ESTIMATION OF RELATIVE BARGAINING POWER IN MARKETS FOR RAW MILK IN THE UNITED STATES

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This study contributes to the empirical industrial organization literature by deriving and estimating the empirical equation containing the parameter for bargaining power and an indicator of competition between suppliers. We specify a reduced form of the price equation, which is composed of the minimum price specified in milk marketing orders and the reduced form of the upper bound for the price in regional raw milk markets in the United States. Estimation results indicate that the relative bargaining power of dairy cooperatives in setting regional raw milk prices is small compared to the power of milk bottlers. We find the price differential in milk marketing orders has contributed to raise the price bargained between dairy cooperatives and milk bottlers.

JEL classification codes: L11, L13, L66, D43, Q13
Key words: bargaining power, minimum price regulation, milk marketing order, price equation

I. Introduction

There are several types of bargaining and the applied bargaining theories differ by the bargaining situation. Regardless of the types of bargaining, however, a bargained (agreed) outcome is attained only when the payoff under agreement is greater than the payoff under disagreement, for all bargaining parties (Nash 1950; Sutton and John 1986; Thomson 1992).
The structure of payoff gains and the procedures that influence these gains are the main issues in bargaining theory and function as criteria in categorizing empirical as well as theoretical models. It is agreed upon that the two most important theoretical divisions of bargaining are non-cooperative bargaining initiated by Stahl (1972) and Rubinstein (1982) and axiomatic cooperative bargaining formulated by Nash (1950). While strategic actions of players over time, terms of agreement, and sequence of moves are the main drivers affecting equilibrium in non-cooperative bargaining, payoff gains in contrast to payoff under disagreement play key roles in cooperative bargaining.

Axiomatic bargaining theory has been applied in many empirical studies, such as wage bargaining (Svenjar 1986; Ashenfelter and Brown 1986; Abowed and Lemieux 1993; Coles and Hildreth 2000), bargaining between hospitals and insurers (Brooks et al. 1997), and bargaining between farmers’ cooperatives and food processors (Prasertsri and Kilmer 2008). In theory, the bargaining power that determines relative payoff gains of each party is defined as the ratio of a party’s capability to draw an agreement by influencing the other party to the cost of failing to reach an agreement. In bargaining between two parties, as in the aforementioned empirical studies, this theoretical definition is applied by being transformed as the ratio of the difference between the bargained outcome and a party’s threat point (the point indicating failure of agreement) to the difference between two disagreement points of each party (Svejnar 1986; Brooks et al. 1997; Coles and Hildreth 2000). Thus, the formulation of a disagreement point is a critical step in the empirical application of bargaining theory.

Generally, disagreement points are not observable, and therefore, most previous studies estimated them based on market level data. Unlike these studies, the present paper provides a practical definition of bargaining power and performs an empirical application without estimating the disagreement points. We show that the disagreement points are actually the same as the upper and lower bounds of bargaining. Based on this, we define the relative bargaining power of buyers as the ratio of the difference between the observed bargained and regulated minimum prices to the difference between the upper bound of bargaining and regulated minimum price, wherein the minimum price is the lower bound for the observed bargained price.

A unique feature of the proposed model in the present paper is that estimation of the upper bound of bargaining is not required. We simply used the minimum price set by policy as a disagreement point of the sellers to estimate the bargaining power. Similar to the work of Coles and Hildreth (2000), which used the change in a policy variable as a variation in the disagreement point, the correlation between bargained price and minimum price in the present paper identifies the relative
Estimation of Relative Bargaining Power

bargaining power. Given that our paper shows that a specific government price regulation can be used as an effective instrument in estimating bargaining power, it has the potential to be applied to many empirical works for identifying market structure. The other contribution of our model is the provision of the parameter that captures competition between sellers. In other words, the reduced form of the price equation in the proposed model contains the parameter for bargaining power and the indicator of competition between suppliers.

In this paper, we specify a reduced form of the price equation, which is composed of the minimum prices specified in milk marketing orders in the United States and the reduced form of the upper bound for the price in regional raw milk markets. Estimation results based on market prices for 30 cities over 10 years found that the relative bargaining power of dairy cooperatives in setting regional raw milk prices is small compared to the power of milk bottlers. Across a wide range of empirical specifications and estimation methods, the calculated relative bargaining power of dairy cooperatives were found to all be below 0.15, relative to the full bargaining power of 1.0, which is implied by monopoly power by dairy cooperatives and no market power by bottlers. Furthermore, the estimated degree of competition among dairy cooperatives, which is consistent with the estimated price equation, indicates that dairy cooperatives have not established effective cartels that allow them to bargain as monopolies in regional raw milk markets.

In the following section, we describe the raw milk markets and dairy policies in the United States. We discuss the price setting mechanism of milk marketing orders in this section and show that milk marketing orders do price discriminate using the regulation of price differentials between the prices in regional and national markets. In Section III, we discuss a conceptual framework to construct the reduced form of milk price equation under bargaining. We suggest a way to understand the equilibrium price that is bargained over the upper and lower bounds. In this section, we provide an empirical equation that represents the milk price equation under bargaining. We suggest a way to understand the equilibrium price that is bargained over the upper and lower bounds. In this section, we present empirical results in Section V. Section VI discusses the implications of the estimated bargaining power. We show that price differentials of milk marketing orders contribute to raise raw milk price by $1.55/cwt on average during the period between 1995 and 2004.\(^1\) By deriving the indicator that represents the competition between dairy cooperatives, we found that dairy cooperatives do not constitute a cartel for bargaining against milk bottlers.

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\(^1\) cwt indicates “per hundred weight”. Thus 1cwt equals 100 pounds.
II. Raw milk markets and milk marketing orders in the United States

Federal and state milk marketing orders in the United States play the most important role in the raw milk market by providing classification of milk, price discrimination, and revenue pooling. Milk marketing orders that were established by the Agricultural Act in 1935 classify raw milk by two broad categories: milk for bottling purposes and milk for manufactured products. Milk for bottling purposes is called Class I milk. Manufacturing milk is classified into three Classes. Class II is milk for soft manufactured products, Class III is milk used to make cheese, and Class IV is milk used to make butter and nonfat dry milk. Milk marketing orders set minimum prices for each class of milk and processors must pay at least minimum prices.

While minimum prices of Class I milk vary by region, there is a single minimum price for manufacturing Class milk. The minimum manufacturing milk price (hereafter, manufacturing price) is calculated by the values (prices) of the milk components such as fat, protein, and other solids, which are determined by supply and demand conditions at national markets. The USDA-Agricultural Marketing Service (AMS) calculates monthly manufacturing milk prices and announces them. The minimum prices for milk used in Class I milk are composed of the manufacturing milk price plus fixed price differentials, which are determined by legislation and vary by region.

The high transportation cost of raw milk makes the market extent of Class I milk to be local. On the other hand the relatively low transportation cost for milk products such as cheese enables those products to be sold elsewhere in the country, thus the market extent to be national. For these reasons, previous studies that assessed the effects of US dairy policy assume competitive manufactured product markets made up of Class II, III, and IV milk (for example, Ipolito and Masson 1978; Suzuki et al. 1994; Cox and Chavas 2001; Balagtas and Sumner 2003). The competitive nature of the manufacturing milk market is very important in understanding the behaviors of the market participants. In other words, each individual milk seller and buyer has no power to influence the price and thus must take the announced minimum price of manufacturing milk as given.

Milk producers in each milk marketing order are paid a uniform, weighted average price for each class of milk (a pool or blend price) according to milk

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2 There exist minimum prices for each class of manufacturing milk. Thus, the manufacturing milk price referred to in this study can be regarded as the average of those prices, as in previous studies (Ipolito and Masson 1978; Suzuki et al. 1994; Cox and Chavas 2001; Balagtas and Sumner 2003).
marketing order, regardless of the usage of each individual farmer’s milk. Thus, the equilibrium quantity is determined under the condition that the blend price is equal to the marginal cost of milk production (Ipolito and Masson 1978; Cox and Chavas 2001; Balagtas and Sumner 2003).

Based upon these characteristics, equilibrium in the regional raw milk market can be described as in Figure 1. In the figure, \( D_i(P_i) \) indicates demand for Class I milk in region \( i \), and \( P_i \) denotes the market price of Class I milk, which is above the minimum price that is composed of the manufacturing milk price (\( P_B \)) plus the fixed price differential (\( d_i \)). The blend price (\( P_{bi} \)) is a weighted average price of \( P_i \) and \( P_B \), and the marginal cost curve in producing milk is indicated by \( MC_i(Q_i) \). The market equilibrium is achieved at point \( E \), where the blend price and marginal cost curves intersect. The allocation of milk into the markets of Class I milk (as \( Q_{bi}^*(P_i) \) in the figure) and manufacturing milk (as \( Q_{Mi}^* \)) is performed by regional dairy cooperatives and not by individual milk producers as will be discussed later.

A very important feature in the raw milk markets from which we can draw implications of market structure is the over-order premiums for Class I milk prices as illustrated in Figure 1. The over-order premiums are the gaps between the actual

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**Figure 1. Equilibrium in a regional raw milk market**
market prices and minimum prices for Class I milk. During 1995 to 2004, the mean of over-order premiums was $1.22/cwt for the major 30 cities in the federal marketing order regions. During the same period, the means of Class I minimum and manufacturing milk prices were $15.24/cwt and $12.74/cwt, respectively. Thus, the mean of the price differential was $2.50/cwt. The premium between the market price and minimum price in the Class I milk markets reveals the dairy cooperatives’ market power, since the minimum price of Class I milk is set above the competitive price, which would be determined by the demand of buyers and the marginal cost of milk producers in Class I milk markets.

III. Specification of the Model

A. Conceptual framework

If dairy cooperatives and milk bottlers are bargaining, milk bottlers in each regional Class I milk market would perceive Class I minimum prices as lower bounds of bargaining, whereas the dairy cooperative would be able to charge the oligopoly price if they had full bargaining power relative to milk bottlers. Thus, we can say that the observed Class I milk price would be the same as the oligopoly price if only dairy cooperatives exercise market power. However, milk bottlers would set the minimum price if they had full bargaining power. Thus, the bargained price will be between the oligopoly and minimum prices, and whether or not it is closer to the minimum or oligopoly prices will be determined based on the relative bargaining power.

We defined the bargaining power of dairy cooperatives using oligopoly price $P_f$ and minimum price $P_{\text{min}}$ as follows:

$$\omega = (P_f^b - P_{\text{min}}) / (P_f - P_{\text{min}}),$$

where $P_f^b$ is the bargained price. If there exists only oligopoly power, $\omega$ is 1. On the other hand, $\omega$ becomes zero under oligopsony power. Equation (1) is in the same line with the empirical derivation of relative bargaining power in Svejnar (1986) and Brooks et al. (1997), which is expressed as the relative weight in the axiomatic bargaining problem in Nash (1950). Svejnar (1986) showed that the ex post bargaining power can be expressed as the ratio of the difference between the bargained price and a party’s disagreement point to the difference between two disagreement points of each bargaining party. In equation (1), the minimum
and oligopoly price act as the disagreement points since those are the two extreme
prices when one of the bargaining parties has no bargaining power at all, as noted
by Svejnar (1986).

Using the definition of equation (1), the actual Class I milk price under bargaining
can be expressed as the average of the oligopoly and minimum prices weighted by
the bargaining power.

\[
P_{f}^{b} = \omega P_{f} + P_{\text{min}}(1-\omega) = \omega P_{f} + (PB+d)(1-\omega),
\]

where \(PB\) is the manufacturing milk price and \(d\) is the fixed price differential. This
expression of bargained price is in the same spirit of bargaining between maximum
and minimum wages, as in Svejar (1986) and Polacheck and Youn (1996), and
bargaining over the price of health care service between hospitals and insurers in
Brooks et al. (1997).

Specification of empirical price equation (2) under bargaining requires the
reduced form of the oligopoly price. For this, we need to derive the supply relation
of Class I milk. The following section discusses the way to derive it.³

**B. Supply relation of Class I milk under oligopoly power by dairy cooperatives**

Based upon the observation of over-order premiums, we can certainly say that dairy
cooperatives exercise market power in regional Class I milk markets. The fact that
the minimum price is set above the competitive price implies that the equilibrium
point will be on the demand curve of buyers regardless of whether bargaining exists
or not. This is because the points that deviate from the demand curve are Pareto-
dominated by the point on the demand curve that yields the same price with larger
quantity, even under bargaining. Thus, all the arguments based on the demand curve
are valid in what follows.

To define the profit maximization problem of regional dairy cooperatives, we
assumed that dairy cooperatives in each region allocate milk into Class I and
manufacturing milk markets, as in previous studies (see, for example, Dahlgran
and Balagtas and Sumner 2003) . We assumed that the average net return per unit
of milk, which an individual dairy cooperative gets from the market for manufacturing

³ As discussed later, the manufacturing milk price \(PB\) impacts oligopoly price; thus, the coefficient on
\(PB\) does not provide direct information about bargaining.
milk, can be represented by the manufacturing milk price. This is because the market for manufacturing milk is national; thus, dairy cooperatives take the manufacturing milk price as given.

In this setting, dairy cooperatives exercise market power by allocating raw milk between Class I and manufacturing milk markets. Since each regional dairy cooperative does not control the total quantity of milk supplied, the quantity that an individual cooperative gets from dairy farmers is given. Based upon these assumptions, profit maximization for representative dairy cooperative $i$ in each region can be defined by:

$$\max_{q_i} \prod = P_f(Q_f)q_f + PB[\bar{q}_i - q_f] - m_iq_f,$$

where $q_f$ is the quantity allocated to Class I milk market by dairy cooperative $i$ in each region, $P_f(Q_f)$ is inverse Class I milk demand, $Q_f$ is total Class I milk allocated by all of the cooperatives ($\sum_{i=1}^{n} q_i = Q_f$, $n$ is number of dairy cooperatives), $PB$ is the manufacturing milk price determined in the national market, $\bar{q}_i$ is the fixed amount of milk supplied to dairy cooperative $i$, and $m_i$ is marketing cost.

First order condition of equation (3) yields optimal quantity $q^*_f$ allocated to Class I milk market. In order to achieve maximum profits, dairy cooperatives should follow the decision rule of equalizing marginal revenues from the Class I milk market and national manufacturing milk market (and this marginal revenue does not need to be equalized with the marginal cost in producing milk).

Since it is not certain whether or not dairy cooperatives and milk bottlers are bargaining, first we assumed that only dairy cooperatives exercise market power in regional Class I milk markets, considering the fact that over-order premiums exist. If symmetric conjectural variations ($\frac{\partial Q_f}{\partial q_i} = \tilde{\theta}$, for all $i$) are assumed as in Bresnahan (1982; 1989), Genesove and Mullin (1998), Wolfram (1999), Shroeter (1988), Sexton and Lavoie (2001), Suzuki et al. (1994), and Kim and Knittel (2006), we can express the decision rule of equal marginal revenues across two kinds of

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4 This simplification does not overlook the fact that some dairy cooperatives produce dairy products such as cheese and butter, since dairy product markets are competitive; thus, dairy cooperatives are not likely to collect monopoly profits over the competitive price.

5 Dairy cooperatives do not control milk production (USDA-Rural Business-Cooperative Service 2002). Thus, milk production cost is not incorporated in the profits of dairy cooperatives.
markets as \( P_j(Q_f) + \frac{\partial P_j(Q_f)}{\partial Q_f} \frac{\partial Q_f}{\partial q^*_f} = PB \), using the first order condition. Aggregation of optimal quantity \( q^*_f \) acquired from this decision rule yields the following supply relation for Class I milk at regional base.

\[
P_f = -\frac{\partial P_j(Q_f)}{\partial Q_f} \theta Q_f + PB ,
\]

where \( \theta = \tilde{\theta}/n \) is the market power parameter of Bresnahan (1989). This parameter is an indicator of the degree of competition between dairy cooperatives under oligopoly. The market power parameter in equation (4) is \( 1/n \) under the Cournot-Nash game and 1 under the cartel, as in Genesove and Mullin (1998) and Wolfram (1999).

### C. Identification of Class I milk price equation

In deriving empirical equation (2), we do not observe \( P_f \), the pure oligopolistic price. Thus, we substituted equation (4) into equation (2). For this, we expressed the reduced form of the oligopoly price equation by introducing the Class I milk demand function into the supply relation of equation (4). However, there is no information about the functional form of Class I milk demand; thus, we considered the flexible form of the demand curve as in Genesove and Mullin (1998):

\[
Q_j(P_f) = \beta(\alpha - P_f)^\gamma .
\]

This form of the demand curve specifies linear demand with \( \gamma = 1 \), quadratic demand curve with \( \gamma = 2 \), log-linear with \( \gamma < 0 \) and \( \alpha = 0 \), and the exponential demand curve at the limit of \( \alpha \) and \( \gamma (\alpha, \gamma \rightarrow \infty, \alpha/\gamma \text{ constant}) \) as discussed in Genesove and Mullin (1998); the corresponding equations are \( Q = \beta(\alpha - P) + \varepsilon \), \( \ln Q = \ln(\beta) + 2\ln(\alpha - P) + \varepsilon \), \( \ln Q = \ln(\beta) + \gamma \ln(P) + \varepsilon \), and \( \ln Q = \ln(\beta) + \frac{\gamma}{\alpha} P + \varepsilon \). Combining equations (4) and (5) yields the price equation under oligopoly as:

\[
P_f = \frac{\theta \alpha}{\gamma + \theta} + PB \frac{\gamma}{\gamma + \theta} .
\]

By combining equations (2) and (6), we can finally express Class I milk price under bargaining as:
In the empirical estimation, we allowed different intercepts in the price equation according to region and time. To estimate this equation, we used the empirical equation of the form

\[ P^b_j = \omega \left( \frac{\theta \alpha}{\gamma + \theta} \right) + (1 - \omega \theta) PB + (1 - \omega) d. \] (7)

If there is no bargaining between dairy cooperatives and milk bottlers (i.e., if only dairy cooperative exercise bargaining power), the estimated coefficient \( \hat{\rho} \) would be close to zero or insignificant. If \( \hat{\rho} \) is estimated to be significant, we can conclude that there is bargaining, and the relative bargaining power of dairy cooperatives can be calculated by \( 1 - \hat{\rho} \). If we allow regional differences in the parameters \( \theta \) and \( \gamma \), we can estimate the empirical equation of the form

\[ P_j = PB_i \varphi + d_j \rho + \xi_{year} + \mu_j + \lambda_{month} + \epsilon_j. \] (8)

Ideally, we can allow regional differences in the estimation of the price differential. However, the data do not show variations over time for each region. Price differentials had been fixed until 1999. In 2000, federal marketing order reform adjusted price differentials, and the adjusted price differentials have been maintained since then. Thus, estimation of the coefficient on the price differential depends on the variations over the regions, which implies a single coefficient on the price differential in the empirical estimations. As a more general case, we estimated the empirical equation by allowing regional and time variations in the parameters \( \theta \) and \( \gamma \) as in the following equation.

\[ P_j = (PB_i \ast \mu_j) \varphi_j + d_j \rho + \xi_{year} + \mu_j + \lambda_{month} + \epsilon_j \]. (9)

Although the general form of equation (5) can incorporate regional- or time-specific variations of demand by allowing variations in the parameters \( \beta \) and \( \alpha \), it cannot capture the changes in demand due to demand shifters such as income and prices of substitutes or complementary goods. If the underlying demand is linear, however, the shifters of demand might affect the empirical estimation of the bargaining power. Thus, when one wants to introduce demand shifters explicitly, linear demand
of the form \( Q_f = \beta_{c1} + \beta_{p1} P_f + \beta_{c1} V \) can be employed, where \( V \) represents demand shifters. By combining the supply relation of equation (4) and this equation, we derived the Class I milk price under oligopoly as equation (11), by eliminating the endogenous variable \( Q_f \).

\[
P_f = -\frac{\beta_{c1}}{\beta_{p1}} \frac{\theta}{1+\theta} + PB \frac{\beta_{c1}}{\beta_{p1}} \frac{\theta V}{1+\theta}.
\]  

(11)

Combination of equations (2) and (11) yields Class I milk price under bargaining as:

\[
P_f^b = -\frac{\beta_{c1}}{\beta_{p1}} \frac{\theta \omega}{1+\theta} + PB(1- \frac{\theta \omega}{1+\theta}) - \frac{\beta_{c1}}{\beta_{p1}} \frac{\theta \omega}{1+\theta} V + (1-\omega) d.
\]

(12)

In the empirical estimation, different intercepts of \( \beta_{c1} \) were allowed in the regional Class I milk demand. Variations in the intercepts of demand due to variations in time were also allowed. Thus, the following empirical equation (13) was estimated for the linear demand case where demand shifters appear explicitly. We also estimated the empirical price equation that allows different coefficients on demand shifters and manufacturing milk price by region.

\[
P_{jt} = V_{jt} \zeta + PB_{jt} \phi + d_{jt} \rho + \xi_{year} + \mu_j + \lambda_{month} + \epsilon_{jt}.
\]

(13)

IV. Data and econometric issues

Data for the empirical estimation include monthly Class I milk prices from 30 cities in 25 different states for federal marketing order regions in the United States during the period from 1995 to 2004. We used the cooperative price of Class I milk in Dairy Market News of USDA-Agricultural Marketing Service (AMS) as the actual Class I milk price that dairy cooperatives are paid. Manufacturing milk price was acquired from the Federal Milk Order Market Statistics of USDA-AMS. We

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6 The cities are Phoenix (AR), Miami (FL), Minneapolis (MN), Little Rock (AR) Denver (CO), Hartford (CT), Atlanta (GA), Des Moines (IA), Chicago (IL), Indianapolis (IN), Louisville (KY), New Orleans (LA), Boston (MA), Baltimore (MD), Detroit (MI), Kansas City (MO), Springfield (MO), St. Louis (MO), Charlotte (NC), Omaha (NE), Cincinnati (OH), Cleveland (OH), Oklahoma City (OK), Philadelphia (PA), Pittsburgh (PA), Dallas (TX), Houston (TX), Seattle (WA), Milwaukee (WI) and Washington, D.C.
calculated the price differential for each city using manufacturing milk prices and Class I minimum prices in *Dairy Market News*.

In order to estimate the empirical equation (13), we considered two kinds of Class I milk demand shifters. Since Class I milk is a derived demand, the shifters that represent milk bottling costs as well as the retail demand shifters will cause variations in Class I milk demand. Thus, we used per capita income, cereal price, juice price, and the price for non-alcoholic beverages for the shifters of retail demand. For the shifters capturing the variation in milk bottling cost, we used manufacturing wage, interest rate, and price of intermediate goods. We used state level data on per capita income from the US Bureau of Economic Accounts website. Since monthly level population data are not announced, annual population data from the US Bureau of Labor Statistics website were used. Monthly data were approximated by dividing the year-to-year differences by 12 and then adding equal increments to each month in order to calculate per capita income on a monthly basis. For other demand shifters, only national average data were available. We found that the interest rate as well as the prices of cereal, cheese, and non-alcoholic beverages did not vary across cities; thus, the national level data are able to capture the effects resulting from changes in these variables. Since we included a city fixed effect in the empirical equations, the regional differences in these variables due to transportation costs can be captured. The prices of intermediate goods and manufacturing wage may differ by city. Thus, we allowed interaction terms between the city fixed effect and these variables. All of the data for the demand shifters are price indices that were acquired from the US Bureau of Labor Statistics website. The income and price data were deflated by the consumer price index. Table 1 reports the summary statistics for the variables. While the Class I milk price increased during the data period, price differentials were kept constant except for a single time variation in 2000. The averages of price differentials were $2.47/cwt from 1995 to 1999 and $2.52/cwt from 2000 to 2004, as presented in Table 1. Manufacturing milk prices for the data period were in the range from $11.01/cwt to $14.98/cwt.

We verified several econometric issues. First, although there was a single time variation in the price differential in 2000, we found regional variations in price differentials as discussed earlier. Thus, these limited time variations in price differentials did not prevent us from identifying the effects of price differentials on Class I milk prices. Another concern is the possible presence of measurement error regarding the actual Class I milk price. The prices in *Dairy Market News* are the average prices that major cooperatives in each city are actually paid. Thus, the prices received by the cooperatives other than major ones are not reflected in the announced
Table 1. Descriptive statistics for variables used in the regression

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<tr>
<td>Class I milk price ($/cwt)</td>
<td>14.74</td>
<td>16.99</td>
<td>15.44</td>
<td>17.03</td>
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<td>17.98</td>
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<tr>
<td>Per capita income (1000$)(^1)</td>
<td>15.20</td>
<td>15.47</td>
<td>15.88</td>
<td>16.60</td>
<td>16.90</td>
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<td>105.0</td>
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<td>100.9</td>
<td>101.1</td>
<td>100.6</td>
<td>98.5</td>
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<td>Consumer Price index for cheese</td>
<td>90.4</td>
<td>92.2</td>
<td>92.0</td>
<td>93.3</td>
<td>97.6</td>
<td>94.5</td>
<td>94.6</td>
<td>94.5</td>
<td>92.0</td>
<td>95.6</td>
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<tr>
<td>Consumer Price index for non alcoholic beverage</td>
<td>86.4</td>
<td>81.9</td>
<td>83.1</td>
<td>81.6</td>
<td>80.6</td>
<td>79.9</td>
<td>78.6</td>
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<td>Price index for intermediate goods</td>
<td>88.69</td>
<td>85.41</td>
<td>83.6</td>
<td>81.8</td>
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<td>80.8</td>
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<td>83.0</td>
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<td>57.8</td>
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Notes: \(^1\) Seasonally adjusted at annual rates. All the price indices are 1982-1984=100. Price indices and per capita income are deflated by CPI (1982-1984 =100).
actual Class I milk prices. The measurement error in the dependent variable ended up with unbiased estimates but yielded larger standard errors. However, our estimation results showed very small standard errors, as will be presented later. Thus, the empirical results in this paper are very robust even in the presence of measurement error in the dependent variable.

Another issue in the estimation is the heterogeneity of variances for the bargained prices. The upper bound of bargaining is not likely to be the same across cities. This forced us to allow heterogeneity of the variances between cities in the empirical estimations. Another issue is the serial correlation that comes from the monthly level data. To handle these issues, we present the estimation results that allows for heteroscedasticity of variance across cities and an AR(1) disturbance. One might think that regional Class I milk prices affect the manufacturing milk price, giving rise to an endogeneity problem. However, we believe that our empirical models have little possibility of this problem. Considering that there are more than 3000 counties in the regions of the federal marketing orders, city-specific actual prices will actually have little impact on the national manufacturing milk market.

V. Results

Table 2 reports the estimation results from the model that allows demand shifters explicitly in the empirical equation (13). The estimated coefficients on the price differential and manufacturing milk price are all significant at the 99 percent level. These results imply that a one dollar increase in the manufacturing milk price yields about a 0.94 or 0.95 dollar increase in the Class I milk price, ceteris paribus. The significant coefficients on the price differential imply that milk bottlers and dairy cooperatives are bargaining in Class I milk markets.

The estimated coefficients on the price differential under the OLS estimation are bigger than those estimated under the method that corrects an AR(1)-error. Using the estimated coefficients on the price differential, the relative bargaining power of dairy cooperatives are calculated as 0.0963, 0.1091, 0.1301, and 0.1267, respectively. These results suggest that the relative bargaining power of milk bottlers are very large compared to that of dairy cooperatives.

One might argue that the estimated coefficient and standard error under the estimation that includes an AR(1)-disturbance do not reject the null hypothesis that the coefficient is one, which implies that there is no bargaining power to the dairy cooperatives. While this is certainly what the hypothesis test suggests, the existence of over-order premiums in all of the cities more strongly indicates that dairy
cooperatives exercise market power against the oligopsony power of milk bottlers. Thus, the statistical test as to whether or not the estimated coefficient on the price differential differs from 1 does not nullify the calculations of the relative bargaining power of diary cooperatives using the coefficients on price differentials. The mean of the coefficients on the price differential indicate that a one dollar increase in the price differential yields about a 0.88 dollar increase in the Class I milk price, ceteris paribus. This result implies that there is an incentive for milk producers to lobby for a higher price differential determined by legislation (Ahn and Sumner 2009).

Table 2. Estimated Class I milk price equation under linear demand

<table>
<thead>
<tr>
<th>Variable</th>
<th>OLS allowing cluster by cities</th>
<th>AR(1)-error corrected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price differential</td>
<td>.9037*** (.1876)</td>
<td>.8699*** (.1696)</td>
</tr>
<tr>
<td></td>
<td>.8909*** (.2464)</td>
<td>.8733*** (.2158)</td>
</tr>
<tr>
<td>Manufacturing milk price</td>
<td>.9433*** (.0097)</td>
<td>.9541*** (.0036)</td>
</tr>
<tr>
<td></td>
<td>.9435*** (.0099)</td>
<td>.9542*** (.0036)</td>
</tr>
<tr>
<td>Personal income</td>
<td>.0623** (.0261)</td>
<td>.0202 (.0306)</td>
</tr>
<tr>
<td></td>
<td>-.0232 (.0996)</td>
<td>-.0509 (.0445)</td>
</tr>
<tr>
<td>Cereal price index</td>
<td>-.0446*** (.0115)</td>
<td>.0006 (.0091)</td>
</tr>
<tr>
<td></td>
<td>-.0458*** (.0113)</td>
<td>-.0017 (.0091)</td>
</tr>
<tr>
<td>Cheese price index</td>
<td>.0286*** (.0062)</td>
<td>.0137*** (.0052)</td>
</tr>
<tr>
<td></td>
<td>.0298*** (.0063)</td>
<td>.0145*** (.0052)</td>
</tr>
<tr>
<td>Price index for non alcoholic beverage</td>
<td>-.0266* (.0153)</td>
<td>-.0271*** (.0084)</td>
</tr>
<tr>
<td></td>
<td>-.0256 (.0154)</td>
<td>-.0267*** (.0083)</td>
</tr>
<tr>
<td>Manufacturing wage index</td>
<td>-.2148 (.4833)</td>
<td>-.3490 (.2935)</td>
</tr>
<tr>
<td>Interest rate index</td>
<td>.0411 (.0472)</td>
<td>.0058 (.0387)</td>
</tr>
<tr>
<td></td>
<td>.0364 (.0488)</td>
<td>.0110 (.0379)</td>
</tr>
<tr>
<td>Price index for intermediate goods</td>
<td>-.0346*** (.0127)</td>
<td>-.0181 (.0122)</td>
</tr>
</tbody>
</table>

| Inclusion of                          |                              |                         |
| - city fixed effect price index for   | Yes                           | Yes                     |
| intermediate goods*                   |                               |                         |
| - city fixed effect manufacturing wage| Yes                           | Yes                     |
| index*                                |                               |                         |
| Adjusted $R^2$                        | 0.9745                        | 0.9781                  |
|                                       | 0.9735                        | 0.9762                  |

Notes: * significant at ten percent or better, ** significant at five percent or better, *** significant at one percent or better. All specifications include city, month, and year fixed effects.
Table 3 presents the estimation results of the empirical equation (8). The coefficients on the manufacturing milk price and the price differential are significant at the 99 percent level. The high adjusted R² suggests that the empirical price equation fits very well. The estimation results from the models that allows different variances in the Class I milk prices across regions are not significantly different from the results based on the estimation results in which an AR(1)-disturbance is corrected.

In Table 3, the coefficients on manufacturing milk price are estimated under the assumption that the curvature of demand (i.e., γ in empirical equation 8) and market power parameter, which indicates the degree of competition between diary cooperatives (i.e., θ in empirical equation 8), are constant across regions. These coefficients indicate that a one dollar increase in the manufacturing milk price yields about a 0.97 or 0.96 dollar increase in the Class I milk price, ceteris paribus. Based on these estimated coefficients, the relative bargaining power of the dairy cooperatives in each case is calculated as 0.1332 and 0.1395, respectively.

Table 4 presents the estimation results based on the empirical equations (9) and (10), which allow fixed effects to the coefficients on manufacturing milk price. Overall, the empirical equation explains the variations in Class I milk price very well, as indicated by a high R². Estimation results show that the results based on OLS do not significantly differ from those based on the model in which an AR(1)-disturbance is corrected. The inclusion of interaction terms between the fixed effect and manufacturing milk price do not impact the estimation results significantly. The calculated relative bargaining power of the diary cooperatives with coefficients, as shown in Table 4, are 0.0876, 0.0986, and 0.0980, respectively. These values are slightly smaller than those calculated with the results in Table 3, and they confirm that the bargaining power of dairy cooperatives is very small relative to that of the milk bottlers.

The calculated relative bargaining power of the dairy cooperatives under different model specifications is summarized in Table 5. Throughout the estimation results

Table 3. Estimated Class I milk price equation without interactions between fixed effect and manufacturing milk price

<table>
<thead>
<tr>
<th>Variable</th>
<th>OLS allowing cluster by city</th>
<th>AR(1)-error corrected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price differential</td>
<td>.8668*** (.0738)</td>
<td>.8605*** (.1721)</td>
</tr>
<tr>
<td>Manufacturing milk price</td>
<td>.9655*** (.0041)</td>
<td>.9597*** (.0032)</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.9732</td>
<td>0.9726</td>
</tr>
</tbody>
</table>

Notes: All specifications include city, month, and year fixed effects. *** significant at one percent or better.
in Tables 2 to 4, estimated coefficients on the price differential are smaller than those on manufacturing milk price, which is very reasonable when $\gamma$ is greater than zero by the coefficients in equation (7).

| Table 4. Estimated Class I milk price equation with interactions between fixed effect and manufacturing milk price |
|-----------------|------------------|------------------|------------------|------------------|
| Variable        | OLS allowing AR(1)-error | OLS allowing AR(1)-error |
|                 | cluster by city corrected | cluster by city corrected |
| Price differential | .9124***  | .9014***  | .9124***  | .9020***  |
|                  | (.0702)  | (.1661)  | (.0684)  | (.1615)  |

Inclusion of
- city fixed effect base price* Yes Yes Yes Yes
- month fixed effect base price* Yes Yes Yes Yes
- year fixed effect base price* Yes Yes Yes Yes

Adjusted R² 0.9758 0.9748 0.9770 0.9762

Notes: All specifications include city, month, and year fixed effects. * significant at ten percent or better, *** significant at one percent or better.

<table>
<thead>
<tr>
<th>Table 5. Estimated relative bargaining power of dairy cooperatives by different model specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model specification</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Linear demand</td>
</tr>
<tr>
<td>With no fixed effects</td>
</tr>
<tr>
<td>With city and time fixed effects</td>
</tr>
<tr>
<td>Flexible demand</td>
</tr>
<tr>
<td>With no fixed effects</td>
</tr>
<tr>
<td>With city fixed effects</td>
</tr>
<tr>
<td>With city and time fixed effects</td>
</tr>
</tbody>
</table>

VI. Implications of estimated bargaining power

A. Implications for effects of price discrimination policy

Regarding these implications, we now can ask two interesting questions: What is the level of upper bound for bargaining? What would be the bargained price under no price differential? The answer to the first question provides very important information to the second question.

Equation (2) implies that if we know the relative bargaining power $\hat{o}$, we can derive the upper bound of bargaining, which we regard as the price that dairy cooperatives
can charge when they have full bargaining power (i.e., when only the dairy cooperatives exercise market power). Using the estimated bargaining power, the upper bound of bargaining can be expressed as $P_j = \left( P^b - (PB + d)(1 - \hat{\omega}) \right) / \hat{\omega}$. The results in Table 2 indicate that the mean value for the calculated relative bargaining power for dairy cooperatives is 0.1267. Together with this calculated value, the average bargained Class I milk price, the price differential, and the manufacturing milk price, we can derive the upper bound of bargaining for Class I milk price. Table 6 presents the simulated upper bounds of bargaining. If dairy cooperatives had been able to exercise full bargaining power for the data period (i.e., if they had been able to charge the price without bargaining with milk bottlers), the actual price of Class I milk would have ranged from $19.22/cwt to $29.34/cwt. These simulated prices of Class I milk are higher than the actual prices by $4.48/cwt to $10.68/cwt, and the difference between the actual market price and simulated oligopoly price has widened during the data period, as indicated by Figure 2. On average, the simulated upper bound of bargaining is $24.70/cwt, which is higher than the actual Class I milk price by $8.26/cwt. The simulated prices in Table 6 suggest that dairy cooperatives could have charged, on average, prices 1.54 times higher than actual Class I milk prices, if they had been able to exercise full bargaining power.

As discussed already, price discrimination according to the price differential is one of the most crucial policy tools in US milk marketing orders. In this study, we simulated the bargained price without price differential in order to assess the effects of this price discrimination policy on bargained prices. Since the upper bound of price is understood as the price that dairy cooperatives charge if they have full bargaining power (i.e., when only dairy cooperatives exercise market power), it is reasonable to say that the upper bound of bargaining does not vary in response to a sole change in the minimum price. Thus, excluding the price differential, we can simulate bargaining prices in each region according to $P^b_{w/d} = \hat{\omega}\hat{P}_j + PB(1 - \hat{\omega})$, where $\hat{P}_j$ is the simulated upper bound of bargaining as in the previous section.

The simulated bargained prices without price differential are presented in Table 6 in the second to last column. The prices under no price differentials are less than the actual Class I milk prices. On average, the actual prices are higher than the simulated bargained prices by $1.52/cwt. Thus, we can say that price differentials in milk marketing orders have contributed to raise Class I milk prices but the effects of those price differentials are not big. These results imply that bargained prices can be raised by raising price differentials through milk marketing orders. The simulated upper bound of prices in Table 5 suggest that the maximum price differential that could have raised Class I milk price under bargaining is $11.96/cwt on average.
Estimation of Relative Bargaining Power

for the data period, since the average of the derived upper bound of price is $24.70/cwt and the average of the manufacturing milk price is $12.74/cwt. The fact that actual Class I milk prices have always been higher than the minimum prices has introduced argument that elimination of price differentials will have no effect on Class I milk prices. Although this is certainly true for oligopoly markets, our simulation results indicate that price differentials play a significant role in raising Class I milk prices. Thus, the price discrimination policy via price differentials is very effective.

Table 6. Simulated upper bound of bargaining and bargained price under no price differentials

<table>
<thead>
<tr>
<th>Year</th>
<th>Actual Class I price ($/cwt)</th>
<th>Announced price differential ($/cwt)</th>
<th>Simulated upper bound of bargaining ($/cwt)</th>
<th>$[B] - [A]$ ($/cwt)</th>
<th>$[B]/[A]$</th>
<th>Simulated bargained price without price differential ($/cwt)</th>
<th>$[C] - [A]$ ($/cwt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>14.74</td>
<td>2.47</td>
<td>19.22</td>
<td>4.48</td>
<td>1.30</td>
<td>12.58</td>
<td>0.96</td>
</tr>
<tr>
<td>1996</td>
<td>16.99</td>
<td>2.47</td>
<td>23.19</td>
<td>6.20</td>
<td>1.37</td>
<td>14.83</td>
<td>1.21</td>
</tr>
<tr>
<td>1997</td>
<td>15.44</td>
<td>2.47</td>
<td>23.71</td>
<td>8.27</td>
<td>1.54</td>
<td>13.28</td>
<td>1.51</td>
</tr>
<tr>
<td>1998</td>
<td>17.03</td>
<td>2.47</td>
<td>24.06</td>
<td>7.03</td>
<td>1.41</td>
<td>14.87</td>
<td>1.33</td>
</tr>
<tr>
<td>1999</td>
<td>17.26</td>
<td>2.47</td>
<td>25.05</td>
<td>7.79</td>
<td>1.45</td>
<td>15.10</td>
<td>1.44</td>
</tr>
<tr>
<td>2000</td>
<td>15.40</td>
<td>2.52</td>
<td>25.57</td>
<td>9.17</td>
<td>1.60</td>
<td>13.20</td>
<td>1.65</td>
</tr>
<tr>
<td>2001</td>
<td>17.98</td>
<td>2.52</td>
<td>26.25</td>
<td>8.27</td>
<td>1.46</td>
<td>15.78</td>
<td>1.52</td>
</tr>
<tr>
<td>2002</td>
<td>15.04</td>
<td>2.52</td>
<td>25.45</td>
<td>10.41</td>
<td>1.69</td>
<td>12.84</td>
<td>1.83</td>
</tr>
<tr>
<td>2003</td>
<td>15.45</td>
<td>2.52</td>
<td>26.13</td>
<td>10.68</td>
<td>1.69</td>
<td>13.25</td>
<td>1.87</td>
</tr>
<tr>
<td>2004</td>
<td>19.00</td>
<td>2.52</td>
<td>29.34</td>
<td>10.34</td>
<td>1.54</td>
<td>16.80</td>
<td>1.82</td>
</tr>
<tr>
<td>Mean</td>
<td>16.43</td>
<td>2.50</td>
<td>24.70</td>
<td>8.26</td>
<td>1.54</td>
<td>14.25</td>
<td>1.52</td>
</tr>
</tbody>
</table>

Note: Oligopoly prices are simulated with the average of actual Class I milk prices for 30 cities in the data set under the mean value of 0.1267 for the calculated relative bargaining power of dairy cooperatives.

Figure 2. Simulated oligopoly price and bargained price without price differential
B. Implications about collective bargaining

Another interesting question is whether or not dairy cooperatives made a cartel for bargaining with milk bottlers. If the simulated upper bounds of bargaining in Table 6 are the monopoly prices, then we can say that they do the collective bargaining against milk bottlers. Although we do not have information on the monopoly prices with which we can compare the simulated prices, equation (13) enables us to derive the degree of competition between dairy cooperatives, which can be an indicator of collective bargaining.

In equation (12), the coefficients on the price differential and manufacturing milk price contain the parameter \( \theta \), which represents the degree of competition between dairy cooperatives. Thus, if the parameter \( \hat{\theta} \) imputed by the estimated coefficient \( \hat{\phi} \) and \( \hat{\rho} \) is one, we can say that dairy cooperatives constitute a cartel. And this implies that dairy cooperatives perform collective bargaining. Using the estimate of \( \hat{\phi} \) and \( \hat{\rho} \), the imputed degree of competition between dairy cooperatives can be calculated as \( \hat{\theta} = \frac{\hat{\phi} - 1}{\hat{\rho} - \hat{\phi}} \). Based on the estimated coefficients in the first and second columns in Table 2, the imputed \( \hat{\theta} \) can be measured as 1.4318 and 1.0741, which supports the hypothesis of collective bargaining. However, the estimated coefficients in the third and fourth columns in Table 2 yield 0.5451 and 0.5661 as the degree of competition between dairy cooperatives. These results imply that dairy cooperatives exercise market power but do not constitute a cartel. Thus, implications about collective bargaining across the estimation results in Table 2 are not consistent.

If we depend on the estimated coefficients on the price differential and manufacturing milk price in empirical equation (7), \( \hat{\theta} \) can be calculated as \( \frac{\gamma (\hat{\phi} - 1)}{\hat{\rho} - \hat{\phi}} \).

Figure 3 presents the imputed \( \hat{\theta} \) according to a different curvature of demand. The degrees of competition were calculated using the estimated coefficients in Table 3. The existence of over-order premiums indicates that dairy cooperatives exercise market power. Thus, we can say that the estimated coefficients in Table 3 are not consistent with the existence of over-order premiums at a curvature below 0. In Figure 3, \( \theta_1 \) and \( \theta_2 \) denote imputed \( \hat{\theta} \), which can be calculated by the estimates in the first and second columns in Table 3, respectively. Figure 3 implies that \( \theta_2 \) becomes 1 at a curvature of 2.5. We believe that the demand function of Class I milk with a curvature of 2.5 is not likely the case. Thus, the imputed degree of competition between dairy cooperatives, at reasonable ranges for the curvature of demand,
indicates that dairy cooperatives do not constitute a cartel and therefore do not perform collective bargaining.

**Figure 3. Imputed degree of competition between dairy cooperatives under flexible demand function**

Note: $\theta_1$ and $\theta_2$ denote the imputed $\hat{\theta}$, which can be calculated by estimates in the first and second columns in Table 3.

**VII. Summary and conclusions**

We presented a practical way to assess relative bargaining power using the upper and lower bounds of bargaining. This paper identified bargaining power by investigating reactions of sellers and buyers to minimum price regulations in US raw milk markets using monthly minimum and market prices for 30 cities over 10 years. By developing a model that characterizes milk allocations by dairy cooperatives in regional raw milk markets, we estimated the relative bargaining power of dairy cooperatives using the reduced form of the price equation under bargaining, which is composed of the minimum price and the reduced form of the upper bound of bargaining.

Our empirical estimations indicate that the relative bargaining power of dairy cooperatives in regional US raw milk markets is very small compared to the power of milk bottlers. The estimated coefficients in the reduced form of the milk price equation imply that dairy cooperatives do not constitute a cartel in bargaining against milk bottlers. These results imply that the price discrimination policy of milk marketing orders in the United States is very effective in increasing raw milk prices.
over which dairy cooperatives, who have relatively low bargaining power, bargain with milk bottlers, who have larger bargaining power.

The US raw milk markets we investigated in this study have explicit lower bounds of bargaining, which enable us to implement empirical estimations in a more convenient way. However, we think that the proposed way of estimating bargaining power is not milk-market specific. We may apply the concept of bounds for bargaining to many well known bargaining situations, such as new car price bargaining or wage bargaining. Other government policies that regulate price such as the price ceiling can be used an indicator of the bound of bargaining. A quantity control policy such as production quota can also be used for the bound of bargaining.

In this paper, we proposed a convenient method that only requires information on one side of disagreement points for the empirical estimation of bargaining power. Thus, we can say that this paper contributes to the literature by providing extended applications of existing bargaining theory.

References


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USDA-Rural Business-Cooperative Service (2002), *Cooperatives in the dairy industry*. 