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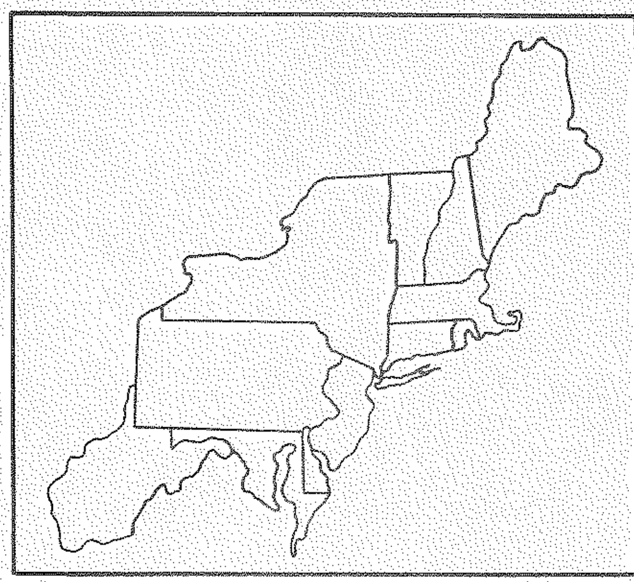
THE SPATIAL ORGANIZATION OF THE NORTHEAST DAIRY INDUSTRY



A Northeast Regional Research Publication

edited
by
Andrew M. Novakovic

Department of Agricultural Economics
Cornell University Agricultural Experiment Station
New York State College of Agriculture and Life Sciences
A Statutory College of the State University
Cornell University, Ithaca, New York, 14853

FOREWORD

The first set of papers in this publication were presented in a symposium at the annual meeting of the Northeast Agricultural Economics Council held at Cook College, Rutgers University on June 22, 1983. The symposium was organized and convened by G. Joachim Elterich for the NE-126 committee. Dr. Paul Christ of Land 'O' Lakes also made a presentation; however, we were unable to obtain a written statement.

The second set of papers are working papers that were prepared for the NE-126 workshop held at Rutgers on June 23, 1983. The workshop was conducted as a coordinating effort for the research being done under the Northeast Regional Dairy Marketing Project NE-126, "An Analysis of the Spatial Organization of the Northeast Dairy Industry." The Technical Committee for the project is composed of workers from the U.S. Department of Agriculture and many of the Agricultural Experiment Stations in Ohio and the northeastern United States. Committee membership at the time of the workshop was as follows:

State Agricultural Experiment Station Representatives

Delaware......................................G. Joachim Elterich
Maine...George K. Criner
New Jersey....................................Mitchell J. Morehart
New York......................................Andrew M. Novakovic
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Publications Office
Department of Agricultural Economics
Cornell University
442 Warren Hall
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POLICY ISSUES OF THE NORTHEAST DAIRY INDUSTRY

by

Andrew M. Novakovic*

Anyone even vaguely familiar with the dairy industry is aware of the market problems and policy controversies that have dominated that industry's attention for the last several years. The last year in which market supplies of milk and dairy products were reasonably well balanced with demand was 1979, when total supply exceeded total demand (as measured by CCC net removals of dairy products) by about 1.6%. By the end of 1982, total supplies had increased over 11% while commercial use of milk products had increased only 1.6%, resulting in a 10% surplus in 1982. Forecasts for 1983 have been hard to make due to uncertainties regarding dairy policy and feed prices, but this trend will most likely continue.

A number of factors, including declining feed prices and a weak economy, contributed to milk production increases that far outpaced changes in consumption, but without a doubt the principal factor was and still is excessively high support prices under the federal dairy price support program.

Without belaboring the historical events, it is clear that the U.S. dairy industry is faced with two problems. One is the dilemma of making new policy choices that will solve the market problems in the least disruptive or painful manner. The second is the problem of burgeoning stockpiles of cheese, butter, and nonfat dry milk which are difficult to market without further eroding prices.

Opinion on the correct course for dairy policy has been split roughly between those who favor a straightforward cut in the support price (the Administration, most of the Senate and most processors) and those who favor trying several other things rather than resort to a price cut (most of the House and most dairy cooperative leaders).

The positions taken by these two groups are virtually diametrically opposed and do not suggest an easy or obvious compromise. Consequently, the various policy-makers and participants have been in a political gridlock for the last two years. It has fallen to Congress to find a compromise. Their first effort at compromise resulted in the program of optional 50¢/cwt. assessments. That compromise was developed largely outside of the Congressional agriculture committees and without much prior discussion with the Administration or industry leaders. The assessments have been unpopular with virtually all groups from the beginning and are vigorously opposed by dairy cooperative leaders.

In the last couple of months a new compromise plan has been brewing. It appears to have the early support, albeit somewhat lukewarm support, of all the necessary political agents and may become law. The compromise plan combines elements of the more popular alternatives. It offers an initial support price

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* Andrew M. Novakovic is an Assistant Professor in the Department of Agricultural Economics at Cornell University.

cut of 50¢/cwt and a mandatory 50¢/cwt. assessment that will help to offset the cost of a paid diversion or set-aside type program that would pay $10 per cwt. to producers who reduce their production from 5 to 30% below a certain base period level. It also calls for a fee of up to 15¢ per hundredweight of milk marketed to be collected from all farmers and used for generic promotion of milk products. The price cuts and voluntary paid diversion plan would begin this October. The paid diversion and assessments would terminate by January 1, 1985 but could then be replaced by further price cuts. By October 1985 it is hoped that the new four-year agricultural bill will contain a less ad hoc approach to dairy policy.

At best the compromise plan would buy some time for the various participants to come up with that longer run plan. At worst, the compromise would be an expensive plan that proves counter productive in the short run and prolongs the agony in the long run.

In all the long and hard debate over current policy options there is an undercurrent of a deeper and ultimately more important discussion. This discussion deals with the fundamental objectives and strategies of the price support program.

At the time of the inception of the price support program, the policy's purpose was clearly to increase farm prices and stimulate production. As the problems of the Depression and World War II began to ease and disappear, the focus of dairy policy seemed to shift from income enhancement to price stability. This change has been subtle and has not been totally formalized by law. Moreover, the relative importance of these goals clearly varies among individuals involved with dairy policy. The current surplus situation is forcing policy makers and industry participants to make choices relative to these goals and is hardening the line between the two factions.

It may or may not help resolve the immediate problem, but a discussion of the explicit goals of price support policy and of the factors that should guide the program's administration must take place if a sensible long run dairy program is to evolve. At present it is difficult to be optimistic that this will happen. Dairy policy is being formulated in a highly politicized and crisis oriented environment; this is hardly conducive to serious thinking about long run policy objectives and procedures.

THE CURRENT DAIRY PROBLEM AND ITS IMPACT ON NORTHEAST FARMERS

by

Richard W. Stammer*

As any research methods class would point out we must first identify if we have a problem. As has been pointed out by previous speakers we certainly do have a problem when 10% of national dairy production is being purchased by the government at an annual cost to taxpayers of over two billion dollars.

How did we get into this situation? The problem had its genesis in the Carter administration when the minimum support was set at 80% of parity - a move opposed by the National Milk Producers Federation. However, this change in the level of support price did not cause a problem until the general economy and the agricultural economy went to pieces beginning in 1980. The price support level of milk has not increased since October 1980 but production and C.C.C. purchases have continued to increase for the following reasons:

1) A poor general economy that both depressed commercial demand and practically reduced alternative opportunities for dairy farmers (i.e. selling land to developers or taking outside employment).

2) Low beef prices which resulted in farmers keeping cows that would otherwise have been culled.

3) Low grain prices which resulted in farmers feeding more grain and increasing production per cow.

4) Poor profitability in all of agriculture relative to dairy, particularly grain production, that resulted in entry of new milk producers and the shift to more dairy production on general farming operations.

5) Low net dairy farm income as a result of declining real prices and high interest rates that resulted in producers adding more cows to maintain their cash flow position. In an analysis done by Springfield Credit Banks of 539 Northeast dairy farms they found that while the average net cash income per cow has declined since 1979, net cash income per farm has remained constant since 1980. This was accomplished by adding more cows. For instance from 1981 to 1982 net cash income per cow declined 4% because expenses increased more than receipts but producers offset this by adding an average of three cows per herd.

What Is the Solution?

During this past year I have worked very closely with several other cooperatives through the National Milk Producers Federation and several Congressmen in trying to reach a solution to the problem. Many solutions have been proposed such as: cutting support prices, the .50 cent and one dollar assessment programs, two tier pricing, paid diversions, cull cow programs, farm retirement

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* Manager of Economics and Communications for Agri-Mark, Inc.

plans, and cutting supports and freezing Class I prices. The previous speaker described the basis of the compromise plan reached by the House and Senate leaders and the administration. However, even after that agreement was made, a new bill is going to be introduced by a New York Congressman to just cut supports $1.50.

Through this whole, often frustrating, process one soon learns that raw politics is often more important than economics. However, one must continue to use strong economic reasoning to support their position.

The major thrust of the industry effort has centered on a few major points:

1) We must address the problem.

2) Recognize that the problem occurred as the joint effect of many factors, not just the support price.

3) Find a solution that eases us out of the problem and results in a stronger more efficient dairy industry - rather than just pulling out the rug.

4) Find a solution that addresses the federal budget problem - (we must recognize that this is a crucial issue with the administration cutting social programs to address the budget deficit problem in order to maintain a tax cut and increased military expenditures).

As such, the industry preferred a paid diversion program financed by farmers to help the industry through the next two years and reduce government expenditures by approximately 1.4 billion dollars.

<u>Will The Compromise Legislation Be Effective and What Will Be the Impact On Farmers?</u>

The compromise legislation contains some elements of the National Milk Producers Federation program - namely paid diversions and a mandatory promotion assessment. The biggest problem with this program is that the paid diversion plan only runs for 15 months as compared to the 24 months proposed in the Federation Plan. We should not make the mistake of assuming that anyone viewed paid diversions as a long run solution to the problem if everything else remained constant. In a long run solution demand must be increased and supply will be cut by having fewer farms - not the same number of farms each producing less milk. However, the paid diversion program was viewed as a short run solution that would ease the transitional hardship on dairy farmers at the same time it provided a holding period for other economic factors causing the problem to correct themselves, which would yield a long run solution. Let me briefly explain: paid diversions would probably give the economic incentives for many farmers, who were considering retirement or going out of business to do so without suffering financial disaster. This orderly exit of farms would be further encouraged with improvements in the general economy and the agricultural sub-sector during this period. Another important factor to realize in assessing the probability of this long run adjustment is that farmers have maintained their net cash income in recent years by living off depreciation. This is shown by the fact, from the Springfield Bank study, that while net cash income has remained constant, average net earnings per farm have declined from $10,500 in 1980 to $850 in 1982. Farmers cannot continue to live off depreciation, and the need to invest new capital in light of declining prices will encourage many producers to exit from production. Farmers whose long run objective was to stay in business would be able to cut production in the short run and still maintain the necessary cash flow to meet expenses. An improving economy with flat milk prices and increased input costs, particularly grain costs as a result of the P.I.K. program, should have allowed a long run solution to the problem to work itself out by the time the paid diversion program ended. I have considerable doubt as to whether the paid diversion program under the compromise legislation is long enough to allow economic forces to adjust and bring about a long run solution to the problem.

Our principal objection to just cutting prices is that it fails to recognize the many facets of the problem and may force out many efficient farmers who have high debt loads.

What Farmers Will Be Hurt By the Programs

I think that Milt Hallberg addresses this question quite well in his paper. Again the results of the Springfield Bank Study would indicate that the key factor to survival is management. While they found that, on the average, larger farms and farms with greater production per cow were more profitable; they also found many profitable smaller farms and many unprofitable large farms. Their analysis indicates a fairly low correlation between size and profitability. Again, I feel a sharp price cut will tend to hurt the farms with heavy debt loads.

One additional factor that must be considered, however, is the impact of reduced total production in the market on the actual farm price. In the Northeast, commercial outlets for milk have been expanding in recent years, particularly the Italian cheese businesses in New York. While currently 10% of the national product is sold to the government, only about 5.5% of production in the Northeast went to the government in 1982. Hence, a 10% reduction in production in the Northeast would tighten up commercial markets considerably and raise the possibility of cooperatives being able to impose over-order prices, such as we had in 1973-74, that would increase producer income. One only has to look at the Southeastern markets to recognize the impact of tight milk supplies on net producer prices even at a time of national surpluses.

IMPACT OF REDUCED INCOMES ON THE NORTHEAST DAIRY INDUSTRY

by

M.C. Hallberg*

My topic for this session presupposes a result--reduced dairy farm incomes--that may or may not come true or that may or may not be widespread. A more appropriate title may have been "What are the likely impacts on the Northeast dairy industry of possible reduced incomes for Northeast dairy farmers?" In any event I believe most dairy industry watchers do expect milk prices relative to costs to fall in the near future as the market and/or policy makers correct for the current surplus milk situation. This correction might take the form of any one or a combination of the following: (1) implementation of a dairy price support program that is less favorable to farmers than has been the case in the recent past, (2) implementation of a milk "refund" program such as was scheduled to go into effect on April 1, (3) implementation of a production control program for dairy, or (4) higher feed prices.

I and several other researchers in the Northeast have over the past several months been engaged in research designed to investigate in some depth the impacts of potentially reduced incomes on the Northeast dairy economy. I will review some of the relevant results of this effort and offer a few thoughts on what this means for the Northeast.

Impact on Dairy Farmers

We have read in the popular press many stories about the impact reduced "real" milk prices will have on dairy farmers. I do not wish to minimize the fact that this event will have a negative impact on dairy farmers' net income position. Reducing profitability is, of course, one way to try to discourage added milk production.

But how large of an impact can we expect? And will it have such an impact that we are likely to see producers exit from dairy farming? If so, what might these producers be expected to do? Can they be provided with some help so that they can become more efficient at producing milk and thus stay in the milk business? Can they be provided with some help to switch to other types of farming or even to seek non-farm jobs if that is their choice? Will it hurt the smaller dairy farmer relatively more than the larger dairy farmer? How will it impact on dairy farmers' ability to repay outstanding debt? What will it do to farmers' cash flow situation?

Our study of the Northeast dairy industry was designed to find answers to just these kind of questions. It was our intent to go beyond the question of

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* M.C. Hallberg is a Professor of Agricultural Economics at The Pennsylvania State University.

This paper is based on research reported in M.C. Hallberg and R.L. Christensen (eds.), Implications of Reduced Milk Prices on the Northeast Dairy Industry, A.E. & R.S. #167, Dept. of Agricultural Economics and Rural Sociology, The Pennsylvania State University, April 1983.

"How will a given policy impact aggregate U.S. or Northeast demand and aggregate U.S. or Northeast supply?" to ask "How will a given program impact the individual producer--who will get hurt, and by how much, and what can be done to help the individual producer?"

One of the more interesting aspects of this study was an analysis of about 1850 actual farms in New York, Pennsylvania and Vermont. Each of these farms was examined through 1984 with the aid of a computer program that estimated family income based on various assumptions about prices and costs thru 1984. The actual farm debt position as of 1981 was known, and appropriate assumptions were made about each farm's future debt position and debt retirement. Income available for family living on each of these farms was estimated under two different milk price scenarios. The first of these assumed a set of prices thru 1984 that would be expected to "clear the market" if there were no lags in adjustment, no government interference, and if there had been no surplus milk prior to 1982. These we termed our "market" prices. They started at $13.40 in 1982 and increased by about 30 cents/cwt per year thereafter. The second set of prices we might term "more likely" prices. These were based on our best estimates of what prices will be in 1982 thru 1984 under the policy adopted in the Omnibus Budget Reconciliation Act of 1982. These prices were estimated to be $13.77 in 1982, about 70 cents lower in 1983, and about 30 cents higher in 1984 over 1983.

The first thing we observed was that not all dairy farmers have the same debt load--a not too surprising finding. Of those farmers with debt, there was a slight drop in debt per cow as the herd size increased up until about 100 cow herds. On farms with more than 100 cows, the pattern was quite mixed. We suspect that many of the latter farmers recently expanded their operation and thus show extremely heavy debt loads at the present time.

Interestingly enough a number of the smaller dairy farmers have little or no debt. Similarly on many of these smaller dairy farms, labor costs are significantly lower than on the larger farms. Presumably this is a reflection of the fact that smaller farmers can often avoid the cost of services and fringe benefits of salaried personnel. These two facts point out that the smaller farmer is not necessarily in more financial difficulty than is his larger couterpart under sharply reduced milk prices.

We also found that cash costs per cwt. of milk produced vary tremendously on these farms--from about $5.00 to as high as $15.50. This, I might point out, is consistent with a fact that has been observed ever since farm management specialists have been studying dairy farmers costs. The significant point is that there does, in fact, appear to be room for efficiency improvements on some of our dairy farms.

The average cash cost per hundredweight on groups of farms of different sizes was nearly identical. On the New York farms, cash costs were somewhat more variable on the larger farms. This is probably what most of us would expect. On the Pennsylvania dairy farms, however, there was about twice as much variability in cash costs on the smaller farms than on the larger ones. This would suggest that some of the smaller dairy farmers in Pennsylvania may need to take a critical look at their dairy operation.

The end result of most interest, I suspect, is the impact of lower milk prices on the dairy farmer's income available for family living. The relevant comparison here is income under our "market" prices versus income under our "more likely" prices.

Under our "more likely" prices, family income was on the average projected to be 20-25 percent higher in 1982, but 65-70 percent lower in 1983 and in 1984 then under our "market" prices. In 1981, 39 percent of our sample farmers had income available for family living of $10,000 or less. Under our "market" prices, 47 percent were expected to have incomes below $10,000 in 1982, 44 percent in 1983, and 43 percent in 1984. Under our "more likely" prices, on the other hand, 41 percent were expected to have had incomes below $10,000 in 1982, 54 percent in 1983, and 54 percent in 1984.

Clearly many of our sample farmers required a source of supplemental income--even in 1981! A few more would appear to have the same needs in 1982 through 1984 under prices that approximated "market equilibrium" prices. Thus even if we had no surplus milk in 1981 and subsequent years, and if support prices are maintained at levels more consistent with market clearing prices, dairy farmers can still be expected to feel the pinch.

Under the policy that was to have been implemented on April 1, roughly ten percent more of our sample dairy farmers appear to be in need of supplemental income for 1983 and 1984 than would have been the case had our "market equilibrium" prices prevailed. Hence a crash program to right the system will create some hardship. We may object to the program worked out by Congress, but I suspect any reasonable alternative would have the same general impacts.

All of this points to the fact that dairy farm incomes are likely to be sharply reduced in 1983 and 1984 under reduced milk prices. Quite clearly milk production will still be a lucrative business for many farmers--for some small ones as well as for some large ones. In some instances this will be so because of relatively low debt loads. In all cases it will be so because these are efficient (i.e., relatively low cost) producers. Others, however, will either be forced to abandon dairy farming altogether or seek additional earning opportunities off the farm.

Alternatives to Milk Production

We did not have information from our sample farms on the amount of income earned from off-farm jobs. What we do know, though, is that many dairy farmers do have off-farm jobs. According to the 1978 Census of Agriculture, for instance, Northeast farmers earned about 62 percent of their net family income from off-farm sources in 1978. A high proportion of these farmers are dairy farmers!

It is becoming increasingly important to all farmers, not just to dairy farmers, to have access to off-farm opportunities, which in turn depends on the amount of non-farm activity in the local economy and on the health of the industries involved. Thus it is just as important to farmers as it is to non-farmers that we maintain a strong general economy and eliminate high unemployment rates.

A disturbing factor here is that the Northeast has over the past two decades experienced a slower rate of growth in manufacturing employment than have other regions of the country. Further, the Middle Atlantic states have a below average percentage of the fast growing industries of the nation.

Another question we addressed in the study was "Can dairy farmers shift to the production of some other agricultural commodity?" The answer to this question depends to a large degree on where the farmer is located. In many parts of the region, the land now supporting dairy is not suited to intensive row crop, or vegetable, or even fruit production. Nor is it suitable for the volume of alternative livestock--e.g., cow-calf or sheep operations--that is necessary to sustain a farm family. Futhermore, enterprises such as cow-calf, sheep, and vealers simply cannot generally be expected to yield an income commensurate with that dairy farmers have become accustomed in recent years. Poultry does not appear to be a feasible alternative either because of the high set up costs, the integrated nature of this industry, and the current demand situation. Swine appears to be a possibility, but here the lack of availability of adequate markets for hogs at the present time is a severe limitation. Vegetable production might be a possibility for some, but here too lack of adequate markets is a severe limitation.

Implications

Given the current situation in the dairy industry, it appears inevitable that dairy farming will be less attractive than in the recent past as the market and/or policy makers attempt to discourage the production of more milk than consumers wish to buy at current pries. To the extent that Northeast dairy farmers cannot compete with their larger and more efficient counterparts in this region or in other regions (e.g., the West and Southwest), some adjustments can be expected.

Reductions in dairy farms because of urbanization and high land prices bid up by developers appears to be waning. Selling out to a developer seems a less likely option today to most dairymen in the region. The majority of dairy farmers in the Northeast have few good alternatives inside or outside of agriculture. Hence shifts will come slowly. Those farmers using good management techniques and modern technology, located on the more productive soils, large enough to take full advantage of scale economies, and surrounded by other dairy farmers on good roads will have a competitive advantage. The smaller farms at some distance from other farms and at the margin of bulk tank routes will face stiff challenges.

As dairy farms become fewer in number and less dense geographically, the number of input suppliers will decrease. Added transportation costs and the prospects of serving a smaller population of farmers will force the smaller supply firms out of business.

Milk processing firms too can be expected to make adjustments in response to changes in the price they must pay for milk. These firms can be expected to be impacted most severely, however, by changes in the number and/or location of dairy farms.

If a number of dairy farms in a given area cease producing milk, the processor in that area may find that he must incur added assembly costs to obtain the same volume of milk, or he must operate at a reduced volume. Added assembly costs may put the firm under severe financial stress. But operating at a reduced volume may also cause financial stress.

In most processing facilities, economies to scale are substantial so that as processing volume falls, per unit processing costs rise. Some fluid milk processing plants are probably already large enough so that a small reduction in volume will not materially affect processing costs. Plants producing manufactured dairy products, however, typically must produce at capacity to realize maximum processing efficiency. Hence as the volume of raw milk available at a reasonable cost declines, some processing facilities may also be forced out of business. This could, in turn, impact producers who would otherwise remain in dairy production to the extent that a nearby market for their milk no longer exists. Thus the trend of fewer processing plants will likely be enhanced.

As supply and/or processing firms move out of the area in which a farmer is located, the farmer will be at a competitive disadvantage no matter how modern is his technology and managerial ability simply because the needed services, input markets, and/or market outlet for his milk are not readily available.

With the current surplus situation, more manufacturing plants are operating at capacity year round. Indeed some of our cooperatives are acquiring additional manufacturing capacity. If future dairy policy is effective in reducing supply to more nearly match demand, these cooperatives may find that they have generated too much excess capacity. This could result in financial stress for these firms and for their farmer members.

Our current policy goal for dairy is to reduce milk production so as to bring milk supply more in line with milk demand. By whatever means this is accomplished, it will result in a reduction of the nation's dairy herd and most likely in some of the nation's dairy farmers. The Northeast can be expected to share in this reduction. Thus we may want to consider a policy for providing assistance to those dairy operators who will withdraw from dairy but wish to stay in farming, and for those who wish to seek off-farm employment. Similarly we may want to consider a policy of assistance for the young farmers who will be replacing those dairymen planning to retire. Dairy cooperatives might, for example, want to explore the possibility of working with their Extension Services, the financial community, and possibly others in setting up such programs of assistance.

A final notion worth some thought relates to the policy option used to encourage reduced milk supply. Production quotas have been increasingly discussed in recent months, but are still as distasteful as ever. The most viable alternative appears to be to lower the "real" price of milk. But with the number of farm families today who look to non-farm jobs for the source of better than one-half of their income, I am skeptical that many of our smaller Northeast dairy farmers will respond to lower milk prices in text book fashion. I am equally skeptical, however, of the efficacy of any of our standard production control schemes, at least in the case of dairy. Perhaps the time has come for an effective policy of whole farm retirement for dairy.

NE-126 WORKSHOP PAPERS

MILK SUPPLY ESTIMATION FOR DELAWARE

by

G. Joachim Elterich*

MODEL SPECIFICATION

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

Economic Considerations

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

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

Variables

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

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* G. Joachim Elterich is a Professor in the Department of Agricultural and Food Economics at the University of Delaware.

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

Statistical Specification

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

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

Estimation Procedures

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

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

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

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

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

Sources of Data

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

RESULTS

Cow Numbers

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

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

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

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

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

Milk Per Cow

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

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

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

Table 1. Cow Numbers

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

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

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

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

Table 2. Milk Per Cow

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

	- def. price of alfalfa at			+ milk price (¢/100 cw.) / conc price ($/t)	
t	-2.383	(3.663)	t	226.8**	(124.0)
t-1	-2.276*	(1.601)	t-1	179.3**	(74.9)
t-2	-1.985	(1.866)	t-2	136.8**	(57.8)
t-3	-1.508	(2.207)	t-3	99.37*	(62.8)
t-4	-0.846	(1.629)	t-4	66.97	(66.8)
			t-5	39.61	(59.31)
Sum of Coefficients	-8.998*	(6.161)	t-6	17.29	(37.41)
			Sum of Coefficients	766.140**	(323.596)

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

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

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

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AN ECONOMETRIC MODEL OF MILK PRODUCTION IN MAINE

by

George K. Criner*

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

THE MILK PRODUCTION MODEL

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

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

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

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* George K. Criner is an Assistant Professor of Agricultural and Resource Economics at the University of Maine at Orono.

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

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

The Number of Cows Equation

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

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

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

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

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

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

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

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

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

where:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$F = 36.81 \qquad DW = 1.909$

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

$NCOW_t$ mean = 58.25 thousand cows

Sy = 1.57 thousand cows

where:

$NCOW_t$ = thousands of dairy cows in Maine;

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

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

F = the F-statistic;

R^2 = the multiple coefficient of determination;

DW = the Durbin-Watson statistic;

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

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

Sy = the standard deviation of the dependent variable;

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

Dh = the Durbin-h statistic.

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

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

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

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

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

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

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

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

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

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

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

then the variance of Y equals:*

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

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

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

(9) $\hat{s}^2_{b_{10}} = 1^2(\text{var } a_0) + 5^2(\text{var } a_1) + 25^2(\text{var } a_2) +$
$2[1(5)\text{var-covar } a_0a_1 + 1(25)\text{var-covar } a_0a_2 + 5(25)\text{var-covar } a_1a_2]$

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

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

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

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

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

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

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

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

<u>The Milk Per Cow Equation</u>

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

1) The deflated weighted average blend price;

2) the quarter the milk is produced in;

3) the deflated price of feeds;

4) the state of the arts in dairying; and

5) previous levels of milk per cow.

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

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

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

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

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

$F = 143.96$ $\qquad$ $DW = 2.025$

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

MPC_t mean = 2.74 thousand pounds

Sy = .25 thousand pounds

Sy.x = .055 thousand pounds

where:

MPC_t = milk per cow in thousands of pounds;

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

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

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

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

F = the F-statistic;

R^2 = the multiple coefficient of determination;

DW = the Durbin-Watson statistic;

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

Dh	=	the Durbin-h statistic,
Sy	=	the standard deviation of the dependent variable; and,
Sy.x	=	the standard error of estimate.

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

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

Estimated Total Production

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

(11) $TOTMILK_t = NCOW_t \cdot MPC_t$

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

(12) $TOTMILKERR_t = TOTMILK_t - TOTMILKHAT_t$

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

$TOTMILK_t \cdot TOTMILKHAT_t$	= .974
$TOTMILK_t$ mean	= 162.97 million pounds of milk
Sy	= 13.316 million pounds of milk
$S_{TOTMILKERR}$	= 3.062 million pounds of milk
$r_{TOTMILKERR_t \cdot TOTMILKERR_{t-1}}$	= -.038

where:

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

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

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

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

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

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

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

MARKET SIMULATIONS

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

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

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

The exogenous variables in the milk production model are:

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

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

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

Simulation Results

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

CONCLUSIONS

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

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

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APPENDIX

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

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

APPENDIX

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

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

APPENDIX

TABLE A2. (continued)

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

APPENDIX

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

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

COST OF BULK MILK ASSEMBLY

by

David E. Hahn*

Background

The movement of raw milk from the dairy farm to the milk processor is a key function in the milk marketing process. A straight, tandem axle truck with a 4,000 gallon tank or a tri-axle truck with a 5,000 gallon tank is commonly used to pick up milk at the farm. If the dairy farm is located near the milk processor (generally within 100 miles), the milk is delivered directly to the processing plant. A 6,000 gallon bulk tanker is commonly used if the bulk milk is hauled long distances (200 miles or more).

Recent Studies of Transportation Costs

The costs of moving bulk milk have increased substantially during the past several years. The rate currently reported in Ohio is $2.00 per loaded mile for one way distances of 200 miles or more, or round trip costs of $1.00 per mile. This rate is for bulk tankers with capacities of 5,900 to 6,100 gallons.

A wide range in hauling charges are assessed dairy producers in Ohio at the present time. The hauling rates vary according to farm location, milk volume, and the competitive environment. In the Columbus area, the average hauling charge currently paid by milk producers is 48 cents per hundredweight plus $2.50 per stop.

During the past decade, several other studies of the costs of transporting bulk and packaged milk have been made (Conner and McCullough, Kerchner, Lough, McBride and Boynton, and Moede, for example). In virtually all of these studies, transportation costs were synthesized from information obtained from trucking firms and milk equipment dealers, and then applied to specific truck sizes. The results of these studies made it apparent that no one transportation function can accurately reflect transportation costs in all situations. Differences in initial truck costs, labor and fuel costs, driving conditions, and maintenance policies all affect transportation costs for a specific haul.

Changes in Transportation Costs, 1969-1983

Estimated changes in transportation costs between 1969 and 1983 are reported in Table 1. These pertain to a three axle diesel tractor pulling a refrigerated, 36 foot trailer with a net weight of 25,000 pounds and a gross

* David E. Hahn is a Professor in the Department of Agricultural Economics and Rural Sociology at The Ohio State University.

weight of 65,000 pounds. The following total cost functions were derived from the data of Table 1:

TC (1969) = 14.15 + .2473M
TC (1975) = 20.23 + .4199M
TC (1979) = 30.95 + .6866M
TC (1983) = 41.68 + .8320M

Where TC = total dollar cost per day

M = round trip mileage

The 1983 data can be used to approximate fixed costs for farm assembly with straight trucks. The cost of a tri-axle, straight truck assembled with a 5,000 gallon bulk tank is approximately equal to the tractor-trailer rig represented in Table 1. If we assume the truck specified above is driven 40,000 miles per year, fixed costs would be 32.5 cents per mile. When variable costs of 83.2 cents are added, total costs per mile would be 115.7 cents. In 1969, total costs per mile for operating this truck would have been 35.7 cents, or approximately 72 percent less than in 1983.

Between 1969 and 1983 fixed costs increased approximately 190 percent. Increases in equipment costs and related insurance costs account for this large increase. During this same period, variable costs increased by approximately 236 percent. Variable costs in all categories increased. As might be expected, driver labor and fuel costs increased the most, 250 percent and 267 percent, respectively.

Traditionally, labor costs have been the largest single component of variable costs associated with the movement of milk and dairy products. As shown in Table 1, labor costs continue to be the most important factor. In 1969, fuel costs accounted for 24 percent of total variable costs and driver labor costs for 33 percent. Fuel costs in 1975 again accounted for 24 percent of total variable costs, but driver labor costs accounted for nearly 43 percent. In 1979, fuel costs accounted for 29 percent of total variable costs and driver labor costs accounted for 38 percent. Driver labor costs increased 45 percent between 1975 and 1979. Fuel costs increased 100 percent during that same period. In 1983, fuel costs accounted for 27 percent of total variable costs and drive labor costs accounted for 35 percent. The assembly function continues to receive the close attention of the dairy industry because these costs continue to escalate.

TABLE 1. Transportation Costs for Hauling Bulk Milk in 6,000 Gallon Bulk Tankers, 1969-1983

	1969 [a]	1975	1979	1983
Fixed Costs (per year)				
Depreciation:				
Tractor [b]	$ 320	$ 358	$ 770	$ 1,200
Trailer [c]	1,120	1,261	1,680	2,940
Interest [d]	1,225	1,375	3,450	5,200
Road Tax (1.5¢/mile at 40,000 miles/year)	600	600	600	800
Licenses	650	1,056	1,056	1,056
Insurance [e]	500	1,662	2,100	2,400
Total Annual Fixed Cost	$4,415	$6,312	$9,656	$13,596
Average Daily Fixed Cost (312 work days/year)	$14.15	$20.23	$30.95	$43.57
Variable Costs (per mile)				
Fuel (Diesel) [f]	$.0600	$.1000	$.2000	$.2200
Tires	.0346	.0488	.0600	.1000
Repairs and Maintenance	.0342	.0520	.0800	.0880
Labor (Driver) [g]	.0825	.1788	.2600	.2893
Depreciation [h]	.0360	.0403	.0866	.1347
Total Variable Costs	$.2473	$.4199	$.6866	$.8320

[a] Adapted from Conner and McCullough, 1970.

[b] Based on purchase prices of $19,000 in 1969, $21,250 in 1975, $45,000 in 1979 and $70,000 in 1983. Ten percent of the capital is recovered on a straight line depreciation schedule for 5 years. The remaining 90 percent of capital is recovered through variable charges.

[c] Based on purchase prices of $13,000 in 1969, $14,600 in 1975, $20,000 in 1979 and $35,000 in 1983.

[d] Computed at 7 percent in 1969 and 1975, and 10 percent in 1979 and 1983 on the average amount of unrecovered capital (investment) per tractor-trailer rig.

[e] $100,000/300,000 bodily injury; $100,000 property damage; fire, theft; and $500 deductible on collision.

[f] Fuel costs were $0.27 per gallon in 1969, $0.45 per gallon in 1975, $1.00 per gallon in 1979 and $1.10 per gallon in 1983; fuel mileage was 4.5 miles per gallon in 1969 and 1975, and 5 miles per gallon in 1979 and 1983.

[g] Wage rate of $3.00 plus 10 percent fringe benefits per hour in 1969, $5.50 plus 25 percent fringe benefits per hour in 1975, $8.00 plus 30 percent fringe benefits per hour in 1979, and $8.90 plus 30 percent fringe benefits in 1983.

[h] Ninety percent of depreciation schedule for tractor to provide for capital recovery over 400,000 miles.

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ESTIMATES OF THE COSTS OF PROCESSING FLUID, SOFT, AND HARD MANUFACTURED MILK PRODUCTS

by

Blair J. Smith*

The NE-126 model of the Northeast dairy industry is structured to accommodate milk and dairy products in three groups on the consumption side of the market. These are the fluid products, the soft manufactured products (mostly ice cream, cottage cheese, sour cream, and yogurt), and a hard products grouping of butter, non-fat dry milk powder, and hard cheese. The costs of processing these product groups are in terms of dollars per hundredweight of raw milk going through each of the three types of plants, and pertain to the year 1980.

The fluid milk processing cost function was estimated from observations of processing costs reported in four different studies [1, 3, 6 and 7]. The report by Jones [4] was used to adjust those reported costs to a common time base (1980).

From the four reports, it was possible to identify 16 cost-quantity observations to which several functional forms were fitted using least-squares multiple regression techniques. The following function was determined to be the most appropriate for use in the NE-126 model:

$$ACF = \underset{(t=48.9)}{224.246623} + \underset{(t=22.3)}{427.536285}\ (1/\sqrt{V})$$

Where:
ACF = Cost of processing raw milk into fluid milk products in cents per cwt.

V = Pounds of raw milk processed per month divided by 100,000

$\overline{R}^2 = 0.97$, $F = 497.8$. The F and all t-statistics are statistically different from zero at probabilities greater than 99.9 percent.

Using the estimating equation shown above, approximate costs for indicated quantities of raw milk processed per month are as follows:

Monthly Volume of Milk Processed (pounds)	Cost per cwt. (cents)	Monthly Volume of Milk Processed (pounds)	Cost per cwt. (cents)
250,000	495	20,000,000	254
500,000	415	25,000,000	251
1,000,000	359	30,000,000	249
2,500,000	310	35,000,000	247
5,000,000	285	40,000,000	246
10,000,000	267	45,000,000	244
15,000,000	259	50,000,000	243

* Blair J. Smith is an Associate Professor in the Department of Agricultural Economics and Rural Sociology at The Pennsylvania State University.

At monthly volumes greater than 50,000,000 pounds, the analysis suggests that processing costs remain constant at 243 cents per hundredweight of milk processed. Figure 1 is a plot of the relevant range of the fluid milk processing cost function.

The hard products manufacturing cost function was synthesized primarily from the reports by Boehm and Conner [2], and Lasley and Sleight [5]. One set of volume-cost estimates was developed from each report.

Lasley and Sleight showed the relationship between monthly volume as a percent of capacity and cost per hundredweight of milk processed for 60 plants in the United States. They arbitrarily set the base cost at $1.00 per cwt for operation at 100 percent of capacity. From data later provided by Sleight, it was determined that the average capacity of the plants in the Lasley and Sleight report was about 25,000,000 pounds per month, and that they operated at about 75 percent of capacity in the years studied.

In 1980, the Commodity Credit Corporation make allowances (manufacturing margins) for butter-powder averaged $1.22 and for cheese $1.02 per cwt of milk processed. These are the assumed costs of converting 100 pounds of milk into those particular products, and were used in the price support program calculations at that time. The Minnesota-Wisconsin manufacturing grade milk price averaged $12.23 at test, and the announced support price averaged $12.33 at test in 1980. Thus, the make allowances appeared to be $0.10 less than those necessary to generate the announced support price. It is concluded, therefore, that the actual costs of manufacturing butter-powder were $1.32 and of cheese $1.12 per cwt. of milk processed in 1980.

About 1.5 times as much milk is used for cheese as is used for butter and powder. Thus, the product-weighted cost of converting raw milk into butter, powder, and cheese was estimated to be $1.20 per cwt. (0.40 x $1.32) + (0.60 x $1.12). This $1.20 is the cost used for the 75 percent level of plant operation, or 18,750,000 pounds of milk (25,000,000 x 0.75). This constituted one cost-volume estimate. The others were developed by scaling the costs associated with other levels of capacity (monthly volumes) shown in Lasley and Sleight.

A second set of cost-volume estimates was developed from the total cost function for cheese manufacture (TCC) reported by Boehm and Conner. This function, estimated for 1975, is as follows:

TCC = $42,466 + $0.52922 (volume of milk processed)

Dividing TCC by varying levels of output yielded a complete set of cost-volume estimates. These were then adjusted to 1980 by assuming a general increase in costs of five percent per year (Jones [4]).

The estimates derived from Lasley and Sleight and Boehm and Conner were averaged, and a function was fitted to the resulting set of cost-volume estimates. The resulting following function will be used in the NE-126 model:

$$\underset{(t=12.8)}{ACH = -43.83928583} - \underset{(t=13.9)}{3860.71598712\,(1/V)} + \underset{(t=37.8)}{2537.6834236\,(1/\sqrt{V})}$$

Where:

ACH = Cost of processing raw milk into hard manufactured products in cents per cwt.

V = Pounds of milk processed per month divided by 100,000

$\overline{R}^2$ = 0.99, F = 9430.0. The F and all t-statistics are significantly different from zero at probabilities greater than 99.9 percent.

Using the estimating equations shown above, approximate costs for indicated quantities of milk processed per month are as follows:

Monthly Volume of Milk Processed (pounds)	Cost per cwt. (cents)	Monthly Volume of Milk Processed (pounds)	Cost per cwt. (cents)
2,500,000	309	17,500,000	126
5,000,000	238	20,000,000	116
7,500,000	198	22,500,000	108
10,000,000	171	25,000,000	101
12,500,000	152	27,500,000	95
15,000,000	137	30,000,000	90

At monthly volumes greater than 30,000,000 pounds, manufacturing costs were assumed to remain constant at 90 cents per hundredweight of milk processed. Figure 2 is a plot of the relevant range of the hard products manufacturing cost function.

The soft products processing cost function (ACS) will be a weighted combination of the fluid and the hard products functions. That is,

ACS = X(ACF) + Y(ACH)

The variables X and Y are the weights to be applied to the fluid and hard products functions, respectively, according to where the soft products cost function lies in the space bounded by the two functions, X and Y are each ≥ 0, and X + Y = 1.0.

For the initial run of the NE-126 model, X will be set equal to 0.8 and Y will be set equal to 0.2. Subsequent runs of the model will use other values for X and Y if later information suggests a different combination of weights would be more appropriate.

FIGURE 1. COSTS OF PROCESSING FLUID MILK PRODUCTS, 1980

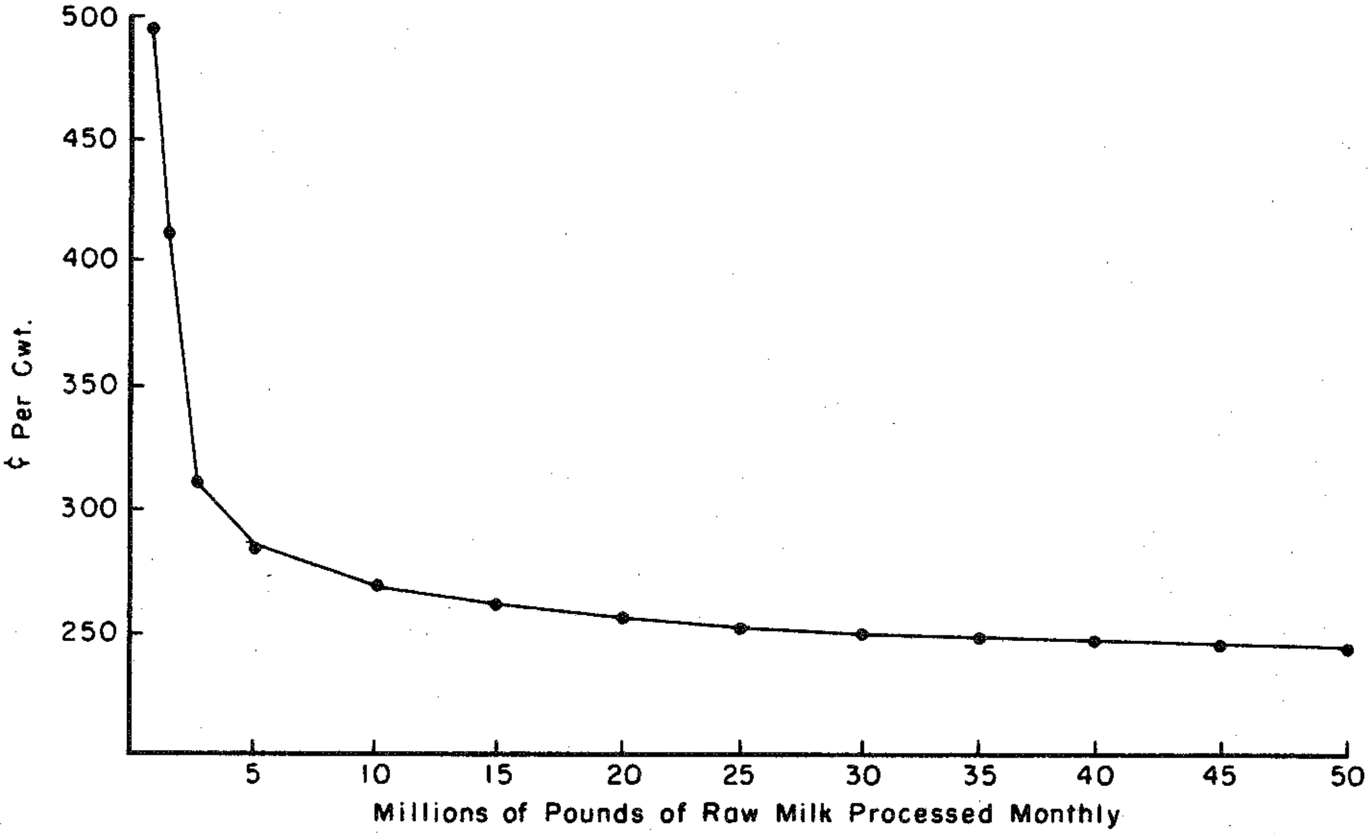
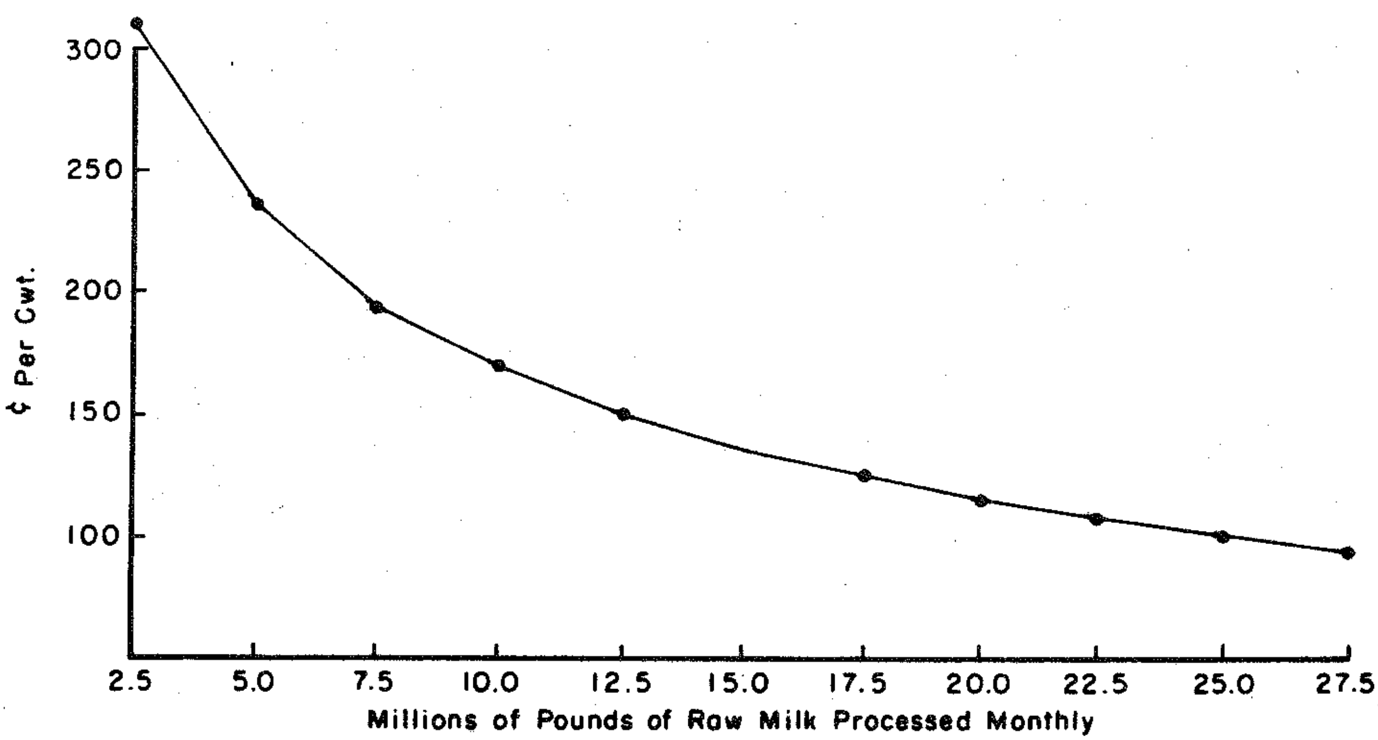


FIGURE 2. COSTS OF MANUFACTURING HARD DAIRY PRODUCTS, 1980



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DEMAND FOR FLUID MILK PRODUCTS IN THE NORTHEAST

by

Wayne M. Gineo*

Introduction

One of the basic problems facing those involved in the marketing of agricultural products is that they must maintain current knowledge on the products and quantities that the "sovereign" consumer will purchase. This paper will attempt to provide information on the consumer demand for fluid milk in the Northeastern United States. Accurate information on the demand for fluid dairy products will enable dairy marketing agencies to increase their efficiency and provide a basis for policy makers to help the dairy industry.

This paper contributes to the NE-126 regional dairy marketing study which is concerned with the long range adjustments the Northeast dairy industry should make in developing the marketing potential of the dairy industry. Since the focus of the NE-126 study is on long run adjustments this paper will focus on the long run determinants of demand for fluid milk products in the Northeast. More specifically, the objective of this study is to quantitatively measure the long run relationship between the quantity of fluid milk demanded and the relevant variables determining the demand for fluid milk in the Northeastern states.

The remainder of this paper will be divided into three sections. The first section will include a discussion of the variables which are hypothesized to determine the demand for fluid milk consumption and the methodology used to quantitatively estimate the demand specification. In the second section the results of the estimation procedure will be reported and analyzed. The final section will provide a brief summary.

Estimation Procedures

Three basic categories of variables were considered a priori as being determinants of long run demand; economic, demographic and product variables. The economic variables used include price of the product, income and the price of a substitute. The effects of these variables are, in general, well known. However, several studies (Boehm and Babb, Prato, Wilson and Thompson, and Rojko) have suggested that there may be no income effect for the demand for fluid milk. However, Boehm has found nominal income to be a significant determinant of fluid milk consumption. In contrast to income, the price of fluid milk has been estimated to be a significant factor in determining fluid milk consumption. Demographic variables such as age or racial composition of the population may

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* Wayne M. Gineo is a graduate research assistant in the Department of Agricultural and Applied Economics at the University of Minnesota. This paper extends a Master's Thesis completed at the University of Connecticut. The author wishes to thank J. William Levedahl, the advisor to the thesis project, for his help in that project and David Hahn for encouragement in the completion of this paper.

also have an effect on fluid milk consumption thus, these variables were included in the analysis. Schrimper has discussed the effects of age composition of the population, and since blacks lack enzymes that breakdown lactose, a milk carbohydrate, they have lower consumption levels.

A product variable, such as the environment in which milk is consumed, also has an impact on the level of consumption. When meals are eaten away from home less milk is consumed. Recently, consumers have been eating out more often. Data showing the trend of consumers' home and away from home eating habits was not available on a regional or state basis thus, a proxy, the number of women employed, was utilized. The work of Kinsey suggested that this may be a good proxy.

The dependent variable used was per capita consumption of all fluid milk products. This data was obtained from Gineo (1980 and forthcoming).

The statistical model used in specifying the determinants of the demand for fluid milk was a single equation and was estimated using ordinary least squares. The single equation model requires the assumption that retail price is not simultaneously determined in the market by the interaction of present demand and supply. Since eighty percent of the milk marketed in the Northeast is under federal milk marketing order jurisdiction, where farm prices are administered, this assumption is not unrealistic.

The data for the model are a combination of time series and cross sectional data. Timewise, there are five observation periods beginning in 1960 with each period being a five year interval (i.e. 1960, 1965, 1970, 1975 and 1980). Cross sectionally, the data consists of observations on sixteen states in each of the five time periods, except for 1960 when consumption data for three states was unavailable. Whenever possible, observations on the variables were taken as three year simple averages of the variable centered on the year of observation.

Rather than considering demand functions for each state separately, the states were partitioned into four groups based on their inclusion in a federal milk market order. The estimation of demand functions for these four regions, enabled the identification of those variables which commonly affected the demand in each of the groups. If the magnitude of a common variable is the same, then the observations from these groups may be pooled and one coefficient may be estimated for the groups. By pooling observations, an aggregate demand equation for the Northeast could be formed. However, before pooling observations, statistical tests must be performed to determine if the effects of common variables are the same. The statistical tests used to identify pooling possibilities in this study are described in Gineo (1980).

Results and Analysis

The final specification of each order is reported below. The numbers in parenthesis below the coefficients are the t-ratios, with "**" signifying significance at the 1% level and "*" signifying significance at the 5% level. the regional estimates are as follows;

Region 1 - Middle Atlantic States (MD, VA, DE, DC, PA)

$$\underset{}{PCC} = \underset{(9.0)^{**}}{271.5} - \underset{(-3.0)^{**}}{0.84(PM)} + \underset{(2.46)^{**}}{4.15(PA5)} + \underset{(2.47)^{**}}{0.48(POJ)} + \underset{(1.11)}{0.01(PB)} - \underset{(-1.40)}{0.06(PWE)}$$

Adjusted R-squared = .92 n = 25

Region 2 - Equation 1 - Eastern Ohio-Western Pennsylvania (OH, WV, PA)

$$PCC = 336.8 - 0.57(PM) + 0.04(POJ) - 0.29(PA5) + 0.21(PB) - 0.14(PWE)$$
(8.5)** (-1.85) (0.28) (0.10) (2.00)* (-3.19)**

Adjusted R-squared = .97 n = 12

Region 2 - Equation 2 - Eastern Ohio-Western Pennsylvania (OH, WV, PA)

$$PCC = 367.3 - 0.95(PM) + 0.16(POJ) - 2.57(PA5) + 0.06(PWE)$$
(8.4)** (-3.21)* (0.90) (-0.83) (-2.75)*

Adjusted R-squared = .96

Region 3 - New England States (ME, NH, VT, RI, MA, CT)

$$PCC = 300.4 - 1.28(PM) + 0.46(POJ) + 3.64(PA5) - 0.05(PB) + 0.09(PWE)$$
(3.66)** (2.24)** (1.41) (0.72) (-0.40) (1.10)

Adjusted R-squared = .87 n = 30

Region 4 - New York-New Jersey (NY, NJ)

$$PCC = 265.8 - 1.16(PM) + 0.85(POJ) + 10.1(PA5) - 0.15(PB) - 0.03(PWE)$$
(2.92)* (-2.77)* (2.42)* (2.06) (-0.83) (-0.32)

Adjusted R-squared = .99 n = 10

where:

PCC = per capita consumption of all fluid milk (pounds)
PM = retail price of a half gallon of milk (cents)
POJ = retail price of 6 ounces of frozen orange juice (cents)
PA5 = percentage of the population under five years of age
PB = percentage of blacks in the population
PWE = percentage of women employed

(Note the association of region numbers and state groups. This association will be used through the remainder of this study.)

Those variables which were significantly different from zero at the 5% level in the individual estimations were carried over to the aggregate specification. Some variables appeared to be significant in the individual estimations but in the aggregate equation they were not. This could be due to the large sample efficiency of the aggregate equation. The results of the testing procedure indicate that, in the aggregate demand specification, certain coefficients are statistically the same in different regions. Thus, these observations were pooled and a single coefficient was estimated. The pooling possibilities are reflected in the results reported for the aggregate equation. The results of the aggregate specification are as follows:

$$PCC = 262.2 + 72.9(D2) + 112.1(D3) - 1.01(PM124) - 1.38(PM3) +$$
$$(11.9)^{**}\ (4.66)^{**}\ (4.88)^{**}\ (-6.74)^{**}\ (9.48)^{**}$$

$$0.51(POJ134) + 4.78(PA5-14)$$
$$(3.58)^{**}\ (2.92)^{**}$$

Adjusted R-squared = .89 n = 77

where:

PCC	=	per capita consumption of fluid milk products (pounds)
D2	=	differential intercept term for region 2 (EOWP)
D3	=	differential intercept term for region 3 (New England)
PM124	=	retail price of a half gallon of milk in regions 1, 2 and 4
PM3	=	retail price of a half gallon of milk in region 3
POJ134	=	retail price of 6 ounces of frozen orange juice in regions 1, 3 and 4
PA5-14	=	percent of the population under five years of age in regions 1 and 4.

The individual results indicate that the effects of certain variables are significant (statistically different from zero at the 5% level) in some regions, yet insignificant in others. But, the retail price of milk appeared to be a determinant of demand in each group of states. Table 1 gives estimates of the own price elasticities of demand for each of the regions separately and in the aggregate specifications. Previous studies have estimated price elasticities of demand for fluid milk products ranging from -0.11 to -0.28. The estimates in this study range from -0.15 to -0.31. The elasticities of this study may be considered long run elasticities and can be expected to be slightly larger than those obtained in other studies which have considered a shorter time period. The price elasticity of -0.28 for regions 1, 2 & 4 estimated in the aggregate equation implies that, ceteris paribus, a ten percent increase in the retail price of milk would result in a 2.8% decline in the consumption of fluid milk. The 2.8% decline suggests that 1981 per capita consumption for the Northeast would decline approximately 6 pounds from 233 to 227 pounds per capita. Overall, this would translate into a decline of 303 million pounds of fluid milk consumed in the Northeast.

TABLE 1. Price Elasticities of the Demand for Fluid Milk (Calculated from the mean)

Region	Elasticity
1 Middle Atlantic	-0.24
2 Eastern Ohio-Western Pennsylvania	-0.15
3 New England; equation 1	-0.27
4 New York-New Jersey	-0.31
1,2,4	-0.28
3 New England; equation 2	-0.29

The coefficient for POJ134 in the aggregate specification suggests that, ceteris paribus, a 10% increase in the price of orange juice results in a 0.6% or 1.5 pound increase in the per capita consumption of fluid milk. The age composition variable (PA5) has a significant impact on per capita consumption in New York, New Jersey and the Middle Atlantic States. The estimated coefficient for PA5-14, of 4.78, suggests that, ceteris paribus, if PA5 in these states increases by 1 percent, per capita consumption will increase by 4.8 pounds per capita.

Per capita income did not appear to be a determinant of per capita consumption in the estimation procedures. This result is consistent with several other studies. Two other variables, PB and PWE, which were hypothesized to be determinants of demand did not appear to have an effect on fluid milk consumption. PWE may be a poor proxy for the number of meals eaten away from home. PB may have been insignificant because, the variable was relatively constant in several states over the observation period.

The results of the demand estimates for fluid milk reveal two interesting points. First, compared to the demand for fluid milk products at the national level, the long run fluid milk demand in the Northeast is determined by relatively few variables (own price, age composition and the price of substitutes). Previous studies have illustrated this point by identifying a greater number of determinants when estimating the demand for fluid milk at the national level. Second, the effects of the determinants of fluid milk demand are similar in magnitude throughout much of the Northeast. Evidence of consumers in the Northeast responding similarly to marginal changes in the variables is given in the aggregate specification where the coefficients for PM, POJ, and PA5 were estimated jointly for each region in which they were determinants.

Summary

This study is a portion of the Regional Project NE-126, which is concerned with determining the least cost spatial organization of the Northeast dairy industry. The objective of this study was to quantitatively measure the relationship between the quantity of fluid milk demanded and the long run determinants of demand.

The demand functions for all fluid milk products on a pounds per capita basis were estimated for each of four groups of states within the Northeast. Through a testing procedure, the data was pooled and an aggregate demand function for the Northeast was estimated. The results of the demand estimations indicate that there are relatively few determinants of the demand for fluid milk products in the Northeast. The variables which affect the demand for fluid milk products are the retail price of milk, the age composition of the population and the price of substitutes. In addition, the results indicate that within the Northeast, consumers respond similarly to changes in the determinants of demand.

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HOUSEHOLD DEMAND FOR MANUFACTURED DAIRY PRODUCTS IN THE NORTHEAST

by

Mitchell J. Morehart*

INTRODUCTION

This study focused on estimating demand functions for selected manufactured dairy products in the Northeast. Emphasis was given to establishing a demand model which encompassed both economic and demographic aspects of consumer response. This study also examined the potential for similarities in consumer response between "hard" and "soft" Class II products.**

Previous Measures of Demand for Manufactured Dairy Products

Demand for milk and milk products has been studied extensively since early in this century. Research has focused on describing the relationship between quantity demanded of a certain product and economic factors such as price and income. This measure of consumer response often was reported as an estimated elasticity. Although methodology and time period of analyses differed among these studies, reported price and income elasticities for several dairy products are summarized in Table 1. In many cases, due to data limitations, research efforts were confined to explaining aggregate behavior. Two primary sources of information for past studies were panel data and time series records kept by the U.S. Department of Agriculture.

Perhaps the most significant contributions to the statistical analysis of demand for dairy products, prior to 1960, were those of Rojko. Rojko (13) employed both ordinary least squares and limited information maximum likelihood methods to estimate supply and demand models for the U.S. dairy industry. Demand equations were estimated for the pre-World War II and the postwar period. Postwar functions accommodated the emergence of margarine as a popular butter substitute. In each case supply was assumed pre-determined or "fixed". One implication of this assumption was the potential for measuring interrelationships among demand for various dairy products. Demand equations were formulated on a single equation basis. Both price and income elasticities were estimated for butter, American cheese and ice cream.

In a later study, Rojko (14) formulated a dairy sector model which utilized both single and simultaneous equation methods. As with earlier analysis, demand equations were developed on a single equation basis with supply assumed to be "fixed".

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* At the time this report was prepared Mitchell Morehart was a Graduate Assistant in the Department of Agricultural Economics and Marketing, Cook College, Rutgers - The State University of New Jersey and now is a Graduate Assistant at The Pennsylvania State University, Department of Agricultural Economics and Rural Sociology.

** In this study, "hard" products are represented by butter and hard cheese while "soft" products include ice cream, soft cheeses and yogurt.

Table 1: Summary of Previous Price and Income Elasticity Estimates for Dairy Products.

Investigator	Item	Elasticity Price	Income
Rojko (1924-41)/*	Butter	-0.39	0.15
	Amer. Cheese	-0.25	0.32
	Ice Cream	-1.08	0.59
Fox (1922-41)	Butter	-0.25	--
Shepherd (1920-41)	Butter	-1.30	--
Shaffer and Quack-enbush (1951-53)	Butter	-0.46	0.60
	Ice Cream	-0.86	0.83
Brandow (1955-57)	Butter	-0.85	--
	Cheese	-0.70	0.45
	Ice Cream	-0.55	0.35
Wilson and Thompson (1947-63)	Fluid Prod.	-0.31	-0.34
	Butfat. Solids	-0.43	0.60
	Nonfat Solids	-0.19	0.71
Prato (1958-68)	Milkfat	-0.19	--
	Nonmilkfat	-0.19	--
George and King (1955, 1965)	Butter	-0.65	0.27
	Cheese	-0.46	0.23
	Ice Cream	-0.53	0.32
Boehm and Babb (1972-74)/**	Butter	-0.76(-0.73)	0.17
	Proc. Cheese	-1.71(-1.80)	0.10
	Amer. Cheese	-1.44(-2.17)	0.16
Hallberg and Fal-lert (1955-73)	Amer. Cheese	-0.50	0.20
	Italian Cheese	-0.80	0.30
	Other Cheese	-0.80	0.30
	Butter	-0.70	0.30
	Ice Cream	-0.33	0.12

/* Dates given represent time period covered by data used in each study.

/** Number in parenthesis represent elasticities obtained from the time series estimation, see Boehm and Babb.

Wilson and Thompson, and Prato developed simultaneous equation models of the U.S. dairy industry for the 1947-1968 period. Using time series data, Wilson and Thompson estimated single equation demand functions. Income and price elasticities were similar to those obtained by Rojko. Prato estimated demand response within his simultaneous model using two-stage least squares. Of particular interest was his use of the partial adjustment hypothesis in an attempt to distinguish between short-run and long-run elasticities. Although no such distinction was made, short-run price elasticities generated for milkfat and solids non-fat were both approximately -0.19.

Two notable and somewhat similar studies were provided by Brandow in 1961 and George and King in 1971. Each analyzed U.S. consumer demand for several major food commodities via a demand matrix. Emphasis was given to interrelationships in product demand at all levels of the marketing system. Brandow used a 29 product matrix specification to estimate price and income elasticities for butter and American cheese for the 1955-57 period. George and King examined interrelationships among 49 commodities based on 1955 and 1965 cross-section data. Estimated elasticities were given for butter, cheese, and ice cream.

Boehm and Babb analyzed the impact of retail prices, income, and other socio-economic factors on household demand for several storable dairy products. Estimation of demand equations involved both time-series and cross-section models. Products considered were butter, nonfat dry milk, and five types of cheese. In the cross-section model, race and household composition significantly contributed to explaining variations in household purchasing rates.

Within the context of a policy simulation model, Hallberg and Fallert modeled retail demand for dairy products. Their methodology followed the simultaneous supply-demand approach with the addition of a recursive equation formulation. Of particular interest was the large number of dairy product categories incorporated into their study. Emphasis also was given to allowing for variables other than price and income to model consumer behavior when using time-series data.

In 1978, Robinson and Babb constructed a demand model for manufactured milk products in which U.S. consumption forecasts were given for the 1977-81 period. Ordinary least squares was used to estimate three separate single equation specifications. Products considered were: fresh cream, ice cream, ice milk, cottage cheese, american cheddar cheese, nonfat dry milk powder, and butter. The data were U.S.D.A. time-series records for the 1950-76 period.

METHODOLOGY

The data used in this study were the "Virginia Tech version of the 1972-1974 Bureau of Labor Statistics Consumer Expenditure Dairy Survey" (CEDS). Original collection of the data was performed by the U.S. Bureau of the Census under contract to the Bureau of Labor Statistics. As reported by Baer, the survey consisted of two distinct components each with its own collection vehicle and sample: a dairy of recordkeeping survey completed by respondents for two one-week periods from July 1972 to June 1974 and a quarterly interview survey conducted for calendar years 1972 and 1973.

Data were made available in two separate tapes. Tape 1 contained expenditure information on food and nonfood items both in aggregated and disaggregated forms. Tape 2 was comprised of expenditure, quantity, and packaging information by day of the week for food items consumed at home. Given such a large data base, errors and inconsistencies were anticipated. With this in mind, Buse developed a clean version of tape 1. Thus, data analyses at Virginia Tech consisted of combining information from tape 1 and tape 2 to form a single data set. In addition, the data were checked for inconsistencies and errors with reference to socio-economic and demographic information, expenditure, quantity and other information. Where errors were found the observation was "flagged" to leave corrective measures to the discretion of users.

Data Analysis

To arrive at the sample used in this study, several organizational steps were taken. Only those households residing in the Northeast which reported an income, and purchased at least one of the five dairy products under consideration (butter, hard cheese, soft cheese, ice cream, and yogurt), were retained from the original data base. Aggregation of similar items was necessary for ice cream and soft cheese types. Observations from households containing severe demographic response errors were then deleted from the subsample. Expenditure records were examined for each of the 4,127 remaining households. Those "flagged" as being either incomplete or outliers were removed. Expenditure records for each week of the two week dairy were combined for products which had multiple expenditures over the period. In order to obtain a figure for quantity purchased that was similar between all products, the standard quantity (units of weight) was multiplied by the number of items purchased. At the same time, expenditures per unit of product were calculated.

Since price information was not readily available, prices were determined for each commodity by dividing total expenditures by quantity purchased. All prices were then converted to price per pound. Similarly, all quantity information was retained as measured in pounds. To determine the accuracy of calculated prices for each item, average monthly prices and an average price for each of the eight possible locations of residence were tabulated.

The final task concerning development of a "clean" subsample of Northeast households purchasing dairy products was to reconstruct the data file to a fixed format. This involved retaining price and quantity information for the five dairy products as well as for substitute product groups. In addition, socio-economic and demographic information for each household accompanied the purchase information. All records for a single household were confined to one line for ease of handling and interpretation.

Empirical Demand Models

Several estimation methods have been applied to the analysis of demand for milk and milk products. Given cross section data, two contrasting approaches were applied in this study: the single equation model and the constant elasticity of demand system. The underlying properties of each procedure are presented in this section.

1) Single Equation Model

Often referred to as "the pragmatic approach," the single equation model has been the most extensively utilized estimation technique for dairy product demand. Within this methodology, those independent variables available in the data are simply specified as a linear function of quantity consumed. Most researchers then employed ordinary least squares to obtain parameter estimates by assuming classical properties for the error term. Application of this model to cross section data produces an estimate of a single point on the demand curve since prices are usually assumed to be fixed over short periods of time. However, the popularity of the single equation model, aside from its simplicity, stems from interest in determining the effect of household characteristics on product demand.

Coefficient interpretation in the single equation model is straightforward, except in the case where own-good prices have been included. Given adequate price variation among households, Kuh argues that own-price elasticities determined from household data typically represent longer term response than those of time series data. These tendencies also were considered in the cross section model of Boehm and Babb.

The validity of the single equation model is hampered by its inability to reconcile simultaneity in demand response and its failure to incorporate theoretical restrictions on parameter values. However, one may employ post estimation tests on elasticities for compliance with demand theory.

2) Constant Elasticity of Demand System (CED)

Use of a systems approach such as CED allows for interaction among commodity demands and the imposition of theoretical restrictions on coefficients prior to estimation.

The general form of a set of demand relationships for the CED system may be written:

$$(1) \quad \log Q_i = \gamma_{\phi i} + \eta_i \log Y_i + \sum_{j=1}^{n} \log P_i$$

$$(i, j=1, 2, \ldots n).$$

Coefficients obtained from this specification are own-price (ε_{ij}), cross-price (ε_{ij}) and income (η_i) elasticities. Error terms appended additively follow the usual assumptions: $E(e_i) = 0$ and $E(e_i, e_j) = w_{ij}$ where e_i denotes the disturbance term of the ith demand equation.

The variance-covariance matrix of the disturbance term is $\Omega = (w_{ij})$, a nonsingular symmetric matrix of dimension n X n. In this case the usual least squares estimators have been shown to be inappropriate (15). A favorable solution is to stack the equations and employ the Aitken estimator. This approach is otherwise known as "seemingly unrelated linear regression." To allow for parameter restrictions within the estimation procedure, one simply employs the constrained Aitken estimator.

To further enhance the contrast between approaches the sample values with zero consumption levels are retained in the estimation of the CED system. Given the consecutive two-week time period for households surveys, nonpurchases may mean that the household consumes out of inventories. This is especially relevant given the storability of such dairy products such as hard cheese. To facilitate this within the CED system a positive constant must be added to zero consumption values since the logarithm of zero is nonexistent. In this study mean values for quantities and prices were used to replace zero values. This choice was made to enable elasticities to be reflective of behavior at the mean.

Stochastic Specification of the Empirical Demand Models

In practical applications, any demand model must be embedded in a stochastic framework. That is, to account for factors not explicitly introduced in a model, a disturbance (error) term is required for each equation of the models put forth. It is assumed here that error terms enter both the single equation model and the CED system in an additive fashion and possess the classical properties.

The variables included in each model are defined with their respective labels. The labels are then utilized in the presentation of results for each product's demand equation in Part III.

1) Single Equation Specification

The general stochastic specification for the single equation demand model was given by:

$$(2) \quad Q_{ih} = B_0 + B_1 X_{1h} + B_2 X_{2h} + B_3 X_{3ih} + B_4 X_{4sh} + B_5 X_{5sh} + \sum_{j=1}^{3} \alpha_j Z_{jh} + \sum_{j=4}^{6} \alpha_j Z_{jh} + \sum_{j=7}^{9} \alpha_j Z_{jh} + \alpha_{10} Z_{10h} + \alpha_{11h} Z_{11h} + \alpha_{12} Z_{12h} + \alpha_{13} Z_{13sh} + \alpha_{14} Z_{14sh} + \alpha_{15} A_{15h} + \alpha_{16} Z_{16h} + \alpha_{17} Z_{17h} + \alpha_{18} Z_{18sh} + \alpha_{19} Z_{19sh} + \sum_{j=20}^{22} \alpha_j Z_{jh} + \alpha_{23} Z_{23h} + \sum_{j=24}^{23} \alpha_j Z_{jh} + \sum_{j=27}^{29} \alpha_j Z_{jh} + e_{ih}$$

where (i = 1, 2, ... 5), (j = 1, 2, ... 29), (s = 1, 2, ... 6)

(h=1, 2, ... 4,127).

Dependent Variable

Q_{ih} = QUAN_(i): the quantity of the i^{th} dairy product, measured in lbs., purchased by the h^{th} household during the period

Independent Variables

X_{1h} = TMINC: total annual money income reported by the h^{th} household.

X_{2h} = TMINCSQ: total annual money income reported by the h^{th} household squared.

X_{3ih} = PRICE_(i): the price per pound paid by the h^{th} household for the i^{th} product.

X_{4sh} = PRICE_(s1): the price per pound paid by the h^{th} household for the s_1^{th} substitute product.[2/]

X_{5sh} = PRICE_(s2): the price per pound paid by the h^{th} household for the s_2^{th} substitute product.

Z_{jh} = LOCATION: location of the h^{th} household during the time period. There are four location classifications which are treated as intercept dummy variables.

Z_0 : excluded class; residence outside an SMSA (population < 50,000).

Z_1 = LGSMSA: residence in SMSA of population > one million

Z_2 = MDSMSA: residence in SMSA with population 400,000 - 999,999.

Z_3 = SMSMSA: residence in SMSA with population 50,000 - 399,999.

[2/] To determine substitute prices within the data base, season and location of residence were considered. There were seven total seasons, three per year, defined as: January-April, May-August, and September-December. There were eight location categories based on SMSA and rural/urban differences in residence. Thus, a possible total of fifty-six various average prices were computed. In many instances substitute good prices represented an aggregate of similar products.

Z_{jh} = LOCATION BY: PRICE — location of the h^{th} household with four slope dummy variables which measure price response differences.

Z_0 = : excluded class, own-price response for residents outside of an SMSA.

Z_4 = LGSMSAXP: own-price response difference for residents of SMSAS with population > one million.

Z_5 = MDSMSAZP: own-price response difference for residents of SMSAS with population 400,000 - 999,999.

Z_6 = SMSMSAXP: own-price response difference for residents of SMSAS with population 50,000 - 3999,999.

Z_{jh} = LOCATION BY: PRICE — location of h^{th} household with four slope dummy variables which measure differences in income response.

Z_0 : excluded class; the income response for residents living outside the defined SMSAS.

Z_7 = LGSMSAXI: income response difference for residents of SMSAS with population > one million.

Z_8 = MDSMSAXI: income response difference for residents of SMSAS with population 400,000 - 999,999.

Z_9 = SMSMSAXI: income response difference for residents of SMSAS with population 50,000 - 399,999.

Z_{10h} = RACE: the race of the h^{th} household head. Two race classes are defined: white and nonwhite. The excluded class was white race.

Z_{11h} = RACEXP: a slope dummy variable representing own-price response differences for nonwhites.

Z_{12h} = RACEXI: a slope dummy variable representing income response differences for nonwhites.

Z_{13sh} = RACEXP(s_1): a slope dummy variable representing differences in substitute good response for nonwhites.

Z_{14sh} = RACEXP(s_2): a slope dummy variable representing substitute good price response differences for nonwhites.

Z_{15h} = MARSTAT: the marital status of the h^{th} household head during the period. Married was the excluded class.

Z_{16h} = MARXP: a slope dummy variable representing own-price response differences for single respondents.

Z_{17h} = MARXI: a slope dummy variable representing income response differences for single respondents.

Z_{18sh} = MARXP(s_1): a slope dummy variable representing substitute price response differences for single respondents.

Z_{19sh} = MARXP(s_2): a slope dummy variable representing substitute price response differences for single respondents.

Z_{jh} = OCCUPATION: occupation of the h^{th} household head during the period. There were four occupation categories defined.

Z_0 : excluded class; unemployed or retired.

Z_{20} = WHCOL: professional, clerical or sales occupation.

Z_{21} = BLCOL: craftsman, operative or unskilled laborers.

Z_{22} = FARMER: respondents employed as farmers.

Z_{23h} = OCCUP2: employment status of the spouse of the h^{th} household head during the period. There were two categories defined as working and unemployed or retired. Nonworking was the excluded category.

Z_{jh} = EDUCATION: education level of the h^{th} household head. There were four education categories defined.

Z_0 : excluded class, no formal education.

Z_{24} = GRAMMAR: grammar school graduate.

Z_{25} = HSGRAD: high school graduate.

Z_{26} = CLGRAD: college graduate and beyond.

Z_{jh} = HOUSEHOLD COMPOSITION : the number of persons in the j^{th} age group residing at the h^{th} household during the period.

Z_{27} = ADULT: the number of persons of age twenty-one or greater.

Z_{28} = TEEN: the number of persons between ages seven and twenty.

Z_{29} = CHILD: the number of persons under age seven.

e_i = DISTURBANCE: the error term for the i^{th} demand equation.

Constant Elasticity of Demand Specifications

The stochastic specification for the constant elasticity of demand system was given as:

$$(3) \quad \ln Q_i = (\phi_{oi} + \phi_{1i} D_1 + \phi_{2i} D_2 + \phi_{3i} D_3 + \phi_{4i} D_4 + \phi_{5i} D_5 + \phi_{6i} D_6 + \phi_{7i} D_7 + \phi_{8i} D_8) + \eta_i \ln Y + \sum_{j=1}^{10} \varepsilon_{ij} \ln P_j + e_i$$

(for all i, j=1, ... 10)

Here the intercept of equation (1) is replaced by the demographic variables. Following Pallak and Wales the intercept was assumed to be a linear function of the demographic variables. This technique which allows for the inclusion of household characteristics is referred to as "translating".

Dependent Variable

Q_i = LNQUAN: the natural logarithm of quantity purchased of the i^{th} commodity measured in pounds.

Independent Variables

D_0 : rural residence, the omitted category.

D_1 = LGSMSA: residence in SMSA of population > 1 million.

D_2 = MDSMSA: residence in SMSA of population 400,000 - 999,999.

D_3 = SMSMSA: residence in SMSA with population 50,000 - 399,999.

D_4 = ADULT: number of persons residing at the i^{th} household of age twenty-one or greater.

D_5 = TEEN: number of persons residing at the i^{th} household between ages seven and twenty.

D_6 = CHILD: the number of persons residing at the i^{th} household under the age of seven.

D_7 = RACE: the race of the i^{th} household head. Two race classes are defined: white and nonwhite. The excluded class was white race.

D_8 = MARSTAT: the marital status of the i^{th} household head during the period. Married was the excluded class.

Y_i = LNTMINC: the natural logarithm of total annual money income of the i^{th} household.

P_j = LNPRICE: the natural logarithm of price paid per pound of the j^{th} product. There were ten products included in the system, five dairy products (butter, BT; hard cheese, HC; soft cheese, SC; ice cream, IC; yogurt, YG) and five substitute or complement product groups (fats & oils, FO; meats, MT; bakery products, BK; fruits, FR; snacks, SK).

EMPIRICAL RESULTS

Single Equation Results

In this section the estimated coefficients for each of the five dairy product equations are presented. Elasticities derived at mean values are provided for own-good price and income. Since cross section data were used in this analysis, estimated price elasticities reflect long-run response. Through the use of interactive dummy variables, differences in elasticities for race, marital status, and level of urbanization also were investigated. In the same context, the substitute price responses were tested for differences between whites and nonwhites as well as single and married respondents. To facilitate comparison of results between products and to maintain consistency, all variables regardless of significance, were retained in each product's equation. The power of the test for significance of difference from zero of each coefficient was set at 0.05 level. Results for each variable are discussed in light of the ceteris paribus assumption. Also, it should be noted that coefficients represented estimates of demand behavior during the 1972-1974 period.

1) Butter Equation

Results of the linear single equation demand function for butter are given in Table 2. Noted first were the low magnitudes and insignificance of both the income and income squared coefficients. The own price effect was highly significant and of the correct sign. The price of margarine and the fats and oils group price had no apparent impact on quantity demanded of butter. However, given their similarities, collinearity may have contributed to this result. Each of the substitute product price coefficients were positive as expected.

Significant intercept differences were found for residents of medium SMSAs, and households in which the spouse was employed. That is, residents of medium sized SMSAs have a larger demand for butter than those who reside in rural areas. Households with working wives have less demand for butter than those with housewives. The value of the intercept coefficient was significant and positive.

Table 2. Single Euqation Results for Butter.

DEP VARIABLE: QUAN_BT

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
MODEL	34	532.901	15.673553	12.139
ERROR	1026	1324.781	1.291209	
C TOTAL	1060	1857.682		
ROOT MSE		1.136314	R-SQUARE	0.2869
DEP MEAN		1.599434	ADJ R-SQ	0.2632
C.V.		71.04473	D.W.	1.765

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR HO: PARAMETER=0/*
INTERCEP	1.912365	0.608351	3.144*
TMINC	.00003184564	0.0000177512	1.794
TMINCSQ	7.02451E-11	2.90227E-10	0.242
PRICE_BT	-2.731502	0.388216	-7.036*
PRICE_MG	0.075284	0.943051	0.080
PRICE_FO	0.954158	0.731933	1.304
LGSMSA	0.504348	0.432517	1.166
LGSMSAXP	-0.184917	0.441594	-0.419
LGSMSAXI	-.0000407743	.00001263761	-3.226*
MDSMSA	1.589896	0.669282	2.376*
MDSMSAXP	-1.566441	0.678825	-2.308*
MDSMSAXI	0.0000079497	.00002026754	0.392
SMSMSA	0.468545	0.598543	0.783
SMSMSAXP	-0.216030	0.633583	-0.341
SMSMSAXI	-.0000271161	.00001756439	-1.544
RACE	1.796835	1.158932	1.550
RACEXP	-2.434621	0.959206	-2.538*
RACEXI	.00000909439	.00002436276	0.373
RACEXPMG	-2.113942	3.784375	-0.559
RACEXPFO	2.622131	2.808892	0.934
MARXPMG	-1.364384	1.844229	-0.740
MARXPFO	0.539274	1.419253	0.380
MARSTAT	-0.901033	0.578159	-1.558
MARXP	1.548154	0.407001	3.804*
MARXI	-.0000042259	.00001425433	-0.296
WHCOL	-0.161875	0.120030	-1.349
BLCOL	0.175247	0.109283	1.604
FARMER	-0.220839	0.181494	-1.217
OCCUP2	-0.185314	0.088490	-2.094*
GRAMMER	0.460451	0.410536	1.122
HSGRAD	0.404870	0.412995	0.980
CLGRAD	0.495066	0.423525	1.169
ADULT	0.368920	0.069857	5.281*
TEEN	0.118925	0.027481	4.328*
CHILD	0.091162	0.057631	1.582

/* The asterisk following the T-ratio indicates the estimated coefficient was determined to be statistically significant at the 0.05 level.

Differences in own-price response were significant in several cases. Lower own-price coefficients included residents of medium sized SMSAs, and nonwhite household heads. A larger own-price response resulted for single respondents. A significantly lower income response for larger sized SMSAs also was determined.

The number of adults and teens in a particular household had a significant impact on quantity demanded of butter. As the number of each increased, the demand for butter was higher.

Estimated price and income elasticities are contained in Table 3. The table is presented such that all possible elasticity differences between race, level of urbanization, and martial status may be examined. The base category in each case was white, married residents of non-SMSAs.

The estimated income elasticities of demand for butter ranged from -0.10 for nonwhite single residents of large SMSAs to 0.39 for nonwhite, married residents of medium SMSAs. The most pronounced differences in income elasticities were between whites and nonwhites, with those whites taking lower values. In general, the range within the base category was consistent with past estimates. Except for income elasticities for residents of large SMSAs, the results indicate butter to be a normal good.

The range in value for price elasticity estimates was quite pronounced. The most elastic response was estimated for nonwhite, married residents of medium sized SMSAs at -3.79. The most inelastic value was for white, single residents of non-SMSAs. Price elasticities were found to be lower for both whites and single respondents. Another interpretation may be that price had a greater influence on the quantity demanded of butter for nonwhites and married couples.

2) Hard Cheese Equation

The single equation results for the hard cheese group are contained in Table 4. As with butter, the coefficients associated with the income variables were insignificant. The own-price coefficient was of correct sign and highly significant. Price of meat products and bakery goods were entered as substitutes. Each was of the correct sign, but only the coefficient for the price of bakery goods was significant.

The intercept coefficient was estimated to be positive, although insignificant. A significant and positive difference in the intercept value emerged for residents of medium SMSAs. There were no significant differences in income response among race, marital status, and level of urbanization. This result further supports the apparently small impact of income on demand for hard cheese products. A negative difference in own-price response was determined for nonwhites and residents of medium SMSAs.

The number of adults and teens had a positive and significant impact on the quantity demanded of hard cheese products. The change resulting from an increase in the number of adults was found to be greater than for an equal change in the number of teens residing in a given household.

The estimated income and price elasticities for hard cheese products are presented in Table 5. Several of the income elasticities were found to be

Table 3. Estimated Income and Price Elasticities of Demand for Butter

Race, Marital Status	Lg. SMSA	Md. SMSA	Sm. SMSA	Non-SMSA
	-Income-			
White, married	-0.07	0.31	0.04	0.25
White, single	-0.10	0.28	0.004	0.22
Nonwhite, married	0.01	0.39	0.11	0.32
Nonwhite, single	-0.03	0.35	0.08	0.29
	-Price-			
White, married	-1.64	-2.42	-1.66	-1.54
White, single	-0.77	-1.55	-0.79	-0.67
Nonwhite, married	-3.01	-3.79	-3.03	-2.91
Nonwhite, single	-2.14	-2.92	-2.16	-2.04

Table 4. Single Equation Results for Hard Cheeses.

DEP VARIABLE: QUAN_HC

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
MODEL	34	922.092	27.120349	15.760
ERROR	2084	3586.292	1.720869	
C TOTAL	2118	4508.384		
ROOT MSE		1.311819	R-SQUARE	0.2045
DEP MEAN		1.618246	ADJ R-SQ	0.1916
C.V.		81.06428	D.W.	1.945

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR HO: PARAMETER=0/*
INTERCEP	1.009293	0.575940	1.752
TMINC	.00001605781	.00001168265	1.375
TMINCSQ	-1.53055E-12	1.59433E-10	-0.010
PRICE_HC	-1.764483	0.225806	-7.814*
PRICE_MT	0.231215	0.341257	0.678
PRICE_BK	2.348996	0.878988	2.672*
LGSMSA	-0.349569	0.335342	-1.042
LGSMSAXP	0.440630	0.250188	1.761
LGSMSAXI	-.0000121782	.0000101759	-1.197
MDSMSA	1.393271	0.478201	2.914*
MDSMSAXP	-0.785037	0.347815	-2.257*
MDSMSAXI	-.0000275246	.00001602576	-1.718
SMSMSA	-0.023678	0.403977	-0.059
SMSMSAXP	0.238945	0.304078	0.786
SMSMSAXI	-.0000165559	.00001421704	-1.165
RACE	0.983261	1.247568	0.788
RACEXP	-0.683316	0.335263	-2.038*
RACEXI	-0.00001447	0.0000178092	-0.813
RACEXPMT	0.235451	1.547450	0.152
RACEXPBK	-0.949892	3.041873	-0.312
MARXPMT	0.190326	0.737775	0.258
MARXPBK	0.529053	1.593704	0.332
MARSTAT	-0.392403	0.768217	-0.511
MARXP	-0.023719	0.210471	-0.113
MARXI	-.0000091688	.00001100977	-0.833
WHCOL	0.072205	0.094848	0.761
BLCOL	0.093560	0.088138	1.062
FARMER	-0.100838	0.147795	-0.682
OCCUP2	0.032259	0.069909	0.461
GRAMMER	0.309184	0.323875	0.955
HSGRAD	0.368277	0.324789	1.134
CLGRAD	0.480760	0.332339	1.447
ADULT	0.273554	0.059734	4.580*
TEEN	0.157125	0.021135	7.434*
CHILD	0.075878	0.043706	1.736

/* The asterisk following the T-ratio indicates the estimated coefficient was determined to be statistically significant at the 0.05 level.

Table 5. Estimated Income and Price Elasticities of Demand for Hard Cheeses.

Race, Marital Status	Lg. SMSA	Md. SMSA	Sm. SMSA	Non-SMSA
		-Income-		
White, married	0.21	-0.09	-0.01	0.12
White, single	-0.05	-0.16	-0.08	0.05
Nonwhite, married	-0.08	-0.20	-0.11	0.18
Nonwhite, single	-0.15	-0.27	-0.18	-0.06
		-Price-		
White, married	-1.01	-0.75	-1.17	-1.34
White, single	-0.99	-0.74	-1.15	-1.33
Nonwhite, married	-1.54	-1.29	-1.70	-1.88
Nonwhite, single	-1.05	-1.27	-1.68	-1.86

negative, particularly for residents of medium and small SMSAs. This divergence from theoretical expectations is largely due to the insignificance of the income coefficient. Positive elasticities were estimated for all members of the base except the category nonwhite single residents and for white married residents of large SMSAs.

Price elasticities of demand for hard cheese products ranged from -0.74 to -1.88. Price response for nonwhites was more elastic than those of whites. Similarly, larger price elasticities were estimated for small and non-SMSA residents. Thus, price had a greater influence on the demand for hard cheese products for nonwhites and residents of less densely populated areas. Inelastic price responses occurred for both single and married, white residents of medium SMSAs.

3) Soft Cheese Equation

Results of the single equation demand function for soft cheese products are contained in Table 6. Estimated income coefficients were again insignificant. Own-price effects were significant and of the proper sign. The prices for fruits and snack products were included as substitute goods. The estimated coefficient for the price of fruits assumed a negative value indicating a complementary relationship. However, the coefficient was determined to be insignificant. The price of snack products had a positive coefficient which was significant.

Intercept differences were significant for residents of both large and small SMSAs. Each coefficient was positive with the larger value estimated for small SMSAs. Price response differences also were significant for residents of small SMSAs.

The remaining significant coefficient was for the number of adults. This indicated that as the number of adults increased in a particular household the quantity demanded of soft cheese products increased.

Income and price elasticities for soft cheese products are given in Table 7. The majority of income elasticities were estimated to be negative. However, given the insignificance of income effects this may not be indicative of the true income response.

Estimated price elasticities, on the other hand, were of anticipated sign. Values ranged from -0.15 for nonwhite, single residents of non-SMSAs to -1.46 for white, married residents of small SMSAs. In general, residents of small SMSAs were more responsive to price changes than residents of other urbanization levels. Price elasticities were consistently lower for nonwhite respondents. Elasticity values also were found to be lower for single respondents.

4) Ice Cream Equation

Estimated coefficients and corresponding statistical measures pertaining to the single equation demand function for ice cream products are contained in Table 8. The only economic variable which had a significant impact for the base group was the price of ice cream. The intercept was significant, its value estimated as 7.17. No other significant intercept differences emerged.

Table 6. Single Equation Results for Soft Cheeses.

DEP VARIABLE: QUAN_SC

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
MODEL	34	442.245	13.007192	6.274
ERROR	1005	2083.556	2.073191	
C TOTAL	1039	2525.801		
ROOT MSE		1.439858	R-SQUARE	0.1751
DEP MEAN		1.661358	ADJ R-SQ	0.1472
C.V.		86.66751	D.W.	1.836

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR HO: PARAMETER=0/*
INTERCEP	0.626124	1.125508	0.556
TMINC	-.0000063754	.0000185692B	-0.343
TMINCSQ	9.52666E-11	3.20573E-10	0.297
PRICE_SC	-1.408293	0.328741	-4.284 *
PRICE_FR	-1.555393	1.415403	-1.099
PRICE_SK	1.164685	0.496652	2.345 *
LGSMSA	0.828693	0.335584	2.469 *
LGSMSAXP	-0.338025	0.376174	-0.899
LGSMSAXI	-.0000210511	.00001381484	-1.524
MDSMSA	0.670322	0.536534	1.249
MDSMSAXP	-0.310303	0.589754	-0.526
MDSMSAXI	-.0000236965	.00002344982	-1.011
SMSMSA	1.986691	0.468442	4.241 *
SMSMSAXP	-1.945840	0.549604	-3.540 *
SMSMSAXI	-.0000392875	.00002331594	-1.685
RACE	-2.816397	5.479223	-0.514
RACEXP	0.675125	0.609184	1.108
RACEXI	-.0000099633	0.0000294829	-0.338
RACEXPFR	1.357997	14.541248	0.093
RACEXPSK	1.698825	2.304400	0.737
MARXPFR	0.527412	2.694653	0.196
MARXPSK	-0.728144	0.944798	-0.771
MARSTAT	-0.044152	1.129414	-0.039
MARXP	0.350826	0.323536	1.084
MARXI	.00001643331	.00001355287	1.213
WHCOL	0.003600836	0.149771	0.024
BLCOL	-0.047239	0.143224	-0.330
FARMER	0.431547	0.229014	1.884 *
OCCUP2	-0.017954	0.112856	-0.159
GRAMMER	0.681933	0.849327	0.803
HSGRAD	0.737904	0.851378	0.867
CLGRAD	0.936890	0.857179	1.093
ADULT	0.304443	0.095746	3.180 *
TEEN	0.042021	0.036093	1.164
CHILD	-0.054782	0.075543	-0.725

/* The asterisk following the T-ratio indicates the estimated coefficient was determined to be statistically significant at the 0.05 level.

Table 7. Income and Price Elasticities of Demand for Soft Cheese.

Race, Marital Status	Lg. SMSA	Md. SMSA	Sm. SMSA	Non-SMSA
		-Income-		
White, married	-0.22	-0.23	-0.35	-0.046
White, single	-0.09	-0.11	-0.23	0.079
Nonwhite, married	-0.28	-0.30	-0.42	-0.114
Nonwhite, single	-0.16	-0.18	-0.30	0.011
		-Price-		
White, married	-0.76	-0.75	-0.46	-0.61
White, single	-0.63	-0.62	-1.33	-0.48
Nonwhite, married	-0.44	-0.43	-1.14	-0.29
Nonwhite, single	-0.31	-0.29	-1.01	-0.15

Table 8. Single Equation Results for Ice Cream.

DEP VARIABLE: QUAN_IC

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
MODEL	34	18176.608	534.606	16.569
ERROR	1448	46720.588	32.265600	
C TOTAL	1482	64897.196		
ROOT MSE		5.680282	R-SQUARE	0.2801
DEP MEAN		7.287134	ADJ R-SQ	0.2632
C.V.		77.94946	D.W.	1.812

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR HO: PARAMETER=0/*
INTERCEP	7.168959	3.234698	2.216 *
TMINC	.00009432535	.00005906702	1.597
TMINCSQ	-1.06702E-09	8.75296E-10	-1.219
PRICE_IC	-14.411690	1.602738	-8.992 *
PRICE_BK	-2.554226	4.866222	-0.525
PRICE_SK	0.055537	2.017212	0.028
LGSMSA	-0.898876	1.011827	-0.888
LGSMSAXP	0.913307	1.968015	0.464
LGSMSAXI	.00001088223	.00004934032	0.221
MDSMSA	0.598857	1.496951	0.400
MDSMSAXP	2.630144	2.849278	0.923
MDSMSAXI	-0.00016364	.00008342607	-1.962 *
SMSMSA	1.044966	1.221091	0.856
SMSMSAXP	-3.377807	2.517385	-1.342
SMSMSAXI	-0.000011973	.00006812493	-0.176
RACE	-7.481565	6.290833	-1.189
RACEXP	-8.794247	3.344818	-2.629 *
RACEXI	0.0001778234	0.0001040601	1.709
RACEXPS	-17.779334	8.091367	-2.197 *
RACEXPB	54.306720	13.964740	3.889 *
MARXPS	-0.461201	4.341799	-0.100
MARXPB	-2.566457	9.165696	-0.280
MARSTAT	0.241388	3.475160	0.069
MARXP	4.471156	1.910413	2.340 *
MARXI	-.0000064255	0.0000570997	-0.113
WHCOL	-0.226454	0.505027	-0.448
BLCOL	0.175222	0.478167	0.366
FARMER	0.522275	0.742137	0.704
OCCUP2	-0.102193	0.356913	-0.286
GRAMMER	2.730673	2.577230	1.060
HSGRAD	2.779627	2.579862	1.077
CLGRAD	2.372949	2.597502	0.914
ADULT	0.781775	0.317892	2.459 *
TEEN	0.823918	0.104710	7.869 *
CHILD	0.458821	0.221163	2.075 *

/* The asterisk following the T-ratio indicates the estimated coefficient was determined to be statistically significant at the 0.05 level.

Although neither substitute good coefficient was significant for whites, those of nonwhites were found to be significant. Bakery goods seem to be a strong complement to ice cream for nonwhites. On the other hand, the substitute relationship for snacks was quite pronounced.

Price response differences were significant for race and marital status. The effect of price on quantity demanded of ice cream for nonwhites was found to be lower than for whites. Single respondents were estimated to be more responsive to ice cream prices. Income response was significantly different and lower for residents of medium SMSAs than for non-SMSA inhabitants.

Each of the three household composition variables produced significant, positive coefficients. The increase in quantity demanded of ice cream was estimated to be greatest when the number of teens increased.

Income and price elasticities calculated for ice cream products are given in Table 9. Income elasticities ranged in value from -0.14 to a high of 0.50. The largest differences in income response were found between whites and nonwhites, where the greatest impact on quantity demanded occurred for nonwhites. In general income elasticity values indicate ice cream to be a normal good.

Price elasticities were larger for both nonwhite and married respondents. The most price responsive group was nonwhite and married residents of small SMSAs, while the lowest occurred for white, single occupants of medium SMSAs.

5) Yogurt Equation

As yogurt was a relatively new product during the period covered by the data, its demand response was not well known. Thus, interpretation of results in Table 10 for the single equation specification was done with no preconceived notion of true tendencies. As has been the case, income coefficients were insignificant. Own-price effects for the base group were significant and held the proper sign. As a substitute good, the coefficient for the price of snack products was positive and significant, while the price of fruits exhibited no apparent substitute relationship.

The remaining significant coefficients all pertained to positive price response differences. Residents of medium and large SMSAs demanded a larger quantity of yogurt than occupants of lower levels of urbanization. Married respondents also demanded larger quantities than did single persons when both experienced equal changes in yogurt prices.

Estimated income and price elasticities for yogurt are presented in Table 11. Several income elasticities retained negative values, particularly for nonwhite respondents. Perhaps yogurt is considered an inferior good by nonwhites. Price elasticities for yogurt also displayed inconsistency in terms of sign. Price response for all non-SMSA residents was estimated to be elastic.

Constant Elasticity of Demand System Results

This section contains results for the constrained constant elasticity of demand (CED) system. Discussion here was confined to the five dairy products at issue in this study. Since estimated coefficients for the CED system are

Table 9. Income and Price Elasticities of Demand for Ice Cream.

Race, Marital Status	Lg. SMSA	Md. SMSA	Sm. SMSA	Non-SMSA
		-Income-		
White, married	0.19	-0.12	0.15	0.17
White, single	0.18	-0.14	0.14	0.16
Nonwhite, married	0.50	0.19	0.46	0.48
Nonwhite, single	0.49	0.18	0.45	0.47
		-Price-		
White, married	-0.61	-0.54	-0.81	-0.65
White, single	-0.41	-0.33	-0.61	-0.45
Nonwhite, married	-1.01	-0.93	-1.21	-1.05
Nonwhite, single	-0.81	-0.73	-1.01	-0.85

Table 10. Single Equation Results for Yogurt.

DEP VARIABLE: QUAN_YG

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE
MODEL	34	612.945	18.027784	3.120
ERROR	293	1693.070	5.778395	
C TOTAL	327	2306.014		
ROOT MSE		2.403829	R-SQUARE	0.2658
DEP MEAN		2.683498	ADJ R-SQ	0.1806
C.V.		89.57818	D.W.	2.86

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T FOR HO: PARAMETER=0/*
INTERCEP	2.143708	2.868307	0.747
TMINC	.00004662536	.00005037755	0.926
TMINCSQ	-2.16632E-10	7.67972E-10	-0.282
PRICE_YG	-10.961096	1.666993	-6.575 *
PRICE_SK	3.593474	1.391297	2.583 *
PRICE_FR	0.452532	3.867313	0.117
LGSMSA	-2.243582	1.306005	-1.716
LGSMSAXP	5.668601	1.923257	2.947 *
LGSMSAXI	-.0000289166	.00004117431	-0.702
MDSMSA	-2.297737	2.317205	-0.992
MDSMSAXP	8.426182	4.230308	1.992 *
MDSMSAXI	-0.000155531	0.000100932	-1.541
SMSMSA	-0.488640	1.711092	-0.286
SMSMSAXP	3.328440	2.416942	1.377
SMSMSAXI	-.0000956066	.00005886589	-1.624
RACE	5.865774	13.345702	0.440
RACEXP	0.140402	6.334621	0.022
RACEXI	-.0000840992	0.0001076668	-0.781
RACEXPSK	2.724137	7.764726	0.351
RACEXPFR	-23.553822	32.878469	-0.716
MARXPSK	-2.271514	3.152597	-0.721
MARXPFR	6.139520	7.986144	0.769
MARSTAT	-2.964473	3.849964	-0.770
MARXP	5.542183	1.966548	2.818 *
MARXI	0.0000032029	.00003273241	0.098
WHCOL	0.108697	0.494488	0.220
BLCOL	0.064172	0.486925	0.132
FARMER	1.590542	0.862745	1.844
OCCUP2	0.086910	0.344484	0.252
GRAMMER	1.292125	1.759739	0.734
HSGRAD	1.148792	1.749448	0.657
CLGRAD	1.342397	1.747117	0.768
ADULT	0.329605	0.266075	1.239
TEEN	-0.055265	0.117402	-0.471
CHILD	-0.241382	0.234092	-1.031

/* The asterisk following the T-ratio indicates the estimated coefficient was determined to be statistically significant at the 0.05 level.

Table 11. Income and Price Elasticities of Demand for Yogurt.

Race, Marital Status	Lg. SMSA	Md. SMSA	Sm. SMSA	Non-SMSA
	-Income-			
White, married	0.10	-0.63	-0.28	0.27
White, single	0.12	-0.61	-0.26	0.29
Nonwhite, married	-0.38	-1.11	-0.77	-0.22
Nonwhite, single	-0.36	-1.09	-0.75	-0.20
	-Price-			
White, married	-1.06	-0.51	-1.54	-2.21
White, single	0.05	0.61	-0.42	-1.09
Nonwhite, married	-1.04	-0.48	-1.46	-2.18
Nonwhite, single	0.08	0.63	-0.39	-1.06

themselves elasticities, coefficient interpretation primarily addressed the issue of elasticity value. Again, elasticities represent long-run response since they were estimated using cross-section data. The contrast to single equation estimation consisted of: (1) differences in functional form; (2) error related simultaneity; (3) the inclusion of zero expenditure households, and, (4) the imposition of additivity (Cournot aggregation) and homogeneity constraints.* Restrictions were imposed at the sample means of the average budget shares of each commodity. It was assumed here that the ten commodities of which the CED system was comprised constituted a complete system, since the sum of expenditures was equal to total expenditures for the system.

Tests for statistical significance of the individual coefficients are large sample approximations and uncompensated for restrictions imposed. However, for lack of a better measure, the t-values still provided a relative indication of a variable's contribution to explaining demand behavior. Therefore, interpretation of CED system results proceeded as though the t-values correctly measured significance. Again, the power of the test was set at the 0.05 level under the null hypothesis. Since the equations were estimated within a system via the "seemingly unrelated" approach, no measures of individual equation performance were provided.

1) Butter System Equation

The estimated coefficients, standard errors and corresponding t-ratios for the constrained CED system estimation of butter demand are presented in Table 12. The income elasticity of demand was found to be significant, but negative. The negative value for the income coefficient implies that butter was considered an inferior good. The own-price elasticity was of the correct sign and highly significant. The inelastic value indicates that quantities demanded of butter were not greatly influenced by the price of butter.

Several of the commodity prices completing the system were found to be statistically significant. Goods hypothesized as substitutes for butter were: yogurt, fats and oils, fruits, and snacks.** The smallest cross-price elasticity value was that of fats and oils. Bakery product prices were determined to be complementary.

Significant intercept components included residents of large SMSAs and family composition. The consumption of butter was estimated to be lower for large SMSA residents than for other levels of urbanization. As the number of adults, teens, or children in a particular household increased the quantities demanded of butter would increase, with the largest impact occurring for a change in the number of adults.

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* The symmetry constraint was withheld due to the cumbersome calculations required for its imposition. Specifically, the number of restrictions required for symmetry to hold were 45 ($\frac{1}{2}$ k [k-1]), where k = 10, i.e., the number of goods in the system (9).

** Note margarine was included in the fats and oils category.

Table 12. Constant Elasticity of Demand System Results for Butter.

MODEL: BUTTER
DEP VAR: LOGQBT

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO/*
INTERCEPT	0.998148	0.093978	10.6210*
LGSMSA	-0.036994	0.015696	-2.3569*
MDSMSA	0.015938	0.022489	0.7087
SMSMSA	-0.011589	0.018715	-0.6192
ADULT	0.040740	0.011978	3.4013*
TEEN	0.015451	0.004674566	3.3054*
CHILD	0.018680	0.008845285	2.1118*
RACE	0.018597	0.021925	0.8482
MARSTAT	-0.00406866	0.017541	-0.2320
LOGINC	-0.036087	0.008531839	-4.2297*
LOGPBT	-0.665015	0.037084	-17.9324*
LOGPHC	0.014456	0.023287	0.6208
LOGPSC	0.00705709	0.026396	0.2674
LOGPIC	0.0001536166	0.017223	0.0089
LOGPYG	0.246492	0.044288	5.5656*
LOGPFO	0.093599	0.028327	3.3042*
LOGPMT	-0.012438	0.017573	-0.7078
LOGPBK	-0.054084	0.016180	-3.3426*
LOGPFR	0.223353	0.042855	5.2118*
LOGPSK	0.182513	0.051763	3.5259*

/* The asterisk following the T-ratio indicates the estimated coefficient was determined to be significant at the 0.05 level.

2) Hard Cheese System Equation

Results for the hard cheese equation are contained in Table 13. The estimated income elasticity was positive and significant, but low in magnitude. The own-price elasticity was highly significant and of anticipated sign. The inelastic value implies a small impact on quantity demanded when hard cheese prices change.

Significant substitute products for hard cheese included yogurt, fruits, and snacks. Of these goods, snack prices held the largest impact on quantities of hard cheese purchased. Cross-price elasticities ranged in value from -0.046 to 0.286.

The number of children and the number of teens in a household were the only intercept components estimated to be significant. Both coefficients were positive but low in magnitude.

3) Soft Cheese System Equation

Table 14 contains the constrained CED system results for soft cheese product demand. The impact of income on quantities demanded of soft cheese was positive but low in magnitude. Own-price response was found to be inelastic and highly significant.

Ice cream, fats and oils, fruit, and snack cross-price elasticities were statistically significant and had positive values. Hence, soft cheese demand response would be opposite to the direction in price change for these goods.

Significant intercept differences were found for residents of small SMSAs and for nonwhite respondents. The demand for soft cheese was determined to be higher for persons living in small SMSAs than that for other levels of urbanization. The intercept coefficient for race indicates that nonwhites have a higher demand for soft cheese than do whites. The intercept value itself was positive and significant.

4) Ice Cream System Equation

The constrained CED system results for ice cream are presented in Table 15. The income elasticity of demand for ice cream was determined to be positive and significant. The low value of the coefficient indicates income has a small impact on quantities demanded of ice cream. The own-price elasticity was of the proper sign and highly significant. The inelastic value for ice cream price response indicates a small impact on demand when its price changes.

Several of the other goods contained in the system had significant cross-price effects. Among those exhibiting a substitute relationship were: yogurt, fats and oils, butter, fruits and snacks. The largest cross-price elasticity value was that of snack products at 0.25.

The only significant intercept difference was for residents of large SMSAs. The coefficient value indicates a larger demand for ice cream when residing in large SMSAs versus other levels of urbanization. The intercept value was found to be positive and significant.

Table 13. Constant Elasticity of Demand System Results for Hard Cheese.

MODEL: HARDCH
DEP VAR: LOGQHC

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO/*
INTERCEPT	-0.083020	0.144492	-0.5746
LGSMSA	-0.018592	0.024163	-0.7694
MDSMSA	0.005723565	0.034620	0.1653
SMSMSA	-0.013486	0.028810	-0.4681
ADULT	0.013012	0.018436	0.7058
TEEN	0.036025	0.007195508	5.0065*
CHILD	0.027999	0.013617	2.0563*
RACE	-0.032194	0.033751	-0.9539
MARSTAT	0.032528	0.026999	1.2048
LOGINC	0.083053	0.013109	6.3358*
LOGPBT	0.019099	0.057088	0.3346
LOGPHC	-0.697941	0.035849	-19.4691*
LOGPSC	-0.040993	0.040634	-1.0088
LOGPIC	-0.010190	0.026513	-0.3843
LOGPYG	0.232967	0.068178	3.4170*
LOGPFO	0.041529	0.043607	0.9524
LOGPMT	-0.030527	0.027051	-1.1285
LOGPBK	-0.046531	0.024907	-1.8682
LOGPFR	0.163253	0.065971	2.4746*
LOGPSK	0.286281	0.079685	3.5927*

/* The asterisk following the T-ratio indicates the estimated coefficient was determined to be significant at the 0.05 level.

Table 14. Constant Elasticity of Demand System Results for Soft Cheese.

MODEL: SOFTCH
DEP VAR: LOGQSC

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO/*
INTERCEPT	0.283712	0.134302	2.1125*
LGSMSA	0.007873138	0.022424	0.3511
MDSMSA	0.040198	0.032128	1.2512
SMSMSA	0.052474	0.026737	1.9626*
ADULT	-0.021450	0.017112	-1.2535
TEEN	-0.00785353	0.006678364	-1.1760
CHILD	-0.013132	0.012637	-1.0392
RACE	0.070429	0.031322	2.2485*
MARSTAT	-0.00666582	0.025060	-0.2660
LOGINC	0.028086	0.012195	2.3031*
LOGPBT	0.006904115	0.052980	0.1303
LOGPHC	0.015552	0.033269	0.4675
LOGPSC	-0.750940	0.037710	-19.9135*
LOGPIC	0.065239	0.024605	2.6514*
LOGPYG	0.056324	0.063272	0.8902
LOGPFO	0.131627	0.040469	3.2526*
LOGPMT	0.012051	0.025105	0.4800
LOGPBK	0.002195238	0.023116	0.0950
LOGPFR	0.161313	0.061224	2.6348*
LOGPSK	0.271649	0.073951	3.6734*

/* The asterisk following the T-ratio indicates the estimated coefficient was determined to be significant at the 0.05 level.

Table 15. Constant Elasticity of Demand System Results for Ice Cream.

MODEL: ICECRM
DEP VAR: LOGQIC

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO/*
INTERCEPT	0.866185	0.116787	7.4168*
LGSMSA	0.047505	0.019499	2.4362*
MDSMSA	-0.00440463	0.027938	-0.1577
SMSMSA	0.011680	0.023249	0.5024
ADULT	0.017107	0.014880	1.1496
TEEN	0.009985636	0.005807294	1.7195
CHILD	-0.00433099	0.010988	-0.3941
RACE	0.033794	0.027237	1.2407
MARSTAT	0.054739	0.021791	2.5120*
LOGINC	0.029275	0.010604	2.7607*
LOGPBT	0.119732	0.046070	2.5989*
LOGPHC	0.050539	0.028930	1.7470
LOGPSC	0.004968052	0.032791	0.1515
LOGPIC	-0.857560	0.021396	-40.0806*
LOGPYG	0.209309	0.055019	3.8043*
LOGPFD	0.083357	0.035190	2.3687*
LOGPMT	-0.017318	0.021830	-0.7933
LOGPBK	-0.016560	0.020101	-0.8239
LOGPFR	0.146216	0.053239	2.7464*
LOGPSK	0.248042	0.064305	3.8573*

/* The asterisk following the T-ratio indicates the estimated coefficient was determined to be significant at the 0.05 level.

5) Yogurt System Equation

Table 16 contains results for the constrained CED system estimation of yogurt demand. The income coefficient was quite small in magnitude and statistically insignificant. Unlike the other demand results for income under the constrained CED system, income had no apparent effect on the quantity of yogurt demanded. The own-price elasticity was found to be significant. The inelastic value indicates a small impact on quantities demanded of yogurt with a change in its price.

Many of the remaining goods in the system had a significant cross-price interaction with yogurt demand. Substitute relationships were determined for butter, hard cheese, ice cream, fats and oils, fruits and snacks. The cross-price effects for the other dairy products were quite small ranging from 0.04 to 0.08. The largest cross-price effect was estimated for snacks, as would be expected given the nature of yogurt as a food product. Interestingly, a complementary cross-price effect occurred for bakery goods.

No significant intercept differences emerged. The intercept itself was estimated to be positive and was found to be statistically significant. Thus, demand response for white, married residents of non-SMSAs (the base group) was representative of all race, marital status, and urbanization levels.

SUMMARY

Given household data, two contrasting approaches have been used to investigate the nature of butter, hard cheese, soft cheese, ice cream, and yogurt demand in the Northeast. Each estimation technique possessed certain merits discussed individually below. An empirical comparison of both models is provided as a basis for future investigation of the proper structure of household demand for dairy products.

Evaluation of Single Equation Results

The "fit" of the single equation demand functions to the data were typical of those achieved in cross section regression. Adjusted R^2 values ranged from 0.15 for the soft cheese equation to 0.26 for both the butter and ice cream functions. In a similar application of the single equation model, the highest R^2 value achieved by Boehm and Babb was 0.19. All tests for the significance of the regression equations (F-test) were statistically significant. Mean square error values were reasonable; the largest occurred for the ice cream equation at 32.27.

The insignificance of income, occupation, and education in explaining demand behavior highlighted the similarities in coefficient results across all demand equations. Perhaps correlation among these variables contributed to their overall insignificance. However, inclusion of each variable afforded a true measure of their impact on consumption behavior. With few exceptions, own-good price, race, marital status, and household consumption were the significant determinants of demand for all dairy products. The influences of race and marital status were most pronounced in own-price response differences. Overall, whites and single person households were found to be less concerned with changes in own-good price than their respective counterparts. The number of adults, teens, or children residing in a particular household generally had a

Table 16. Constant Elasticity of Demand System Results for Yogurt.

MODEL: YOGURT
DEP VAR: LOGQYG

VARIABLE	PARAMETER ESTIMATE	STANDARD ERROR	T RATIO/*
INTERCEPT	0.771634	0.063782	12.0980 *
LGSMSA	0.016357	0.010650	1.5359
MDSMSA	0.011709	0.015259	0.7674
SMSMSA	0.011186	0.012698	0.8810
ADULT	-0.00124381	0.008127165	-0.1530
TEEN	-0.00348606	0.00317174	-1.0991
CHILD	-0.00368201	0.006001513	-0.6135
RACE	0.019219	0.014876	1.2919
MARSTAT	0.007880138	0.011902	0.6621
LOGINC	0.006990308	0.005791324	1.2070
LOGPBT	0.080185	0.025162	3.1868 *
LOGPHC	0.040379	0.015800	2.5556 *
LOGPSC	0.007968755	0.017910	0.4449
LOGPIC	0.040014	0.011686	3.4242 *
LOGPYG	-0.570677	0.030050	-18.9912 *
LOGPFD	0.040670	0.019220	2.1161 *
LOGPMT	0.013160	0.011923	1.1037
LOGPBK	-0.022336	0.010978	-2.0345 *
LOGPFR	0.163576	0.029077	5.6256 *
LOGPSK	0.200070	0.035121	5.6965 *

/* The asterisk following the T-ratio indicates the estimated coefficient was determined to be significant at the 0.05 level.

positive impact on quantities demanded of all products. There were no apparent similarities in factors determining demand for either "hard" or "soft" product groups. One might conclude the single equation model was not well equipped to handle an investigation of this type of product interaction.

Elasticity values for the base group (white, married residents of non-SMSAs) generally fell within the range of previous estimates. To illustrate, the butter income elasticity of demand for the base group was estimated at 0.25, while the range of previous estimates was between 0.15 and 0.60. Similarly, price elasticity values of the base group for hard cheese (-1.34) and soft cheese (-0.61) were within the range of previous measures of cheese price elasticity (-0.25 to -1.71). The elastic response for hard cheese types and inelastic price response for soft cheeses was also consistent with past analyses.

To summarize, application of the single equation model allowed for the separate determination of price, income, and sociodemographic impacts on each product's demand. Furthermore, the large degrees of freedom enabled testing for both intercept and slope differences in demand response associated with household characteristics for each product through use of dummy variables. The results suggest that price and income response differed between race, marital status, and level of urbanization. Price response differences were also tested for substitute goods through use of interactive dummy variables. This test was determined to be significant for the ice cream function, where it was shown that the influence of snack and bakery good prices on quantities demanded of ice cream were different between white and nonwhite races. Finally, the results indicated the single equation model is best suited for those interested in exploring the role of sociodemographic variables on product demand. More importantly, the specification allows for a multitude of tests on income and price response differences between households.

Constant Elasticity of Demand System Performance

One drawback of a "systems approach," such as the CED system, is that measures of individual equation performance were not readily available. Thus, the evaluation of individual equation results derived here were based on the validity of parameter estimates. On the other hand, a weighted coefficient of determination and weighted mean square error were available measures for assessing the entire system. The R^2 reported for the system was 0.13 and the mean square error was estimated at 1.21.

With the exception of the estimated income elasticity of demand for butter, all price and income elasticities conformed to theoretical expectations. Price elasticity values for each dairy product were less than unity indicating an inelastic own-price response. Given this result, one might conclude that, over the long-run, changes in the prices of dairy products have a small impact on quantities demanded. The majority of income elasticity values were estimated to be positive but low in magnitude in comparison with previous estimates.

The influence of sociodemographic factors varied across all equations, although similarities between "hard" and "soft" product types were found. In particular, household composition had a significant impact on demand for "hard" products while it did not for "soft" products. The estimated coefficient for race was negative for "hard" products but positive for "soft" product types.

The large number of significant cross-price elasticities estimated for each product suggests that perhaps determination of product interation was enhanced through implementation of the CED system. Similarities between all dairy products included the positive effect of fruit and snack prices on demand response. That is, fruit and snack prices emerged as complements to each of the dairy products investigated. Several significant cross-price effects also were found among the dairy products themselves. For example, yogurt prices had a positive impact on quantities demanded of butter, hard cheese, and ice cream.

Due to the nonavailability of diagnostic measures, the CED system results were difficult to evaluate. The large number of significant variables and the presence of few unreasonable parameter estimates for individual product equations indicates this was a viable modeling approach. Two notable benefits to this approach were the direct estimation of elasticities and its ability to gauge product interactions.

An Empirical Comparison of Demand Models

Theoretical and analytical properties contributing to the contrast between the single equation and CED system approach were herein previously treated. The question remains, however, as to the degree to which empirical results reflect the contrast in methodologies. Comparison of coefficient values were limited to those variables common to both methods of estimation. Additional criteria for comparison included computational burden and the computer costs associated with each approach.

Regarding price and income estimates, the most notable differences occurred in the significance of income response. The effect of income was determined to be insignificant for all products under single equation estimation, while under the CED system all income parameters were found to be significant. With the exception of soft cheese and ice cream, estimated own-price elasticities for the single equation model were elastic or greater than unity.* On the other hand, own-price elasticities for all products in the CED system were estimated to be inelastic.

Several similarities emerged between approaches in terms of intercept differences associated with sociodemographic factors. Significant intercept differences occurred for household composition variables in both butter and hard cheese equations of each model. A positive intercept difference was estimated for small SMSA residents in each soft cheese equation. Yogurt equation results for both approaches produced no significant intercept differences. The direction of cross-price effects were consistent between models for butter, ice cream, and yogurt. Meat and bakery products exhibited a substitute relationship for hard cheese types in the single equation model, while a complementary relationship occurred in the CED system results. The effect of fruit prices were opposite (in sign) between estimation methods for soft cheese demand.

Estimation of the CED system was far more cumbersome due to the imposition of theoretical constraints and the addition of substitute good equations necessary to complete the system. However, once established, computer time was

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* Own-price elasticities, generated through the single equation approach, which were used for comparison are those of the base group.

less expensive for estimation of the CED system than for the five single equation demand functions. Cost differences are primarily attributed to the larger number of variables contained in the single equation model.

The comparison of empirical results demonstrated that the choice of estimation method greatly influenced coefficient estimates. This was especially prevalent for the parameters associated with economic variables, where dramatic differences were encountered. No effort was made here to rationalize empirical differences, as the analytics required are beyond the scope of this study. Obviously, the choice of demand model ultimately depends on the researchers' objectives and data availability.

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AN OUTLINE OF THE NORTHEAST DAIRY SECTOR SIMULATOR

by

James E. Pratt, Andrew M. Novakovic, and David L. Jensen*

One of the principal objectives of the NE-126 regional research project is to study the spatial organization of the Northeast dairy sector. The Northeast Dairy Sector Simulator, or NEDSS, has been constructed to assist in this analysis.

As its name implies, NEDSS is a model of the Northeast dairy sector. It has been designed to be a complete and rather detailed model of the entire Northeast dairy sector. It does not attempt to describe behavior in any other economic sector or geographic region. However, the model could easily be adapted to any geographic region or subregion which had a similarly structured dairy sector. A brief discussion of the model and its distinctive characteristics is provided below.

NEDSS is a transshipment and plant location model that combines network flow and facilities location methodologies. The model concept draws on the plant location formulation described by King and Logan in 1964 and used, in modified forms, in more recent dairy sector analyses (Beck and Gordon, Boehm and Conner, Buccola and Conner, Kloth and Blakley, and Thomas and DeHaven). It also builds on the plant location application discussed by Fuller et al., on the transshipment model discussed by McLean et al., and on the dairy sector networks constructed by Babb et al., and Novakovic et al..

NEDSS differs from its predecessors in the scope of its analysis. This is made possible through the use of recently developed solution techniques. Typically, previous plant location models were forced to seriously restrict the size of the problems which they analyzed. This usually resulted in limiting the numbers of supply or processing points or in independent analyses of each product class. Also, in most of the previous analyses, the movements of processed products from processing to consumption points were ignored.

The dairy sector is viewed at three market levels in NEDSS; these are referred to as supply, processing, and consumption. Raw milk production at the farm level is assumed to be homogeneous and suitable as input for any processed dairy products. At the processing level, milk is assumed to be processed into three dairy product groups: 1) fluid milk products (Class I under Federal Orders), 2) soft manufactured products (Class II under most Federal Orders), and 3) storable manufactured products such as cheese, butter, nonfat dry milk, and miscellaneous hard manufactured products (Class III under most Federal Orders). All three product groups are consumed at the retail level.

NEDSS is capable of simultaneously analyzing the optimal location of processing plants and corresponding optimal milk movements for each of the three

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* James E. Pratt, Research Associate, and Andrew M. Novakovic, Assistant Professor, are in the Department of Agricultural Economics at Cornell University. David L. Jensen is an Assistant Professor in the Department of Applied Mathematics and Statistics at the State University of New York in Stony Brook.

products previously defined by considering the cost of assembly, processing and distribution between over 1,500 economic units, representing over 280 geographic locations.

Transshipment Formulation

The problem solved by NEDSS can be described as a specially structured transshipment problem. A transshipment problem is a network flow problem in which there are supply, demand, and transshipment nodes having positive, negative, and zero supply, respectively. There are arcs from one node to another which are assigned a non-negative cost and capacity.

Figure 1 depicts the transshipment formulation of a problem in which there are three unique geographic locations--A, B, and C--and production occurs at points A and B, consumption of each of three products exists at points A and C, and processing may occur at any points A, B, and/or C. Product flows move over the arcs from supply points through processing points to demand points in order to satisfy product demands; it is assumed that supply equals demand. A flow is an assignment of non-negative values to each of the arcs. A flow is feasible with respect to the capacities and supplies if the flow on every arc is no larger than the capacity of the arc and the sum of the flows out of a node minus the sum of the flows into the node is equal to the amount of supply at that node. The cost of the network is equal to the sum over all arcs of the flow on each arc times its cost. A transshipment problem is solved when a feasible flow of minimum cost is found.

In NEDSS application raw milk is aggregated at the farm level into geographic centers. These aggregations correspond to the supplies in the transshipment model. As in the case of farms, dairy processing plants are grouped into processing centers. The processing centers fall into three categories according to the type of finished product - fluid, soft, or hard dairy products - into which the raw milk is converted and form a subset of the transshipment nodes. Each center may have a limit on the amount of raw milk which may be processed into each product type. Demands are also grouped geographically into centers with a demand for each of the three product types. The raw milk is shipped from the supply centers to the processing centers and from processing centers to the demand centers subject to the following restrictions:

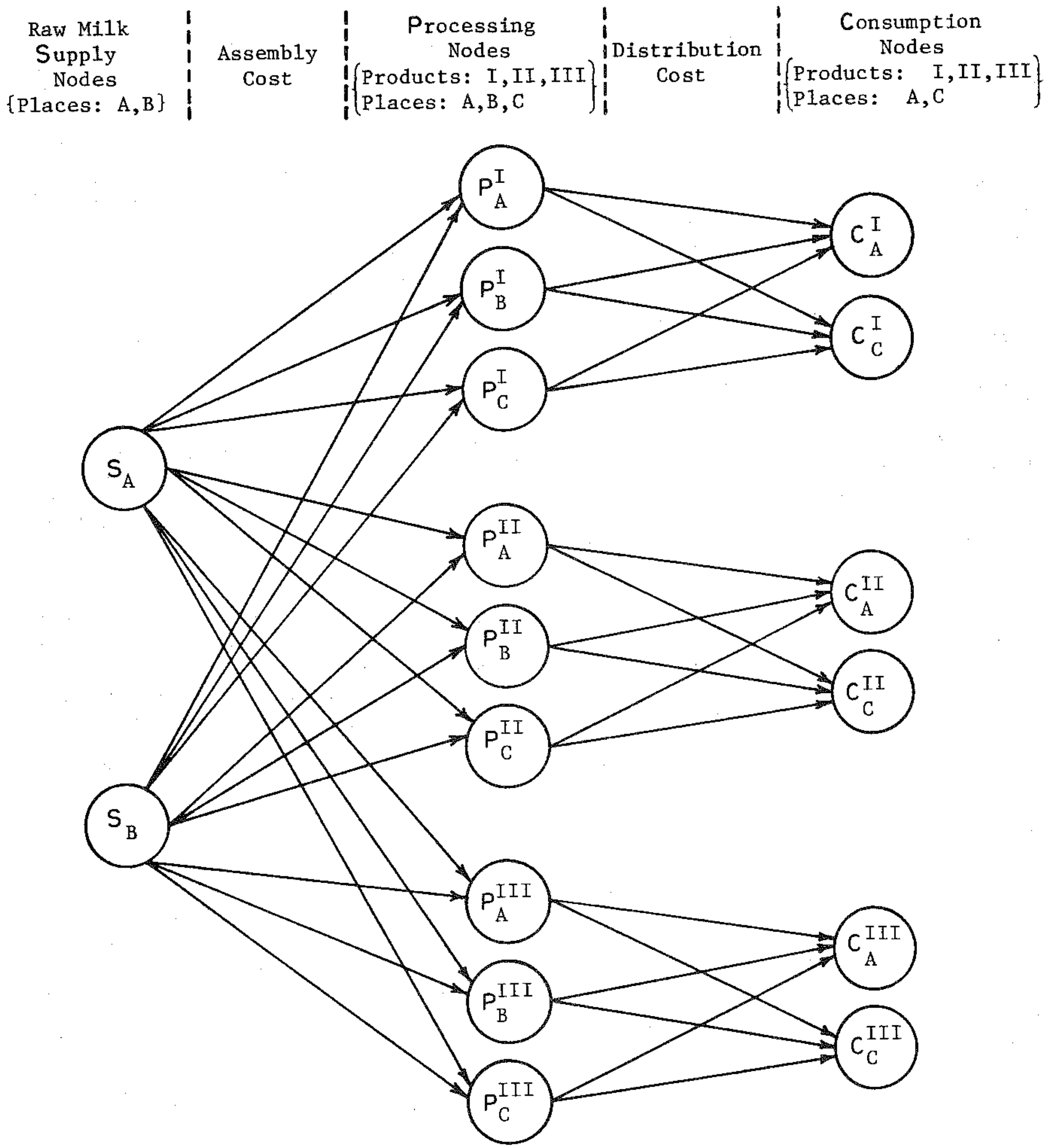
1) The amount of milk shipped from a supply center to the processing centers does not exceed the amount of milk collected at the supply center.

2) No processing center processes more raw milk than its capacity for any product type.

3) The shipments from the processing centers to the demand centers meet the demands for each demand product type at each center.

There are transportation costs associated with shipments of the raw milk to the processors, as well as with shipments of the finished products to the demand centers. There is also a processing cost associated with each processing center and product type. The model is solved when we find a set of shipments satisfying the restrictions above while minimizing transportation plus processing costs.

FIGURE 1. EXAMPLE TRANSSHIPMENT NETWORK



Production

The transshipment formulation of the Northeast dairy sector spatially disaggregates the region into a number of subregions based on the 308 counties included in the study area. Basically, each county which had more than 1,000 head of dairy cows in 1974 defines a production region which is represented by a single point within that county. Counties which had fewer cows are combined with neighboring (larger) counties. This resulted in 236 supply points being delineated (Figure 2).

The supply component of NEDSS, draws from the supply response work of Masud and Elterich and Criner (the latter is reported in this proceedings). Point estimates of milk production are calculated from adaptations of these supply models and alternative assumptions regarding projected exogeneous variables. These point estimates are then used as the production of raw milk entering the transshipment network at production points.

The cost of bulk milk assembly used in NEDSS is based on the work of Hahn (reported in this Proceedings).

Consumption

Consumption regions consist of subregions, comprised of one or more counties, of the 308 counties included in the study area. These subregions were delineated on the basis of county populations and are represented geographically by a single point within each subregion. This resulted in 141 consumption points being delineated (Figure 3).

Milk product consumption for each of the three product categories is treated similarly to milk supply in NEDSS. The demand response work by Morehart (reported elsewhere in this proceedings) has been adapted to the model. Point estimates of consumption are calculated for each consumption area given a set of assumed exogenous variables. These point estimates are then used as the consumption level for final products in the network at each consumption point.

The cost of distributing the three product types from processing to demand centers is based on the work of Metzger.

Processing

Processing of each class of product is allowed to take place at any of the 284 geographic points which are the union of the production points and consumption points, as shown in Figures 2 and 3. The choice of processing locations can be constrained by the user (e.g., existing locations) or selected by the model in a cost-minimizing fashion. Plant capacity estimates used in this study were assembled by Novakovic and Pratt with extensive help from Lynn Sleight, John Rourke (of AMS-USDA), and Homer Metzger (formerly of the University of Maine) as well as other members of the NE126 technical committee (see Hahn, Novakovic, and Pratt).

First, a list of 595 plants operating within the geographic area in 1982 was compiles. Each plant was then categorized with respect to its major product; fluid, soft, or hard dairy products (see Figures 4-6). From these lists, plants were combined into groups of three or more. With the aid of the Dairy

FIGURE 2. SUPPLY POINTS USED IN NEDSS

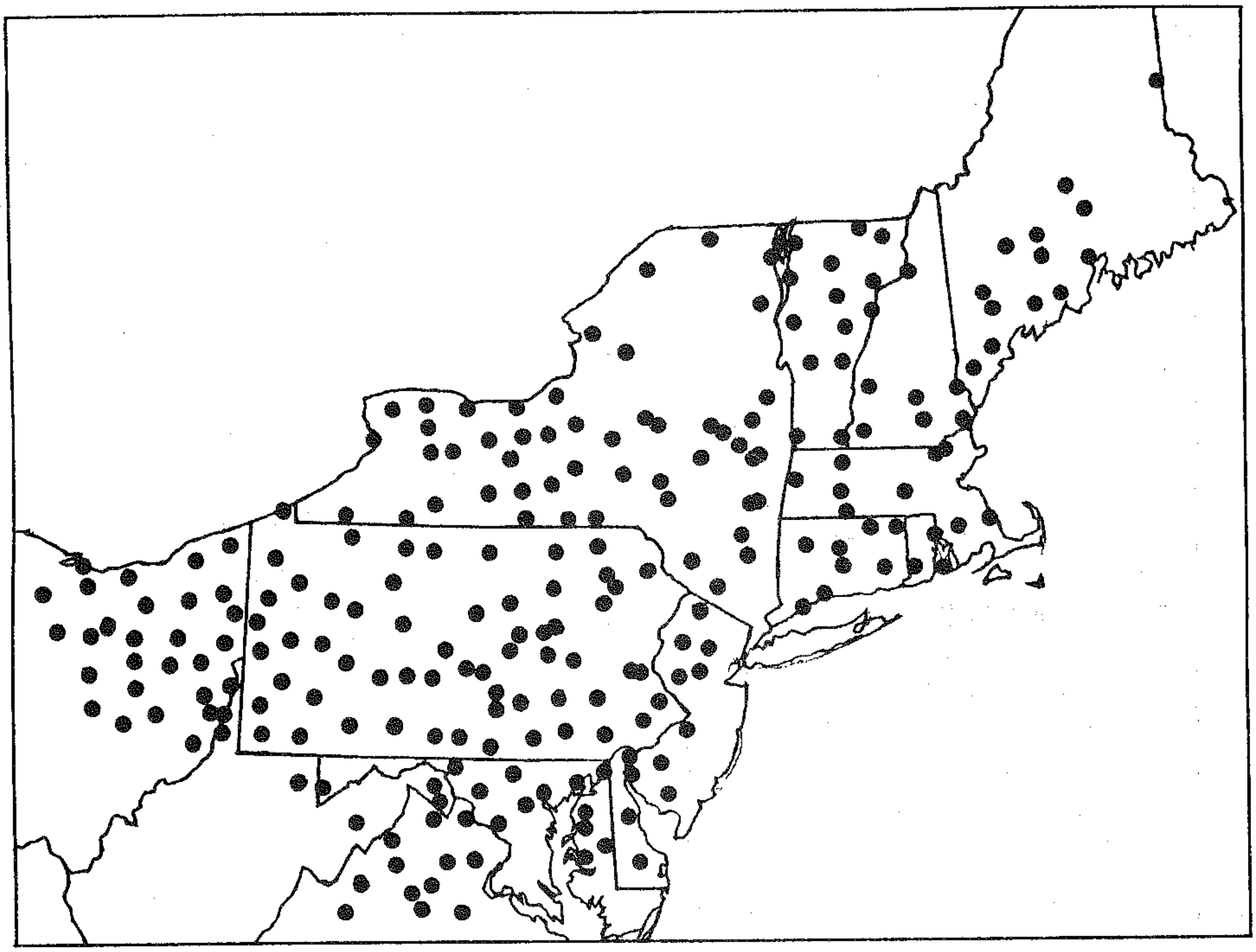


FIGURE 3. CONSUMPTION POINTS USED IN NEDSS.

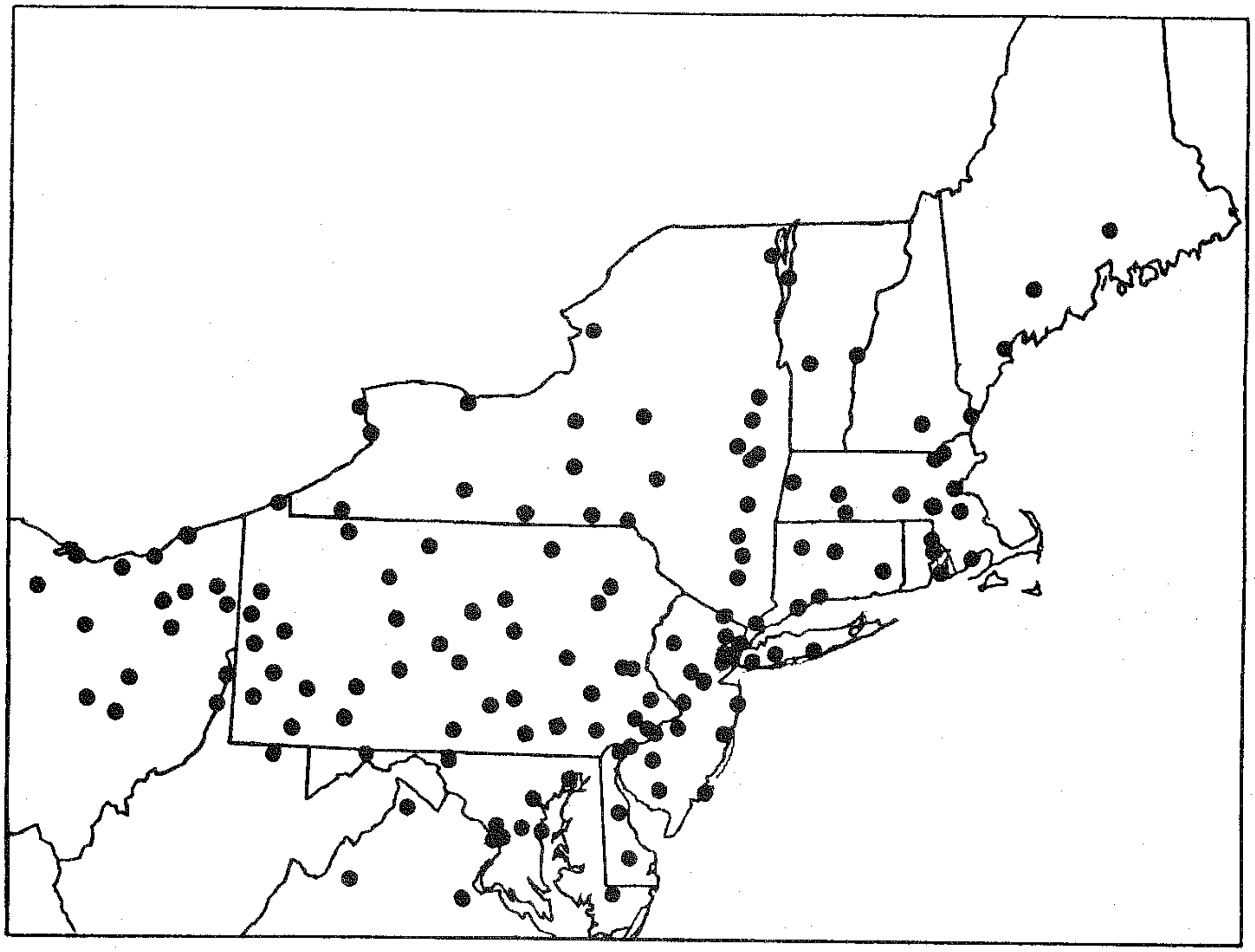


FIGURE 4. ACTUAL LOCATIONS FOR FLUID PRODUCT PROCESSING PLANTS

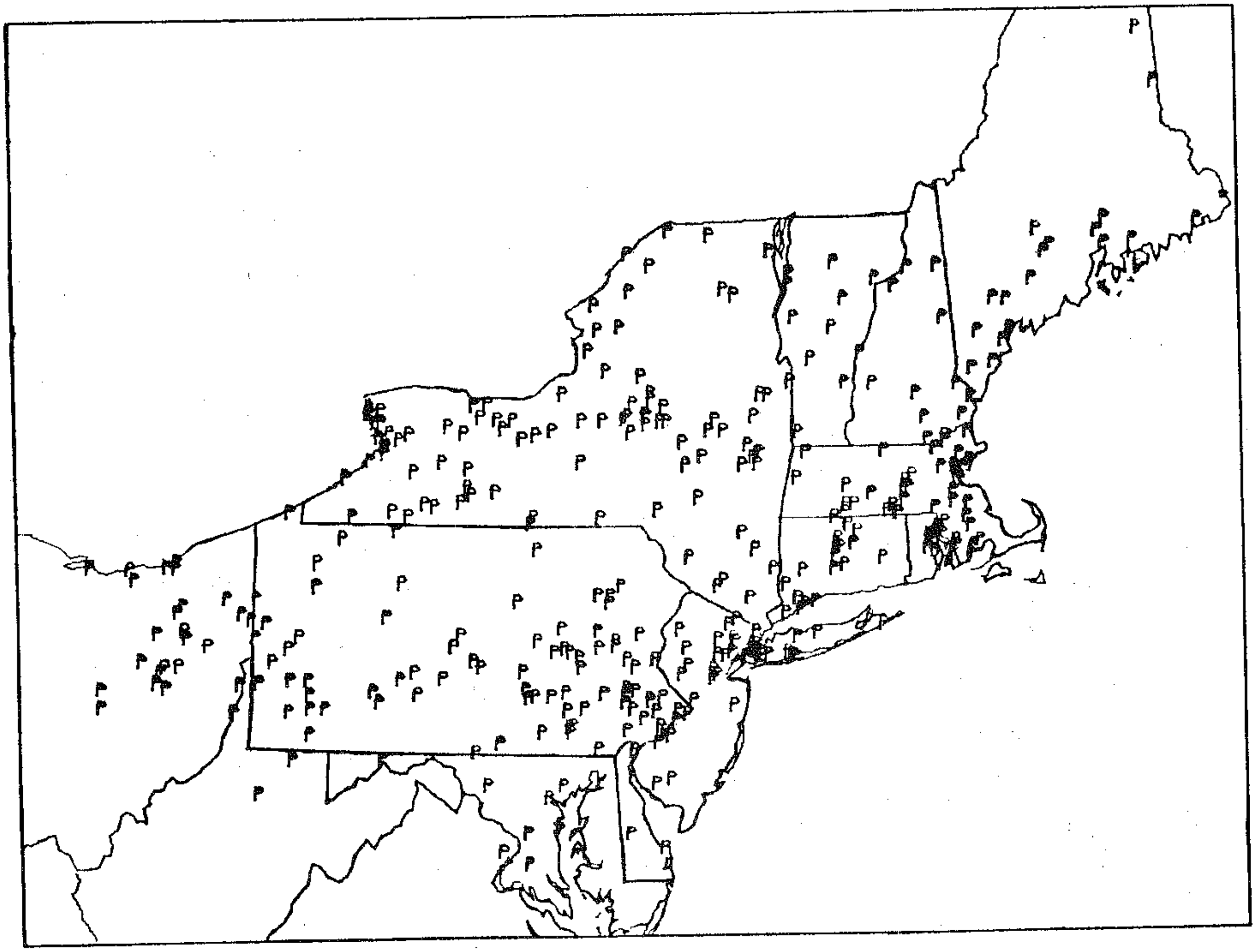


FIGURE 5. ACTUAL LOCATIONS FOR SOFT DAIRY PRODUCT PROCESSING PLANTS

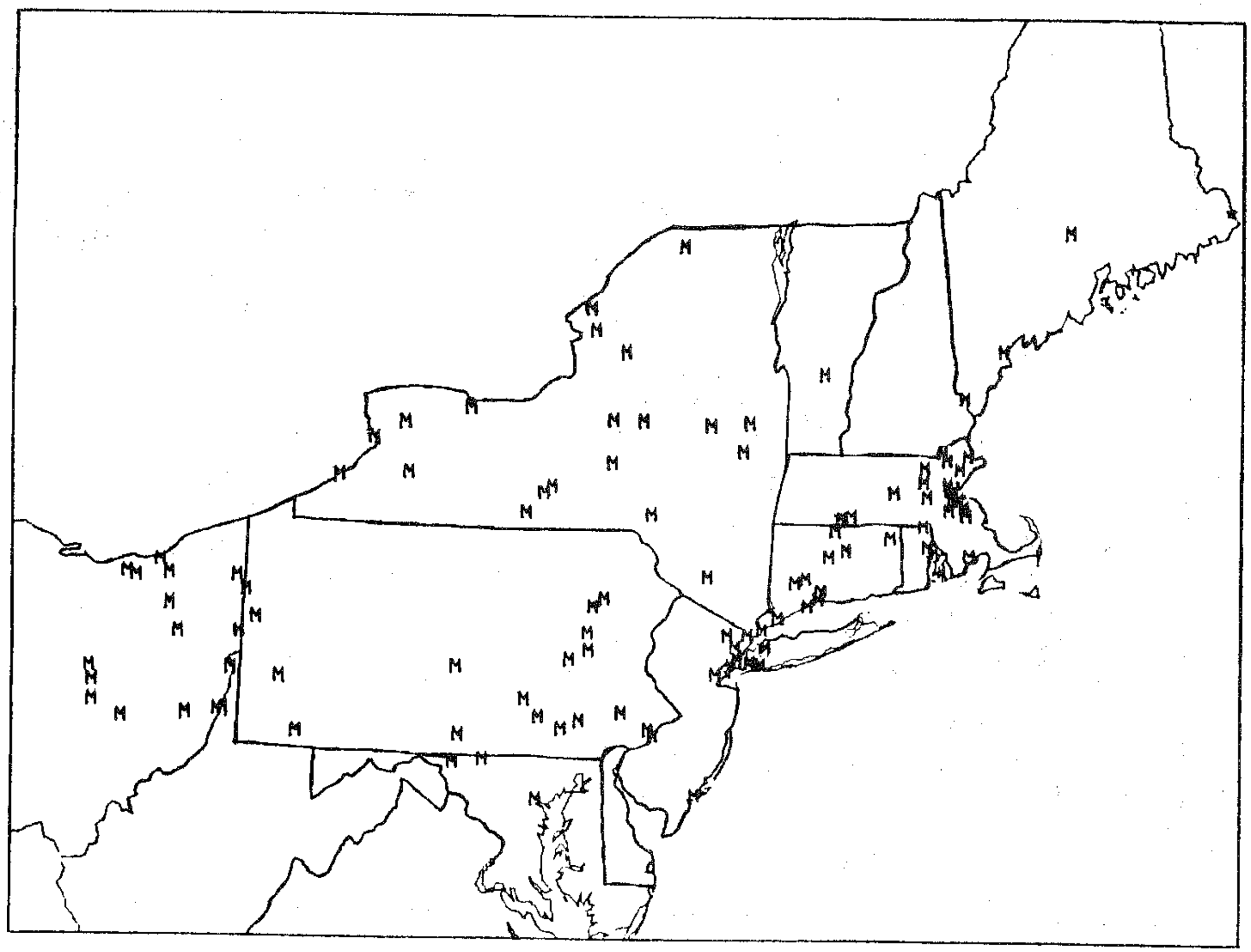
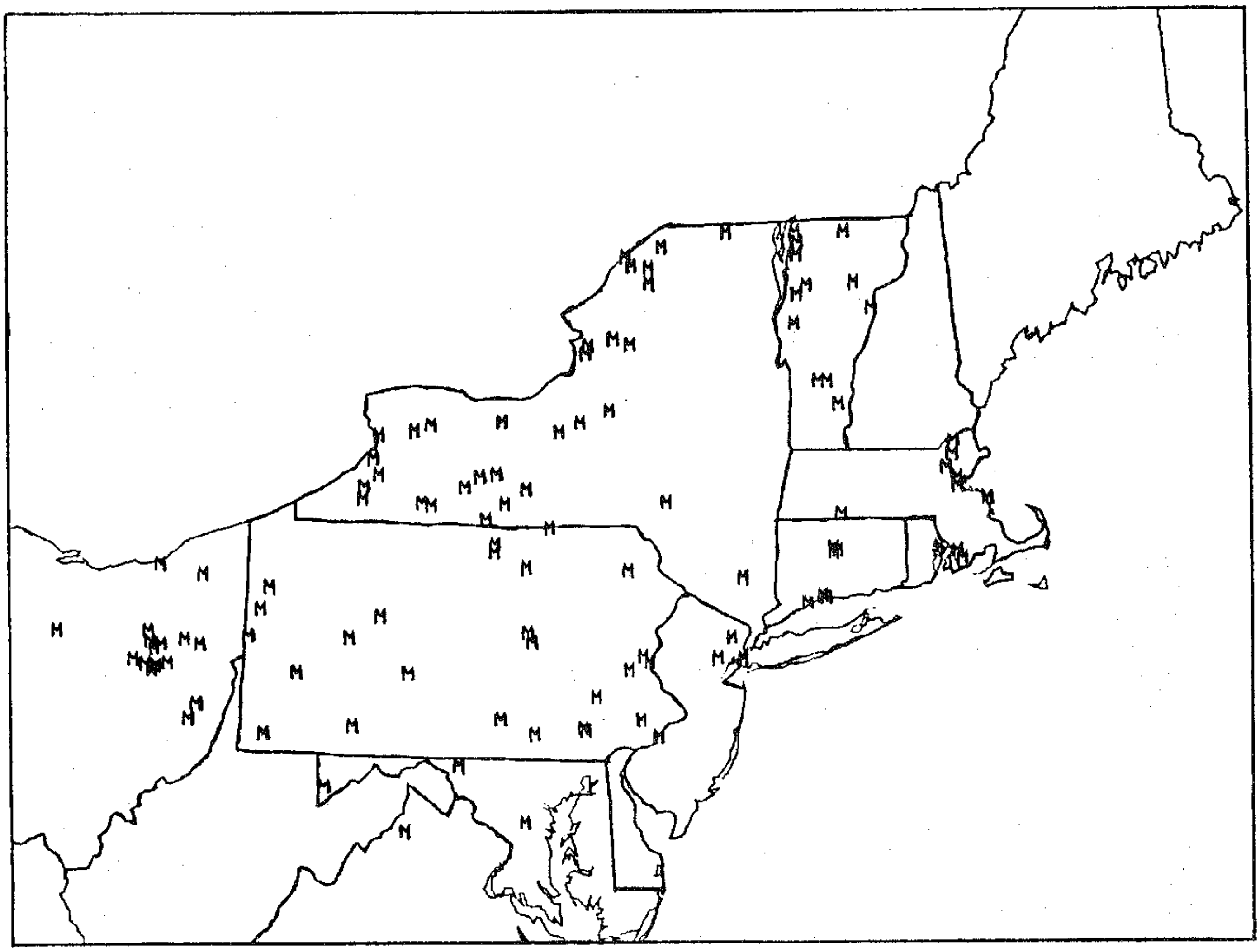


FIGURE 6. ACTUAL LOCATIONS FOR HARD DAIRY PRODUCT PROCESSING PLANTS



Division of AMS-USDA, state milk marketing officials, and University staff, estimates of processing capacity for the resulting 80 fluid plant groups, 10 soft product groups, and 17 hard product groups were made. Figures 7-9 depict the locations of these aggregation points.

The cost of processing raw milk into the three products used in NEDSS is based primarily on the work of Smith (reported in this proceedings).

Geographic Distances

Transportation cost for moving raw milk from production points to processing points and finished products from processing points to consumption points is a function of the distance travelled. Generally, there are $(N^2 - N)/2$ distances which must be derived in some way for N points. For this problem, with 284 points, there are 40,186 such distances to be determined.

To determine all of these distances by hand would be an enormous task susceptible to significant error. Fortunately, a methodology exists whereby this task can be reduced to manageable proportions. 'Shortest Path Algorithms' (Gilson & Witzgall) need only information on the distance between adjacent points in a network in order to find the shortest distance between any two points. Thus, by simply making measurements of the approximately 750 distances between adjacent points in the road network connecting all of the 284 geographic points used in this model, we are able to use a shortest path algorithm to quickly and efficiently determine the 40,186 distances which are needed.

A Model with Positive and Normative Characteristics

NEDSS is an optimizing model. It minimizes the cost of assembling, processing, and distributing milk and milk products. Although NEDSS is, in this sense, a normative model, it is not designed to say what prices ought to be or how milk ought to be produced, processed or consumed. The model is intended to describe the economic performance of the dairy sector assuming that milk is transported and processed efficiently within and across geographic areas. In that sense, it does have positive characteristics.

NEDSS can be operated in several different modes with respect to processing capacities and processing costs; 1) processing capacity at any potential location may be assumed to be unlimited and processing costs per unit can be assumed to be constant with respect to volume processed, 2) processing capacities at each potential processing location may be constrained to some amount and processing costs assumed constant, 3) processing capacities can be unlimited with processing costs per unit assumed to be declining with increased volume, and 4) processing capacities can be constrained and processing costs assumed to decline.

Numerical Implementation

In order to include processing capacities, the typical network formulation of an (uncapacitated) transshipment problem, as represented, in Figure 1 needs to be modified. In Figure 10, a second set of processing nodes is added to the usual array of production, processing and consumption nodes so that the arc from each processor node to the "dummy" processor node could include a capacity, ("cap.= ___"), and a processing cost, (RI, RII, or RIII). The numbers at the

FIGURE 7. LOCATIONS OF AGGREGATED FLUID PRODUCT PROCESSING PLANTS

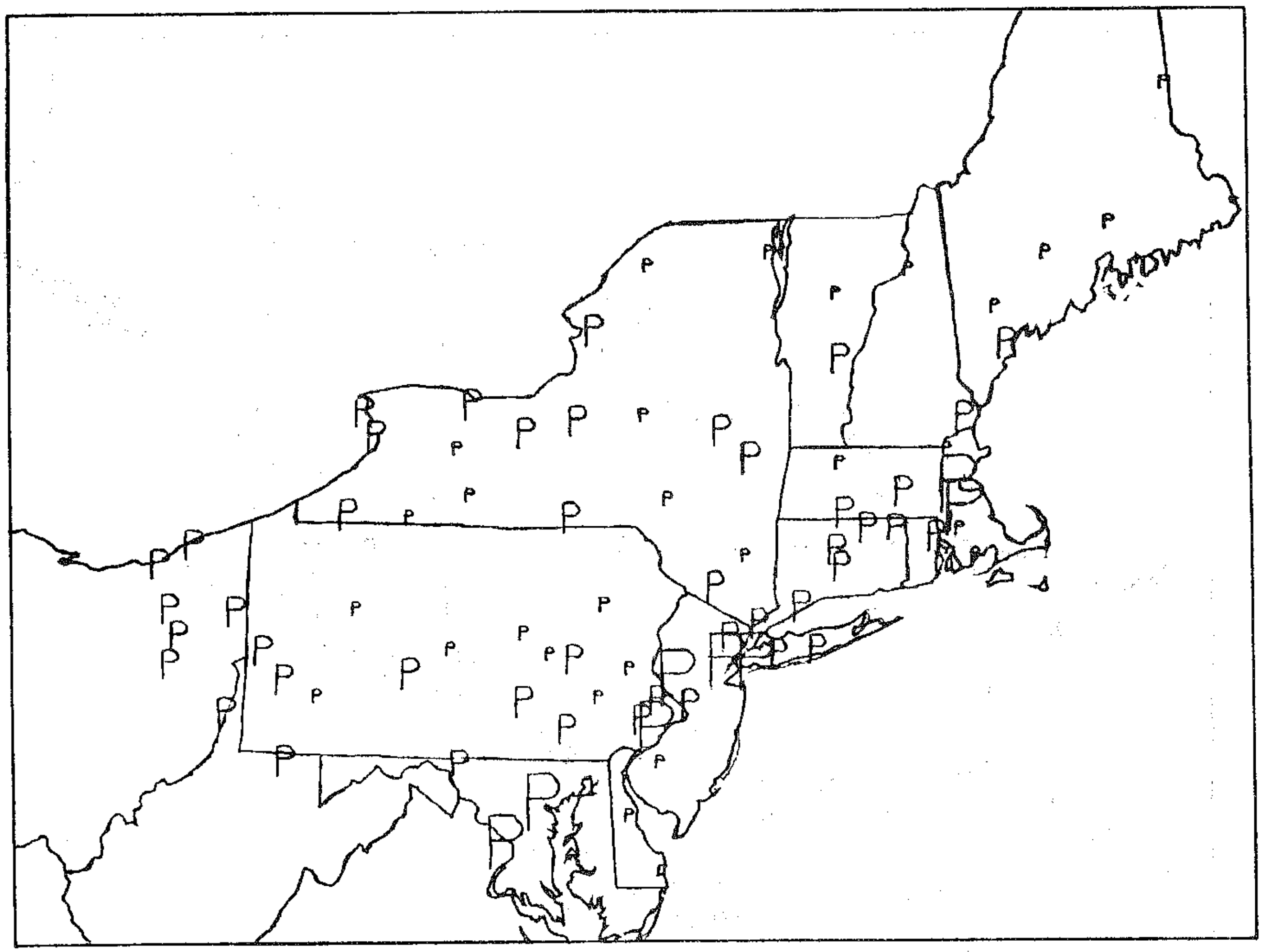


FIGURE 8. LOCATIONS OF AGGREGATED SOFT DAIRY PRODUCT PROCESSING PLANTS

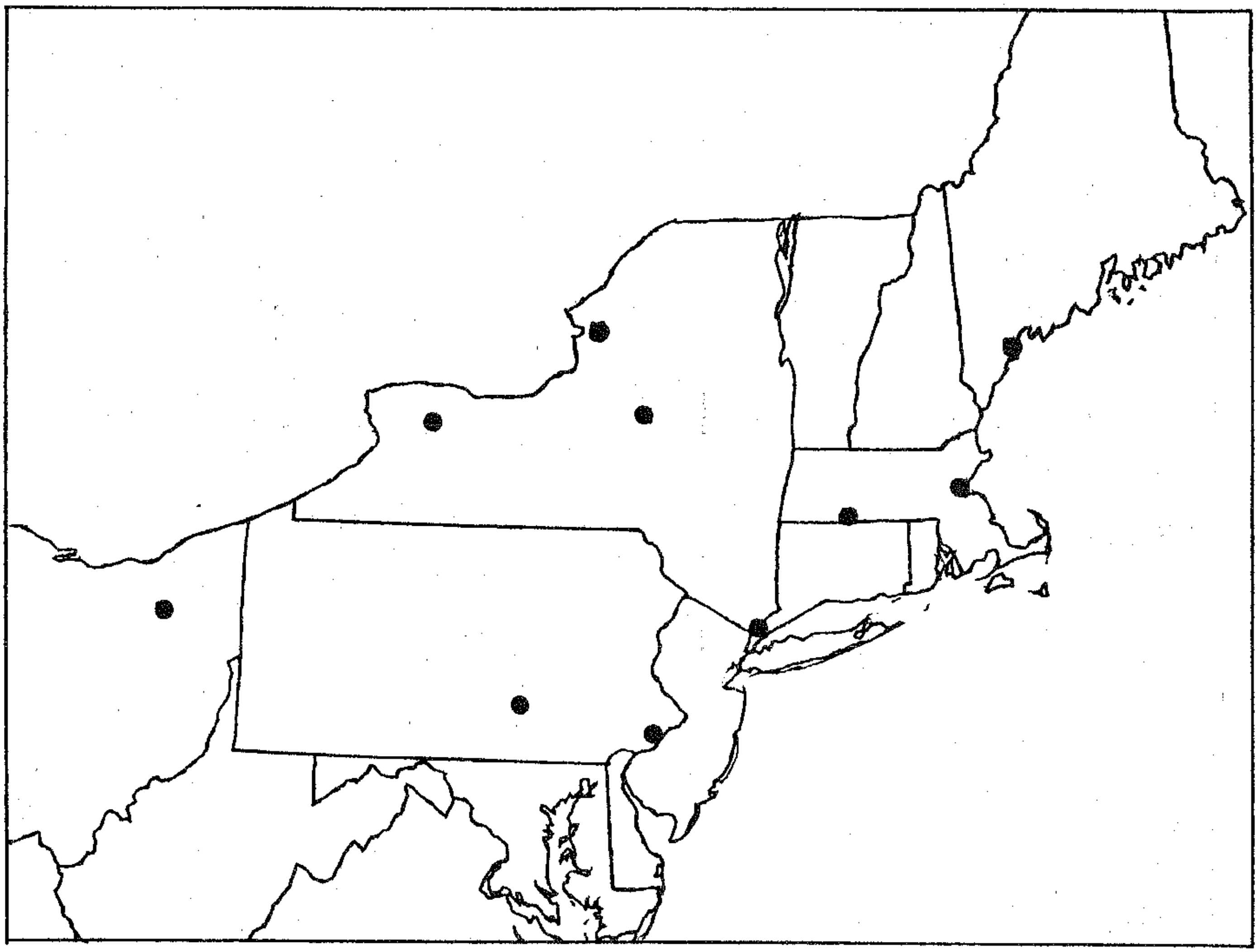


FIGURE 9. LOCATIONS OF AGGREGATED HARD DAIRY PRODUCT PROCESSING PLANTS

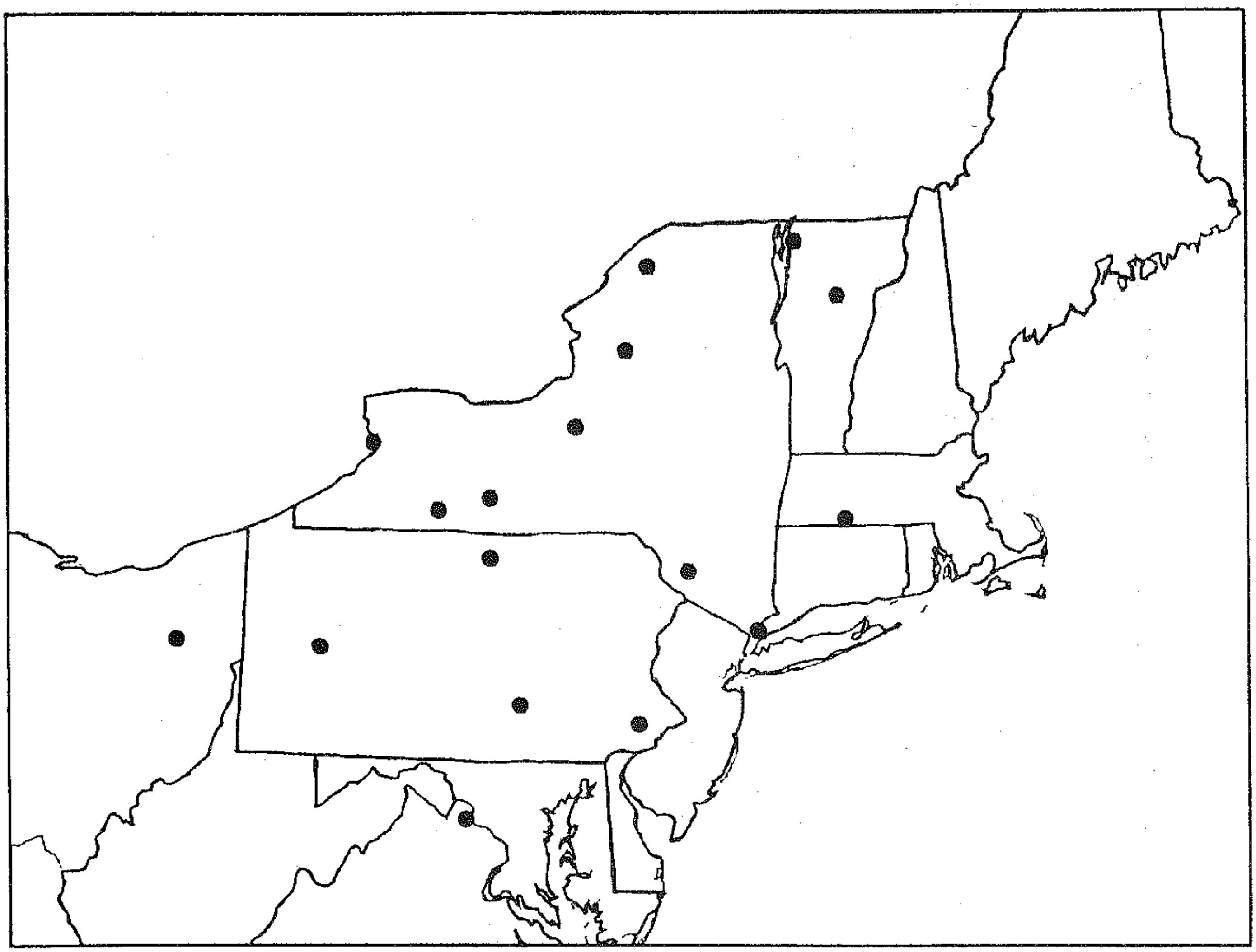
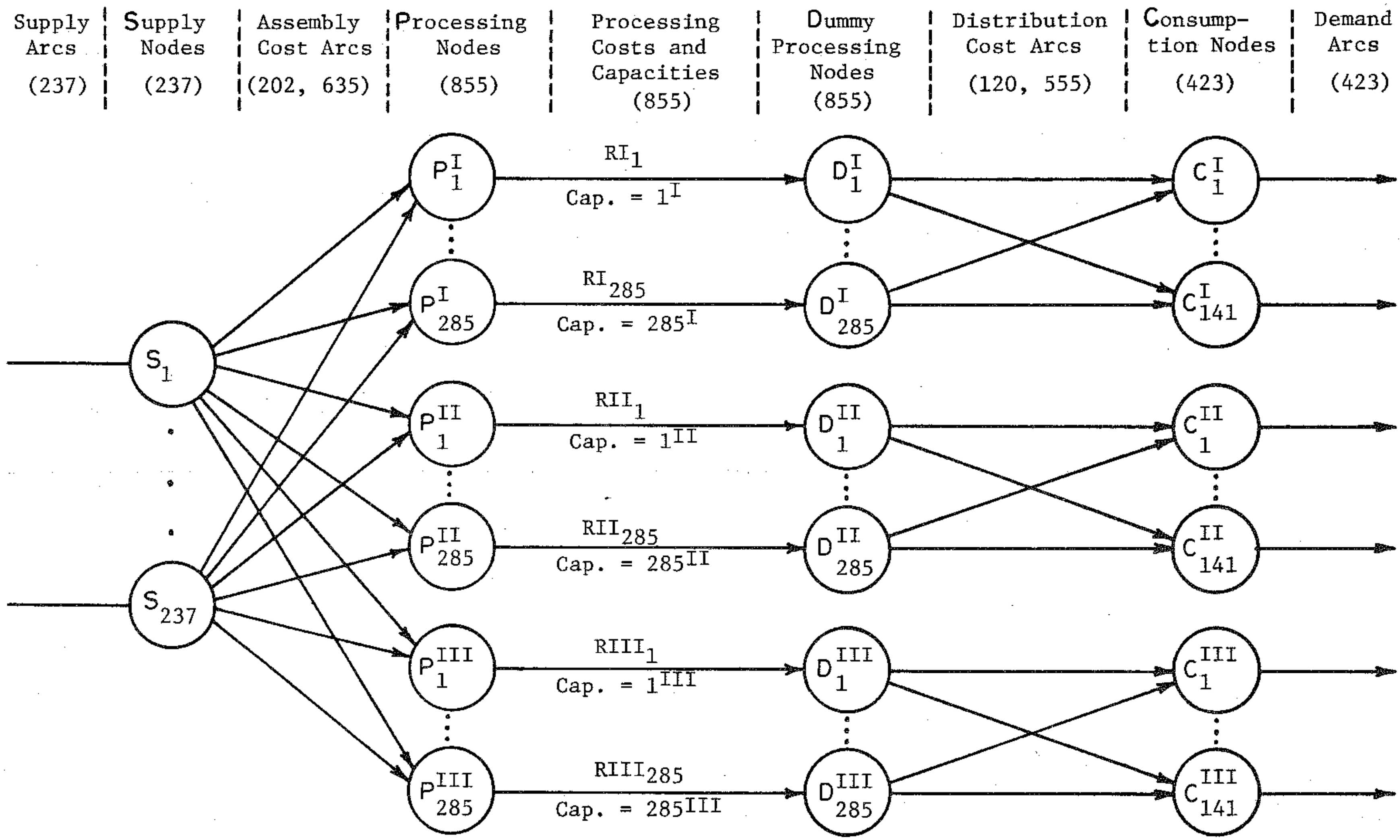


FIGURE 10. NETWORK REPRESENTATION OF NEDSS



top of the figure represent the number of nodes or arcs in each section of the NEDSS network. As can be seen, there are a total of 324,705 arcs and 2,370 nodes. This is a very large problem which requires substantial computing resources simply to generate, as well as to solve.

The network solver used in the NEDSS system is an implementation of the primal simplex method for linear programs. The implementation takes advantage of:

1) the network structure of the linear program. This is accomplished by implementing the revised simplex method and maintaining the basis and its inverse using list structures. The list structures used are those developed by Michael Grigoriadis and Tau Hsu for RNET, a 'minimum cost network flow' computer program written in Fortran at Rutgers University. The significance of using list structures to maintain the basis is that the pivot operations of the simplex method can be performed in a number of steps proportional to the number of nodes in the network. This is much faster than they can be performed by a general purpose simplex code.

2) the unique structure of this particular application. In Figure 10, it can be seen that there are actually 4 separate transportation problems embedded in the network; 1) production to processing, 2) class I processing to class I consumption, 3) class II processing to class II consumption, and 4) class III processing to class III consumption. Each of these sections is "bipartite", i.e. the set of nodes can be partitioned into two subsets so that all arcs begin in one set and end in the other. This information may be used to store the endpoints, (FROM(i) and TO(i)), of an arc, (i), as functions or subroutines with very efficient internal storage requirements that are independent of the size of the problem.

3) the small percentage of arcs which are capacitated. From the problem description we have, the only arcs which are capacitated are the processing arcs. There are fewer of these arcs than there are nodes in the graph. We utilize this observation to store the capacities as a function with internal storage equal to the number of processors plus some amount independent of the problem size.

   The exploitation of these special properties (along with the implementation of a program capability for using prior feasible solutions as initial, restart solutions for a subsequent problem) allows for the efficient solution of this very large problem.

A Sample Solution

To demonstrate the general capabilities of NEDSS, a hypothetical, but reasonably representative, example problem was generated and solved. This involved the specification of raw milk production at each production point and final product consumption levels at each consumption point, as well as bulk milk transportation costs and final product distribution costs. This example problem was solved as an uncapacitated problem such that any potential processing point could process as much of any product as needed in order to minimize the total marketing cost (assembly and distribution). No economies of scale in processing costs were allowed, so that for each product type, all potential processing locations faced equal and constant unit processing costs.

Figures 11-13 depict the flows of raw milk from production points, "s", to processing points, "p". Any point which is both a supply and a processing point which is depicted by what appears to be a "B". The lines representing flows provide a quick and concise picture of the solution, which involves hundreds of bulk milk movements. Figures 14-16 depict the flows of final products from processors, "P", to consumption centers, "D". Again, points which are both processing and consumption centers are depicted by what appears to be a "B".

As can be seen from these figures, the general result for this hypothetical example is that milk destined for Class I use moves longer distances as bulk milk while milk destined for Class II and Class III use moves longer distances as final products. Also, since the region is milk deficient, milk moving into the region comes in from the Midwest as Class III final products, destined mainly for the large metropolitan markets on the Atlantic Coast. Class II product demands are entirely satisfied by in-area raw milk and are generally processed outside of the large metropolitan areas and moved to these areas as final products.

Those familiar with dairy markets will find this solution to be quite predictable. As a sample solution, these results are somewhat unexciting by themselves. However, they should demonstrate the range, power and flexibility of the model for comparing the implications of policy and general economic changes that affect milk supply, processing, and/or demand. By altering supply/demand situations as well as the various cost parameters and by using the different solution nodes, the sensitivity of plant locations and product flows to these changes can by systematically investigated.

FIGURE 11. FLOWS OF BULK MILK FROM PRODUCTION POINTS (S) TO FLUID MILK PROCESSING POINTS (P)

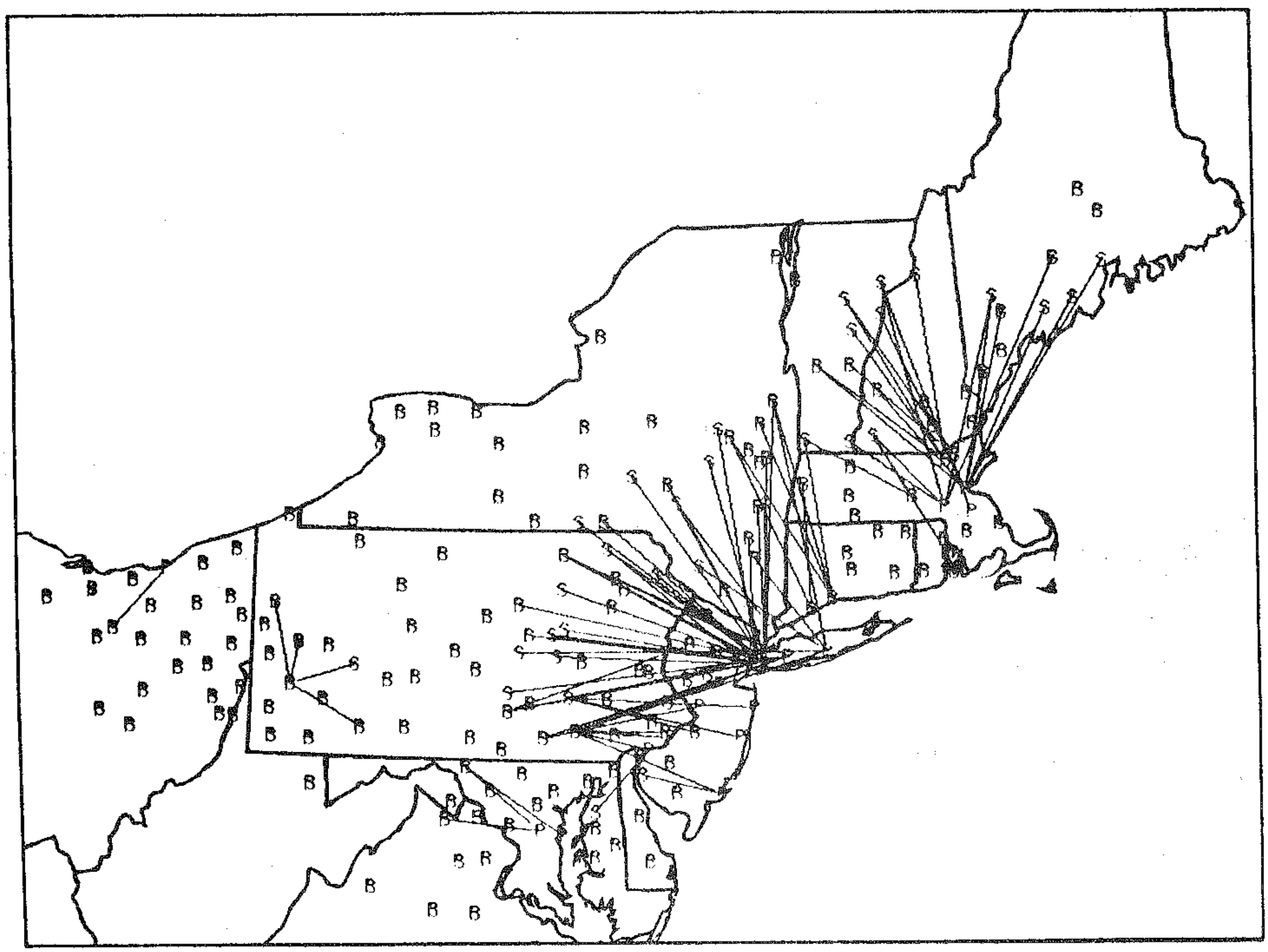


FIGURE 12. FLOWS OF BULK MILK FROM PRODUCTION POINTS (S) TO SOFT DAIRY PRODUCT PROCESSING POINTS (P)

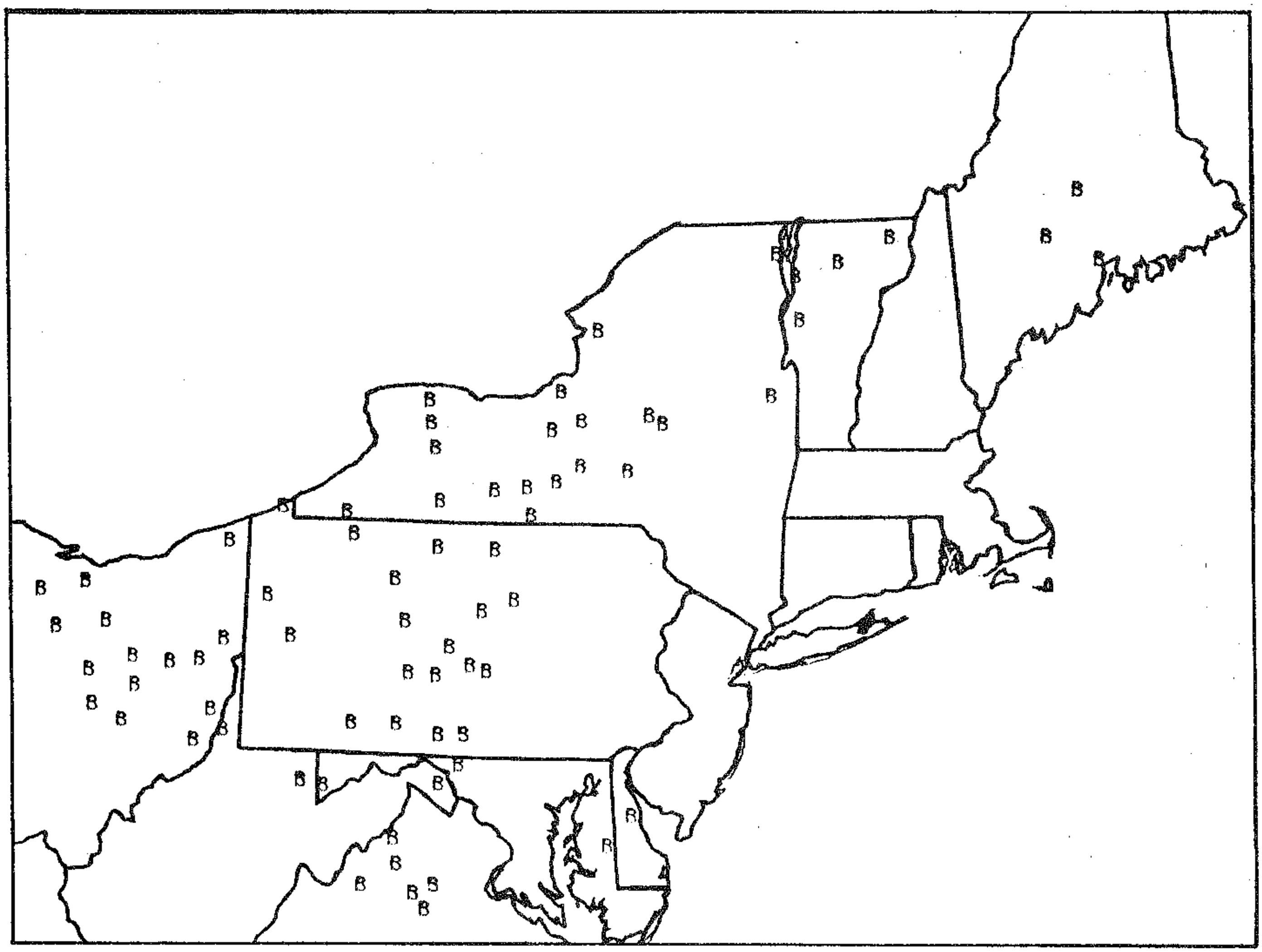


FIGURE 13. FLOWS OF BULK MILK FROM PRODUCTION POINTS (S) TO HARD DAIRY PRODUCT PROCESSING PLANTS

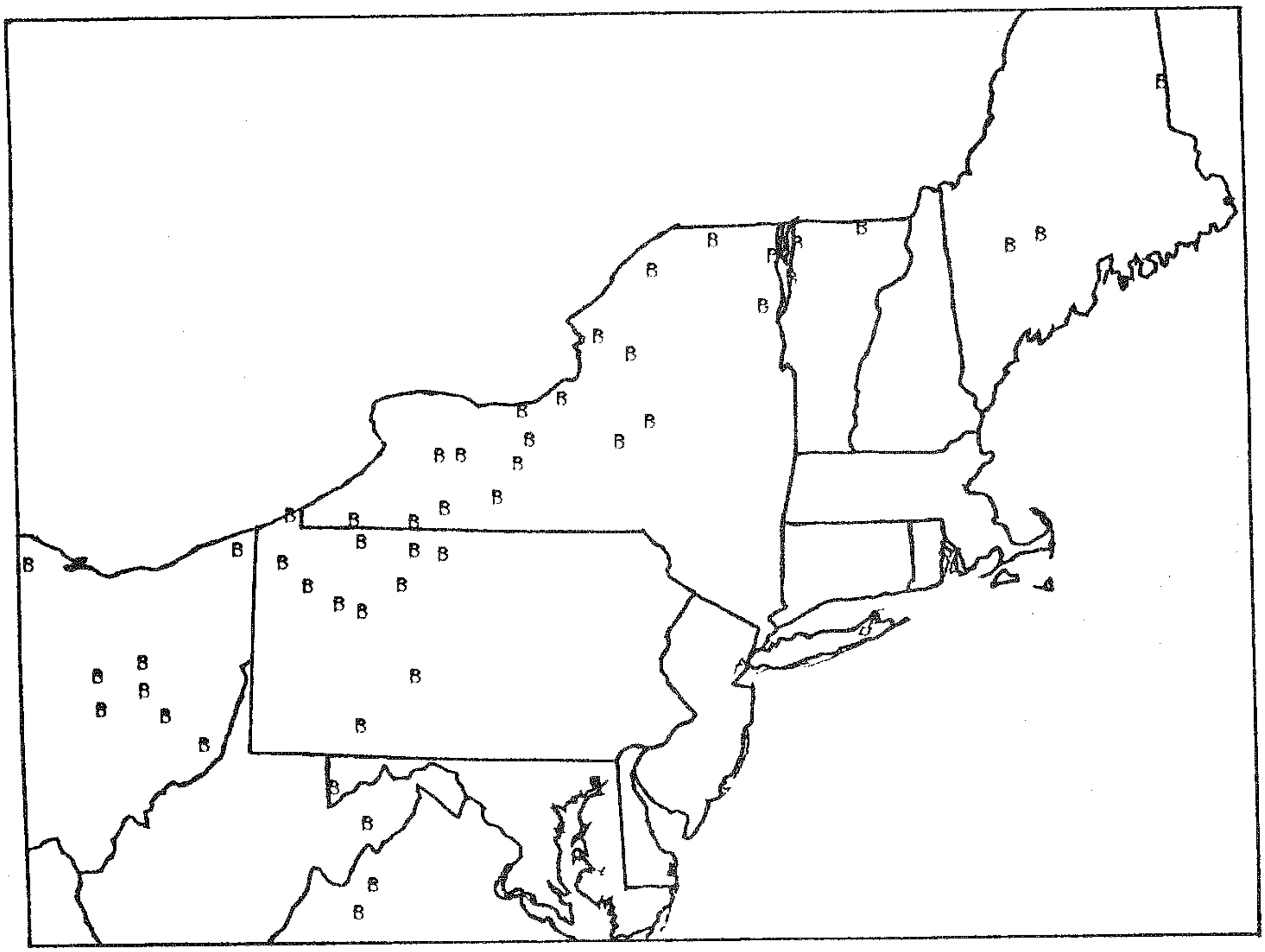


FIGURE 14. FLOWS OF PROCESSED FLUID MILK PRODUCTS FROM PROCESSING POINTS TO CONSUMPTION POINTS

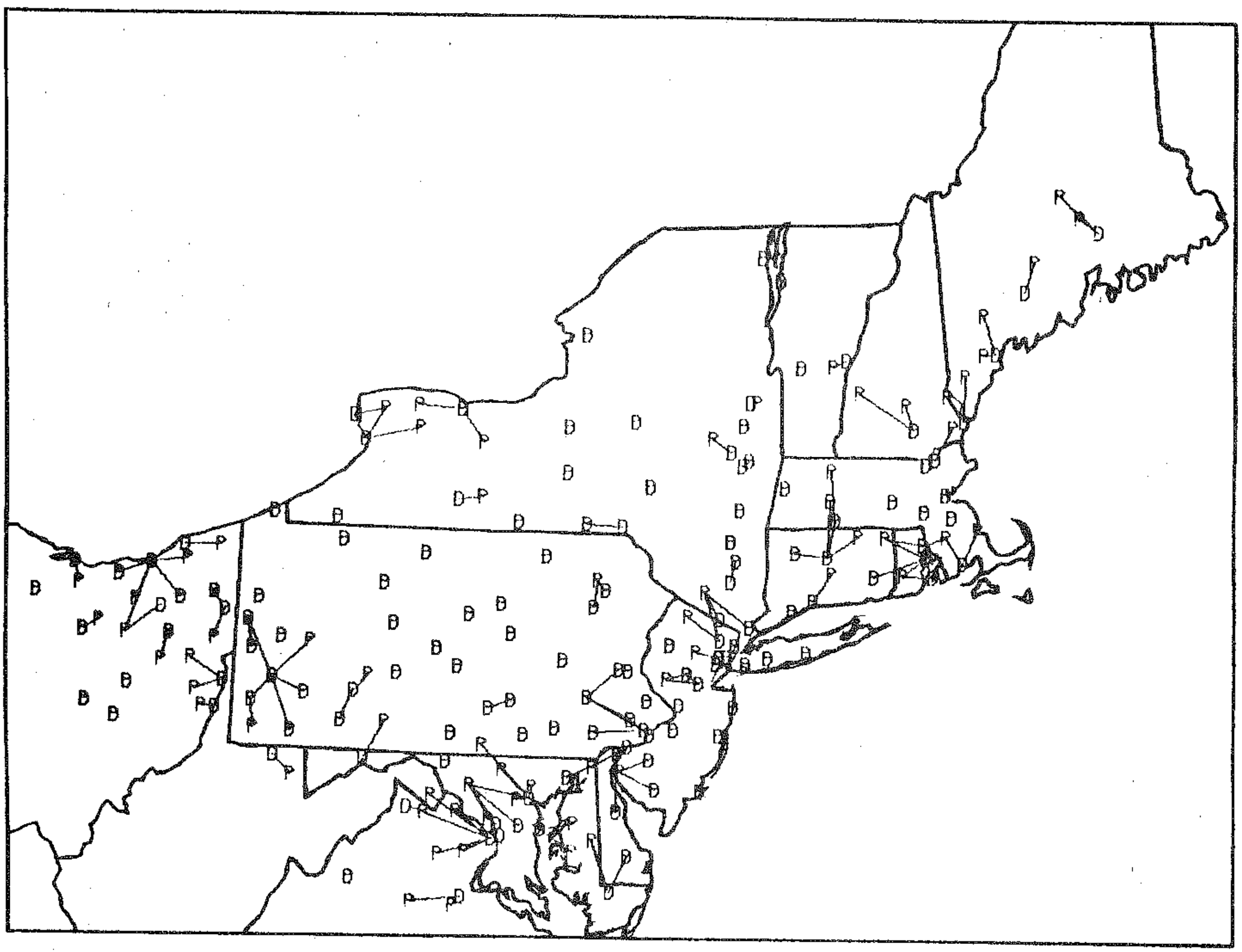


FIGURE 15. FLOWS OF PROCESSED SOFT DAIRY PRODUCTS FROM PROCESSING POINTS (P) TO CONSUMPTION POINTS (D)

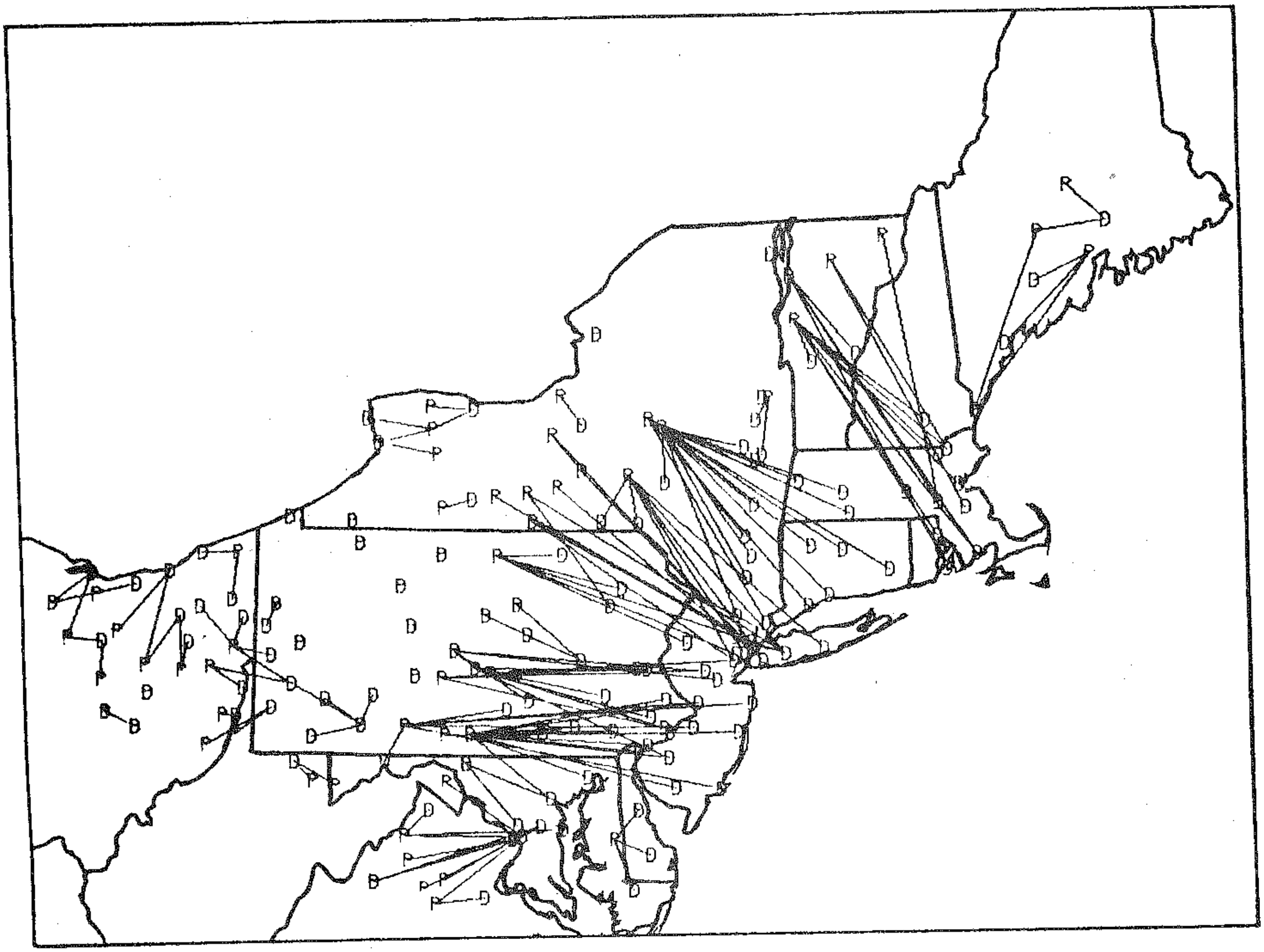
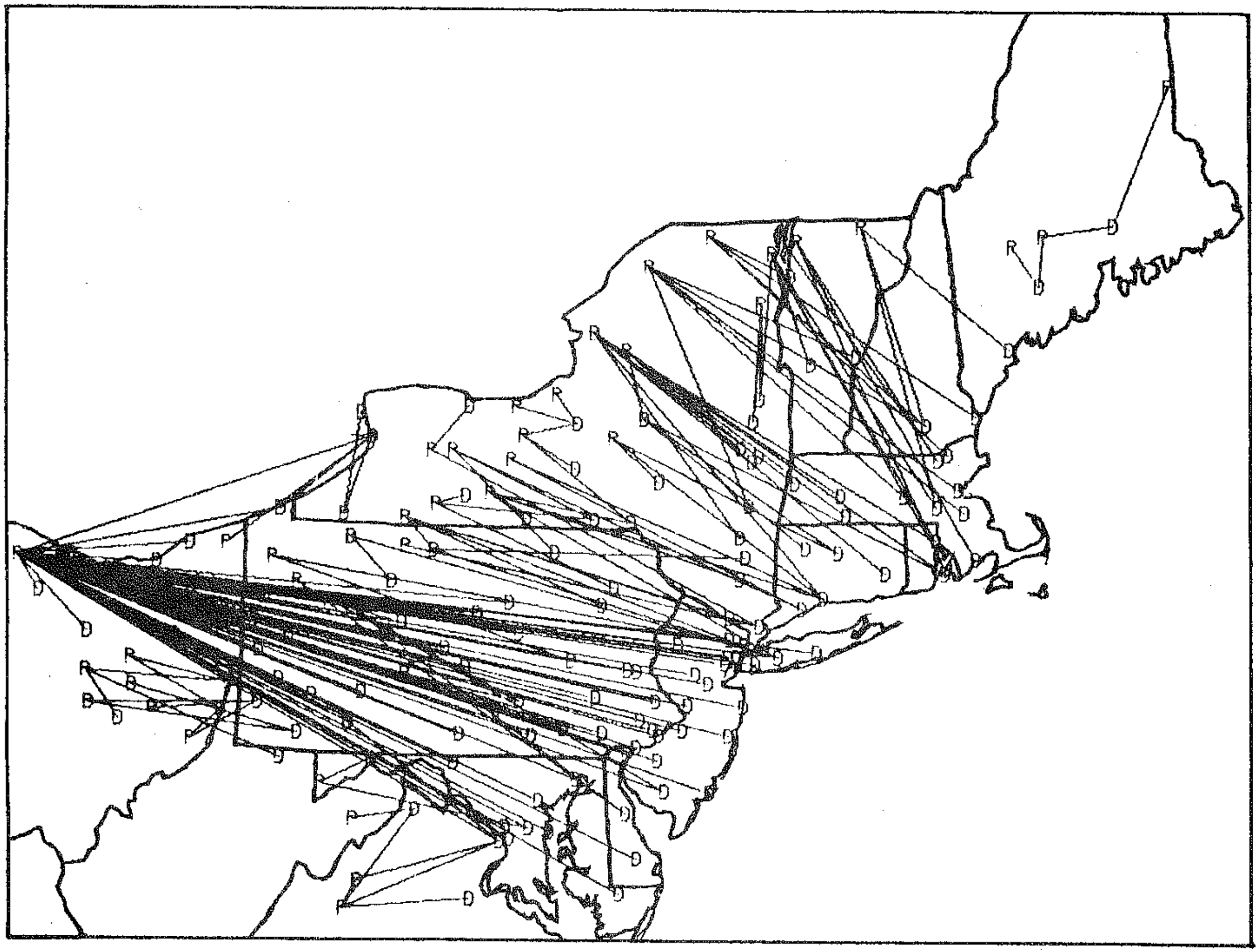


FIGURE 16. FLOWS OF PROCESSED HARD DAIRY PRODUCTS FROM PROCESSING POINTS (P) TO CONSUMPTION POINTS (D)



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TECHNICAL APPENDIX

TECHNICAL APPENDIX: THE SUPPLY DATA BASE METHODOLOGY

by

Lynn G. Sleight*

Supply analysis was based on dairy-relevant data for State or sub-State areas for the period 1966-80 by calendar quarter. Committee members tabulated the best-known data available for their State(s), and ERS-USDA assembled the information as Logical Group DAN in its automated data bank, T-DAM. This system permitted data withdrawal by any researcher either in manual or in machine-readable form.

National level data were entered for selected variables. Pennsylvania was divided into three dairy-homogeneous sub-State areas.

Reports of the Statistical Reporting Service of USDA were the principal sources. "Milk Production," "Agricultural Prices," and "Farm Labor" provided 11 of the 12 State-level variables. Off-farm wage rates were taken from Bureau of Labor Statistics "Employment and Earnings." This was also the source for general economic data.

Variables reported only annually in the smaller States were derived quarterly by indexing annual data by neighboring States' quarterly patterns over recent years (usually, 3 most recent).

Variables in the data base are: (1966-1980 quarterly)

	Description	Area Reported
1.	Milk cow numbers	State, U.S.
2.	Milk production per cow	State
3.	Price, all milk wholesale	State, U.S.
4.	Price, cows (incl. cull dairy cows)	State, U.S.
5.	Price, 16 percent protein dairy ration	State, U.S.
6.	Price received, alfalfa hay, baled (all hay in States where alfalfa is not reported)	State, U.S.
7.	Milk production	State, U.S.
8.	Price received, steers and heifers	State, U.S.
9.	Value of concentrates fed to milk cows	State, U.S.
10.	Farm wage rate, all hired, hourly, no perquisites	State
11.	Non-farm wage rate	State
12.	Consumer price index, all items	U.S.
13.	Consumer price index, food	U.S.
14.	Index of prices paid by farmers for fuels and energy	U.S.
15.	Money supply (M1-B), seasonally adjusted	U.S.
16.	Saving as percent of disposable income	U.S.
17.	Unemployment rate	U.S.
18.	Disposable personal income, in both current and 1972 dollars	U.S.
19.	Per-capita disposable personal income, in both current and 1972 dollars	U.S.

States included are: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island and Vermont.

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* Lynn G. Sleight is an economist in the Dairy Section of the Economic Research Service of the U.S. Department of Agriculture.