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IMPERFECT COMPETITION MODEL AND DEREGULATION:

U.S. DAIRY POLICY

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Abstract

An imperfect competition model of the U.S. milk market is developed for analyzing effects of dairy policy deregulation. Estimated "market power" parameters indicate the U.S. milk market has been getting more competitive over time. The usefulness of the model is demonstrated by showing the relative differences of dynamic simulation results among the imperfect competition model, an exogenous fluid (Class I) differential model, a perfect competition model, and a government control model.

Imperfect Competition Model and Deregulation: U.S. Dairy Policy

Introduction

On November 20, 1992, the U.S. and the European Community (EC) made a joint statement on the General Agreement on Tariffs and Trade (GATT) negotiation that "in agriculture we have resolved our differences on the main elements concerning domestic support, export subsidies and market access in a manner that should enable the Director General to move the negotiations to a successful conclusion."[1]

Now is the time to consider the impact of deregulation of the U.S. dairy industry, whose three main federal programs are the dairy price support program, federal milk marketing orders and import quotas. Some significant deregulative policy adjustment have already been implemented including sizeable cuts in the support price, which has increased volatility in milk prices. Although it is unclear how further deregulation will be implemented, an appropriate framework to evaluate its effects can be developed. Since the dairy industry is regulated by federal milk marketing orders which allows for price discrimination of milk in fluid and manufactured markets, the dairy industry operates under conditions that are not perfectly competitive. In addition to the premiums associated with the federal minimum Class I (fluid) differentials, dairy cooperatives use additional bargaining power to obtain over-order payments.

Existence of over-order payments indicate that some fluid

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[1]Night-Ridder Money Center News No.11435, November 20, 1992.

price differential might remain even after deregulation of federal milk marketing orders, support prices, and import quotas. A model incorporating conditions of less than perfect competition is necessary if one is to estimate how large the fluid differential might be without existing regulations. To determine the model of deregulation, the Class I, or fluid differential, must be endogenized.

The American Agricultural Economics Association Task Force Report stated in 1986 that "since the 1930's, agricultural economists have emphasized that some model beside pure competition is needed. But no one has yet proposed such a model in a form capable of generating comparative-static results concerning the effects of marketing orders as compared to no orders." (p. 34) As far as the authors know, this is the first imperfect competition model to include the Class I differential as an endogenous variable.

The purpose of this paper is to present an imperfect competition model to evaluate the market effects of deregulating the U.S. dairy industry, i.e., eliminating support prices, import quotas, and/or marketing orders. Dynamic simulations allow us to compare results from the imperfect competition model under deregulation with results from other conventional models.

In this study we use a time-specific, constant "market power" parameter to measure the degree of noncompetitiveness in the U.S. milk market. The parameter is related to "conjectural elasticity" (Appelbaum) in an individual firm level. While the conjectural variation (or elasticity) approach has been criticized by some game theorists (Tirole), our empirical definition of conjectural variations is different from the game theoretical one.[2] In this study "conjectural variations" language is not used in order to clearly show that our "market power" parameter is an aggregate indicator of market competitiveness and is different from the game theoretical definition of a conjectural variation or elasticity.

Imperfect Competition Created by Milk Marketing Orders and Dairy Cooperatives

At the turn of the century, about 40 years before federal milk marketing orders were introduced, dairy cooperatives introduced the use of classified pricing and pooling of funds to generate greater returns to dairy farmers (Cassels). However, they were not very successful largely due to independent producers. The problem arose because an independent farmer had an economic incentive to sell his milk to a fluid dealer rather than a cooperative because the fluid dealer could pay slightly more than the cooperative's pooled return or blend price, but still lower than cooperative's Class I (fluid) price. Due to the

[2]The approach's usefulness in empirical analyses to estimate the degree of noncompetitiveness in an industry has been widely accepted (Appelbaum; Azzam; Azzam and Pagoulatos; Azzam and Schroeter; Bresnahan 1982, 1989; Chen and Lent; Durham and Sexton; Holloway; Iwata; Karp and Perloff; Maier; Schroeter; Schroeter and Azzam; Sullivan; Suzuki, Lenz and Forker; Wann and Sexton; Wilson and Casavant).

independent-producer problem the cooperatives lobbied for and eventually obtained government regulation in the form of marketing orders (Novakovic and Pratt).

Under the marketing order system the minimum Class I differential is fixed by the federal government. However, the effective price for fluid milk use typically is higher than the minimum Class I price in most markets as a result of cooperatives' bargaining for over-order payments (Fallert, p. 154). Consequently, the effective fluid milk price differential is the minimum Class I differential plus any over-order payment.

It is argued that the degree of competitiveness among fluid milk processors and the bargaining power of cooperatives influences the magnitude of the over-order payments.[3] The ability of producers to negotiate over-order payments depends on the producer organization's share of the total supply. If milk handlers can buy milk from non-cooperative producers, it will be

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[3]The U.S. Department of Justice (USDJ) and the U.S. Department of Agriculture (USDA) have long battled over the legality of over-order payments (or premiums). The USDJ considers over-order payments as "undue price enhancement" (USDJ 1977, 1978; Baumer, Masson, and Masson; Madhavan, Masson, and Lesser; Masson and Eisenstat 1978, 1980). The USDA, on the other hand, considers over-order payments as the cost recovery for the cooperatives' service, such as the fine-tuning of prices to cover transportation costs not covered in federal order minimum prices; additional costs of standardizing milk to customers' needs in form, time, and place; and, in some cases, a pure negotiated price premium that may not be cost-related (Fallert; Jesse and Johnson; Babb; Babb and Bessler). Because many nearby reserve or surplus producing areas other than Minnesota and Wisconsin (M-W) have been developing (Buxton 1979; McDowell, Fleming, and Spinelli), it seems that Class I differentials do not have to cover full transportation costs from Eau Claire, Wisconsin to each market. While this debate is interesting, it is not the focus of the paper.

difficult for a cooperative group to obtain premiums above the minimum Class I price (Robinson, p. 115).

The existence of over-order payments probably implies that today's cooperatives could maintain classified pricing and pooling of funds even in the absence of marketing orders (Dobson and Salathe).[4] By using a model with the price differential as an endogenous variable one should be able to estimate the impact of the relationship between the degree of competition and the extent of regulation on producer blend returns.

Theoretical Model

To measure the degree of noncompetitiveness, a perfectly competitive market is defined as a basis of comparison. In a perfectly competitive market, cooperatives are without market power. In such a market, individual dairy farmers directly compete without any revenue pooling, and the price impacts of transportation and Grade A production costs can be ignored. According to Robinson,

> "Class II or manufacturing milk prices are approximately the same in all markets and are linked to the M-W price. Uniform pricing of manufacturing milk is necessary because products derived from surplus milk are easily transported between regions. Cheese, butter, and skim-milk powder produced in federal-order markets must compete with similar products manufactured from grade B milk in Minnesota and Wisconsin. Handlers operating in federal-order markets will not purchase surplus milk if it is priced higher than

[4]In areas where cooperatives have less market share such as the Northeast, they may not be able to maintain even the current minimum price differential without marketing orders. As a whole, however, this would not likely occur in most regions.

> what unregulated plants pay for manufacturing milk in the Midwest." (Robinson, p. 116)

Therefore, even without the federal order program one would expect a relatively uniform manufacturing milk price nationwide. In a perfectly competitive market, the fluid milk price and the manufacturing milk price would tend to be equal. This follows because farmers, without cooperative market power, would compete with each other in local markets until the price difference between fluid and manufacturing milk disappears. This implies that, in any market with reserve milk in excess of fluid needs,[5] the fluid and manufacturing milk prices would be equal. Consequently, in the absence of marketing orders and with cooperatives having no market power, a relatively uniform farm milk price would exist throughout the country.

If one specifies that, under imperfect competition, the role of dairy cooperatives is to allocate their raw milk supply to fluid and manufacturing markets so as to maximize total milk sales revenues, the first order condition is to equate marginal revenues from fluid and manufacturing milk. Under perfect

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[5]If a market has no milk in excess of fluid uses, there would be some locational or transportation differentials without marketing orders and cooperatives. This would occur because fluid plants tend to be located near population centers, while manufacturing plants tend to be located near farms. Consequently, fluid plants have to acquire and transport milk from further distances than manufactured processors. For simplicity, we ignore such possibilities because the number of deficit areas and the magnitude of fluid differentials would be difficult to predict. Several previous studies, which tried to estimate welfare losses caused by marketing orders, also assumed no differentials as a benchmark for comparison (Buxton 1977; Dahlgran; Ippolito and Masson; Masson and Eisenstat).

competition, the condition is simply expressed as:

(1) $P_f = P_m$,

where P_f is fluid milk price, P_m is manufacturing milk price.

Under monopoly or collusion, the condition is:

(2) $P_f(1 - 1/\epsilon) = P_m(1 - 1/\eta)$,

where $\epsilon = |(\partial Q_f/\partial P_f)\cdot(P_f/Q_f)|$ and $\eta = |(\partial Q_m/\partial P_m)\cdot(P_m/Q_m)|$ are price elasticities of fluid and manufacturing milk demand in absolute terms, respectively; Q_f is aggregate quantity of fluid milk marketed; and Q_m is aggregate quantity of manufacturing milk marketed.

To express an intermediate degree of imperfect competition, a "market power" parameter, θ, is introduced. Then, equality across markets of "perceived" marginal revenue is expressed as:

(3) $P_f(1 - \theta/\epsilon) = P_m(1 - \theta/\eta)$.

θ ($0 \leq \theta \leq 1$) is considered an aggregate indicator of cooperatives' market behavior. Cooperatives compete with each other and they sometimes have tacit or non-tacit coordination to restrict their competition. Their market power is reduced by the countervailing power of processors. θ aggregates all of these factors. Although processors' oligopsonistic power is not explicitly incorporated in the model, values of θ reflects their power. Because θ depends on the same cooperatives' behavior in both fluid and manufacturing markets, θ can be assumed to be the same for both markets. Marginal cost does not enter in equation (3) because milk production cannot be managed by cooperatives, but rather it is determined by individual farmers' response to blend prices they receive.

Because the "market power" parameter (θ) is not derived from demand or costs, but rather depends on behavior (Helpman and Krugman), it is difficult to estimate θ as a function of some explanatory variables. Instead, solving (3) for θ yields:

(4) $\theta = (P_f - P_m)/(P_f/\epsilon - P_m/\eta)$,

or (5) $\theta = (P_f - P_m)/[Q_m/(\partial Q_m/\partial P_m) - Q_f/(\partial Q_f/\partial P_f)]$.

With values of milk price elasticities estimated by demand functions and observations of P_f, P_m, Q_f, and Q_m, θ can be derived using (4) or (5), assuming that θ is constant in each time period and that cooperatives approximately realize the condition expressed by (3).[6]

The market power parameter can be considered independent of variables on the right hand sides of equations (4) and (5) because the parameter depends on behavior (Helpman and Krugman). This allows us to introduce the derived time-specific constant θ into the U.S. milk market model (Dixit; Suzuki, Lenz and Forker). Thus, the full dairy sector model with the fluid differential (P_f-P_m) endogenous is:

Milk production:

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[6]In this paper, θ is derived by estimating both fluid and manufacturing demand equations without directly estimating equation (3). Alternatively, one can estimate the fluid (manufacturing) demand equation and equation (3) into which the manufacturing (fluid) demand equation is substituted. In the alternative method, θ is directly estimated as a coefficient of (3) (Bresnahan 1982). However, it is difficult to capture time-varying θ's in the option because θ is estimated as an average value in the estimation periods.

(6) $Q = f(BP)$

Fluid milk demand:

(7) $Q_f = g(P_f)$

Manufacturing milk demand:

(8) $Q_m = h(P_m)$

Milk sales maximizing allocation:

(9) $P_f + \theta \cdot Q_f/(\partial Q_f/\partial P_f) = P_m + \theta \cdot Q_m/(\partial Q_m/\partial P_m)$

Milk uses identity:

(10) $Q \equiv Q_f + Q_m + FUSE$

Blend price:

(11) $BP = (P_f \cdot Q_f + P_m \cdot Q_m)/(Q - FUSE)$,

where Q is aggregate milk production, BP is blend price, and FUSE is on-farm use of milk produced (assumed to be exogenous), with all other variables as previously defined. With the six variables (Q, Q_f, Q_m, P_f, P_m, BP) taken as endogenous, the model can be solved simultaneously. Because this model expresses farmers' supply and processors' demand for raw milk, government purchases of dairy products and changes in commercial inventories are not treated separately, i.e., manufacturing milk demand (Q_m) includes commercial manufacturing demand, government purchases of dairy products, and changes in commercial inventories on a milk-equivalent basis.

Empirical Model Estimation[7]

[7]The data and sources are the same as Appendix B of Liu et al. (pp. 45-54).

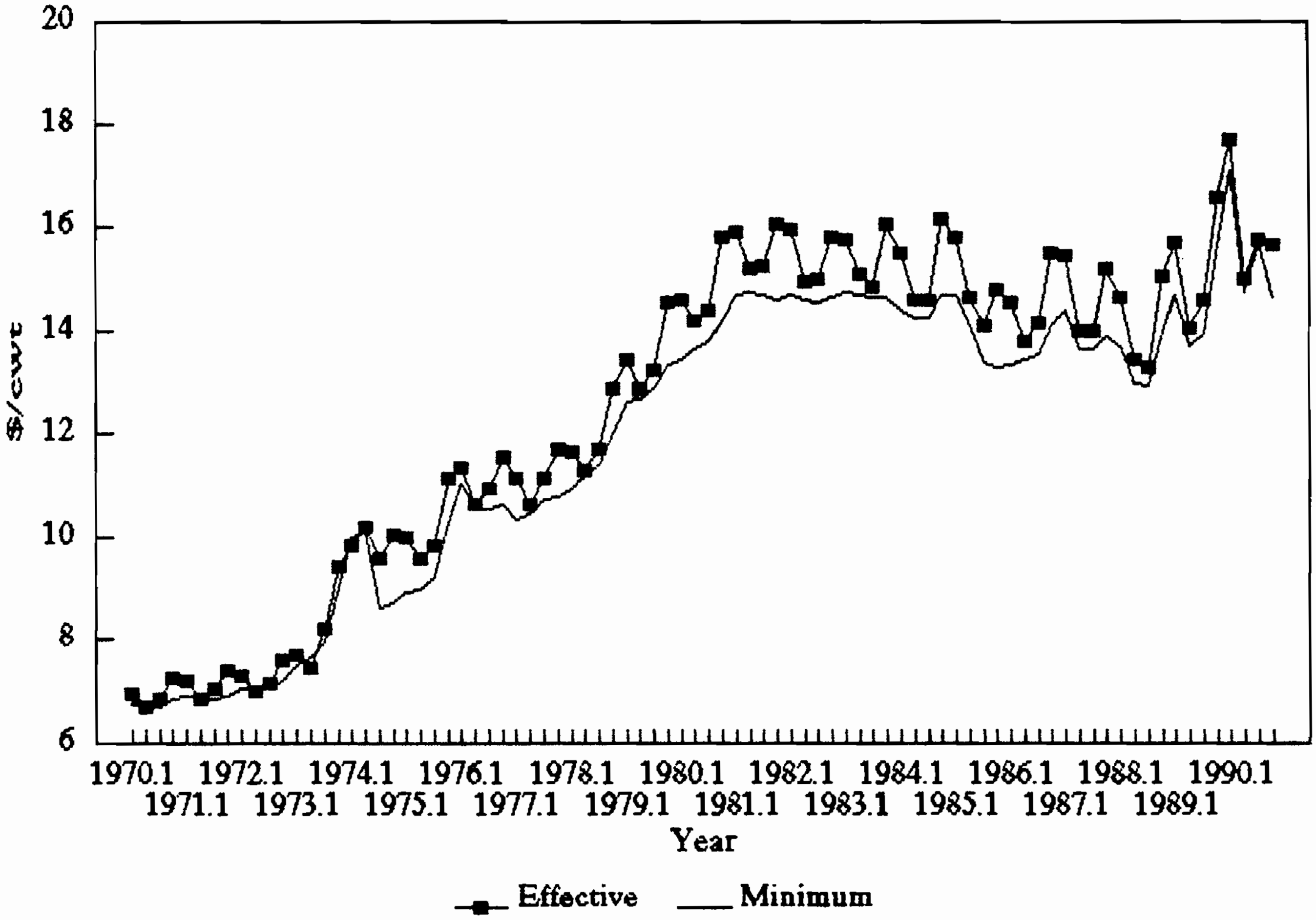
Over-Order Payment Data

The effective fluid milk price is equal to the M-W price (the manufacturing class price in most federal orders) + minimum Class I differential + over-order payment. Although the only available data on over-order payments pertain to "announced" over-order payments in 35 markets by USDA, it is difficult to collect the over-order payment data for all cooperatives over time and to make a national average time-series data. Instead, we estimate the effective fluid milk price (P_f) using the following equation;

$$(12)\quad P_f = [BP\cdot(Q\text{-}FUSE)-P_m\cdot Q_m)]/Q_f$$

The difference between Class II and III is minor and neglected. The blend price (BP) is the all milk price reported by USDA which is affected by over-order payments. The differences between the estimated effective fluid milk price and the minimum Class I price are shown in figure 1. The effective prices are higher than the minimum prices in almost all years, indicating the existence of over-order payments. Figure 1 implies that most previous models had an internal data inconsistency because they used the minimum Class I price and the all milk price.

Figure 1. Class I Prices



Supply Function

Milk supply (Q) is estimated as a function of the current and lagged milk-feed price ratio (MF = blend price / feed price), time trend (TREND) representing technical progress, intercept dummy variables for the Milk Diversion Program (MDP) and the Dairy Termination Program (DTP), and harmonic seasonality variables (SIN1, COS1, and COS2). The results are presented in table 1, along with the rest of the estimated equations. A polynomial distributed lag is imposed to account for lagged effects of MF. The second degree polynomial distributed lag with both endpoints constrained to lie close to zero, with the six quarter lag length, provided the most significant results. This lag length seems reasonable considering the biological reproduction cycle. The long run price elasticity of milk supply is 0.224, which is similar to Chavas and Klemme's estimated two-year price elasticity of 0.20. To overcome significant first-order autocorrelation in the disturbance term, the Cochrance-Orcutt procedure was employed. Two-Stage-Least-Squares (TSLS) estimation was used because both milk production and the blend price are endogenous in the model.

Fluid Milk Demand Function

The fluid milk demand function is a derived demand function at the processor level. All quantities in the model are measured on a milk-fat equivalent basis. Per capita fluid milk marketed (Q_f/N) is explained by the effective fluid milk price (P_f), per

Table 1. Estimated Equations

Milk Supply (1970.1 - 90.4)

$$\ln(Q)^{a} = 3.899 + 0.019\ \ln(MF) + 0.032\ \ln(MF)_{-1} + 0.040\ \ln(MF)_{-2}$$
$$(24.75)^{b}\quad (3.86)\quad (3.86)\quad (3.86)$$
$$+\ 0.043\ \ln(MF)_{-3} + 0.040\ \ln(MF)_{-4} + 0.032\ \ln(MF)_{-5}$$
$$(3.86)\quad (3.86)\quad (3.86)$$
$$+\ 0.019\ \ln(MF)_{-6} + 0.0039\ TREND - 0.024\ MDP - 0.041\ DTP$$
$$(3.86)\quad (8.17)\quad (-1.67)\quad (-2.94)$$
$$-\ 0.0053\ SIN1 - 0.052\ COS1 + 0.0071\ COS2 + 0.734\ (U^{Q})_{-1}$$
$$(-1.94)\quad (-19.57)\quad (5.40)\quad (7.57)$$

Adj. $R^2 = 0.95$ D.W. = 1.79

Fluid Demand (1975.1 - 90.4)

$$Q_f/N = -\ 0.077 - 0.105\ (P_f/CPI) + 0.0011\ (INC/CPI)$$
$$(-2.49)\quad (-3.16)\quad (2.70)$$
$$+\ 1.0\times10^{-7}\ (GA_f) + 1.7\times10^{-7}\ (GA_f)_{-1} + 2.0\times10^{-7}\ (GA_f)_{-2}$$
$$(3.10)\quad (3.10)\quad (3.10)$$
$$+\ 2.0\times10^{-7}\ (GA_f)_{-3} + 1.7\times10^{-7}\ (GA_f)_{-4} + 1.0\times10^{-7}\ (GA_f)_{-5}$$
$$(3.10)\quad (3.10)\quad (3.10)$$
$$+\ 6.8\times10^{-7}\ (BA_f) + 0.387\ AU19 + 0.0016\ SIN1 + 0.0023\ COS1$$
$$(2.60)\quad (4.85)\quad (8.28)\quad (10.15)$$
$$+\ 0.00018\ COS2 + 0.788\ (U^{Qf/N})_{-1}$$
$$(3.70)\quad (4.94)$$

Adj. $R^2 = 0.92$ D.W. = 2.02

Manufacturing Demand (1975.1 - 90.4)

$$Q_m/N = 0.378 - 1.113\ (P_m/CPI) - 0.0069\ (INC/CPI)$$
$$(4.66)\quad (-3.96)\quad (-3.55)$$
$$+\ 3.6\times10^{-7}\ (A_m) + 5.4\times10^{-7}\ (A_m)_{-1} + 5.4\times10^{-7}\ (A_m)_{-2}$$
$$(2.34)\quad (2.34)\quad (2.34)$$
$$+\ 3.6\times10^{-7}\ (A_m)_{-3} - 0.0059\ DTP + 0.018\ D89.4$$
$$(2.34)\quad (-1.71)\quad (2.80)$$
$$-\ 0.022\ D90.4 - 0.0013\ SIN1 - 0.0074\ COS1 + 0.00074\ COS2$$
$$(-3.16)\quad (-1.98)\quad (-9.08)\quad (2.12)$$
$$+\ 0.670\ (U^{Qm/N})_{-1}$$
$$(3.78)$$

Adj. $R^2 = 0.78$ D.W. = 1.74

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[a]Q is milk production (billion pound); MF is (blend price)/(feed price), where blend price is all milk price ($/cwt) and feed

price is U.S. average price of 16% protein dairy feed (\$/ton); TREND is time trend variable equal to 1 for 1970, quarter 1,...,; MDP is intercept dummy variable for the Milk Diversion Program equal to 1 for 1984, quarter 1 through 1985, quarter 2, equal to 0 otherwise; DTP is intercept dummy variable for the Dairy Termination Program equal to 1 for 1986, quarter 2 through 1987, quarter 3, equal to 0 otherwise; SIN1, COS1, and COS2 are harmonic seasonality variables representing the first wave of the sine function, the first wave of the cosine function, and the second wave of the cosine function, respectively; U_{-1} is lagged residual; Q_f is fluid milk marketed (billion pound); N is U.S. population (million person); P_f is effective Class I price estimated using equation (12) (\$/cwt); CPI is consumer price index for all items (1982-84 = 100); INC is disposable personal income per capita (\$1,000); GA_f and BA_f are generic and branded fluid advertising expenditures deflated by the media price index (\$1,000), respectively: AU19 is ratio of persons under 19 years old to the total population (total=1); Q_m is manufacturing milk marketed (billion pound); P_m is M-W price (\$/cwt); BA_m is branded manufacturing advertising expenditures (including branded butter advertising, branded ice cream advertising, and branded cheese advertising) deflated by the media price index (\$1,000); D89.4 is intercept dummy variable equal to 1 for 1989, quarter 4, equal to 0 otherwise; D90.4 is intercept dummy variable equal to 1 for 1990, quarter 4, equal to 0 otherwise.

[b]Figures in parentheses are t-values.

capita income (INC), the ratio of persons under 19 years old to the total population (AU19), current and lagged fluid advertising expenditures (branded BA_f, and generic GA_f), and harmonic seasonality variables (SIN1, COS1, and COS2). A polynomial distributed lag is imposed to account for lagged generic fluid advertising effects. The second degree polynomial distributed lag with both endpoints constrained to lie close to zero, with the five quarter lag length, provides the most significant results. The effects are the largest four to six months later and erode in about a year. No lagged effects of branded fluid advertising are found to be significant, but the current effect is significant. Calculated at mean data points, the elasticities of fluid demand with respect to price, income, and branded fluid advertising are -0.293, 0.483, and 0.0089, respectively. Liu, et al.'s estimated elasticities of retail fluid demand with respect to price and income were -0.282 and 0.154, respectively. The long run generic advertising elasticity is 0.054, which is similar to Kinnucan and Forker's estimate of 0.051 in New York City, but larger than Liu et al.'s estimate of 0.0175 for retail-level national fluid demand. The fluid demand function was estimated using a linear form because other functional forms (double-log, semi-log, log-inverse, and inverse) resulted in negative marginal revenue estimates and were thus rejected because negative fluid milk marginal revenue precludes discussion of the collusion case expressed by equation (2).[8] TSLS was used to estimate this equation because both quantity and price are endogenous in the model.

Manufacturing Milk Demand Function

The manufacturing demand function is a derived demand function for raw milk at the manufacturer level. Per capita manufacturing milk marketed (Q_m/N) is a function of the manufacturing milk price (P_m), per capita income (INC), the ratio of persons under 19 years old to the total population (AU19), current and lagged manufacturing milk advertising expenditures (branded BA_m, and generic GA_m), an intercept dummy variable for the DTP, and harmonic seasonality variables (SIN1, COS1, and COS2). Intercept dummy variables are also included for the fourth quarters of 1989 and 1990 because regression residuals for both periods were very large. The outlier for the fourth quarter of 1989 is likely due to the unusually strong demand for nonfat dry milk during that quarter, but we have no explanation for the fourth quarter of 1990 outlier. A polynomial distributed lag is imposed to account for lagged branded manufacturing advertising effects. The second degree polynomial distributed lag with both endpoints constrained to lie close to zero, with three quarter lag length, provides the most significant results. On the other hand, it is difficult to estimate any significant effects of

[8]The manufacturing demand function was also estimated using a linear form to be consistent with the fluid demand function.

generic manufacturing advertising. The variable, AU19, was also not significant. Consequently, these variables were dropped from the model. The estimated coefficient on income variable is negative, which is not consistent with what one would expect. Because each dairy product has a very different demand trend and structure, disaggregated estimation would likely produce better results, however, this is beyond the scope of our present analysis. Calculated at mean data points, the elasticities of manufacturing demand with respect to price and long run branded advertising are -1.575 and 0.234, respectively. The estimated price elasticity is relatively large compared to previous studies such as -0.928 by Liu, et al. Again, TSLS was used to estimate this equation because both manufacturing demand and price are endogenous in the model.

"Market Power" Parameter

A "market power" parameter's value of one implies monopoly or collusion and a value of zero implies perfect competition or price-taking behavior. As shown in table 2, derived annual average θ's using equation (4) or (5) indicate that the U.S. milk market is not perfectly competitive nor is it purely monopolistic. On a scale from 1 to 0, the data implies only slight "market power" which has been declining over time.

Table 2. Estimated "Market Power" Parameters (Annual Average)

Year	"Market Power" Parameter
1977	0.089 (0.029)[a]
1978	0.075 (0.024)
1979	0.076 (0.025)
1980	0.076 (0.025)
1981	0.076 (0.025)
1982	0.072 (0.024)
1983	0.071 (0.023)
1984	0.066 (0.022)
1985	0.073 (0.024)
1986	0.067 (0.022)
1987	0.069 (0.023)
1988	0.059 (0.019)
1989	0.052 (0.017)
1990	0.065 (0.022)

[a]Figures in parentheses are standard errors.

Simulations

To determine the validity of the estimated model in conducting analyses of deregulation, values for the endogenous variables, given the values for the exogenous variables, are determined in a fully dynamic simulation by the Gauss-Seidel technique for the historical period 1986-90. As illustrated by the mean absolute percent errors shown in table 3, the largest error is less than 4%, which is quite reasonable for a dynamic simulation.

Table 3. Mean Absolute Percent Errors[a]

Endogenous Variables	Mean Absolute Percent Error
	%
Fluid Milk Price (P_f)	3.34
Manufacturing Milk Price (P_m)	3.97
Blend Price (BP)	3.74
Fluid Milk Demand (Q_f)	1.23
Manufacturing Milk Demand (Q_m)	2.75
Milk Production (Q)	1.69

[a]The formula is: $(1/n)\sum|(P-A)/A|\times 100$, where P is the predicted value and A is the actual value.

It is unclear how deregulation will be implemented. Because our focal point is to examine the relative differences among model results with different degrees of competition, we assume that there is complete elimination of support prices, import quotas, and/or marketing orders. To simulate cases where the manufacturing milk market is open to foreign imports, equation (9) is replaced by

(13) $P_f + \theta \cdot Q_f/(\partial Q_f/\partial P_f) = P_m$,

assuming that the manufacturing milk price is given as the imported product price measured on a milk-fat equivalent basis. In addition, Q_m is replaced by Q_{mI} (total manufacturing milk demand including dairy imports in milk equivalents) in (8), i.e.:

(14) $Q_{mI} = h(P_m)$

In addition, the following definitional identity for imports is added.

(15) $Q_I \equiv Q_{mI} - Q_m$,

where Q_I is dairy imports in milk equivalents.

Model 1. Imperfect Competition

Given these assumptions, our imperfect competition model for simulation in a case where there are no price supports, no import quotas, and no marketing orders is:

(16) $Q = f(BP)$

(17) $Q_f = g(P_f)$

(18) $Q_{mI} = h(P_m)$

(19) $P_f + \theta \cdot Q_f/(\partial Q_f/\partial P_f) = P_m$

(20) $Q \equiv Q_f + Q_m + FUSE$

(21) $BP = (P_f \cdot Q_f + P_m \cdot Q_m)/(Q - FUSE)$

(22) $Q_I \equiv Q_{mI} - Q_m$,

We refer to this model as Model 1.

Model 2. Exogenous Class I Differential

If one does not have an imperfect competition model to estimate the fluid differential after deregulations, a possible second option may be to assume that the current effective fluid differential remains unchanged even after deregulations. To contrast this second best option with Model 1, the second model replaces equation (19) with:

(23) $P_f = P_m + DIFF$,

where DIFF is the exogenous Class I differential. Previous models, such as the Ministerial Trade Mandate (MTM) model of the Organization for Economic Cooperation and Development (OECD) and USDA's SWOPSIM have specified an exogenous Class I differential (OECD; Roningen).

Model 3. Perfect Competition

As discussed earlier, in the perfectly competitive case, where cooperatives have no market power and there are no price supports, no import quotas, and no marketing orders, fluid differentials are not likely to exist. For this situation, (19) is replaced by

(24) $P_f = P_m$.

This is the perfect competition model (Model 3).

Model 4. Government Control

If marketing orders were maintained in the absence of price supports and import quotas, the federal government can attenuate the negative farm-level effects by setting any minimum Class I price (for example, keeping the current level), or increasing the minimum Class I differential. This policy choice is also worth simulating for comparison. We simulate a case where the government maintain the minimum Class I price level. For this situation, (19) is replaced by

(25) $P_f = P_I$,

where P_I is current minimum Class I price (Model 4). The characteristics of these four models are summarized in table 4.

Table 4. Characteristics of the four models

	Price Supports	Import Quotas	Marketing Orders	Dairy Coops	Fluid Differential
Model 1	no	no	no	yes	determined reflecting coops' current market power
Model 2	no	no	no	yes	current effective differential kept constant
Model 3	no	no	no	no	no differential
Model 4	no	no	yes	yes	current minimum Class I price kept unchanged

The manufacturing price (P_m) level must be specified for all four models. Because our model is a single-country model, we cannot determine the level endogenously by solving a multi-country model such as OECD's MTM, or USDA's SWOPSIM (OECD; Roningen). Several studies have estimated trade liberalization effects using a multi-country model, and have shown that world dairy product prices would be substantially higher in the long run (Blayney and Fallert, p.39). Although the U.S. domestic dairy product prices were two to three times higher than the world prices in mid 80's, both prices have been getting closer in the past two or three years. Estimates of the differences between domestic and world prices vary widely depending on choice of a base year for simulation. As our focal point is to examine the differences among four model results with different degrees of competition, we assume a 20% decline from the current P_m level for each year as an example.

Comparison of Simulation Results

We use the historical time periods for our simulations to avoid having to estimate the future values for exogenous variables. Our dynamic simulation results from 1986 to 1990 are shown in figures 2 through 4.

Model 1 is a base simulation for comparison because our purpose is to illustrate the usefulness of the proposed imperfect competition model. Comparison of Model 1 with Models 2 and 3 illustrates how the imperfect competition model yields more accurate estimates of deregulation effects than the conventional exogenous differential and perfect competition models would. Comparison of Model 1 with Model 4 examines how the negative effects of deregulations are attenuated by keeping the current minimum Class I price level.

The differences in results between the imperfect competition and exogenous differential models tend to be less than 7%. For instance, Model 2's results show that, compared to Model 1, the fluid milk price would be 2.6% to 6.7% lower, the blend price would be 1.2% to 3.1% lower, and milk production would be 0.4% to 0.6% smaller.

In the imperfect competition model, $\partial P_f/\partial P_m$ is expressed by

(26) $\partial P_f/\partial P_m = 1/(1 + \theta) = 0.942,$

where 0.942 is an average of simulation periods. This means that fluid milk prices decline by 94% of the magnitude of manufacturing price declines. On the other hand, in the exogenous differential model,

(27) $\partial P_f/\partial P_m = 1.$

Therefore, the exogenous differential model should overestimate the negative effects of deregulations compared to the imperfect competition model, but the differences should be relatively small in the U.S. milk market. As equation (26) shows, the larger θ is, the smaller $\partial P_f/\partial P_m$. In other words, as the market becomes less competitive, the gap between the fluid milk price and the manufacturing milk price becomes higher.

Not surprisingly, the negative effects of deregulations on farmers are estimated to be much larger in the perfect competition model. Model 3 's results show that, compared to Model 1, the fluid milk price would be 17% to 42% lower, the blend price would be 8.5% to 23% lower, and milk production would be 2.9% to 4.0% smaller. Because dairy cooperatives with market power would exist even after deregulations, Model 3's results would not be realistic.

If the government maintained marketing orders and the current minimum Class I price level, the negative effects of deregulations would be attenuated. Model 4's results show that, compared to Model 1, the fluid milk price would be 0.4% to 15%

higher, the blend price would be 0.1% to 6.0% higher, and milk production would be 0.4% to 0.9% larger. It should be noted that the negative effects estimated by Model 4 would be smaller than by Model 1, only when

(28) $\Delta P_m \cdot (\partial P_f / \partial P_m) > P_f - P_I$,

where ΔP_m is the magnitude of manufacturing milk price declines in absolute terms, the average value of $\partial P_f / \partial P_m$ is 0.942, and $P_f - P_I$ is the over-order payment. In other words, keeping the current minimum Class I price level would be useful to attenuate the deregulation effects when the magnitude of manufacturing milk price declines is larger than $(P_f - P_I)/(\partial P_f / \partial P_m)$.

Figure 2. Simulated Fluid Milk Prices

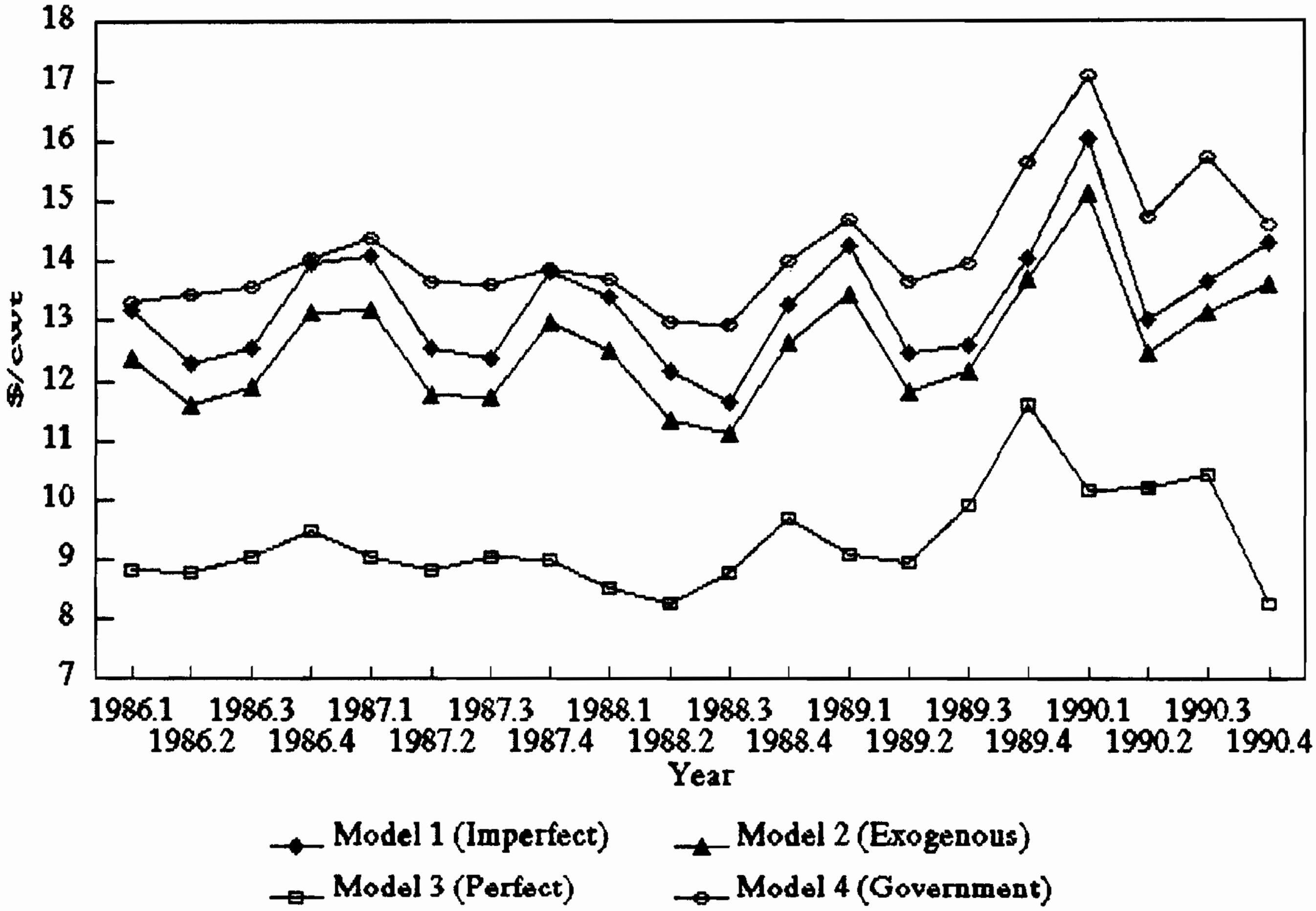


Figure 3. Simulated Blend Prices

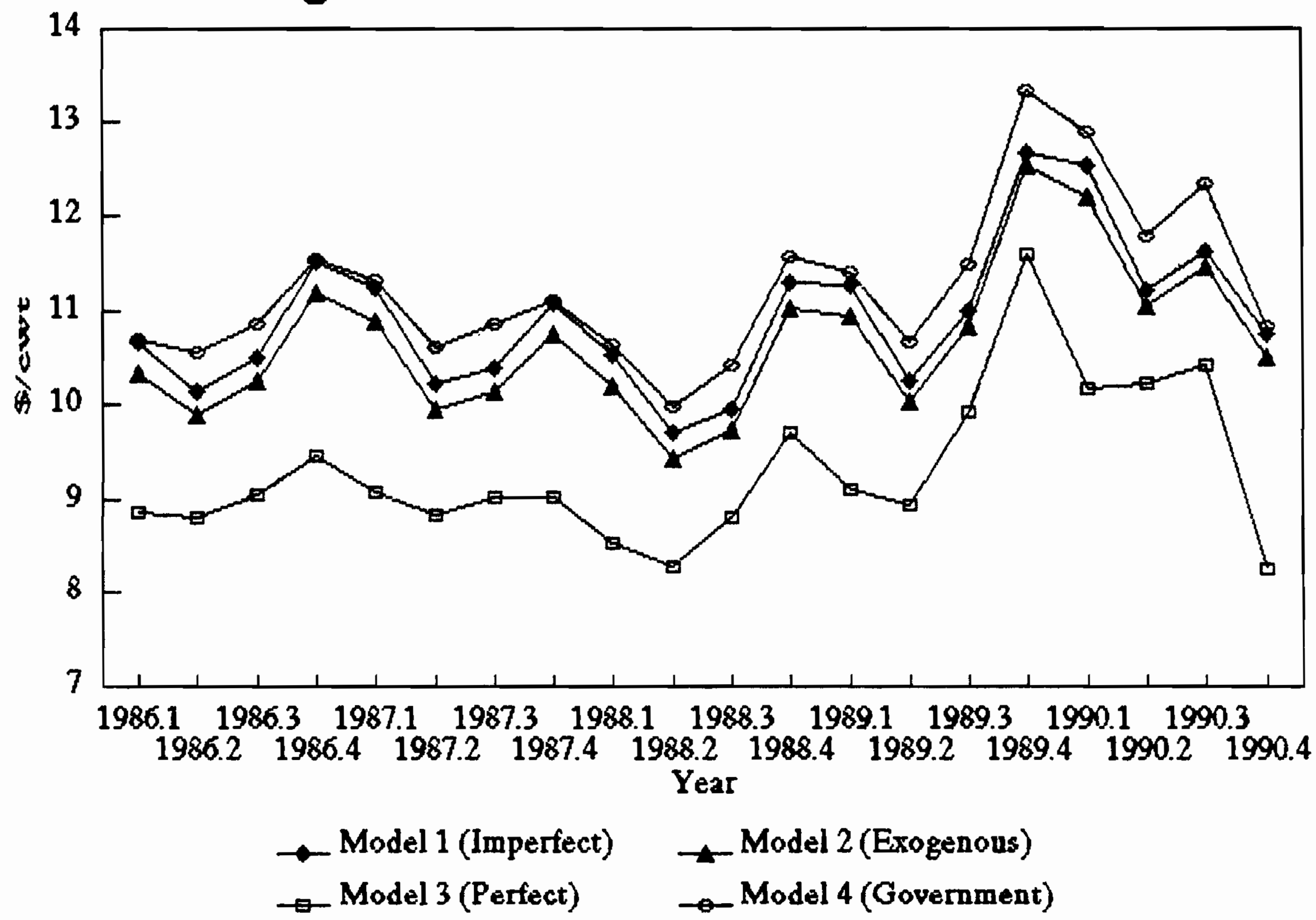
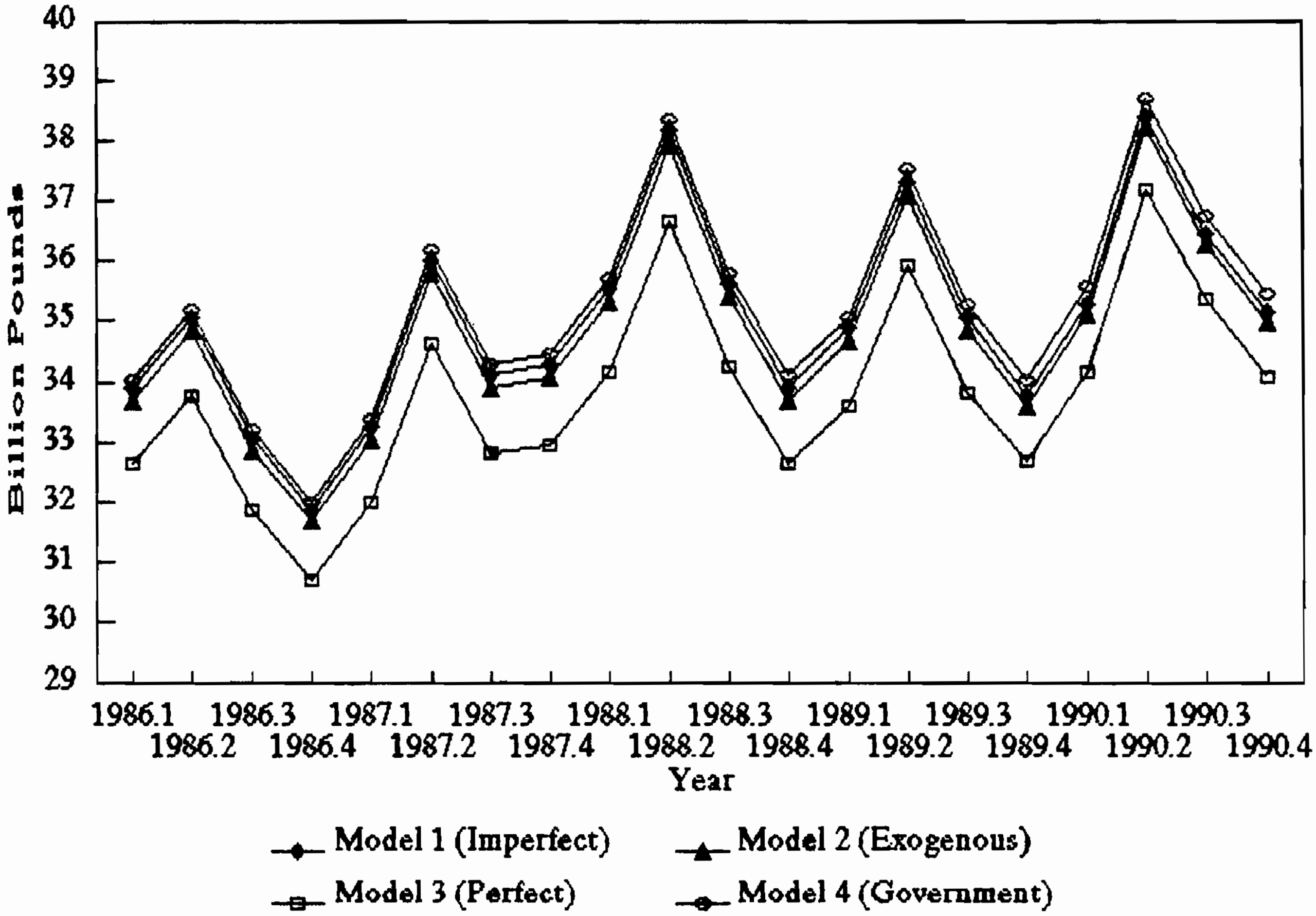


Figure 4. Simulated Milk Production



Conclusions

This is the first development of an imperfect competition model for the U.S. dairy market using "market power" parameter estimates. Our estimated parameters implies that there is only slight "market power" which has been declining over time.

The usefulness of the model is demonstrated by showing the relative differences of dynamic simulation results among the imperfect competition model, an exogenous fluid (Class I) differential model, a perfect competition model, and a government control model.

Because fluid milk prices decline by about 94% of the magnitude of manufacturing price declines under the current degree of competitiveness, the exogenous differential model overestimates the negative effects of deregulations compared to the imperfect competition model. The perfect competition model greatly overestimates the negative impacts of deregulations as long as dairy cooperatives with market power remain after deregulations. The imperfect competition model improves the overestimation by conventional models.

When the magnitude of manufacturing milk price declines is larger than (over-order payment) / 0.94, the negative effects of deregulations can be attenuated by keeping the current minimum Class I price level. The imperfect competition model provide a basis to evaluate the usefulness of the government policy options.

References

American Agricultural Economics Association. Federal Milk Marketing Orders: A Review of Research on Their Economic Consequences. Occasional Paper No. 3 by the Task Force on Dairy Marketing Orders, June 1986.

Appelbaum, E. "The Estimation on the Degree of Oligopoly Power." J. Econometrics 19(1982):287-99.

Azzam, A. M., and E. Pagoulatos. "Testing Oligopolistic and Oligopsonistic Behavior: An Application to the U.S. Meat-Packing Industry." J. Agr. Econ. 41(1990):362-70.

Azzam, A. M., and J. R. Schroeter. "Implications of Increased Regional Concentration and Oligopsonistic Coordination in the Beef Packing Industry." West. J. Agr. Econ. 16(1991):374-81.

Azzam, A. M. "Testing the Competitiveness of Food Price Spread." J. Agr. Econ. 43(1992):248-56.

Babb, E. M., and D. A. Bessler. Factors Affecting Over-Order Payments in Federal Milk Marketing Orders 1965-80. Research Bulletin 977, Agricultural Experiment Station, Purdue University, June 1983.

Babb, E. M. Case Studies of Over-Order Payments in Federal Milk Marketing Orders. Staff Paper 557, Food and Resource Department, University of Florida, May 1989.

Babb, E. M. Over-Order Payments in Federal Milk Marketing Orders, 1970-87. Staff Paper 371, Food and Resource Economics Department, University of Florida, November 1989.

Baumer, D. L., R. T. Masson, and R. A. Masson. "Curdling the Competition: An Economic and Legal Analysis of the Antitrust Exemption for Agriculture." Villanova Law Review 31(1986): 183-252.

Blayney, D. P., and R. Fallert. The World Dairy Market - Government Intervention and Multilateral Policy Reform. Staff Report AGES 9053, U.S. Dept. of Agriculture, Economic Research Service, Washington DC, August 1990.

Bresnahan, T. B. "The Oligopoly Solution Concept is Identified." Economics Letters 10(1982):87-92.

Bresnahan, T. B. "Empirical Studies of Industries with Market Power." In Handbook of Industrial Organization, Volume II, edited by R. Schmalensee and R. D. Willig, 1011-57. Amsterdam: Elsevier Science Publishers B. V., 1989.

Buxton, B. M. "Welfare Implications of Alternative Classified Pricing Policies for Milk." Amer. J. Agr. Econ. 59(1977):525-29.

Buxton, B. M. "Post-Regulation Research: Milk Marketing Order Regulations." Amer. J. Agr. Econ. 61(1979):779-86.

Cassels, J. M. A Study of Fluid Milk Prices. Cambridge: Harvard University Press, 1937.

Chavas, J-P., and R. M. Klemme. "Aggregate Milk Supply Response and Investment Behavior on U.S. Dairy Farms." Amer. J. Agr. Econ. 68(1986):55-66.

Chen, Z., and R. Lent. "Supply Analysis in an Oligopsony Model." Amer. J. Agr. Econ. 74(1992):973-79.

Dahlgran, R. A. "Welfare Costs and Interregional Income Transfers Due to Regulation of Dairy Markets." Amer. J. Agr. Econ. 62(1980):288-96.

Dixit, A. "Optimal Trade and Industrial Policies for the US Automobile Industry." In Empirical Methods for International Trade, edited by R. Feenstra, 141-65. Cambridge: The MIT Press, 1988.

Dobson, W. D., and L. E. Salathe. "The Effects of Federal Milk Orders on the Economic Performance of U. S. Milk Markets." Amer. J. Agr. Econ. 61(1979):213-27.

Durham, C. A. and R. J. Sexton. "Oligopsony Potential in Agriculture: Residual Supply Estimation in California's Processing Tomato Market." Amer. J. Agr. Econ. 74(1992):962-72.

Fallert, R. F. "Federal Milk Marketing Order Issues and Research Needs." in Dairy Models and Modeling for Policy Analysis: Concepts and Issues. Proceedings of a Seminar Sponsored by NC-176, NE-153, and S-166, 153-61, Ohio State University, October 1986.

Helpman, E., and P. K. Krugman. Trade Policy and Market Structure. Cambridge: The MIT Press, 1989.

Holloway, G. J. "The Farm-Retail Prices Spread in an Imperfectly Competitive Food Industry." Amer. J. Agr. Econ. 73(1991):979-89.

Ippolito, R. A., and R. T. Masson. "The Social Cost of Government Regulation of Milk." J. Law and Econ. 21(1978):33-65.

Iwata, G. "Measurement of Conjectural Variations in Oligopoly." Econometrica 42(1974):947-66.

Jesse, E. V., and A. C. Johnson, Jr. An Analysis of Cooperative Over-Order Pricing of Fluid Milk. Technical Bulletin 1708, U.S. Dept. of Agriculture, Economic Research Service, Washington DC, August 1985.

Karp, L. S., and J. M. Perloff. "Dynamic Oligopoly in the Rice Export Market." Rev. Econ. and Statist. 71(1989):462-70.

Kinnucan, H. W., and O. D. Forker. "Allocation of Generic Advertising Funds Among Products: A Sales Maximization Approach." Northeast. J. Agr. and Resource Econ. 17(1988):64-71.

Liu, D. J., H. M. Kaiser, O.D. Forker, and T. D. Mount. The Economic Implications of the U.S. Generic Dairy Advertising Program: An Industry Model Approach. A. E. Research 89-22, Dep. Agr. Econ., Cornell University, November 1989.

Madhavan, A. N., R. T. Masson, and W. H. Lesser. Cooperation for Monopolization?: An Empirical Analysis of Cartelization. July 1992.

Maier, L. The Costs and Benefits of U. S. Agricultural Policies with Imperfect Competition in Food Manufacturing. Cornell University Ph. D thesis, 1991.

Masson, R. T., and P. M. Eisenstat. "The Pricing Policies and Goals of Federal Milk Order Regulations: Time for Reevaluation." South Dakota Law Review 23(1978):662-97.

Masson, R. T., and P. M. Eisenstat. "Welfare Impacts of Milk

Orders and the Antitrust Immunities for Cooperatives." Amer. J. Agr. Econ. 62(1980):270-78.

McDowell, H., A. Fleming, and F. Spinelli. U.S. Milk Markets under Alternative Federal Order Pricing Policies. Staff Report AGES 9068, U.S. Dept. of Agriculture, Economic Research Service, Washington DC, November 1990.

Novakovic, A. M., and J. Pratt. Geographic Price Relationships under Federal Milk Marketing Orders. A. E. Research 91-8, Dep. Agr. Econ., Cornell University, September 1991.

Organization for Economic Cooperation and Development (OECD). The OECD Ministerial Trade Mandate Model for Policy Analysis: Documentation. OECD/GD(91) 159,Paris, August 1991.

Robinson, K. L. Farm and Food Policies and Their Consequences. Prentice-Hall Inc., New Jersey, 1989.

Roningen, V. O. A Static World Policy Simulation (SWOPSIM) Modeling Framework. Staff Report AGES 860625, U.S. Dept. of Agriculture, Economic Research Service, Washington DC, August 1985.

Schroeter, J. R. "Estimating the Degree of Market Power in the Beef Packing Industry." Rev. Econ. and Statist. 70(1988): 158-62.

Schroeter, J. R., and A. M. Azzam. "Marketing Margins, Market Power, and Price Uncertainty." Amer. J. Agr. Econ. 73(1991): 990-99.

Sullivan, D. "Testing Hypotheses about Firm Behavior in the Cigarette Industry." J. Polit. Econ. 93(1985):586-98.

Suzuki, N., J. E. Lenz, and O. D. Forker. "A Conjectural Variations Model of Reduced Japanese Milk Price Supports." Amer. J. Agr. Econ. 75(1993):210-18.

Tirole, J., The Theory of Industrial Organization. The MIT Press, 1988.

U. S. Department of Justice. Milk Marketing - A Report of the U. S. Department of Justice to the Task Group on Antitrust Immunities. January 1977.

U. S. Department of Justice. Response to the USDA Comments on the Department of Justice Report on Milk Marketing. October 1978.

Wann, J. J., and R. J. Sexton. "Imperfect Competition in Multiproduct Food Industries with Application to Pear Processing." Amer. J. Agr. Econ. 74(1992):980-90.

Wilson, W. W., and K. L. Casavant. "Some Market Power Implications of the Shipping Act of 1984: A Case Study of the U.S. to Pacific Rim Transportation Markets." West. J. Agr. Econ. 16(1991):427-34.

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