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NATURAL EXPERIMENTS ON THE RAW-MILK PRICES FOR DISCLOSING MARKET POWER

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oligopoly power, milk, dairy, experiment

Abstract
This study measures the degree of oligopoly power of domestic marketers in the Korean white fluid milk market using natural experiments. It extends the number of experiments to eight times covering more than 20 years and considers a dynamic game to check the robustness of the estimates covered by previous studies. The results show that the estimates obtained by the eight experiments and a dynamic game are quite similar to those obtained by a one-shot experiment with a static game. The results show that the Korean white fluid milk market is far from perfect competition.

I. Introduction

A natural experiment occurs when a subset of the population is subjected to an exogenous variation such as a policy shock (See Cameron and Trivedi, 2005; 54-58). Recently, this technique has been used in social science to see the impacts of a policy shock (See, for example, Eissa and Liebman, 1996 and Meyer and Rosenbaum, 2001).

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A natural experiment is an observational study in which the assignment of treatments to subject has been haphazard.[1] This study uses data obtained not by arbitrary experiments but by naturally generated policy variables. This study divides the sample periods into two groups for a natural experiment. One group is under the policy shock and the other group is not under the policy shock. By comparing the impacts of the shock in two groups, we can measure the net impact of the shock.

This paper focuses on white fluid milk products that are almost homogeneous products. The white fluid milk market in Korea is served by a few processors. The sum of market shares of top three milk processors (Seoul, Maeil, and Namyang) is 58 percent in total domestic raw milk production. Hence, there is a great potential of market power of these processors in the Korean white fluid milk market.

The price setting mechanisms in the raw milk market and the retail fluid milk market are quite different. The raw milk price in the raw milk market is exogenously determined by the Korea Dairy Committee (KDC) that is a semi-government agency. The KDC raises the reference price for the raw milk price when there is an increase of producing cost of making raw milk more than five percent (Song et al. 2005). The raw milk price paid to raw milk producers is decided by the reference price and standard adjustments for quality and fat ratio. During this process, milk collectors or processors are known to have no power to set the raw milk price; hence, they are price takers in the raw milk market. On the contrary, in the retail fluid milk market, the marketers are known to set the retail fluid milk price for their economic benefits.[2]

This study focuses on measuring the oligopoly power of the domestic marketers as a whole in the retail market for white fluid milk products. The reason for this classification is that our observation of market prices is limited only to the raw milk price in the raw milk market and retail price for white fluid milk products in the retail market.

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[1] http://en.wikipedia.org/wiki/Natural_experiment (Jun. 14, 2011)

[2] There are many economic agents along the marketing channels from the raw milk market to the retail market: raw milk collectors, raw milk processors, distributors, retailers and so on. We group these economic agents into one group named as “marketers” in this study. Hence, in this study, there are three economic agents: producers, marketers, and consumers.

One of the major limitations in estimating market power is the lack of cost information, especially marginal cost. After the 1980s, agricultural economists use the New Empirical Industrial Organization (NEIO) approach. The NEIO approach estimates the degree of market power by estimating several structural equations with strong assumptions on cost and demand functions. Corts (1999) criticized these strong assumptions and, furthermore, the NEIO estimate could be biased if the estimation model does not precisely represent the real game. Most of the previous empirical studies reviewed by Sexton and Lavoie (2001) and Kaiser and Suzuki (2006) are not free from the Corts's criticism.

To avoid a bias caused by misspecification on the cost function, some studies do not specify cost function. Instead, they use cost shifters to check the competitiveness of an industry by comparing the changes in cost shifters and prices. Sumner (1981) and Sullivan (1985) used excise taxes, and Goldberg and Knetter (1999) used exchange rates as cost shifters to check the competitiveness in an industry.

This paper uses a shock of raw milk price as a cost shifter and checks how much of the shock is transferred to the retail price to see the degree of oligopoly power of the domestic marketers in the white fluid milk market in Korea. The raw milk price is given to domestic marketers. Therefore, we can use a natural experiment in which the raw milk price is used as an exogenous shock to the endogenous retail fluid milk price. This paper calculates and compares the changes in the raw milk price and the retail fluid milk price when an exogenous shock is happened in the raw milk price. To do so, we divide the samples into two time series groups. One group is under the shock of raw milk price and the other group is not under the shock of raw milk price. By comparing these two groups, we can measure the net impact of the shock of raw milk price on the retail fluid milk price. As a result, we can tell the degree of oligopoly power of domestic marketers in the retail market for white fluid milk products in Korea.

The main idea of this study is to measure how much of the shock in marginal cost of the marketers is transferred to the retail price in the retail market. Wohlgenant (2001) argued that marketing margins can be explained by many factors other than shifts in marginal cost, such as shifts in demand and supply, time lags, technical change, etc. This paper adopts a differences-in-differences method to control all the factors other than the shift in raw milk

price (See Cameron and Trivedi, 2005; 878-879). By netting out the changes of all the factors other than marginal cost we can calculate the net impact of the marginal cost on the retail price.

Another issue is to separate out all the changes in marginal cost other than raw milk price. White fluid milk products are made by raw milk and marketing inputs. This paper only considers the shock of raw milk price; hence we have to eliminate all the changes in prices of marketing inputs. White fluid milk products are made by fixed proportions between raw milk and other marketing inputs. That is, the use of raw milk is separable and independent from the use of other inputs. Therefore, we can deal with the changes in the prices of marketing inputs separately from the changes in the raw milk price.

Ahn (2006) measured the degree of oligopoly power of processors in the Korean fluid milk market using the NEIO approach. Following Corts' criticism, Jeon (2009 a) argued that the estimate obtained by the NEIO approach could be biased using seasonal variations in the demands for fluid milk products. Jeon (2009 b) estimates the degree of oligopoly power using raw milk prices based on a natural experiment. But his study used only one shock of raw milk price in 2004. To obtain the credibility of the estimate, Jeon used raw milk prices of eight regions. This study extends Jeon's (2009 b) study in two aspects. One aspect is that it uses more data to obtain more precise estimates. The other is that this study develops a dynamic game under which this study considers the dynamic expectations of domestic marketers about raw milk price changes. One of the objectives of this study is to ascertain whether the estimates obtained by Jeon (2009 b) are robust under the periods other than 2004 and under a dynamic game reflecting expectations.[3]

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[3] Through natural experiments, this study reduces the bias problem originated from the mis-specification on demand and cost sides. In addition, this study considers not only a static game but also a dynamic game based on expectations on future prices. However, this study is conducted based on conjectural elasticity, which is not fully free from Corts's criticism. He argues that "relying on the conjectural variations model to provide the mapping from equilibrium variation to equilibrium values is fundamentally flawed." The NEIO estimate could be biased if the empirical estimation model does not represent the real game.

II. Theoretical Model

This paper divides the product markets into two markets: raw milk market and retail fluid milk market. Economic agents along the marketing channels from the raw milk market to the retail market are grouped into "marketers" in this study.

The profit of a representative marketer *i* can be represented as

$$(1) \qquad \pi_i = \left\{P^r(Q^r) - P^f\right\}q_i - C(q_i) - F_i \qquad (i = 1,2,...,N),$$

where $P^r(Q^r)$ is the inverse demand function, Q^r is the total quantity of white fluid milk consumed, P^f is the raw milk price paid to the producers, which is taken by the processor *i* as given, q_i is the quantity of fluid milk sold by the single processor *i*, $C(q_i)$ is the processing and marketing cost of the processor *i*, and F_i is the fixed cost for the processor *i* to make fluid milk.[4] The market clearing condition can be written as

$$Q^r = \sum_i q_i \quad .$$

The optimal condition for the profit maximizing problem of the processor *i* is obtained as

$$(2) \qquad P^r(Q^r) = \Lambda\ \theta\ + P^f + c,$$

where the parameter $\Lambda(=-\frac{\partial P^r}{\partial Q^r}Q^r)$ has the information on demand side, the parameter $\theta(=-\frac{\partial Q^r}{\partial q_i}\frac{q_i}{Q^r})$ is a conjectural elasticity that indicates the degree of market power of marketers in the fluid milk, and *c* is the average of marginal cost of marketers other than raw milk price.[5] Oligopoly power parameter θ lies between 0 and 1. If θ is 0, an industry is perfectly competitive; and if θ

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[4] This study assumes that the use of raw milk is separable and independent from the use of other inputs. Hence, the raw milk price paid to the producers (P^f) and the processing and marketing cost ($C(q_i)$) are separated in equation (1).

[5] If we differentiate equation (2) with respect to q_i we obtain

is 1, the industry is a monopoly or the marketers are perfectly collusive. The Lerner's Index is obtained from equation (2) as

$$(3) \quad L = \frac{P^r - (P^f + c)}{P^r}$$

that is equal to $(\frac{\Lambda\theta}{P^r})$.

III. NATURAL EXPERIMENTS

1. Data

Marketers use raw milk and marketing inputs to make final fluid milk products. The prices of raw milk and marketing inputs determine the marginal cost of marketers. The retail price of final fluid milk products is decided by the marginal cost and the degree of oligopoly power of the marketers. This study focuses on the shocks in the raw milk price on cost side and the corresponding changes in the retail price of fluid milk products by controlling the changes in the prices of marketing inputs other than raw milk price.

The key variables are the raw milk price and the retail price of white fluid milk products. For empirical purpose, this study uses monthly price data of raw milk price and retail price from January 1985 to December 2008. The Indexes for raw milk price and retail price are obtained from the Korea Statistical Information Service. These indexes are transformed into prices using the prices in December 2008 as the basis price.

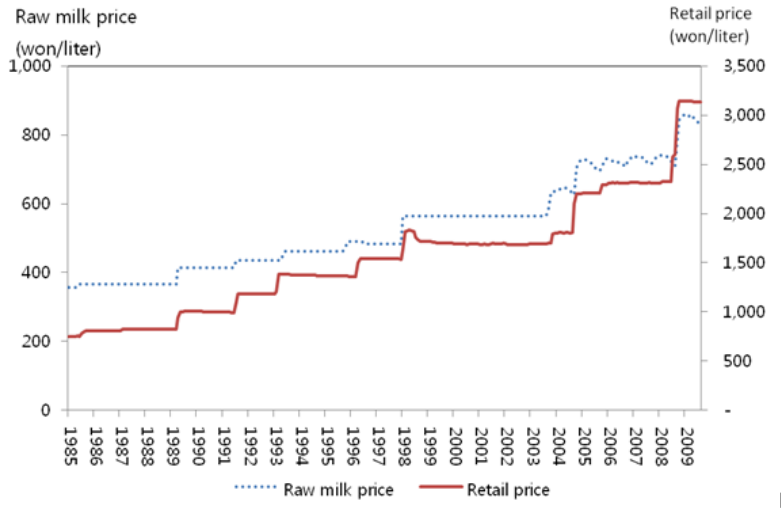
$$\frac{\partial \pi_i}{\partial q_i} = \{P^r(Q^r) - P^f\} + \frac{\partial P^r(Q^r)}{\partial Q^r}\frac{\partial Q^r}{\partial q_i} q_i - c = 0 \ .$$

The equation could be manipulated as

$$P^r(Q^r) = -\frac{\partial P^r(Q^r)}{\partial Q^r} Q^r \frac{\partial Q^r}{\partial q_i}\frac{q_i}{Q^r} + P^f + c = \Lambda\ \theta\ + P^f + c \ ,$$

where Λ is $(-\frac{\partial P^r}{\partial Q^r}Q^r)$ and θ is $(-\frac{\partial Q^r}{\partial q_i}\frac{q_i}{Q^r})$.

FIGURE 1. Trends of Raw Milk Price and Retail Price of White Fluid Milk



Note: The statistics for the raw milk price after 2003 reflects seasonal variations. After 2003, seasonal variations are reflected in the raw milk price. From 2004 to 2008, volatilities in raw milk price show seasonality but there is no change in reference price for raw milk.

Source: Korea Statistical Information Service

Figure 1 shows a close relationship between the raw milk price and the retail price. There were eight shocks in the raw milk price and the corresponding increase of the retail price. The moving patterns of the two prices inform us that the shocks in the raw milk price are directly transferred to the retail price. The ratios of shocks transferred to the retail price are not the same in each event of the shock of raw milk price. But, the variations of transfer between two prices may tell us about the market power of the marketers in the Korean fluid milk market.

2. Applying Natural Experiments

A natural experiment is executed to see how much of a shock in marginal cost of the marketers is transferred to the retail price. Applying a natural experiment is to compare the changes of raw milk price paid by marketers and the changes of retail price received by marketers. We only focus on the shock of the raw milk price other than the changes of marketing input prices. The main concerns in the natural experiment are to account for the changes in unobservable prices

of marketing inputs such as wage and gas expenditure and all factors other than marginal cost that affect changes in retail prices such as demand shifts, risk, etc. To control for these concerns, a differences-in-differences method is applied.

A natural experiment consists of several steps. The first step is to segment the sample data into two time series groups: a Treatment group that is affected by the shock of raw milk price and a Control group that is not affected by the shock of raw milk price. The second step is to sort out all factors that affect the retail price other than the raw milk price. For accounting for these concerns, the two groups should be selected under the same conditions except the shock of raw milk price. Then, a differences-in-differences method can sort out all factors other than the shock of raw milk price by selecting two groups and subtracting the changes in one group from the changes in other group.

The shocks of the raw milk price caused by changes of reference price for raw milk determined by the KDC happened in 1989, 1991, 1993, 1995, 1998, 2003, 2004, and 2008. To account for full changes in raw milk price and the retail price, we calculate the changes of prices in three months. For example, if there was a shock in the price in April, we calculate the change of price from March to May. In the eight experiments, the monthly price data for the periods when the shock begins and ends are classified as the Treatment group. And the monthly price data for the same months of the previous three years before the shock are classified as the Control group.[6] This paper selects the price data for the Treatment and Control groups from the same months but from different years to control for the potential seasonal variations.

An econometric model for a natural experiment can be derived as

$$P^r(Q^r) = \Lambda\theta + P^f + c + \varepsilon,$$

where ϵ is a disturbance term. The first difference equation for the Treatment group can be written as

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[6] For the control groups, the price changes should not be under the periods of reference price shift. For the experiment in 2004, the treatment group is the price changes from September to November and the control group is the average of the price changes during the same months of the years 2001 and 2002. The price change in 2003 is not included because there is a reference price shift during the periods and the data is not suitable for the control group. For the other seven experiments except 2004, there are no problems for the data use for the control groups.

$$(P_A^{r,T} - P_B^{r,T}) = (\Lambda_A^T\theta - \Lambda_B^T\theta) + (P_A^{f,T} - P_B^{f,T}) + (c_A^T - c_B^T) + (\varepsilon_A^T - \varepsilon_B^T),$$

where the subscript *A* and *B* indicates "the periods when the shock ends and starts" respectively and the superscript *T* represents the Treatment group. In a similar way, the first difference equation for the Control group can be obtained as

$$(P_A^{r,C} - P_B^{r,C}) = (\Lambda_A^C\theta - \Lambda_B^C\theta) + (P_A^{f,C} - P_B^{f,C}) + (c_A^C - c_B^C) + (\varepsilon_A^C - \varepsilon_B^C),$$

where the superscript *C* represents the Control group.

The second differences-in-differences equation can be obtained by subtracting the difference of the Control group from the difference of the Treatment group as

$$(\Delta P^{r,T} - \Delta P^{r,C}) = (\Delta\Lambda^T - \Delta\Lambda^C)\theta + (\Delta P^{f,T} - \Delta P^{f,C}) + (\Delta c^T - \Delta c^C) + (\Delta\varepsilon^T - \Delta\varepsilon^C)$$

where $\triangle$ indicates the price changes between the two periods when the shock starts and ends. If we take the expectation above, we obtain

$$(4) \quad (E\Delta P^{r,T} - E\Delta P^{r,C}) = (E\Delta\Lambda^T - E\Delta\Lambda^C)\theta + (E\Delta P^{f,T} - E\Delta P^{f,C}),$$

where we assume that $E\triangle c^T = E\triangle c^C$, i.e., the expected values of differences in marketing input prices are the same between the Treatment and Control groups. This assumption is plausible because the patterns of price changes in marketing inputs in short periods are almost the same along the sample years in average sense (See the Appendix 1). In addition, this study assumes $E\triangle\epsilon^T = E\triangle\epsilon^C$, i.e., the expected value of differences in unobservable disturbances are the same between the two groups.

From equation (4), the Lerner's Index is obtained as

$$(5) \quad L = \left\{ \frac{(E\Delta P^{r,T} - E\Delta P^{r,C}) - (E\Delta P^{f,T} - E\Delta P^{f,C})}{(E\Delta P^{r,T} - E\Delta P^{r,C})} \right\}$$

that is equal to $\left\{ \frac{(E\Delta\Lambda^T - E\Delta\Lambda^C)\theta}{(E\Delta P^{r,T} - E\Delta P^{r,C})} \right\}$.

Table 1 shows the estimates for the Lerner's Index using equation (5). There were eight shocks in the raw milk price, so eight experiments are executed to measure the Lerner's Index for each event of shock in the raw milk price and the corresponding retail price. The estimated Lerner's Indexes are measured around 0.7 except for the Lerner's Index for the year 2003. The average of the eight Lerner's indexes is calculated as 0.74 and the standard error is calculated as 0.17. The distribution of the estimates is skewed to the right and zero is not included in the area of three standard deviations from the mean. Therefore, we can conclude that the behaviors of the marketers in the fluid milk market are quite different from the perfectly competitive market. The degree of oligopoly power of the marketers is quite stable around 0.7 irrespective of the elapse of time except year 2003.[7] The results indicate that Jeon (2009 b)'s findings could be generalized to other periods.[8]

TABLE 1. Measuring the Lerner's Index of marketers in the Korean fluid milk market based on nominal prices

	$E\Delta P^{f,T} - E\Delta P^{f,C}$	$E\Delta P^{r,T} - E\Delta P^{r,C}$	Lerner's Index
Year	Unit: Won	Unit: Won	
1989	48	175	0.73
1991	21	192	0.89
1993	26	202	0.87
1995	26	178	0.85
1998	82	283	0.71
2003	66	102	0.35
2004	93	388	0.76
2008	119	516	0.77

[7] As competition in beverage products market became severe the stock of milk powders increased and dairy industry talked about production quota in raw milk production in 2003. Under this environment, it may be hard for milk processors to exert full market power in 2003.

[8] Jeon (2009 b) obtained 0.8 using 2004 data.

TABLE 2. Measuring the Lerner's Index of marketers in the Korean fluid milk market based on real prices

Year	$E\Delta P^{f,T} - E\Delta P^{f,C}$ Unit: Won	$E\Delta P^{r,T} - E\Delta P^{r,C}$ Unit: Won	Lerner's Index
1989	74	359	0.79
1991	31	322	0.90
1993	40	326	0.88
1995	38	233	0.84
1998	62	293	0.79
2003	66	102	0.35
2004	91	402	0.77
2008	108	469	0.77

Note: The raw milk price is deflated by the Producer Price Index (2005=100) and the retail price is deflated by the Consumer Price Index (2005=100).

One may suspect the reason why the corresponding changes in the retail price are greater than the changes in the raw milk price is differences in inflation. Generally, the rate of changes in the retail price for the products consumed by consumers is greater than the rate of changes in the price for the products received by producers. Therefore, this study checks how the estimates could be changed when we use the real prices that are obtained by deflating the nominal price by the price index. The raw milk price is deflated by the Producer Price Index (2005=100) and the retail price is deflated by the Consumer Price Index (2005=100) for another experiment. The results are shown in Table 2. The results in Table 2 are not much different from those in Table 1. The average of the eight estimated Lerner's indexes is calculated as 0.76 and the standard error is calculated as 0.17. Hence, the results obtained in this study are still robust to inflation.

3. Extension to a Dynamic Game

Estimates for market power are in part determined by modeling choices. The estimates of this study are from the assumption of a static game. In order to check for a potential bias in the measurement argued by Corts (1999), a dynamic model is developed to check the robustness of the estimates of this study.

Figure 1 shows that once marketers raise the retail price then they cannot raise the retail price until the reference price for raw milk is raised by the KDC further. That is, the marketers raise the retail price when there is a reference price increase decided by the KDC and they are stuck with that price for two to three years until the next increase of reference price. Therefore, if there is a chance for raising the retail price, the marketers would raise the retail price enough to compensate for the relatively low deflated retail price in the future.

Considering the behaviors of the marketers in a dynamic game, the profit of a representative marketer *i* can be re-defined as

$$(6) \quad \pi_i = \sum_{t=0}^{T} \delta^t \left\{ P_t^r (Q_t^r) - P_t^f - c_t \right\} q_{ti} - F_i,$$

where parameter *t* is time and δ is a discounting factor which equals to $\frac{1}{1+\gamma}$ (γ is an interest rate). For simplicity, this study assumes that the demand for fluid milk in each period is not changed for short periods of time. This study also assumes that if the retail price is decided as P^r at *t* = 0, the retail price is decided as $\phi^t P^r$ at time *t* ($0 < \phi < 1$) unless there is no change in the reference price of raw milk. Under these assumptions, the Lerner's Index for the dynamic game is derived as

$$L^D = \left\{ \frac{P^r \left\{ 1 + \delta\varphi + ... + (\delta\varphi)^T \right\} - (P^f + c) \left\{ 1 + \delta + ... + (\delta)^T \right\}}{P^r \left\{ 1 + \delta\varphi + ... + (\delta\varphi)^T \right\}} \right\}$$

(see the Appendix 2 for derivation).

Similarly, for the dynamic game, the Lerner's Index using a differences-in-differences method is measured as

$$(7) \quad L^D = \left[\frac{\left\{ 1 + \delta\varphi + ... + (\delta\varphi)^T \right\} (E\Delta P^{r,AS} - E\Delta P^{r,NS}) - \left\{ 1 + \delta + ... + (\delta)^T \right\} (E\Delta P^{f,AS} - E\Delta P^{f,NS})}{\left\{ 1 + \delta\varphi + ... + (\delta\varphi)^T \right\} (E\Delta P^{r,AS} - E\Delta P^{r,NS})} \right].$$

For the dynamic game, we need information for some parameters: $\delta(\text{or}\,\gamma), \phi$ and *T*. The parameter *T* depends on the expectations of the marketers

about how long the reference price for raw milk will last without any change. Historically the reference price is increased every two or three years on average after 1980 as shown in Figure 1. Here, the interval of an experiment is two months, hence T will be 12 (or 18) if the marketers expect the reference price will last two years (or three years). The real retail price has decreased around 0.5 percent on average between two months during the sample periods. So we set the parameter ϕ at 0.995. This study assumes that annual interest rate is six percent which is equivalent to one percent in two months. Hence, the parameter γ is 0.01 or δ is 0.99.

The Lerner's Indexes for the dynamic game is measured slightly smaller than the estimates for the static game but they are close (Table 3). The average of the Lerner's Indexes for the dynamic game is around 0.76 when T is 12 and 0.75 when T is 18. Therefore, even with considering the expectations of marketers, the estimates for the Lerner's Index are robust.

TABLE 3. Comparing the Lerner's Index of marketers obtained under a static game and that under a dynamic game

	Static game	Dynamic game	
Year	T=1	T=12	T=18
1989	0.79	0.79	0.78
1991	0.90	0.90	0.90
1993	0.88	0.87	0.87
1995	0.84	0.83	0.83
1998	0.79	0.78	0.78
2003	0.35	0.33	0.32
2004	0.77	0.77	0.76
2008	0.77	0.76	0.76
Average	0.76	0.76	0.75
Std. Err.	0.17	0.18	0.18

Note: The raw milk price is deflated by the Producer Price Index (2005=100) and the retail price is deflated by the Consumer Price Index (2005=100).

Ⅳ. CONCLUSIONS

This paper contributes to a methodology in estimating market power. Generally, there is a limitation in estimating market power due to lack of information on

cost side. Natural experiments are used to estimate the degree of market power with no assumption and no information on cost side. By controlling all the factors other than the shock of raw milk price, this study measures the degree of oligopoly power of the domestic marketers in the retail fluid milk market in Korea.

Two important conclusions can be obtained from the findings. First, the degree of oligopoly power of the marketers is measured around 0.7, and it is quite stable during 25 sample periods except the estimate for the year 2003. Hence, we conclude that Jeon (2009 b)'s findings in 2004 could be accepted under other periods. Second, the results are robust to the type of games whether they are measured under a static game or a dynamic game. Although we consider the expectations of the domestic milk marketers in the dynamic game, the estimates of market power parameter are quite stable.

The existence of market power has several implications. Imperfect competition has different outcomes in distributional effects compared with perfect competition under policy shocks. Hence, the distributional impacts of raw-milk pricing and quota in raw-milk production have to be mentioned with caution. Together, we also have to take into account of efficiency problem in production and marketing of fluid-milk products. These issues have to be dealt with more in the future.

REFERENCES

Ahn, B. 2006. “Estimation of Market Power of White Fluid-milk Processors.” *Journal of Rural Development* 29(2): 39-54.

Cameron, A.C. and P.K. Trivedi. 2005. *Microeconometrics: Methods and Applications*. Cambridge: Cambridge University Press.

Corts, K.S. 1999. “Conduct Parameters and the Measurement of Market Power.” *Journal of Econometrics* 88(2): 227-250.

Eissa, E. and J. Liebman. 1996. “Labor Supply Response to the Earned Income Tax Credit.” *Quarterly Journal of Economics* 111(2): 605-637.

Goldberg, P.K. and M.M. Knetter. 1999. “Measuring the Intensity of Competition in Export Markets.” *Journal of International Economics* 47(1): 27-60.

http://en.wikipedia.org/wiki/Natural_experiment (Jun. 14, 2011)

Jeon, S. 2009a. “Incentive Compatibility in Estimating Oligopoly Power in Domestic Fluid-milk Market.” *Korean Journal of Agricultural Management and Policy*

36(1): 80-99.

Jeon, S. 2009b. "Measuring Oligopoly Power of Processors in Regional Fluid-milk Markets by Natural Experiments." *Korean Journal of Agricultural Economics* 50(3): 1-20.

Kaiser, H.M. and N. Suzuki. 2006. *New Empirical Industrial Organization and the Food System*. New York: Peter Lang Pub, Inc.

Karp, L.S. and J.M. Perloff. 1989. "Dynamic Oligopoly in the Rice Export Market." *The Review of Economics and Statistics* 71(3): 462-470.

Karp, L.S. and J.M. Perloff. 1993. "A Dynamic Model of Oligopoly in the Coffee Export Market." *American Journal of Agricultural Economics* 75(2): 448-457.

Korea Statistical Information Service. 2009. KOSIS online. Home page on-line. http://www.kosis.kr (accessed June 1, 2009).

Meyer, B. and D. Rosenbaum. 2001. "Welfare, the Earned Income Tax Credit, and the Labor Supply of Single Mothers." *Quarterly Journal of Economics* 116(3): 1063-1114.

Sexton, R.J., and N. Lavoie. 2001. "Food Processing and Distribution: An Industrial Organization Approach." B.L. Gardner and G.C. Rausser (ed.), *Handbook of Agricultural Economics*: 865-932. Amsterdam, Netherlands: North Holland Press.

Song, J., M. Jeong, H. Kim, H. Lee, and B. Ahn. 2005. *A Study on the Analysis of the Milk Demand and Supply Management System in Korea*. Research Report R495: 15-19. Seoul, Korea: Korea Rural Economic Institute.

Sullivan, D. 1985. "Testing Hypotheses about Firm Behavior in the Cigarette Industry." *The Journal of Political Economy* 93(3): 586-598.

Sumner, D.A. 1981. "Measurement of Monopoly Behavior: An Application to the Cigarette Industry." *The Journal of Political Economy* 89(5): 1010-1019.

Wohlgenant, M.K. 2001. "Marketing Margins: Empirical Analysis." B.L. Gardner and G.C. Rausser (ed.), *Handbook of Agricultural Economics*: 933-70. Amsterdam, Netherlands: North Holland Press.

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Appendix 1

This study assumes that the expected values of differences in marketing input prices are the same between the Treatment group and the Control group. As representative cost factors for marketing inputs, we consider two indexes: one is the index for electricity, water and gas and the other is the index for services that includes transportation, finance, labor, etc. Table A.1 shows the results of natural experiments on the price indexes of three major inputs. The net change for raw milk price is 8.43 between the two groups, which is big enough compared with the net changes for the other two indexes. Therefore, the shocks in other marketing inputs other than raw milk do little change the results of this study. So the assumption above could be justified.

TABLE A.1. Comparing rate of changes of the Indexes of major inputs

	Index for raw milk price	Index for electricity, water, and gas	Index for services
Average of the first difference in the Treatment group	8.64	0.96	0.64
Average of the first difference in the Control group	0.21	0.26	0.36
Average of Differences-in-differences	8.43	0.70	0.28

Note: All indexes are adjusted to have 100 in 2005 for a comparison. All indexes are deflated by the Producer Price Index (2005=100). The size of differences-in-differences for each index shows the relative importance of that index in a natural experiment.

Source: Korea Statistical Information Service.

Appendix 2

Equation (6) is expressed as

$$\pi_i = \sum_{t=0}^{T} \delta^t \left\{ P_t^r(Q_t^r) - P_t^f - c_t \right\} q_{ti} - F_i$$
$$= \delta^0 \left\{ \varphi^0 P^r(Q^r) - P^f - c \right\} q_i + \delta^1 \left\{ \varphi^1 P^r(Q^r) - P^f - c \right\} q_i + \delta^2 \left\{ \varphi^2 P^r(Q^r) - P^f - c \right\} q_i + \ldots - F_i .$$

If we differentiate the equation above with respect to q_i and rearrange it, we obtain

$$\delta^0 \left\{ \varphi^0 P^r(Q^r) - P^f - c \right\} + \delta^0 \varphi^0 \left(\frac{\partial P^r}{\partial Q^r} \frac{\partial Q^r}{\partial q_i} \frac{Q^r}{P^r} \frac{q_i}{Q^r} P^r \right) +$$
$$\delta^1 \left\{ \varphi^1 P^r(Q^r) - P^f - c \right\} + \delta^1 \varphi^1 \left(\frac{\partial P^r}{\partial Q^r} \frac{\partial Q^r}{\partial q_i} \frac{Q^r}{P^r} \frac{q_i}{Q^r} P^r \right) +$$
$$\delta^2 \left\{ \varphi^2 P^r(Q^r) - P^f - c \right\} + \delta^2 \varphi^2 \left(\frac{\partial P^r}{\partial Q^r} \frac{\partial Q^r}{\partial q_i} \frac{Q^r}{P^r} \frac{q_i}{Q^r} P^r \right) +$$
$$\ldots +$$
$$\delta^T \left\{ \varphi^T P^r(Q^r) - P^f - c \right\} + \delta^T \varphi^T \left(\frac{\partial P^r}{\partial Q^r} \frac{\partial Q^r}{\partial q_i} \frac{Q^r}{P^r} \frac{q_i}{Q^r} P^r \right) = 0.$$

The parameter Λ is $\left(-\frac{\partial P^r}{\partial Q^r} Q^r\right)$ and θ is $\left(\frac{\partial Q^r}{\partial q_i} \frac{q_i}{Q^r}\right)$, so the condition above becomes

$$\delta^0 \left\{ \varphi^0 P^r - P^f - c \right\} + \delta^1 \left\{ \varphi^1 P^r - P^f - c \right\} + \ldots + \delta^T \left\{ \varphi^T P^r - P^f - c \right\}$$
$$= \delta^0 \varphi^0 \Lambda \theta \frac{P^r}{P^r} + \delta^1 \varphi^1 \Lambda \theta \frac{P^r}{P^r} + \ldots + \delta^T \varphi^T \Lambda \theta \frac{P^r}{P^r} \quad .$$

That is

$$P^r \left\{ 1 + \delta\varphi + \ldots + (\delta\varphi)^T \right\} - (P^f + c) \left\{ 1 + \delta + \ldots + (\delta)^T \right\} = L^D P^r \left\{ 1 + \delta\varphi + \ldots + (\delta\varphi)^T \right\}$$

where $L^D = \frac{\Lambda\theta}{P^r}$.

Therefore, the Lerner's Index in the dynamic game is obtained as

$$L^D = \left\{ \frac{P^r \left\{1 + \delta\varphi + ... + (\delta\varphi)^T \right\} - (P^f + c)\left\{1 + \delta + ... + (\delta)^T \right\}}{P^r \left\{1 + \delta\varphi + ... + (\delta\varphi)^T \right\}} \right\} .$$