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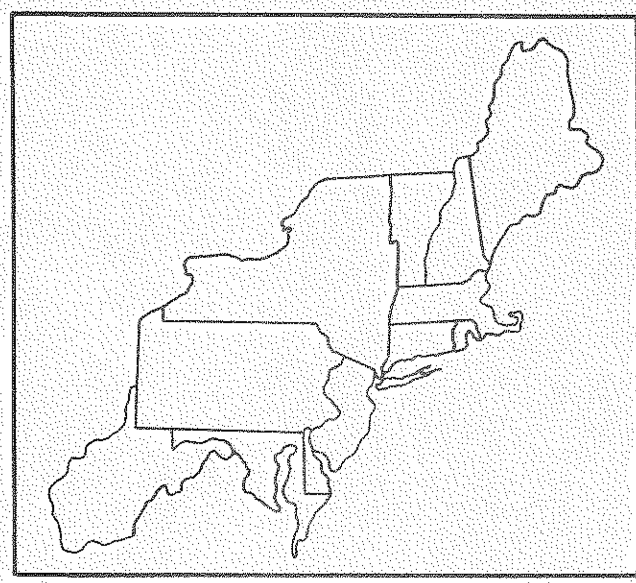

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MILK SUPPLY ESTIMATION FOR DELAWARE

by

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MODEL SPECIFICATION

The milk supply model for Delaware has two components reflecting the behavior of dairy farmers. These are 1) the number of milk cows and, 2) milk production per cow. Multiplying these components determines the aggregate production of milk in the state.

Economic Considerations

Due to the biological nature of the production process and the large fixed investments in dairy farming, the output response to any price change is hypothesized to be slow and gradual. Thus, the impact of changes in milk prices, feed costs, and wage rates on milk production are assumed to be distributed over time.

It is hypothesized that changes in prices have a shorter range impact on milk production per cow, while a longer run should be considered for the number of milk cows. On the one hand, farmers can make, on relatively short notice, adjustments in feeding rates in accordance with changes in output and input prices. On the other hand, changes in the price of milk or changes in feed costs should have a more delayed impact on the number of cows, since building up a herd is both time and capital consuming, due to 1) the biological restraints, i.e., it takes up to 3 years from decision to expand to actually increase the cow numbers out of one's own herd; and 2) the physical restraints of building or adding facilities will require careful considerations, since they are costly and have long run impacts.

Variables

The number of milk cows is expected to be a function of distributed lag prices of milk cows (-), feed (-), and milk (+).** The variables expected to influence milk production per cow are technology (time +), seasonality of milk production (+ or -), and lagged prices for 16 percent dairy ration (-), alfalfa hay (-), and milk (+). Other variables such as different technology proxies (e.g. artificial insemination, bulk handling, and labor productivity in dairy production), manufacturing wage rates, and the prices of beef, utility cows, steers, heifers and calves were initially assumed to affect the two functions. Early analysis, however, indicated unsatisfactory relationships with these variables.

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** Plus or minus signs indicate the hypothesized sign of the estimated parameters.

Statistical Specification

A number of distributed lag models have been used to estimate supply response in agricultural production. The most popular form is the partial adjustment, distributed lag model formulated by Nerlove. It is easy to estimate and derive the short-run and long-run supply elasticities from this model. However, one problem with this formulation is that the adjustment process to a price change for the estimated value of the "adjustment coefficient" is restricted by the geometrically declining specification. Thus, with the maximum adjustment occurring during the first period, the Nerlovian model fails to represent both economic and behavioral realities in the case of milk. An alternative technique is the polynomial of low order. In this alternative formulation, the coefficients of the lag distribution first rise and then decline after reaching a maximum.*

This study uses a second-degree polynomial distributed lag price of milk cows, feed, and milk as well as farm wage rates to capture both the short-run and intermediate-run effects of changes in these variables on milk supply.** The primary criterion used for lag lengths of variables is the time required for the price-cost relationship to influence the actual decision of farmers. Additional criteria in determining lag periods are the sign and statistical level of significance of the coefficients. Preliminary investigations were undertaken for all lagged variables before deciding on the final lag form. Hence, four quarters were used for the milk production per cow function and 12 quarters for the number of milk cows.

Estimation Procedures

Both equations were estimated using the Cochrane-Orcutt iterative procedure (Kmenta, p. 287-288) to eliminate the problem of autocorrelated residuals.*** To capture seasonal variations, quarterly data for the 15-year period of 1966 through 1980 were used.

During this period, inflation rates averaged over 10 percent per year. Thus, the expected production response was based on changes in real prices as opposed to nominal prices. Recently Bell, Roop, and Willis (1979) presented some econometric considerations for deflating time series data. Specifically, deflating yields efficient, unbiased estimations when the undeflated residuals are heteroscedastic. Another advantage is that extreme observations will have less effect on the estimation. Deflating may also remedy problems of severe multicollinearity. Hence, all prices, except the price of milk, were deflated by the 1967 index of prices paid (for commodities, interest, taxes and wages) by farmers. The 1967 index of prices received for dairy products was used to deflate milk prices.

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* For details see Chen, Courtney and Schmitz, Johnston and Kmenta.

** A third degree polynominal distributed lag formulation proved to be less satisfactory with respect to statistical measures in test runs.

*** The Time Series Processor (TSP) computer program was utilized to estimate the polynomial distributed lag model.

Sources of Data

The time series data used in this study were collected and adopted from various publications and unpublished series of the United States Department of Agriculture, and the Maryland-Delaware Crop Reporting Board.

RESULTS

Cow Numbers

About 89 percent of the total variation in cow numbers is explained by milk prices and farm wage rates, lagged over 11 and 4 quarters, respectively, along with prices of milk cows and alfalfa hay (Table 1, Equation 1). Most of the coefficients are statistically significant either at the five or ten percent level of probability. The signs of all significant coefficients conform with theoretical and empirical expectations. The Durbin-Watson statistic indicates no problem with autocorrelation.

Equation 1 suggests that decisions to vary herd size are strongly influenced by changes in cow and milk prices, but are less affected by factors such as labor and feed costs.*

Negative adjustments to changes in deflated price of milk cows are largest after three quarters. That is, a dollar increase in the cost for replacement cows in the current quarter can be associated with a decrease of 7 cows nine months later.

Milk prices, particularly during the last four to eight quarters, had a strong influence on cow numbers. A deflated dollar per 100 pounds higher milk price leads farmers to expand their herds by 563 to 634 cows per quarter. The price coefficients for the first two quarters are insignificant, which imply that dairy farmers react gradually to milk price changes.

To account for the fixity of labor, a four-quarter average for changing wages is used. A decrease of 169 to 180 cows per quarter is associated with a deflated 10 cent increase in farm wage. Farm wages, especially during the last two to four quarters, had a significant impact on herd size, but only at the ten percent probability level. Changes in hay prices had an insignificant effect on cow numbers.

Milk Per Cow

Technology, seasonality, and lagged prices of alfalfa hay (over 4 quarters) and milk-concentrate price ratio (over 6 quarters) explain nearly 84 percent of the total variation in milk production per cow Table 2 (Equation 2). The regression coefficients are generally significant and have the expected signs. The Durbin-Watson statistic indicates the absence of autocorrelated residuals.

A one unit increase in the milk-concentrate price ratio is associated with an average quarterly increase of 99 to 227 pounds of milk per cow, with the

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* The original formulation includes prices of concentrates, but results show severe collinearity with milk prices.

Table 1. Cow Numbers

Equation 1. Y = -5628.64 - 20.876 def. price of alfalfa, t-4 - 7.394** def. price of milk cows, t-3
(30.629) (3.786)

- def. farm wage		
t	5.559	(11.68)
t-1	-9.057	(8.205)
t-2	-16.92*	(12.82)
t-3	-18.03*	(13.80)
t-4	-12.39*	(9.603)
Sum of Coefficients	-50.838	

+ def. price of milk at time		
t	-0.021	(2.103)
t-1	1.922	(2.161)
t-2	3.512*	(2.587)
t-3	4.749*	(3.063)
t-4	5.633*	(3.442)
t-5	6.164**	(3.671)
t-6	6.342**	(3.725)
t-7	6.167**	(3.592)
t-8	5.640**	(3.268)
t-9	4.759**	(2.748)
t-10	3.526**	(2.031)
t-11	1.939**	(1.116)
Sum of Coefficients	50.332	

$\bar{R}^2 = 0.889$
Durbin-Watson Statistic = 2.107
F-value = 47.991
Standard deviation in parenthesis.
Significance of coefficients * at 10 percent, ** at 5 percent.

Table 2. Milk Per Cow

Equation 2. $Y = 1234.51 + \underset{(2.705)}{15.006}\ \text{Time} - \underset{(31.521)}{58.729}\ \text{Winter} - \underset{(36.791)}{61.236}\ \text{Spring} + \underset{(31.006)}{3.292}\ \text{Summer}$

- def. price of alfalfa at		
t	-2.383	(3.663)
t-1	-2.276*	(1.601)
t-2	-1.985	(1.866)
t-3	-1.508	(2.207)
t-4	-0.846	(1.629)
Sum of Coefficients	-8.998*	(6.161)

+ milk price (¢/100 cw.) / conc price ($/t)		
t	226.8**	(124.0)
t-1	179.3**	(74.9)
t-2	136.8**	(57.8)
t-3	99.37*	(62.8)
t-4	66.97	(66.8)
t-5	39.61	(59.31)
t-6	17.29	(37.41)
Sum of Coefficients	766.140**	(323.596)

$\bar{R}^2 = .83$
Durbin Watson Statistic =
F-value =
Standard deviation in parenthesis.
Significance of coefficients * at 10 percent, ** at 5 percent.

highest effect occurring in the first quarter. A real hay price increase of one dollar during the recent quarter decreased milk output by slightly over 2 pounds per cow. These findings point to the fact that short-run changes in input and output prices have an immediate impact on milk production through adjustments in the feeding rates.

Technology is positively related to production. Milk per cow increases by 15 pounds per quarter over time. The estimates of the seasonal effect variable fluctuated, possibly with weather and pasture conditions. Milk production per cow is about 59 to 61 pounds lower in the winter and spring quarters, respectively. Although the summer coefficient is statistically insignificant, milk production per cow apparently is higher during this season, which is a somewhat surprising result.

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