1985

Disequilibrium in the U.S. dairy industry: two approaches to analyzing regional responses to policy changes

R. Q. Grafton
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Disequilibrium in the U.S. dairy industry:  
Two approaches to analyzing regional responses 
to policy changes

BY

R. Q. Grafton

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of the 
Requirements for the Degree of
MASTER OF SCIENCE

Department: Economics 
Major: Agricultural Economics

Signatures have been redacted for privacy

Iowa State University 
Ames, Iowa 
1985
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GENERAL INTRODUCTION

Over 80% of the U.S. milk supply is governed by federal or state regulation making the dairy industry one of the most highly controlled sectors of the U.S. economy. The origin of these controls lies in the depression of the 1930s when the prices for dairy products dropped from 103% of the 1910-1914 parity price index in 1929 to 61.7% of the index in May 1933. It was because of this crisis situation and a newly elected administration and Congress, both more inclined to intervene in the market-place, that legislation was enacted to regulate the industry.

The resulting legislation was the 1933 Agriculture Adjustment Act, a forerunner for much of the regulation in the industry today. The goals of this Act, with respect to the dairy industry, may be summarized as follows (MacAvoy 4).

1. To raise the income of dairy farmers.

2. To maintain "orderly marketing conditions", i.e., to ensure an orderly supply of milk and to avoid unreasonable fluctuations in supply and price.
3. To assure the adequate and dependable supply of fluid grade milk.

4. To prevent excessive price levels not in the public interest.

Examination of these objectives reveals that in 1980 the average gross family income from dairying with a 54 cow herd was $28,983, an amount greater than that for an average non-farm family (Babb and Boynton 1). With the exception of the 1980s, dairy products and prices have maintained a fairly constant trend over the past 20 years.

Whether price levels for dairy products have exceeded those in the "public interest" is a subjective question.¹ USDA purchases however of butter, cheese and non-fat dry milk have supported the milk price paid to the farmer. In turn, this has been partially offset by classified pricing for fluid grade quality milk² which differentiates between a class 1 price, the price paid to the farmer for milk consumed directly in fluid form, and the class 2 and 3 prices paid for

¹ It is worth noting that dairy support prices almost tripled between 1970-1982, compared to an increase of 2.3 times in the implicit G.N.P price deflator.

² Commonly referred to as Grade A milk.
purposes other than fluid use.\footnote{Although a class 1 price is payable for milk utilized in fluid consumption, the farmer in Federal Orders actually receives a blend price. This price is a weighted average of the class 1 and class 2 and 3 prices according to how much milk is utilized for fluid consumption within an Order.} This differential has exceeded the extra costs in producing fluid grade milk (see Dobson and Buxton\cite{1}) and thus ensured an "adequate" supply of Grade A production. The result is that 84% of the nation’s milk supply is fluid grade quality while only 45% of production is actually consumed in a fluid form. The surplus Grade A milk has flowed into manufactured products which are more price elastic than fluid milk (see Hutton and Helmberger\cite{3}). As a consequence, classified pricing has led to both higher fluid milk prices than under no regulation and a price enhancement to the Grade A producer. In turn, this has meant greater milk supplies for manufacturing, in part negating the Federal price support policy.

The current regulations, including classified pricing, federal product purchases, and import controls have been a subject of a great deal of study. A feature of a number of these studies has been an examination of the welfare effects of regulation and a comparison of the current situation to a hypothetical competitive equilibrium. This thesis examines disequilibrium in a more limited sense and defines equilibrium as a situation where supply and commercial demand are approximately equal for the industry as a whole.
irrespective of the market structure.

The 1980s has been a period of disequilibrium with Federal support purchases accounting for around 13% and 7% of total milk production in 1983 and 1984 respectively. The purpose of this study was to focus on just one aspect of the current problem, the support price level. The aim was to evaluate the effects of different milk price levels upon production in the various milk supply regions of the U.S. To this end, a linear programming and a simultaneous econometric model were used for the analysis.
ORGANIZATION OF THE THESIS

The thesis is organized in a format of two papers each of which uses a different model to analyze the problem.

The first paper uses a spatial linear programming model to generate shadow prices for the different production regions. These prices are then used to evaluate the regional consequences of a fall in the support price. The second article uses a simultaneous econometric model to forecast regional and national effects of various price support levels.

The thesis concludes with a summary of the results and implications of both papers.
The U.S. dairy industry has been in the limelight of public scrutiny recently due to the large surpluses of Government owned stocks of dairy products. This is despite a small decline since 1981 in both the average price and manufactured price of milk, as well as a paid diversion to dairy farmers in 1984 of $10/cwt for every cwt of milk marketings reduced. Also, with current federal expenditures running at $1.6 billion/year on price supports, supply responses to changes in milk prices need to be examined.

In setting the support price, federal regulators must keep in mind not only the slow adjustment process in supply (see Dahlgran 8), but also the regionalized nature of the industry. Policy makers must also reconcile the desire to ensure the continuing existence of most dairy farmers, against the need to reduce the currently large federal expenditures on the dairy program.

This study examines the U.S. dairy industry to ascertain both relative regional production efficiencies and regional production shifts in response to support price adjustments.

4 See Tables 6 and 7.
Review of the Literature

A large number of studies have examined the U.S. dairy industry in both a normative and positive framework. A convenient way of categorizing such studies is by the models used for analysis. This discussion examines econometric and programming models separately.

Since the 1950s there have been a large number of studies to determine milk supply response and price and income elasticities of various dairy product demands. Although computed elasticities have varied considerably between studies the conclusion has been that supply is inelastic\(^5\) in the short-run, and in general, demands for a range of dairy products appear to be price inelastic.\(^6\)

A number of national supply and demand models have been estimated - the first by Wilson and Thompson, 1967. The most detailed econometric model was by Hallberg and Fallert, 1976, which had 18 product demands and 9 supply regions. A more recent model, the USDA FAPSIM dairy model (22), 1982, had six product demands and a national milk supply. However, despite the large number of analyses, little work has been done on

\(^5\) See Halvorson (16), Wipf and Houck (24), Hammond (17), and Dahlgran (8).

\(^6\) See Brandow (3), Wilson and Thompson (23), George and King (12), Prato (19).
regional responses and how they should influence policy decisions.

The programming approach to examining the dairy industry has focused upon the net welfare gains and losses for producers and consumers under various regulatory structures. In addition, programming models have emphasized the regional impacts of policy alternatives. As Blakley and Riley stressed in their 1974 study, "any pricing system change will have differential (regional) impacts." They concluded that lower producer prices without traditional class 1 differentials would lower receipts to all regions of the country, but the biggest burden would fall upon producers in the Northeast and Southeast. In a different study, Hallberg et al. concluded that in 1975 the U.S. dairy industry deviated substantially from an equilibrium situation with producers as a whole in the Northeast and South Atlantic regions being the net gainers from current regulations.

These studies, as with Dahlgran's research, have had as their purpose the examination of regional income transfers and the welfare costs/benefits under present and alternative scenarios. The object of the present study was specifically to examine regional efficiencies in production and relate

---

7 For some studies in this area consult, Gruebele (13), Hammond (17), and Buxton (5).

8 See Riley and Blakley (21), Blakley and Riley (2), Babb et al. (1), Hallberg et al. (14).
them directly to policy analysis. This paper uses the most recent data available and incorporates differing production costs from different sized farms, an approach not used before in a national dairy model.

Methodology

The data used for the analysis were based upon 1983 budgets for medium, large, and extra-large dairy operations in ten states. The budgets (see Buxton 4) themselves were developed from interviews with dairy producers, government and university employees, and secondary sources. The value of these budgets to this research was twofold; first, they provided the most up-to-date information on dairying costs and returns; secondly, the breakdown of budgets according to farm size enabled us to more accurately model the actual industry situation.

The Model

We constructed a simple static linear programming model that divided the 48 contiguous states into five regions. The model objective was to maximize the total gross profit of U.S. dairy producers.

9 See Figure 1.
The complete model structure was as follows:

Max \[ P_{mfd}Q_{mfd} + \sum_{j} P_{jfl}Q_{jfl} - \sum_{j} \sum_{b} C_{jb}Q_{jb} - \sum_{j} C_{jz}T_{jz} \]

Subject To:

Region Budget Identities

\[ Q_{1k1} + Q_{1k2} = Q_{1k} \]
\[ Q_{ne1} + Q_{ne2} + Q_{ne3} = Q_{ne} \]
\[ Q_{nw1} + Q_{nw2} = Q_{nw} \]
\[ Q_{se1} + Q_{se2} + Q_{se3} = Q_{se} \]
\[ Q_{sw1} + Q_{sw2} + Q_{sw3} = Q_{sw} \]

Production Identities

\[ Q_{1kmfd} + Q_{nemfd} + Q_{nwmf} + Q_{semf} + Q_{swmf} = Q_{mfd} \]
\[ Q_{1kmf} + Q_{1kfm} + Q_{1kt} = Q_{1k} \]
\[ Q_{nemf} + Q_{nefm} + Q_{net} = Q_{ne} \]
\[ Q_{nwmf} + Q_{nwfm} + Q_{nwt} = Q_{nw} \]
\[ Q_{semf} + Q_{sefm} + Q_{set} = Q_{se} \]
\[ Q_{swmf} + Q_{swfm} + Q_{swt} = Q_{sw} \]

Regional Production Constraints

\[ Q_{1k} \leq 39933 \]
\[ Q_{ne} \leq 49264 \]
\[ Q_{nw} \leq 8406 \]
\[ Q_{se} \leq 13487 \]
\[ Q_{sw} \leq 23429 \]
Firm Size Restrictions

\[
Q_{1k2} \leq 0.20Q_{1k}
\]
\[
Q_{ne1} \geq 0.75Q_{ne}
\]
\[
Q_{ne2} \geq 0.20Q_{ne}
\]
\[
Q_{nw1} \geq 0.75Q_{nw}
\]
\[
Q_{se1} \geq 0.60Q_{se}
\]
\[
Q_{se2} \geq 0.30Q_{se}
\]
\[
Q_{sw1} \geq 0.30Q_{sw}
\]
\[
Q_{sw2} \geq 0.50Q_{sw}
\]

Fluid Consumption Identities

\[
Q_{1kfm + T_{ne} + T_{nw} + T_{se} + T_{sw}} = 3338
\]
\[
Q_{nefm + T_{kn} + T_{n} + T_{se} + T_{sw}} = 21997
\]
\[
Q_{nwfm + T_{knw} + T_{nenw} + T_{senw} + T_{sw}} = 2082
\]
\[
Q_{sefm + T_{kse} + T_{nse} + T_{nsew} + T_{swse}} = 8428
\]
\[
Q_{swfm + T_{lks} + T_{nsew} + T_{ns} + T_{sesw}} = 14673
\]
\[
Q_{1kfm + T_{ne} + T_{nw} + T_{se} + T_{sw}} = Q_{1kfl}
\]
\[
Q_{nefm + T_{kn} + T_{n} + T_{se} + T_{sw}} = Q_{nefl}
\]
\[
Q_{nwfm + T_{knw} + T_{nenw} + T_{senw} + T_{sw}} = Q_{nwfl}
\]
\[
Q_{sefm + T_{kse} + T_{nse} + T_{nsew} + T_{swse}} = Q_{sefl}
\]
\[
Q_{swfm + T_{lks} + T_{nsew} + T_{ns} + T_{sesw}} = Q_{swfl}
\]
Transport Identities

\[ T_{l1kne} + T_{lknw} + T_{lkse} + T_{lksw} = Q_{1kt} \]
\[ T_{nenl} + T_{nenw} + T_{nese} + T_{nesw} = Q_{net} \]
\[ T_{nw1k} + T_{nwne} + T_{nwse} + T_{nwsw} = Q_{nwt} \]
\[ T_{s1elk} + T_{sene} + T_{senw} + T_{sesw} = Q_{set} \]
\[ T_{sw1l} + T_{swne} + T_{swse} + T_{swse} = Q_{swt} \]

where

\[ P_{mfd} = \text{Price of milk at farm level for milk used in manufacture.} \]
\[ Q_{mfd} = \text{Quantity of milk used in manufacture.} \]
\[ P_{jfl} = \text{Price of Grade A milk in region } j. \]
\[ Q_{jfl} = \text{Quantity of Grade A milk directly used in fluid consumption in region } j. \]
\[ C_{jb} = \text{Costs of production less miscellaneous income in region } j \text{ on farm size } b. \]
\[ Q_{jb} = \text{Quantity of milk produced in region } j \text{ on farm size } b. \]
\[ C_{jz} = \text{Transport costs from region } j \text{ to region } z. \]
\[ T_{jz} = \text{Quantity of milk transported from region } j \text{ to region } z. \]
\[ l1k = \text{Lake region} \]
\[ ne = \text{Northeast region} \]
\[ nw = \text{Northwest region} \]
\[ se = \text{Southeast region} \]
\[ sw = \text{Southwest region} \]
\[ Q_{jmfd} = \text{Quantity of milk used in manufacture in region } j. \]
Q_{jfm} = \text{Quantity of Grade A milk produced in region } j \text{ and used directly in meeting region } j \text{'s fluid milk demand.}

Q_{jt} = \text{Total quantity of Grade A milk transported out of region } j \text{ to meet fluid milk demands in other regions.}

Q_j = \text{Quantity of milk produced in region } j.

All milk quantities are in million pound units.

In the model, the budgets from only one state were used to represent the cost structure for a given region. This was because of the difficulty in accurately assigning farm size constraints using budgets from a number of states within a region. The budgets and farm sizes for each region are given below:

* Northeast – New York, with budgets on 52, 200, and 600 cow dairy farms.

* Lake States – Minnesota, with budgets on 52 and 125 cow dairy farms.

* Southeast – Florida, with budgets on 350, 600, and 1436 cow dairy farms.

* Southwest – Arizona, with budgets on 359, 834, and 1436 cow dairy farms.
* Northwest - Idaho, with budgets on 200 and 550 cow dairy farms.

Utilizing farm size restrictions from the 1978 census of agriculture the above budget sizes were then imposed on the base run to simulate the actual industry situation.

The model included milk for both fluid consumption and manufacturing and constrained the solution to ensure regional fluid consumption demands were met. Fluid milk demand in a region could be satisfied from that region’s own Grade A milk production and/or Grade A milk transported from another region. No milk for manufacture was allowed to be transported as it is much cheaper to ship manufactured dairy products than milk in a bulk form. Hence, if it was profitable to ship milk in bulk to be manufactured in another region, it would be surprising for it not to be more profitable to establish manufacturing capacity in the local region.

The category of Grade A production included milk to directly meet fluid milk demand in the local region and milk transported to meet fluid milk consumption in other regions. Because Grade A milk production accounts for over 80% of milk production in the U.S. and fluid milk consumption accounts for less than half total production, some Grade A production must go directly into manufacturing. However,
since Grade A and Grade B milk receive more or less the same price if utilized in manufacture, this "surplus" of Grade A milk was not directly accounted for in the model.

Milk for manufacture was not specified at its 1982 levels in the model to avoid full identification of the activities and prevent the transportation of milk between the nodes specified in the model. Milk for manufacture would be produced only if it was profitable and then only to a maximum of the production constraint less aggregate fluid consumption demand.

The model was initially run using actual 1982 prices, the Grade A milk prices being a weighted average of the average state prices that make up a specific region. All costs came directly from the budgets used, with the exception of transport costs which were calculated on a formula using 1979 transport cost data (see English and Campos 10). The actual values of the transport cost coefficients were calculated from the direct road distances between the nodal points specified in the model. Actual 1982 values were also used for determining regional production constraints with the 1982 production level being the right hand side value for each region.

---

10 See Figure 1.
Results and Discussion

Three basic scenarios are reported in this study:

1) A gross margin analysis of the 1982 dairy industry situation with and without farm size constraints.

2) A full cost of production analysis of the 1982 dairy industry situation with farm size constraints.

3) An analysis of an hypothetical gross margin and full cost of production situation without regional production and farm size constraints.

The purpose of the first run was to see how accurately the model represented the actual situation in 1982, and then to ascertain how the regional shadow prices for milk varied as certain changes were made within the model. The results did not purport to be projections for the future, but rather, represented possible effects of price changes under the current structure, as well as the possible adjustments from moving the industry to a more competitive situation.

The "gross margin" formulations excluded interest and depreciation, while the full cost formulations kept all budget costs in the objective function. The gross margin
analysis was included because in the data used six out of the thirteen budgets had production costs less miscellaneous income exceeding $15.00/cwt. In addition, these six budgets given the firm size constraints specified in the model account for most of the U.S. production. This was not considered representative of most farmers who have been established in farming for a number of years, and who would probably not incur the high fixed costs specified in the data. It should be noted though Buxton argued that the fixed ownership costs in the budgets "... reflect an amount needed to maintain the long-term viability of the operation" (see Buxton 4).

**A gross margin analysis of the 1982 dairy industry situation with and without farm size constraints**

The activity levels and shadow prices shown in Table 1 were generated using the following 1982 prices in the objective function:

\[
\begin{align*}
P_{mfd} & = \$12.49/\text{cwt} \\
P_{lkf1} & = \$13.20/\text{cwt} \\
P_{nef1} & = \$13.06/\text{cwt} \\
P_{nwf1} & = \$13.47/\text{cwt} \\
P_{sef1} & = \$14.68/\text{cwt} \\
P_{swf1} & = \$13.70/\text{cwt} 
\end{align*}
\]
Table 1. Gross margin solution, with regional and farm size constraints

<table>
<thead>
<tr>
<th>Activity</th>
<th>Activity Level (millions lbs)</th>
<th>Shadow Price ($/cwt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q_{mfd}</td>
<td>78942</td>
<td>-</td>
</tr>
<tr>
<td>Q_{lk}</td>
<td>39933</td>
<td>$2.42/cwt</td>
</tr>
<tr>
<td>Q_{ne}</td>
<td>49264</td>
<td>$0.79/cwt</td>
</tr>
<tr>
<td>Q_{nw}</td>
<td>8406</td>
<td>$3.37/cwt</td>
</tr>
<tr>
<td>Q_{se}</td>
<td>8428</td>
<td>$0.00/cwt</td>
</tr>
<tr>
<td>Q_{sw}</td>
<td>23429</td>
<td>$3.49/cwt</td>
</tr>
<tr>
<td>Milk transported</td>
<td>0</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 2. Gross margin solution, with regional but no farm size constraints

<table>
<thead>
<tr>
<th>Activity</th>
<th>Activity Level (millions lbs)</th>
<th>Shadow Price ($/cwt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q_{mfd}</td>
<td>84001</td>
<td>-</td>
</tr>
<tr>
<td>Q_{lk}</td>
<td>39933</td>
<td>$4.31/cwt</td>
</tr>
<tr>
<td>Q_{ne}</td>
<td>49264</td>
<td>$3.60/cwt</td>
</tr>
<tr>
<td>Q_{nw}</td>
<td>8406</td>
<td>$3.84/cwt</td>
</tr>
<tr>
<td>Q_{se}</td>
<td>13487</td>
<td>$0.87/cwt</td>
</tr>
<tr>
<td>Q_{sw}</td>
<td>23429</td>
<td>$4.63/cwt</td>
</tr>
<tr>
<td>Milk Transported</td>
<td>0</td>
<td>-</td>
</tr>
</tbody>
</table>
This solution was very similar to the actual 1982 situation, except that in these results no milk was produced for manufacture in the Southeast. This discrepancy may be explained by the nature of returns to dairy farmers under federal regulations. Under Federal Orders farmers receive a blend price for their milk which is a weighted average of the milk sold within the Order according to the amount utilized in manufacturing and fluid consumption. Therefore, although the 1982 price for manufactured milk may have been insufficient to generate significant Grade B milk production in the Southeast\(^{11}\), the blend price in Federal Orders was high enough to generate surplus Grade A milk in the region. This surplus was then utilized in manufactured products, a fact not captured in the results.

As a point of note, no milk was transported between regions; from the range analysis transport costs would have to fall 28% before such transport would occur. This is not to say, however, there could be no milk transported between points among regions much closer than the nodes specified in the model, as in fact is the case.

Of particular interest are the shadow prices for each of the regions which represent the marginal profit or increase in the objective function from increasing local production by

\(^{11}\) Milk eligible for fluid milk consumption accounted for some 93% of total production in the Southeast in 1982.
one unit. Despite the differences between the pricing structure in the model and Federal Orders, these shadow prices are useful in determining a price in each region that will avoid continuing increases in production. In the solution, differing shadow prices would indicate differing responses from a uniform change in the support price. Hence, a drop of a $1.00/cwt in the manufactured price and all regional Grade A prices would indicate a decline in production in both the Southeast and Northeast while production would continue to expand in the Lake region, the Northwest and Southwest. Such a result is of considerable importance to regulators who try to reconcile the desire to ensure the continuing operation of most dairy producers with the need for budgetary prudence.

Shifts in production between regions caused by changes in milk prices would no doubt occur simultaneously with adjustments within regions. Hence, the model was rerun to ascertain the shadow prices under regional production constraints without farm size constraints. The results of this solution are given in Table 2.

The shadow prices, given no farm size constraints, still indicate, at least in the Southeast region, there would be a decline in production given a $1.00/cwt reduction in the manufacturing and fluid milk prices. Therefore, even if the Southeast could adjust its production to the largest and most efficient scale of operation, production would still shift
out of the region.

A full cost of production analysis of the 1982 dairy industry situation with farm size constraints

A comparison of the gross margin results with a solution incorporating the full costs of production was also carried out. These results are presented in Table 3.

A loss is generated as an optimal solution in the full cost run since each regional fluid milk demand must be met regardless of profitability.

As this solution radically differs from the actual 1982 situation, the value placed on these results is much less than in the gross margin case. Of interest are the differing shadow prices to the gross margin analysis, and in particular the positive shadow price for the Southeast region. This result stems from the fact that although it is unprofitable to produce milk in the Southeast it is still less costly than in the Northeast under the full cost scenario. This difference makes the transport of milk from the Southeast into the Northeast more profitable than meeting the Northeast fluid demand with local production. The positive shadow price therefore represents the improvement in the solution in increasing the Southeast production constraint by one unit so that more milk may be transported into the Northeast to supplant local production.
Table 3. Full cost solution, with regional constraints

<table>
<thead>
<tr>
<th>Activity</th>
<th>Activity Level (millions lbs)</th>
<th>Shadow Price ($/cwt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qmfd</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Q1k</td>
<td>0</td>
<td>$0.00/cwt</td>
</tr>
<tr>
<td>Qne</td>
<td>5196</td>
<td>$0.00/cwt</td>
</tr>
<tr>
<td>Qnw</td>
<td>8406</td>
<td>$0.56/cwt</td>
</tr>
<tr>
<td>Qse</td>
<td>13487</td>
<td>$1.44/cwt</td>
</tr>
<tr>
<td>Qsw</td>
<td>23429</td>
<td>$3.09/cwt</td>
</tr>
<tr>
<td>Tnw1k</td>
<td>3338</td>
<td>-</td>
</tr>
<tr>
<td>Tsene</td>
<td>5054</td>
<td>-</td>
</tr>
<tr>
<td>Tswne</td>
<td>8756</td>
<td>-</td>
</tr>
<tr>
<td>Tnwne</td>
<td>2986</td>
<td>-</td>
</tr>
</tbody>
</table>

objective function value (332 million)
An analysis of an hypothetical gross margin and full cost of production situation without regional production or farm size constraints

No constraint situation, gross margin analysis
Analysis was also carried out to discover where production would take place given no farm size or regional production constraints. This analysis was carried out on both gross margin and full cost bases. The results are presented in Tables 4 and 5.

In the gross margin solution, the Southwest appeared to have a comparative advantage in producing milk. However, milk was transported from the Northeast to the Southeast to meet the Southeast regional fluid demand. Apparently, the Southwest's comparative advantage was negated by the lower transport cost from the Northeast to the Southeast.

Although the results were generated without regional or farm size constraints, there was no suggestion this is a long-run competitive equilibrium. Clearly, such factors as adjustment costs and regional constraints on production, e.g., scarce water supplies in the Southwest, would preclude such a result. What the solution indicates is that the Southwest is the region of greatest economic efficiency for milk production in the U.S. Hence, the removal of the current regulatory structure would probably accelerate the current trend of milk
Table 4. Gross margin solution, without regional or farm size constraints

<table>
<thead>
<tr>
<th>Activity</th>
<th>Activity Level (millions lbs)</th>
<th>Shadow Price ($/cwt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qmfd</td>
<td>84001</td>
<td>-</td>
</tr>
<tr>
<td>Q1k</td>
<td>3338</td>
<td>-</td>
</tr>
<tr>
<td>Qne</td>
<td>30425</td>
<td>-</td>
</tr>
<tr>
<td>Qnw</td>
<td>2082</td>
<td>-</td>
</tr>
<tr>
<td>Qse</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Qsw</td>
<td>98674</td>
<td>-</td>
</tr>
<tr>
<td>Tnese</td>
<td>8428</td>
<td>-</td>
</tr>
<tr>
<td>Total Production</td>
<td>134519</td>
<td>$4.88/cwt</td>
</tr>
</tbody>
</table>

Table 5. Full cost solution, without regional or farm size constraints

<table>
<thead>
<tr>
<th>Activity</th>
<th>Activity Level (millions lbs)</th>
<th>Shadow Price ($/cwt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Qmfd</td>
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<td>-</td>
</tr>
<tr>
<td>Qnw</td>
<td>2082</td>
<td>-</td>
</tr>
<tr>
<td>Qse</td>
<td>8428</td>
<td>-</td>
</tr>
<tr>
<td>Qsw</td>
<td>102012</td>
<td>-</td>
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<tr>
<td>Tswlk</td>
<td>3338</td>
<td>-</td>
</tr>
<tr>
<td>Total Production</td>
<td>134519</td>
<td>$2.54/cwt</td>
</tr>
</tbody>
</table>
production shifting westward (see Buxton et al. 6).

**No constraint situation, full costs of production analysis**

The results in Table 5 were generated to ascertain whether the Southwest is the most economically efficient region under a full cost of production analysis.

As with the gross margin solution, there was a shift in production to the Southwest given no regional or firm size constraints. However, production still occurred in all areas except the Lake region which had its fluid consumption demand supplied from the Southwest. Every other region met its own fluid demand, with all milk for manufacture being produced in the Southwest.

The quite different results in terms of activity levels for regions other than the Southwest between the gross margin analysis and the full cost basis stemmed from the different proportion that ownership costs contribute to total costs between regions. For instance, on a 52 cow operation in Minnesota, interest and depreciation account for 22% of total costs, while on a 1436 cow operation in Florida these costs account for just 4.7% of the total cost of production.
Conclusions

Under a gross margin analysis, a shadow price for milk ranging from $3.49/cwt in the Southwest to a zero value in the Southeast, indicates a policy solution to rectify the current surplus problem must take account of regional differences in production. It is therefore quite possible to achieve declining milk production in one region, combined with increasing production in another and at the same time have continuing surpluses of milk.

This result presents a very real dilemma to the policy maker the desire for fiscal frugality must be weighed against the opposing goal of ensuring the continuing existence of the small scale, and generally less efficient producer. A compromise of such objectives, the most likely scenario for the future, would probably still continue the current trend milk production shifting westwards but at a slower rate than given no federal regulations. The net beneficiaries of the current regulations are, of course, the less efficient producers - found in their greatest concentration in the South and Northeast, as well as low income individuals who are eligible for dairy product donations. The losers are the consumers of dairy products who are forced to pay a higher price than they would under a competitive situation, as well as the tax paying public obliged to foot the bill for the
current support price structure.

Recommendations

This study uses a simple spatial model to generate its results. The incorporation of some of the real constraints on production, as well as accounting for the adjustment costs in changing the structure both between and within regions would no doubt increase the acceptability and usefulness of these results to decision makers. In addition, the inclusion of the next best alternative to dairying in each of the regions would add greatly to the insight of the adjustment process from policy changes.

Finally, a quadratic programming approach to determine the manufactured milk price may also be desirable. However, it is questionable with the highly inelastic demand\textsuperscript{12} for milk whether the model solution may not generate results substantially below current production levels.

\textsuperscript{12} Refer to Hutton and Helmberger (18).
Table 6. Net Government expenditures on dairy support programs 1960-1984 (millions dollars)\textsuperscript{a}

<table>
<thead>
<tr>
<th>Year Beginning July 1</th>
<th>Net Support Purchases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960-61</td>
<td>173.9</td>
</tr>
<tr>
<td>1961-62</td>
<td>539.0</td>
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<tr>
<td>1962-63</td>
<td>454.0</td>
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<td>1963-64</td>
<td>311.7</td>
</tr>
<tr>
<td>1964-65</td>
<td>157.2</td>
</tr>
<tr>
<td>1965-66</td>
<td>26.1</td>
</tr>
<tr>
<td>1966-67</td>
<td>283.9</td>
</tr>
<tr>
<td>1967-68</td>
<td>357.1</td>
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<tr>
<td>1968-69</td>
<td>268.8</td>
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<tr>
<td>1969-70</td>
<td>168.6</td>
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<tr>
<td>1970-71</td>
<td>315.4</td>
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<tr>
<td>1971-72</td>
<td>267.0</td>
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<tr>
<td>1972-73</td>
<td>135.8</td>
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<tr>
<td>1973-74</td>
<td>31.4</td>
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<tr>
<td>1974-75</td>
<td>485.8</td>
</tr>
<tr>
<td>1975-76</td>
<td>69.6</td>
</tr>
<tr>
<td>1976-77\textsuperscript{b}</td>
<td>43.5</td>
</tr>
<tr>
<td>1977-78</td>
<td>446.4</td>
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<tr>
<td>1978-79</td>
<td>244.3</td>
</tr>
<tr>
<td>1979-80</td>
<td>1274.0</td>
</tr>
<tr>
<td>1980-81</td>
<td>1967.2</td>
</tr>
<tr>
<td>1981-82</td>
<td>2231.3</td>
</tr>
<tr>
<td>1982-83</td>
<td>2592.0</td>
</tr>
<tr>
<td>1983-84</td>
<td>1588.1</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Dairy Outlook and Situation, December 1984 (9).

\textsuperscript{b} Start of fiscal year changed to October 1 in 1976.
Table 7. Dairy products removed from the commercial market by USDA programs 1970-1983 (million pounds)\textsuperscript{a}

<table>
<thead>
<tr>
<th>Marketing Year\textsuperscript{b}</th>
<th>Cheddar Cheese</th>
<th>Butter</th>
<th>Nonfat dry milk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>56.8</td>
<td>305.4</td>
<td>452.3</td>
</tr>
<tr>
<td>1971</td>
<td>87.0</td>
<td>262.4</td>
<td>463.5</td>
</tr>
<tr>
<td>1972</td>
<td>20.1</td>
<td>220.2</td>
<td>259.9</td>
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<td>1973</td>
<td>4.9</td>
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<td>41.6</td>
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<tr>
<td>1974</td>
<td>93.5</td>
<td>66.9</td>
<td>393.6</td>
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<tr>
<td>1975</td>
<td>33.3</td>
<td>26.1</td>
<td>274.8</td>
</tr>
<tr>
<td>1976</td>
<td>96.9</td>
<td>114.9</td>
<td>186.4</td>
</tr>
<tr>
<td>1977\textsuperscript{c}</td>
<td>87.4</td>
<td>133.9</td>
<td>345.5</td>
</tr>
<tr>
<td>1977</td>
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<td>786.9</td>
</tr>
<tr>
<td>1981</td>
<td>598.6</td>
<td>381.9</td>
<td>948.8</td>
</tr>
<tr>
<td>1982</td>
<td>820.3</td>
<td>410.3</td>
<td>1047.2</td>
</tr>
<tr>
<td>1983</td>
<td>542.0</td>
<td>239.4</td>
<td>769.1</td>
</tr>
</tbody>
</table>

\textsuperscript{a} Dairy Outlook and Situation, December 1984 (9).

\textsuperscript{b} Start of marketing year April 1 until 1977, October 1977 to present.

\textsuperscript{c} April-September transition period.


Appendix:
Glossary of Terms (11)

**Blend Price** – The weighted average price received by Grade A dairy farmers supplying a milk order market. It is the Class 1 price times the proportion of the market’s milk used to produce Class 1 products, plus the Class 2 and 3 prices times their respective shares of the market’s milk used in Class 2 and 3 products.

**Class 1 differential** – The difference or price spread between the Class 1 price and the Class 3 price.

**Class 3 price** – The minimum price stipulated by milk orders, that handlers must pay for fluid-grade milk used to produce manufactured dairy products. In most orders this is the Minnesota-Wisconsin price.

**Federal milk marketing orders** – A regulation issued by the Secretary of Agriculture and administered by the U.S. Department of Agriculture to control the purchase of Grade A milk in an area. Each "Order" defines a specific geographic region, usually around a population center, and determines the minimum prices that may be paid by handlers for raw fluid grade milk and the blend price received by farmers.
**Fluid-grade milk (Grade A)** - Milk approved by designated health authorities (Federal, State, or municipal) for bottled fluid milk products.

**Manufacturing milk** - Grade B or Grade A milk used in the production of a manufactured product.

**Manufacturing-grade milk (Grade B)** - Milk that is not approved by designated health authorities (Federal, State, or municipal) for bottled fluid milk products. This milk can only be used to produce manufactured dairy products such as butter, nonfat dry milk, and cheese, as it does not meet the necessary sanitary standards.

**Minnesota-Wisconsin price** - A price announced by the U.S Department of Agriculture which is an estimate of the average price paid by unregulated handlers for manufacturing grade milk (Grade B) in the two states.
PAPER 2: DISEQUILIBRIUM IN THE U.S. DAIRY INDUSTRY
AN ECONOMETRIC FORECASTING APPROACH TO ANALYSIS

The Problem

Federal programs to regulate the dairy industry began in earnest with the 1933 Agricultural Adjustment Act which was passed after farm income had fallen from $11.9 billion in 1929 to $5.2 billion in 1931 (see Martin 17). Important legislative changes since have included the 1937 Agricultural Marketing Agreement, the 1949 and 1981 Agriculture and Food Acts, and most recently the 1983 Dairy and Tobacco Adjustment Act.

The forthcoming 1985 Farm Bill is expected to bring further changes in the support program for the industry. The incentive for changing the present structure comes from a desire for budgetary prudence reinforced by the currently high expenditures ($1.5 billion in fiscal year 1984) on the federal dairy program. This current oversupply situation caused federal dairy product support purchases to account for around 7% of total milk marketings in 1984. However, oversupply in the industry is not new, with support purchases significantly above the norm having occurred in the years 1953–54, and 1962–64 (7).

The milk price levels needed to bring supply and demand
closer together therefore require serious examination. Recent studies (24) have indicated that a drop in real milk prices of 15-20% is needed to achieve a desired balance between dairy production and consumption. The upcoming Farm Bill will determine whether the present program remains, but with a lower support price, or a new structure such as target pricing (see Rausser and Farrell 20) will be established.

The purpose of this study was to project the effects on milk production and dairy product supply, demand, and stock levels at differing farm milk prices.

**Review of the Literature**

The U.S. dairy industry has been the subject of a great deal of study over the past 30 years. Aspects of the industry examined have included the welfare and transfer costs of regulation\(^1\), evaluations on class 1 differentials\(^2\), import controls\(^3\), and restrictions on reconstituted milk (see Whipple 26). In addition, a large number of models have examined various short and long-run elasticities

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\(^1\) See Dahlgran (6), Heien (13), Blakley and Riley (1), Ippolito and Masson (15).

\(^2\) See Buxton (3), Fallert and Buxton (9).

\(^3\) See Salathe et al. (23), Novakovic and Thompson (18).
of supply and demand. Analysis of price and income elasticities has focused on a national scale, although notable exceptions exist.4

Industry supply elasticities have been calculated from total supply equations, or estimated using cow numbers and yield per cow to derive total supply. Estimates of short-run supply elasticities for U.S. milk prices have varied from 0.03 to 0.6304, and long-run values have ranged from 0.145 to 2.5.5

The small supply response in the short-run is partially explained by the fact it takes 2-3 years to increase herd sizes for the industry as a whole. Thus, milk supply is highly inelastic in the short-run due to biological production constraints, but become much more elastic as producers are able to adjust their herds over time.

Yields per cow effect supply in both the short and long-run. Changes in the milk price alters the milk/feed price ratio which in turn influences feeding practices and thereby productivity. Jackson found the milk price to be significant in determining concentrates fed to cows, which

4 See Buxton (4), Dahlgran (6), Jackson (16), and Riley and Blakley (21).

5 Wilson and Thompson (27) in 1965 estimated the short-run supply elasticity at 0.03 while Jackson (16), in 1973, derived a value of 0.6304. For long-run elasticities, Halvorson (12) in 1958 found a value of 0.145 compared to Dahlgran’s 1983 estimate (5) of 2.5 based on a significantly longer time period.
explains variations in productivity. In the long-run, underlying technical changes in the industry, such as genetic improvement, could lead to increasing yields even with reductions in the milk price (see Dahlgrgan 5). One end result may be declining milk prices and cow numbers yet increasing milk production.

This study, rather than using separate supply equations to evaluate regional producer effects and supply responses from changes in the milk price, utilized a simultaneous econometric model for analysis. The desirability of such an approach is that it incorporates a demand structure and retail product prices, which in turn determine the milk price to the farmer. This structure captured some of the dynamic nature of the industry and evaluated milk supply, dairy product demands, stock levels, and price responses due to changes in the milk price received by the farmer.

Simultaneous structures of the industry are not new. Past approaches, with the exception of Hallberg and Fallert (11), only determined national milk supplies. Given the very regionalized nature of the industry an aggregate approach passes over some important policy implications (see Grafton 10). For instance, a uniform drop in the support price may mean a decline in supply in one region and an

---

6 See Hallberg and Fallert (11), Hutton and Helmberger (14), Salathe et al. (22), Westcott and Carman (25), and Wilson and Thompson (27).
increase in another.

The desire to capture regional supply responses coupled with reservations with respect to previous studies resulted in the model used in this study.

The Model

A simultaneous model of 44 equations was built to analyze the problem using data for the period 1960-1982. Validation results for the model over this time-frame are presented in Table 1.

The model consisted of five major parts: regional milk supplies; and production; consumption; stocks; and price levels of the major dairy products. The nine milk production regions came from Hallberg and Fallert's 1976 study. The products determined in the model were cheese (all types), butter, non-fat dry milk, evaporated and condensed milk, and fluid milk. The residual in total milk production was accounted for in an identity that equated total milk supplied to total milk utilized.

A discussion of the component parts of the model follows.

---

7 See Figure 1.
Table 1. Model validation results for the period 1960-1982

<table>
<thead>
<tr>
<th>variable</th>
<th>RMS% error</th>
<th>Nbr. of parameters</th>
<th>R-square&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPRODN</td>
<td>0.0888</td>
<td>3</td>
<td>0.96</td>
</tr>
<tr>
<td>CPRODN</td>
<td>0.4434</td>
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<td>0.98</td>
</tr>
<tr>
<td>BPRODN</td>
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<td>0.73</td>
</tr>
<tr>
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<td>0.88</td>
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<tr>
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<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CCIVC</td>
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<td>-</td>
</tr>
<tr>
<td>BCIVC</td>
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<td>-</td>
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</tr>
<tr>
<td>SCIIVC</td>
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<td>-</td>
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<tr>
<td>FLCAP</td>
<td>0.0367</td>
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<td>0.86</td>
</tr>
<tr>
<td>RRPE</td>
<td>0.1472</td>
<td>2</td>
<td>N/A</td>
</tr>
<tr>
<td>RRPC</td>
<td>0.0464</td>
<td>2</td>
<td>N/A</td>
</tr>
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<td>RWSSP</td>
<td>0.1898</td>
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<td>FLUIDP</td>
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<td>0.52</td>
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<tr>
<td>SWCN</td>
<td>0.0353</td>
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<td>3</td>
<td>-</td>
</tr>
</tbody>
</table>

<sup>a</sup> Where applicable.
Regional milk supplies

Total milk production in the model is the summation of the nine regional milk supplies. In turn, the regional productions are determined as follows:

Milk production in region i = Yield per cow in region i * Cow numbers in region i.

Genetic improvement and the use of growth hormones will be the major factors behind long-term changes in productivity (see Boehlje and Cole 2). For this reason, yield per cow was left exogenous in the projections and set at levels forecasted by the Congressional Office of Technological Assessment (see Wise et al. 28). The percentage change in the national projection for productivity was then used to derive regional productivity projections.

Cow numbers were endogenously determined and took the following form:

\[
\begin{align*}
\text{NWCN} & = 621.12 - 21.16 \text{NWMP} + 80.74 \text{LAG2(MFDP/NWVALF)} \\
& (49.88) (6.75) (63.65) \\
\text{SWCN} & = 528.74 + 24.26 \text{SWMP} + 24.68 \text{LAG2(MFDP/SWVALF)} \\
& (65.81) (9.55) (74.11) \\
\text{MTCN} & = 439.89 - 20.55 \text{MTMP} + 31.26 \text{LAG2(MFDP/MTVALF)} \\
& (28.75) (2.83) (26.76) \\
\text{PLCN} & = 1750.19 - 133.79 \text{PLMP} + 120.08 \text{LAG2(MFDP/PLVALF)} \\
& (118.14) (8.71) (70.06)
\end{align*}
\]

8 See Figure 1.
\[
\text{LKCN} = 4912.236 - 1990.46\text{LKMPC} + 130.69\text{LAG2(MFDP/LKVALF)} \\
(318.02) \quad (43.16) \quad (275.37)
\]

\[
\text{CBCN} = 6417.36 - 464.23\text{CBMPC} + 350.73\text{LAG2(MFDP/CBVALF)} \\
(443.09) \quad (52.42) \quad (380.70)
\]

\[
\text{SCCN} = 2756.19 - 209.22\text{SCMPC} + 250.28\text{LAG2(MFDP/SCVALF)} \\
(203.40) \quad (20.66) \quad (240.88)
\]

\[
\text{SACN} = 876.21 - 37.77\text{SAMPC} + 13.14\text{LAG2(MFDP/SAVALF)} \\
(52.29) \quad (3.08) \quad (26.18)
\]

\[
\text{NECN} = 6642.20 - 388.97\text{NEMPC} + 550.13\text{LAG2(MFDP/NEVALF)} \\
(398.78) \quad (90.60) \quad (640.57)
\]

Standard errors are in parentheses.

where

\text{MFDP} = \text{Manufactured milk price at farm level (}$/\text{cwt}$)

\text{NWMCN} = \text{Northwest milk cow numbers (thousands)}

\text{SWMCN} = \text{Southwest milk cow numbers (thousands)}

\text{MTMCN} = \text{Mountain milk cow numbers (thousands)}

\text{PLCMCN} = \text{Plains milk cow numbers (thousands)}

\text{LKCNCN} = \text{Lake milk cow numbers (thousands)}

\text{CBCNCN} = \text{Corn Belt milk cow numbers (thousands)}

\text{SCCN} = \text{South Central milk cow numbers (thousands)}

\text{SACCN} = \text{South Atlantic milk cow numbers (thousands)}

\text{NECN} = \text{Northeast milk cow numbers (thousands)}

\text{NWMPCN} = \text{Northwest milk production per cow (lbs/cow/year)}

\text{SWMPCN} = \text{Southwest milk production per cow (lbs/cow/year)}

\text{MTMPCN} = \text{Mountain milk production per cow (lbs/cow/year)}

\text{PLMPCN} = \text{Plains milk production per cow (lbs/cow/year)}

\text{LKMPCN} = \text{Lake milk production per cow (lbs/cow/year)}

\text{CBMPCN} = \text{Corn Belt milk production per cow (lbs/cow/year)}

\text{SCMPCN} = \text{South Central milk production per cow (lbs/cow/year)}

\text{SAMPCN} = \text{South Atlantic milk production per cow (lbs/cow/year)}

\text{NEMPCN} = \text{Northeast milk production per cow (lbs/cow/year)}

\text{NWVALFCN} = \text{Northwest average dairy ration cost ($/cwt$)}

\text{SWVALFCN} = \text{Southwest average dairy ration cost ($/cwt$)}

\text{MTVALFCN} = \text{Mountain average dairy ration cost ($/cwt$)}

\text{PLVALFCN} = \text{Plains average dairy ration cost ($/cwt$)}

\text{LKVALFCN} = \text{Lake average dairy ration cost ($/cwt$)}

\text{CBVALFCN} = \text{Corn Belt average dairy ration cost ($/cwt$)}

\text{SCVALFCN} = \text{South Central average dairy ration cost ($/cwt$)}

\text{SAVALFCN} = \text{South Atlantic average dairy ration cost ($/cwt$)}

\text{NEVALFCN} = \text{Northeast average dairy ration cost ($/cwt$)}
Production

The dairy product supply equations are given below.

\[
\begin{align*}
EPRODN &= -206.93 + 30.39 \text{LAG}(\text{RPE/AHEDW}) + 0.9606 \text{LAG}(EPRODN) \\
&\quad (275.63) (35.09) (0.0517) \\
CPRODN &= -68.25 + 39.21 \text{LAG}(\text{RPC/RPB}) + 1.064 \text{LAG}(CPRODN) \\
&\quad (235.03) (260.66) (0.0571) \\
BPRODN &= 203.25 + 273.52 \text{LAG}(\text{RPB/RPC}) + 0.6038 \text{LAG}(BPRODN) \\
&\quad (150.33) (388.95) (0.2546) \\
SPRODN &= -342.37 + 946.24 \text{LAG}(\text{RPB/RPC}) + 0.6299 \text{LAG}(SPRODN) \\
&\quad (410.85) (761.82) (0.2028)
\end{align*}
\]

Standard errors are in parentheses.

where

- \(EPRODN\) = Evaporated and condensed milk production (millions lbs)
- \(CPRODN\) = Cheese production, all types (millions lbs)
- \(BPRODN\) = Butter production (millions lbs)
- \(SPRODN\) = Non-fat dry milk production (millions lbs)
- \(\text{RPE}\) = Retail price evaporated milk (cents/14.5 oz. can)
- \(\text{RPC}\) = Retail price of cheese (cents/lb)
- \(\text{RPB}\) = Retail price of butter (cents/lb)
- \(\text{AHEDW}\) = Average hourly earnings of unsupervised workers in the manufacture of dairy products ($/hour)

It was hypothesized that the relative profitabilities between butter and cheese were important in determining their respective supplies. This same effect was also expected for non-fat dry milk since it is a complementary product to butter. Evaporated milk supply was considered separately with the ratio of its price to dairy factory workers wages representing a production profitability index.

Consumption

Product demands were not determined directly but were
calculated as a residual from changes in production and stock levels. This approach was taken to directly calculate product prices from inverse demand functions.

The consumption equations are as follows:

\[
\begin{align*}
\text{ECIVC} &= \text{EPRODN} - \text{EMILC} - \text{EOPSTK1} + \text{LAG}(\text{EOPSTK1}) - \text{NXEP} \\
\text{CCIVC} &= \text{C PRODN} - \text{CMILC} - \text{COPSTK1} + \text{LAG}(\text{COPSTK1}) - \text{NXCP} \\
\text{BCIVC} &= \text{BPRODN} - \text{BMILC} - \text{BOPSTK1} + \text{LAG}(\text{BOPSTK1}) - \text{NXBP} \\
\text{SCIVC} &= \text{S PRODN} - \text{SMILC} - \text{SNFU} - \text{SOPSTK1} + \text{LAG}(\text{SOPSTK1}) - \text{NXSP}
\end{align*}
\]

where

\[
\begin{align*}
\text{ECIVC} &= \text{Civilian consumption evaporated and condensed milk (million lbs)} \\
\text{CCIVC} &= \text{Civilian consumption cheese, all types (million lbs)} \\
\text{BCIVC} &= \text{Civilian consumption butter (million lbs)} \\
\text{SCIVC} &= \text{Civilian consumption non-fat dry milk (million lbs)} \\
\text{EMILC} &= \text{Military consumption evaporated milk (million lbs)} \\
\text{CMILC} &= \text{Military consumption cheese (million lbs)} \\
\text{BMILC} &= \text{Military consumption butter (million lbs)} \\
\text{SMILC} &= \text{Military consumption non-fat dry milk (million lbs)} \\
\text{EOPSTK1} &= \text{End of year stocks evaporated milk (million lbs)} \\
\text{COPSTK1} &= \text{End of year stocks cheese (million lbs)} \\
\text{BOPSTK1} &= \text{End of year stocks butter (million lbs)} \\
\text{SOPSTK1} &= \text{End of year stocks non-fat dry milk (million lbs)} \\
\text{NXEP} &= \text{Net exports of evaporated milk (million lbs)} \\
\text{NXCP} &= \text{Net exports of cheese (million lbs)} \\
\text{NXBP} &= \text{Net exports of butter (million lbs)} \\
\text{NXSP} &= \text{Net exports of non-fat dry milk (million lbs)} \\
\text{SNFU} &= \text{Non-food utilization of non-fat dry milk (million lbs)}
\end{align*}
\]

Since production equals consumption for fluid milk its demand was determined directly as follows:

\[
\begin{align*}
\text{FLCAP} &= 0.3131 - 0.0260(\text{FLUIDP/FOODDEX}) - 0.0000453RDISY \\
&\quad (0.075) (1.23) \quad (0.0000099) \\
&\quad + 0.00252PUSPU25 \quad (0.00168)
\end{align*}
\]
MUFM = POPN*FLCAP

Standard errors are in parentheses.

where

FLCAP = Per capita fluid milk consumption (lbs/person)
FLUIDP = Class I price of milk ($/cwt)
FOODDEX = Food price index (1972=100)
RDISY = Per capita disposable income (1972 dollars)
PUSPU25 = Proportion of US population under 25 years of age
MU FM = Fluid milk consumption (billion lbs)

Prices

Nominal prices for the products determined in the model

were derived from the inverse demand functions given below.

\[ RRPE = 0.00011RDISY - 0.000046ECIVC \]
\[ \phantom{RRPE} (0.000008) \] \[ (0.00002) \]

\[ RRPC = 0.00034RDISY - 0.00006CCIVC \]
\[ \phantom{RRPC} (0.000018) \] \[ (0.00002) \]

\[ RWSSP = 0.00016RDISY - 0.000025SCIVC \]
\[ \phantom{RWSSP} (0.000009) \] \[ (0.000036) \]

\[ RPE = RPFLUID*RRPE \]
\[ RPC = CPI*RRPC \]
\[ RWSSP = CPI*RWSSP \]
\[ CPI = Consumer price index (1972=100) \]

Standard errors are in parentheses.

The butter price was set exogenous in the model because
the sign on consumption with respect to the real price of
butter was significantly positive and not negative as
hypothesized. In addition, the equation tracked poorly in an
historical simulation.

The manufactured price for milk was determined from
the product prices of butter, cheese and non-fat dry milk. In turn, the fluid price for milk to the farmer was derived from the manufactured milk price.

\[ \text{MFDP} = 0.0147 \text{RPC} + 0.0197 \text{RPB} + 0.0543 \text{WSSP} \]
\[ \text{FLUIDP} = 1.43 + 0.9811 \text{MFDP} \]

Standard errors are in parentheses.

**Stocks**

The demands for all product stocks, as given below, were hypothesized to be a function of naive expectations and previous stock levels.

\[ \text{EOPSTK}_1 = 0.2715 \text{LAG(RPE)} + 0.9640 \text{LAG(EOPSTK}_1) - 0.6404 \text{TREND} \]
\[ \text{COPSTK}_1 = 1.489 \text{LAG(RPC)} + 0.6286 \text{LAG(COPSTK}_1) \]
\[ \text{BOPSTK}_1 = 0.8347 \text{LAG(RPB)} + 0.4635 \text{LAG(BOPSTK}_1) \]
\[ \text{SOPSTK}_1 = 4.847 \text{LAG(WSSP)} + 0.4728 \text{LAG(SOPSTK}_1) \]

Standard errors are in parentheses.

**Model closure**

The model was closed by converting the production of each dairy product to milk equivalent units which were then
equated to total U.S. milk production.

\[
\text{MUTOT} = \left( (\text{BCON}\times\text{BPRODN}) + \left(\frac{\text{SCON}\times\text{SPRODN}}{2}\right) + (\text{CCON}\times\text{CPRODN}) + (\text{ECON}\times\text{EPRODN}) + \text{MUOTHE} + \text{MUFM} \right)
\]

\[
\text{MUTOT} = \left( \frac{\text{TMPRODN} - \text{MCFFC}}{1000} \right)
\]

Where

\begin{align*}
\text{MUTOT} &= \text{Total utilization of milk production (billions lbs)} \\
\text{TMPRODN} &= \text{Total U.S. milk production (millions lbs)} \\
\text{BCON} &= \text{Factor converting butter production to milk equivalent units} \\
\text{SCON} &= \text{Factor converting non-fat dry milk to milk equivalent units} \\
\text{CCON} &= \text{Factor converting cheese production to milk equivalent units} \\
\text{ECON} &= \text{Factor converting evaporated milk production to milk equivalent units} \\
\text{MUOTHE} &= \text{Utilization of milk for purposes other than cheese, butter, non-fat dry milk, evaporated milk and fluid milk consumption (billions lbs)} \\
\text{MUFM} &= \text{Fluid milk consumption (billions lbs)} \\
\text{MCFFC} &= \text{Milk consumed on farms and fed to calves (millions lbs)}
\end{align*}

The model predicted well for most variables in an historical simulation; the least satisfactory equations were those for butter and non-fat dry milk stocks. The root mean square percentage error, a measure of the deviation of the simulated variable from its actual time path in percentage terms, is presented for each of the endogenous variables in Table 1.
Results and Discussions

Three milk price scenarios were run with the model for the years 1983-1990. These projections set the three product prices that determine the manufactured milk price; cheese, butter and non-fat dry milk to 0.75, equal to, and 1.5 times their actual 1982 values.

In the original runs of the model the 1983 and 1984 milk supply projections were approximately 7% below actual values. For this reason, the intercepts of all the supply equations were adjusted upwards, but by no more than the standard error of their coefficients.

Scenario one: product prices set equal to 1982 levels

This forecast kept the manufactured milk price at $12.94/cwt for the period, a figure close to the 1983 average value of $12.62/cwt. In this projection, the results of which may be viewed in Table 3, the regional ration costs were kept to an average of their 1981/1982 values.

The simulation indicated that current nominal price levels would bring supply and demand much closer together by the year 1990 with total milk production projected to be around 130 billion pounds. This would provide for total ending stocks of around 5% of total marketings, most of which of which would be held by the Government. Although support
Table 2. Variable definitions for Tables 3, 5 and 6

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<td>Lake milk production</td>
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<td>South Atlantic milk production</td>
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<tr>
<td>NETMP</td>
<td>Northeast milk production</td>
<td>million pounds</td>
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Table 3. Scenario one: supply projections from 1983 to 1990 on the basis of $12.94/cwt price for manufacturing milk

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a Projected supplies are in million pound units.

b See table 2 for explanation of variables.

c Actual values for 1983-84 are in brackets.
Table 4. Regional elasticities of milk production with respect to milk productivity and the milk price for the forecast period 1983-1990

<table>
<thead>
<tr>
<th>Region</th>
<th>Milk Productivity</th>
<th>Manufacturing Milk Price</th>
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purchases of around 5% of total marketings would be considerably below the 12% level of 1983 (8), the support level would still be higher than the average of the 1970s. This projection of declining production at current price levels runs contrary to some of the current thinking (8), i.e., that cow numbers will remain constant for 1985 while productivity is expected to increase 1.5-2.0%.

Of equal interest is the relative changes in regional production levels. Holding the manufactured milk price at the current level would cause declining production in the South Central, Northeast, Plains, Corn Belt, and Mountain regions, with supply remaining constant in the Lake and South Atlantic regions and increasing in the Northwest and Southwest. A simulation using the same milk price but an upward trend of around 15% in feed prices from 1982-90 generated similar results except that production reached 130 billion pounds in 1989, a year earlier than with constant feed prices, and gave an ending value of total milk supply of 128 billion pounds. The sensitivity of the results to the projection of yields per cow were evaluated with higher productivity projections carried out on all three milk price scenarios. The results in each case however were not significantly different from those presented in tables 3, 5 and 6.
The results support the hypothesis that regional responses in production vary considerably across the country and that these differences should be taken into account by policy makers. These differences are evidenced in both the simulations and the differing regional milk elasticities given in Table 4. The elasticities derived from the model should, however, be accepted with the reservation that the model was built for simulation purposes only, and hence the milk price did not influence the exogenously projected yields per cow. Hence, the elasticities of milk production to the milk price were calculated using only cow numbers while the linkage between the milk price upon yield per cow, which in turn influences cow numbers, was not considered.

**Scenario two: product prices held at 0.75 times 1982 levels**

This scenario dropped the manufactured milk price to $9.71/cwt which resulted in the total milk supply falling from 138 billion pounds in 1983 to around 127 billion in 1987, as shown in Table 5. This level of production would approximately equate supply with demand. However, if this price level was continued, by 1990 total production was projected to be 122 billion pounds, a situation that would probably require additional imports to satisfy consumer demand for dairy products.
Table 5. Scenario two: supply projections from 1983 to 1990 on the basis of $9.71/cwt price for manufacturing milk.a

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</table>

a Projected supplies are in million pound units.

b See table 2 for explanation of variables.

c Actual values for 1983-84 are in brackets.
Table 6. Scenario three: supply projections from 1983 to 1990 on the basis of $19.41/cwt price for manufacturing milk\textsuperscript{a}

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\textsuperscript{a} Projected supplies are in million pound units.

\textsuperscript{b} See table 2 for explanation of variables.

\textsuperscript{c} Actual values for 1983-84 are in brackets.
As far as regional effects, only the Southwest had increases in production over the period, with the largest declines in production occurring in the Plains, Corn Belt and South Central regions. Initially, it was hypothesized that the increase in production for the Southwest at this price level was primarily due to the positive coefficient on yield per cow. Setting this coefficient to zero still resulted in increasing production for the region, although at much lower levels.

**Scenario three: product prices held at 1.5 times 1982 levels**

This projection had a significant increase in the manufacturing milk price from current levels of around $12.50/cwt to $19.41/cwt. The results, listed in table 6, show increases in milk supply between 1982 and 1990 for every region except the Corn Belt. Of interest was the decline in total milk production from 153 billion pounds in 1986 to 148 billion in 1990. This was attributed to declining cow numbers over the period brought on by the projected increases in cow productivity. Given such a profitable milk/feed price ratio farmers it seems unlikely farmers would reduce their herds. It is possible that the declining trend in cow numbers over the model's estimation period, captured in the coefficients of the supply equations, was continued in these projections. If this was the case, then the projected values
of production levels may be underestimated for all scenarios.

Conclusions

The results imply that a drop in the support price for milk would lead to differing regional responses. The results indicate that the Southwest would continue to have increases in production even given a 20% drop in the manufactured price of milk. Conversely, the projections showed that following substantial increases in the milk price production would still decline in the Corn Belt.

The implication for policy is that examining only national milk supply and demand ignores some very important regional considerations. For example, in the Southwest there was a 40% increase in milk supply between 1970-71 and 1980-81 compared to a fall in production of around 7% in the Plains and Corn Belt regions for the same period. The increased production in the Southwest was caused in part by the establishment of large scale dry-lot operations of upwards of 2000 cows. These enterprises appear to take advantage of economies of size and generate substantially higher rates of return on investment than the small-scale dairy operations found in the traditional dairying areas of the Lake states and Northeast. The changing structure of the industry, as well as the difference in production costs across regions.
(see Grafton 10) generated the various supply responses in the model projections.

In addition, the results show a lagged effect of the milk price upon production, a result indicated in past regional elasticity estimates. Awareness of this response by policy makers is necessary to avoid swapping an oversupply situation in one period for deficits in the next.

Suggestions for Further Research

The forecasts indicate a declining trend in cow numbers in all three price scenarios continuing the trend of the past 20 years9, with the exception of temporary increases in cow stocks in the early 1980s. Current studies (see Dahlgran 5) indicate that this trend would be unlikely to continue given current milk price levels. Therefore, the possibility exists that the given supply projections may be biased downwards.

One approach that may improve the accuracy in forecasting supply is to adopt a multi-equation method in estimating cow numbers (see Salathe et al. 22). An approach with separate equations for cow replacements and slaughters for deriving total stocks may better capture the actual decision making process in cow stock determination.

9 National cow numbers fell from 15.3 million in 1965 to 10.8 million in 1984.
Literature Cited


6. Dahlgr

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SUMMARY AND IMPLICATIONS

Both papers in this study examine some of the regional consequences of different milk price levels. The first article concluded that the Southwest was an area of comparative advantage for milk production, and that milk prices would need to drop some $3.50/cwt before production would decline in the region. The programming solutions also indicated that the milk price need decline only slightly to reduce milk supplies in the Southeast. These results cannot be compared directly to the econometric approach since each model uses different regions for the analysis. However, the econometric projections do support some of the programming results, for example, given a decline in milk prices of more than 20% below current levels production in the Southwest would still continue to increase.

Examination of the programming scenario at 1982 prices with all regional and farm size constraints included indicated production would continue to increase in all regions except the Southeast. At similar milk prices, the econometric model indicated increases in production would occur only in the Northwest and Southwest of the country. These differences may be explained by the fact that the programming approach captures the dairy industry as it
exists today, while the econometric model uses past trends to project future changes in the industry.

This study quantifies the different regional responses from equivalent changes in milk prices. The implication for dairy research is that regional models must be used to fully evaluate the effects of changes in the current support price structure. The implication for policy is that with the current support structure achieving a goal of balancing supply and commercial demand in the industry cannot be made without significant structural changes such as the loss of livelihood of many small-scale farmers in traditional dairying regions.

The contribution of this thesis is that it quantifies the regional differences in the U.S. dairy industry and directly relates them to policy.
LITERATURE CITED


