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Regional Milk Supply Analysis

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INTRODUCTION

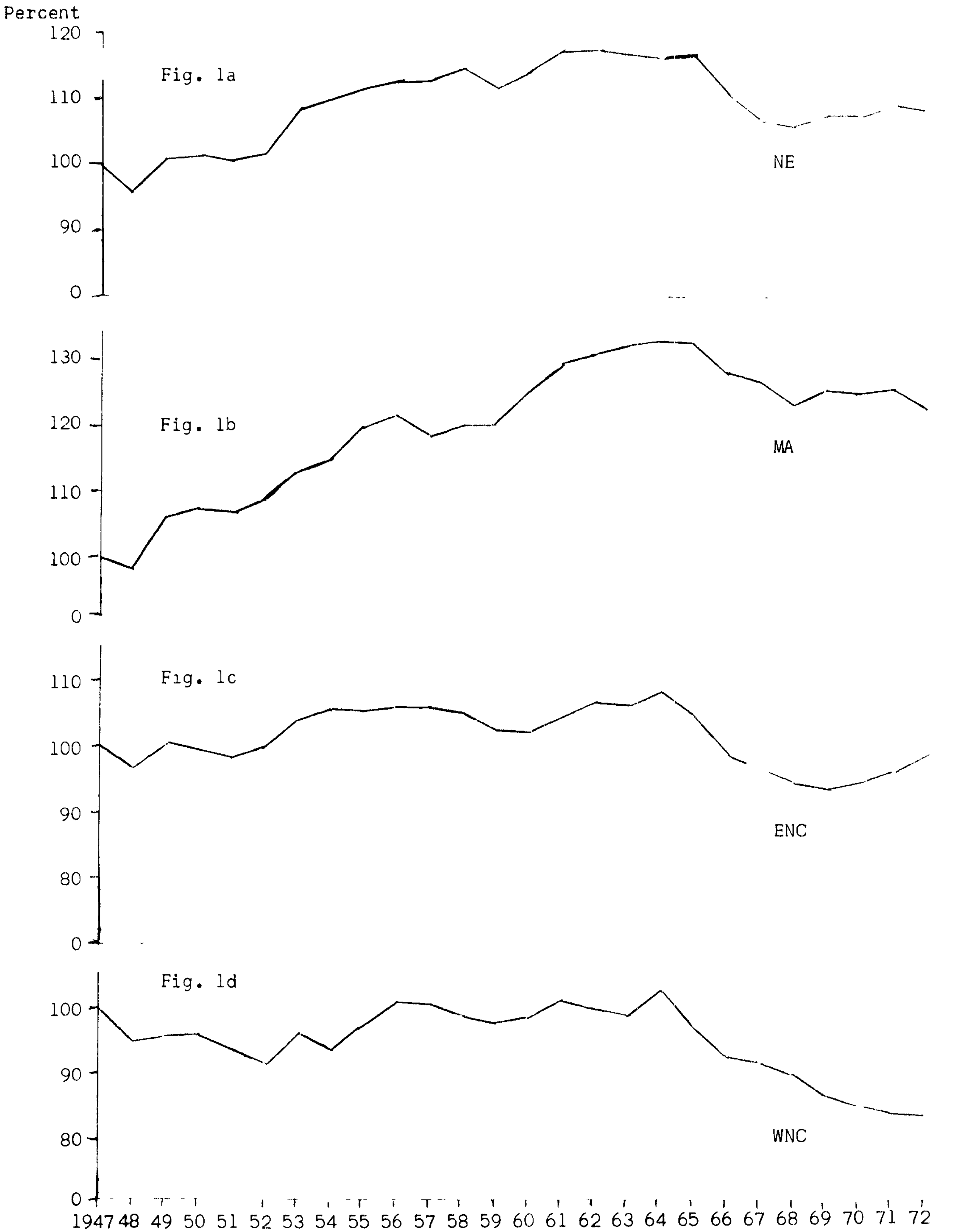
Regions of the U.S. differ substantially in respect to those characteristics which are likely to influence or determine milk production. Among the more important of these characteristics are land quality, topography, climate, alternative farm production activities, non-farm opportunities, and even levels of milk prices. One could hypothesize that milk supply responds differently in each region because of the varying economic and technical constraints imposed on the individual milk producing units by these differences. The objective of the study reported here is to estimate separate supply functions for subregions of the U.S. and to determine if production does respond differently to determinants of milk production among the regions.

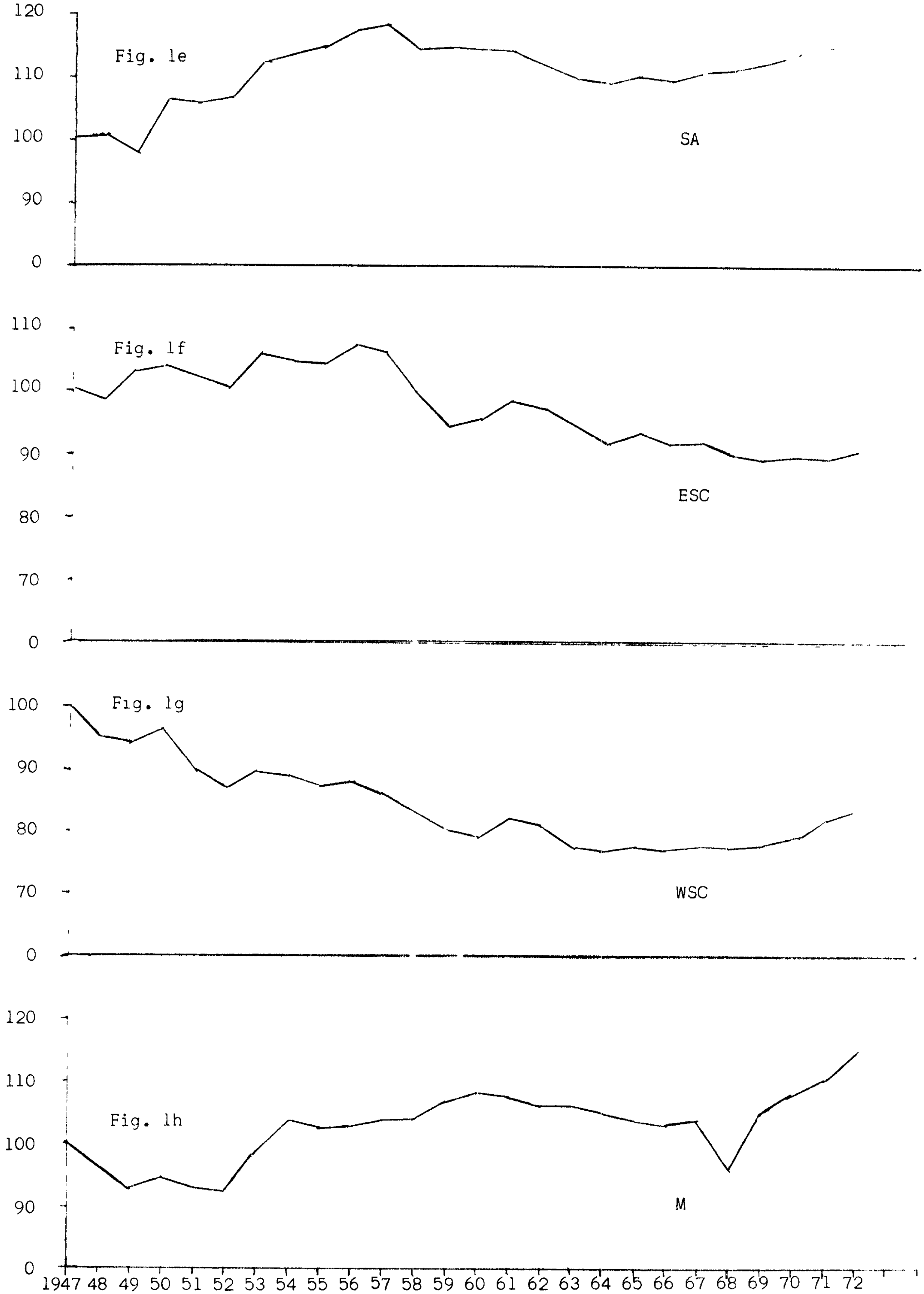
This disaggregated approach to estimating U.S. milk supply relationships should provide more detailed and perhaps more useful results for production forecasts and policy evaluation. Whether it will improve the overall accuracy of the estimated supply relationships and forecasts is to be determined. It should, for example, provide a more solid basis for evaluating quantity response of milk producers in specified federal order markets to price changes. It should help explain the different long term patterns in regional milk production and how milk production in each region will respond to specified or anticipated changes in determinants of milk production.

The patterns of milk production in the nine major crop reporting regions of the U.S. and the entire U.S. are illustrated for the period 1947 to 1972 in Figure 1a to 1j in terms of annual levels of milk production as a percentage of 1947 levels. Though the regional trends are not strong, they exhibit divergent patterns. The New England, Middle Atlantic, South Atlantic, Mountain and Pacific regions exhibit upward patterns in milk production with the strongest upward trend in the Pacific region, 1972 milk production being about 50% higher in 1972 than in 1947 as opposed to a 15 to 25% increase for the other regions with upward trends. Three regions exhibit rather moderate downward trends in milk production, the West North Central, East South Central and West South Central, with the largest decline in the West South Central region. The East North Central region has no upward or downward trend. Overall, total U.S. milk production was about the same in 1972 as in 1947 (see Figure 1j), but the regional trends indicate some shift in the relative importance of most regions in the total picture.

Though the period is relatively short to determine if recurring cyclical patterns occur in milk production, several of the regions exhibit cycles which vary in length from 9 to 15 years. The East North Central Region exhibits one cycle from 1951 to 1960 and another from 1960 to 1969. The South Atlantic region exhibits a cycle that began in 1949 and ended in 1964. The Mountain regions had a cyclical pattern that began in 1952 and terminated in 1968. Production in other regions and even total U.S. production does not seem to indicate any long-term cyclical pattern of production. It does not appear that analysis of cyclical patterns of production or that use of models which generate cyclical patterns will generally be useful for explaining or predicting milk supply.

Figure 1. Annual Milk Production in U.S. Regions as a Percent of 1947 Production.

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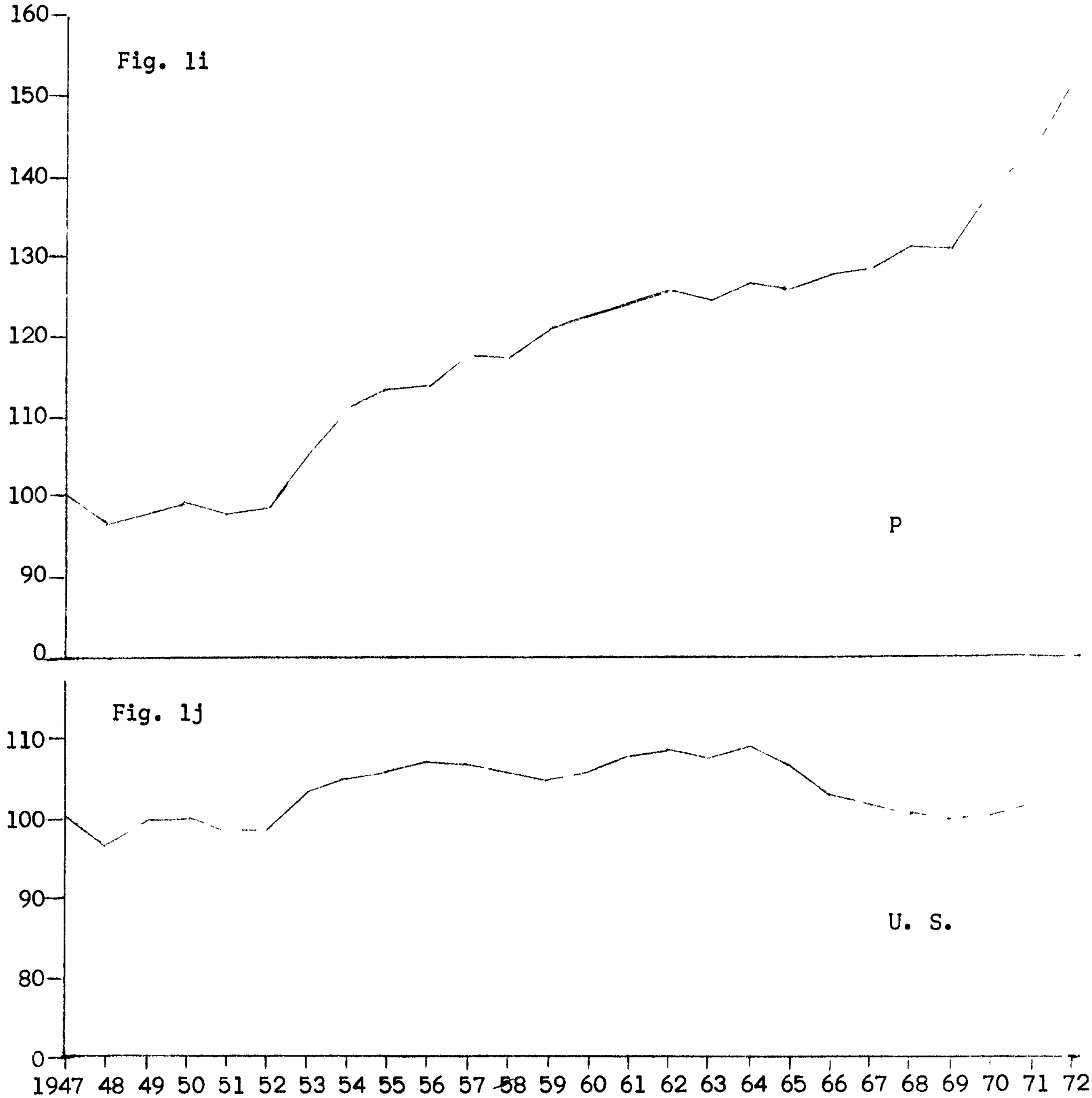
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Analysis of U.S. milk supply has been the subject of numerous studies. Most of the studies have been for aggregate U.S. supply relationships or they have dealt with supply for specific markets or states.

A number of techniques of supply analysis have been used. A common approach has been to estimate supply relationships from time series observations on aggregate market variables by least squares techniques. A study by Kadlec, Jensen and Kehrberg for the Louisville milk market estimated milk supply by estimating marginal cost curves for typical farms in alternative classifications of farm sizes and then summing the relationships to obtain the market supply curve.[1/] Another study used linear programming to generate marginal cost curves for typical farms and then aggregated these relationships to obtain the market supply relationship for the Topeka, Kansas market.[2/] These programming approaches seem to imply an instantaneous adjustment to changes in product and input prices. Consequently, use of elasticities from such a procedure may not represent the actual adjustment that can or will take place within a market.

The results of estimated supply elasticities for a number of the studies which we reviewed are presented in table 1.[3/] Except for the Louisville

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1/ Kadlec, J.E., H.R. Jensen, and E.W. Kehrberg, "Estimating Supply Functions for Milk in the Louisville Milkshed with Farm Cost Data", Research Bulletin No. 720, Agric. Exp. Station, Purdue University, Lafayette, Indiana, May 1961.

2/ Kelley, Paul, and Dale Knight, "Short-Run Elasticities of Supply for Milk", JFE, Vol. 47, No. 1, Feb. 1965, pp. 93-104.

3/ Two rather extensive studies of milk production have been conducted by the Northeast Dairy Adjustment Committee and the Lakes States Dairy Adjustment Study.

Table 1. Selected Estimates of Supply Elasticities

Researcher and Source	Time Period	Region or State	Elasticities Short-run	Long-run
Chen, Courtney, & Schmitz(AJAE) Feb. 72	1953-68 Quarterly	California	.29	2.52
Wipf, Larry & J. P. Houck, Report #532	1945-64 Annual	U.S.	.027 to .140	.041 to .192
Kadlec, J.E., H.R. Jensen & E.W. Kehrberg	1957 Annual	Louisville Milk Market	.58 to .82	--
Halvorson, Harlow, JFE Dec. 1958, pp. 1107-1113	1927-57 1944-57 Annual	U.S.	.128 to .185 .180 to .312	.398 to .439 .154 to .886
Wilson, R.R. and Thompson, R.G., JFE, May 1967	1947-63 Annual	U.S.	Immediate .003	.521
Ladd, G.W. & George Winter, JFE, Feb. 1961	1926-56 Annual	Iowa	.065	--
Kelley, Paul & Knight, Dale, JFE, Feb. 1965	1960	Topeka Mkt.	Price Increase .04 to .187 Price Decrease	--
Cromarty, Wm., Jour. of Am. Stat. Am., Sept. 1959,pp.556-574	1929-53 Annual	U.S.	.212	2.53

market study all the short-run supply relationships are highly inelastic, 0 to .31. The differences among them can be attributed to differences in areas, data, estimating procedures and model specification. Inspection of the results in the table seem to indicate that supply has become less inelastic over time.

The long-run elasticities of supply are much more inconsistent than short-run estimates. They range from .041 in the Wipf-Houck study to 2.52 in the California study. The results of our analyses should throw additional light on this characteristic.

PROCEDURE

The number of regions and the area to be included in each region for estimating supply relations should ideally be determined so that each region is essentially homogeneous for all important factors that influence milk production. Obviously, adherence to this criterion would result in such a large number of regions, probably exceeding the number of states, that obtaining data for estimation would be impossible. A criteria that we followed is that one should limit the number of regions so that for policy and analysis purposes, the results can be easily and quickly used. This should probably not exceed 10 regions. Because the Statistical Reporting Service of the USDA reports and classifies the states into nine standard regions for much of its crop and livestock reporting, and these regions are homogeneous in many factors regarding milk production, we decided to follow this classification. Analysis of these regions should indicate whether some other grouping is more appropriate. The nine regions with the states listed in each region and abbreviations for each region named are indicated in table 2. In addition supply functions will be estimated for the entire U.S. for purposes of comparison.

Two kinds of distributed lag models will be used for estimating the supply relationships for each of the regions. A major advantage of the distributed lag models is that they permit one to estimate simultaneously short and long-run elasticities of demand. The most widely used lag model is the partial adjustment distributed lag model as developed by Nerlove.4/

Table 2. Regional Classifications for Milk Supply Analysis*

Region	Abbreviation	States Included	
New England	NE	New Hampshire Vermont Massachusetts	Rhode Island Connecticut Maine
Middle Atlantic	MA	New York New Jersey	Pennsylvania
East North Central	ENC	Ohio Indiana Illinois	Michigan Wisconsin
West North Central	WNC	Minnesota Iowa Missouri North Dakota	South Dakota Nebraska Kansas
South Atlantic	SA	Delaware Maryland Virginia West Virginia	North Carolina South Carolina Georgia Florida
East South Central	ESC	Kentucky Tennessee	Alabama Mississippi
West South Central	WSC	Arkansas Louisiana	Oklahoma Texas
Mountain	M	Montana Idaho Wyoming Colorado	New Mexico Arizona Utah Nevada
Pacific	Pac	Washington Oregon	California

* These are the standard census regions for statistical reporting.

4/ Nerlove, Marc, Estimates of the Elasticities of Supply of Selected Agricultural Commodities, JFE, Vol. 38, No. 2, May 1956, pp. 496-509.

With this type of model, the change in milk production from the previous year is specified as a proportion of the difference between desired level of milk production and actual milk production in the previous year as follows:

$$Q_t - Q_{t-1} = \gamma \left(Q_t^* - Q_{t-1}\right) \qquad (1.1)$$

where:

Q_t^* is the desired level of production. If we specify that Q_t^* is a function of last year's price plus other variables, X_n, that influence production decision, a linear form of this relation would be:

$$Q_t^* = a + bP_{t-1} + \sum_{n=1}^{n} C_n X_n \qquad (1.2)$$

Substitution of equation (1.2) into equation (1.1) yields an equation in observable variables that can be estimated by standard statistical techniques:

$$Q_t = a + \gamma bP_{t-1} + \sum_{n=1}^{n} \gamma cX_n + (1 - \gamma)\, Q_{t-1} \qquad (1.3)$$

The γ can be derived from the estimated coefficient of Q_{t-1}. The estimated coefficients, γ b for example, are the measures of short-run adjustments. Division of the estimated coefficients by γ, the coefficient of adjustment, yields the long-run response of supply to a change in the given variable.

The above formulation of a distributed lag is perhaps the most convenient to estimate and, also, the easiest from which to derive elasticities, both short and long-run. Yet the adjustment process to price change for the normal estimated values of γ, where $0 \leq \gamma \leq 1$, is constrained to a geometrically declining form with maximum adjustment during the first year of the period. Now the nature of the production process in dairying is such that the maximum possible supply response to a price change could not occur until at least the second year following the change. That is, a time period where producers could retain all heifer calves for herd expansion. It requires about 2 to 3 years before they come into production.

It should be noted that the adjustment process to price increases may be different than for price decreases. Reduction in milk production can be accomplished by increased culling which can be done almost immediately. The partial adjustment model can be modified to account partially for differences which might occur by separating the price variable into two series, one for price increases and one for price decreases. Unfortunately, the coefficient of adjustment for the original Nerlove model is the same for all variables in the system. Nevertheless, the procedure may provide some insights into the response patterns to price increases and decreases.

Other models of distributed lags have been developed and used in agricultural supply analyses. One which has recently been applied to California milk supply is a polynomial lag model.5/ In this formulation of a lag assume a general distributed lag model of the following form:

$$Q_t = \sum_{r=o}^{k} B_r P_{t-r} \qquad (2.1)$$

where:

- Q_t is quantity of milk in time period t.
- P_{t-r} is price at time period t-r.
- k is the specified time unit of adjustment.
- r is a time unit within the total adjustment period, and
- B_r are the coefficients in the structure.

5/ Chen, D., R. Courtney, and A. Schmitz, "A Polynomial Lag Formulation of Milk Production Response," AJAE, Vol. 54, No. 1, Feb. 1972, pp. 77-83.

If it is specified that the coefficients B lie on a polynomial; a second order would, a priori, seem most appropriate for most agricultural processes, then:

$$B_r = \alpha_o + \alpha_1 r + \alpha_2 r^2 \qquad (2.2)$$

and equation (2.1) can be rewritten:

$$Q_t = \sum_{r=o}^{k} (\alpha_o + \alpha_1 r + \alpha_2 r^2) P_{t-r} . \qquad (2.3)$$

By imposing the restriction that B = o when r = k, then:

$$\alpha_o + \alpha_1 k + \alpha_2 k^2 = o \text{ and} \qquad (2.4)$$

solving for α_o and substituting in (2.2) we have:

$$B_r = - \alpha_1 k - \alpha_2 k^2 + \alpha_1 r + \alpha_2 r^2 \qquad (2.5)$$

$$= \alpha_1 (r-k) + \alpha_2 (r^2 - k^2). \qquad (2.6)$$

Equation (1) can now be rewritten:

$$Q_t = \alpha_1 \sum_{r=o}^{k} (r - k) P_{t-r} + \alpha_2 \sum_{r=o}^{k} (r^2 - k^2) P_{t-r}. \qquad (2.7)$$

The price variables for which the coefficient α_1 and α_2 can now be estimated are:

$\sum_{r=o}^{k} (r-k) P_{t-r}$ and

$\sum_{r=o}^{k} (r^2 - k^2) P_{t-r}$

The estimates together with the r and k can be used to compute B_r for any given period according to equation (2.6). The total adjustment to a one unit price change is calculated by summing the coefficients B_r for all values of r. One needs however, with this model, to specify ex ante, the number of time units in the adjustment period.

The polynomial lag model can be expanded to include those other factors, denoted by X_n, that influence supply. Thus

$$Q_t = l_1 \sum_{r=o}^{k}(r-k)\ P_{t-r} + \sum_{r=o}^{k}(r^2 - k^2)\ P_{t-r} + C_n X_n \quad (2.8)$$

Polynomial lags can be constructed for any or all other variables in the system. For this analysis, we will apply the polynomial lag only to the price variable.

In comparison to the Nerlove partial adjustment model the polynomial lag provides certain kinds of flexibility. Though the Nerlove model permits the data to determine the number of time periods necessary for a given amount of the total adjustment to take place, the adjustment within this period is usually constrained to a geometrically declining adjustment even though actual adjustment may not operate in this manner. The polynomial lag model permits the adjustment process to conform to other actual patterns of adjustment, but the number of time periods for adjustment is not determined by the model.

The variables other than price that will be included in the analyses of regional supplies are: input prices, prices of products from alternative farm activities, prices or proxies variables for non-farm job opportunities in the region, and technical and structural characteristics of the industry that influence supply. As stated earlier alternative farm enterprises differ from region to region so that some of the variables listed below will not be included in the analyses for all regions. The variables to be considered are the following:

Quantity of Milk

Qit: Milk production in region i in period t.

Price Variables

P_{it}: Average price per cwt. of milk in region i in period t.

C_{it}: Average price received per cwt. of cattle in region i in period t.

RE_{it}: Index of average farm real estate price in region i in period t.

WW_{it}: Average weighted hourly wage rate in region i in period t.

W_{it}: Average hourly wage rate in region i in period t.

F_{it}: Price per cwt. of 16% dairy ration in region i in period t.

H_{it}: Average price per ton of baled hay in region i in period t.

HO_{t}: Average U.S. price per cwt. of hogs in period t.

S_{t}: Average U.S. price per bushel of soybeans in period t.

CO_{t}: Average U.S. price per bushel of corn in period t.

WH_{t}: Average U.S. price per bushel of wheat in period t.

SM_{t}: Average U.S. price per ton of soybean meal in period t.

CN_{t}: The index of average U.S. cotton prices.

FV_{t}: Index of average U.S. fresh vegetable prices in period t.

Employment Variables

E_{it}: Number of persons employed in region i in period t.

UR_{it}: Percent of unemployment in region i in period t.

Other Variables

A_{it}: Percent of total dairy cows bred artificially in region i in period t.

PA_{it}: Average overall pasture condition in region i in period t.

CR/M_{it}: Percentage of milk marketed as farm separated cream in region i.

Table 3. Milk Supply Estimates (equation in actual observations) 6/

Region	Equations										R²
New England	Q_{1t} =	3804.482 (s^2=1102.001)	+ .3909 Q_{1t-1} (2.626)***	+ 151.938 P_{1t-1} (2.533)**	- 11.747 C_{1t} (-3.149)***	+ 25.404 A_{1t-3} (3.090)***	- 9.954 RE_{1t} (-2.617)***	- 777.339 WW_{1t-1} (-2.559)**	- 13.508 HO_{t-1} (-3.277)***		.945
Middle Atlantic	Q_{2t} =	14410.380 (s^1=4718.966)	+ .522 Q_{2t-1} (2.596)***	+ 385.465 P_{2t-1} (1.495)*	- 29.483 C_{2t} (-1.906)**	+ 111.331 A_{2t-3} (3.365)***	- 39.439 RE_{2t} (-2.224)***	- 3125.030 WW_{2t-1} (-2.460)**	- 330.413 S_{t-1} (-2.432)**		.968
East North Central	Q_{3t} =	36778.675 (s=7416.924)	+ .456 Q_{3t-1} (3.793)	+ 635.333 P_{3t-1} (1.834)**	- 66.296 C_{3t} (-1.872)**	+ 147.621 A_{3t-3} (3.239)***	- 105.052 RE_{3t} (-2.650)***	- 4840.495 WW_{3t-1} (-2.125)**	- 143.241 HO_{t-1} (-4.132)***		.901
West North Central	Q_{4t} =	22261.503 (s=4289.004)	+ .706 Q_{4t-1} (8.087)***	+ 174.705 P_{4t-1} (.518)	- 85.935 C_{4t} (-3.289)***	+ 126.665 A_{4t-3} (2.099)**	- 5889.710 WW_{4t-1} (-3.611)***	- 59.434 HO_{t-1} (1.722)*	- 14.365 SM_{t-1} (-1.423)*		.916
South Atlantic	Q_{5t} =	6243.930 (s=1943.571)	+ .374 Q_{5t-1} (2.857)**	+ 184.394 P_{5t-1} (1.283)	- 26.672 C_{5t} (-3.669)***	- 33.496 RE_{4t} (-4.742)***	+ .344 E_{5t} (3.699)***	+ 55.424 UR_{5t-1} (1.730)*	- 11.110 HO_{t-1} (-1.355)*	- 11.386 AC_{t-1} (-2.366)**	.924
East South Central	Q_{6t} =	5732.804 (s=1636.016)	+ .637 Q_{6t-1} (4.405)***	+ 142.968 P_{6t-1} (1.913)**	- 17.615 C_{6t} (-2.673)***	+ 26.137 A_{6t-3} (1.893)**	- 1515.377 WW_{6t-1} (-3.551)***	- 16.178 HO_{t-1} (-1.678)*	- 7.411 SM_{t-1} (-2.418)**		.914
West South Central	Q_{7t} =	3691.934 (s=1488.418)	+ .358 Q_{7t-1} (2.030)**	+ 190.587 P_{7t-1} (2.298)**	- 12.031 C_{7t} (-1.888)**	+ 24.775 A_{7t-3} (1.967)**	- 10.481 RE_{7t} (-2.065)**	+ 63.956 UR_{7t-1} (2.008)**	- 3.424 CN_{t-1} (-2.334)**	+ 36.155 CR/M_{7t} (2.642)***	.958
Mountain	Q_{8t} =	4615.318 (s=1950.566)	+ .256 Q_{8t-1} (.969)	+ 155.577 P_{8t-1} (1.109)	- 15.750 C_{8t} (-2.179)**	+ 8.643 A_{8t-3} (1.335)*	- 14.682 RE_{8t} (-1.868)**	+ 40.606 UR_{8t-1} (1.057)	- 6.936 AC_{t-1} (-2.529)**		.736
Pacific	Q_{9t} =	1107.049 (s=1349.237)	+ .640 Q_{9t-1} (4.084)***	+ 748.577 P_{9t-1} (4.991)***	- 38.831 C_{9t} (-3.781)***	+ 24.482 A_{9t-3} (1.276)	- 32.260 RE_{9t} (-2.602)***	+ 151.603 UR_{9t-1} (3.126)***	+ .419 E_{9t} (3.913)***	- 1.355 AC_{t-1} (-2.833)***	.989
U.S. (Total)	Q_{10t} =	91048.491 (s=14255.188)	+ .390 Q_{10t-1} (4.455)***	+ 2216.990 P_{10t-1} (2.322)**	- 405.511 C_{10t} (-6.145)***	+ 165.871 A_{10t-3} (1.716)*	- 196.083 RE_{10t} (-2.335)**	+ 765.087 UR_{10t-1} (3.093)***	- 242.330 HO_{t-1} (-3.798)***	- 64.209 FV_{t-1} (-1.458)*	.953

6/ Except for the intercept, the values in parentheses under the coefficients are t values.

*** significant at the 1 percent probability level
** significant at the 5 percent probability level
* significant at the 10 percent probability level

The source and/or method of calculating each variable is presented in Appendix A. Data used was for the period 1947 to 1972. All the price variables were converted to real prices by deflating them with the Consumer Price Index.

ANALYTICAL RESULTS

Ordinary least squares was used to estimate the two models derived in the preceding section. The Nerlove adjustment model was fitted in terms of both actual observations and in logarithms of the observations. In general, the results were somewhat better with the actual observation. The overall fit, R^2 was about the same with both approaches, but the significance of the estimated coefficients tended to be higher for variables in actual values.

The polynomial lag model was estimated for actual values of observations only. Estimating in logs requires recalculation of new price variables.

Various specifications and combinations of the variables were used to obtain the best results. The criteria for selection of the specifications for use here were the commonly accepted criteria plus one other: (1) The estimated coefficient has to have the expected sign. (2) Except for the milk price variable the coefficient should approach at least the 10 percent level of significance using the one-tailed t test. In some cases a variable with a non-significant coefficient was retained in order to obtain the proper sign on the price coefficient. (3) The use of the variable should be based on an economic or technical rationale. (4) The regional estimates were chosen so that the sum of the milk price coefficients and the sum of cattle price coefficients approached the values of the estimated coefficients on the variables for the aggregate U.S. supply relation. For coefficients of logarithms of the observations, this requires that the sum of the regional coefficients weighted by the regions share of total milk production equal the coefficient of the variable in the aggregate U.S. supply relation. Obviously measurement and estimating errors will lead to some discrepancies.

Table 3 presents the estimated equations which were selected from among all estimates of equations in actual values of observations. The R^2's (adjusted for degrees of freedom) indicated the proportion of total variation in milk production for the 26 year period 1947-1972 that can be accounted for by these equations. The best fit is for the Pacific region where 98.9 percent of the variation in quantity is explained by the regression. The poorest fit was for the Mountain region where only 73.6 percent of the quantity variation could be accounted for with the estimated equation. Except for the Mountain regions, the estimated equations in table 3 accounted for 90 percent or more of the quantity variations for all regions.

The following discussion deals with specific responses and adjustments as indicated by the estimates in table 3 on other variations of the supply models.

The Adjustment Period

Some insight into the process of adjustment of milk production to a change in any of the determinants of milk production is given by the coefficients on Q_{it-1} in table 4. These values yield a measurement of the percent of total desired adjustment of milk production that occurs in the first year to changes in the factors influencing milk production for that year. Thus milk production in year t is partially determined by milk price for the preceding year. A change in the milk price in New England, for example means that 61 percent of the desired adjustment in milk production is made between year t and the following year. The same percentage of desired adjustment is made for the U.S. The smallest percent of adjustments are made in the West North Central and Pacific regions where 31 and 36 percent of the adjustments are made during the first year. The most rapid adjustment is made in the Mountain region, 74 percent of desired milk supply adjustment is made in the first year.

Table 4. Adjustment Coefficients and Number of Years for 95 Percent of Total Adjustment to Occur for Milk Supply in U.S. Regions

Region	Percent of Total Adjustment Which Occurs in First Year	Number of Years for 95 Percent of Total Adjustment to Occur
NE	61	3.19
MA	48	4.59
ENC	54	3.76
WNC	29	8.75
SA	63	3.02
ESC	34	6.50
WSC	64	2.86
M	74	2.17
Pac	36	6.71
U.S.	61	3.18

The number of years required for a given percentage of total adjustment to take place can be derived for the Nerlove form of the model.7/

7/ The proportion (P) of adjustment remaining after any given (n) number of years is $(1-\gamma)^n = p$. Thus for specified level of p, .05 for example,

$$n = \frac{\log p}{\log (1-\gamma)}$$

For five of the regions and the entire U.S., about 95 percent of the milk supply adjustment is made in three years or less after changes in one or more of the factors determining milk production in those regions. The longest period of adjustment is in the West North Central region, where according to our estimates, it requires about nine years to make 95 percent of the desired adjustment in milk production.

One might question why the large differences in adjustment periods among regions. The regions do differ in many respects, but the process of milk production is essentially the same regardless of the region. Thus, adjustments should be made with equal ease or difficulty for all regions. One explanation lies in the nature of the estimating model. The adjustment coefficient for any given region with this formulation is restricted to be equal for all factors influencing milk production. If, however, for some factors, adjustment is made rapidly and for others, adjustments are made with delays, then the estimated adjustment coefficient is an average of the adjustment to all factors. Depending on the relative importance of changes in factors determining milk production for each region during the period considered, 1947-1972 for our analysis, the adjustment patterns will differ.

Response to Price Changes and Supply Elasticities

The impact of price changes on milk supply, column 1, table 5, is the estimated coefficient on lagged price from the Nerlove formulation of the supply relations (in table 3). These values indicate the actual adjustment in millions of pounds of milk to each dollar change in the real price of milk. Real price was calculated by deflating actual prices by the Consumer Price Index with the 1967 base.

All of the estimates in the table have positive values which is consistent with the theory of supply. It means that price increases with everything else fixed causes milk production to increase or that price decreases will cause milk production to decrease. As stated above, one of the criteria for selection of estimated equations was that the sum of these responses to price for regions should approximate the response to price as estimated for the aggregate U.S. supply relation. In this case, regional responses to price change sum to 2769.6, somewhat higher than the single aggregate U.S. estimate, yet these equations resulted in more consistent results than other specifications.

Conversion of the estimates in column 1 of table 5 to percentage responses, the price elasticities of supply, permits one to determine the degree of responsiveness of milk supply and to compare regions with regard to relative responsiveness of milk production to price change.[8/] The elasticity is the response of milk production in percent to a one percent change in milk price. Columns 2 and 3 of the table list these elasticities for both the short-run and the long-run. The short-run is the one year adjustment to price change, the long-run periods are roughly the periods calculated in the last section.

Milk supply in the short-run is relatively unresponsive to price change. Production is least responsive in the West North Central region. For each one percent change in milk price, production changes in the same direction by .03 percent. Production is most responsive in the Pacific region, .37 percent for each 1 percent change in price. The other short-run elasticities vary from

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8/ All elasticities were calculated at the mean values of prices and quantities for the period of analysis, 1947-1972.

Table 5. Response of Milk Production to Changes in Real (Deflated) Milk Price

Region	Response in Millions of lbs. to Each $1/cwt. Change in Price	Price Elasticities of Milk Supply (Percent Change in Milk Production to a One Percent Change in Milk Price) Short-run	Long-run
NE	151.9**	.219	.359
MA	385.5*	.123	.258
ENC	635.3**	.083	.152
WNC	174.7	.030	.101
SA	184.4	.142	.227
ESC	143.0**	.109	.299
WSC	190.6**	.183	.285
M	155.6	.176	.236
Pac.	748.6**	.374	1.040
U.S.	2217.0***	.089	.145

*** Estimated coefficient statistically significant at the 1% probability level, 1 tailed t-test.

** Estimated coefficient statistically significant at the 5% probability level, 1 tailed t-test.

* Estimated coefficient statistically significant at the 10% probability level, 1 tailed t-test.

.08 to .22. The range of these estimates are consistent with those estimated in the studies cited earlier. There is not a strong indication that supply is becoming more inelastic.

The long-run elasticities of supply except for the Pacific region, also indicate relatively small response to price changes. A one percent price change will bring a .10 percent total change in milk production in the long-run in the West North Central region and a .36 percent change in New England. The relatively high elasticity in the Pacific region. 1.04, is somewhat consistent with the results of the Chen, Courtney, and Schmitz study.9/ They estimated a long-run price elasticity of supply of 2.53 for California.

A number of analysts of agricultural supply have attempted to measure separately, the responses of agricultural supply to price decreases and price increases.10/ The basis for this procedure is that during periods of rising prices, farmers are optimistic about the future and they are likely to have profits to reinvest. Therefore, they adopt new output increasing technology. Thus, output response to price increases is composed of a shift to the right of the supply curve representing a shift of the production function and movement up the shifting supply curve. When prices fall new techniques are not dropped. The response to price is then only a shift down a stable supply curve. Hence, supply should be more elastic (responsive) to price increases than to price decreases. For this study a model with separate variables for price increases and decreases was estimated for each region.11/

9/ Chen, Dean, R. Courtney, and A. Schmitz, op. cit.

10/ See W. W. Cochrane, "Conceptualizing the Supply Relation in Agriculture," Journal of Farm Economics, Vol. 37, Dec. 1955, pp. 1161-1176, and Halvorson, Harlow, "The Response of Milk Production to Price," JFE, Vol. 40, Dec. 1958, pp.1101-1113.

11/ Based on technique outlined by R. Wolffram, "Positivistic Measures of Aggregate Supply Elasticities: Some New Approaches", AJAE, Vol. 53, May 1971, pp. 356-359. The calculation of price variables as described in that article is as follows:

Let X_i be the original observation on price for periods i = 1 to n

Let X'_i be the new price observation for price increases for periods i=1 to n

Let X''_i be the new price observation for price decreases for period i=1 to n

Let the first period observation on X' and X'' take the values of X_1 or $X'_1=X_1$ and $X''=X_1$

For subsequent years (all years i=2 to i=n) $X'_i = X'_{i-1}+\phi(X_i-X_{i-1})$ and $X''_i=X''_{i-1}+(1-\phi)(X_i-X_{i-1})$

where: $\phi = 1$ if $(X_i-X_{i-1}) > 0$; $\phi = 0$ if $(X_i-X_{i-1}) < 0$

The estimated equations are presented in appendix 2.

The estimated milk production responses to price increases and price decreases are rather poor. In one region, the West South Central, the relationship between the two coefficients was the opposite of that hypothesized. That is, milk production was less responsive to price increases than to price decreases. Only three of the regional estimates yielded responses that were different statistically when tested by t-test for difference between means at the five percent probability level. These were the East North Central, the South Atlantic, and the East South Central regions. The short run price elasticities for these regions for price increases are .458, .330, and .239 respectively. The short-run elasticities for price decreases are .156, .098 and .087 respectively. For the South Atlantic and East South Central regions these estimates bracket the elasticities presented in table 3. But, for the ENC region, the values are both larger than the single elasticity estimate presented in table 3. Because of the lack of strong evidence for all regions that production responses to price changes differ for price increases and price decreases and because the overall fit of the supply relationships were not improved with the modification additional analysis with this technique was not undertaken.

The estimated equations with the price variables calculated with a polynomial form of the adjustment to price are presented in appendix 2.[12/] The coefficients on the price variables, PX_1 and PX_2, need to be unscrambled to determine quantity response in a given year to the price changes.[13/] These

12/ This method requires selection of the period of adjustment. On the basis of the adjustment period estimated in the Nerlove formulation of the lag, a period of four years was used to allow for the adjustment.

13/ For a discussion of this unscrambling process, see Chen, Courtney, and Schmitz, op. cit.

values can be used to calculate price elasticities for any year in the adjustment period.

Results from this form of the supply model were poor. The estimated coefficients were significant for several of the regions, but the elasticities calculated from them are inconsistent with the hypothesized relationship between changes in price and changes in quantity supplied. For all regions for at least some years in the adjustment period, the estimated elasticities indicate that milk production would increase in response to price decreases. For the Pacific region, the elasticities of milk supply for each year in the adjustment period with respect to a price change in year t were estimated as follows:

Year		Elasticity
t+1		.345
t+2		.102
t+3		-.037
t+4		-.071
	Total	.339

The maximum response occurred in the year following the price change, a .345 percent increase in milk production to a one percent price change. The second year following the change, production increased another .102 percent, but decreased in the next two years. The total elasticity for the four year period is .339, about the same as that estimated with the Nerlove formulation of the lag. Thus, even though the formulation of the estimating model permitted a different pattern of adjustment, maximum positive response occurred in the first year.

The polynomial lag model of supply did not improve the estimates of either the short-run or long-run price elasticities of supply nor did it strongly suggest a different time pattern of adjustment than with the Nerlove model. With this formulation, only one region yielded a maximum positive price-quantity relationship in other than the first year of the adjustment period. A modification of the model, beginning the four year adjustment period at the year of the price change rather than the following year did not improve the results. For these reasons, in addition to the difficulty of rationalizing negative price-quantity relationships for supply, no additional analyses or projections were undertaken with the polynomial forumlation.

The measures of supply response to price changes described above are calculated from real prices for milk, that is, actual milk prices deflated

Table 6. Regional Milk Prices Deflated by Consumer Price Index (1967=100)

Region	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958
							Dollars/cwt.						
NE	7.12	8.27	7.88	8.38	7.31	6.91	7.07	7.21	6.43	6.22	6.41	6.35	6.45
MA	6.43	7.39	6.98	7.39	6.18	5.84	6.23	6.25	5.69	5.37	5.39	5.43	5.65
ENC	5.42	6.46	5.83	6.27	4.73	4.72	5.32	5.52	4.74	4.29	4.35	4.53	4.38
WNC	5.27	6.09	5.59	5.96	4.65	4.69	5.18	5.40	4.62	4.22	4.25	4.26	4.10
SA	7.27	7.98	7.88	7.96	7.25	7.06	7.28	7.43	7.00	6.55	6.58	6.57	6.45
ESC	8.22	7.20	6.80	7.10	5.76	5.58	6.16	6.39	5.48	4.97	5.13	5.17	4.97
WSC	6.44	7.28	7.59	7.88	7.13	6.78	7.35	7.94	6.94	6.25	6.43	6.46	6.15
M	5.40	6.10	5.99	6.21	5.45	5.24	5.59	6.03	5.39	4.94	5.09	5.17	5.04
Pac	6.42	7.15	6.71	6.84	5.98	5.62	6.17	6.68	6.03	5.24	5.22	5.42	5.34
U.S.	5.91	6.82	6.38	6.77	5.53	5.40	5.89	6.10	5.39	4.93	5.00	5.09	4.99

Table 6. Continued

Region	1959	1960	1961	1962	1963	1964	1965	1966	1967
NE	6.09	6.25	6.08	5.76	5.63	5.15	5.57	5.45	5.91
MA	5.47	5.46	5.24	5.09	4.91	4.85	4.87	4.84	5.21
ENC	4.12	4.12	4.25	4.29	4.06	4.01	4.02	4.05	4.66
WNC	3.88	3.87	3.86	3.94	3.75	3.70	3.70	3.73	4.23
SA	6.35	6.27	6.18	6.04	5.93	5.89	5.90	5.85	6.10
ESC	4.87	4.93	4.94	4.84	4.69	4.71	4.76	4.73	5.26
WSC	5.94	5.75	5.68	5.58	5.31	5.40	5.41	5.31	5.90
M	4.83	4.75	4.66	4.69	4.57	4.56	4.55	4.53	4.96
Pac	5.07	5.11	5.01	4.97	4.85	4.74	4.77	4.74	4.91
U.S.	4.77	4.77	4.75	4.71	4.51	4.47	4.47	4.48	4.95

	1968	1969	1970	1971	1972
NE	5.93	5.96	5.86	5.73	5.62
MA	5.38	5.43	5.42	5.26	5.19
ENC	4.72	4.76	4.72	4.63	4.60
WNC	4.28	4.31	4.32	4.27	4.25
SA	6.22	6.15	6.03	5.87	5.78
ESC	5.30	5.28	5.19	4.99	4.91
WSC	5.87	5.91	5.91	5.75	5.54
M	5.01	4.98	4.92	4.87	4.83
Pac	4.97	4.91	4.80	4.70	4.66
U.S.	5.02	5.04	5.00	4.91	4.83

by the consumer price index. These deflated or real prices are reproduced in table 6 for the years of the analysis 1947-1972. They indicate part of the reason for the declines in milk production that have been observed in some regions for much of the period. The table shows that prices have generally fallen throughout the period. There was a slight recovery in 1960, but at no time have real prices achieved their 1947-1949 levels. Real milk prices in those years ranged from $5.99 to $8.29 per cwt. for the nine regions. For the last two years of the period, 1971-1972, real price did not exceed $6.00 per cwt. in any of the regions.

To obtain some idea of the net impact of the price changes on milk production, the percentage decline in milk production can be multiplied times the estimated long-run supply elasticity. Thus, for New England, the real milk price decline of 31 percent from 1947 to 1971 implies an 11.1 (.359 X 31) percent decline in milk production for the period 1948 to 1972. Similar kinds of net impacts could be calculated for other regions. Without some off-setting factors, improved technology of milk production or favorable prices of alternative activities or inputs, milk production would have shown substantial declines for all areas. The nature of some of these other factors and their impacts are discussed below.

Alternative Farm Enterprises

The relative profitability of feasible alternatives to milk production should influence the quantity of milk production. If hog production becomes more profitable relative to milk production in the East North Central region, milk production should decline as resources are transferred to that enterprise. Measures of profitability are difficult to obtain, however, prices should be

Table 7. Impact of Prices for Alternative Farm Products on Milk Production

Region	Impact on milk production of a one unit change in:			
	Cattle Price in Dollars per cwt.[a]		Hog Price in Dollars per cwt.[a]	
	Quantity response in millions of pounds to a $1/cwt. price change	Elasticity with respect to cattle price	Response in millions of pounds to a $1/cwt. price change	Elasticity of quantity with respect to hog price
NE	- 11.747***	-.048	- 13.508***	-.067
MA	- 29.483**	-.034	--	--
ENC	- 66.296**	-.046	-143.241***	-.089
WNC	- 85.935***	-.085	--	--
SA	- 26.072***	-.065	- 11.110*	-.029
ESC	- 17.615***	-.055	- 16.178*	-.050
WSC	- 12.031**	-.041	--	--
M	- 15.750**	-.088	--	--
Pac	- 38.831***	-.091	--	--
U.S.	-405.511***	-.083	242.330***	-.044

a/ All prices were deflated by the consumer price index.

*** significant at the 1 percent probability level

** significant at the 5 percent probability level

* significant at the 10 percent probability level

reasonably good indicators of relative profit levels. Rising prices of other farm products should be associated with declining milk production or vice versa.

To obtain measures of the impact of these other product prices on milk production, prices of farm products which might alternatively be produced in

Table 7. Continued

Region	Index of all crop prices		Index of all cotton prices		Index of fresh vegetable prices	
	Response in mil. of lbs. to a 1% change in price	Elas. with respect to all crop prices	Response in mil. of lbs. to a 1% change in price	Elas. with respect to cotton price	Response in mil. of lbs. to a 1% change in price	Elas. with respect to fresh vegetable price
NE	--	--	--	--	--	--
MA	--	--	--	--	--	--
ENC	--	--	--	--	--	--
WNC	--	--	--	--	--	--
SA	-11.386**	-.167	--	--	--	--
ESC	--	--	--	--	--	--
WSC	--	--	-3.424**	-.082	--	--
M	-6.936**	-.192	--	--	--	--
Pac	-1.355***	-.016	--	--	--	--
U.S.	--	--	--	--	-64.209*	-.053

*** significant at the 1 percent probability level

** significant at the 5 percent probability level

* significant at the 10 percent probability level

each region were included in the estimating equations. Those that gave significant results for one or more of the regions were cattle prices, hog prices, all crop prices and fresh vegetable prices. For estimation, all these prices were deflated by the Consumer Price Index and except for cattle prices, they were lagged one period. The variables in the estimated equations described above are denoted respectively as C_{it}, HO_{t-1}, AC_{t-1}, CN_{t-1}, and FV_{t-1}. The estimated coefficients are reproduced in the first column under each indicated price in table 7.

Cattle price yielded significant results for all regions. The values in the first column under cattle price are the measures of quantity adjustment of milk production in millions of pounds to a one dollar per cwt. change in cattle price. The negative sign means that quantity changes in the direction opposite the price change. For the West North Central region, an important cattle producing region, a one dollar increase in real cattle prices causes milk production to decline by 85 million pounds.

The standardized measure of this response, the elasticity of milk supply to cattle price is listed in the second column under that product. For cattle price, this indicates a rather consistent pattern of response. Each one percent change in cattle price brings a somewhat less than .10 percent opposite change in milk production. The range in values for the nine regions and the total U.S. is from -.03 to -.09.

Hog prices were found to be significantly related to milk production in only four regions, New England, East North Central, South Atlantic, and East South Central. The elasticities of response to hog prices are similar to those for cattle -.03 to -.09. The significant result for New England is baffling in that hog production in terms of value of farm production in that region is relatively unimportant. Perhaps, its price is a proxy for some other farm production alternative in that region.

Movement in the all crop index had the most impact on milk production in the Mountain region. For each one percent change in all crop price, milk production changed by 1.92 percent in the opposite direction.

Cotton prices were associated with milk production in the West South Central region, a .08 percent opposing change for each one percent change in cotton price.

For the aggregate U.S. relation, fresh vegetable prices were associated with milk production. In some areas of the U.S. one would find that this enterprise competes with dairying for resources. This is likely to be the case in truck farming areas around population center areas which may also be the milkshed for the center.

It may also be noted in table 2 that soybean price was significantly associated with milk production in the Middle Atlantic region. Since this is not an important soybean producing region, these relationships may be more properly interpreted as a response to input prices, a soybean product, meal, being an important ingredient and cost component in dairy rations.

Input Characteristics and Prices

Both quality and prices of milk production inputs should have an impact on the level of milk production. Unfortunately, the only readily available measure of input quality is a monthly report of indexes of pasture conditions by state.[14/] These indexes were incorporated into the regional models of milk production by taking a simple average of the monthly observations for all states in the region for each year. This composite index, however, showed no significant relationship for any of the regions. In fact, many of our estimates indicated the opposite relation from that which would be expected. One would expect that the better the pasture conditions in a given year the greater the supply of milk.

The failure to observe a positive relation between pasture conditions and milk production may have several causes. (1) The computed simple average

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14/ AMS, "Crops and Markets", USDA Annual publication.

of monthly indexes for the states in the region may be a poor indication of average pasture conditions for the region. (2) The reported state indexes of pasture conditions may inaccurately represent pasture conditions. Because estimating pasture conditions is a very subjective process, inaccuracies are likely to exist. Nevertheless, future work should involve new procedures for developing regional pasture condition indexes.

Prices of several dairy production inputs were analyzed for their impact on milk production, baled hay prices, 16 percent dairy ration price, soybean meal price, and land price. All prices were deflated by the Consumer Price Index. The regional baled hay prices and dairy ration prices for each region were simple averages of monthly state prices for the inputs. Like the results for pasture condition, these two prices did not exhibit a significant relationship to milk production. The same reasons as with pasture conditions may explain the inability to obtain significant and plausible results.

For three regions, prices of ingredients in dairy cow rations did yield significant results. In the West North Central and East South Central regions, deflated average U.S. soybean meal price lagged by one year (denoted by SM_{t-1} in table 2) was negatively associated with the level of milk production. The response in actual value together with the standardized measure of response are listed under soybean meal in table 8. The standardized response indicates that a one percent increase in meal price is associated with .05 and .09 percent declines in milk production in the West North Central and East North Central regions respectively. In the Middle Atlantic region average U.S. soybean price appeared to be related to milk production. As indicated in a preceding section, this probably is an indicator of input price, not a

Table 8. The Impact of Input Prices on Milk Production 1947-1972.

Region	Real Estate Price		Soybean Meal Price in Year t-1	
	Quantity response in mils. of lbs. to a 1% change in deflated land price	Elasticity of quantity with resp. to deflated land price	Quantity response in mils. of lbs. to a $1. per ton change in deflated soybean meal price	Elasticity of quantity with resp. to deflated soybean meal price
NE	- 9.954***	-.190	--	--
MA	- 39.439***	-.188	-330.413[a]/**	-.055
ENC	-105.052***	-.337	--	--
WNC	--	--	- 14.365*	-.045
SA	- 33.496***	-.302	--	--
ESC	--	--	- 7.411**	-.085
WSC	- 10.481**	-.127	--	--
M	- 14.682**	-.269	--	--
Pac	- 32.260***	-.234	--	--
U.S.	196.083**	-.129	--	--

a/ soybean price per bushel. Deflated by CPI.

*** significant at the 1 percent probability level

** significant at the 5 percent probability level

* significant at the 10 percent probability level

production alternative. In that region a one percent change in soybean price is associated with a .06 percent change in the opposite direction in milk production. All are relatively small responses. It would take roughly a 50 percent change in real meal prices in the West North Central region to change milk production by one percent.

Table 9. Impact of Technical Change on Milk Production 1947-1972.

Region	Artificial Insemination in Year t-3: Response of milk production in millions of pounds to proportion of cows bred artificially in region	Elasticity of milk production with respect to cows bred artificially [a/] long
NE	25.404***	.375
MA	111.331***	.418
ENC	147.621***	.254
WNC	126.665**	.213
SA	--	--
ESC	26.137**	.108
WSC	24.775**	.103
M	8.643*	.094
Pac	24.482	.097
U.S.	165.871*	.070

a/ calculated at the 1970 values of At-3 and quantity

*** significant at the 1 percent probability level

** significant at the 5 percent probability level

* significant at the 10 percent probability level

Deflated land prices were significantly related to the level of milk production in seven of the nine regions (see the coefficients on RE_{it} in table 2). The absolute impact of a one percent change in the index of land prices are reproduced in table 5. The elasticity of milk production to this input appears higher than that for the other inputs, ranging from -.13 to -.34. The relatively small range of variability in these responses plus the statistical significance associated with each indicates that they should be good estimates of the relation.

Technical Change

Technical change includes any change in resource combinations or improved resource quality that increases output from a given expenditure. In dairying, the quality of dairy cattle has been improved for a number of years by artificial breeding programs. To measure the impact, the percent of total dairy cattle in each region which were bred artificially was incorporated into the estimating equations.[15/] Two specifications were considered, one with a two year lag and one with a three year lag. The three year lag (indicated by A_{it-3} in table 3) yielded the best results.

The elasticities of milk production with respect to artificial insemination indicate that a one percent increase in the percent of cows bred artificially will cause milk production in these regions to increase from .09 to .42 percent (see table 9). Considering the percentages of cows bred artificially were zero or nearly zero at the beginning of the period of analysis and now range from 26.9 to 64.5 for the regions, this aspect of technological improvement has probably been one of the chief reasons that milk production did not decline. It offset the decline that would have been realized because of declining real milk prices.

Market Induced Supply Changes

During the period 1947 to 1972 several characteristics of the regional markets for milk and milk products underwent substantial change. Some of the regions experienced a large shift from farm separated cream sales to farm sales

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15/ For first part of the period of analysis, percentages of cows bred artificially were reported only for combined groups of our regional classes. Consequently, the combined regional percentages were used for each of the included regions for the entire period. The New England and Middle Atlantic analyses, for example, used the same series even though actual percentages were somehwat different It was assumed that changes in percentages in each region were indicated in the combined percentages.

of whole milk. This was related largely to changing product demands. Additionally, the Pacific and South Atlantic regions experienced large growth in population and economic activity with the resulting impact on markets for fluid milk products in particular. These changes in market potential should be expected to generate changes in milk production apart from the price induced changes. Two variables were incorporated into the analyses to determine if such an impact existed.16/ They were percent of total farm milk sales sold as farm separated cream and the total employment in the region to reflect change in economic activity. (Indicated by CR/M and E in table 2).

Table 10. Impact of Change in Market Structure on Milk Production.

	Size of Market as reflected in regional employment.		Shift in Market from cream sales to whole milk sales.	
Region	Response of milk production in mils. of lbs. to total employment in region - thousands of persons employed in the region.	Elasticity of milk production with respect to total employment in region.	Response of milk production in mils. of lbs. to percent of milk sold as farm separated cream.	Elasticity of milk production with respect to percent of milk sold as farm separated cream.
SA	.344***	.283	--	--
WSC	--	--	36.155***	.052
Pac	.419***	.155	--	--

*** significant at the 1 percent probability level.

16/ One could argue that CR/M and E_t impact solely on demand and, therefore, affect supply only through price. To measure this net effect, a simultaneous equation system would be required.

Only the West South Central region exhibited a response to cream sales and this was relatively small (see table 10). For each one percent decrease in the percent of total milk sold as cream, total milk production declined by .05 percent.

The impact of economic activity as measured by employment on milk production was associated with milk production in the two regions where such changes were important, the South Atlantic and the Pacific regions. A one percent growth in employment was associated with a .28 and .16 percent increase in milk production in the respective regions (table 7).

Non-farm Alternatives

The opportunities for dairy farm labor to find employment in non-agricultural occupations should have an impact on milk production. These opportunities might be considered from one or both of two perspectives, (1) the availability of non-farm jobs which could be represented by unemployment rates, and (2) the attractiveness of non-farm jobs which may be indicated by the wage rate. Of the various specifications of these two factors, one of two were found to be associated with milk production in each of the regions.

For five regions, New England, Middle Atlantic, East North Central, West North Central, and East South Central the lagged real wage rate adjusted downward by the percent of unemployment was negatively associated with milk production (indicated by WW_{it-1} in table 2). The elasticity of milk production with respect to this adjusted wage rate is listed in column 2 under wage rate in table 11. The response is fairly stable from region to region varying from -.36 to -.59. Thus a 10 percent increase in the adjusted real wage in these regions will be associated with a 3.6 to 5.9 percent decline in milk production.

Table 11. Impact of Non-farm Job Opportunities on Milk Production 1947-1972.

Region	Wage rate in year t-1 [a] for level of unemployment in region		Unemployment rate in year t-1	
	Response of milk production in mils. of lbs. to hourly wage rate in region	Elasticity of milk production with respect to wage rates in region	Response of milk production in mils. of lbs. to a 1% change in unemployment rate in region	Elasticity of milk production with respect to the unemployment rate
NE	- 777.339	-.381	--	--
MA	-3125.030	-.425	--	--
ENC	-4840.995	-.357	--	--
WNC	-5889.710	-.590	--	--
SA	--	--	55.424	.031
ESC	-1515.377	-.417	--	--
WSC	--	--	63.956	.046
M	--	--	40.606	.042
Pac	--	--	151.603	.066
U.S.	--	--	765.087	.030

a/ actual wage deflated by the Consumer Price Index.

The unemployment rates lagged one year yielded better results for the other four regions and the U.S. than wage rates. Here also, the relative responses were quite similar among the four regions. A one percent change in the unemployment rate is associated with a .03 to .07 change in the same direction in milk production.

COMPARISON OF PREDICTED WITH ACTUAL LEVELS OF MILK PRODUCTION

Predicted levels of milk production from the supply equations of table 3 and actual levels of milk production are plotted in figures 2a through 2j for each region. Examination of these relations indicates graphically how good a job the equations do in explaining milk production during the period of analysis, whether the estimated model picks up changes in direction of milk production immediately or with a lag and the nature of the variations of predicted milk production from actual.

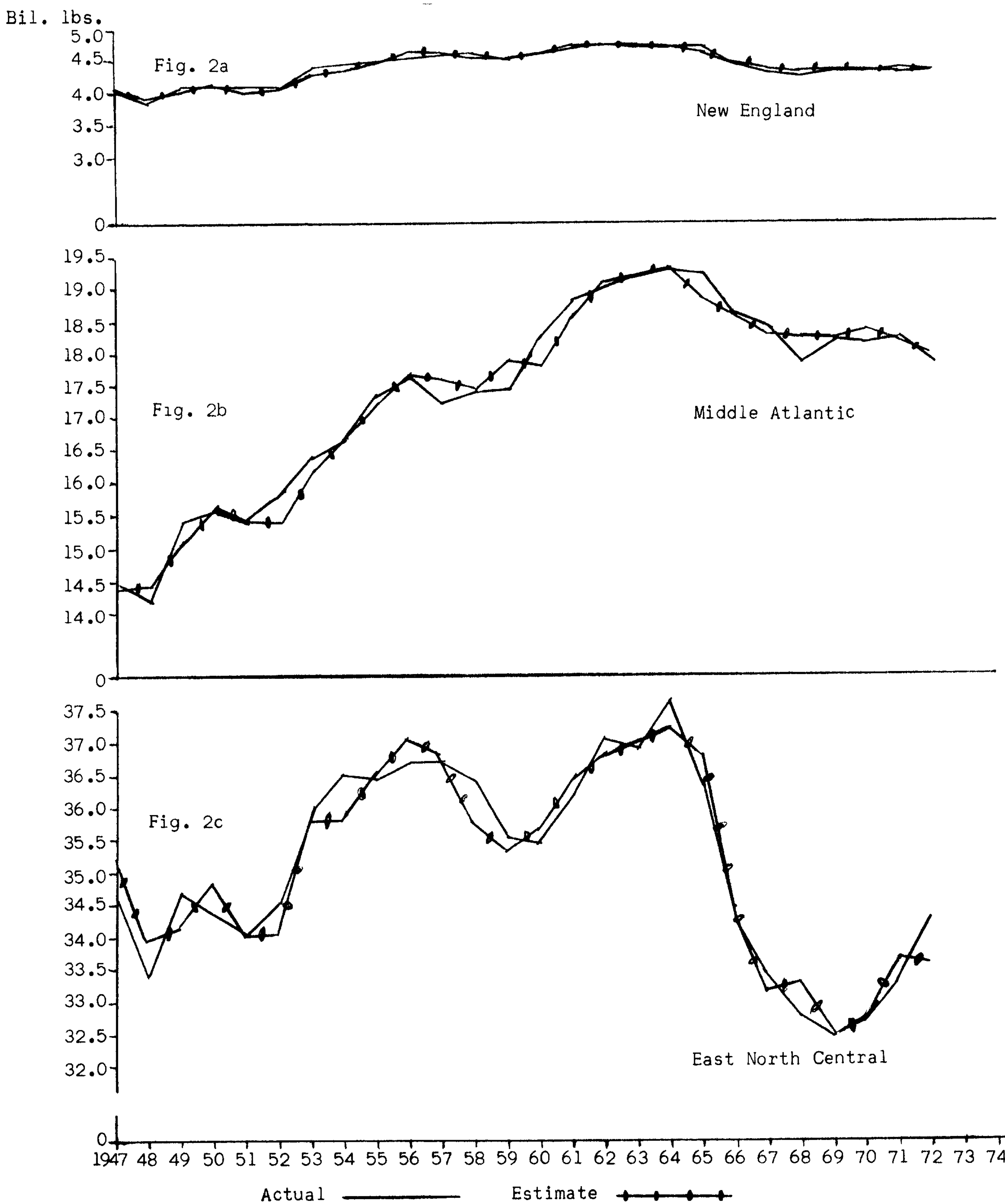
For those regions with significant changes in directions of milk production, the estimated relations appear to often lag by about a year in picking up the change. In the West North Central region, there were nine reversals in direction in milk production. The estimated relation showed the change occurring with a lag of one year for four of the changes and failing completely to pick up the change for several (see figure 2d).

The aggregate U.S. estimates appear better to reflect changes in milk production than for the regions. All the reversals in direction were estimated with the model in the same year they occured. However, for one year, 1967, the model predicted a reversal that did not occur.

1973 AND 1974 PROJECTIONS OF MILK PRODUCTION

Milk production projections with the supply models presented in table 2, were made for the years 1973 and 1974. Projections for 1973 provide a check as we now have at least preliminary statistics on all milk production as well as all of the determinants of milk production. However, it should be noted that ERS began a different basis of reporting farm real estate indexes in 1972.

Figure 2. Projected and Actual Milk Production in U.S. Regions 1947-1972.



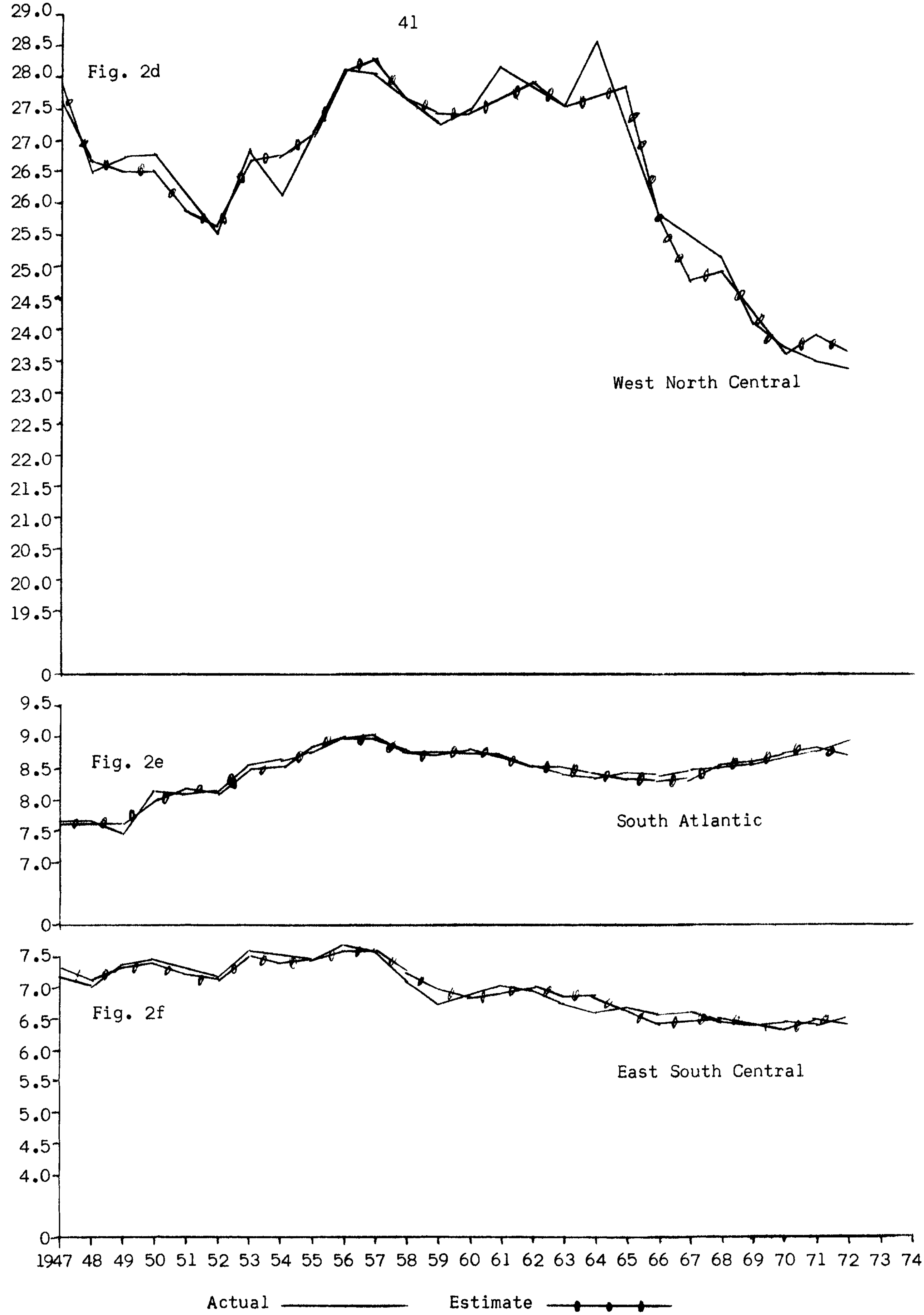


Fig. 2d
West North Central
Fig. 2e
South Atlantic
Fig. 2f
East South Central
1947 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74
Actual
Estimate

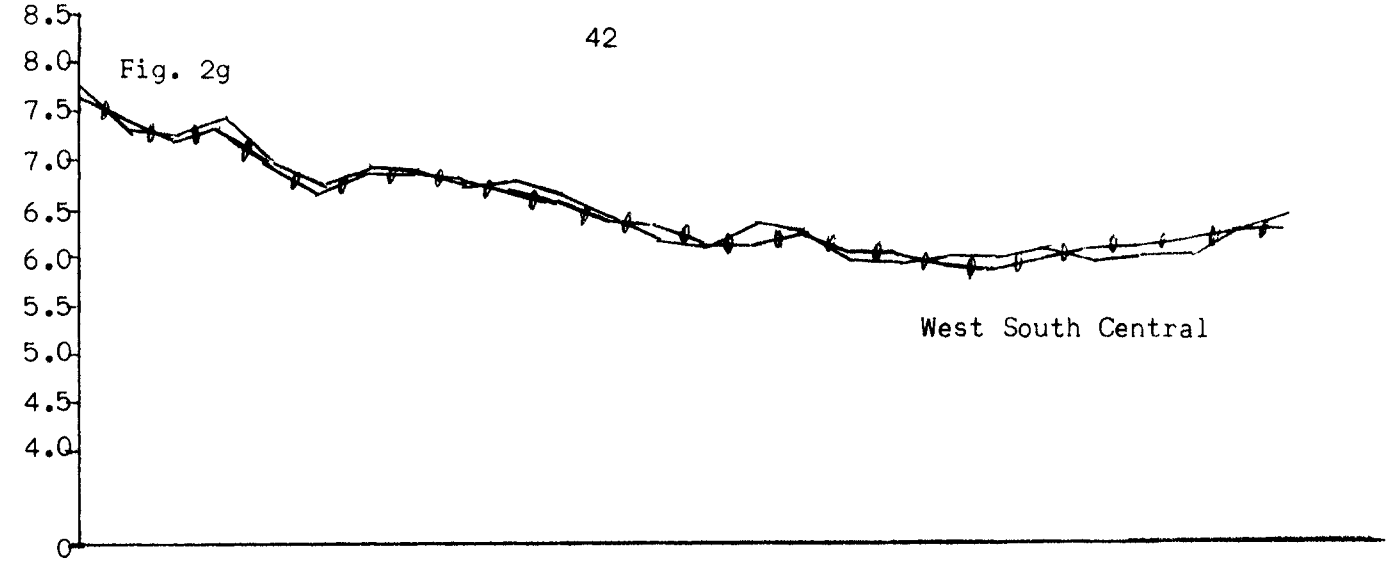


Fig. 2g
West South Central
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
0

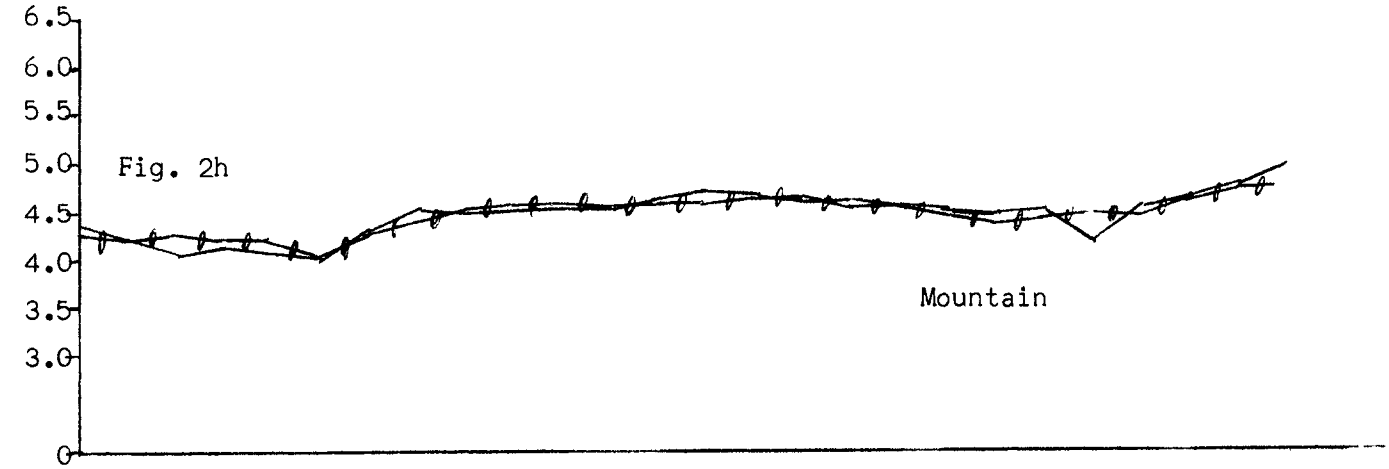


Fig. 2h
Mountain
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5.5
5.0
4.5
4.0
3.5
3.0
0

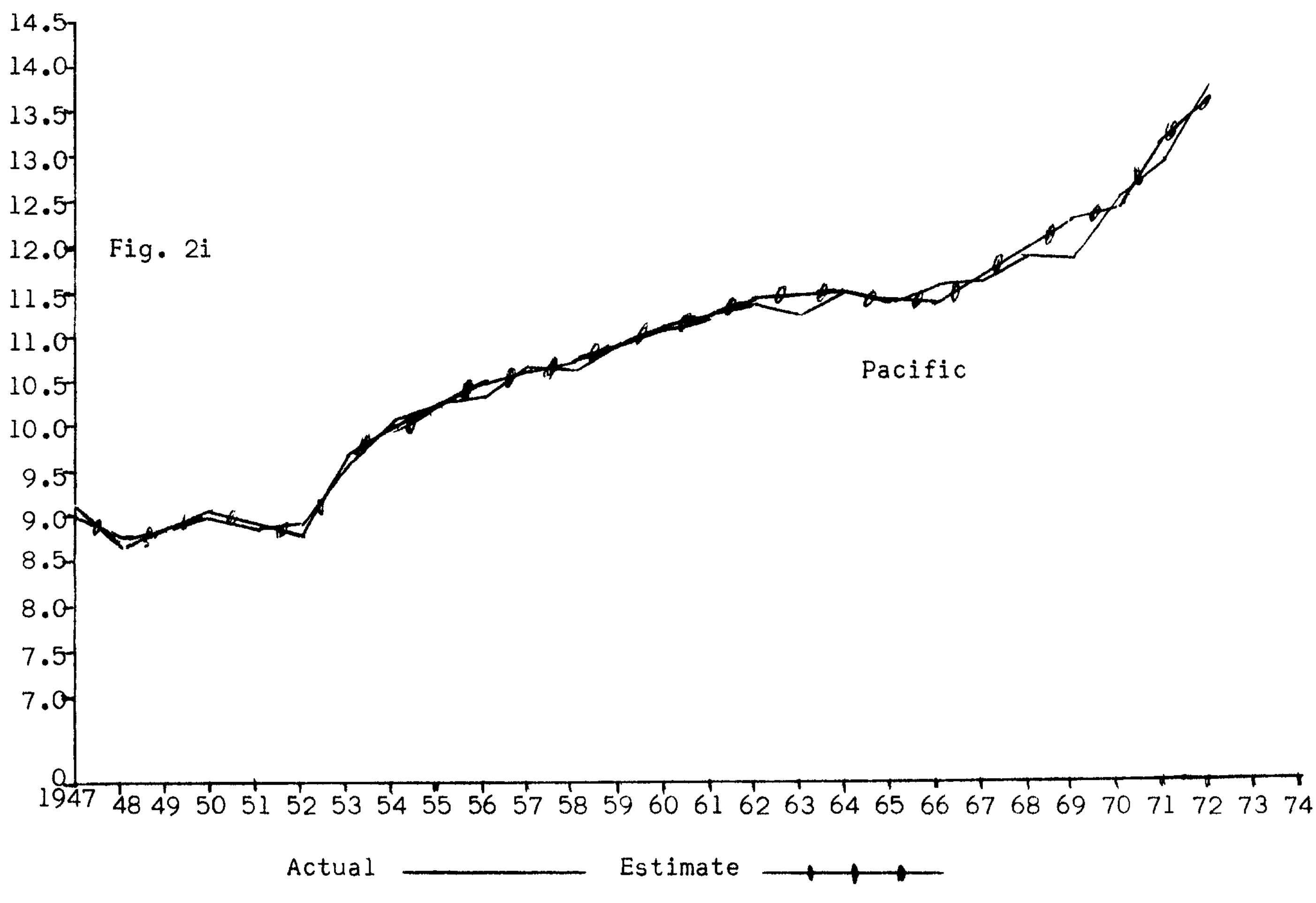
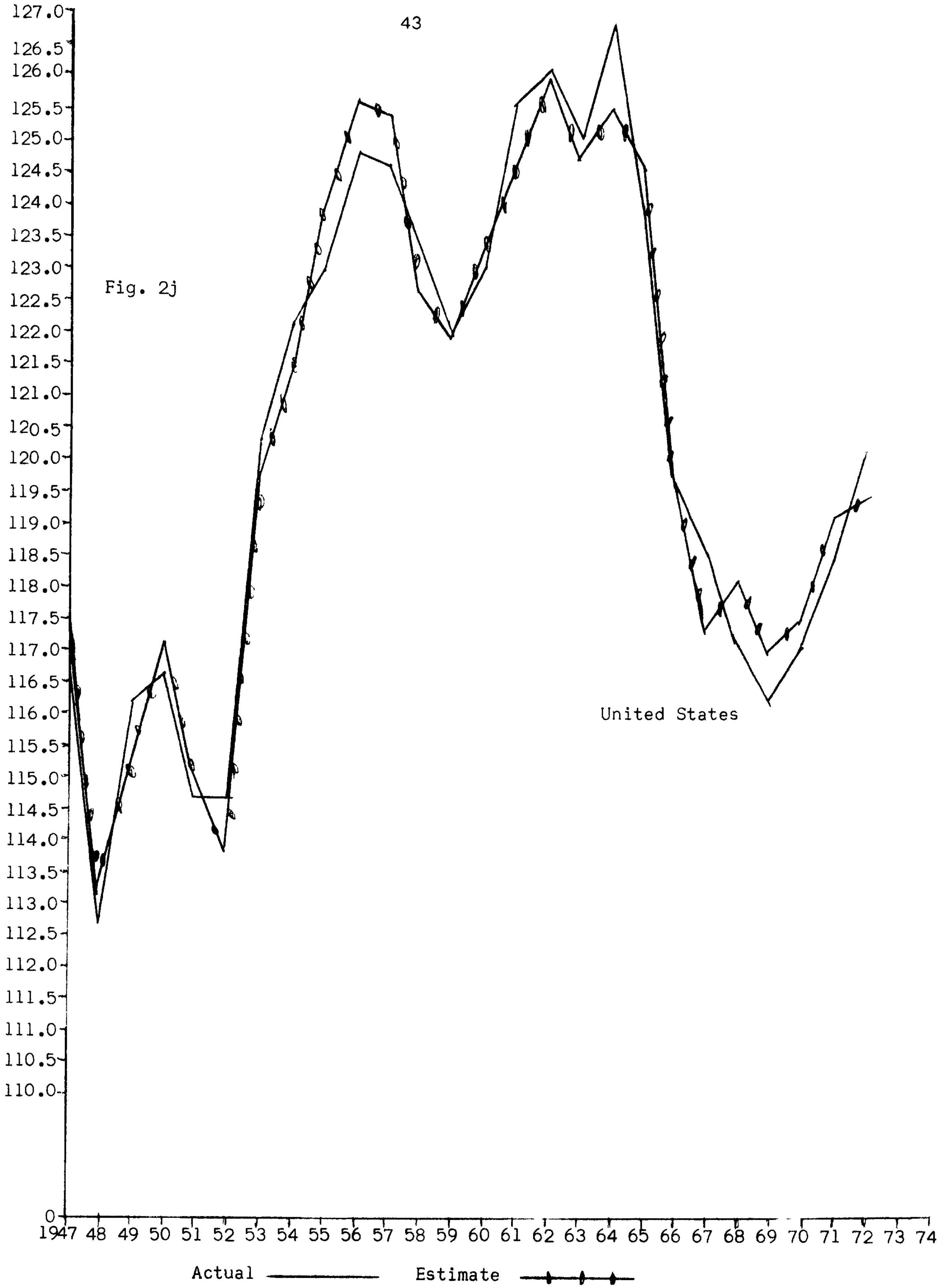


Fig. 2i
Pacific
14.5
14.0
13.5
13.0
12.5
12.0
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
0
1947 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74
Actual
Estimate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1947 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74
Fig. 2j
United States
Actual
Estimate

Table 12. Projected Levels of Milk Production in the U.S., 1973 and 1974, (excluding Alaska and Hawaii).

Region	1972 Actual Production*	1973 Actual Production		1973 Projected Production		Error	1974 Projected Production	
	Mils. of lbs.	Mils.* of lbs.	Percent change 1972-73	Mils. of lbs.	Percent change 1972-73	Percent Projected exceeded or fell short of actual	Mils. of lbs.	Percent change 1973-74
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NE	4371	4178	-4.4	4065.4	-7.0	-2.7	4003.8	- 4.2
MA	17982	17020	-5.3	17077.3	-5.0	+ .3	16055.2	- 5.7
ENC	34057	32548	-4.4	31356.7	-6.9	-3.7	29738.4	- 8.6
WNC	22778	22069	-3.1	21715.2	-4.7	-1.6	20073.7	- 9.0
SA	8930	8686	-2.7	8567.1	-4.1	+1.4	8130.5	- 6.4
ESC	6490	6096	-6.1	6229.5	-4.0	+2.2	5037.2	-17.4
WSC	6435	6179	-4.0	6200.5	-3.6	+1.7	6125.3	- .9
Moun.	4995	4994	0	4771.4	-4.5	-4.5	4632.0	- 7.2
Pac.	13712	13694	- .1	14213.0	+3.7	+3.8	14031.1	+ 2.5
Total of Regions	119750	115464	-3.6	114196.2	-4.6	-1.1	107827.2	- 6.6
U.S.	119750	115464	-3.6	116298.5	-2.9	+ .7	111804.6	- 3.2

*SOURCE: "Milk Production, April, 1974," SRS, USDA, Washington, D.C., May 9, 1974.

Thus we adjusted the reported figures to make them comparable with the indexes used in estimating the models. For 1974, data are now available for some of the determinants of milk production because of their lagged impact on production. Values need to be assumed or projected for three of the variables, beef cattle prices, real estate prices and total employment for two of the regions. All values used in the projections are reproduced in Appendix table 2.

The 1974 beef cattle price used for these projections is slightly lower than 1973 levels in real terms. These values were based on discussions with livestock specialists in the U. of M.'s Agricultural and Applied Economics department. They are predicting actual average cattle prices to be at about 1973 levels for 1974. Deflating by the CPI which is likely to rise at least 6 percentage points for 1974 results in a fall in real cattle price.

USDA reports on farm real estate prices forecasts a slowing down of land price rises in 1974. We assumed a 5 percent real price increase on land in 1974.

For the two regions where total employment was needed for the regional forecasting model, recent trends indicate an annual increase of about 500,000 persons for the South Atlantic region and 300,000 for the Pacific region. These increases were used for 1974 projections.

The projections with the models reveal a better overall estimate for 1973 from the aggregate U.S. relation than for most regions (see column 6, table 12.) The aggregate U.S. model overestimated actual 1973 milk production by .7 percent. Only the Middle Atlantic projection was better than this in percentage error. The poorest projections were the Mountain and Pacific regions, the former falling 4.5 percent short of actual production and the latter exceeding actual production by 3.8 percent. The sum of the regional projections fell short of actual production by 1.1 percent for 1973.

All the projections, except for the Pacific region predicted declines in milk production (see column 5 of table 12). In that region, the model predicted an increase of 3.8% when in fact production was almost the same as 1972. For the Mountain region, production remained constant while the forecast was for a decline of 3.7 percent.

The East North Central and New England region forecasts were considerably below actual production. For New England this seems to have occurred because of the rather large change in land price which indicated a large decrease in production. For the East North Central region the projected supply decline occurred because of large changes in cattle and hog prices.

The 1974 forecast for the U.S. with the aggregate model is for a 3.2 decline from 1973 levels. The total of the regional estimates indicate a decline of -6.2 percent. This is out of line with current trends in monthly milk production. January 1974 milk production in the U.S. was 3.2 percent below a year earlier,17/ with monthly declines in milk production during the last part of 1973 narrowing.

The projections for the two years indicate that the regional models are less reliable for projections than the single aggregate model. Some yielded reasonably accurate forecasts for 1973, but for longer term projections these models can probably best be used to supplement the information from the aggregate U.S. forecasting model.

SUMMARY AND CONCLUSIONS

The objective of this study was to analyze the milk supply relations for regions of the U.S. The U.S. was divided into 9 geographical regions and the response of milk production in those regions to product prices, input prices, technological and market changes, and returns in other farm and non-farm activities were measured. Elasticities of milk production to milk prices were estimated. The regional elasticities ranged from .03 to .37 in the short-run to .10 to 1.04 in the long-run. Production has been most responsive to price in the Pacific region.

17/ "Dairy Situation", DS-349, ERS, USDA, Washington, D.C., March 1974, p. 5.

In general milk production response to input price changes did not show up in the analyses. Soybean prices or soybean meal price did yield acceptable results for three regions.

Prices in alternative farm and non-farm enterprises (as measured by prices) generally was highly correlated with milk production. Cattle prices in all regions influenced milk production. Hog price also was significant in a number of regions. Unemployment rates or wage rates were significantly related to milk production for all regions.

Improvement in the quality of dairy cows as represented by the percentages of cattle bred artificially was an important factor in maintaining milk production throughout the 1947-72 period. Changes in most of the other variables exerted downward pressure on milk production.

Except for the Mountain region, the models did a good job of explaining levels of milk production and changes in milk production. However, the single aggregate national model did a better job than the sum of the regional models in explaining milk production. Furthermore, for forecasting, the aggregate model did a better job in forecasting 1973 production than summing the regional forecasts. For 1974 the aggregate U.S. model forecast is more consistent with current monthly trends in milk production.

One important conclusion from our analysis was that alternative specifications of producing regions should be considered. The determinants of milk production which were considered are likely to have varying impacts from one part of a region to another. For example, in the West North Central region, opportunities and alternatives to milk production are different in Minnesota, Iowa and Missouri than in the four Plain States. Market opportunities and production alternatives are different in the southern Mountain region than in the north.

In conclusion, it appears that the regional analyses provide additional insights into past behavior in milk production. However, for forecasting the aggregate U.S. model gives the best results. The regional forecasts should be used only to help discern and explain tendencies in regional production and not as a reliable forecast of actual levels.

APPENDIX I

DATA SOURCES FOR VARIABLES USED IN ANALYSIS OF MILK SUPPLY

All Crop Price Index (U.S. average)	"Working Data for Demand Analysis," Economic Research Service, U.S. Department of Agriculture, Washington, D.C., 1973.
All Milk Price (by regions)	Dairy Statistics, Statictical Bulletin 303, ERS, U.S. Department of Agriculture, Washington, D.C., 1962; "Dairy Statistics," Statistical Bulletin 430, ERS, U.S. Department of Agriculture, Washington, D.C., 1968; "The Dairy Situation," Periodical Reports, ERS, U.S. Department of Agriculture, Washington, D.C.
Beef Cattle Prices (by state and region)	"Agricultural Statistics," Annual reports, U.S. Government Printing Office, Washington, D.C.; "Agricultural Prices," Monthly reports, Crop Reporting Board, SRS, Washington, D.C.
Commercial Vegetable Prices (Index of all U.S. prices)	"Agricultural Statistics," _op. cit._, "Agricultural Prices," _op. cit._
Consumer Price Index (U.S. base year: 1967)	"Working Data for Demand Analysis," _op. cit._
Corn Prices (U.S. average)	"Agricultural Statistics," _op. cit._ "Agricultural Prices," _op. cit._
Cotton Prices (Index of average U.S. prices)	"Agricultural Statistics," _op. cit._
Cows Bred Artificially (by region)	Calculated from data in "Dairy Statistics," Nos. 430 and 303, _op. cit._ and "Dairy Herd Improvement Letters," National Cooperative Dairy Herd Improvement Program, ARS, U.S. Department of Agriculture, Beltsville, Md.

Cream Price (by region)	"Milk--Production, Disposition and Income," Annual Summaries, 1940-1972, Crop Reporting Board, SRS, U.S. Department of Agriculture, Washington, D.C.
Dairy Ration Price, 16% Protein (by region)	"Agricultural Statistics," op. cit. "Agricultural Prices," op. cit.
Employment and Labor Force (by region)	"Employment and Earnings, 1937-58," U.S. Department of Commerce, Washington, D.C. and "Statistical Abstract of the United States," U.S. Bureau of the Censis, U.S. Department of Commerce, Washington, D.C.
Fresh Vegetable Prices (Index of average U.S. prices)	"Agricultural Statistics," op. cit.
Hay Prices (by region)	"Agricultural Statistics," op. cit. and "Agricultural Prices," op. cit.
Hog Prices (U.S. average)	"Agricultural Statistics," op. cit.
Land Prices (by region)	"Farm Real Estate Market Developments," Periodic reports, ERS, U.S. Department of Agriculture, Washington, D.C.
Soybean Prices (U.S. average)	"Agricultural Statistics," op. cit.
Wage Rates on U.S. Manufacturing Industries (average hourly rate by region)	"Statistical Abstract of the United States," op. cit. and "Employment and Earnings, 1937-58," op. cit.

Appendix Table 1. 1973 and 1974 Values of Independent Variables in Milk Supply Models. (All Prices Deflated by CPI)

Regions		1/ Qt-1	2/ Pt-1	2/ Ct	3/ At-3	4/ Re	5/ URt-1	2/ HOt-1	5/ Et	2/ St-1	2/ SMt-1	2/ ACt-1	2/ CMt-1	6/ CR/M	2/ FVt-1	5/ WWt-1
New England	1973	4,371	5.29	24.49	65.9	126.7	--	20.03	--	--	--	--	--	--	--	2.71
	1974	4,178	6.02	23.45	67.4	131.7	--	28.41	--	--	--	--	--	--	--	2.69
Middle Atlantic	1973	17,982	5.28	24.72	65.9	132.0	--	--	--	2.65	--	--	--	--	--	2.97
	1974	17,020	5.61	23.67	67.4	137.0	--	--	--	4.80	--	--	--	--	--	2.95
East North Central	1973	34,057	4.63	29.36	59.8	110.6	--	20.03	--	--	--	--	--	--	--	3.34
	1974	32,548	5.14	28.11	61.3	115.6	--	28.41	--	--	--	--	--	--	--	3.33
West North Central	1973	22,778	4.31	31.59	40.9	--	--	20.03	--	--	105.60	--	--	--	--	2.91
	1974	22,069	4.83	30.25	43.4	--	--	28.41	--	--	207.24	--	--	--	--	2.86
South Atlantic	1973	8,930	5.75	28.02	--	124.8	5.6	20.03	11028	--	--	92	--	--	--	--
	1974	8,686	6.19	26.83	--	129.8	4.9	28.41	11028	--	--	121	--	--	--	--
East South Central	1973	6,490	5.63	30.39	31.1	--	--	20.03	--	--	105.60	--	--	--	--	2.42
	1974	6,096	5.43	29.10	30.8	--	--	28.41	--	--	207.24	--	--	--	--	2.41
West South Central	1973	6,435	5.21	31.31	31.1	114.3	5.6	--	--	--	--	--	102	.2	--	--
	1974	6,179	5.88	29.29	30.8	119.3	4.9	--	--	--	--	--	110	.1	--	--
Mountain	1973	4,995	4.61	32.33	63.6	100.1	5.6	--	--	--	--	92	--	--	--	--
	1974	4,994	5.23	30.96	68.9	105.1	4.9	--	--	--	--	121	--	--	--	--
Pacific	1973	13,712	4.60	30.85	63.6	95.5	5.6	--	9480	--	--	92	--	--	--	--
	1974	13,694	4.89	29.54	68.9	100.5	4.9	--	9980	--	--	121	--	--	--	--
United States excluding Alaska and Hawaii	1973	119,750	4.84	30.48	52.5	109.2	5.6	20.03	--	--	--	--	--	--	102	--
	1974	115,464	5.28	29.19	54.8	114.2	4.9	28.41	--	--	--	--	--	--	120	--
Total of Regions	1973	119,750														
	1974	115,464														

1/ Milk Production Monthly
2/ Ag Prices Monthly (All prices deflated by CPI)
3/ Data from Monthly Newsletter of DHIA 1970 and 1971 values which were needed for these projections were calculated by adjusting reported figures for percentages of cows bred artificially for changed method of reporting in 1970.
4/ Farm Real Estate Market Developments - Economic Research Service USDA
5/ "Employment & Earning Monthly" - Bureau of Labor Statistics
6/ Estimated value by linear extrapolation of recent trend

APPENDIX II. Milk Supply Estimates With Price Variables for Price Increases and Decreases

Region	Equations 1/	R^2
New England	$Q_{1t} = 2330.068 + .411\, Q_{1t-1} + 178.603\, DP_{11} + 149.821\, DP_{12} - 11.850\, C_{1t} + 24.921\, A_{1t-3} - 9.697\, RE_{1t} - 830.448\, WW_{1t-1} - 13.475\, HO_{t-1}$ (s=1613.607) (2.416)** (1.530)* (2.413)** (-3.078)*** (2.888)*** (-2.411)** (-2.249)** (3.182)***	.942
Middle Atlantic	$Q_{2t} = 11489.077 + .523\, Q_{2t-1} + 392.088\, DP_{21} + 336.540\, DP_{22} - 29.515\, C_{2t} + 111.271\, A_{2t-3} - 39.433\, RE_{2t} - 3132.170\, WW_{2t-1} - 329.404\, S_{t-1}$ (s=9641.548) (2.006)** (.544) (1.348)* (-1.811)** (3.218)*** (-2.160)** (-2.097)** (-1.903)**	.966
East North Central	$Q_{3t} = 9445.551 + .789\, Q_{3t-1} + 3423.273\, DP_{31} + 1168.749\, DP_{32} - 1.899\, C_{3t} + 49.383\, A_{3t-3} - 183.495\, RE_{3t} + 241.356\, UR_{3t-1} - 91.839\, HO_{t-1}$ (s=12167.602) (5.751)*** (3.927)*** (3.374)*** (-.044) (1.673)* (-5.385)*** (1.966)** (-3.031)***	.926
West North Central	$Q_{4t} = 16490.299 + .664\, Q_{4t-1} + 172.390\, DP_{41} + 86.838\, DP_{42} - 135.547\, C_{4t} - 2426.432\, W_{4t-1} + 340.185\, UR_{4t-1} - 76.874\, HO_{t-1}$ (s=11148.378) (4.983)* (.178) (.257) (-4.462)*** (-3.786)*** (2.673)*** (-2.371)**	.915
South Atlantic	$Q_{5t} = 3035.855 + .354\, Q_{5t-1} + 426.702\, DP_{51} + 127.198\, DP_{52} - 22.549\, C_{5t} - 32.704\, R_{5e} + .311\, E_{5t} + 57.835\, UR_{5t-1} - 11.056\, HO_{t-1} - 9.112\, AC_{t-1}$ (s=3988.947) (2.569)*** (.958) (.709) (-2.371)** (-4.456)*** (2.810)*** (1.754)** (-1.323) (-1.435)*	.921
East South Central	$Q_{6t} = 4297.977 + .578\, Q_{6t-1} + 310.744\, DP_{61} + 113.728\, DP_{62} - 12.873\, C_{6t} + 22.887\, A_{6t-3} - 1861.863\, WW_{6t-1} - 16.897\, HO_{t-1} - 5.881\, SM_{t-1}$ (s=2034.685) (3.885)*** (2.039)** (1.370)* (1.796)** (1.634)* (-3.871)*** (-1.747)** (-1.809)**	.915
West South Central	$Q_{7t} = 2451.508 + .374\, Q_{7t-1} + 169.744\, DP_{71} + 203.483\, DP_{72} - 13.049\, C_{7t} + 24.769\, A_{7t-1} - 10.679\, RE_{7t} + 62.803\, UR_{7t-1} - 3.709\, CN_{t-1} + 32.655\, CR/M$ (s=2222.955) (1.785)** (1.060) (1.700)* (-1.401)* (1.909)** (-1.984)** (1.866)** (-1.550)* (1.220)	.955
Mountain	$Q_{8t} = 3063.987 + .278\, Q_{8t-1} + 231.249\, DP_{81} + 24.255\, DP_{82} - 9.396\, C_{8t} + 8.962\, A_{8t-1} - 16.937\, RE_{8t} + 23.831\, UR_{8t-1} - 123.791\, Wh_{t-1}$ (s=2969.872) (.950) (1.044) (.169) (-1.073) (1.262) (-1.916)* (.551) (.713)	.695
Pacific	$Q_{9t} = 6037.353 - .651\, Q_{9t-1} + 887.007\, DP_{91} + 728.335\, DP_{92} - 32.840\, C_{9t} + 23.896\, A_{9t-3} - 33.873\, RE_{9t} + 157.869\, UR_{9t-1} + 43.479\, E_{9t} - 9.827\, AC_{t-1}$ (s=3516.808) (4.038)*** (3.312)*** (4.656)*** (-2.256)** (1.214) (-2.654)*** (3.162)*** (3.748)*** (1.258)	.989
U.S.	$Q_{10t} = 63712.790 + .423\, Q_{10t-1} + 3045.991\, DP_{101} + 2384.088\, DP_{102} - 387.955\, C_{10t} + 153.508\, A_{10t-3} - 195.994\, RE_{10t} + 814.011\, UR_{10t-1} - 231.872\, HO_{t-1} - 59.918\, FV_{t-1}$ (s=30212.329) (3.885)*** (1.652)* (2.325)** (-5.163)*** (1.512)* (-2.284)** (3.025)*** (-3.404)*** (-1.310)	.951

1/ Except for the intercept, the values in parentheses under the coefficients are t values.
*** significant at the 1 percent probability level.
** significant at the 5 percent probability level.
* significant at the 10 percent probability level.

For description of variables see page 14. In addition DP_{i1} is a price variable for price increases in region i and DP_{i2} is a price variable for price decreases in region i.

APPENDIX II. Milk Supply Estimates (Equations with polynomial lag on price; continued)

Region	Equations 1/	R^2
New England	$Q_{1t} = 7418.033 + 98.451\ PX_{11} - 19.363\ PX_{12} - 10.819\ C_{1t} + 33.780\ A_{1t-3} - 13.965\ RE_{1t} - 1227.459\ WW_{1t-1} - 15.293\ HO_{t-1}$ (s=725.372) (3.151)*** (-2.261)** (-2.445)** (4.966)*** (-4.168)*** (-3.889)*** (-3.220)***	.929
Middle Atlantic	$Q_{2t} = 30545.974 + 67.854\ PX_{21} - 24.268\ PX_{22} - 23.788\ C_{2t} + 150.124\ A_{2t-3} - 45.754\ RE_{2t} - 4381.289\ WW_{2t-1} - 1.963\ S_{t-1}$ (s=4710.931) (.360) (-.618) (-1.284) (5.180)*** (-2.399)** (-2.389)** (-1.963)**	.960
East North Central	$Q_{3t} = 64312.905 + 333.175\ PX_{31} - 83.998\ PX_{32} - 93.730\ C_{3t} + 145.438\ A_{3t-3} - 157.931\ RE_{3t} - 4815.061\ WW_{3t-1} - 118.053\ HO_{t-1}$ (s=3734.121) (1.069) (-1.354)* (-2.264)** (2.647)*** (-3.418)*** (-1.734)** (-2.673)***	.860
West North Central	$Q_{4t} = 58378.865 + 718.709\ PX_{41} - 200.174\ PX_{42} - 62.994\ C_{4t} + 21.569\ A_{4t-3} - 92.885\ RE_{4t} - 4451.749\ WW_{4t-1} - 46.287\ CO_{t-1}$ (s=4156.039) (1.810)** (-2.503)** (-1.655)* (.255) (-2.239)** (-1.442)* (-.944)	.844
South Atlantic	$Q_{5t} = 11699.853 + 61.915\ PX_{51} - 10.652\ PX_{52} - 33.320\ C_{5t} - 40.318\ R_{5e} + 33.974\ E_{5t} + 36.056\ UR_{5t-1} - 11.195\ HO_{t-1} - 18.299\ AC_{t-1}$ (s=1173.236) (.410) (-.364) (-4.123)** (-3.432)*** (2.526)** (.958) (.994) (-4.510)***	.883
East South Central	$Q_{6t} = 8925.963 - 148.120\ PX_{61} + 33.142\ PX_{62} - 31.397\ C_{6t} - 25.154\ A_{6t-3} - 601.632\ WW_{6t-1} - 3.204\ SM_{t-1}$ (s=2446.242) (-1.215) (1.265) (-2.951)** (-1.001) (-.603) (-.585)	.836
West South Central	$Q_{7t} = 6559.375 + 61.112\ PX_{71} - 10.374\ PX_{72} - 8.123\ C_{7t} + 29.877\ A_{7t-3} - 13.499\ RE_{7t} + 46.472\ UR_{6t-1} - 3.157\ CN_{t-1} + 62.211\ CR/M_{7t}$ (s=1231.896) (.706) (-.598) (-1.105) (1.773)* (-1.520)* (1.304) (-1.813)*** (8.038)***	.944
Mountain	$Q_{8t} = 7135.202 + 133.913\ PX_{81} - 27.717\ PX_{82} - 17.946\ C_{8t} + 8.761\ A_{8t-3} - 19.846\ RE_{8t} + 52.250\ UR_{7t-1} - 8.276\ AC_{t-1}$ (s=1590.949) (1.031) (-1.001) (2.733)** (1.158) (1.381)* (1.381)* (-2.280)**	.727
Pacific	$Q_{9t} = 6636.496 + 592.459\ PX_{91} - 104.939\ PX_{92} - 41.254\ C_{9t} + 73.857\ A_{9t-3} - 61.941\ RE_{9t} + 179.675\ UR_{8t-1} + .705\ E_{9t} - 7.499\ AC_{t-1}$ (s=1991.938) (3.616)*** (-2.964)** (-2.490)** (3.305)*** (-3.414)*** (2.367)** (3.955)*** (-.923)	.975
U. S.	$Q_{10t} = 166053.150 + 1879.204\ PX_{101} - 420.429\ PX_{102} - 414.171\ C_{10t} + 223.099\ A_{10t-3} - 355.299\ RE_{10t} + 1007.708\ UR_{9t-1} - 168.491\ HO_{t-1} - 26.477\ FV_{t-1}$ (s=4986.815) (2.854)*** (-3.306)*** (-6.505)*** (2.407)** (-4.216)*** (4.246)*** (-2.565)** (-.6226)	.955

1/ Except for the intercept, the values in parentheses under the coefficients are t values.
*** significant at the 1 percent probability level.
** significant at the 5 percent probability level.
* significant at the 10 percent probability level.

For description of variables see page 14. In addition PX_{i1} and PX_{i2} are the calculated price variables from the polynomial formulation as described in the text.