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Assessment of the Political Market Power of Milk Producers Reflected in U.S. Milk Pricing Regulations

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ABSTRACT

ASSESSMENT OF THE POLITICAL MARKET POWER OF MILK PRODUCERS REFLECTED IN U.S. MILK PRICING REGULATIONS

We investigate revealed political market power reflected in prices of a government-organized cartel of milk producers that practices price discrimination, but does not control overall production. Under U.S. milk marketing orders, processors pay minimum prices for raw milk according to the end-uses to which milk will be put. The minimum prices applied to beverage uses vary by region.

We assess the political market power of milk producers relative to buyers in two ways. First, we consider the profit-maximizing pattern of price discrimination for producers in each region. Government-sanctioned regional cartels act as monopolists in regional beverage milk markets and oligopolists in the national market for manufacturing milk products. Our model allows for monopoly solutions in regional markets and a Nash equilibrium in the national market. We simulate the implied price differentials with representative parameters for demand and supply elasticities. Actual price differentials are far below those consistent with profit maximization by the producer cartels. The announced price differentials are about seven percent of simulated price differentials, implying that the government-set prices are far below those that maximize producer returns and are consistent with a significant role for buyers and others in the political process.

Second, we develop a model of policy preference functions that allows for several regional regulators. In our model, regulators choose price differentials to maximize policy preferences given welfare weights between consumer surplus and producer surplus. In addition to the regional beverage milk market, regulators account for the impact of their own local decisions on the national manufacturing milk price. With broadly accepted elasticities from the literature, we derive the welfare weights that are implied by actual price differentials. The derived welfare weights imply that the political market power of milk producers is also about seven percent of that implied by full monopoly power. These results suggest that in setting price differentials, milk producers have more political weight than buyers, but that their political power is small relative to full monopoly power in setting prices.

JEL Classification: *L12, L13, L43, L66, O18*

Assessments of the Political Market Power of Milk Producers Reflected in U.S. Milk Pricing Regulations

I. Introduction

Agricultural policies that control quantity supplied or price may have effects on the market that are similar to those of monopolists or oligopolists that exercise market power. Examples of policies that may create market power for producers include special legal provisions for agricultural cooperatives (the Clayton Act of 1914, the Capper Volstead Act of 1922, the Cooperative Act of 1926, and the Agricultural Marketing Act of 1929) and milk marketing orders that provide price discrimination and pooling, production or marketing quotas (Milk marketing orders were established based on the Agricultural Act of 1935 and the Agricultural Marketing Agreement Act of 1937). Numerous studies examine the effects of these policies (see Balagtas and Sumner, 2006 for a review) but few studies investigate the political power of producers that make the implementation of these policies possible.

Often, the political power of producers imputed by policies is assessed in the context of political equilibrium between interest groups, as in Krueger (1974) and Zusman (1976). The political equilibrium attained by agricultural policies is usually explored using the policy preference function, as in the studies reviewed by De Gorter and Swinnen (2002). In the policy preference function approach, the implementation of a certain level of policy is understood as the regulator's decision in the problem of maximizing weighted social surplus. Thus, different sets of welfare weights between interest groups are considered to yield different levels of implemented policy. The welfare weights in the policy preference function are often regarded as indicators of political power, since the regulator's assignment of welfare weights to each interest group is affected by relative political power between those groups. In this context, most studies that have used the policy preference function assess political power using the welfare weights imputed by the observed level of policy. Notable examples include Rausser and Freebairn (1974), Sarris and Freebairn (1983), Gardner (1987), Lopez (1989), Rausser and Foster (1990), Beghin and Foster (1992), and Swinnen and de Gorter (1998). However, these studies do not address the link between implemented level of policy and market power, and neglect the possibility of politically-created market power. In other words, previous studies do not explore the full linkage between political power, implemented policies and market power. We extend this literature by drawing the parallel with Ramsey pricing.

In this paper, we investigate revealed political market power reflected in prices of a government-organized cartel that practices price discrimination, but does not control overall production. We suggest ways to assess market power created by policy that is driven by relative political power between interest groups in the milk markets. To incorporate key characteristics of milk pricing policy, we develop price differential models that simultaneously allow monopoly solutions in regional beverage milk markets and an oligopoly solution in the national market for manufacturing milk products. We also develop a model of policy preference functions that allows for several regional regulators. We model political markets in which regulators account for the impact of their own local decisions on the national manufacturing milk price, in addition to the impacts on the regional beverage milk market.

The dairy industry is large, geographically diverse and is governed by an inordinately complex array of government programs. Farm value of milk production was about $27 billion in 2004 and retail value of dairy products was several multiple of this value. Thus understanding the effects of political market power in milk pricing is of interest in its own right. Furthermore, examining market power implied by the government-run dairy cartel is helpful in understanding government regulation of industry pricing more broadly.

In the next section, we describe conceptual framework for assessing political market power. In section III, We present models to assess political market power of milk producers. We discuss how we derive optimal price differentials that yield maximum profits to producers and explain how we derive the welfare weights imputed by observed price differentials. In section IV, we explain the data and parameters that are used in the models and present the results of political market power assessments. We summarize the analyses and draw conclusions in Section V.

II. Conceptual framework for assessing political market power

The policy preference function has been widely used in modeling the political equilibrium between interest groups. As defined by Sarris and Freebairn(1983), Lopez (1989), Rausser and Foster (1990), Oehmke and Yao (1990), Beghin and Foster (1992), Swinnen and de Gorter (1998), and de Gorter and Swinnen (2002), the standard form of policy (or political) preference function considers producers and consumers as interest groups in the political market. Consider the following equation:

$$(1)\quad \underset{P}{Max}\, PPF = (1-w)Z(P) + w\prod(P)$$

, where w is welfare weight, $Z(P)$ is surplus for consumers, $\prod(P)$ is surplus for producers, and P is a policy instrument. In this setting, the observed policy level $\overline{P}$ is understood as the one that maximizes policy preference function of equation (8) given the welfare weight *w*.

II.1. Relationship between the policy preference function approach and Ramsey pricing

We propose that the policy preference function can be understood in the spirit of Ramsey pricing (Ramsey, 1927). Within the Ramsey pricing model, the Ramsey price is typically described as the price that maximizes consumer surplus subject to a constraint of some fixed level (often zero) of firm profits. In milk marketing orders, for which we assess political market power by producers as a case study, the marketing order regulation that creates the price differential shifts surplus from consumers to producers. Thus the context is different but the same idea is applied.

To frame the regulation that shifts surplus from consumers to producers in a standard Ramsey pricing scheme, we consider a maximization of consumer surplus subject to a constraint that assumes producer profits of positive value from zero. We assume that the regulator's objective is to achieve the profits of $\prod^R$ for producers. Then, the most efficient way for the regulator to obtain this policy objective is to maximize consumer surplus by guaranteeing at least the target level of profits $\prod^R$ for producers. We can define this problem as $\underset{p}{Max}\, Z(P)$ subject to $\prod(P) \geq \prod^R$, where *Z(P)* is total surplus obtained by all the consumers, and *P* is a policy instrument. An equivalent mathematical expression of the problem is to maximize producer profits subject to a constraint on consumer welfare (i.e., $\underset{p}{Max} \prod(P)$ subject to $Z(P) \geq Z^R$). When the policy instrument is price, this problem is the same as standard Ramsey pricing, one form of second-best pricing for a regulated firm (Ramsey, 1927; Baumol and Bradford, 1970; Ross, 1984).

If we set up a Lagrangian for this problem, we have the following equation:

(2) $\underset{P}{Max}\, L = Z(P) + \lambda(\prod(P) - \prod^{R})$.

If we rewrite λ in equation (2) as $\frac{w}{1-w}$, equation (2) is a different expression of equation (1) in that the policy level $\overline{P}$ that maximizes equation (1) also maximizes the objective function of equation (2). This implies that we can understand the policy preference function in the spirit of the regulator's application of the Ramsey-Pricing scheme.

To interpret equation (1) in a Ramsey pricing scheme, λ must be positive, since the weight *w* is between zero and 1 ($0 \le w \le 1$). In this case, positive λ forces producer profits to be fixed at $\prod^{R}$ by the condition of complementary slackness ($\lambda(\prod(P) - \prod^{R}) = 0$ and $\lambda \ge 0$ or $\prod(P) - \prod^{R} \ge 0$). This fact suggests that the profits attained by producers at the policy level $\overline{P}$ is the one that the regulator wants to achieve. As we show in next sections, larger λ corresponds to higher producer profits.

II.2. Two ways of assessing the degree of political market power

The policy preference function of equation (1) includes three interesting cases as presented in table 1. When the welfare weight is 1 (*w*=1), the problem defined by equation (1) is the profit maximization problem of a monopoly or cartel of producers. When the welfare weight is 0.5 (*w*=0.5), the problem is equal to the competitive equilibrium. When the welfare weight is between 0.5 and 1 (0.5 < *w* < 1), the problem describes an equilibrium in an oligopoly market. These cases help us understand the transformation between political power and market power. Since there is a one to one relationship between w and policy level P, and between w and the degree of market power, we can employ two methods of assessing the degree of political market power reflected in the observed policy level $\overline{P}$. If we derive the welfare weight $\overline{w}$ that is imputed by the observed policy level $\overline{P}$, we can assess the degree of political market power reflected in $\overline{P}$ by $\frac{\overline{w}-0.5}{1-0.5}$. If we derive the policy level P_m that is a solution of equation (1) under w=1, the degree of political market power reflected in $\overline{P}$ can be measured by $\frac{\overline{P}-P_0}{P_m-P_0}$, where P_0 is the policy level that yields the competitive solution. (In a Ramsey pricing setting, P_0 is the competitive price determined by supply and demand).

III. Models for assessing political market power of producers reflected in US milk pricing regulation

We apply the presented ways to assess political market power of producers reflected in U.S. milk pricing regulations. U.S. milk pricing provides us with a unique opportunity to model political market power of producers in terms of three different aspects. First, most milk produced in United States is marketed through federal or state milk marketing orders. Milk marketing orders regulate price differentials in regional beverage milk markets and the national manufacturing milk market. Milk marketing orders do not control milk production to regulate price differentials. Thus, in the policy preference function model that we want to apply, the choice variable must be the price differential rather than prices or quantity supplied to markets. Second, as discussed later, the choices of price differentials in each region determine the allocation of milk between the regional beverage and national manufacturing milk markets, and consequently the regional beverage milk and national manufacturing milk prices. This implies that to derive welfare weights $\overline{w}$ that yield observed price differentials, we need to develop a policy preference function model in which regulators account for the impact of their own local decisions on the national manufacturing milk price. Thus an empirical model that allows several regulators is needed. Third, the fact that manufacturing milk price is determined by the summation of the quantity supplied from each region implies that the regional cartels of producers, which choose each region's P_m in the previous section, cannot exercise monopoly power in the national manufacturing milk market. Thus to derive each region's P_m, we need a unique model in which regional cartels act as monopolists in regional beverage milk markets and oligopolists in the national manufacturing milk market.

III.1. Brief description of milk marketing orders

Since 2000 11 federal marketing orders (Northeast, Appalachian, Southeast, Florida, Mideast, Upper Midwest, Central, Southwest, Arizona-Las Vegas, Western, Pacific Northwest) have been operating in the US.[1] About 70 percent of all US milk is sold through federal marketing orders. Most of the remaining milk is marketed under state marketing orders. The California milk marketing order alone regulates about 20 percent of U.S. milk marketing. Under milk marketing orders, processors must pay minimum prices for Grade A milk according to different end-uses. Class I is the milk used for bottling purposes, Class II is the milk for soft manufactured products, Class III is the milk used to make cheese, and Class IV is the milk used to make butter and nonfat dry milk.

[1] In April 2004, Western federal marketing order was terminated.

The minimum prices for milk used in fluid products (i.e., Class I price) are composed of fixed price differentials and manufacturing milk price. Price differentials, which are determined administratively, vary by region. Minimum prices for the milk used for manufacturing purposes (i.e., Class II, III, and IV prices) are set by adding processing costs to the manufacturing milk price using different formula. The manufacturing milk price is calculated by the values (prices) of milk components such as fat, protein, and other solids, which are determined by supply and demand in national markets. Thus, in the milk marketing orders, the instruments used to discriminate prices between Class I and manufacturing milk markets are price differentials.

Each milk marketing order pools revenues from all end-use classes. Thus, milk producers are paid by the uniform, market wide, weighted average price of each class of milk regardless of the usage of each individual farmer's milk. Milk marketing orders do not limit the supply of milk; additional benefits to milk producers are created through price discrimination alone. By reducing the allocation of milk into Class I milk market and by pooling revenues from all the markets, marketing orders raise Class I milk prices and give higher uniform (blend) prices to the milk producers and larger quantity supplied in manufacturing milk markets (Ippolito and Masson, 1978). Therefore, marketing orders can be understood as cartels in that they create surplus to producers through price discrimination. However, milk marketing orders are not the cartels that create additional surplus by controlling quantity supplies.

III.2. Stylized model for milk marketing orders

Among the studies that assess the effects of price discrimination by milk marketing orders, the model of Ippolito and Masson (1978) has been used widely. (See, for example, Dahlgran (1980), Kaiser, Streeter, and Liu (1988), Sumner and Wolf (1996), Cox and Chavas (2001), and Balagtas and Sumner (2003).) To model the political market power reflected in the price discrimination of milk marketing orders, we follow the stylized assumptions of Ippolito and Masson (1978). We assume that milk marketing orders classify Grade A milk into two end-uses. Class F milk (fluid milk) is used for beverage milk and Class M milk (manufacturing milk) is used for manufactured products. Figure 1 describes the equilibrium of a milk marketing order. Since shipping cost of fluid milk is higher compared to the manufactured products, Class F milk demand is inelastic relative to Class M milk. The manufactured products are traded in the national market. Thus, figure 1 depicts that Class M milk demand is very elastic compared to Class F milk. We can define the following system to describe milk supply, demand, and equilibrium conditions of the marketing order for region *i*.

(3) $Q_{Fi} = Q_{Fi}(P_{Fi})$: fluid milk demand function in region *i*

(4) $P_{Fi} = P_M + P_{di}$: fluid milk price in region *i*

(5) $P_M = P_M(\sum Q_{Mi})$: inverse manufacturing milk demand function at national level

(6) $Q_i = Q_{Mi} + Q_{Fi}$: total quantity demanded in region *i*

(7) $MC_i = MC_i(Q_i)$: inverse milk supply in region *i*

(8) $P_{bi} = P_{Fi}Q_{Fi}(P_{Fi})/Q_i + P_M(\sum Q_{Mi})Q_{Mi}/Q_i$: average revenue (blend price) in region *i*

(9) $MC_i = P_{bi}$: equilibrium condition in region *i*

In the above system, P_{di} is the price differential determined by the regulator of milk marketing order in region *i*.[2] Without marketing order regulations, the equilibrium point

[2] In this system, we do not consider transportation costs between regions. However, transportation costs would not affect the main results of this paper, as we show later.

is b in figure 1; with marketing order regulations, the equilibrium point is a. Thus, the price discrimination of a milk marketing order combined with pooling creates additional surplus to the milk producers by the area □$P_b abP_c$.

The equilibrium condition of equation (9) and figure 1 show that the price differential determines the quantity allocated into the fluid and manufacturing milk markets and the total milk supplied in each marketing order region. Thus, it plays a critical role in determining milk producer profits. However, there are no economic principles for determining the price differentials. Figure 1 illustrates that if we have a higher blend price that is achieved by a higher price differential P_{di}^{*}, we have more producer profits. This fact provides the reason why producers lobby for higher price differentials.

III.3. The derivation of optimal price differentials which maximize producer profits

Because the policy instruments used by milk marketing orders are price differentials, the policy level P_0 for the competitive market in table 1 is zero (P_0=0). As discussed, if regulators put the value of 1 as the welfare weight w in their policy preference functions, the problem of regulators depicted by equation (1) is the same as the profit maximization problem of producers' cartels in each region. We may regard the price differentials that maximize producer profits as the target of producer lobbying efforts. We can say that producers have full political market power under the optimal price differentials that maximize their regional producer profits.

To derive optimal price differentials, we need to define a set of regional producer cartel profit maximization problems. Since milk marketing orders do not control the supply of milk, regional total milk quantity supplied is determined by the condition that marginal cost of production equals average revenue by which producers are paid, as in equation (9). We can define the profit maximization problem of the producer cartel in region *i* as

(10) $\underset{P_{di}}{Max}\prod_i = P_{bi}Q_i - \int_0^{Q_i} MC_i(Q)dQ$, subject to equations from (3) to (9).[3]

We can rewrite the equilibrium condition of equation (9) as the following:

$$MC_i[Q_{Fi}(P_M(\sum_i Q_{Mi}) + P_{di}) + Q_{Mi}]$$

(11) $$= (P_M(\sum_i Q_{Mi}) + P_{di})\frac{Q_{Fi}(P_M(\sum_i Q_{Mi}) + P_{di})}{Q_{Fi}(P_M(\sum_i Q_{Mi}) + P_{di}) + Q_{Mi}} + P_M(\sum_i Q_{Mi})\frac{Q_{Mi}}{Q_{Fi}(P_M(\sum_i Q_{Mi}) + P_i^d) + Q_{Mi}}.$$

This equation implies the following market clearing steps. First, if the quantity $\sum_{j\neq i} Q_{Mj}$ is given, the optimal price differential P_{di}^* that maximizes profit maximization problem defined by equation (10) determines Q_{Mi}^* for region *i*. Following same process, the price differentials P_{dj}^* in all other regions determine the quantities Q_{Mj}^*. These equilibrium quantities determine the equilibrium manufacturing milk price P_M^*. This manufacturing milk price determines regional fluid milk price $P_{Fi}^* = P_M^* + P_{di}^*$, corresponding regional fluid milk demand $Q_{Fi}^*(P_{Fi}^*)$, and total regional milk supply $MC_i^*(Q_{Mi}^*+Q_{Fi}^*)$.

To get the optimal price differentials P_{di}^* for all the regions, we need to solve the profit maximization problem of each regional producer cartel at the same time. We solve these problems by deriving decision rules for each producer cartel. The decision rules

[3] Among the prior studies that investigate imperfect competition in milk markets, Kawaguchi et al. (1997) present a monopoly model which also makes the assumptions listed above in equations (3) to (8). However, they do not discuss their reasoning for applying the monopoly model to milk marketing orders. Nor do they include the equilibrium condition of equation (9). Further, the objective function of the monoplist in their study is different from the one defined above in that their monopolist chooses quantities of fluid and manufacturing milk rather than price differentials. Their model does not incorporate the competition between regional monopolists in the national manufacturing milk market.

WE derive yield a Cournot-Nash equilibrium in the national manufacturing milk market. The equilibrium condition of equation (11), which is a constraint on the maximization problem for each regional producer cartel, implies that Q_{Mi}^* is a function of P_{di}^* given all the quantity of manufacturing milk from other regions. And this implies that each regional cartel regards P_M^* as a function of P_{di}^* given all the quantity Q_{Mj}, for region $j \neq i$. Therefore, the total regional quantity supplied Q_i^* that is depicted by $Q_{Fi}(P_M(\sum_{j \neq i} Q_{Mj} + Q_{Mi}(P_{di}^*)) + P_{di}^*) + Q_{Mi}(P_{di}^*)$ can be regarded as a function of P_{di}^* under the assumption of Cournot competition in the national manufacturing milk market. With this assumption, we can define following implicit function by using the equilibrium condition of equation (9).

$$F(Q_i^*, P_{di}^*) = MC_i(Q_i^*)Q_i^* - [P_{di}^* + P_M(Q_{Mi}(P_{di}^*) + \sum_j Q_{Mj})]Q_{Fi}(P_{di}^* + P_M(Q_{Mi}(P_{di}^*) + \sum_j Q_{Mj}))$$
$$- P_M(Q_{Mi}(P_{di}^*) + \sum_j Q_{Mj})Q_{Mi}(P_{di}^*).$$

Since we assume upward an sloping supply curve, higher equilibrium quantity supplied (i.e., Q_i^*) yields higher revenue and profits. This fact suggests that we have maximum profits when the marginal change in equilibrium quantity supplied due to a one-unit change in the price differential is zero ($\frac{\partial Q_i^*}{\partial P_{di}^*} = 0$). The implicit function theorem yields the relationship between these two marginal changes by $\frac{\partial Q_i^*}{\partial P_{di}^*} = -\frac{\partial F(.)/\partial P_{di}^*}{\partial F(.)/\partial Q_i^*}$. And the term $-\partial F(.)/\partial P_{di}^*$ is calculated as follows, from the above-defined implicit function:

$$(12)\ [1 + \frac{\partial P_M}{\partial Q_M}\frac{\partial Q_M}{\partial Q_{Mi}}\frac{\partial Q_{Mi}}{\partial P_{di}^*}]Q_{Fi} + P_{Fi}\frac{\partial Q_{Fi}}{\partial P_{Fi}}[1 + \frac{\partial P_M}{\partial Q_M}\frac{\partial Q_M}{\partial Q_{Mi}}\frac{\partial Q_{Mi}}{\partial P_{di}^*}] + [\frac{\partial P_M}{\partial Q_M}\frac{\partial Q_M}{\partial Q_{Mi}}\frac{\partial Q_{Mi}}{\partial P_{di}^*}]Q_{Mi} + P_M\frac{\partial Q_{Mi}}{\partial P_{di}^*}.$$

At the optimum, equation (12) equals zero due to the condition of $\frac{\partial Q_i^*}{\partial P_{di}^*} = 0$. If we rearrange equation (12), we can derive decision rule that achieves maximum producer profits, $P_{Fi}[1+\frac{1}{\eta_{Fi}}\frac{\partial Q_M}{\partial Q_{Mi}}]\frac{\partial Q_{Fi}}{\partial d_i^*} = -P_M[1+\frac{1}{\eta_M}\frac{\partial Q_M}{\partial Q_{Mi}}\frac{Q_{Mi}}{Q_M}]\frac{\partial Q_{Mi}}{\partial d_i^*}$, where η_M is the elasticity of manufacturing milk demand, and η_{Fi} is the elasticity of fluid milk demand in region *i*. The right hand side is calculated by rearranging the first two terms in equation (12) by

$$P_{Fi}\frac{\partial Q_{Fi}}{\partial P_{Fi}}[1+\frac{1}{\partial Q_{Fi}/\partial P_{Fi}}\frac{Q_{Fi}}{P_{Fi}}][1+\frac{\partial P_M}{\partial Q_M}\frac{\partial Q_M}{\partial Q_{Mi}}\frac{\partial Q_{Mi}}{\partial P_{di}^*}] = P_{Fi}[1+\frac{1}{\eta_{Fi}}]\frac{\partial Q_{Fi}}{\partial P_{Fi}}\frac{\partial P_{Fi}}{\partial d_i^*} = P_{Fi}[1+\frac{1}{\eta_{Fi}}]\frac{\partial Q_{Fi}}{\partial d_i^*}.$$

And the left hand side is derived by rearranging the last two terms in equation (12) by $-P_M[1+\frac{Q_M}{P_M}\frac{\partial P_M}{\partial Q_M}\frac{\partial Q_M}{\partial Q_{Mi}}\frac{Q_{Mi}}{Q_M}]\frac{\partial Q_{Mi}}{\partial d_i^*}$. Since we assume Cournot competition (i.e., $\frac{\partial Q_M}{\partial Q_{Mi}}=1$), the decision rule can be finally expressed as:

(13) $P_M[1+\frac{1}{\eta_M}s_{Mi}] = P_{Fi}[1+\frac{1}{\eta_{Fi}}]$, where $s_{Mi} = \frac{Q_{Mi}}{Q_M}$.

Equation (13) is obtained by the condition $\frac{\partial Q_{Fi}^*}{\partial P_{di}^*} = -\frac{\partial Q_{Mi}^*}{\partial P_{di}^*}$ which is satisfied due to the fact of $\frac{\partial Q_i^*}{\partial P_{di}^*} = \frac{\partial Q_{Fi}^*}{\partial P_{di}^*} + \frac{\partial Q_{Mi}^*}{\partial P_{di}^*} = 0$ at the optimal price differential P_{di}^*. The decision rule expressed by equation (13) shows the marginal revenues from the two markets must be equalized at the optimum. However, this condition does not force the marginal revenue to be equalized with the marginal cost of milk production. This reflects that the decision rule expressed by equation (13) captures the principle of no supply control of the milk marketing orders. Equation (13) suggests a way to solve the simultaneous maximization problem defined by equation (10) for all regions. Instead of solving this simultaneous maximization problem, we can solve a set of simultaneous equation problems that is composed of equations (3) through (9), and equation (13), for all the regions to get the optimal price differentials P_{di}^*. The prices P_{di}^* are the solutions that allow regional monopoly and national Cournot-Nash equilibria.

III.4. Derivation of welfare weights implied by observed price differentials

To model the policy preference function for milk marketing orders, we adopt the expression of equation (2) instead of equation (1) and do not include the term $-\lambda \prod^{R}$, since it doesn't affect the optimal solution. Unlike prior studies that have used a policy preference function with a single regulator, the fact that price differentials in each regional milk marketing order are determined separately requires us to utilize a policy preference function model that allows several regulators. The model we describe below shows how we incorporate several regulators.

We can define the regulator's maximization problem in region *i* by the following equation:

$$(14)\ \underset{P_{di}}{Max} W_i = CS_i + \lambda_i PS_i = \int_{P_{Fi}}^{A} Q_{F\,i}(P)dP + \int_{P_M}^{B} \frac{Q_{Mi}}{Q_M} Q_M(P)dP + \lambda_i [Q_i P_{bi} - \int_0^{Q_i} MC_i(Q)dQ],$$

subject to equations (3) through (9) for region *i*.

The terms CS_i and PS_i are the consumer surplus and producer profits in region *i*, λ_i is the relative welfare weight for producers in region *i*, and *A* and *B* denote the intercepts of demand curves of fluid and manufacturing milk. Since there is only one national manufacturing milk market, we assume that the regulator in region *i* cares about the manufacturing milk consumers who buy the milk produced in region *i.* Thus he calculates consumer surplus from the manufacturing milk market by $\int_{P_M}^{B} \frac{Q_{Mi}}{Q_M} Q_M(P)dP$.[4]

For a given λ_i, we can find the optimal price differential P_{di}^{*} that maximizes the

[4] Or we can define consumers surplus by $\int_{P_M}^{B-\sum_j Q_{Mj}} Q_{Mi}(P)dP$ using residual manufacturing milk demand for region *i*. In this case, however, the first order condition for equation (14) is the same as equation (15). Thus the results are same.

objective function of equation (12) as in Lopez (1989), Buccola and Sukume (1993), and Bullock (1994). Conversely, we can empirically determine the welfare weights by estimating what value of λ_i yields the observed price differential as in Sarris and Freebairn (1983), and Oehmke and Yao (1990). In this study, we want to derive the welfare weight λ_i that yields the announced price differential P_{di}^*. For this, we need to solve the simultaneous equation problem that is composed of the first order condition for equation (14), equations (3) through (9), and the announced price differential P_{di}. However, the welfare weight λ_i^* cannot be derived by solving the single simultaneous equation problem for region *i*, since the manufacturing milk price also depends on the price differentials determined by the regulators in the other regions. Thus, we need to solve the simultaneous equation problems for all the region *i*'s at the same time to derive the welfare weights λ_i^*.

We propose to solve this problem as follows. The first order condition of the above social welfare maximization problem of equation (14) is:

$$\begin{aligned}\frac{dW_i}{dP_{di}} &= -Q_{Fi}\frac{\partial P_{Fi}}{\partial P_{di}} - \frac{Q_{Mi}}{Q_M}Q_M\frac{\partial P_M}{\partial P_{di}} \\ &+ \lambda_i[Q_{Mi}\frac{\partial P_M}{\partial Q_M}\frac{\partial Q_M}{\partial P_{di}} + P_M\frac{\partial Q_{Mi}}{\partial P_{di}} + P_{Fi}\frac{\partial Q_{Fi}}{\partial P_{Fi}}\frac{\partial P_{Fi}}{\partial P_{di}} + Q_{Fi}\frac{\partial P_{Fi}}{\partial P_{di}} - MC_i\frac{\partial Q_i}{\partial P_{di}}] = 0\end{aligned} \tag{15}$$

However, equation (15) cannot be used to solve the simultaneous equation problems unless we have information about marginal changes in prices and quantities of fluid and manufacturing milk due to a one-unit change in the price differential (i.e., $\frac{\partial P_{Fi}}{\partial P_{di}}$, $\frac{\partial P_M}{\partial P_{di}}$, $\frac{\partial Q_{Fi}}{\partial P_{di}}$, $\frac{\partial Q_M}{\partial P_{di}}$, and $\frac{\partial Q_i}{\partial P_{di}}$). We assume regulators in each region do not believe that the quantity of manufacturing milk in other regions changes in response to changes in the quantity of manufacturing milk in their own regions. With this assumption of Cournot competition in the manufacturing milk market ($\frac{\partial Q_M}{\partial Q_{Mi}}$=1), we can derive the following conditions:

$$(16)\ \frac{\partial Q_M}{\partial P_{di}} = \frac{\partial Q_M}{\partial Q_{Mi}}\frac{\partial Q_{Mi}}{\partial P_{di}} = \frac{\partial Q_{Mi}}{\partial P_{di}}$$

$$(17)\ \frac{\partial P_{Fi}}{\partial P_{di}} = (1+\frac{\partial P_M}{\partial Q_M}\frac{\partial Q_M}{\partial Q_{Mi}}\frac{\partial Q_{Mi}}{\partial P_{di}}) = (1+\frac{\partial P_M}{\partial Q_M}\frac{\partial Q_{Mi}}{\partial P_{di}})$$

$$(18)\ \frac{\partial Q_{Fi}}{\partial P_{di}} = \frac{\partial Q_{Fi}}{\partial P_{Fi}}\frac{\partial P_{Fi}}{\partial P_{di}} = \frac{\partial Q_{Fi}}{\partial P_{Fi}}(1+\frac{\partial P_M}{\partial Q_M}\frac{\partial Q_M}{\partial Q_{Mi}}\frac{\partial Q_{Mi}}{\partial P_{di}}) = \frac{\partial Q_{Fi}}{\partial P_{Fi}}(1+\frac{\partial P_M}{\partial Q_M}\frac{\partial Q_{Mi}}{\partial P_{di}})$$

$$(19)\ \frac{\partial P_M}{\partial P_{di}} = \frac{\partial P_M}{\partial Q_M}\frac{\partial Q_M}{\partial Q_{Mi}}\frac{\partial Q_{Mi}}{\partial P_{di}} = \frac{\partial P_M}{\partial Q_M}\frac{\partial Q_{Mi}}{\partial P_{di}}$$

$$(20)\ \frac{\partial Q_i}{\partial P_{di}} = \frac{\partial Q_{Mi}}{\partial P_{di}} + \frac{\partial Q_{Fi}}{\partial P_{di}} = \frac{\partial Q_{Mi}}{\partial P_{di}} + \frac{\partial Q_{Fi}}{\partial P_{Fi}}(1+\frac{\partial P_M}{\partial Q_M}\frac{\partial Q_{Mi}}{\partial P_{di}})$$

Equations (16) through (20) all contain the term $\frac{\partial Q_{Mi}}{\partial P_{di}}$, which represents the marginal change in the quantity of manufacturing milk in region *i* due to a one-unit change of price differential in region *i*. As discussed earlier, if a regulator determines P_{di}, it determines $Q_{Mi}(P_{di})$ in the equilibrium condition of equation (11). Thus, we can derive the explicit form of $\frac{\partial Q_{Mi}}{\partial P_{di}}$ at the equilibrium by defining the following implicit function from the equilibrium condition of equation (11).

$$F(Q_{Mi}, P_{di}) = [Q_{Fi}(P_M(\sum_i Q_{Mi}) + P_{di}) + Q_{Mi}]MC_i(Q_{Fi}(P_M(\sum_i Q_{Mi}) + P_{di}) + Q_{Mi})$$
$$-[P_M(\sum_i Q_{Mi}) + P_{di}][Q_{Fi}(P_M(\sum_i Q_{Mi}) + P_{di})] - P_M(\sum_i Q_{Mi})Q_{Mi} = 0$$

The implicit function theorem yields following equation (21).

$$\frac{\partial Q^*_{Mi}}{\partial P^*_{di}} = -\frac{\partial F(.)/\partial P^*_{di}}{\partial F(.)/\partial Q^*_{Mi}}$$

$$(21)\quad = -\frac{\frac{\partial Q_{Fi}}{\partial P_{Fi}}MC_i + Q_i\frac{\partial MC_i}{\partial Q_i}\frac{\partial Q_{Fi}}{\partial P_{Fi}} - Q_{Fi} - P_{Fi}\frac{\partial Q_{Fi}}{\partial P_{Fi}}}{(\frac{\partial Q_{Fi}}{\partial P_{Fi}}\frac{\partial P_M}{\partial Q_M}+1)MC_i + Q_i\frac{\partial MC_i}{\partial Q_i}(\frac{\partial Q_{Fi}}{\partial P_{Fi}}\frac{\partial P_M}{\partial Q_M}+1) - \frac{\partial P_M}{\partial Q_M}Q_{Fi} - P_{Fi}\frac{\partial Q_{Fi}}{\partial P_{Fi}}\frac{\partial P_M}{\partial Q_M} - \frac{\partial P_M}{\partial Q_M}Q_{Mi} - P_M}$$

Equations (16) to (21) are used to compose the first order condition of the policy preference function. These equations show that the first order condition for equation (15) can be expressed with the slopes of fluid and manufacturing milk demands ($\frac{\partial P_M}{\partial Q_M}$ and $\frac{\partial Q_{Fi}}{\partial P_{Fi}}$), the slope of supply ($\frac{\partial MC_i}{\partial Q_i}$), equilibrium quantities, and the prices of fluid and manufacturing milk.

The welfare weights λ_i^* are the solutions to the simultaneous equation problem composed of equations (3) to (9), equations (15) to (21), and the actual price differential P_{di}^*'s for all the regions.

IV. Measuring political market power of milk producers

IV.1. Data and parameters

The 1996 farm bill mandated consolidation of 31 federal marketing orders into 10 to 14 orders. Complying with this bill, the federal marketing order reform in 1999 launched 11 consolidated marketing orders. The reform in 1999 also adjusted Class I price differentials in almost all the federal marketing order regions. The new price differentials became effective on January 1, 2000. In this study, we assess milk producers' political market power that affected the adjustments of price differentials in 1999 reform. Thus, the base year of the analysis is 2000 for this study. We apply the models discussed in the previous section to 11 federal and California milk marketing orders.[5]

We parameterize demands and supplies with elasticities from previous studies and observed quantities as well as price data. The data for utilizations of raw milk, Class I

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[5] As discussed, California milk marketing order accounts for most of milk marketing outside federal milk marketing orders. We include California milk marketing order in the analyses, since we believe the supply and demand conditions in California have significant impacts on national manufacturing milk market.

milk prices, and price differentials are acquired from Federal Marketing Order Statistics and California Dairy Information Bulletin. The data are annual quantities and average prices for each Class of milk. Data used in the analysis are reported in table 1. In 2000, the quantity of milk marketed through the California marketing order was 31,826 million pounds. Among federal milk marketing order (FMMO) regions, Northeast produced the largest amount of milk (23,969 million pounds). The second largest milk producing region in FMMO was Upper Midwest. Florida produced the smallest amount of milk. The Upper Midwest region marketed most of its milk for manufacturing purposes. In 2000, the percentage of manufacturing utilization in Upper Midwest was 82.53%. Most milk in the Florida region was marketed as fluid purposes (88.09% in 2000). Thus, among the FMMO regions, manufacturing milk price was highest in Florida. Class I prices of 2000 are in the range from $13.34/cwt to $15.53/cwt. The blend price was highest in Florida ($15.06/cwt) and lowest in Upper Midwest ($11.86/cwt). The annual average of manufacturing milk price in 2000 was $11.55/cwt.

We assume linear supply and demand, consistent with previous studies that have evaluated the effects of dairy policies (Ippolito and Masson, 1978; Cox and Chavas, 2001; Sumner and Cox, 1998; Sumner and Wolf, 2000; Balagtas and Sumner, 2003). Demands for fluid milk (Class F milk) are constructed by using the quantity used for Class I milk and Class I milk prices in each region, and assumed elasticity of fluid milk demand. Demand for manufacturing milk (Class M milk) is constructed by using the quantity used for manufacturing milk, manufacturing milk price, and assumed elasticity of manufacturing milk demand. Supply curves of milk production are set using total milk marketed as well as blend prices of milk in each region, and assumed elasticity of supply.

Most recent studies on dairy industry use or estimate very inelastic farm level fluid milk (i.e., Class I milk) demand. For example, Balagtas and Sumner (2003) report that the demand elasticities of fluid milk used in the agricultural economics literature range from -0.076 to -0.34. Suzuki and Kaiser (1997) use a fluid milk demand elasticity of -0.16. Xiao, Kinnucan and Kaiser (1998) estimate -0.16 as the fluid milk demand elasticity. Cox and Chavas (2001) use -0.13 as the fluid milk demand elasticity. In this paper, we assume -0.2 as the fluid milk demand elasticity within regional fluid milk (Class I milk) markets as in Balagtas and Sumner (2003).[6]

Unlike fluid milk demand, elasticities of manufacturing milk demand and milk supply in the agricultural economics literature vary widely. Few studies have estimated manufacturing milk demand elasticity. Kaiser, Streeter, and Liu (1988) estimate -0.455 as the manufacturing milk demand elasticity. Kawaguchi, Suzuki, and Kaiser (2001) report manufacturing milk demand elasticity from prior studies as being between -0.22 and -1.62. Balagtas and Sumner (2003) report estimated demand elasticities of dairy products from -0.17 to -0.73. Previous studies estimate or specify milk supply elasticities in the range from 0.22 to 2.53 (0.22 to 1.17 in Chavas and Klemme (1986), 0.224 in Susuki, Kaiser, and Lenz (1995), 0.37 in Cox and Chavas (2001), 0.4 to 0.9 in Ippolito and Masson (1978), 0.583

[6] Estimates of retail demand elasticity of fluid milk vary more than do farm-level elasticities. For example, Park, Holcomb, Raper and Capps (1996), and Schmit and Kaiser (2002) estimate -0.47 and -0.14 as the retail fluid milk demand elasticity. Bergtold, Akobundo and Peterson (2004) estimate -0.28 as the retail demand elasticity for whole milk. Dhar and Foltz (2005), and Chidmi, Lopez and Cotterill (2005) estimate retail fluid milk demand elasticities of -1.04 and -0.6102. However, fluid milk demand elasticity at the farm level (i.e., demand elasticity of Class I milk) is likely to be more inelastic than these estimates.

in Helmberger and Chen (1994), 0.63 to 1.573 in Milligan (1978), 0.77 to 1.56 in Levins (1981), 2.53 in Chen, Courtney and Schmitz (1972)). Due to the large variation in elasticity estimates found in the literature, we present empirical results simulated with a range of different elasticities, instead of choosing specific manufacturing milk demand and supply elasticities.

IV.2. Results of assessing political market power of milk producers

(1) Political market power relative to regional monopoly power

Optimal price differentials that give maximum profits to the producers in each region are solved numerically using GAMS. We simulate optimal price differentials using 224 different combinations of manufacturing milk demand elasticity and milk supply elasticity. Manufacturing milk demand elasticities range from -0.2 to -1.5, and milk supply elasticities range from 0.5 to 2.0, with increments of 0.1 for both.

Table 3 reports means and standard deviations of simulated optimal price differentials for each region. Very small standard deviations of optimal price differentials imply that elasticities of manufacturing milk demand and milk supply do not significantly affect the optimal price differentials. Thus, the results are very robust with respect to fluid milk demand elasticity. We also simulate optimal price differentials under different elasticities of fluid milk demand. Table 4 reports the results of sensitivity analysis for several fluid milk demand elasticities. The results in table 4 also present very small standard deviations of optimal price differentials under each fluid milk demand elasticity. These results again imply that simulated optimal price differentials are not significantly affected by variations of manufacturing milk demand and milk supply elasticities.

As we see in table 3, all the observed price differentials are far below the optimal price differentials. The national average of optimal price differentials is $36.91/cwt, which is much higher than the national average observed price differential of $2.53/cwt.[7] Florida has the highest optimal price differential ($41.17/cwt), while California shows the lowest price differential ($34.94/cwt). The Northeast, Appalachian, Southeast and Southwest regions have optimal price differentials that are more than $38/cwt. California and Upper Midwest have optimal price differentials that are less than $35/cwt. The average national calculated degree of political market power is 0.068. The average national standard deviation for the calculated degree of political market power is 4.029E-4, which implies that calculated degree of political market power is not affected by manufacturing milk demand or supply elasticities. Generally, the regions that have higher observed price differentials show a higher degree of political market power. The calculated degree of political market power of Northeast, Applalachan, Southeast and Florida is over 0.08. Among these regions, Florida shows the highest degree of political market power (0.097). Upper Midwest shows the lowest degree of political market power (0.052). These results suggest that there

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[7] We should note that we also simulate the optimal price differentials incorporating a government price support program that supports the manufacturing milk price of 9.99$/cwt. The simulated optimal price differentials are very similar to the results in table 3. (See table A2 in the appendix.) We also should note that we simulate the case in which regional producers' cartels face residual manufacturing milk demands and set different prices accordingly. This case is simulated to reflect existing transport costs. All the simulated optimal price differentials are very similar to the results in table 3. The average simulated optimal price differential of the regions is 36.54$/cwt for this case.

are significant possibilities to increase surplus of producers by raising price differentials.[8]

The average of simulated monopoly prices of fluid milk is about $45/cwt, which is more than three times higher than the actual Class I milk prices, and the simulated quantities demanded under monopoly prices are about half of the quantities that are actually demanded. These prices and quantities are likely within a reasonable range if it can be demonstrated that consumers, if faced with the retail price derived by the monopoly Class I milk prices, would purchase half amount of the milk that they actually buy at current retail prices.

During the year from 2000 to 2004, the average retail price of whole milk in the major 30 cities of federal marketing order regions was $3.0/gallon. While the average of Class I milk prices for the same cities was $15.16/cwt which is equivalent to $1.35/gallon, (one gallon of milk equals 8.62 pound of milk). Thus the average mark-up over the Class I milk price was $1.65/gallon. The simulated monopoly price of $45/cwt implies that milk bottlers pay $3.88/gallon in procuring the Class I milk. If milk bottlers set the retail price by adding fixed mark-up to the Class I milk price, the average retail price given monopoly Class I milk price will be $5.53/gallon ($1.65/gallon+$3.88/gallon). This price is 1.84 times higher than the actual retail prices. Thus, with constant marketing and processing costs a tripling of the farm price implies only an 84 percent increase in the retail price. Thus our estimates imply that an 84 percent increase in retail price causes a 50 percent decline in the quantity of milk consumed. If milk

[8] If we assess the political market power of milk producers using 2004 data, the national average of simulated political market power is 0.038. See the appendix for details.

bottlers do not add fixed mark-ups in setting the retail prices, the margin falls with lower quantities sold. This is because retail demand is more elastic than the demand at farm level (demand of milk bottlers). Thus, under this circumstance, we may expect that the retail prices will increase by less than 84 percent at the monopoly Class I milk prices. These facts indicate that our estimates do not understate the quantity decline that could be incurred by monopoly Class I milk prices.

Table 4 reports the simulated optimal price differentials under fluid milk demand elasticities other than -0.2. If we assume more elastic fluid milk demand, we have smaller optimal price differentials. Thus, on average we have calculated the degree of political market power to be 0.052, 0.162, 0.3, and 0.419, under the fluid milk demand elasticities of -0.15, -0.5, -1.0, and -1.5, respectively. The last column in table 4 shows the fluid milk demand elasticities that yield observed price differentials under the manufacturing milk demand and supply elasticities of -0.9 and 1.3, which are the median values of the elasticities used in prior studies. The simulated fluid milk demand elasticities that yield observed price differentials are in the range of -2.570 to -5.250. These fluid milk demand elasticities are not realistic at all and far below the estimated values in recent studies. Thus, we can conclude that the observed price differentials are not consistent with the differentials that give maximum profits to producers.

(2) **Political market power measured by welfare weights in the policy preference function**

The welfare weight in equation (2) can be interpreted as the slope of the level curves of the policy preference function. This implies that a level curve of the policy preference curve is tangent to the welfare transformation curve at the point where the policy level chosen by the regulator yields observed consumer and producer surplus. Gardner (1983) shows that changing one policy instrument while holding all other instruments constant generates a surplus transformation curve between the two interest groups. Bullock (1994) proves that if the number of interest groups is equal to the number of policy instrument less 1, maximization of the policy preference function gives a unique solution. Rausser and Foster (1990) and Bullock (1994) illustrate that one policy instrument generates a convex surplus transformation curve between producers and consumers. The unique solution is attained by the tangency between the welfare transformation curve and the level curve of the policy preference function.

Figure 2 illustrates the political market equilibrium in the Northeast milk marketing order region. To derive the political equilibrium, we follow three steps. First, we hold manufacturing milk quantities supplied by other regions constant at the initial equilibrium. By solving equations (2) to (9), an exogenous choice of price differential P_{di}^* in the equilibrium condition of equation (8) yields equilibrium prices and quantities, and corresponding consumer and producer surplus in region *i*. Thus, by applying different price differentials, we can draw welfare transformation curves for each region. If we apply higher price differentials, we have more surplus to producers and less surplus to consumers. As previous studies have proven, the regions all have convex welfare transformation curves. Second, following the methodology presented in the previous section, we derive the welfare weights λ_i by solving equations (3) to (9) and equations (15) to (21), and observed price differentials for all the regions. The welfare weight λ_i is interpreted as the slope of the level curves of each region's policy preference function. Third, we match the welfare transformation curves with the level curves of the policy preference functions. In figure 2, we present the political equilibrium in the Northeast region under the fluid milk demand elasticity of -0.2, and the manufacturing milk demand as well as milk supply elasticities of -0.9 and 1.3. Figure 2 shows that the tangent points of the welfare transformation curves are where observed price differentials are applied. Figure 2 implies that if regulators use higher welfare weights (associated with steeper slopes on the level curves of the policy preference functions), the political equilibrium points move downward, and producers receive more surplus.

We derive imputed welfare weights that yield the observed price differentials by applying manufacturing milk demand elasticities from -0.2 to -1.5 and milk supply elasticities from 0.5 to 2.0 under the assumption of fluid milk demand elasticity of -0.2. Table 5 presents the means and standard deviations of the imputed welfare weights. Small standard deviations relative to the means suggest that the results are very robust for a given fluid milk demand elasticity. The national average of imputed welfare weights is 1.155, and the national average of standard deviation is 0.044. Florida shows the highest welfare weight (1.362) while Upper Mideast shows the lowest welfare weight (1.063). Welfare weights for Appalachian and Southeast are over 1.2, while welfare weights for Central, Western, Pacific Northwest and California are below 1.1.

The regions that have higher imputed welfare weights show a higher degree of political market power. The national average of degree of political market power which is calculated using imputed welfare weights is 0.070. (Regional calculations of political market power range from 0.030 (Upper Midwest) to 0.151 (Florida). The national average of political power calculated in this fashion is very similar to the national average of the degree of political market power which is measured by the ratio of observed to optimal price differentials in table 3 (0.068). However, for some regions, the "welfare weight"-measured political market power is higher than the "differential ratio"-measured political market power; for other regions, the opposite is true. Interestingly, in the regions showing higher welfare weight-measured political market power, this value exceeds the differential ratio-measured political market power. Those regions are Northeast, Appalachian, Southeast, Florida, Mideast and Southwest.

Oehmke and Yao (1990) measure the welfare weight imputed from the US wheat price support program as 1.43. Im (1999) measures the welfare weight imputed from the Korean rice price support program as 1.33. Atici (2005) calculates the measured welfare weights that are imputed from border protection for ES wheat, corn, sugar, beef and milk to be 1.58, 2.46, 2.25, 2.05, and 1.77, respectively. If these welfare weights were converted using the method proposed in this paper, the degree of market power in these studies would range from 0.142 to 0.344, which is higher than our calculations in the milk marketing order context. This suggests that the political market power of US milk producers is small relative to those of the producers in the above industries. [9]

Table 8 reports the imputed welfare weights under different fluid milk demand

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[9] The assessment of political market power based on 2004 data is two percent of monopoly power on average. See appendix for detail.

elasticities other than -0.2. If we assume more elastic fluid milk demand, we have bigger imputed welfare weights. Thus, on average we have calculated degree of political market power of 0.068, 0.101, 0.154 and 0.214 under the fluid milk demand elasticities of -0.15, -0.5, -1.0 and -1.5, respectively. Figure 3 shows comparisons between differential ratio-measured and welfare weight-measured political market power. Figure 3 shows that there is a specific level of fluid milk demand elasticity under which differential ratio-measured and welfare weight-measured political market power are same. WE infer that the specific elasticity of fluid milk demand is close to -0.2. Although the differential ratio-measured political market power is different from the welfare weight-measured political market power under all the other elasticities, we may think these two measures of political market power are the upper and lower bounds under each fluid milk demand elasticity.

V. Summary and Conclusion

Announced price differentials between fluid and manufacturing milk determine milk consumption and total milk supplied in each marketing order region in US. This paper investigates political market power reflected in the price differentials for 11 federal and the California milk marketing orders. We suggest two ways to assess political market power. One is to assess the political market power by comparing announced price differentials to the optimal ones that give maximum profits to producers. The other is to assess the political market power by deriving the welfare weights for milk producers in the policy preference functions.

Simulation results based upon data from 2000 show that observed price differentials are far below the optimal price differentials. The announced price differentials are about seven percent of optimal price differentials. The national average of imputed welfare weights that yields observed price differentials is 1.155, which implies that political market power of milk producers is again about seven percent of monopoly power. These results suggest that in setting price differentials, milk producers have more political power than buyers, but their political power is small relative to full monopoly power in setting prices. Thus there are significant possibilities to increase producers surplus by raising price differentials.

Our analysis has some limitations. We do not model dynamic adjustments in dairy products pricing. Because the models simplify milk marketing orders' milk classification schemes we are not able to consider the interaction between producer surplus and the surplus of each dairy product's consumers. Nor do we consider substitution between manufacturing and fluid milk in the demand functions of these milk products.

Despite these limitations, this paper contributes to the literature in three senses. First, this paper suggests a way to investigate how political power is transformed into market power. By measuring the degree of political market power, we can investigate further into the relationship between political market power and possible factors that affect it. The proposed ways to assess political market power are not industry-specific; they can be extended to other industries in which government policies transform surplus from producers to consumers, or vice versa. Second, this paper provides an extended monopoly model. We model producer cartels which act as monopolists in regional beverage milk markets and oligopolists in the national market for manufacturing milk products. Thus, our model allows for monopoly solutions in regional markets and a Nash equilibrium in the national market. This modeling approach can be applied to other industries. One possible area is wheat trading. For example, CWB (Canadian Wheat

Board) and AWB (Australian Wheat Board) act as monopolists in domestic markets and oligopolists in the international market. Thus, the prices set by CWB and AWB can be modeled in the same framework as the price setting in milk marketing orders. Third, we develop a model of policy preference functions that allows for the existence of several regulators. Our model shows that the political equilibrium in one region is linked with the equilibria in other regions. To date, the studies that apply a policy preference function generally assume one regulator operating with a partial equilibrium model. However, any policy aimed at a specific industry usually affects other industries, on which some other policies may also be acting. Thus, if we want to assess the political power of interest groups in a more general context, we need a model in which regulators account for the impact of their decisions on other industries. Our model suggests how one might incorporate political equilibria in the presence of such interactions between industries.

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Table 1 Policy preference function and market power under different welfare weights

	Welfare weight (w)	Criterion function (Policy preference function)	Policy level (Solution of criterion function)
Competitive Market	0.5	$\underset{p}{Max}\, PPF_c = Z(P) + \prod(P)$	P_0
Observed political market	$\overline{w}$	$\underset{p}{Max}\, PPF_p = (1-\overline{w})Z(P) + \overline{w}\prod(P)$	$\overline{P}$
Monopoly Market	1	$\underset{p}{Max}\, PPF_m = \prod(P)$	P_m

Note: Two ways of assessing the degree of political market power are $\frac{\overline{w}-0.5}{1-0.5}$ and $\frac{\overline{P}-P_0}{P_m-P_0}$.

Table 2 Price and quantity in the base year (2000)

Federal Marketing Order Regions	Class I price ($/cwt)	Blend price ($/cwt)	Price differential ($/cwt)	Quantity used for Class I milk (mil. lbs)	Quantity used for manufacturing purposes (mil. lbs)
Northeast	14.81	12.98	3.26	10,513	13,456
Appalachian	14.65	13.68	3.10	4,343	1,974
Southeast	14.65	13.57	3.10	4,867	2,620
Florida	15.53	15.06	3.98	2,526	342
Mideast	13.55	12.50	2.00	6,716	7,465
Upper Midwest	13.34	11.86	1.79	4,092	19,331
Central	13.56	12.16	2.01	4,875	11,161
Southwest	14.55	12.92	3.00	3,970	4,742
Arizona-Las Vegas	13.90	12.29	2.35	973	2,136
Western	13.45	12.03	1.90	1,014	3,034
Pacific Northwest	13.46	12.14	1.91	2,100	4,676
California	13.46	11.94	1.91	6,493	25,333

Source: U.S. Department of Agriculture-AMS / CDFA.
Note: Manufacturing milk price is $11.55/cwt. Blend prices are calculated using equation (8), prices and quantities of Class I, and manufacturing milk.

Table 3 Simulated optimal price differential and degree of political market power of milk producers in the base year (2000)

	Simulated optimal price differential		Calculated degree of political market power	
	Mean ($/cwt)	Standard Deviation ($/cwt)	Mean	Standard Deviation
Northeast	38.901	0.127	0.084	2.719E-4
Appalachian	38.763	0.273	0.080	5.549E-4
Southeast	38.752	0.263	0.080	5.359E-4
Florida	41.196	0.301	0.097	6.957E-4
Mideast	35.390	0.207	0.057	3.266E-4
Upper Midwest	34.416	0.129	0.052	1.940E-4
Central	35.376	0.190	0.057	3.015E-4
Southwest	38.440	0.251	0.078	5.023E-4
Arizona-Las Vegas	36.392	0.296	0.065	5.170E-4
Western	35.184	0.288	0.054	4.353E-4
Pacific Northwest	35.159	0.266	0.054	4.045E-4
California	34.938	0.061	0.055	9.525E-5
National Average	36.909	0.221	0.068	4.029E-4
(Standard Deviation)	(2.186)		(0.015)	

Note: Fluid milk demand elasticity is assumed to be -0.2. Simulations are conducted using 224 different combinations of manufacturing milk demand elasticity and milk supply elasticity. Manufacturing milk demand elasticity ranges from -0.2 to -1.5, and milk supply elasticity ranges from 0.5 to 2.0, with increments of 0.1 for both.

Table 4 Simulated optimal price differentials under different fluid milk demand elasticities at base year (2000)

	Simulated optimal price differentials with η_F =-0.15[1)]		Simulated optimal price differentials with η_F =-0.5[1)]		Simulated optimal price differentials with η_F =-1.0[1)]		Simulated optimal price differentials with η_F =-1.5[1)]		Demand elasticities of fluid milk that yield observed price differentials[2)]
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	
Northeast	51.307	0.169	16.542	0.038	9.067	0.019	6.564	0.041	-2.914
Appalachian	51.098	0.322	16.527	0.166	9.089	0.110	6.596	0.078	-4.428
Southeast	51.086	0.312	16.518	0.157	9.081	0.102	6.589	0.071	-4.318
Florida	54.200	0.353	17.753	0.189	9.911	0.131	7.283	0.098	-3.809
Mideast	46.803	0.254	14.814	0.105	7.929	0.052	5.622	0.024	-4.610
Upper Midwest	45.583	0.180	14.281	0.023	7.542	0.046	5.281	0.079	-3.012
Central	46.791	0.239	14.794	0.083	7.907	0.029	5.597	0.017	-3.930
Southwest	50.692	0.300	16.355	0.143	8.966	0.087	6.490	0.055	-4.063
Arizona-Las Vegas	48.065	0.349	15.345	0.181	8.301	0.120	5.938	0.086	-5.250
Western	46.524	0.341	14.737	0.173	7.893	0.112	5.597	0.078	-5.955
Pacific Northwest	46.496	0.318	14.716	0.153	7.874	0.093	5.578	0.060	-5.383
California	46.267	0.108	14.514	0.051	7.679	0.105	5.388	0.137	-2.570
National Average	48.743	0.270	15.575	0.122	8.437	0.084	6.044	0.069	-4.187

[1)] Simulations are conducted using 224 different combinations of manufacturing milk demand elasticity and milk supply elasticity. Manufacturing milk demand elasticity ranges from -0.2 to -1.5, and milk supply elasticity ranges from 0.5 to 2.0, with increments of 0.1 for both.

[2)] Elasticities of manufacturing milk demand and milk supply are assumed to be -0.9 and 1.3, which are median values of the elasticities used in previous studies.

Table 5 Imputed welfare weights and degree of political market power of milk producers in the base year (2000)

	Imputed welfare weight λ		Calculated degree of political market power	
	Mean	Standard Deviation	Mean	Standard Deviation
Northeast	1.191	0.053	0.087	0.022
Appalachian	1.248	0.075	0.109	0.030
Southeast	1.239	0.072	0.106	0.029
Florida	1.362	0.114	0.151	0.041
Mideast	1.128	0.036	0.060	0.016
Upper Midwest	1.063	0.012	0.030	0.006
Central	1.096	0.024	0.046	0.011
Southwest	1.181	0.051	0.082	0.021
Arizona-Las Vegas	1.113	0.029	0.053	0.013
Western	1.080	0.019	0.038	0.009
Pacific Northwest	1.092	0.023	0.044	0.010
California	1.072	0.015	0.035	0.007
National Average	1.155	0.044	0.070	0.018
(Standard deviation)	(0.091)		(0.037)	

Note: Fluid milk demand elasticity is assumed to be -0.2. Simulations are conducted using 224 different combinations of manufacturing milk demand elasticity and milk supply elasticity. Manufacturing milk demand elasticity ranges from -0.2 to -1.5, and milk supply elasticity ranges from 0.5 to 2.0, with increments of 0.1 for both.

Table 8 Calculated welfare weight (λ) with different fluid milk demand elasticities in the base year (2000)

	Imputed λ with η_F =-0.15		Imputed λ with η_F =-0.5		Imputed λ with η_F =-1.0		Imputed λ with η_F =-1.5	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Northeast	1.178	0.052	1.282	0.056	1.471	0.059	1.730	0.059
Appalachian	1.234	0.074	1.336	0.080	1.515	0.090	1.749	0.103
Southeast	1.225	0.071	1.327	0.077	1.504	0.086	1.737	0.098
Florida	1.344	0.112	1.482	0.124	1.739	0.145	2.106	0.175
Mideast	1.120	0.036	1.183	0.037	1.287	0.039	1.411	0.040
Upper Midwest	1.055	0.012	1.111	0.012	1.203	0.010	1.317	0.015
Central	1.088	0.024	1.150	0.024	1.253	0.024	1.377	0.023
Southwest	1.168	0.050	1.263	0.054	1.427	0.059	1.642	0.065
Arizona-Las Vegas	1.103	0.028	1.175	0.030	1.295	0.033	1.443	0.035
Western	1.072	0.018	1.129	0.019	1.222	0.020	1.332	0.021
Pacific Northwest	1.084	0.023	1.142	0.024	1.237	0.025	1.350	0.025
California	1.064	0.015	1.124	0.014	1.224	0.012	1.350	0.023
National Average	1.145	0.043	1.225	0.046	1.365	0.050	1.545	0.057

Note: Fluid milk demand elasticity is assumed to be -0.2. Simulations are conducted using 224 different combinations of manufacturing milk demand elasticity and milk supply elasticity. Manufacturing milk demand elasticity ranges from -0.2 to -1.5, and milk supply elasticity ranges from 0.5 to 2.0, with increments of 0.1 for both.

Figure 1. Milk marketing order equilibrium[10]

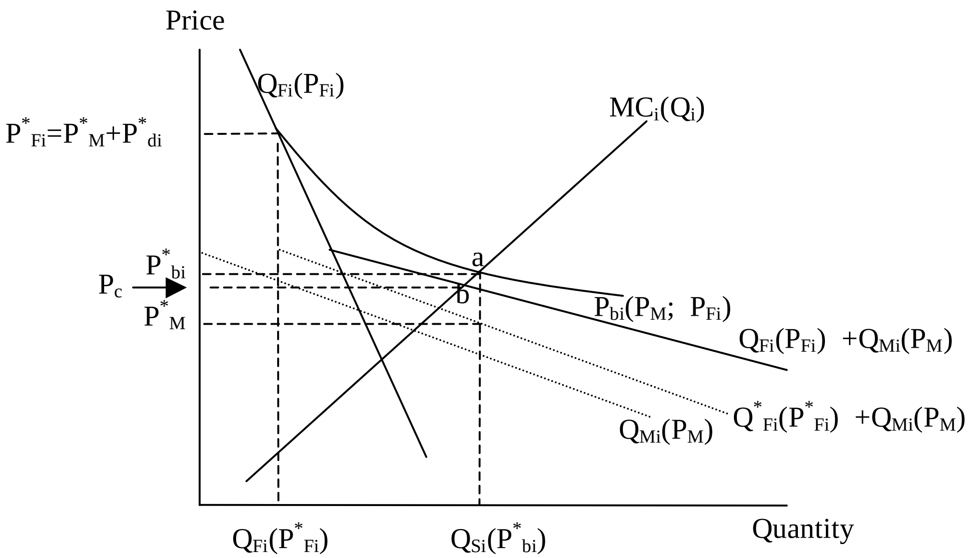
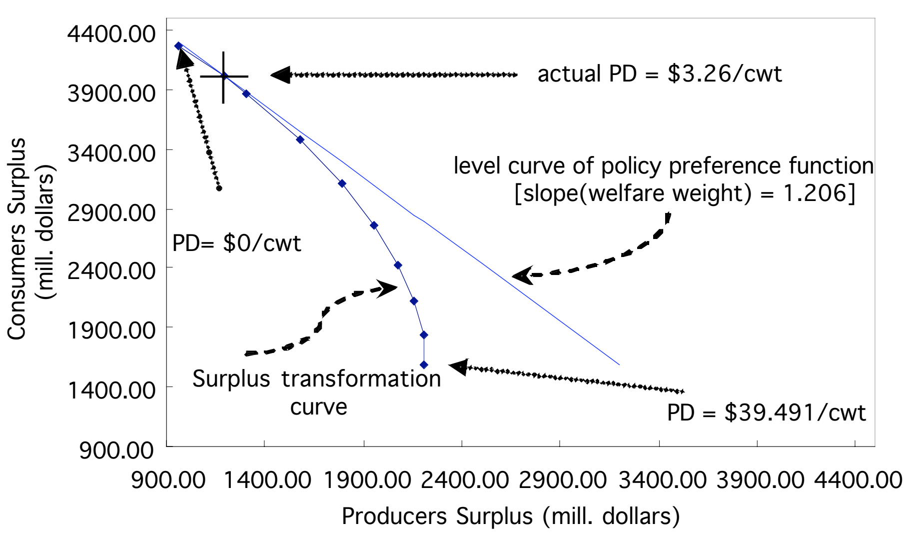


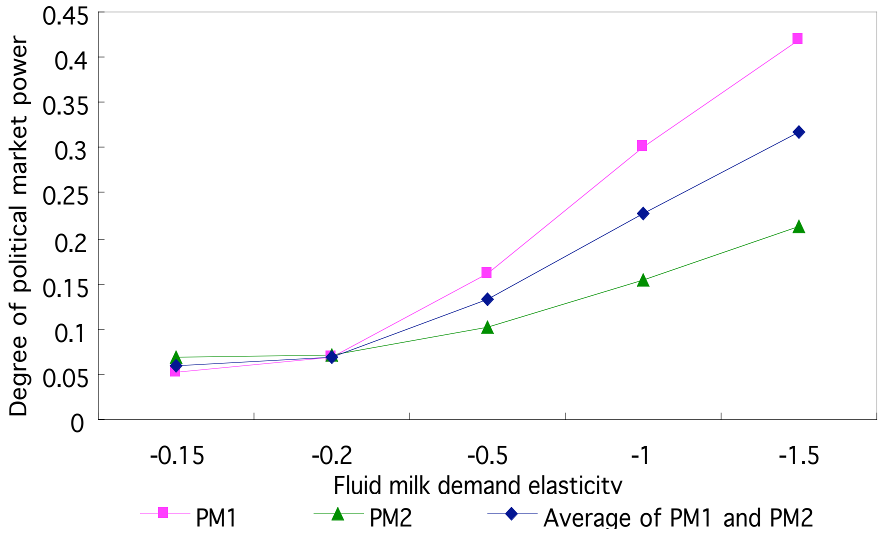
Figure 2 Equilibrium in the political market for Northeast



Note: Fluid milk demand elastcity is assumed to be -0.2. Elasticities of manufacturing milk demand and supply are assumed as -0.9 and 1.3 which are the median values of the elasticities used in previous studies.

[10] This figure assumes that the quantity of manufacturing milk supplied by other regions is fixed.

Figure 3 National average of the degree of political market power of milk producers under different fluid milk demand elasticities



Note: PM1 and PM2 are differential ratio-measured and welfare weight measured political market power

APPENDIX

Table A1 Calculated monopoly price differentials and political market power in the base year (2000) under a price support program

	Simulated optimal price differential		Calculated degree of political market power	
	Mean ($/cwt)	Standard Deviation ($/cwt)	Mean	Standard Deviation
Northeast	39.187	0.206	0.083	4.434E-4
Appalachian	39.048	0.052	0.079	1.053E-4
Southeast	39.037	0.062	0.079	1.261E-4
Florida	41.480	0.022	0.096	5.056E-5
Mideast	35.675	0.122	0.056	1.929E-4
Upper Midwest	34.703	0.207	0.052	3.119E-4
Central	35.661	0.141	0.056	2.245E-4
Southwest	38.725	0.075	0.077	1.511E-4
Arizona-Las Vegas	36.677	0.027	0.064	4.786E-5
Western	35.469	0.036	0.054	5.425E-5
Pacific Northwest	35.444	0.060	0.054	9.114E-5
California	35.226	0.282	0.054	4.418E-4
National Average	37.194	0.108	0.067	1.867E-4

Note: Manufacturing milk price is set at 9.9$/cwt by the condition of $P_M(\sum_i q_{mi} + G) = 9.9$, where G denotes government' purchase. Fluid milk demand elasticity is assumed to be -0.2. Simulations are conducted using 224 different combinations of manufacturing milk demand elasticity and milk supply elasticity. Manufacturing milk demand elasticity ranges from -0.2 to -1.5, and milk supply elasticity ranges from 0.5 to 2.0, with increments of 0.1 for both.

Table A2 Price and quantity of year 2004

Federal Marketing Order Regions	Class I price ($/cwt)	Blend price ($/cwt)	Price differential ($/cwt)	Quantity used for Class I milk (mil. lbs)	Quantity used for manufacturing purposes (mil. lbs)
Northeast	18.15	16.47	3.17	10,692	11,980
Appalachian	17.97	17.06	2.99	4,325	1,878
Southeast	17.97	16.92	2.99	4,640	2,524
Florida	18.88	18.29	3.90	2,440	434
Mideast	16.85	15.74	1.87	6,493	9,449
Upper Midwest	16.68	15.42	1.70	4,549	12,844
Central	16.85	15.68	1.87	4,346	7,243
Southwest	17.88	16.35	2.90	4,139	4,652
Arizona-Las Vegas	17.16	15.71	2.18	967	1,933
Pacific Northwest	16.80	15.58	1.82	2,153	4,363
California	16.56	15.21	1.58	5,065	30,189

Source: U.S. Department of Agriculture-AMS / CDFA.
Note: Manufacturing milk price is $14.98/cwt. The blend prices are calculated using equation (8), prices and quantities of Class I, and manufacturing milk.

Table A3 Calculated monopoly price differentials and political market power at year 2004

	Simulated optimal price differential		Calculated degree of political market power	
	Mean ($/cwt)	Standard Deviation ($/cwt)	Mean	Standard Deviation
Northeast	47.479	0.170	0.067	2.392E-4
Appalachian	47.095	0.362	0.064	4.817E-4
Southeast	47.082	0.350	0.064	4.666E-4
Florida	49.839	0.400	0.078	6.177E-4
Mideast	43.667	0.245	0.044	2.414E-4
Upper Midwest	43.055	0.227	0.039	2.065E-4
Central	43.725	0.295	0.043	2.894E-4
Southwest	46.760	0.328	0.062	4.295E-4
Arizona-Las Vegas	44.738	0.396	0.049	4.277E-4
Pacific Northwest	43.491	0.354	0.041	3.314E-4
California	42.542	0.034	0.038	3.007E-5

Note: Fluid milk demand elasticity is assumed to be -0.2. Simulations are conducted using 224 different combinations of manufacturing milk demand elasticity and milk supply elasticity. Manufacturing milk demand elasticity ranges from -0.2 to -1.5, and milk supply elasticity ranges from 0.5 to 2.0, with increments of 0.1 for both.

Table A4 Calculated welfare weights and political market power at year 2004

	Simulated welfare weight λ		Calculated degree of political market power	
	Mean	Standard Deviation	Mean	Standard Deviation
Northeast	1.156	0.044	0.072	0.019
Appalachian	1.193	0.059	0.088	0.024
Southeast	1.183	0.054	0.083	0.023
Florida	1.279	0.087	0.121	0.034
Mideast	1.086	0.023	0.041	0.010
Upper Midwest	1.057	0.013	0.028	0.006
Central	1.081	0.021	0.039	0.010
Southwest	1.141	0.039	0.066	0.017
Arizona-Las Vegas	1.086	0.022	0.041	0.010
Pacific Northwest	1.071	0.018	0.034	0.008
California	1.040	0.007	0.020	0.003

Note: Fluid milk demand elasticity is assumed to be -0.2. Simulations are conducted using 224 different combinations of manufacturing milk demand elasticity and milk supply elasticity. Manufacturing milk demand elasticity ranges from -0.2 to -1.5, and milk supply elasticity ranges from 0.5 to 2.0, with increments of 0.1 for both.