufacturing-milk price estimates in five States and at the national level. One-month-ahead forecasts for these models produce forecast errors of less than 1 percent when compared with the final estimates. At the State level, time series forecasts outperformed current procedures.

This analysis was motivated for several reasons. First, the milk series was selected since it was known to behave in a cyclic pattern. Second, the preliminary price is already a type of forecast since only partial data are available. And finally, Brandt and Bressler (1983) applied some of the same techniques to livestock prices.

The data used in this analysis covered the period from 1935 through 1983 for all-milk and 1948 through 1983 for fluid- and manufacturing-milk. Data prior to 1979 were used to fit the models and forecasting performance was evaluated using the 1979 through 1983 data. States included in the analysis were California, Iowa, Pennsylvania, Tennessee, and Wisconsin.

METHODS

In this section, we will present an overview of the methods used to fit and test a time series model as well as the method used to evaluate forecast performance. No attempt will be made to present the theory of time series or justify the procedures. In fact some simplification of the actual model structure will be made to make the modeling concepts more understandable. Steps employed in developing a time series model are easy to apply and require only tenacity of the user and the ability to look at pictures and recognize patterns. In fact most series are fit using detective type techniques with a logical trial and error progression.

The three major stages we followed in model development were: 1) identifying the series, 2) verifying the fit of the identified series, and 3) evaluating the model.

In the identification stage, we used several pictorial tools to determine the appropriate model. In the verification stage, we used statistical criteria to decide how well the selected model fit the data. In the evaluation stage, we used data not employed to build the model to compare model forecasts with actual values. This final step produces a true test of how the model will perform. For this reason it is important when building the model to retain at least 1 year of data for the evaluation test. In our application, we retained 5 years of data from 1979 through 1983 for this purpose. Figures 1 and 2 of the appendix provide an example of the time series model in this paper. The series contained in the figures are the actual manufacturing milk series for the U.S. from 1970 to 1977 and the trend adjusted series for the same period.

The types of evaluation criteria used in this paper were suggested by Makridakis, et al. (1982) when they compared various heuristic and statistical approaches in the modeling of 1001 time series. These criteria include descriptive statistics computed from the forecasts as well as distributions for forecast errors. The descriptive statistics we considered were the average error, the average absolute error, the root mean square error, and the largest absolute error. The error distributions we examined were counts of forecast errors rounded to the nearest $0.10 and counts of differences between forecast procedures rounded to the nearest $0.10.

DEFINITIONS

In order to present the models, we define the following terms and provide examples related to the milk price series.

Time series: A sequence of periodic measurements observed at a constant time interval; e.g., monthly fluid milk price estimates.

Time series model: A model containing previous values of the series (differences or autoregressive terms) and/or errors from previous model forecasts (moving average terms).

Lag i: The i^{th} previous time period of the series—Lag 1 is the previous month. Lag 12 is the same month in the previous year.

Difference (d): The substracting of values in the series at two different lags. A first difference is subtracting the previous month series value from the current month value.

Autoregressive term (AR): A term in the model consisting of a model parameter times a previous realized value of the series.

Moving average term (MA): A term in the model consisting of a model parameter times a model forecast error for a previous period of the series.

Time series are often described using the following shorthand notation, (AR, d, MA), which describes the AR, MA, and d terms in the model. For example, a model with an AR term at lag 1 and a first difference is written (1,1,0). Sometimes a subscript is placed outside the parenthesis to indicate that several model terms within the parenthesis are calculated at that lag. For example, a difference and a moving average term at lag 12 is written $(0,1,1)_{12}$. The number of parenthesis notations used to describe a model is equal to the number of different differences applied.

For those more interested in the theory and development of time series models, the following references are listed in order of difficulty and length of presentation, with the first being the shortest and simplest: Montgomery and Johnson (1976), Nelson (1973), Pankrantz (1983), and Box and Jenkins (1976).

MODEL

Time series models were fit to three milk price series in five States and nationally. The all-milk series covered 1935 through 1978. The fluid and manufacturing series ran from 1948 through 1978. Two models were applied to all three series. Both models contained differences at lags 1 and 12 and moving average terms at lags 1 and 12. The second model also contained an autoregressive term at lag 2. In the notation of time series the first model would be represented as a $(0,1,1)(0,1,1)_{12}$ model and the second would be $(2,1,1)(0,1,1)_{12}$. Both models were fit to the entire series through 1978 and to a shorter series from 1973 through 1978. This was due to an unequal variance problem in the data. In linear regression, unequal variances increase the variability of the parameter estimates; but the estimated parameters are still unbiased. The same result appears to hold for a time series.

In the following analysis, model 1 is the $(0,1,1)(0,1,1)_{12}$ model developed from the short data series while model 2 is the same time series model developed from the long data series. Model 3 is the $(2,1,1)(0,1,1)_{12}$ model developed from the short data series and model 4 is the same time series model developed from the long data series. The representation for each model in terms of the forecast for the current time period value of series follows. The $(0,1,1)(0,1,1)_{12}$ model is written as:

$$\hat{y}_t = y_{t-1} + y_{t-12} - y_{t-13} - \beta\,(y_{t-1} - \hat{y}_{t-1}) - \gamma\,(y_{t-12} - \hat{y}_{t-12})$$
$$+ \beta\gamma\,(y_{t-13} - \hat{y}_{t-13})$$

where β and γ are model parameters

y_{t-i} = an actual value of the series for i time periods before the current time period, where i = 1, 12, and 13; and

$\hat{y}_{t-i}$ = a forecast from the model for i time periods before the current time period, where i = 0, 1, 12, and 13.

The $(2,1,1)(0,1,1)_{12}$ model is written as:

$$\hat{y}_t = y_{t-1} + (y_{t-12} - y_{t-13}) - \beta (y_{t-1} - \hat{y}_{t-1}) - \gamma (y_{t-12} - \hat{y}_{t-12})$$
$$+ \beta \gamma (y_{t-13} - \hat{y}_{t-13}) - \alpha_2 [(y_{t-2} - y_{t-3}) - (y_{t-14} - y_{t-15})]$$

where

α_2, β , and γ are model parameters and y_{t-i} and $\hat{y}_{t-i}$ are defined as before. More previous realized values of the series are used in this model.

The $(2, 1, 1) (0, 1, 1)_{12}$ model appears to be very complex. Yet, if we examined the model components, we will discover that the model is very simple and quite intiutive.

In building a forecast model to predict the current month milk price, the simplest model we might consider would use the previous month's price as our forecast, which is the first term of our complex model, (y_{t-1}). Our first improvement would be to add a forecast of the change in price from the previous month. We could calculate this change by subtracting the previous month's price from a year ago from the current month's price from a year ago. These are the second two terms of the model, $(y_{t-12} - y_{t-13})$. A second improvement would be to realize that forecasts we made in the past for the above three prices using this model were in error. A way to true up our model would be to weight these forecast errors in the current forecast. These errors are calculated in the three model terms, $(y_{t-1} - \hat{y}_{t-1}$, $y_{t-12} - \hat{y}_{t-12}$, and $y_{t-13} - \hat{y}_{t-13})$, and then multiplied by weighting constant r and β. Finally, we would want one term in the model to measure dramatic changes in the time series. The term $[(y_{t-2} - y_{t-3}) - (y_{t-14} - t_{t-15})]$ is included to do this. Normal changes of up to 5-percent in this time series are captured in the previous month's price and the forecast error for that price. Larger or abnormal changes are not detected as well. These larger changes persist for a longer duration so that a term is required with a longer historical look. The term included in this model compares the change between the second and third month of the current year to the second and third month of a year ago. If the time series is following its normal pattern with normal changes this term will be zero. If there is an abnormal shift in the series this term detects such a shift and corrects the forecast. An example,in figure 3 using the Wisconsin manufacturing milk price forecasting model to predict the price for October 1983,follows:

Figure 3: Actual prices and forecasts from the Wisconsin Manufacturing Milk Price Series required to calculate a forecast for October 1983.

	Current year				Previous Year			
	Date	Lag	Actual Price	Forecasted Price	Date	Lag	Actual Price	Forecasted Price
Current month	83/10	0	13.34		82/10	-12	13.29	13.41
Previous month	83/09	-1	13.01	12.93	82/09	-13	13.02	12.88
Two months ago	83/08	-2	12.65	12.71	82/08	-14	12.66	12.82
Three months ago	83/07	-3	12.61	12.67	82/07	-15	12.64	12.67

Record basic forecast model:

$$\hat{y}_t = y_{t-1} + (y_{t-12} - y_{t-13}) - \beta\,(y_{t-1} - \hat{y}_{t-1}) - \gamma\,(y_{t-12} - \hat{y}_{t-12})$$
$$+ \beta\gamma\,(y_{t-13} - \hat{y}_{t-13}) - \alpha_2\,[(y_{t-2} - y_{t-3}) - (y_{t-14} - y_{t-15})]\,.$$

Substitute year and month for the subscripts:

$$\hat{y}_{83/10} = y_{83/9} + (y_{82/10} - y_{82/9}) - \beta\,(y_{83/9} - \hat{y}_{83/9})$$
$$-\gamma\,(y_{82/10} - \hat{y}_{82/10}) + \beta\gamma\,(y_{82/9} - \hat{y}_{82/9})$$
$$- \alpha_2\,[(y_{83/8} - y_{83/7}) - (y_{82/8} - y_{82/7})]\,.$$

Substitute lag values for the year and month:

$$\hat{y}_0 = y_{-1} + (y_{-12} - y_{-13}) - \beta\,(y_{-1} - \hat{y}_{-1}) - \gamma\,(y_{-12} - \hat{y}_{-12})$$
$$+ \beta\gamma\,(y_{-13} - \hat{y}_{-13}) - \alpha_2\,[(y_{-2} - y_{-3}) - (y_{-14} - y_{-15})]\,.$$

Substitute previous data:

$$= 13.01 + (13.29 - 13.02) - \beta\,(13.01 - 12.93) - \gamma\,(13.29 - 13.41)$$
$$+ \beta\gamma\,(13.02 - 12.88) - \alpha_2\,[(12.65 - 12.61) - (12.66 - 12.64)]\,.$$

Given $\beta = (-.6713)$, $\gamma = (.7383)$, and $\alpha_2 = (.2038)$ now solve

$$= 13.01 + (.27) - (-.6713)(.08) - (.7383)(-.12) + (-.6713)(.7383)(.14)$$
$$- (.2038)\,[(.04) - (-.02)]$$
$$= 13.01 + .27 + .0537 + .0886 - .0694 - .0122$$
$$= 13.34.$$

The model forecasted the October price exactly.

RESULTS

Table 1a through table 1d contain the one-step-ahead forecast statistics for 1979 through 1983. Table 1a shows that all four models produce about the same result for each of the forecast statistics. Models 2 and 4, which were developed from the long data series, performed slightly better but there was not an appreciable difference between any of the models. The average absolute forecast error ranged from 0.6 percent to 1.2 percent for all models. The largest forecast errors were reasonable except for the Iowa manufacturing series. A forecast error of $1.00 occurred in Iowa in August of 1983. The official estimates for June, July, and August are $12.50, $12.90, and $12.30; respectively. Normally the June and July values are very close to each other with July slightly lower or within $0.10 of June. August again is normally within $0.10 of July. This pattern was followed in 20 of the 24 published States from June to July and in 23 of the 24 published States from July to August. The four models did not predict the Iowa result well. We contacted the Iowa SSO to see if statisticians there could explain this large irregularity. They examined their July data and discovered a possible reporting error that would change the July final estimate from $12.90 to $12.40. Using this new figure, we found the model forecast errors for July and August were $0.03 and $0.03, respectively. The statistics in table 1a were revised to included this new result.

TABLE 1A--FORECAST STATISTICS FROM FOUR MILK PRICE
TIME SERIES MODELS BASED ON 1979-83 DATA

MODEL TYPE	STATE	AVERAGE ERROR 1	2	3	4	ROOT MEAN SQUARE ERROR 1	2	3	4	AVE MILK PRICE
		CENTS PER CWT								$/CWT
FLUID	CALIF	-1.9	-1.5	-2.2	-1.6	13.3	13.0	13.8	13.0	12.84
	IOWA	-2.6	-2.7	-1.7	-2.2	12.7	12.4	12.2	12.0	13.02
	PENN	-2.4	-2.6	-2.1	-2.3	16.8	15.8	17.5	16.4	13.72
	TENN	-2.9	-2.1	-2.3	-1.8	19.4	18.1	19.3	17.9	13.60
	WISC	-2.9	-2.9	-1.9	-2.1	9.9	9.9	9.4	9.5	12.99
	U.S.	-2.2	-2.1	-1.7	-1.6	12.3	11.1	11.6	10.4	13.36
MFG	CALIF	-2.5	-2.4	-2.3	-2.0	17.2	17.1	17.3	17.4	11.94
	IOWA	-1.6	-2.4	-1.3	-1.9	12.7	12.6	13.8	12.6	12.39
	PENN	-3.6	-3.9	-3.8	-3.7	18.4	16.8	18.3	16.8	12.16
	TENN	-2.2	-2.4	-1.9	-2.0	11.8	11.0	11.7	11.0	11.55
	WISC	-2.4	-2.8	-1.7	-2.3	10.3	10.3	10.4	10.3	12.58
	U.S.	-1.9	-2.3	-1.2	-1.8	9.6	9.6	9.5	9.5	12.23
ALL	CALIF	-2.0	-.8	-1.8	-.7	13.3	12.7	13.5	12.8	12.81
	IOWA	-2.3	-2.3	-1.6	-1.8	14.4	13.5	14.6	13.7	12.78
	PENN	-2.3	-2.5	-2.0	-2.3	17.1	16.4	17.6	16.9	13.72
	TENN	-2.8	-2.1	-2.4	-1.8	18.6	17.2	18.0	17.0	13.36
	WISC	-2.7	-2.5	-1.8	-1.8	9.8	9.9	9.5	9.5	12.87
	U.S.	-2.0	-1.8	-1.4	-1.3	10.7	10.7	10.6	10.5	13.20

MODEL TYPE	STATE	AVERAGE ABSOLUTE ERROR 1	2	3	4	LARGEST ERROR 1	2	3	4	RANGE MILK PRICE
FLUID	CALIF	9.6	9.2	10.5	9.3	36.1	33.9	37.2	34.9	2.97
	IOWA	10.0	9.8	9.8	9.6	37.3	35.1	36.6	35.5	2.60
	PENN	12.7	11.9	13.6	12.7	46.8	39.8	46.4	40.2	2.80
	TENN	15.3	14.2	15.5	14.3	51.6	53.8	48.7	53.6	2.90
	WISC	7.7	7.7	7.3	7.4	36.3	36.3	32.4	33.7	2.30
	U.S.	9.8	8.9	9.3	8.4	25.9	25.9	26.4	26.3	2.70
MFG	CALIF	12.1	12.1	12.1	12.4	69.9	68.2	71.6	72.1	3.12
	IOWA	10.9	10.6	11.0	9.6	43.0	43.2	42.5	43.8	2.60
	PENN	14.7	13.7	14.7	13.7	45.8	44.1	46.8	42.5	2.10
	TENN	9.7	9.1	9.5	8.9	27.2	24.4	27.4	24.5	2.30
	WISC	7.3	7.1	7.3	7.1	45.5	44.5	45.3	44.1	2.38
	U.S.	7.5	7.3	7.5	7.4	31.3	30.9	31.7	31.1	2.30
ALL	CALIF	9.6	9.4	10.0	9.4	41.0	35.3	41.0	35.4	2.94
	IOWA	11.3	10.4	11.1	10.4	40.7	40.7	42.8	41.7	2.60
	PENN	12.9	12.3	13.5	12.9	50.2	45.9	50.1	45.2	2.80
	TENN	15.0	13.6	14.7	13.8	48.4	46.0	44.9	45.1	2.90
	WISC	7.7	7.8	7.4	7.4	39.3	39.4	36.9	37.5	2.33
	U.S.	8.8	8.8	8.8	8.7	24.7	25.2	24.6	24.3	2.60

Table 1b compares model forecasts to the final estimates using a counting procedure. In the estimating program, milk prices are rounded to the nearest $0.10. To obtain a true understanding of how the models performed, each forecast was rounded to the nearest $0.10. Next, the difference between the forecast and the final estimate was calculated and the absolute value determined. Finally, a count of differences was made for the categories $0.00, $0.10, $0.20, $0.30, and $0.40 or more. These tabulations are presented in table 1b. Model 4 developed from the long data series produces slightly better forecasts and is not as likely to generate a forecast with an error of $0.30 or more.

TABLE 1B—COUNTS OF FORECAST ERRORS, 1979-83, ROUNDED TO THE NEAREST $0.10 PER CWT, FOR THE FOUR TIME SERIES MODELS

MODEL TYPE	MODEL #	0	.10	.20	.30	.40
	1	122	143	61	23	11
FLUID	2	120	151	58	24	7
	3	108	160	52	31	9
	4	113	161	58	19	9
	1	111	155	60	24	10
MFG	2	117	163	56	14	10
	3	113	150	65	23	9
	4	120	161	55	15	9
	1	112	156	59	20	13
ALL	2	117	156	55	24	8
	3	115	149	66	18	12
	4	121	150	61	20	8
	1	345	454	180	67	34
SUMMARY	2	354	470	169	62	25
	3	336	459	183	72	30
	4	354	472	174	54	26

Table 1c compares model forecasts and the preliminary estimate to the final estimate. For each of the two early estimate procedures, a forecast error to the nearest $0.10 was obtained, as was calculated for table 1b. Next the error from the preliminary estimate was subtracted from the error for each model forecast. If the result was negative, the the model forecast was closer to the final estimate by that amount. If the result was zero, then both early estimates were the same. And, if the result was positive, then the preliminary estimate was closer. The results are contained in table 1c by model for each series and accumulated by model across series. These results suggest that the modeling procedure produces estimates closer to the final estimate more often than the preliminary estimate method. Furthermore model 4 is again slightly better with 338 forecasts closer to the final estimate, 314 the same, and 248 worse than the preliminary estimate.

TABLE 1C—COUNT COMPARISONS BETWEEN ABSOLUTE FORECAST ERRORS FROM MODELS AND THE PRELIMINARY PRICE ESTIMATES, 1979-83

MODEL TYPE	MODEL #	MODEL FORECAST CLOSER TO FINAL ESTIMATE	MODEL FORECAST AND PRELIMINARY ESTIMATE THE SAME	PRELIMINARY PRICE CLOSER TO FINAL ESTIMATE
	1	111	108	81
FLUID	2	114	103	83
	3	104	115	81
	4	119	104	77
	1	94	105	101
MFG	2	100	107	93
	3	96	103	101
	4	106	99	95
	1	104	111	85
ALL	2	113	100	87
	3	105	111	84
	4	113	111	76
	1	309	324	267
SUMMARY	2	327	310	263
	3	305	329	266
	4	338	314	248

In Wisconsin estimates are made to the nearest penny. Therefore, we can examine forecast statistics to determine which model performs better. The results for Wisconsin are contained in table 1d. Each model possesses a smaller average absolute error and root mean square error than the preliminary estimate for fluid and all milk. Each model competes well with the manufacturing preliminary estimate. The largest errors from the model exceed the largest errors from the preliminary estimate, which would suggest that more model values will be closer to the final estimate since the average absolute error and the RMSE are smaller. Models 2, 3, and 4 are better for different statistics. Model 4 was selected for further analysis.

TABLE 1D--FORECAST ERROR STATISTICS FOR WISCONSIN, FOUR TIME SERIES MODELS AND PRELIMINARY ESTIMATES, 1979-83

MODEL TYPE	AVERAGE ERROR					ROOT MEAN SQUARE ERROR				
	1	2	3	4	PRELIM	1	2	3	4	PRELIM
					CENTS PER CWT					
FLUID	-2.9	-2.9	-1.9	-2.1	-2.6	9.9	9.9	9.4	9.5	10.4
MFG	-2.4	-2.8	-1.7	-2.3	1.3	10.3	10.3	10.4	10.3	10.3
ALL	-2.7	-2.5	-1.8	-1.8	-1.2	9.8	9.9	9.4	9.5	10.0

MODEL TYPE	AVERAGE ABSOLUTE ERROR					LARGEST ERROR				
	1	2	3	4	PRELIM	1	2	3	4	PRELIM
FLUID	7.7	7.7	7.3	7.4	8.6	36.0	36.0	32.0	34.0	23.0
MFG	7.3	7.1	7.3	7.1	7.3	46.0	44.0	45.0	44.0	29.0
ALL	7.7	7.8	7.4	7.4	7.9	39.0	39.0	37.0	37.0	23.0

Tables 2a to 2d in the appendix contain more detailed comparisons between the preliminary estimate and the forecasts from model 4. Tables 2a and 2b are similar to tables 1b and 1c in that forecast performance is summarized the same way. Each table provides a more detailed breakdown by State and price series. From table 2a, we can see that the model performs better at the State than at the national level. From table 2b, we see that the model does in fact forecast some large price changes better than our current procedure at the State level, but performance at the national level is not as good.

Tables 2c and 2d are summaries of the State forecasts only. Again the same type of computations found in tables 1b and 1c are made. The purpose of these tables is to discover when during the year the model may perform better than the current preliminary price procedure. From table 2c, we observe that the model is weaker for the manufacturing series than for the all-milk or the fluid series. No pattern leaps out to suggest when to use the model verses the current procedure. Several interesting results can be seen in that the preliminary price for fluid milk is weakest in July and November, while the model is weaker in August and December. Table 2d is also interesting; but, again, no consistent pattern can be determined. The model did quite well for the all series in April and November but a pattern across series could not be detected.

Finally, a $(2,1,1)(0,1,1)_{12}$ time series model was fit to data from 1973 to 1983 and year-ahead forecasts made for these data. The results of these forecasts are contained in table 3 of the appendix. The purpose of this exercise was to demonstrate that the time series contains significant structure valuable to forecasting. The results are mixed at the State level and would probably be most consistent for the U.S. models. At the U.S. level, the results are quite good for the fluid and all series. The average absolute forecast error is $0.12 for each series with RMSE's of 0.16 and 0.17 respectively. In fact 16 of the 24 forecasts are within $0.10 of the final estimate value. The manufacturing results are not as good. Errors run between $0.20 and $0.30 for all periods up to September, when errors increase to $0.40 and $0.50. This result is not as discouraging as it would seem. In the fall of the year, some milk plants paid their customers a premium. They paid the premium on manufacturing milk and the amount of the premium was about $0.30. If this amount is subtracted from the year-ahead forecasts for the fall, then the modeled error returns to the range for the earlier months. The other result that can be observed from this table is that the forecast from the model stays close to the final value in the early months then drifts away. Without previous month data to true up the forecast, the model has a difficult time adjusting to level changes. However the model does seem to work reasonably well for forecasts up to 3 months ahead.

CONCLUSIONS

Box-Jenkins time series models developed for the all-, fluid-, and manufacturing-milk price series outperformed the preliminary milk price estimation procedure in five States and was competitive at the national level. The best performing time series model was developed from the long data series and contained differences at lags 1 and 12, moving average terms at lags 1 and 12, and an autoregressive term at lag 2. Reasonable State and national forecasts could be produced for up to 3 months ahead.

RECOMMENDATIONS

We recommend that this modeling technique be used to replace or supplement the current preliminary milk price estimation procedures for these three estimates at the State level. We also recommend that these same techniques be applied to other preliminary series to see if similar results are possible.

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Figure 1: U.S. Manufacturing Milk Price Series
from January 1970 to December 1977
Raw data in dollars

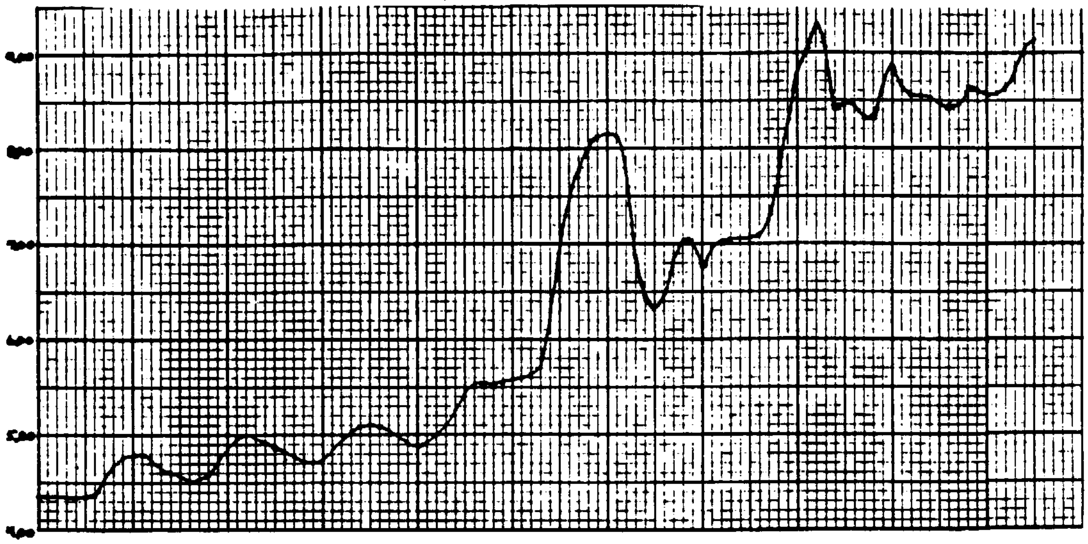

Figure 2: U.S. Manufacturing Milk Price Series
from January 1970 to December 1977
Adjusted for trend in cents

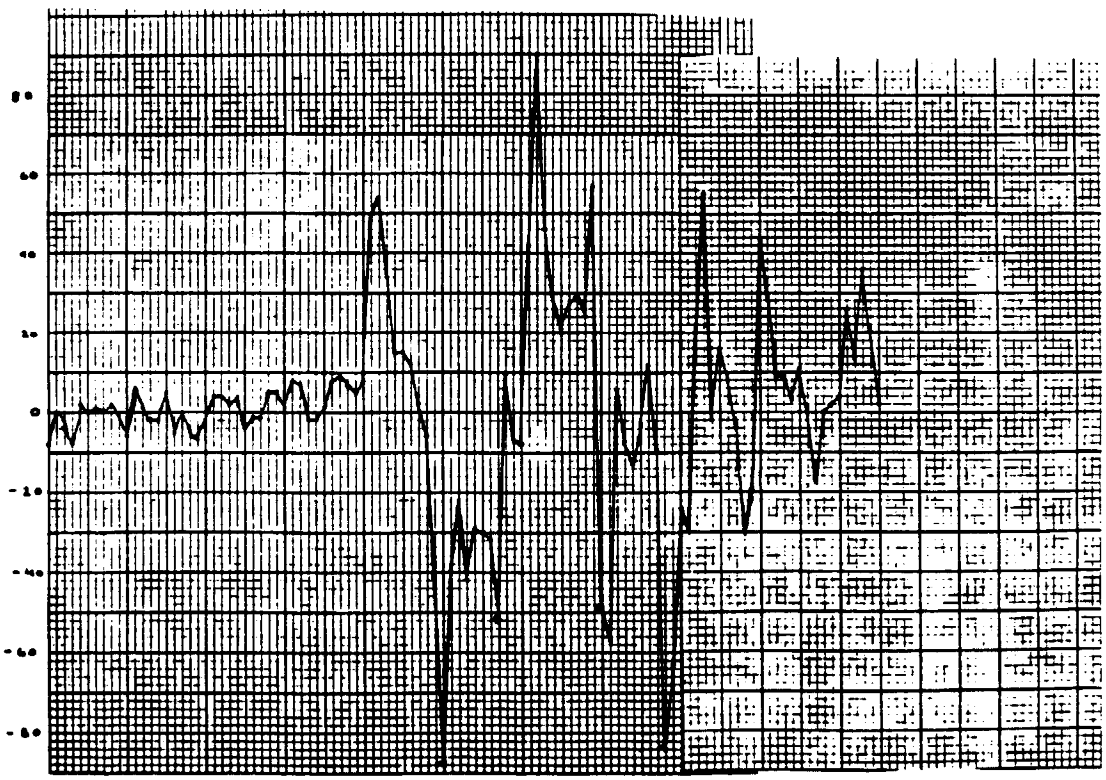

TABLE 2A--COUNTS OF ABSOLUTE ERROR DIFFERENCES, ROUNDED TO THE NEAREST $0.10 PER CWT, PRELIMINARY ESTIMATE AND MODEL 4 FORECAST, BY STATE, FOR MILK PRICE SERIES 1979-83

STATE	TYPE	PRELIMINARY ESTIMATE					MODEL 4 FORECAST				
		0	10	20	30	40	0	10	20	30	40
	FLUID	10	25	10	11	4	26	19	8	6	1
CALIF	MFG	18	12	14	11	5	17	21	15	5	2
	ALL	9	21	18	8	4	24	23	8	4	1
	FLUID	17	21	12	7	3	16	36	5	2	1
IOWA	MFG	19	24	12	2	3	18	31	5	2	4
	ALL	16	23	16	3	2	20	24	12	2	2
	FLUID	13	25	11	6	5	15	25	11	7	2
PA	MFG	21	11	15	7	6	12	26	14	6	2
	ALL	13	25	11	6	5	19	19	12	8	2
	FLUID	14	28	11	3	4	16	16	21	3	4
TENN	MFG	18	30	10	2	0	22	25	13	0	0
	ALL	17	23	13	4	3	13	23	16	6	2
	FLUID	20	29	10	1	0	22	34	3	0	1
WISC	MFG	34	17	7	2	0	24	31	3	1	1
	ALL	22	28	9	1	0	27	28	4	0	1
TOTAL		261	342	180	74	44	291	381	150	52	26
	FLUID	34	24	1	0	1	18	31	10	1	0
U S	MFG	33	25	2	0	0	27	27	5	1	0
	ALL	36	23	1	0	0	18	33	9	0	0
TOTAL		103	72	4	0	0	63	91	24	2	0

TABLE 2B--COMPARISON OF ABSOLUTE ERROR DIFFERENCES, ROUNDED TO THE NEAREST $0.10 PER CWT, BETWEEN MODEL 4 FORECASTS AND PRELIMINARY ESTIMATE, BY STATE, FOR MILK PRICE SERIES 1979-83

STATE	TYPE	-40	-30	-20	-10	0	10	20	30	40	TOTAL
	FLUID	2	4	10	18	13	8	2	3	0	60
CALIF	MFG	0	4	16	11	9	10	6	2	2	60
	ALL	2	2	14	18	12	7	4	1	0	60
	FLUID	0	0	6	25	17	11	0	0	0	60
IOWA	MFG	0	2	2	15	24	14	1	2	0	60
	ALL	0	1	4	18	20	15	2	0	0	60
	FLUID	0	3	3	16	20	15	2	1	0	60
PA	MFG	0	1	9	12	17	16	4	1	0	60
	ALL	1	1	5	15	21	13	3	1	0	60
	FLUID	0	0	4	14	17	20	5	0	0	60
TENN	MFG	0	0	2	17	26	14	1	0	0	60
	ALL	0	0	3	12	24	16	5	0	0	60
	FLUID	0	0	4	10	37	8	1	0	0	60
WISC	MFG	0	1	1	13	23	20	1	1	0	60
	ALL	0	0	3	14	34	7	2	0	0	60
TOTAL		5	19	86	228	314	184	39	12	3	900
	FLUID	1	0	0	5	25	26	2	1	0	60
U S	MFG	0	0	1	8	34	14	2	1	0	60
	ALL	0	0	0	7	21	31	1	0	0	60
TOTAL		1	0	1	20	80	71	5	2	0	180

TABLE 2C—COUNTS OF ABSOLUTE ERROR DIFFERENCES, ROUNDED TO THE NEAREST $0.10 PER CWT, PRELIMINARY ESTIMATE AND MODEL 4 FORECAST, BY MONTH, FOR MILK PRICE SERIES 1979-83

TYPE	MONTH	PRELIMINARY ESTIMATE					MODEL 4 FORECAST				
		0	10	20	30	40	0	10	20	30	40
FLUID	1	9	10	4	2	0	11	10	1	2	1
	2	9	9	4	1	2	5	16	3	1	0
	3	4	14	2	5	0	14	10	1	0	0
	4	7	5	8	1	4	11	7	5	2	0
	5	6	10	4	5	0	7	9	5	2	2
	6	5	17	2	1	0	7	13	5	0	0
	7	4	18	3	0	0	9	11	3	2	0
	8	10	18	4	2	1	4	12	5	2	2
	9	2	14	6	1	2	9	9	6	1	0
	10	7	9	6	3	0	5	9	9	1	1
	11	5	10	7	2	1	9	11	2	2	1
	12	8	3	4	4	6	4	13	3	3	2
MANUFACTURING	1	8	13	2	1	1	7	10	6	1	1
	2	10	8	3	3	1	7	13	3	2	0
	3	10	6	4	3	2	9	9	6	1	0
	4	8	8	7	1	1	6	12	3	3	1
	5	10	2	10	1	2	7	12	5	1	0
	6	10	9	4	2	0	7	15	3	0	0
	7	12	7	3	2	1	6	17	1	0	1
	8	10	6	7	2	0	11	9	4	0	1
	9	6	10	4	2	3	10	11	1	2	1
	10	5	12	4	3	1	7	10	6	2	0
	11	11	7	4	2	1	9	7	8	0	1
	12	10	6	5	3	1	7	9	4	2	3
ALL	1	8	10	5	2	0	11	9	1	3	1
	2	7	11	4	1	2	10	11	2	2	0
	3	8	10	4	3	0	10	13	2	0	0
	4	8	6	7	2	2	13	6	6	0	0
	5	7	8	9	1	0	8	8	6	1	2
	6	7	13	4	1	0	7	14	2	2	0
	7	6	15	4	0	0	9	10	4	2	0
	8	11	6	5	2	1	7	6	8	2	2
	9	3	10	9	1	2	8	7	7	2	1
	10	4	11	7	3	0	3	12	8	2	0
	11	2	15	5	2	1	11	9	4	1	0
	12	9	3	4	3	6	6	12	2	3	2

TABLE 2D—COMPARISON OF ABSOLUTE ERROR DIFFERENCES, ROUNDED TO THE NEAREST $0.10 PER CWT, BETWEEN MODEL 4 FORECASTS AND PRELIMINARY ESTIMATE, BY MONTH, MILK PRICE SERIES 1979-83

TYPE	MONTH	-40	-30	-20	-10	0	10	20	30	40
FLUID	1	0	0	1	5	14	5	0	0	0
	2	0	1	2	7	5	9	1	0	0
	3	0	3	3	8	9	2	0	0	0
	4	1	0	4	9	7	4	0	0	0
	5	0	0	3	7	7	5	2	0	1
	6	0	0	1	5	13	6	0	0	0
	7	0	0	0	8	12	4	0	1	0
	8	0	0	0	6	8	7	3	1	0
	9	0	1	3	8	9	4	0	0	0
	10	0	1	1	4	11	5	1	2	0
	11	0	0	4	9	5	6	1	0	0
	12	1	1	4	6	5	6	2	0	0
MANUFACTURING	1	0	0	0	6	9	9	1	0	0
	2	0	1	4	3	7	9	0	1	0
	3	0	1	2	8	7	6	1	0	0
	4	0	0	1	6	12	4	1	0	1
	5	0	0	4	8	6	6	1	0	0
	6	0	3	5	9	7	1	0	0	0
	7	0	1	2	3	9	10	0	0	0
	8	0	1	3	3	12	5	1	0	0
	9	0	2	2	7	12	1	0	1	0
	10	0	0	5	4	9	6	0	1	0
	11	0	2	2	5	6	5	4	0	1
	12	0	0	4	6	4	5	3	3	0
ALL	1	0	0	0	6	15	4	0	0	0
	2	1	0	3	5	11	4	1	0	0
	3	0	0	4	7	9	5	0	0	0
	4	1	1	2	8	11	1	1	0	0
	5	0	0	3	5	8	5	4	0	0
	6	0	0	2	5	11	5	2	0	0
	7	0	0	1	7	9	7	0	1	0
	8	0	1	1	3	6	10	4	0	0
	9	0	1	3	6	9	5	1	0	0
	10	0	0	2	7	8	6	1	1	0
	11	0	1	2	10	10	2	0	0	0
	12	1	0	5	6	5	7	1	0	0