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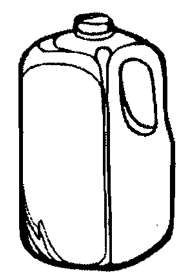

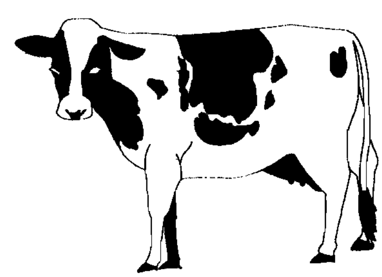

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Impact of Federal Marketing Orders on the Structure of Milk Markets in the United States

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The 1996 Farm Bill mandated a reduction in the number of federal milk marketing orders (FMMOs) in the United States (from 33 to between 10 and 14) through the merger and consolidation of existing orders. This change is supposed to be made by 1999. The drastic reduction in FMMOs will undoubtedly have major consequences for milk markets in the United States. Because the law calls for arguably the largest change in marketing orders since their inception in the 1930s, the U.S. Department of Agriculture and various university researchers are currently studying the potential economic impacts of FMMO mergers and consolidations. One of the key issues researchers are addressing is the appropriate structure for interregional milk pricing for the newly formed orders. In answering this question, it is useful to know the impact of current FMMOs on the structure of milk markets in the United States.

FMMOs regulate the terms and conditions of Grade A milk (eligible for beverage consumption) sales in the United States. The main economic feature of FMMOs is classified pricing of milk, which price discriminates milk according to how the milk is used. Milk used in beverage products, or Class I products (the most price inelastic of all dairy products), receives a price premium (Class I differential), while milk going into more price elastic manufactured products (Classes II, III, and IIIa) receives lower prices (see discussion below). FMMOs may provide market power to farmers or their cooperatives to counterbalance the market power of fluid milk processors. The degree of market power created can be measured by the size of the Class I differential created by orders.

All previous studies on FMMOs and the structure of interregional milk pricing in the United States have used Takayama and Judge-type spatial equilibrium models (e.g., Cox, Chavas, and Jesse; McDowell, Fleming, and Spinelli; Novakovic and Pratt). These models are used to determine optimal levels of milk shipments among regions in the United States, as well

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as shadow prices on the value of milk for each region, which is useful information for evaluating regional Class I price surfaces. A potential drawback of these models, however, is the assumption that markets are perfectly competitive. In reality, the structure of U.S. milk markets may be better characterized as imperfectly competitive due to the existence of large and dominant dairy cooperatives, milk processors, and retail supermarket chains, as well as the influence of FMMOs. Therefore, a more generalized spatial equilibrium model that can impose any degree of market structure would be beneficial.

In this paper, we develop a spatial equilibrium model that allows for the inclusion of any degree of market structure from perfect competition to monopoly. To our knowledge, the only other spatial equilibrium model allowing for any degree of market structure is a recent one developed by Kawaguchi, Suzuki, and Kaiser to study the Japanese milk market structure. No similar spatial study has been conducted for U.S. milk markets. Since FMMOs may give some market-power-equivalent to dairy cooperatives by setting minimum Class I price differentials, the model is used to investigate the impact of milk marketing orders on market structure. To determine what degree of market-power-equivalent is created by the current orders, we simulate possible Class I and manufacturing milk prices which could be created by dairy cooperatives without the FMMO system, under alternative assumed market structures. The simulation results are then compared with current regional milk prices under the FMMO system to gain insight on the impact of orders on market structure.

FMMO Pricing and Simplifying Assumptions

FMMOs generally classify milk into four uses: Class I (milk used in beverage products), Class II (milk used in soft manufactured products), Class III (milk used in hard dairy products), and Class IIIa (milk used in nonfat dry milk). The Class III price is the base for milk pricing under the FMMO system. For almost all marketing orders, the Class III price is equal to the Basic Formula Price calculated from the Minnesota-Wisconsin (MW) price, which is the actual price paid for manufacturing grade (Grade B) milk in these two states. While FMMOs apply only to Grade A milk, Grade B milk prices are used as the pricing base since the manufactured product market is national in scope, and therefore Grade A milk processed into manufactured products competes with Grade B milk in Wisconsin and Minnesota. Some marketing orders have a Class IIIa price for nonfat dry milk, which is usually lower than the Class III price. The Class II milk price for soft dairy products is about 30 cents higher than the Class III price. While these class prices are the minimum prices regulated handlers must pay farmers, the actual manufacturing milk prices are often higher in some orders because of over-order payments.

In the model, all manufacturing milk is aggregated into one product and the average manufacturing price is used. Over-order payments for manufacturing milk are not included in the model since this data is not available. Dairy farmers, or their cooperatives, are assumed to be price takers in the manufacturing milk market because they face nationwide competition from other cooperatives and proprietary milk handlers based on the MW price.

The Class I price is determined by adding the Class I differential to the Class III price for each marketing order. The Class I differential increases with distance from Minnesota and Wisconsin. The Class I differential partially reflects the cost of shipping milk from the largest surplus or reserve area in the United States to other orders. The Class I price is also a minimum price, and there are over-order payments in many markets through negotiations between dairy cooperatives and proprietary milk handlers. Over-order Class I premiums are not incorporated in the model since they are unavailable.

There were 40 FMMOs and about 300 dairy cooperatives in the United States in 1993, which is the year chosen for this analysis. The model uses the same regional classification used by Cox, Chavas, and Jesse, who modeled the U.S. dairy market as 13 regions. All prices are calculated as weighted averages based on the amount of milk in each region. The California state order is included as a separate order in this analysis. It is assumed that cooperatives are the agents making milk marketing decisions in the model. Although there is more than one cooperative in one region, it is difficult to incorporate data on milk prices and quantities disaggregated to the cooperative level. Therefore, only the number of cooperatives in each region is considered in the model, meaning the size and all the equilibrium decisions of each cooperative are assumed to be the same within the region.

Because the dairy price support program (DPSP) is supposed to exist until 1999, the program is incorporated in this analysis. In 1993, the DPSP supported the manufacturing milk price at $10.00 per hundredweight (3.5 percent butterfat). The DPSP is incorporated into the model by requiring the government to purchase manufactured dairy products to support the manufacturing grade milk price at $10.00 per hundredweight.

Conceptual Model

Although Class I differentials (not including over-order payments) are mandated by the FMMO system, they are not guaranteed in this model. In order to estimate the degree of market-power-equivalent due to current FMMOs, the model simulates Class I and manufacturing milk prices which could be created by dairy cooperatives themselves without the FMMOs, under alternative assumed market structures.

Consider n (=13) regions with fluid and manufacturing milk markets. The fluid market in region i is called market i, and the manufacturing market in region i is called market n+i. Because manufactured milk is processed within each region and is not shipped outside the region as bulk milk, we only consider the transportation costs for interregional raw milk shipments for fluid processing. Since the manufactured products market is nationwide, dairy cooperatives are assumed to be price takers with respect to manufacturing milk marketing. It is assumed that the manufacturing milk price for each region is given as a uniform national price reflecting nationwide demand and supply conditions of the manufacturing milk market. In order to determine equilibrium manufacturing milk price, a downward-sloping national demand function for manufacturing milk is incorporated into the model.

The focus of this paper is on dairy cooperative market-power-equivalent due to the existence of FMMOs. To simplify the model, it is assumed that fluid milk processors have no market power in buying milk from cooperatives. This assumption is reasonable since there are many fluid processors in the U.S. It is also assumed that each region has a linear marginal raw milk cost function and a linear fluid demand function, with all functions known by all cooperatives (or consignment sellers), and that the size and all the equilibrium decisions of each cooperative are the same within each region.

It is assumed that milk producers in region i consign their annual milk supply to cooperatives in region i. Each cooperative's role is to allocate farmers' raw milk among the n fluid markets (1 to n) and the manufacturing market (n+i) in region i to maximize sales revenues net of transportation costs. Farmers are paid a blend price (weighted average price for milk sold in the fluid and manufacturing milk markets) and are assumed to be price takers who produce milk based on the level of the blend price. The following notation is used for the variables described above:

N_i: the number of cooperatives in region i (i=1, 2, ..., n),

D_j: quantity of milk demanded in fluid market j (j=1, 2, ..., n),

D^m: quantity of milk demanded in the national manufacturing milk market,

FS_i: quantity of raw milk supplied and consigned in region i (i=1, 2, ..., n),

PS_i: marginal revenue net of transportation costs for each market for region i (i=1, 2, ..., n),

X_{ij}: quantity of raw milk shipped from region i to fluid market j (i=1, 2, ..., n; j=1, 2, ..., n),

$X_{i(n+i)}$: quantity of raw milk shipped from region i to the manufacturing milk market n+i (i=1, 2, ..., n),

$X_{ij}(k)$: the portion of X_{ij} shipped by cooperative k in region i, where $X_{ij} = \sum_{k=1}^{N_i} X_{ij}(k)$,

$X_{i(n+i)}(k)$: the portion of $X_{i(n+i)}$ shipped by cooperative k in region i, where $X_{i(n+i)} = \sum_{k=1}^{N_i} X_{i(n+i)}(k)$,

PD_j: demand price in fluid market j (j=1, 2, ..., n),

PD^m: demand price in the national manufacturing market,

BP_i: producer's pooled (blend) price in region i (i=1, 2, ..., n),

P^{ccc}: support price for manufacturing milk,

$D_j=\alpha_j-\beta_j PD_j$: demand function in fluid market j (j=1, 2, ..., n),

$D^m=\alpha^m-\beta^m PD^m$: demand function in the national manufacturing market,

$FS_i= -\nu_i+\eta_i BP_i$: marginal cost function for raw milk in region i (i=1, 2, ..., n),

T_{ij}: unit transportation cost of shipping raw milk from region i to fluid market j (i=1, 2, ..., n; j=1, 2, ..., n),

R_i: total milk sales revenue net of transportation costs in region i (i=1, 2, ..., n).

Using the above notation, the total milk sales revenue maximization problem, net of transportation costs, aggregated for all regions can be expressed as:

(1) Max. $\sum_{i=1}^{n} R_i = \sum_{j=1}^{n}\sum_{i=1}^{n} PD_j X_{ij} + \sum_{i=1}^{n} PD''' X_{i(n+i)} - \sum_{j=1}^{n}\sum_{i=1}^{n} T_{ij} X_{ij}$

When cooperative k in region i believes that a change in their fluid supply will cause a change in all other cooperatives' fluid supply to market j, the cooperative's "perceived" marginal fluid revenue in market j is:

(2) $$\frac{\partial(PD_j X_{ij}(k))}{\partial X_{ij}(k)} = PD_j - \frac{1}{\beta_j}(r_{ij}(k)+1)X_{ij}(k),\ (k=1, 2,\ldots, N_i),$$

where $r_{ij}(k)$ is the conjectural variation of cooperative k in region i with respect to changes in all other cooperatives' fluid supply to market j.

As the size and all the equilibrium decisions of each cooperative are assumed to be the same within each region, equation (2), in equilibrium, can be rewritten as:

(3) $$\frac{\partial(PD_j X_{ij}(k))}{\partial X_{ij}(k)} = PD_j - \frac{1}{\beta_j}(r_{ij}+1)\frac{X_{ij}}{N_i},\ (k=1, 2,\ldots, N_i),$$

where r_{ij} is the common conjectural variation of the region i cooperative.

Using the relationship expressed in (3), the total revenue maximization problem for all regions can be re-specified as the following net social payoff maximization problem (ANSP) adjusted for imperfectly competitive markets:

(4) Max: ANSP =

$$\sum_{j=1}^{n}\int\left[\frac{\alpha_j}{\beta_j} - \frac{1}{\beta_j}D_j\right]dD_j + \sum_{i=1}^{n} PD''' X_{i(n+i)} - \sum_{j=1}^{n}\sum_{i=1}^{n}\frac{1}{\beta_j}(r_{ij}+1)\frac{1}{N_i}\int X_{ij}dX_{ij} - \sum_{j=1}^{n}\sum_{i=1}^{n} T_{ij}X_{ij}$$

(5) s.t. $D_j \le \sum_{i=1}^{n} X_{ij}$, for all j,

(6) $\sum_{j=1}^{n} X_{ij} + X_{i(n+i)} \le FS_i$, for all i,

(7) $D_j \ge 0$, $X_{ij} \ge 0$, $X_{i(n+i)} \ge 0$ for all i and j.

When the market is perfectly competitive (r_{ij} = -1), the term $-\sum_{j=1}^{n}\sum_{i=1}^{n}\frac{1}{\beta_j}(r_{ij}+1)\frac{1}{N_i}\int X_{ij}dX_{ij}$ is zero and (4) is equal to the original Takayama and Judge model.

Using the Lagrange function (L) with the multipliers λ_j and θ_i for the constraints (5) and

(6), respectively, the Kuhn-Tucker optimality conditions for the maximization problem can be expressed as:

(8) $$\frac{\partial L}{\partial D_j} = \frac{\alpha_j}{\beta_j} - \frac{1}{\beta_j} D_j - \lambda_j \le 0, D_j \frac{\partial L}{\partial D_j} = 0, \text{ for all j},$$

(9) $$\frac{\partial L}{\partial X_{ij}} = -\frac{1}{\beta_j}(r_{ij}+1)\frac{X_{ij}}{N_i} - T_{ij} + \lambda_j - \theta_i \le 0, X_{ij}\frac{\partial L}{\partial X_{ij}} = 0, \text{ for all i and j},$$

(10) $$\frac{\partial L}{\partial X_{i(n+i)}} = PD''' - \theta_i \le 0, X_{i(n+i)}\frac{\partial L}{\partial X_{i(n+i)}} = 0, \text{ for all i},$$

(11) $$-\frac{\partial L}{\partial \lambda_j} = D_j - \sum_{j=1}^{n} X_{ij} \le 0, \lambda_j \frac{\partial L}{\partial \lambda_j} = 0, \text{ for all j},$$

(12) $$-\frac{\partial L}{\partial \theta_i} = \sum_{j=1}^{n} X_{ij} + X_{i(n+i)} - FS_i \le 0, \theta_i \frac{\partial L}{\partial \theta_i} = 0, \text{ for all i}.$$

The Lagrange multipliers, λ_j and θ_i, measure the fluid demand price (PD_j), and "perceived" marginal revenue net of transportation costs for each market (PS_i), respectively. The Kuhn-Tucker conditions represented by (9) and (10) indicate that each cooperative must equalize marginal revenue, net of transportation costs, across all fluid markets where it sells milk to the manufacturing milk price (if it sells milk to the manufacturing milk market). That is:

(13) $$PD_j - \frac{1}{\beta_j}(r_{ij}+1)\frac{X_{ij}}{N_i} - T_{ij} = PD''', \text{ if } X_{ij} > 0, \text{ and } X_{i(n+i)} > 0, \text{ for all i and j}.$$

The equilibrium values can be calculated by the quadratic programming model solution.

To complete the model, farmers' milk supply functions need to be incorporated. Producers in region i, as price takers, determine their supply based on the producer blend price. Specifically, milk production levels are determined by equating marginal cost and the blend price, i.e.,

(14) $$BP_i = \frac{R_i}{FS_i} \text{ for all i},$$

(15) $FS_i = -\nu_i + \eta_i BP_i$ for all i.

In the comparative-static equilibrium, FS_i in (15) must be equal to FS_i given in the above milk sales maximization problem. Equilibrium values for FS_i can be found by continuing an iterative solution process until values for FS_i become stationary, as was done by Kawaguchi, Suzuki, and Kaiser in their Japanese milk market model.

To reach equilibrium, the national manufacturing milk demand function needs to be incorporated. In equilibrium, the manufacturing milk price (PD^m) for each cooperative in the above sales maximization problem must satisfy the condition that the sum of milk shipped to manufacturing milk market n+i, or $\sum_{i=1}^{n} X_{i(n+i)}$, must be equal to manufacturing milk demand, D^m. If the equilibrium value of PD^m is larger than the support price level (P^{ccc}), then the following equations must be satisfied:

(16) $\sum_{i=1}^{n} X_{i(n+i)} = D^m$,

(17) $D^m = \alpha^m - \beta^m PD^m$, if market-clearing $PD^m > P^{ccc}$.

Equilibrium values for $\sum_{i=1}^{n} X_{i(n+i)}$ and PD^m are found by continuing a similar iteration procedure until $\sum_{i=1}^{n} X_{i(n+i)}$ becomes approximately equal to D^m. On the other hand, if the equilibrium value for PD^m is below P^{ccc}, then PD^m is replaced by P^{ccc}, and the CCC purchases in raw milk equivalents will be given as $\sum_{i=1}^{n} X_{i(n+i)}$ - D^m.

An Application of the Model to the U. S. Milk Market

The data set used in this analysis comes from several sources, including Cox, Chavas, and Jesse; Suzuki and Kaiser; and USDA's Dairy Market Statistics and Federal Milk Order Market Statistics. Based on Cox, Chavas, and Jesse, the 13 regions include: North East (NE), Middle Atlantic (MA), South Atlantic (SA), South East (SE), Central (C), East South Central (ESC), West South Central (WSC), East North Central (ENC), Upper Midwest (UM), West Central (WC), North West (NW), Mountain (MOU), and California (CA). Table 1 shows how FMMOs in 1993 were included in the 13 regions. The number of cooperatives in region i (N_i) is estimated using data from *Hoard's Dairyman*, May 10, 1994. For 1993, N_1=8 in NE, N_2=91 in MA, N_3=8 in SA, N_4=12 in SE, N_5=5 in C, N_6=3 in ESC, N_7=10 in WSC, N_8=57 in ENC, N_9=63 in UM,

N_{10}=16 in WC, N_{11}=7 in NW, N_{12}=13 in MOU, and N_{13}=16 in CA.

Table 2 shows the data set used in this analysis. Prices (3.5 percent butterfat) are weighted averages calculated using the FMMO data (except for California), and milk quantity data includes not only order milk, but also other source milk. Based on supply elasticities for the 13 regions from Cox, Chavas, and Jesse, the regional price and quantity observations in Table 2, and the application of a national fluid demand price elasticity estimated by Suzuki and Kaiser (-0.158) to all regions, the linear marginal cost and fluid milk demand functions for each region are:

(18) $FS_1 = 3206.88 + 92.31BP_1$, $D_1 = 3360.52 - 30.86PD_1$,

(19) $FS_2 = 8442.72 + 999.64BP_2$, $D_2 = 9569.71 - 88.70PD_2$,

(20) $FS_3 = 3369.54 + 29.47BP_3$, $D_3 = 3571.27 - 33.13PD_3$,

(21) $FS_4 = 2066.05 + 259.78BP_4$, $D_4 = 7515.42 - 67.02PD_4$,

(22) $FS_5 = -1782.88 + 423.12BP_5$, $D_5 = 2179.36 - 20.88PD_5$,

(23) $FS_6 = 1254.74 + 117.88BP_6$, $D_6 = 3354.73 - 30.66PD_6$,

(24) $FS_7 = 3109.76 + 498.74BP_7$, $D_7 = 5508.61 - 51.30PD_7$,

(25) $FS_8 = 147.50 + 1140.82BP_8$, $D_8 = 9445.81 - 95.04PD_8$,

(26) $FS_9 = 29984.60 + 440.95BP_9$, $D_9 = 2698.14 - 28.45PD_9$,

(27) $FS_{10} = -3910.28 + 1028.72BP_{10}$, $D_{10} = 3040.91 - 31.17PD_{10}$,

(28) $FS_{11} = 4700.64 + 423.66BP_{11}$, $D_{11} = 2217.57 - 22.43PD_{11}$,

(29) $FS_{12} = 2864.16 + 190.02BP_{12}$, $D_{12} = 2833.63 - 27.62PD_{12}$,

(30) $FS_{13} = 15109.38 + 679.79BP_{13}$, $D_{13} = 7573.32 - 81.62PD_{13}$,

where FS_i and D_j are measured in million pounds, and BP_i and PD_j are measured in dollars per hundredweight.

Using the U.S. total and average data in Table 2, Class I percentage (43.1percent) reported in Federal Milk Order Market Statistics, and a national manufacturing milk demand elasticity estimated by Suzuki and Kaiser (-0.217), the national manufacturing milk demand function is specified as:

(31) $D^m = 115724.53 - 1733.22PD^m$.

The estimated national average manufacturing milk price was \$11.91/cwt (3.5 percent butterfat) in 1993.

Unit transportation costs for raw milk, T_{ij}, are taken from Cox, Chavas, and Jesse and are shown in Table 3. Note that the transportation cost matrix is asymmetric, or T_{ij} is not necessarily the same as T_{ji}.

Results

The model was solved for three forms of market structure: perfect competition, monopoly, and Cournot-Nash equilibrium, where a cooperative believes other cooperatives will not change their supply in response to its actions. These results were compared to actual observations for 1993. Since the simulated results do not include FMMOs, the simulated market structure closest to the actual observations provides a measure of the impact of FMMOs on market structure.

Perfect Competition Equilibrium

Perfect competition means all cooperatives do not consider price changes caused by supply changes, or each cooperative in region i recognizes its marginal revenue in fluid market j as:

$$(32) \quad \frac{\partial(PD_j X_{ij}(k))}{\partial X_{ij}(k)} = PD_j.$$

Tables 4 to 6 summarize the results. Compared with actual observations, the perfect competition solution resulted in lower Class I milk prices, higher manufacturing milk prices, and more milk going into fluid markets. The manufacturing milk price, under perfect competition, was $12.61 per hundredweight, while the actual manufacturing milk price was $11.91 in 1993. Except in two Class I-deficit regions, the Class I differential disappeared. Compared with actual observations, blend prices were slightly lower in most regions due to the absence of Class I differentials (the simulated U.S. average was $12.70, while the actual average was $12.89). However, the difference in regional blend prices between the perfect competition solution and actual observations was relatively small because the higher simulated manufacturing prices offset the lower simulated Class I prices. Because blend prices are, on average, lower under perfect competition, simulated U.S. milk production was slightly lower than the actual observation level.

To satisfy Class I deficit markets, there were some interregional Class I milk shipments under perfect competition. In this case, interregional milk movements occurred only from C to

SE and ESC. The SE and ESC regions did not have enough milk production to meet their fluid demand, and the nearest reserve area to these regions was C.

Monopoly Equilibrium

Under monopoly, it is assumed that cooperatives jointly recognize their marginal revenue in fluid market j as:

$$(33) \quad \frac{\partial\left(PD_j \sum_{s=1}^{n} X_{sj}\right)}{\partial X_{ij}(k)} = PD_j - \frac{1}{\beta_j}\sum_{s=1}^{n} X_{sj} .$$

Compared to the perfect competition condition (32), condition (33) implies that increasing milk shipments to market j reduces milk prices and marginal revenue to each cooperative in any region.

The monopoly solution, in general, resulted in unrealistic price and quantity levels compared with actual 1993 observations (see Tables 4 to 6). For instance, the simulated Class I milk supply under monopoly was only one-half of the actual level. The huge reduction in Class I milk supply resulted in unrealistically high Class I prices ($50 to $60 per hundredweight). While the Class I milk supply was reduced, there was a huge increase in milk going into manufactured products. In fact, the monopoly solution resulted in a surplus of 52 billion pounds of milk being bought by the government under the DPSP--substantially higher than the 6.5 billion pounds the government actually purchased in 1993. The huge surplus of manufacturing milk caused the manufacturing milk price to be at the $10 support level. The national average blend price was $17.42, which was substantially higher than the actual $12.89 level in 1993. Interestingly, although monopolies usually result in the least production, total milk supply in the monopoly equilibrium was significantly higher than in the perfect competition solution (30 billion pounds, or 29 percent higher). This was due to the result that blend prices were substantially higher in the monopoly case and cooperatives had no power to control supply. The huge divergence between simulated and actual prices and quantities suggests current minimum Class I differentials under the FMMO system are far from the monopoly levels.

Cournot-Nash Equilibrium

In the Cournot-Nash case, cooperatives consider price changes caused only by their own supply changes. That is, "perceived" marginal revenue of each cooperative in region i in fluid market j is expressed as:

$$\frac{\partial(PD_j X_{ij}(k))}{\partial X_{ij}(k)} = PD_j - \frac{1}{\beta_j}\frac{X_{ij}}{N_i}. \qquad (34)$$

Compared to the other market structures, the Class I price, Class I differential, and manufacturing milk price, as well as total milk supply and demand in the Cournot-Nash solution were the closest to actual 1993 observations (Tables 4 to 6). For example, the simulated average Class I differential for the United States was $2.22 compared to $2.28, which was the differential in 1993. Compared with actual observations, the Cournot-Nash solution resulted in slightly lower Class I milk prices, higher manufacturing milk prices, and more milk going into fluid markets. The manufacturing milk price, under the Cournot-Nash solution, was $12.07 per hundredweight, while the actual manufacturing milk price was $11.91 in 1993. Similar to the perfect competition solution, the simulated blend prices were slightly lower than actual observations in most regions (the simulated U.S. average was $12.61, while the actual average was $12.89). Because blend prices were, on average, lower under Cournot-Nash, simulated U.S. milk production was slightly lower than the actual observation level.

Comparison of Conjectural Variations among Scenarios

In the monopoly case, values for r_{ii} were calculated as:

$$r_{ii} = \frac{N_i \sum_{s=1}^{n} X_{si}}{X_{ii}} - 1 = N_i - 1. (\because X_{ii} = \sum_{s=1}^{n} X_{si} \text{ in practice}). \qquad (35)$$

For example, the conjectural variation of a cooperative in region 1 regarding market 1 was 7. On the other hand, all r_{ii}s were -1 in perfect competition, or price taking behavior, and 0 in the Cournot-Nash case. These values implied the degree of market-power-equivalent given to dairy cooperatives by current federal orders was far from monopoly and closer to perfect competition.

Conclusions

A spatial equilibrium model that allows for the inclusion of any degree of market structure from perfect competition to monopoly was developed and applied to the U.S. dairy sector. The model was used to investigate the impact of milk marketing orders on market structure by simulating possible Class I and manufacturing milk prices which could be created by dairy cooperatives without the FMMO system, under alternative assumed market structures. The simulation results were then compared with current regional milk prices under the FMMO system to gain insight on the impact of orders on market structure.

It was clear from the results that the current FMMO system does not create much monopoly power for dairy cooperatives. The simulated prices and quantities for the monopoly solution were substantially different from actual observations. On the other hand, the simulation prices and quantities assuming Cournot-Nash behavior were the most similar to actual observations. While not as close as the Cournot-Nash solution, the results of the perfect competition solution simulation were also fairly similar to actual observations. These results suggest FMMOs have had a moderate impact on market structure approximately equivalent to some degree of imperfect competition relatively close to perfect competition.

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Table 1. The Federal Milk Marketing Orders Included in the 13 Regions in 1993.

Region	Marketing Orders Included
1 NE	New England
2 MA	New York-New Jersey, Middle Atlantic
3 SA	Carolina
4 SE	Georgia, Upper Florida, Tampa Bay, Southeastern Florida
5 C	Tennessee Valley, Nashville, Paducah, Memphis
6 ESC	Central Arkansas, Greater Louisiana, New Orleans-Mississippi, Alabama-West Florida
7 WSC	Southwest Plains, Texas
8 ENC	Michigan Upper Peninsula, Southern Michigan, Eastern Ohio-Western Pennsylvania, Ohio Valley, Indiana, Central Illinois, Southern Illinois-Eastern Missouri, Louisville-Lexington-Evansville
9 UM	Chicago Regional, Upper Midwest
10 WC	Iowa, Nebraska-Western Iowa, Kansas City, Eastern South Dakota, Black Hills
11 NW	Pacific Northwest, Southwestern Idaho-Eastern Oregon
12 MOU	Eastern Colorado, Western Colorado, Great Basin, Central Arizona, New Mexico-West Texas
13 CA	(California)

Table 2. Data Set for the Analysis (1993).

Region	FMMO Blend Price	FMMO Class I Price	Class I Differential	Milk Production	Milk Supply Elasticity	Fluid Demand
	$/cwt	$/cwt	$/cwt	Million Pounds		Million Pounds
1 NE	13.51	14.86	2.65	4,454	0.28	2,902
2 MA	13.21	14.72	2.60	21,648	0.61	8,264
3 SA	14.13	14.71	2.72	3,786	0.11	3,084
4 SE	14.77	15.30	2.86	5,903	0.65	6,490
5 C	13.79	14.24	2.34	4,052	1.44	1,882
6 ESC	14.11	14.93	2.98	2,918	0.57	2,897
7 WSC	13.25	14.65	2.65	9,718	0.68	4,757
8 ENC	12.80	13.56	1.63	14,750	0.99	8,157
9 UM	12.00	12.94	1.16	35,276	0.15	2,330
10 WC	12.44	13.31	1.36	8,887	1.44	2,626
11 NW	12.02	13.49	2.12	9,793	0.52	1,915
12 MOU	12.84	14.00	2.06	5,304	0.46	2,447
13 CA	11.45	12.66	1.70	22,893	0.34	6,540
Average/Total	12.89	14.19	2.28	149,382	NA	54,292

Note: Prices, except for California, are weighted averages calculated using USDA/AMS's Dairy Market Statistics and Federal Milk Order Market Statistics. Quantities, supply elasticities, and prices for California are from Cox, Chavas, and Jesse.

Table 3. Interregional Unit Transportation Costs ($/cwt).

To: From	NE 1	MA 2	SA 3	SE 4	C 5	ESC 6	WSC 7	ENC 8	UM 9	WC 10	NW 11	MOU 12	CA 13
NE	0.00	1.07	2.08	3.47	3.89	5.00	5.55	3.57	4.02	4.58	8.15	6.54	8.16
MA	1.00	0.00	1.13	2.88	3.19	4.17	4.93	2.81	3.41	3.94	7.54	5.95	7.55
SA	1.96	1.13	0.00	2.18	2.36	3.36	4.19	2.27	2.91	3.43	7.20	5.59	7.20
SE	3.07	2.53	1.92	0.00	2.26	2.06	3.03	2.80	3.73	3.75	7.60	5.89	7.06
C	2.68	2.28	1.69	1.65	0.00	1.40	2.02	1.28	2.04	2.26	6.02	4.29	5.86
ESC	3.70	3.22	2.60	1.71	2.26	0.00	1.33	2.26	2.88	2.40	6.23	4.39	5.50
WSC	4.44	4.13	3.51	2.75	2.16	1.62	0.00	3.03	3.59	1.93	5.08	3.29	4.33
ENC	2.59	2.18	1.71	1.95	0.93	1.65	2.65	0.00	1.47	2.12	5.59	4.06	5.52
UM	2.58	2.27	1.94	2.49	1.48	2.29	3.04	1.32	0.00	2.18	5.05	3.84	5.32
WC	3.42	3.06	2.67	2.58	1.92	1.65	1.50	1.91	1.95	0.00	4.54	2.93	4.49
NW	7.96	7.62	7.27	7.43	6.21	6.67	5.68	6.26	5.74	5.16	0.00	2.36	1.81
MOU	6.02	5.67	5.32	6.31	4.81	4.94	4.08	4.29	4.36	3.21	2.42	0.00	2.22
CA	7.98	7.63	5.54	7.01	6.17	5.75	4.95	6.35	6.21	5.24	1.74	2.08	0.00

Source: Cox, Chavas, and Jesse.

Table 4. Comparison of Blend Prices and Manufacturing Prices in each Case with Observations.

Blend Price ($/cwt)

Region	Actual	Perfect Competition	Difference	Monopoly	Difference	Cournot-Nash	Difference
1 NE	13.51	12.61	0.90	17.78	-4.27	12.27	1.24
2 MA	13.21	12.61	0.60	17.69	-4.48	12.67	0.54
3 SA	14.13	12.61	1.52	17.56	-3.43	12.35	1.78
4 SE	14.77	14.26	0.51	19.12	-4.35	13.13	1.64
5 C	13.79	12.61	1.18	17.47	-3.68	12.41	1.38
6 ESC	14.11	14.01	0.10	18.87	-4.76	12.51	1.60
7 WSC	13.25	12.61	0.64	17.57	-4.32	12.62	0.63
8 ENC	12.80	12.61	0.19	17.50	-4.70	13.11	-0.31
9 UM	12.00	12.61	-0.61	17.35	-5.35	12.17	-0.17
10 WC	12.44	12.61	-0.17	17.52	-5.08	12.67	-0.23
11 NW	12.02	12.61	-0.59	16.94	-4.92	12.47	-0.45
12 MOU	12.84	12.61	0.23	17.51	-4.67	13.24	-0.40
13 CA	11.45	12.61	-1.16	16.53	-5.08	12.78	-1.33
Average	12.89	12.70	0.19	17.42	-4.53	12.61	0.28

Manufacturing Milk Price ($/cwt)

	Actual	Perfect Competition	Difference	Monopoly	Difference	Cournot-Nash	Difference
Average	11.91	12.61	-0.70	10.00	1.91	12.07	-0.16

Table 5. Comparison of Class I Prices and Class I Differentials in each Case with Observations.

Class I Price ($/cwt)

Region	Actual	Perfect Competition	Difference	Monopoly	Difference	Cournot-Nash	Difference
1 NE	14.86	12.61	2.25	59.46	-44.60	13.95	0.91
2 MA	14.72	12.61	2.11	58.94	-44.22	13.11	1.61
3 SA	14.71	12.61	2.10	58.91	-44.20	13.95	0.76
4 SE	15.30	14.26	1.04	61.07	-45.77	14.74	0.56
5 C	14.24	12.61	1.63	57.18	-42.94	13.96	0.28
6 ESC	14.93	14.01	0.92	59.71	-44.78	14.53	0.40
7 WSC	14.65	12.61	2.04	58.69	-44.04	15.14	-0.49
8 ENC	13.56	12.61	0.95	54.69	-41.13	13.47	0.09
9 UM	12.94	12.61	0.33	52.42	-39.48	13.36	-0.42
10 WC	13.31	12.61	0.70	53.78	-40.47	14.53	-1.22
11 NW	13.49	12.61	0.88	54.43	-40.94	16.02	-2.53
12 MOU	14.00	12.61	1.39	56.30	-42.30	15.56	-1.56
13 CA	12.66	12.61	0.05	51.39	-38.73	15.37	-2.71
Average	14.19	12.88	1.31	56.85	-42.66	14.29	-0.10

Class I Differential ($/cwt)

Region	Actual	Perfect Competition	Difference	Monopoly	Difference	Cournot-Nash	Difference
1 NE	2.65	0	2.65	49.46	-46.81	1.88	0.77
2 MA	2.60	0	2.60	48.94	-46.34	1.04	1.56
3 SA	2.72	0	2.72	48.91	-46.19	1.88	0.84
4 SE	2.86	1.65	1.21	51.07	-48.21	2.67	0.19
5 C	2.34	0	2.34	47.18	-44.84	1.89	0.45
6 ESC	2.98	1.40	1.58	49.71	-46.73	2.46	0.52
7 WSC	2.65	0	2.65	48.69	-46.04	3.07	-0.42
8 ENC	1.63	0	1.63	44.69	-43.06	1.40	0.23
9 UM	1.16	0	1.16	42.42	-41.26	1.29	-0.13
10 WC	1.36	0	1.36	43.78	-42.42	2.46	-1.10
11 NW	2.12	0	2.12	44.43	-42.31	3.95	-1.83
12 MOU	2.06	0	2.06	46.30	-44.24	3.49	-1.43
13 CA	1.70	0	1.70	41.39	-39.69	3.30	-1.60
Average	2.28	0.27	2.01	46.85	-44.57	2.22	0.06

Table 6. Comparison of Milk Supply and Class I Demand in each Case with Observations.

Milk Supply (Million Pounds)

Region	Actual	Perfect Competition	Difference	Monopoly	Difference	Cournot-Nash	Difference
1 NE	4,454	4,371	83	4,848	-394	4,340	114
2 MA	21,648	21,048	600	26,129	-4,481	21,106	542
3 SA	3,786	3,741	45	3,887	-101	3,734	52
4 SE	5,903	5,771	132	7,034	-1,131	5,476	427
5 C	4,052	3,553	499	5,610	-1,558	3,470	582
6 ESC	2,918	2,906	12	3,479	-561	2,730	188
7 WSC	9,718	9,399	319	11,874	-2,156	9,402	316
8 ENC	14,750	14,533	217	20,114	-5,364	15,100	-350
9 UM	35,276	35,545	-269	37,636	-2,360	35,352	-76
10 WC	8,887	9,062	-175	14,115	-5,228	9,127	-240
11 NW	9,793	10,043	-250	11,878	-2,085	9,983	-190
12 MOU	5,304	5,260	44	6,192	-888	5,381	-77
13 CA	22,893	23,682	-789	26,348	-3,455	23,797	-904
Total	149,382	148,914	468	179,146	-29,764	148,995	387

Class I Demand (Million Pounds)

Region	Actual	Perfect Competition	Difference	Monopoly	Difference	Cournot-Nash	Difference
1 NE	2,902	2,971	-69	1,526	1,376	2,930	-28
2 MA	8,264	8,451	-187	4,341	3,923	8,407	-143
3 SA	3,084	3,154	-70	1,620	1,464	3,109	-25
4 SE	6,490	6,560	-70	3,423	3,067	6,528	-38
5 C	1,882	1,916	-34	985	897	1,888	-6
6 ESC	2,897	2,925	-28	1,524	1,373	2,909	-12
7 WSC	4,757	4,862	-105	2,498	2,259	4,732	25
8 ENC	8,157	8,247	-90	4,248	3,909	8,165	-8
9 UM	2,330	2,339	-9	1,207	1,123	2,318	12
10 WC	2,626	2,648	-22	1,365	1,261	2,588	38
11 NW	1,915	1,935	-20	997	918	1,858	57
12 MOU	2,447	2,485	-38	1,279	1,168	2,404	43
13 CA	6,540	6,544	-4	3,379	3,161	6,318	222
Total	54,292	55,038	-746	28,390	25,902	54,155	137

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