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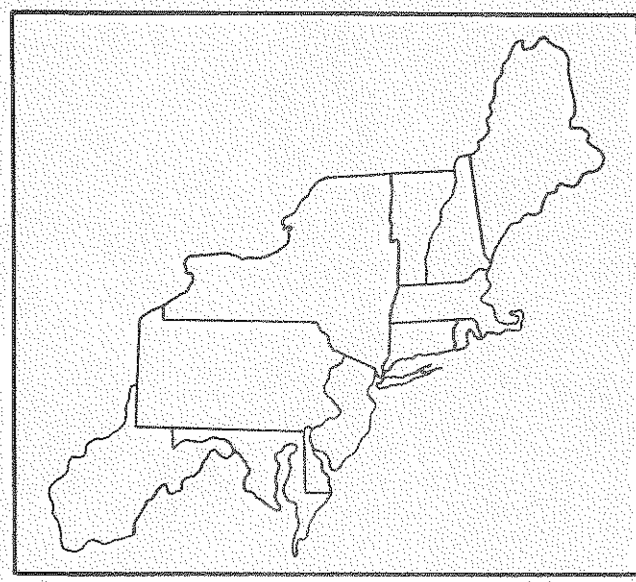

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AN ECONOMETRIC MODEL OF MILK PRODUCTION IN MAINE

by

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The dairy industry is a very important component of the agricultural sector in Maine and in the Northeast. In 1980 milk sales ranked first or second in terms of gross producer cash receipts in every state in the Northeast (USDA, 1981). Gross producer receipts for milk produced in Maine equaled roughly 105.1 million dollars in 1982.** Recent U.S. government surpluses of manufactured dairy products prompted Congress to legislate two fifty-cent milk price deductions. The first of these milk price deductions went into effect April 16, 1983 and the second October 1, 1983. The purpose of this study is to estimate an econometric model of Maine milk production and to use this model to analyze the effect of the recent price deductions on Maine milk production.

THE MILK PRODUCTION MODEL

Econometric milk production or supply models often model milk supply as the product of number of cows and milk per cow (Masud and Elterich, Milligan and Novakovic, among others). This separation allows for the modeling of two distinct decisions being made by the producers; the first being what number of cows to have, and the second being what level of milk production to have per cow. The decision of number of cows is more of a long-run decision while the decision of milk per cow is more of a short-run decision.

Quarterly data from 1966 through 1982 were used in estimating the model. The bulk of the data came from Metzger. The updating required to bring the data through 1982 came from USDA, 1982a; Zucchi, 1983; and USDA, 1982-83.

Average Maine milk blend prices were not available for 1982 at the time of analysis and were estimated. The average Maine blend price is a weighted average of the average Federal Order 1 blend price for milk going to Boston and the average Maine blend price for milk staying in Maine. The Maine blend price is based on the Boston Class I and Class II prices. Since a large share of Maine produced milk goes to the Boston market and since the Maine blend price is tied to the Boston price, the two move in the same pattern as the Boston blend price. The Boston blend price was available for 1982 and was used to estimate the weighted average Maine blend price. This was done by adjusting upward the 1982 Boston blend prices by a percentage equal to recent experiences. It was felt that estimating the 1982 weighted average Maine blend price was

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** It should be noted that this dollar figure is a rough estimate. It is arrived at by multiplying the 1982 total Maine milk production of 7,320,000 cwt. (USDA, 1983a, p. 19) by the estimated 1982 average Maine milk price of $14.24/cwt. This average price was determined as a quantity weighted average price of Maine milk zoning out of Maine to the Boston market ($13.62) and the average price of Maine milk staying in Maine ($15.00).

appropriate since (1) the relationship between the weighted average Maine blend price and the Boston blend price has been extremely stable over time, and (2) the inclusion of one estimated variable was judged to be a better alternative than dropping the 1982 observation entirely.

The Number of Cows Equation

The number of dairy cows in Maine in a given quarter ($NCOW_t$) was estimated to be a function of:

1. $NCOW_{t-1}$, thousands of cows in the previous quarter;

2. $MFPRATIO_{t-5}$ - $MFPRATIO_{t-12}$, the milk feed price ratio for the fifth through twelfth lagged quarters; and,

3. $PSTEER_t$, the \$/cwt. price of steers.

As is fairly common with milk supply models, a distributed lag function was used in the number of dairy cows equation. The distributed lag is employed as there is a substantial time lag between the decision to expand a herd size and when the new cows come into production. It is hypothesized that the herd size in a given quarter is partially based on relative prices in several previous quarters. In this study the prices included in the distributed lag were represented by the milk/feed price ratio. While the prices of the output and inputs could have been used separately in distributed lag functions, it was decided that using the ratio was the best option. Using the price of milk divided by the price of feed is a method of deflating the milk price where the deflator, the feed price, is a major cost component of milk production. Deflating the milk price was considered imperative because of the price changes due primarily to inflation. Examination of the data reveals that prior to 1973 the Maine blend price was consistently below \$8.00/cwt. (Metzger, p.29). By 1976 the blend price had jumped to roughly \$10.84/cwt., and while some of this movement was due to changes in supply and demand conditions, there is little doubt that a large part of this movement was due to general inflation. The blend price changes which were due primarily to inflation by far overshadow any price movements reflecting supply and demand changes. In order to exclude the general price movements from movements in the blend price the blend prices were deflated with the feed price.

The Almon distributed lag was employed due to its ease of employment and its flexible nature. In the Almon distributed lag the parameter estimates are approximated by a polynomial. In this study the parameters which are being approximated represent the effect on total Maine herd size ($NCOW_t$) of the milk/feed price ratio in previous quarters. Once a lag interval and the degree of polynomial have been specified the Almon distributed lag technique yields estimates of the effect on herd size of the milk/feed price ratio in previous quarters.

The lag interval used in the number of dairy cows equations was the fifth through twelfth quarters. Although other studies (Masud and Elterich, Milligan and Novakovic) have included the first through the fourth lagged quarters attempts at including the lagged milk/feed price ratio for these quarters were unsuccessful. The exclusion of the first through fourth quarter lagged milk/feed price ratio implies that the number of cows in a given quarter is not a function of prices in the past year. Buxton in some preliminary milk supply equations found a similar lack of responsiveness to the most recent year lagged prices for many states (Buxton).

A second degree polynomial was used for the estimation of the lag structure. In order to explain the Almon distributed lag technique let the number of cows equation be represented in general form as:

$$(1)\quad NCOW_t = b_5MF_{t-5} + b_6MF_{t-6} + b_7MF_{t-7} + b_8MF_{t-8} + b_9MF_{t-9} + b_{10}MF_{t-10} + b_{11}MF_{t-11} + b_{12}MF_{t-12} + Z_t$$

where:

$NCOW_t$ = thousands of dairy cows in Maine in a given quarter,

$b_5, b_6, \ldots b_{12}$ = the parameters associated with the fifth through twelfth lagged milk/feed price ratio, respectively,

$MF_{t-5}, MF_{t-6}, \ldots MF_{t-12}$ = the fifth through twelfth lagged milk/feed price ratio, respectively.

Z_t = the effect of all other explanatory factors and the error term.

The Almon distributed lag approximates the parameters (b's) with the following:

$$b_5 = a_0(0)^0 + a_1(0)^1 + a_2(0)^2$$
$$b_6 = a_0(1)^0 + a_1(1)^1 + a_2(1)^2$$
$$b_7 = a_0(2)^0 + a_1(2)^1 + a_2(2)^2$$
$$\vdots$$
$$b_{12} = a_0(7)^0 + a_1(7)^1 + a_2(7)^2$$

where: a_0, a_1, a_2 are unknown constant parameters.

By performing the exponential operation for all b's and collecting terms and substituting for the b's, the number of dairy cows equations becomes:*

$$(2)\quad NCOW_t = a_0 \sum_{j=5}^{12} MF_{t-j} + a_1 \sum_{j=6}^{12} MF_{t-j} + a_2 \sum_{j=6}^{12} MF_{t-j} + Z_t.$$

Note that the use of the Almon distributed lag scheme has reduced the number of parameters which require direct econometric estimation. Instead of having to estimate $b_5, \ldots, b_{12}$ the Almon scheme requires the direct estimation of a_0, a_1, a_2. Considering the usual high degree of correlation between lagged prices this aspect of the Almon scheme is important with respect to multicollinearity. In the Almon scheme the first summation variable is the constant effect of the various lagged milk/feed price ratios, the second summation variable is the linear effect and the third summation is the quadratic

* For a more lengthy and detailed discussion and explanation of the Almon distributed lag see: Intriligator, pp. 182-83, and Koutsoyiannis, pp. 299-304.

portion. (For tractability, the other explanatory variables ($NCOW_{t-1}$ and $PSTEER_t$) and their parameters as well as the intercept and error term were included in Z_t in the above equation.)

The number of cows in the previous quarter was included to represent the effect on the current herd size of the previous quarter's herd size. Dairying is not an agricultural enterprise which one can enter into or withdraw from very quickly. Similarly for the entire state, net expansions or contractions are tied to the past herd size. The number of dairy cows in Maine in a given quarter is very much affected by the number of cows in the previous quarter.*

The current price of steers was included in the number of cows equation as a proxy for the cull milk price. As the price of cull cows goes up, ceteris paribus, one would expected that more cows would be culled. Other explanatory variables, such as the price of hay and the farm wage rate, were originally included in the number of cows equation but were omitted due to poor statistical fit or improper sign.

The number of dairy cows equation which was estimated with ordinary least squares is as follows;

$$(3)\quad NCOW_t = \underset{(2.93)}{19.608} + \underset{(5.15)}{.6133}NCOW_{t-1} - \underset{(-.03)}{.0182}\sum_{j=5}^{12} MF_{t-j} + \underset{(.28)}{.1310}\sum_{j=6}^{12} MF_{t-j}$$

$$- \underset{(-.10)}{.0068}\sum_{t=6}^{12} MF_{t-j} - \underset{(-2.18)}{.0282}PSTEER_t + e_t$$

$F = 36.81 \qquad DW = 1.909$

$R^2 = .844 \qquad Dh = .38$

$NCOW_t$ mean = 58.25 thousand cows

Sy = 1.57 thousand cows

where:

$NCOW_t$ = thousands of dairy cows in Maine;

MF_{t-j} = the milk/feed price ratio in the t-j quarters;

$PSTEER_t$ = the \$/cwt. price of steers;

F = the F-statistic;

R^2 = the multiple coefficient of determination;

DW = the Durbin-Watson statistic;

e_t = the random disturbance term associated with the equation. The error term is assumed to be identically and independently distributed with a normal distribution;

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* The herd size is a type of capital stock. By employing the stock adjustment model one obtains a herd size equation which includes a one period lagged endogenous variable (Intriligator, p.181).

Sy = the standard deviation of the dependent variable;

Sy.x = the standard error of estimate; and,

Dh = the Durbin-h statistic.

The t-statistics for all directly estimated parameters are in parenthesis below their respective estimated parameters. The t-statistics for the estimates of a_0, a_1, and a_2 are quite low. These t-statistics are not, however, the t-statistics associated with the lagged milk/feed price ratios. In order to test the null hypothesis that the parameters associated with the lagged milk/feed price ratios are equal to zero using the t-statistic, the estimated parameters and their standard errors must be calculated. The parameter estimates and their standard errors must be calculated. The parameter estimates and their standard errors can be calculated from the Almon scheme. According to the Almon distributed lag scheme as specified for this problem the parameter associated with each lagged value is the sum of three components. Consider the parameter associated with MF_{t-10}, that is, b_{10} which equals:

(4) $$b_{10} = a_0(5)^0 + a_1(5)^1 + a_2(5)^2$$

By substituting the estimates of $\hat{a}_0$, a_1, and a_2 into (4) one can determine the estimate of b_{10} designated as $\hat{b}_{10}$:

(5) $$\hat{b}_{10} = -.0182(1) + .1310(5) - .0068(25) = .4669$$

The t-statistic when testing the null hypothesis that b_j equals zero is:

(6) $$t = \hat{b}_j \,/\, \hat{s}_{b_j}$$

where: $\hat{b}_j$ is the parameter estimate for the MF_{t-j} and,

$\hat{s}_{b_j}$ is the standard error of the MF_{t-j} parameter estimate

The individual parameters associated with $MF_{t-5},\ldots,MF_{t-12}$, can be estimated as in (5). In order to calculate the t-statistics for $\hat{b}_5,\ldots,b_{12}$ their associated standard errors $(s_{b_5},\ldots,s_{b_{12}})$ must be calculated.

Each of the $b_5,\ldots,b_{12}$ are linear combinations of a_0, a_1, a_2. The variances of the $b_5,\ldots,b_{12}$ are thus dependent on the variances and covariances of a_0, a_1, a_2. More specifically if:

(7) $$Y = \sum_{i=1}^{n} C_i X_i$$

then the variance of Y equals:*

(8) $$\text{Var } Y = \sum_{i=1}^{n} C_i^2 \text{ var } X_i + 2 \sum_i^n \sum_j^n C_i C_j \text{ var-covar } X_i X_j$$

Consider for example b_{10}. Its estimated variance is:

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* For a proof of this see Freund and Walpole, p. 157.

(9) $\hat{s}^2_{b_{10}} = 1^2(\text{var } a_0) + 5^2(\text{var } a_1) + 25^2(\text{var } a_2) +$

$2[1(5)\text{var-covar } a_0a_1 + 1(25)\text{var-covar } a_0a_2 + 5(25)\text{var-covar } a_1a_2]$

Substituting the variances and covariances of a_0, a_1, a_2 (Table 1) into (9) yields a $\hat{s}^2_{b_{10}}$ of .0705.

TABLE 1. The Estimated Variance-Covariance Matrix for $\hat{a}_0$, $\hat{a}_1$, and $\hat{a}_2$.

	$\hat{a}_0$	$\hat{a}_1$	$\hat{a}_2$
$\hat{a}_0$	.3618	-.2464	.0302
$\hat{a}_1$	-.2464	.2156	-.0297
$\hat{a}_2$	.0302	-.0297	.0043

The square root of $\hat{s}^2_{b_{10}}$ equals .2657 which is the standard error of b_{10}, $(\hat{s}_{b_{10}})$. By dividing $\hat{b}_{10}$ by $\hat{s}_{b_{10}}$ one obtains the t-statistic for testing the null hypothesis that b_{10} equals zero. The t-statistic for b_{10} equals 1.758 which is significant at the 5 percent level. Table 2 lists the derived estimated coefficients of $MF_{t-5},\ldots,MF_{t-12}$, $(\hat{b}_5,\ldots,\hat{b}_{12})$ and their associated t-statistics. The derived parameter estimates for $MF_{t-5},\ldots,MF_{t-12}$ and their associated t-statistics were judged as satisfactory. While several of the t-statistics are below one the general Almon pattern is in agreement with a priori expectations of a positive or near zero constant Almon variable coefficient (a_0 equal to -.0182), a positive linear Almon variable coefficient (a_1 equal to .1310), and a negative quadratic Almon variable coefficient (a_2 equal to -.0068).

TABLE 2. The Derived Estimated Parameters for Various Lagged Milk/Feed Price Ratios and Their Associated t-Statistics.

Variable	Parameter Estimate	t-Statistic
MF_{t-5}	-.0182	-.0303
MF_{t-6}	.1060	.3534
MF_{t-7}	.2166	.7937
MF_{t-8}	.3136	.9284
MF_{t-9}	.3971	1.1915
MF_{t-10}	.4669	1.7581
MF_{t-11}	.5232	1.6461
MF_{t-12}	.5659	.8793
$\sum_{j=5}^{12} MF_{t-7}$	2.5711	

The statistical fit of the entire estimated number of cows equation (equation (3) with the Almon variables replaced with the $\hat{b}$'s) was judged as good. The coefficient of determination shows that 84.40 percent of the variation in number of dairy cows was explained by the model. The Durbin-Watson statistic is close to two, but it is not strictly applicable as a test for auto-correlation for this equation due to the inclusion of the lagged endogenous variable as a regressor (Maddala, p. 371). An appropriate test for auto-correlation in this case is the Durbin-h statistic which equals .38. A test for first-order auto-correlation at the 5 percent level using the Durbin-h statistic reveals that the null hypothesis that no auto-correlation exists cannot be rejected.

The average number of dairy cows in Maine between 1973 and 1982 was 58,253. The standard deviation in the number of cows equaled 1,570 cows. The standard error of estimate equaled 665 cows which is 1.14 percent of the mean. The standard error of estimate is less than half of the standard deviation in the number of cows. Over the entire period of estimation (1973 through 1982), the greatest absolute error of the model occurred in the fourth quarter of 1981 where the model predicted 1,460 fewer cows in Maine than were recorded. The error equaled only 2.47 percent of the observed number of cows. Appendix A1 lists actual, predicted, and the error number of cows for 1973 through 1982.

The Milk Per Cow Equation

The pounds of milk produced per cow in Maine in a particular quarter is thought to be a function of:

1) The deflated weighted average blend price;

2) the quarter the milk is produced in;

3) the deflated price of feeds;

4) the state of the arts in dairying; and

5) previous levels of milk per cow.

Deflated prices were used in estimating the milk per cow equation to abstract from the effect of general price movements. As was discussed earlier the major movements in the nominal blend price were primarily the result of general inflation and not due to changes in supply and demand conditions. Milk production per cow varies naturally over the course of the year and this variation was accounted for with the use of dummy variables. The state of the arts in dairying in the U.S. has been continually improving. Constant advancements are being made in breeding, milking technology, and feed efficiency. The amalgamation of these effects was proxied by a time trend variable.

The basis for including previous milk production per cow to explain milk production in Maine are as follows: It is general knowledge in the dairy industry that radically changing the herd's environment over a short period of time is not a good management practice. For instance when changing from one feed ration to the next it is suggested that the new feed ration be gradually mixed in with the feed being replaced. The effect of this practice would carry over to milk production. Suppose for whatever reason a producer has his herd producing at relatively high production levels. Further suppose that suddenly the producer desires to lower his production to relatively low levels. This change in production per cow from relatively high to relatively low production levels would not occur immediately. To account for this lag in adjustment the lagged milk per cow was included as an explanatory variable.

The milk per cow equation estimated with ordinary least squares is as follows:

$$(10)\quad MPC_t = \underset{(2.45)}{.6575} + \underset{(4.94)}{.6527}MPC_{t-1} + \underset{(1.69)}{.0388}DBLENDP_t - \underset{(-3.02)}{.1205}D1$$

$$+ \underset{(2.39)}{.1102}D2 + \underset{(17.09)}{.3867}D3 + \underset{(2.91)}{.0048}TIME_t - \underset{(-1.18)}{.0019}DRATIONP_t + e_t$$

$F = 143.96 \qquad DW = 2.025$

$R^2 = .959 \qquad Dh = -1.134$

MPC_t mean = 2.74 thousand pounds

Sy = .25 thousand pounds

Sy.x = .055 thousand pounds

where:

MPC_t = milk per cow in thousands of pounds;

$DBLENDP_t$ = weighted average Maine blend price deflated with the producers (farmers) price index;

D1, D2, and D3 = dummy variables for the fourth, third, and second quarters, respectively;

$TIME_t$ = a time trend variable beginning with one in the first quarter of 1970;

$DRATIONP_t$ = price of 16% ration deflated with the producers (farmers) price index;

F = the F-statistic;

R^2 = the multiple coefficient of determination;

DW = the Durbin-Watson statistic;

e_t = the random disturbance term associated with the equation. The error term is assumed to be identically and independently distributed with normal distribution;

Dh = the Durbin-h statistic,

Sy = the standard deviation of the dependent variable; and,

Sy.x = the standard error of estimate.

The t-statistic for each parameter is in parentheses below its respective coefficient. All coefficients are of their expected sign and five of the t-statistics are greater than two. The t-statistic associated with the deflated weighted average blend price is significant at the 5 percent level. Although the deflated ration price has a somewhat low t-statistic the variable was retained due to the correct sign and the theoretical justification for its inclusion.

The statistical fit of this equation was judged to be excellent. Both the R^2 and F-statistic are high and the standard error of estimate is less than one-fourth of the standard deviation of the dependent variable. The test for auto-correlation using the Durbin-h statistic results in the failure to reject the null hypothesis that no auto-correlation exists. The greatest absolute error occurred in the second quarter of 1981 where the equation predicted milk per cow at 110 pounds or 3.50 percent greater than that observed. Table A2 in the Appendix lists actual, predicted, and error milk per cow in Maine for the second quarter of 1970 through 1982.

Estimated Total Production

In this study total milk production ($TOTMILK_t$) is defined to equal the number of cows times milk per cow, that is:

(11) $TOTMILK_t = NCOW_t \cdot MPC_t$

Even though total milk production in Maine was not directly estimated its goodness of fit required evaluation. The estimated total milk production in Maine ($TOTMILKHAT_t$) was calculated as the product of estimated number of cows and estimated milk per cow. The model's total milk error ($TOTMILKERR_t$) was calculated as follows:

(12) $TOTMILKERR_t = TOTMILK_t - TOTMILKHAT_t$

To evaluate the goodness of fit of the estimated total production the following were calculated:

$TOTMILK_t \cdot TOTMILKHAT_t$ = .974

$TOTMILK_t$ mean = 162.97 million pounds of milk

Sy = 13.316 million pounds of milk

$S_{TOTMILKERR}$ = 3.062 million pounds of milk

$r_{TOTMILKERR_t \cdot TOTMILKERR_{t-1}}$ = -.038

where:

$r_{TOTMILK_t \cdot TOTMILKHAT_t}$ = the correlation coefficient between the endogenous variable ($TOTMILK_t$) and the predicted total milk ($TOTMILKHAT_t$);

SY = the standard deviation in the endogenous variable ($TOTMILK_t$);

$S_{TOTMILKERR}$ = the standard deviation in error total milk produced ($TOTMILKERR_t$ equals $TOTMILK_t$ − $TOTMILKHAT_t$).

$r_{TOTMILKERR_t \cdot TOTMILKERR_{t-1}}$ = the correlation coefficient between the error total milk production and the previous quarter's error total milk production.

The correlation coefficient between total milk production and estimated total production was .974. In the case of ordinary least squares, the coefficient of multiple determination (R^2), represents the portion of endogenous variable variation explained by the regressors. A similar measure of goodness of fit for the total milk production equation was constructed. The amount of total variation in total milk production explained by the model equaled .947, designated R^2*.*

The standard deviation of the error term is substantially less than the standard deviation of the actual total milk production. A further check of the model's goodness of fit was to calculate the correlation between the error total milk production and the previous quarter's error total milk production. The correlation between the error term and the previous quarter's error term equaled −.038. A test for correlation reveals that the null hypothesis that the correlation coefficient equals zero can not be rejected. Appendix Table A3 lists actual, estimated, and error total milk production in Maine.

By far the worst absolute prediction of total Maine milk production occurred in the fourth quarter of 1976 where the model predicted that 151.9 million pounds of milk would be produced while only 144 million pounds of production was observed. The standard deviation of the error for total milk production equaled 3.062 million pounds. The overall fit of the model was judged as quite good. The calculated statistics as a whole are good to excellent and the model's estimates are good.

MARKET SIMULATIONS

The ultimate purpose of estimating the previous equations was to use these equations in assessing the effect on the Maine milk industry of two fifty-cent milk price reductions. In order to make predictions or forecasts with econometric models one must supply the models with a set of future values of the exogenous variables. For example, the number of dairy cows equation (3)

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* The R^2* was calculated as follows: Let Y equal $TOTMILK_t$, $\overline{Y}$ equal $TOTMILK_t$ mean, and $\hat{Y}$ equal $TOTMILKHAT_t$. Total variation in the dependent variable is $\Sigma(Y-\overline{Y})^2$ and variation explained by the model is $(\hat{Y}-\overline{Y})^2$. The ratio of $(\hat{Y}-\overline{Y})^2$ to $(Y-\overline{Y})^2$ is the portion of total endogenous variable variation explained by the model.

includes as an explanatory variable the 16% protein dairy ration price. In order to predict the milk production per cow, one is required to predict or explain the 16% ration price. Perhaps a more palatable approach is to conduct a sensitivity analysis which amounts to calculating predictions (or more appropriately called simulations) using various 16% ration prices and reporting the various results.

The exogenous variables in the milk production model are:

1. $TIME_t$, time;
2. $PSTEER_t$, the price of steers;
3. PPI_t, the producers price index (used as a deflator);
4. D1, D2, and D3, the quarter dummy variables;
5. $RATIONP_t$, the price of 16% ration; and,
6. $BLENDP_t$, the blend price;
7. MF_{t-j}, the milk feed price ratio;
8. $DBLENDP_t$, the deflated weighted average blend price; and,
9. $DRATIONP_t$, the deflated ration price.

Some of the above exogenous variables are functions of other exogenous variables (e.g. $DRATIONP_t = RATIONP_t/PPI_t$) which reduces the number of variables for which future values must be established. In all simulations the variables $TIME_t$, D1, D2, and D3 were allowed to follow their usual pattern.

The remaining exogenous variables for which future values had to be established were $PSTEER_t$, PPI_t, $RATIONP_t$, and $BLENDP_t$. In all simulations average 1982 PPI_t and $PSTEER_t$ values were used. It was decided to hold the producers price index (PPI_t) constant as opposed to speculating on any future general price movements. The price of steers ($PSTEER_{ty}$) was fixed at its average 1982 level primarily because there has been relatively little variation in the steer prices since 1980. If, for example, because of the federal grain PIK (payment in kind) program the price of steers begins to increase substantially then higher steer prices could be used in future simulations. In recent years the feed ration price has had a fair amount of variation in it. In 1981 the 16% ration price averaged roughly over 7 percent higher than the 1981 average price. As a sensitivity check model simulations were run using both the 1981 and 1982 average 16% ration price.

Simulation Results

Three model simulations were conducted to assess the effect of the two fifty-cent price deductions on Maine milk production. The price deductions are assumed to have the same effect on milk production as would equivalent price reductions. The downward price adjustments arranged by the Federal government was not to lower the price of milk but to deduct from previously established prices. Class I and Class II milk utilizations were assumed not to change significantly from their 1982 levels.

Three simulations of future Maine milk production were conducted. Simulation A is a baseline simulation and uses the 1982 milk prices without any price deductions. This simulation is to be used primarily for comparisons. Simulation B uses the 1982 Maine blend prices with one-dollar deducted. Simulations A and B use 1982 average feed prices. As was mentioned earlier the 1982 average feed price was lower than the 1981 average feed price. To investigate the impact on milk production of a higher feed price the third simulation, simulation C, was conducted. Simulation C could be considered a "worst possible" scenario in that it uses the one-dollar deduction and the 1981 average feed prices, which are 7 percent higher than the 1982 average feed prices.

All simulations were calculated using a Gauss-Seidel solution finding program (Washington State University). Although the model was not simultaneous the program made the calculations of the Almon variables easier and facilitated the calculating of several scenarios.

TABLE 3. Number of Dairy Cows in Maine: 1982 and Simulations for 1983 through 1988

Year	Simulations*		
	A	B	C
	- 1,000 head -		
1982	58.49	58.49	58.49
1983	55.90	55.90	55.73
1984	54.58	54.25	53.67
1985	54.43	53.92	53.26
1986	54.43	53.87	53.20
1987	54.43	53.86	53.19
1988	54.41	53.86	53.19

* The simulations are as follows: Simulation A uses 1982 milk prices with no deduction and 1982 average feed ration prices. Simulation B uses 1982 milk prices with one-dollar deducted and 1982 average feed ration prices. Simulation C uses 1982 milk prices with one-dollar deducted and 1981 average feed ration prices.

Tables 3, 4, and 5 show the simulation results for number of cows, the milk per cow, and total milk production for the years 1982 through 1988, where the 1982 values are included for comparisons. The baseline solutions, simulation A, show cow numbers decreasing and then leveling off. In 1982 Maine had an average of 58,490 dairy cows. The 1988 baseline number is 54,410 dairy cows. The baseline solutions show the Maine number of dairy cows decreasing by 4,080 or roughly 7 percent. As was expected simulation C had a greater negative effect on the state herd size than any other scenario.

TABLE 4. Milk Per Cow in Maine: 1982 and Simulations for 1983 through 1988

	Simulations*		
Year	A	B	C
	- 1,000 pounds -		
1982	12.50	12.50	12.50
1983	12.87	12.83	12.75
1984	12.82	12.67	12.55
1985	13.00	12.82	12.70
1986	13.22	13.03	12.90
1987	13.43	13.24	13.12
1988	13.65	13.47	13.35

* These simulations are the same as those in Table 3. See Table 3 footnote *.

TABLE 5. Total Milk Production in Maine: 1982 and Simulations for 1983 through 1988

	Simulations*		
Year	A	B	C
	- 1,000 pounds -		
1982	731	731	731
1983	719	717	711
1984	700	688	674
1985	707	691	676
1986	719	702	687
1987	731	714	698
1988	743	726	710

* These simulations are the same as those in Table 3. See Table 3 footnote *.

The one-dollar deduction and the higher feed prices (1981 levels) resulted in a simulation value of 53,190 dairy cows in Maine in 1988, a 5,300 cow or 9 percent reduction from the 1982 level.

The baseline milk per cow solutions, as shown in Table 4, reveal that the average milk production per cow increases from its 1982 level of 12,500 pounds to 13,650 pounds in 1988. Simulations B and C show the milk per cow decreasing and then increasing. This temporary dip is caused by the reduction in milk per cow due to lower prices eventually being surpassed by the effect of gains in the dairying state of the art. Recall that a time trend was included in the milk per cow equation (equation 10) to represent the continual increases in the dairying state of the arts.

Table 5 contains the simulation results for total Maine milk production. The baseline simulation (simulation A) shows total milk production decreasing from its 1982 level of 731 million pounds to 700 million pounds in 1984. This equaled a 4.2 percent decrease. After 1984, baseline milk production increases to 743 million pounds in 1988. The simulations B and C follow the same pattern as simulation A but as expected show less milk produced in a given year (a result of lower prices). In 1988, simulation C milk production equaled 710 million pounds which is 33 million or 4.4 percent less than the 1988 baseline level.

CONCLUSIONS

The purpose of this study was to estimate an econometric model of milk production in Maine and to use this model to analyze the effect of two fifty-cent milk price deduction. The first fifty-cent price deduction took place April 16, 1983 and the second October 1, 1983. The effect of the two fifty-cent price deductions was represented by comparing three model simulations. Simulation A was a baseline simulation and used prices without deductions and also used 1982 average feed ration prices. Simulation B and C both had one-dollar milk price deductions while simulation B used 1982 average feed ration prices while simulation C used 1981 average feed ration prices. The results of these simulations were presented in Tables 3, 4, and 5.

Milk production in all three simulations declines in 1983 and 1984 and then begins to increase in 1984. The baseline milk production level in 1988 equaled 743 million pounds of milk. This is 12 million more pounds of milk than the 1982 average of 731 million pounds. The simulation B and C levels of milk production for 1988 equaled 726 and 710 million pounds of milk, respectively.

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APPENDIX

TABLE A1. Actual, Estimated, and Error Number of Dairy Cows in Maine, 1973 through 1983.

Year	Quarter	Actual	Estimated	Error
		--	1,000 HEAD	--
1973	1	61.09	60.69	.40
1973	2	60.07	60.63	-.56
1973	3	58.89	59.84	-.95
1973	4	58.92	59.21	-.29
1974	1	59.91	59.20	.71
1974	2	61.05	59.97	1.08
1974	3	59.93	60.76	-.83
1974	4	60.08	60.12	-.04
1975	1	60.08	60.09	-.01
1975	2	61.07	59.81	1.26
1975	3	60.00	60.21	-.21
1975	4	60.00	59.39	.61
1976	1	58.96	59.29	-.33
1976	2	59.03	58.65	.38
1976	3	59.07	58.69	.38
1976	4	58.06	58.73	-.67
1977	1	57.94	58.14	-.20
1977	2	57.91	57.83	.08
1977	3	57.99	57.93	.06
1977	4	57.95	58.06	-.11
1978	1	58.10	57.93	.17
1978	2	56.90	57.85	-.95
1978	3	56.04	57.18	-1.14
1978	4	56.07	56.61	-.54
1979	1	56.09	56.17	-.08
1979	2	56.07	55.53	.54
1979	3	56.00	55.90	.10
1979	4	56.00	55.95	.05
1980	1	56.93	56.25	.68
1980	2	57.00	56.93	.07
1980	3	56.91	57.19	-.28
1980	4	56.95	57.06	-.11
1981	1	55.97	57.31	-1.34
1981	2	57.00	56.71	.29
1981	3	57.05	57.34	-.29
1981	4	59.04	57.58	1.46
1982	1	58.90	58.66	.24
1982	2	59.06	58.35	.71
1982	3	57.98	58.45	-.47
1982	4	58.01	57.92	.09

APPENDIX

TABLE A2. Actual, Estimated, and Error Milk Per Cow in Maine, Second Quarter 1970 through 1982.

Year	Quarter	Actual	Estimated	Error
		--	1,000 pounds	--
1970	2	2.69	2.66	.03
1970	3	2.61	2.64	-.03
1970	4	2.37	2.37	.00
1971	1	2.38	2.33	.05
1971	2	2.74	2.72	.02
1971	3	2.72	2.70	.02
1971	4	2.48	2.48	.01
1972	1	2.46	2.42	.04
1972	2	2.84	2.79	.05
1972	3	2.71	2.77	-.06
1972	4	2.46	2.45	.01
1973	1	2.39	2.39	.00
1973	2	2.78	2.72	.06
1973	3	2.70	2.71	-.01
1973	4	2.41	2.44	-.03
1974	1	2.32	2.38	-.06
1974	2	2.67	2.72	-.05
1974	3	2.72	2.65	.07
1974	4	2.43	2.46	-.03
1975	1	2.38	2.41	-.03
1975	2	2.80	2.76	.04
1975	3	2.75	2.77	-.02
1975	4	2.50	2.53	-.03
1976	1	2.51	2.50	.01
1976	2	2.88	2.88	.00
1976	3	2.81	2.85	-.04
1976	4	2.48	2.59	.11
1977	1	2.52	2.48	.04
1977	2	2.97	2.89	.08
1977	3	2.88	2.95	-.07
1977	4	2.64	2.67	-.03
1978	1	2.53	2.62	-.09
1978	2	2.97	2.94	.03
1978	3	2.98	2.97	.01
1978	4	2.80	2.75	.05
1979	1	2.71	2.75	-.04
1979	2	3.05	3.07	-.02
1979	3	3.00	3.03	-.03
1979	4	2.75	2.78	-.03

APPENDIX

TABLE A2. (continued)

Year	Quarter	Actual	Estimated	Error
		---	1,000 pounds	---
1980	1	2.71	2.74	.03
1980	2	3.07	3.12	-.05
1980	3	3.11	3.05	.06
1980	4	2.95	2.85	.10
1981	1	2.93	2.88	.05
1981	2	3.14	3.25	-.11
1981	3	3.19	3.14	.05
1981	4	2.93	2.95	-.02
1982	1	2.92	2.89	.03
1982	2	3.20	3.27	-.08
1982	3	3.26	3.20	.06
1982	4	3.12	3.02	.10

APPENDIX

TABLE A3. Actual, Estimated, and Error Total Milk Production in Maine, 1973 through 1982.

Year	Quarter	Actual	Estimated	Error
		--	million of pounds	--
1973	1	146	145.0	1.0
1973	2	167	165.1	1.9
1973	3	159	161.9	-2.9
1973	4	142	144.5	-2.5
1974	1	139	140.8	-1.8
1974	2	163	163.3	-.3
1974	3	163	161.2	1.8
1974	4	146	147.9	-1.9
1975	1	143	144.9	-1.9
1975	2	171	165.1	5.9
1975	3	165	167.0	-2.0
1975	4	150	150.2	-.2
1976	1	148	148.2	-.2
1976	2	170	168.7	1.3
1976	3	166	167.5	-1.5
1976	4	144	151.9	-7.9
1977	1	146	144.0	2.0
1977	2	172	167.2	4.8
1977	3	167	171.0	-4.0
1977	4	153	155.0	-2.0
1978	1	147	151.8	-4.8
1978	2	169	169.9	-.9
1978	3	167	169.6	-2.6
1978	4	157	155.7	1.3
1979	1	152	154.4	-2.4
1979	2	171	170.5	.5
1979	3	168	169.5	-1.5
1979	4	154	155.3	-1.3
1980	1	156	154.0	2.0
1980	2	175	177.7	-2.7
1980	3	177	174.6	2.4
1980	4	168	162.6	5.4
1981	1	164	165.1	-1.1
1981	2	179	184.4	-5.4
1981	3	182	179.9	2.1
1981	4	173	169.8	3.2
1982	1	172	169.9	2.1
1982	2	189	191.3	-2.3
1982	3	189	187.1	1.9
1982	4	181	175.1	5.9