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REVISED APRIL, 1994

COMPETITIVENESS OF DAIRY PRODUCERS IN A DEREGULATED MARKET

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July 1997

SP-97-09

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TABLE OF CONTENTS

COMPETITIVENESS OF REGIONAL AND STATE DAIRY PRODUCERS IN A DEREGULATED MARKET

ABSTRACT

This study determines the competitiveness of dairy producers in different production areas in a deregulated market. A nonlinear mathematical programming model minimizes the total costs of producing milk and shipping to the final consumer. Low-cost producing states like California, Wisconsin, and Texas will expand production in a competitive market and other states close to consuming centers can also compete.

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Introduction

The marketing environment for dairy producers throughout the country is becoming increasingly market-oriented. Since 1988, the price support level has been below market prices and government removals have steadily declined. The 1996 Farm Bill continued the trend towards less regulation by mandating the removal of the price support program by 2000 and the consolidation of existing Federal Milk Marketing Orders. With dairy policy becoming more market-oriented, the industry in general is facing the possibility of further deregulation in the future as the government takes a less visible role. With less regulation, the dairy industry is subjected to market forces that result in increased price volatility. For example, 1996 price levels in the U.S. dairy industry reached record levels by September and then declined to near record lows in December. Along with an uncertain price, producers in a competitive market may experience a level of interregional competition that has been suppressed in a regulated market. With market-oriented dairy policies, supply decisions are going to be based on producers' comparative advantages.

The primary objective of this study is to determine the impact of a deregulated dairy industry on the competitiveness of milk producers throughout the country. Federal Milk Marketing Orders are controversial because opponents claim the orders promote production in inefficient production areas and elevate the price of fluid milk while depressing the price of manufacturing grade milk. A review of the literature identifies several studies that examine the effects of deregulation. Examples are Cox (1995) and Babb (1990), both of which use a spatial equilibrium model to predict price levels in a competitive market. The focus of the current study is to project the location of milk production in a deregulated market by analyzing both the cost of production and transfer costs, a spatial dimension, in a framework designed to minimize combined production and transfer costs.

Empirical Model

The location of milk production throughout the country is dependent on many economic factors. Processing capacity, transportation costs, location of consumers, and cost of production advantages are a few of the economic forces that help determine where milk is produced in a competitive market. Of all these forces, the competitiveness of dairy producers is directly related to producers' costs of production and their distance from the consumers. Assuming that milk handlers operate in a competitive output market where minimizing total costs implies that profits are maximized, the location of milk production in a deregulated market will be determined primarily by dairy producers' costs of production and the industry's transportation costs of shipping dairy products to consumers. In this study, the empirical model is developed around these two cost variables. The competitiveness of dairy producers is examined in a National Dairy Model that compares both cost of production across market areas and spatial relationships among producers and consumers. The National Dairy Model is a math programming model that minimizes the total costs of producing milk and the transfer costs of shipping dairy products to the final consumer. The methodology, components, and data requirements of the dairy model are detailed in the sections that follow.

National Dairy Model

The National Dairy Model (NDM) minimizes the total costs of producing milk and the costs of shipping dairy products to the final consumer. Components of the NDM include translog cost functions, regional supply areas, consumption centers, transportation costs, and milk exports. The objective function and the constraints needed to complete the NDM are illustrated in equations (1) through (10).

(1) $$TMC = \sum_{A=1}^{50} [HAUL_A + COP_A]$$

(2) $$HAUL_A = \sum_{D=1}^{50} [QFT_{SD} * D_{SD} * FHR + QMT_{SD} * D_{SD} * MHR] + \sum_{X=1}^{4} QXT_{SX} * D_{SX} * XHR \qquad A = 1, \ldots, 50$$

(3) $$COP_A = \{\delta_0 + \gamma_y \ln QS_A + \frac{1}{2}\gamma_{yy}(\ln QS_A)^2 + \sum_{i=1}^{3} \alpha_i \ln w_i + \sum_{i=1}^{3} \alpha_{iy} \ln w_i \ln QS_A + \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3} \alpha_{ij} \ln w_i \ln w_j\} * FNUM_A \qquad A = 1, \ldots, 50$$

(4) $$\sum_{A=1}^{50} QS_A * FNUM_A = \sum_{D=1}^{50} [QFD_D + QMD_D] + \sum_{X=1}^{4} QXD_X$$

(5) $$\sum_{S=1}^{50} QFT_{SD} = QFD_D \qquad D = 1, \ldots, 50$$

(6) $$\sum_{S=1}^{50} QMT_{SD} = QMD_D \qquad D = 1, \ldots, 50$$

(7) $$\sum_{S=1}^{50} QXT_{SX} = QXD_X \qquad X = 1, \ldots, 4$$

(8) $$QS_A * FNUM_A = \sum_{D=1}^{50} [QFT_{SD} + QMT_{SD}] + \sum_{X=1}^{4} QXT_{SX} \qquad A = 1, \ldots, 50$$

(9) $$QS_A * FNUM_A \leq PROD_A * PF \qquad A = 1, \ldots, 50$$

(10) $$QS_A, QFT_{SD}, QMT_{SD}, QXT_{SX}, HAUL_A, COP_A \geq 0$$

TMC	= Total Marketing Costs of the U.S. dairy industry;
$HAUL_A$	= Total transportation costs of manufactured and fluid products for market area *A*;
COP_A	= Total costs of production for market area *A*;
QFT_{SD}	= Pounds of fluid milk shipped from supply point *S* to consumption center *D*;

D_{SD} = Distance in miles from supply point S to consumption center D;

FHR = Fluid hauling rate per mile, per pound of fluid milk;

QMT_{SD} = Pounds of manufactured product on a milk equivalent basis shipped from supply point S to consumption center D;

MHR = Manufactured hauling rate per mile, per pound of product on a milk equivalent basis;

QXT_{SX} = Pounds of manufactured product on a milk equivalent basis shipped from supply point S to export facility X;

D_{SX} = Distance in miles from supply point S to export facility X;

XHR = Export hauling rate per mile, per pound of product on a milk equivalent basis;

QS_A = Pounds of raw milk supplied by the representative firm in market area A;

w_i = Mean prices of feed, hired labor, and hauling;

$FNUM_A$ = Number of dairy farms in market area A;

QFD_D = Quantity demanded of fluid milk at consumption center D in pounds;

QMD_D = Quantity demanded of manufactured products at consumption center D in milk equivalent pounds;

QXD_X = Quantity demanded of manufactured products at export facility X in milk equivalent pounds;

$PROD_A$ = Production in pounds of milk for market area A in 1994;

and

PF = Production factor.

The mathematical programming model detailed in equations (1) through (10) is solved using the General Algebraic Modeling System (GAMS). Equation (1) is the objective function of the NDM. The design of the objective function instructs GAMS to minimize the sum of total marketing costs

(*TMC*) for all 50 market areas. Total marketing costs are defined as the sum of transportation costs of dairy products from supply areas to the final consumer and producers' costs of production. The detailed components of total marketing costs are solved in equations (2) and (3). The total transportation cost, solved by equation (2), involves shipments of fluid and manufactured products to domestic consumers as well as manufactured products sold in the export market. The milk equivalent quantity of fluid and manufactured products shipped from a supply point to various consumption centers is an endogenous variable whose value is determined by the model. The distance in miles and hauling rates are both exogenous variables.

The other component of total marketing costs is cost of production, equation (3). The translog cost function in equation (3) is a farm-level cost function that represents the technology on dairy farms across states. The three inputs in the translog function are feed, custom milk hauling, and hired labor. On average, these three inputs account for approximately 77% of variable costs on all U.S. dairy farms (Short and McBride 1996). The parameter estimates for the cost functions are estimated with data from the 1989 and 1993 Farm Costs and Returns Surveys. In the NDM, the quantity of milk produced by a market area is the only endogenous variable in the translog cost function. Because the cost function represents the technology on a single farm, the total costs and quantity of milk supplied by the representative farm are multiplied by the number of farms in that market area. The result of this operation yields the total costs and quantity of milk produced by a state, not just the representative farm.

The optimal solution in the NDM is found subject to constraints that help simulate a competitive market. For example, equation (4) ensures that the total quantity of milk produced by all market areas is equal to the milk equivalent demand for all dairy products. The total milk equivalent demand for dairy products in 1994 was composed of domestic commercial disappearances and exports. The sum of these variables represents the milk equivalent consumption of all dairy products in both the domestic and export markets. The quantity of domestic commercial disappearances and exports are exogenous variables whose values are consistent with 1994 data. Equations (5) and (6) maintain that the shipments of fluid milk and manufactured products from supply points to a consumption center must equal the center's milk equivalent demand for these dairy products. Equation (7) ensures that the sum of shipments from supply points to export facilities is equal to the milk equivalent demand for manufactured products at each export facility.

Equation (8) reveals the relationships between quantity of milk produced by a state and quantity of milk shipped from that state's supply point. This constraint forces a market area's production into the domestic and/or export markets. An additional constraint on quantity of milk produced is equation (9). The total milk production from a market area must be less than or equal to the area's 1994 production level multiplied by a production factor. For example, if the production factor is equal to one, a market area can produce up to the region's 1994 production level. Increasing the production factor to 1.1, for example, allows the NDM to determine if the objective function decreases when production in a particular area is allowed to increase up to 10% of the 1994 production level. The production factor is an exogenous variable that is useful when conducting sensitivity analysis. The final constraint, equation (10), is a nonnegativity constraint for the value of the unknown decision variables.

Data Requirements

The specific data requirements of the NDM are associated with dairy production, per capita consumption of dairy products, cost of production estimates, transportation costs of dairy products, and quantity of exports. In order to establish a base run and obtain results that are consistent with yearly marketing activities in a regulated market, a time span is selected that represents a typical year in the dairy industry. For example, years that contain unusual weather patterns, buyout programs, or unseasonable variations in price are not considered a typical year in the dairy industry. The most recent year in which data are available and saw no dramatic changes in dairy policy or the marketing environment is the 1994 calendar year.

The first data category describes the formation of supply points and the 1994 production levels associated with each market area. The NDM has 50 supply points that represent all 48 contiguous states. With the exception of Virginia, each state has one supply point in the NDM. The 1994 production levels associated with each market area are obtained from the USDA's *Milk Production, Disposition, Income*. These production levels are represented by the variable $PROD_A$ in equation (9) of the NDM.

The NDM also has 50 different consumption centers. The location of each consumption center corresponds to the largest population center in the market area. Each consumption center has a fixed level of demand that is representative of the market area's total per capita consumption of dairy products on a milk-equivalent, milkfat basis. The NDM solves for the quantity of raw milk that needs to be produced by each market area in order to satisfy the exogenous level of demand for dairy products at each consumption center. The consumption centers' milk equivalent demand for dairy products is found by using 1990 census data and 1994 total commercial disappearances of milk and dairy products. The 1990 census data are used to determine the regional population shares for each market area in the NDM. The domestic commercial disappearance of each market area is then calculated by multiplying the area's population share by the total 1994 U.S. commercial disappearance. The results of these calculations represent a region's milk equivalent (milkfat basis) demand for all dairy products. The procedures used to determine the exogenous demand levels in the NDM are consistent with those of Cox (1995).

The data needed to complete the spatial dimension of the NDM are distance and hauling rates. Both export facilities and consumption centers are linked to supply points by distance. The hauling rates in the NDM vary depending on whether the shipment is fluid milk, manufactured products shipped to consumption centers, or manufactured products shipped to export alternatives. For example, shipments of fluid milk from the supply points to the consumption centers are the most expensive types of shipments in the NDM. The hauling rate for these shipments is $0.42/cwt./100 miles (Nubern and Kilmer 1995). The hauling rate used for shipments of manufactured products from the supply points to consumption centers is $0.028/cwt./100 miles. This hauling rate is the milk equivalent of $1.75 per loaded mile of manufactured dairy products. The final type of shipment in the NDM is shipments of manufactured products to exporting facilities. The hauling rate assigned to these shipments is $0.027/cwt./100 miles. This hauling rate is also the milk equivalent of $1.75 per loaded mile.

The final data needed to complete the NDM are related to exports. Although trade in U.S. dairy products is relatively small, international and regional trade agreements are expected to increase exports of dairy products. Given these recent policy changes, the NDM is formulated to predict changes in the U.S. supply of milk resulting from increased exports. After consulting with Peter Vitaliano of the National Milk Producers Federation, the location of four export facilities were included in the NDM: (1) Seattle, (2) Los Angeles, (3) New Orleans, and (4) Baltimore. The reason for two facilities on the west coast is the growing export opportunities in the Mexican and Pacific Rim markets. The total quantity of dairy exports is determined exogenously and is representative of a marketing environment where the U.S. is a net exporter of dairy products. Since the quantity of dairy products exported from each facility is confidential, the NDM is formulated so that each location exports an equal share of the total U.S. exports. Through sensitivity analysis, the total quantity of exports is varied to determine the impacts on the optimum solution.

Estimating Translog Cost Functions

A dairy producer's costs of production are a critical component of the NDM, equation (3). If all other factors are equal across farms, those farms with lower costs of production are more competitive in the marketplace. If a deregulated market results in more production and subsequently, lower prices, the farms with cost advantages are more likely to remain profitable. In order to capture these cost advantages in a way that could be incorporated into the math programming model, the cost functions for a number of states were estimated econometrically with data collected from the USDA's Farm Costs and Returns Survey.

The Agriculture and Consumer Protection Act of 1973 mandates dairy cost of production estimates. These cost estimates are updated annually based on data collected from the USDA's Farm Costs and Returns Survey (FCRS). The FCRS data are confidential data that can be accessed only after special permission is granted from individuals at the Rural Economy Division of the Economic Research Service (ERS). Once permission is obtained, use of the database is confined to regional offices of the National Agricultural Statistical Service or the ERS office located in Washington, D.C.

The FCRS uses a multiframe stratified random sample. In this sample, each farm included in the survey represents a number of similar farms (Short 1996). The survey expansion factor, which is the inverse of the probability of the sampled farm being selected, determines how many similar farms are represented by a farm that is surveyed (Hanson *et al.* 1989). The survey is conducted every four years with the most recent years being 1993 and 1989. The data collected with the survey are farm-level cost of production data for the major dairy producing states. The 1989 survey obtained data from 1,037 dairy producers located in 26 states. As a result of budget constraints, the 1993 survey obtained data from only 695 dairy producers located in 15 states. After the expansion factor is applied to the 1993 survey, the 695 respondents represent 105,230 dairy producers (Short 1996).

In order to more accurately approximate the technology on today's dairy farms, the 1993 FCRS data were used to estimate the translog cost function for most market areas. Because the 1993 survey did not include any states in the Appalachia region, cost functions for states in this region, as well as some states in other areas of the country, are estimated using 1989 FCRS data that have been indexed up to 1993 levels using USDA Prices Paid Indexes. The states and some characteristics of the farms that are included in the 1989 and 1993 FCRS database are detailed in Table 1.

Even though the USDA survey provides detailed cost estimates that are consistent across states, there are some caveats about the data that justify a brief discussion. For instance, the FCRS database used in this study is developed with 1,001 respondents located in 27 states. Some people may suggest that the FCRS data are not representative of the national dairy industry because 21 of the contiguous states are excluded from the survey. Although the survey includes only 56% of the contiguous states, these 27 states accounted for approximately 86% of national milk production in 1993. Because such a large percentage of national milk production is represented in the database, the FCRS database can be used with confidence to develop state-level cost functions that allow the study to have a national interpretation.

Another issue when using the FCRS data is missing observations. The three inputs in the translog cost function are labor, feed, and hauling. Although all respondents reported feed expenses, not all producers reported expenses related to hired labor and/or hauling. The reasons these expenses were not reported for some observations are (1) the operation is small and the owner can manage the day-to-day responsibilities of the dairy farm without any hired labor, and (2) the dairy operation owns the equipment needed to transport milk off the farm. Observations that reported no labor and/or hauling expenses result in input prices for these two variables equal to zero. Any input price that is equal to zero is treated as a missing observation. Since there are a limited number of data for each state, these missing observations are not deleted from the FCRS database, however. The FCRS database is edited for missing observations related to input prices by using the average price paid for hired labor and hauling. An operation that did not report any expenses related to custom hauling or hired labor apparently did not consider the opportunity cost of their time and equipment. For each state, the average input price for hired labor and hauling is determined from data provided by the remaining respondents and the missing observations are replaced. By using this procedure, the number of observations within each state remains at the total number of original respondents (Table 1).

Table 1: Summary Statistics For States Included In the 1989 and 1993 FCRS Database

State	# of Farms in FCRS	Avg. Herd Size	Avg. Production Per Cow (lbs)	Number of Dairy Farms
Arizona	18	NA	NA	72
California	40	586.51	15,378.54	2,468
Connecticut[1]	9	NA	NA	370
Florida	26	858.09	13,797.25	210
Georgia	33	178.33	14,096.11	603
Idaho[1]	16	NA	NA	1,987
Illinois[1]	45	54.19	14,399.88	3,143
Indiana[1]	28	47.47	12,925.50	3,196
Iowa	30	51.46	13,774.26	5,113
Kentucky[1]	31	48.92	11,436.69	3,492
Maine[1]	14	NA	NA	827
Massachusetts[1]	4	NA	NA	589
Michigan	54	67.41	13,820.74	5,221
Minnesota	68	52.48	13,912.43	12,228
Missouri	27	50.88	11,361.63	4,393
New Hampshire[1]	11	NA	NA	294
New York	88	66.62	14,848.61	10,878
North Carolina[1]	40	109.47	14,434.14	874
Ohio	40	43.83	15,145.93	6,530
Pennsylvania	80	52.99	15,201.48	12,191
South Dakota[1]	32	50.44	13,391.07	2,329
Tennessee[1]	34	64.55	12,706.29	2,152
Texas	39	185.52	13,696.52	2,311
Vermont	39	72.99	13,828.20	2,285
Virginia[1]	42	91.34	14,160.10	1,359
Washington	33	103.91	16,899.39	2,727
Wisconsin	80	56.56	14,544.61	25,226

[1] Indicates a state surveyed in 1989, but not 1993.
NA = Mean not reported due to low number of observations.

The FCRS is used to obtain farm-level data for total costs, output, and prices of feed, hauling, and hired labor. Total costs, the dependent variable in the translog cost model, represents a firm's total cash expenses. To estimate cost functions for the states included in the survey, the FCRS data are pooled. Pooling the FCRS data overcomes the degrees of freedom issues and still allows one to identify a separate cost function for each of the states included in the survey. The farm-level data for input prices, output, and total costs are pooled across states within the same survey year, resulting in two databases. The 1993 database contains 695 observations and represents 15 states while the 1989 database has 307 observations from 12 different states. The 1989 database represents states that were not surveyed in 1993. In both the 1993 and 1989 databases, slope and intercept dummy variables are used to help determine the influence of quantity produced and location of production on the firm-level cost functions. Once the dummy variables are included in the translog cost model, the parameters for the cost function are estimated with an econometric model by using ordinary least squares (OLS). Samples of the total, marginal, and average cost curves that are derived from this process are illustrated in Figures 1, 2, and 3.

California's cost curves are presented in Figure 1. These curves indicate economies of size throughout the range of the total output. Georgia and Ohio also have marginal and average cost curves that are steadily decreasing. The majority of the states in the FCRS database, however, have cost curves that resemble those of Michigan (Figure 2). Michigan's average and marginal cost curves have the traditional "U" shape described in many economics textbooks, and MC cuts through the curve from below.

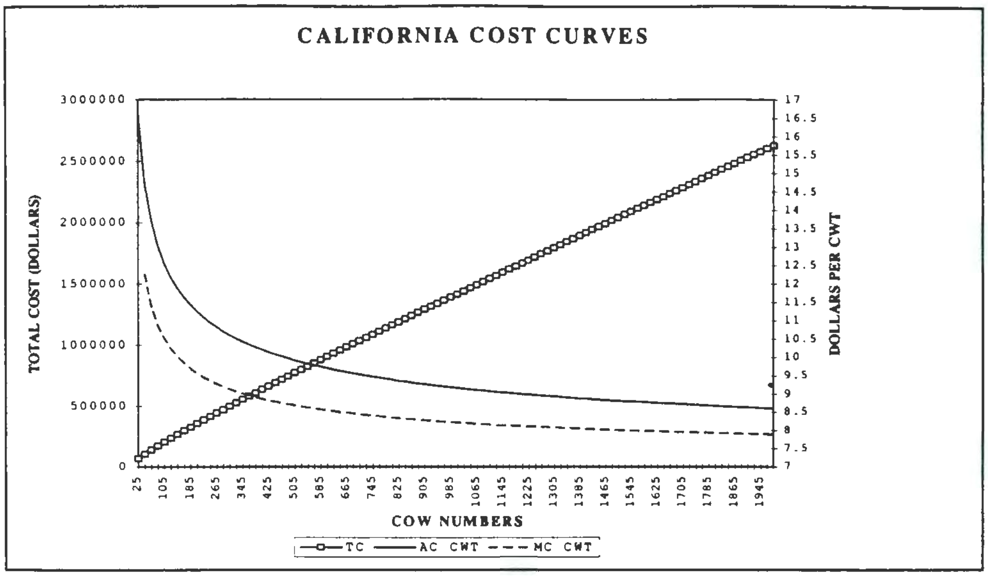

Figure 1: Total, Marginal, and Average Cost Curves For California

Figure 3 is a final example of the type of cost curves obtained from the translog model. In 11 out of 27 states, the average and marginal curves are steadily increasing and do not intersect over the range of the data. These 11 states are Florida, Idaho, Iowa, Maine, Missouri, New Hampshire, Pennsylvania, South Dakota, Texas, Virginia, and Washington. Although the shapes of the marginal and average cost curves in these 11 states are not consistent with theoretical expectations, the total costs curves are increasing throughout the range of the data, a necessary condition for using the cost curves

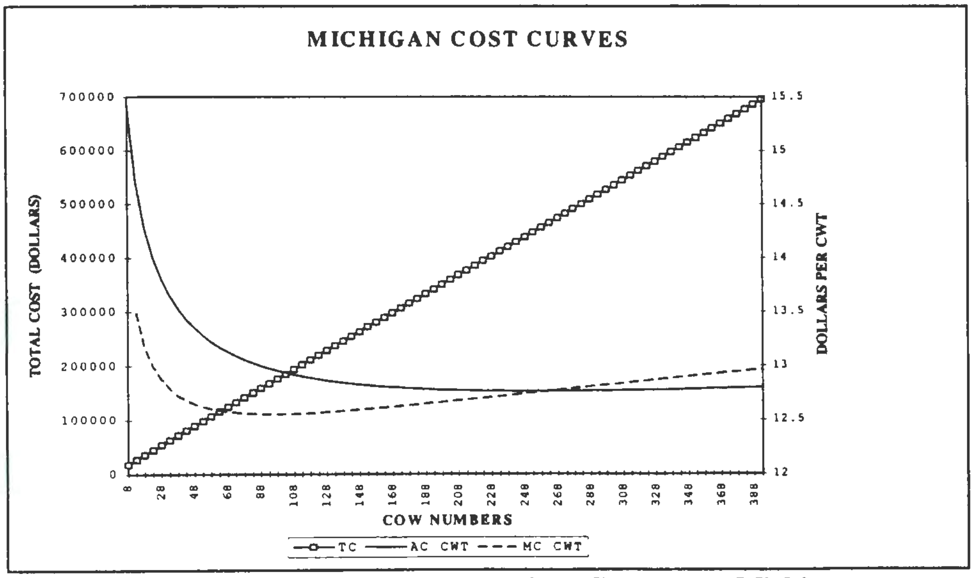

Figure 2: Total, Marginal, and Average Cost Curves For Michigan

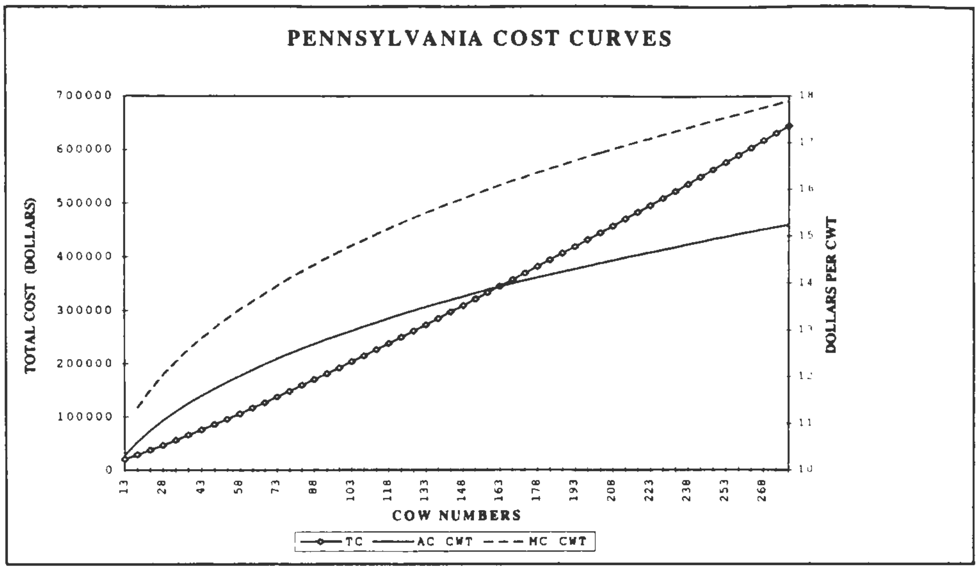

Figure 3: Total, Marginal, and Average Cost Curves For Pennsylvania

in the NDM. Through sensitivity analysis, the optimum solution of the NDM should indicate if the cost curves for these eleven states result in a competitive disadvantage for producers located in these areas.

Results Of Marketing Scenarios

The National Dairy Model (NDM) is a versatile model that can be easily adapted to accommodate alternative marketing scenarios. The NDM is designed to simulate the geographic distribution of milk production in a competitive market. The NDM is solved with varying production factors (*PF*). For the base run, the *PF* is 1.0. In subsequent runs, total milk supply in the NDM is increased. Increases treated in this paper were 5% (*PF*=1.05) and 30% (*PF*=1.30). After the different versions of the NDM are solved in GAMS, there are several types of information that are retrieved from each simulation. For example, the value of the objective function can be used to compare and contrast alternative scenarios. Another result obtained from the NDM is a state's percentage change in total production. The results of the base solution for each scenario report the states' 1994 share of national milk production. In the remaining simulations where the production factor is varied, the results of the models identify a state's percentage change in total production relative to the base solution. The output from each simulation also provides information about a market area's percentage of fluid and manufactured shipments. Given a state's total production, the NDM results report what percentage of total production is shipped as fluid and manufactured products. A state's percentage of total production that is shipped to the export market is another type of information retrieved from the GAMS output. If a state does provide milk to the export market, the state's share of total exports is also reported.

Base Run

The purpose of the base run was to replicate 1994 production patterns. The results from this simulation are a benchmark that is used for comparison with the results from simulations that have varying production factors. The base model is programmed so that each state produces the equivalent of its 1994 total production. When the production factor is 1.0, the optimal solution to the NDM is found at the point where each state maintains its 1994 market share. The results for the base model are presented in Table 2.

The first column in Table 2 is a state's share of total production, which is equal to each state's market share in 1994. Table 2 also shows a state's percentage of fluid and export shipments. The percentage of manufactured shipments can be determined by subtracting the state's percentage of fluid and export shipments from a base of 100. Based on class utilization statistics from the Federal Milk Marketing Orders, the types of shipments from the market areas appear to be consistent with historical data. For example, the results show that production in states like Virginia, North Carolina, Georgia, Florida, South Carolina, Illinois, and Indiana is designated for fluid use. Although market order statistics do not show 100% class one utilization rates in these areas, the statistics do confirm that these areas are historically a high (>60%) class one utilization market (*Federal Milk Marketing Order Statistics* 1995). A comparison of Class II and III utilization rates from federal order statistics also

Table 2: Production Levels, Fluid and Export Shipments By State For Variations Of the NDM Given 1994 Marketing Conditions and 3% Export Level

	% Change In Total Production[A]			Fluid Shipments (%)			Export Shipments (%)[B]		
State	Base	*PF=5%*	*PF=30%*	Base	*PF=5%*	*PF=30%*	Base	*PF=5%*	*PF=30%*
AL	0.33	5.00	30.00	100.00	100.00	100.00			
AZ	1.39	5.00	30.00	53.78	51.22	41.37			
AR	0.49	5.00	30.00	73.62	70.11	56.63			
CA	16.30	5.00	30.00	28.05	26.71	21.58	8.93 (50)	8.50(50)	10.31(75)
CO	1.02	5.00	-11.63	56.55	53.85	63.99			
CT	0.35	5.00	21.36	100.00	100.00	100.00			
DE	0.09	5.00	7.64	100.00	100.00	100.00			
FL	1.71	-31.74	-65.17	100.00	100.00	100.00			
GA	1.04	5.00	30.00	100.00	100.00	100.00			
ID	2.45	5.00	-17.78	6.32	6.02	7.69			
IL	1.66	5.00	30.00	100.00	100.00	67.07			
IN	1.47	5.00	30.00	100.00	100.00	100.00			
IA	2.58	-62.90	-83.47	16.53	44.55	100.00			
KS	0.72	5.00	30.00	100.00	100.00	100.00			
KY	1.30	5.00	30.00	83.33	66.77	44.92			
LA	0.60	5.00	30.00	100.00	100.00	82.76			
ME	0.42	-53.01	-63.62	45.32	96.43	100.00			
MD	0.86	5.00	-0.22	96.41	91.82	100.00			
MA	0.29	-100.00	-100.00	100.00	—	—			
MI	3.61	5.00	-60.47	39.53	37.65	100.00			
MN	6.09	5.00	-100.00	11.04	10.52	—	5.17 (11)	5.48(12)	
MS	0.48	5.00	30.00	92.61	82.17	63.85			
MO	1.77	5.00	-44.67	48.12	41.90	76.43			
MT	0.20	-7.68	-30.74	61.38	66.49	88.62			
NE	0.72	-2.48	-25.70	33.53	34.38	45.13			
NV	0.27	5.00	30.00	0.00	0.00	0.00			
NH	0.20	-38.07	-51.01	100.00	100.00	100.00			
NJ	0.22	5.00	30.00	100.00	100.00	100.00			
NM	2.17	5.00	30.00	10.75	10.23	8.27			
NY	7.44	5.00	30.00	0.00	0.00	1.72			
NC	0.96	5.00	30.00	100.00	100.00	100.00			
ND	0.57	-6.23	-29.10	0.00	0.00	0.00	73.00(14)	71.21(13)	
OH	2.95	5.00	30.00	59.93	56.79	44.71			
OK	0.83	5.00	30.00	100.00	99.52	66.45			
OR	1.12	-23.93	-60.89	39.11	51.41	100.00			
PA	6.67	-2.15	-19.29	87.25	88.73	100.00			
RI	0.02	5.00	8.69	100.00	100.00	100.00			
SC	0.27	5.00	30.00	100.00	100.00	100.00			
SD	1.04	-3.87	-26.99	19.81	20.61	27.13			
TN	1.28	5.00	30.00	43.98	73.89	59.96			
TX	4.06	5.00	30.00	64.35	61.28	49.50		0.54(1)	
UT	0.93	5.00	-16.88	28.39	27.04	34.16			
VT	1.60	5.00	30.00	51.19	70.79	60.20			
SW VA	0.06	5.00	5.25	100.00	100.00	100.00			
E VA	0.16	5.00	10.51	100.00	100.00	100.00			
W VA	1.03	5.00	-4.49	61.70	57.32	71.94			
WA	3.39	-22.73	-72.38	22.06	28.54	79.86	21.48(25)	27.00(24)	
WV	0.18	5.00	30.00	100.00	100.00	100.00			
WI	14.60	5.00	30.00	0.00	0.00	3.54			3.84(25)
WY	0.06	-7.54	-30.60	0.00	0.00	0.00			

[A] The results in the BASE column represent the state's 1994 market share. The results for varying production factors are the percentage change in the state's milk production relative to the base solution.

[B] Values in () represent a state's share of total exports reveals that the NDM model correctly identified market areas where the majority of the production is used in manufactured products (e.g., California, New Mexico, Idaho, Iowa, Michigan, Minnesota, Wisconsin, and New York). Based on these results, the NDM appears to be accurate in simulating marketing conditions throughout the U.S. dairy industry in 1994.

The last column in Table 2 identifies the states that have shipments to export facilities. If a state has export shipments, the percentage of total exports produced by that state is shown in parentheses. In the base run, California and Washington account for 75% of total exports. The remaining 25% of exports is shipped from states located in the Upper Midwest.

5% Production Increase Factor

With a 1.05 production factor, many states increase their total production by the maximum allowable 5% (Table 2). Since total demand is fixed in the NDM, increasing production in some states is offset by decreasing production in other states. Some of the larger dairy states that show a decrease in milk production are Florida, Iowa, Oregon, Pennsylvania, and Washington. Both Iowa and Washington are located near the low-cost producing regions of the country. With the 1.05 production factor, production in states like California and Wisconsin is increased at the expense of surrounding states (e.g., Washington and Iowa).

The percentage of fluid and manufactured shipments are generally consistent with the results of the base run. Compared to the base solution, there are only minor changes in fluid and manufactured shipments. In most cases, these changes occur when a state's total production is reduced. For example, as production in Iowa, Maine, and Washington is reduced, the percentage of fluid shipments increases. Because fluid products are more expensive to transport, a state experiencing a loss in production will continue to supply fluid milk to the local market while the demand for manufactured products is satisfied with shipments from other low-cost producing states.

On the other hand, increasing production in a state generally results in a smaller percentage of fluid shipments (Table 2). The percentage being smaller does not mean that a state is shipping less fluid milk. When a state increases production, if the quantity of milk shipped as fluid products remains unchanged, the percentage of fluid shipments will decrease because of more production in the state. Finally, export shipments across all three models remain virtually unchanged from the base solution. The only difference is that Texas begins shipping some products to the export market.

30% Production Increase Factor

When the NDM is evaluated with a 1.30 production factor, a number of states are completely removed from milk production (Table 2). For example, production in Massachusetts and Minnesota is reduced by 100%. The NDM continues to reduce milk supply in Florida, Iowa, Oregon, Pennsylvania, and Washington. Most of the production that remains in these states is used to satisfy local demand in the fluid market. Other states that appear to be less competitive as more flexibility is added to the NDM are Idaho, Missouri, New Hampshire, and Utah. The major dairy states (e.g., California, Wisconsin, Texas, New York, New Mexico, and Arizona) expand production by the maximum allowed 30%, an expected result.

With increased flexibility, California, New Mexico, and Wisconsin are still the dominant sources of manufactured products. In terms of exports, California produces 75% of total exports. Wisconsin supplies the remaining 25% of exported dairy products.

Spatial Scenario

The spatial scenario is used to determine what states would produce milk if costs of production are assumed to be equal across states. The spatial scenario is simulated with the same marketing conditions outlined in the models with varying costs of production. In order to assess the impacts on the solution at different degrees of flexibility, the spatial scenario is evaluated with production factors of 5% and 30%. A comparison of the results from both the spatial scenario and costs of production models should provide information about the importance of a state's location advantages versus the costs of production advantages.

Like the scenario with varying costs of production, a base run is simulated for the spatial scenario. The purpose of the base run is to replicate 1994 production patterns in a scenario that is concerned only with transportation costs of dairy products. The results of this simulation are a benchmark that can be used for comparison with the results from the spatial models with production factors of 5% and 30%.

When the production factor is 5%, the NDM identifies two regions that have a decrease in milk production: (1) California and (2) Washington. The decrease in milk supply relative to the base level is 15.92% for California and 41.89% for Washington. Because the shadow prices in the base solution for these two areas are positive and very large (i.e., CA = 13,162 and WA = 14,310), one should not be surprised that supply in these areas is reduced when the NDM becomes less constrained. Except for California and Washington, whose shadow prices are zero in the simulation when the production factor is 5%, the shadow prices for the remaining market areas are negative. For a minimization model, a negative shadow price for a state indicates that the objective function can be reduced as production is increased in that state. To account for the decrease in production from California and Washington, the remaining 48 supply areas increase production by 5%. The final simulation in the spatial scenario is a model where the production factor is increased to 30%. With a 130% production capacity, a total of seven market areas show a decrease in total production. Some of the largest decreases in quantity supplied belong to Idaho (80.75%), Minnesota (70.91%), Nevada (100%), and North Dakota (100%).

The changes in total production from these spatial models reveal a definite pattern in which market areas should reduce or expand milk production when the decision criteria is transportation costs. In each of the models, the *TMC* is minimized by reducing production in market areas that are distant from major consumption centers and that have a small percentage of fluid shipments. In general, these market areas are major production regions located in the Pacific Northwest, West, and Upper Midwest. California, Washington, Idaho, Minnesota, and Wisconsin are five large supply regions that consistently lose production in the spatial scenario. As market share is reduced in these regions, the milk supply is increased in production regions that are east of the Rocky Mountains and near the majority of the U.S. population.

When the results of both the spatial scenario and models with varying costs of production are compared, one can determine if a state's competitive advantage is based primarily on location and/or costs of production. For example, the results with costs of production indicate that the milk supply in Nevada, California, and Wisconsin increases as the NDM becomes more flexible. In contrast, the spatial scenario reduces milk production in these states. Based on these results, the costs of production advantages in Nevada, California, and Wisconsin clearly outweigh any disadvantages these states might encounter as a result of location given current transportation costs. On the other hand, a comparison of the results identifies some states that have location advantages which are overshadowed by high costs of production. Some of these states are Florida, Iowa, Michigan, and North Carolina. In the cases of Idaho, Minnesota, and Washington, the results of both scenarios verify that these states are competitively disadvantaged because of location and/or costs of production.

Conclusions

The results of this study indicate that milk production in a deregulated market will be dominated by low-cost producing states. Some of these states are Arizona, California, New York, Texas, and Wisconsin. As the NDM becomes less constrained, these states and many others increase market share as milk supply is reduced in high-cost producing states. According to the results of the

NDM, some states that are less competitive in a deregulated market are Florida, Iowa, Michigan, Minnesota, North Carolina, and Washington. In general, these areas are not competitive due to intra-regional competition from low-cost producers in surrounding states.

The results of the study also lead to some conclusions about the effectiveness of historical dairy programs in achieving a competitive equilibrium. The objective function of the NDM is to minimize total marketing cost (*TMC*), which is defined as the sum of each state's cost of production and transportation cost from shipping dairy products to the final consumer. Because the base run of the NDM is designed to replicate 1994 production levels, the objective value from this simulation can be interpreted as the *TMC* in a regulated dairy industry. As the production factor is increased and the NDM becomes more flexible, the *TMC* is representative of the cost of producing and shipping dairy products in a competitive market that is not constrained by federal and state policies.

With the geographic distribution of milk production in 1994, the NDM returns a *TMC* of $18.2 billion, or $12.08 per cwt. of milk produced in 1994. The $12.08 per cwt. represents the cash costs of producing and shipping milk to consumers in a regulated dairy industry. As the production factor is increased by 5% and 30%, the *TMC* is reduced to $18.0 and $17.4 billion, respectively. With a production factor of 1.30, the *TMC* is reduced 4.39%, or $800 million dollars ($0.53 per cwt.). The $800 million dollar decrease in *TMC* should be interpreted as an estimate of the annual costs of a regulated dairy industry. Based on these results, dairy policies appear to have been fairly effective in achieving a cost-efficient distribution of milk production, a "solution" not markedly different from what would be expected in a competitive market. In the most flexible version of the NDM, the *TMC* is reduced by only $800 million compared to the base solution. Even though dairy programs may have been reasonably successful at approximating a competitive equilibrium in the dairy market, the future of Federal Milk Marketing Programs and price supports may depend on whether consumers and policy makers view $800 million annually as a significant cost of the traditional policies.

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