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GEOGRAPHIC PRICE RELATIONSHIPS IN THE

U.S. FLUID MILK INDUSTRY:

A MATHEMATICAL PROGRAMMING ANALYSIS

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May 1989

No. 89-16

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PREFACE

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This paper is a selected paper to be presented at the 1989 American Agricultural Economics Associate Annual Meeting, July 30 through August 2, 1989, Louisiana State University, Baton Rouge, LA.

Computations were conducted using the Cornell National Supercomputer Facility, a resource of the Center for Theory and Simulation in Science and Engineering at Cornell University. The Center is funded in part by the National Science Foundation, New York State, and the IBM Corporation as well as by members of the Corporate Research Institute.

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Current policy debates consider the impacts of federal milk marketing orders on regional milk prices. A spatial model of the U.S dairy sector calculates shadow prices at fluid milk processing locations. Geographic shadow price relationships conform to traditional regulatory logic, however, relative levels differ from those implemented under federal policy.

INTRODUCTION

Federal milk marketing order (FMMO) pricing provisions have been the subject of one controversy or another since their inception in the late 1930s. A common point of consideration has been the question of how to evaluate regional price differences which are, at least in part, influenced by the class I price differentials specified under FMMOs.

FMMO minimum price provisions encourage a pattern of regional prices paid by fluid milk processors whereby prices are lowest in the upper Midwest and generally increase concentrically with distance. Spatial prices generally follow this pattern east of the Rocky Mountains, but are lower on the West Coast. The traditional rationale for this pattern hinges on aligning regional prices to transportation costs from primary surplus milk producing areas to areas which are not self-sufficient.

Under provisions set forth in the Food Security Act of 1985, class I differentials were raised in almost all FMMO areas. Small increases were made in the Midwest, the Northeast, and the Northwest; elsewhere, increases were greater the farther the area was from the Upper Midwest. For example, the increase in the Oregon-Washington Order (Portland) was zero, in the Upper Midwest Order (St. Paul, MN) it was 8¢/cwt., in the New York-New Jersey Order (New York City) it was 30¢/cwt., in the Texas Order (Dallas) it was 96¢/cwt., and in the Southeast Florida Order (Miami) it was $1.03/cwt. This made the spatial price differences, relative to the Upper Midwest, in Portland, New York City, Dallas, and Miami $1.95, $1.94, $2.08, and $2.98, respectively.

Although some industry members argue that the increase in mandated class I differentials was offset by decreases in non-regulated price premiums, upper Midwestern industry members and advocates have complained that changes in class I differentials were not merited and that FMMO spatial pricing provisions generally discriminate against them.

The purpose of this study is to estimate the spatial values of milk at class I processing locations from shadow prices derived in a detailed spatial model of the U.S. dairy sector and to compare the extent to which FMMO differentials reflect differing spatial values of milk.

THE MODEL

The U.S. Dairy Sector Simulator (USDSS) is a spatial model of the dairy industry. It draws from modelling work done by King and Logan, Beck and Goodin, Boehm and Conner, Buccola and Conner, Kloth and Blakely, Thomas and DeHaven, Fuller, Randolph, and Klingman, and McLean.

USDSS is formulated as a transshipment model which combines network flow and plant location solution procedures. The U.S. dairy industry is viewed at three market levels in USDSS: farm supply, dairy product processing, and dairy product consumption. Five dairy product groups are distinguished at the processing and consumption levels: fluid milk products (class I), soft dairy products (class II), hard cheeses, butter, and nonfat dry milk and other condensed and evaporated milk products.

USDSS is capable of simultaneously analyzing the optimal location of processing facilities and corresponding milk and dairy product movements by considering unit costs of assembly, processing, and distribution among nearly 3,600 economic units covering the 48 contiguous states. Milk supply is represented by 240 supply points. There are 234 consumption points, and up to 436 locations may be chosen as processing centers for each product. Given estimated milk marketings, dairy product consumption, and assembly, processing, and distribution costs, USDSS solves for optimum, least cost, processing locations and product flows, given any constraints on processing locations and/or capacities.

TRANSSHIPMENT FORMULATION

USDSS combines network flow and facilities location methods in a single-time period, single-commodity transshipment model. It contains three functional market levels: supply, processing, and consumption. In Figure 1, they are represented by circles, triangles, and squares, respectively. Flows from supply points to processing points traverse the arcs which connect the circles and triangles. Milk from any supply source is eligible to move to any processing facility of any product type (each circle is connected to all triangles in Figure 1). There are 523,200 arcs connecting the 240 supply points to the 436 potential processing centers for each product type. Movements over these arcs occur at costs which are calculated as functions of distance.

At the processing level (triangles connected to triangles in Figure 1), milk is processed into one of five dairy product groups: fluid milk products; soft manufactured products; hard cheeses; butter; and nonfat dry milk and other evaporated and condensed products. Processing can be capacitated at any geographic point and may incur a point specific unit processing cost. These unit costs and capacities are specified on the

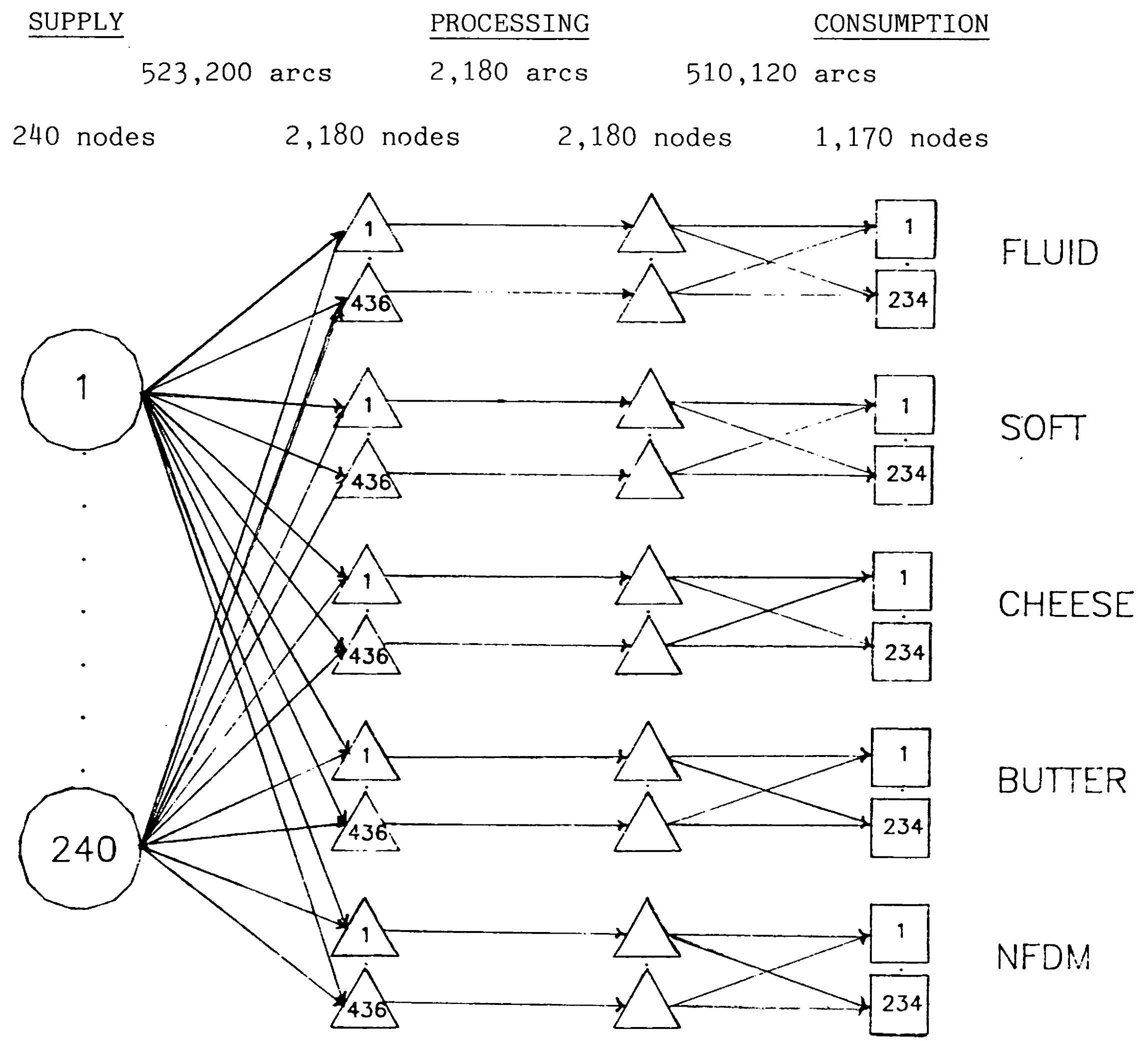

Figure 1. The transshipment formulation of the U.S. dairy industry

arcs between triangles. There are 2,180 potential processing points, i.e., 436 geographic points for each of five product types.

There are 234 geographic consumption points specified in USDSS (depicted as squares in Figure 1). Each of the five product types is consumed at each consumption point (1,170 effective consumption points). For each product, all potential processing points (triangles) are connected to all appropriate consumption points (squares). There are 510,120 possible product distribution movements. Each product movement incurs a distribution cost which is a function of distance.

SUPPLY

For the transshipment formulation of milk supply in USDSS, each of the 3,107 U.S. counties and independent cities in the 48 contiguous states was aggregated into one of 240 multi-county areas (Figure 2). These aggregation areas were selected on the basis of the spatial distribution of milk cows within each state. No supply aggregation area included counties from more than one state. Within each supply area, a single geographic point, a city, was chosen to represent the supply of the entire area (Figure 3). Baseline total 1985 state milk marketings by producers were apportioned to each county. Depending on the availability of data for each state, either (1) 1985 National Agricultural Statistics Service (NASS) estimates of county milk production in each area, (2) 1985 NASS estimates of milk cow numbers in each area, or (3) 1982 Census of Agriculture milk cow estimates were used to derive the county estimates. These county supply estimates were then aggregated to the multi-county supply areas.

CONSUMPTION

Each of the 3,107 counties and independent cities in the U.S. was aggregated into one of 234 multi-county consumption areas (Figure 4). These aggregation areas were selected to conform to state and FMMO boundaries, as well as to reflect the spatial distribution of population within each state. Within each consumption area, a single geographic point, a city, was chosen to represent the consumption of the entire area (Figure 5). U.S. Census of Population county estimates for 1985 were aggregated to each consumption center to generate spatial consumption estimates for each product class. These population estimates were combined with estimated per capita consumption, and/or estimates of product production to derive geographic consumption estimates.

PROCESSING

The researchers identified all dairy processing facilities operating in the contiguous 48 states in 1985. To integrate this information with the USDSS spatial structure, actual processing plant locations were assigned to the representative consumption or supply cities seen in Figures 3 and 5. In each multi-county consumption area, fluid milk plants were assigned to the city which represented that area's

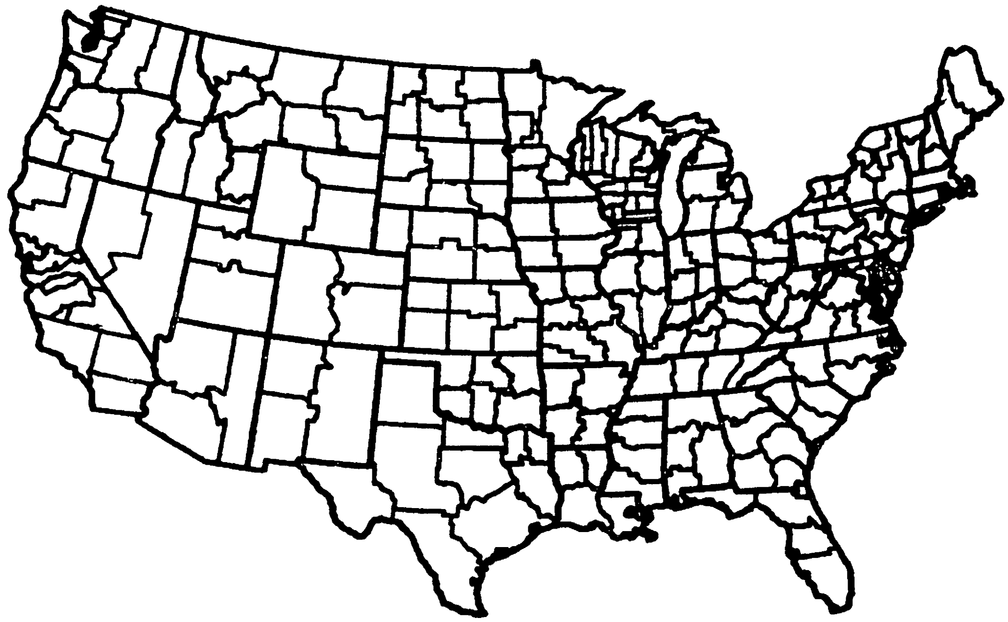

Figure 2. 240 multi-county supply areas

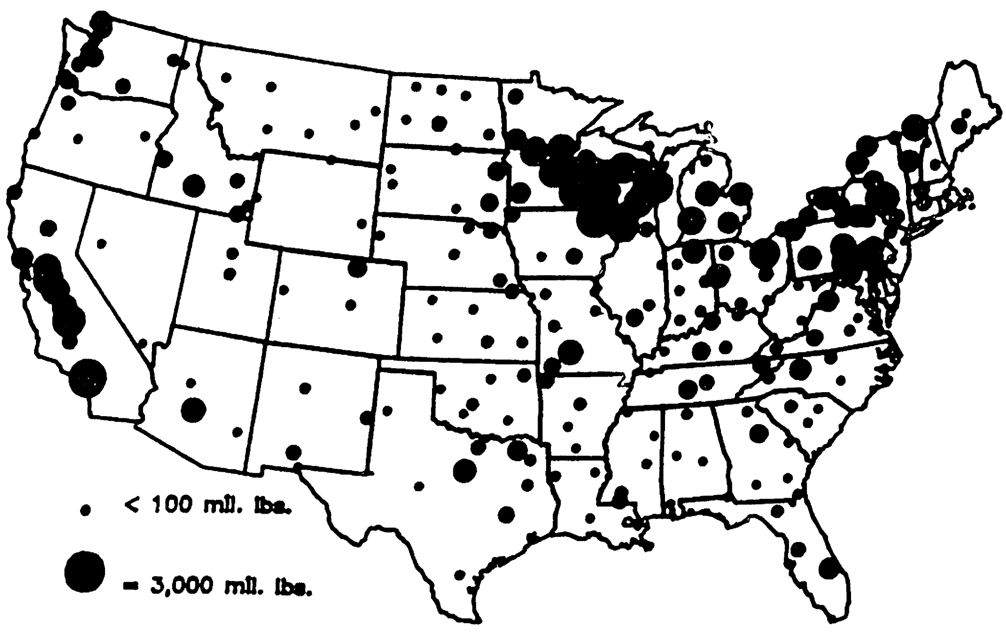

Figure 3. Relative milk supplies at 240 supply points, 1985

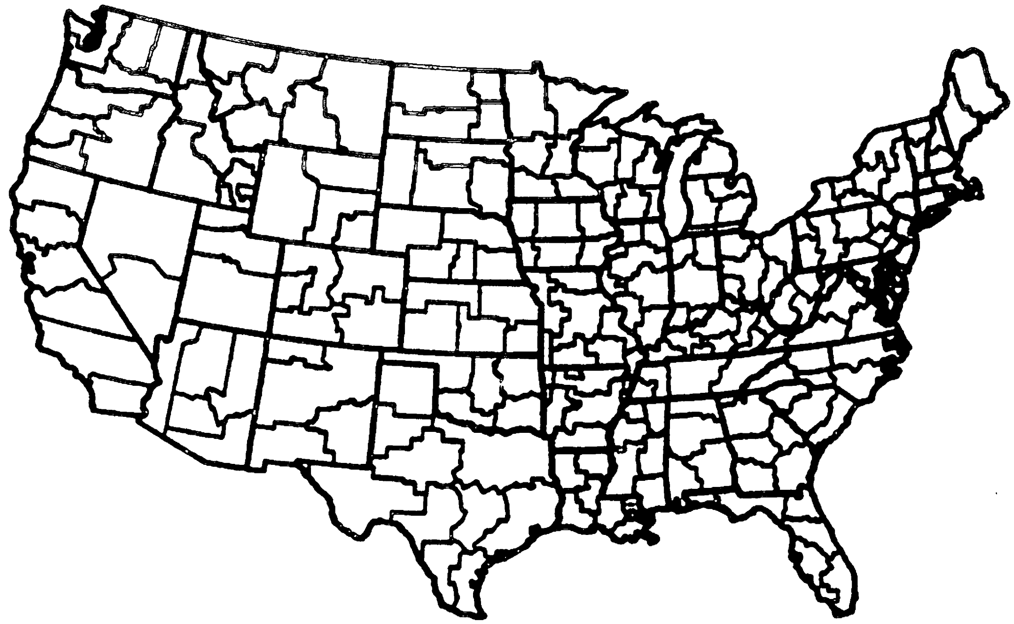

Figure 4. 234 multi-county consumption areas

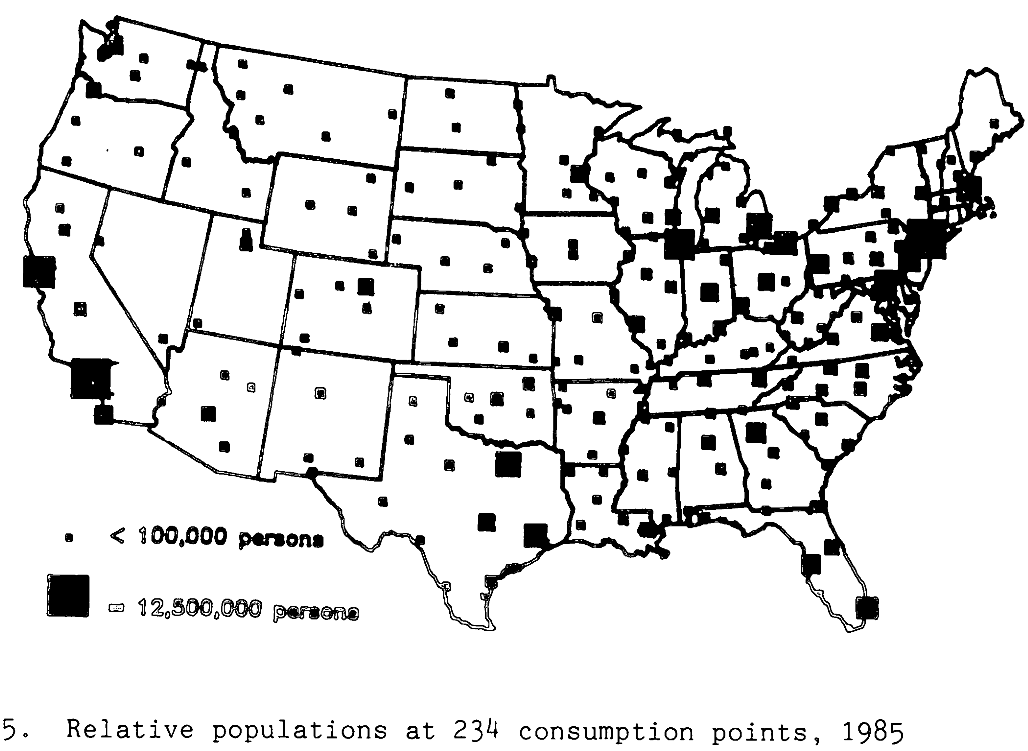

Figure 5. Relative populations at 234 consumption points, 1985

consumption. Similarly, all other product processing plants (soft, cheese, butter, and other manufactured products) in a multi-county supply area were assigned to the city which represented that area's supply. USDSS cities which were identified as potential processing centers for each product were given unlimited capacities, while those cities having no actual processing locations assigned to them were constrained to zero capacites. In this way, only those centers which had processing capabilities in 1985 were allowed to become active in the analysis reported here.

COSTS

Milk Transportation

Dairy producers are assessed a wide range of hauling charges. Hauling rates vary according to farm location, milk volume, and the competitive environment. Milk moved over long distances is often moved between plants rather than between farms and plants. Differences in initial truck costs, labor and fuel costs, driving conditions, and maintenance policies all affect transportation costs for a specific haul. While USDSS could incorporate geographically specific cost functions, data to support such a specification do not exist. After consultation with U.S.D.A. researchers and other industry experts, it was decided to use a single cost function to represent all milk movements.

Processing

Individual processing costs may be specified for each geographic processing location used in USDSS. However, insufficient information is available on regional differences in processing costs. Since USDSS ensures that all geographic consumption requirements for each product class are met, the level of processing costs for any product class, when all regions have equal costs, has no effect on optimal movements or plant locations. Thus, for this analysis, no processing costs were specified.

Product Transportation

Tractor-trailer operating costs for three dairy products, fluid milk, ice cream, and butter, were reported in a 1982 study by Metzger. These costs, updated to 1985, were used for fluid, soft products, and butter. It was assumed that the cost of moving cheese, on a product pound basis, was equal to that of butter, and, after consultations with USDA and industry experts, a general freight cost was synthesized for use with the other condensed, evaporated, and dry manufactured products.

THE SPATIAL VALUE OF CLASS I MILK

The transshipment problem was solved and the computed values of milk supplies at class I processing centers were calculated. These computed

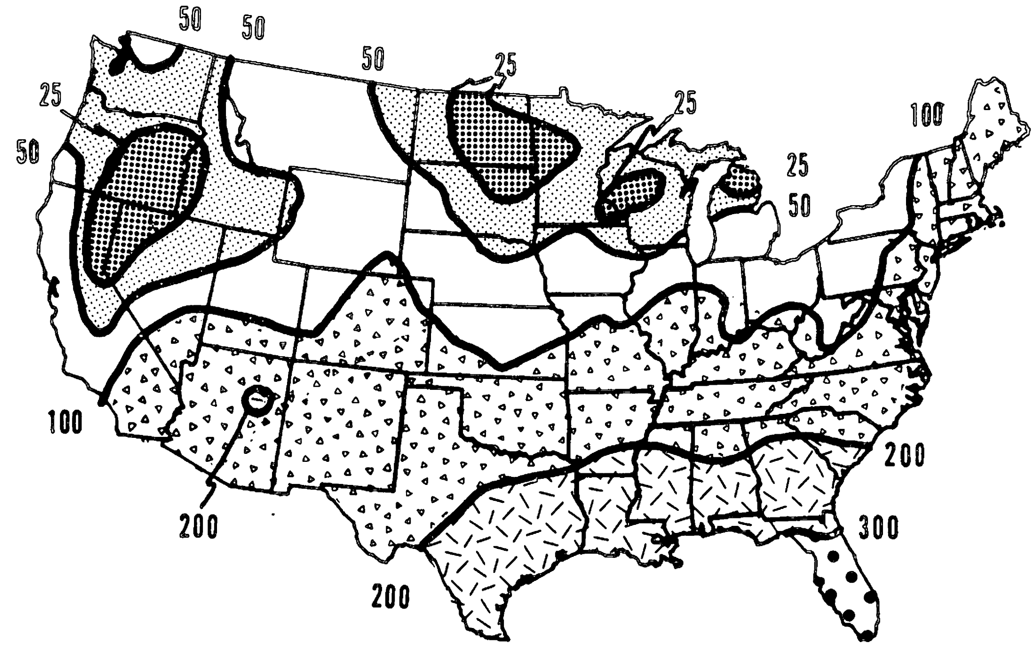

Figure 6. Equal-value class I processing shadow price lines, base scenario, 1985

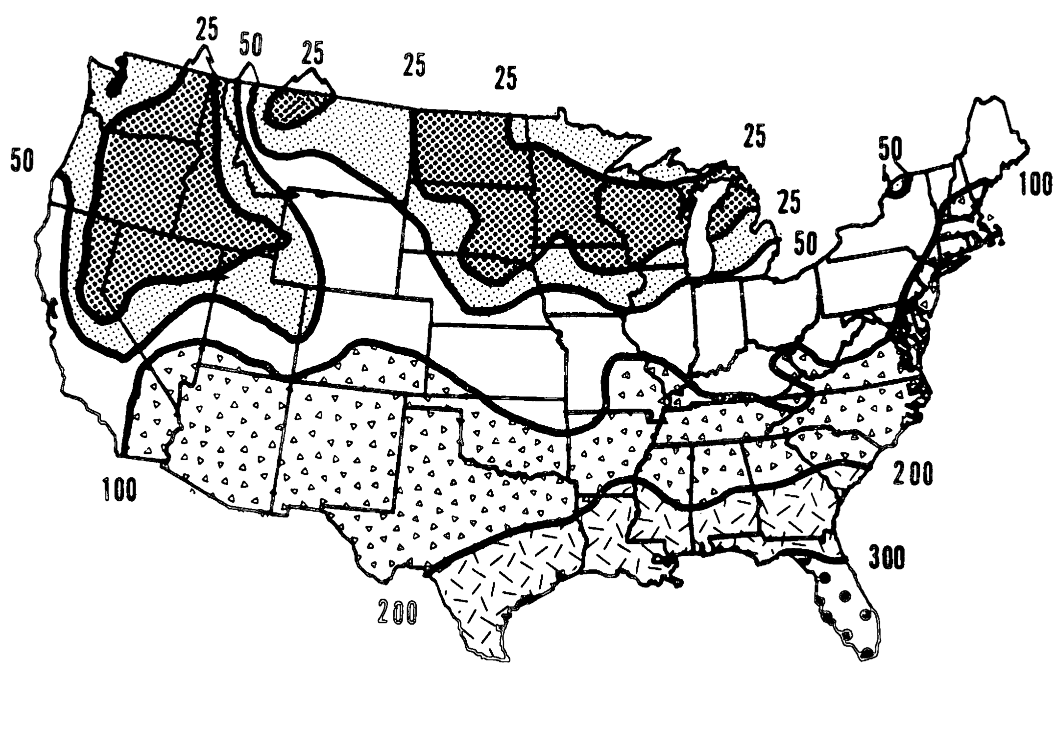

Figure 7. Equal-value class I processing shadow price lines, no CCC purchase scenario, 1985

values, or shadow prices, indicate the amount by which the total system costs could be reduced if one more unit of milk supply were available at a particular, operating class I processing center. Figure 6 displays equal-valued differential lines and areas at 25¢, 50¢, and 100¢ intervals. The 25¢ regions, for example indicate regions in which class I shadow prices range from 0¢ to 25¢ higher than the smallest value in the U.S., which is 28¢ at Fargo, North Dakota.

It can be seen that there are four distinct low-priced areas: 1) north central Wisconsin; 2) an area centered on the Minnesota-North Dakota-South Dakota border; 3) the northern lower Peninsula of Michigan; and 4) an area in the isolated Nevada-Oregon-Idaho border area. The 50¢ value area embraces the northern 25¢ areas and includes an expanded northwestern area covering most of the Pacific Northwest. The 100¢ line extends south from northern New York through Pennsylvania and Maryland and then generally westward to California. The 200¢ line crosses the Southeast to south Texas, and the 300¢ line crosses northern Florida.

The base solution for 1985 includes the fact that there is sizeable surplus milk production. In 1985, USDA purchases of surplus dairy products were the equivalent of 13 billion pounds of milk. A preferable, longer term situation would have little or no surplus. To capture the effect of balanced national markets, the transshipment problem was reformulated such that USDA purchases of manufactured products were not included in consumption requirements. Figure 7 displays equal-valued differential lines and regions for this solution.

There are three distinct low-priced areas in this solution; 1) most of the upper Midwest, 2) the inland Pacific Northwest, and a small area in Montana. Thus, the lowest priced areas in the north central U.S. tend to merge and the low priced area in the West expands. The areas having a 50¢ value expand, and a new 50¢ value area in northern New York emerges. The 100¢, 200¢, and 300¢ boundaries are quite similar to the first scenario; generally their northern boundary moves south slightly.

CONCLUSION

Under both a base 1985 and a balanced national market scenario, USDSS class I shadow prices increase in easterly and southerly directions from the low-valued Midwestern area and Pacific Northwest region. This is consistent with traditional FMMO logic whereby minimum class I prices are lowest in the upper Midwest and in the West. While shadow prices increase at rates which closely reflect those in effect as current class I differentials, there are some slight differences. For example, USDSS calculated shadow prices in Florida actually exceed the current relative FMMO differentials in both scenarios studied. Increases in shadow prices in an easterly direction from the upper Midwest, toward New England, and in a southwesterly direction, toward Texas and New Mexico, tend to be less than the current FMMO relative differentials. For the Northwest, USDSS gives relative shadow prices which are lower than FMMO relative differential levels.

The model also identified distinct, low-valued areas within higher-valued regions. For example, northern New York appeared as a low-valued area (less than 50¢) in the second scenario. Other distinct areas were identified using finer value gradations than those reflected in Figures 6 and 7. Such areas are low-valued relative to their immediate neighbors, but exist within higher-valued areas relative to the Midwest. Any attempts to institute multiple-base point/zone systems of spatial pricing should also recognize that unique base points/zones may have different base levels.

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