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Analysis of Korean Dairy Industry

Econometric Estimations of Supply and Demand, and Simulation Analysis of Policy Changes

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FOREWORD

Milk is by its nature produced on a daily basis, and due to the difficulty in storage many countries have intervened in the dairy market. Currently, the domestic milk is three times more expensive than imported milk. However, as it is practically open to overseas dairy products, the domestic dairy product market cannot survive without the support from the government. The ongoing negotiation in Doha Development Agenda (DDA) for additional tariff reduction facilitated the need to reform dairy policy in Korea.

This study was intended to analyze the plausible impact of DDA by scenarios on dairy industry in Korea. Thus, the dairy product demand function and the milk supply functions in Korea were modeled and estimated. The demand functions for the fluid milk, cheese, milk powder, butter were estimated respectively. To build the mid- to short-term milk supply reaction models, the model of number of dairy cows and the model of milk production volume per head were separated. In addition, the effects of the expanded market liberation under the DDA were analyzed by milk component (fat, solid and solid not-fat). The result shows that deep tariff reduction would have a significant impact on the income of dairy farm households, so income support policy is required.

This report was conducted jointly by University of California at Davis and KREI. I appreciate the authors, especially Dr. Hyunok Lee and Byungil Ahn, for their excellent work. I hope this result would benefit the policy makers and other researchers in understanding Korean milk supply and demand structure and the plausible impact of trade liberalization on Korean dairy industry.

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Dr. Jung-Sup Choi
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EXECUTIVE SUMMARY

This report provides the research findings from the three parts of studies that were conducted under the overall research project examining the Korean dairy industry. Each part of the study is organized into a separate chapter in this report, and the tree studies include: 1) econometric estimations of supply responses in milk production, 2) econometric estimations of demand for dairy products, and 3) an investigation of the impacts of Doha negotiations on milk production and component consumption in Korea. While the supply and demand studies presented in the first two chapters deal with mostly domestic issues and markets, the third chapter incorporates international trade as an important element in the study.

In the first chapter, we develop and estimate a milk supply response model. The supply model is general enough to incorporate the short and intermediate runs in milk production. The model consists of two equations which represent per cow milk yield and herd size (the number of milking cows). Using the annual data for the period of 1980-2003, we estimate milk production which can be expressed as the multiplication of two equations representing the number of milking cows and yield per cow. Empirical findings on supply response can be summarized by focusing on our results with respect to three important price variables, prices of milk, feed, and beef. Our results indicate that milk supply is most sensitive to changes in feed price among these three price variables. In the short run, our estimated supply elasticity is -0.53 with respect to feed price, while the elasticities with respect to milk price and beef price are 0.30 and -0.23, respectively. In the intermediate run, consistent with our expectation, we obtained more elastic supply responses. Our estimated elasticities at the means are -1.62, 0.77, and -0.69 with respect to feed price, milk price and beef price, respectively.

In the demand study, we estimate the consumption of six dairy products including fluid milk, fermented milk, baby formula, cheese, butter, and milk powder. Demand for milk powder is estimated using quarterly data while the demand estimations of the rest, five dairy products use annual data. Annual data include the period of 1975-2004 and the quarterly data include the period of 1996-2004.

While the primary objective of our demand estimation is to obtain the own price elasticities that are required for later policy simulation work, our estimation results generate many interesting findings. Our results on fluid milk consumption are comparable to the findings of the previous studies. Our results indicate that fluid milk consumption is elastic with respect to income with the income elasticity of 1.21. While the own price elasticity of fluid milk demand is estimated at -0.96, fermented milk consumption is sensitive to own price, with the price elasticity estimated at -2.16. Butter consumption is also price elastic, with the own price elasticity of -1.8. The income elasticities of both fermented milk and butter demand are less than one. Cheese consumption is not price elastic (the own price elasticity of -0.87), but its income elasticity is 2.7, which is highest among the products estimated. Finally, our results indicate that milk powder consumption responds moderately to both price and income, with the price and income elasticities of -0.51 and 0.99, respectively. Note that we used quarterly data in the estimation of milk powder demand. Given that, it is not surprising that milk powder demand is less responsive to price and income changes than demand for other products.

In the third chapter, we present a simulation model and assess the impact of changes in trade policy that may emerge with the completion of the DDA negotiation. More import access for imported dairy products in Korea implies lower prices for consumers and Korean producers and additional imports of manufactured dairy products. We quantify the magnitude of these effects, under the situation where fluid beverage milk will continue to be supplied by the domestic source. Specifically, this study considers the period of a 10 year horizon for trade policy analysis by comparing future effects of changes in trade policy to baseline projections to 2015. An innovation of our simulation model is that we model processed milk product supply, demand, and trade on milk component basis. Three outputs are considered in our model, fluid milk, milk fat, and milk non-fat-solids. The specific tariff cuts used in the trade liberalization scenario are the 50 percent decline for high over-quota dairy product tariffs and 25 percent decline for the much lower within quota tariffs and single tariffs by 2015.

Our simulation results indicate that the tariff reductions cause a 7.6 percent reduction of the fat component price and 7.5 percent reduction of the non-fat-solid (NFS) price in Korea. Use of fat for manufactured products increases by 3.7 percent and use of NFS increases by 3.3 percent. The price of raw milk used for manufactured products falls by 7.5 percent as determined by the reduced prices of imported components. Of course, the price of raw milk used in fluid products is set by the government and does not change. Domestic raw milk production falls only modestly, by 2.1 percent. With gradually increasing fluid milk consumption (and domestic supply of fluid milk), the decline in raw milk production implies a significant decline in domestic raw milk used for manufactured products. Our study indicates that this decline is 18.8 percent. Reductions in raw milk used for manufactured products and increased use of overall milk fat and NFS for manufactured products imply that component imports must increase. Our results indicate that imports of fat increase by 10 percent and imports of NFS increase by 9.3 percent. Even under substantial tariff cuts and with no effective change in domestic dairy policy, our study suggests that the impacts on Korean milk producers are relatively minor with modest changes in production and prices.

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INTRODUCTION

In recent decades, Korea has been a growing agricultural import market as its economy has expanded and its markets have opened somewhat. At the same time, many Korean agricultural tariffs remain high and tariff rate quotas restrict imports for many products. Dairy products are among those for which relatively high trade barriers remain.

World agricultural markets are entering another key period of policy adjustment. The WTO framework agreement under the current Doha Development Agenda (DDA) negotiation, which was signed in August 2004, means that a plan for completing this round of negotiations is at hand. In the agriculture negotiations, detailed specifications of export subsidy, import access and domestic support commitments are to be developed. When completed, these specifications will set the path for policy adjustments to be implemented over the following six to ten years.

This paper has two broad objectives. The first objective is to empirically assess the supply and demand situation of Korean dairy sector, and the second is to assess the effects of changes in trade policy on the Korean dairy market. In particular, this paper is organized in three parts. Parts I and II mainly deal with issues related to domestic markets and part III focuses on international trade. In part I, we empirically estimate the supply of raw milk and part II estimates demand for dairy products using historical data. In part III, we present a simulation model and assess the impact of trade policy changes that may emerge with the completion of the DDA negotiation (Song and Sumner 1999).

Part I

Estimating Supply Responses of Milk Production

This paper develops a milk supply model in Korea and empirically estimates milk supply responses. Our milk supply model is based on two important equations representing the number of milking cows and milk production per milking cow. Total milk production can be expressed as the multiplication of these two equations. Given dairy farming involves milking cows as an essential input, the business of milk production likely requires decision-making that involves multi-periods. To reflect such a dynamic nature of decision making processes involved in dairy farming, we develops two models that differentiate between the short run and intermediate run. In what follows, the first section develops these two models and the second section presents empirical specifications and results.

1. Model Development

We first begin with an identity equation that defines the number of cows. To produce milk, cows have to be at least 2 years old. Thus, the number of milking cows in the current period depends on the number of calves that were acquired two years ago and the culling rate of milking cows. We can define the number of milking cows at period t, NC_t, as:

(1) $NC_t = NC_{t-1} - Sl_t + r \times Cal_{t-2}$,

where NC_{t-1} is the number of milking cows in the previous period t-1, Sl_t is the number of culled cows in the current period t, r is the survival ratio of calves, and Cal_{t-2} is the number of calves acquired in period t-2.

If we denote average milk production per milking cow as y_t, total milk supply in period t, TM_t, can be expressed as:

(2) $TM_t = y_t \times NC_t = y_t(NC_{t-1} - Sl_t + r_t \times Cal_{t-2})$.

We now define average milk production per milking cow that can be expressed as a function of milk price, feed price, and beef price in period t (Levins, 1982; Chavas and Klemme, 1986):

(3) $y_t = f_y(Pm_t, Pf_t, Pb_t)$,

where Pm_t, Pf_t, and Pb_t are the prices of milk, feed, and beef in period t, respectively.

Based on equations (1) through (3), we define the supply response models of the short run and the intermediate run below.

1.1. Short run milk supply response model

The short run is defined as a situation where adjustments in the decision-making involved in milk production are allowed in the current, single period but not in multiple periods. Thus, in light of equations (1) and (3), milk supply in the short run is determined by controlling the culling rate and yield per cow given the number of calves that has been predetermined in period t-2. We assume the number of culled cows in period t is a function of milk, feed, and beef prices $Sl_t = f_s(Pm_t, Pf_t, Pb_t, NC_{t-1})$). Using this expression, equation (1) can be rewritten as

(4) $NC_t = NC_{t-1} - f_t(Pm_t, Pf_t, Pb_t, NC_{t-1}) + r \times Cal_{t-2}$.

The short term supply response model is a simultaneous equation system consisting of equations (3) and (4). We expect that the estimated coefficient on the variable Cal_{t-2} is smaller than one since the survival ratio of calf cannot be greater than one.

1.2. Intermediate run supply response model

Dairy farmers adjust the number of calves by evaluating the expected return from milk production in the future. However, the adjustment of the number of calves in the current period does not affect the current milk supply (but, future milk production). We define the intermediate term supply response by allowing the adjustment of the number of calves in the supply response model. The following set of functions is specified to determine the number of milking cows in period *t*.

(5) $NC_{t-1} - Sl_t = f_{sr}(Pm_t, Pf_t, Pb_t)$.

(6) $Cal_{t-2} = f_{ac}(E_{t-2}(Pm_t), E_{t-2}(Pf_{t-1}), E_{t-2}(Pf_t))$.

We have two age groups of milking cows in the current period, the group of cows which have been milked (thus, older than two) and the group of first year milking cows which just turned two in period t. Equation (5) represents the number of these older cows after the culling in period *t*, and is assumed to be a function of milk, feed, and beef prices.

However, the number of first year milking cows is directly related to the decision of acquiring the calves which was made two years ago. Thus, we need to first specify the process of calf acquisition in period *t-2*, which is represented by equation (6). It is reasonable to assume that the dairy farmer's decision on acquiring calves depends on the expected returns in the future, which in turn depend on the expected prices. Thus, denoting E to be the expectation operator, equation (6) indicates that the number of calves in period *t-2* is determined as a function of the expected milk price of milk of period *t* ($E_{t-2}(Pm_t)$) and the expected feed prices of feed of periods *t-1* and *t-2* ($E_{t-2}(Pf_t)$ and $E_{t-2}(Pf_{t-1})$). Note that these expectations are formed in period *t-2*.

Finally, combining equations (4) through (6), we arrive at equation (7) that describes the number of milking cows in period *t*:

(7) $NC_t = f_{sr}(Pm_t, Pf_t, Pb_t) + r \times f_{ac}(E_{t-2}(Pm_t), E_{t-2}(Pf_t), E_{t-2}(Pf_{t-1}))$.

The intermediate run supply response model consists of equations (3) and (7), and is solved simultaneously.

2. Empirical Estimation

2.1. Data

We use annual data for the period spanning from 1980 to 2003. Variables include the raw milk price, the number of milking cows, average milk production per milking cow, the number of calves, and feed price. Data were collected from the *Dairy Yearbook* published by the Korean Ministry of Agriculture and Forestry. Our data set was further supplemented with the beef price index collected from the Korean National Statistics office. All the current prices were deflated using the consumer price index. Table 1-1 provides data information for some selected years.

2.2. Estimation of short run supply response

We specify the following system of empirical equations.

$$y_t = \beta_0 + \beta_m \ln Pm_t + \beta_f \ln pf_t + \beta_b \ln Pb_t + \beta_{d93} D93 + \beta_{d02} D02 + \varepsilon_{yt}$$

$$NC_t = \alpha_0 + \alpha_m \ln Pm_t + \alpha_f \ln pf_t + \alpha_b \ln pb_t + \alpha_{nc} NC_{t-1} + \alpha_{calf} Cal_{t-2} + \alpha_{d02} D02 + \alpha_{d03} D03 + \varepsilon_{nt},$$

where ε's are error terms and variables denoted with D are dummies. Specifically, $D93=1$ if $t \geq 1993$ and $D93=0$ otherwise; $D02=1$ if $t \geq 2002$ and $D02=0$ otherwise; $D03=1$ if $t \geq 2003$ and $D03=0$ otherwise. The dummy variable D93 captures the effect of the quality monitoring regulations that were introduced in 1993 by the "Raw Milk Sanitary Grades" law. Dummy variable D02 represents the effects of the milking cow retirement policy introduced in 2002. Dummy variable D03 represents the effects of the partial elimination of milk price support beginning in 2003 by limiting government price support only up to the amount of raw milk that has a contract with the Dairy Committee.

We estimate the above system using the three stage least squires method (3SLS). Table 1-2 reports the estimation results. As expected, the milk price has positive effects on the number of milking cows and average production per cow, and the feed price negatively affects y_t and NC_t. The effect of beef price is negative on NC_t but positive on y_t. The positive effect of beef price on y_t is consistent with the intuition. The high beef price leads to an increase in culling milking cows, and when this happens, we can expect less productive cows to be culled first, which in turn leads to an increase in per cow milk production.

2.3. Estimation of intermediate run supply response

An important issue involved in the estimation of intermediate term supply response is how we specify the expectations of the future milk and feed prices in period *t-2*. For this, we adopt the naive expectation assumption. The government guaranteed raw milk price has been unchanged for the last 5 years. Further, over the last 15 years, the government has changed the raw milk price only four times only to increase the price. Given such a trend of government guaranteed price, it is not unreasonable to assume that dairy farmers expect that the current raw milk price would continue into the near future ($E_{t-2}(Pm_t)=Pm_{t-2}$), which is consistent with the process under naïve expectation. Given most feeds in Korea are imported, the feed price in Korea critically depends on the world market. Thus, for simplicity, our study assumes that the current feed price would continue into the near, that is, $E_{t-2}(Pf_{t-1})=E_{t-2}(Pf_t)=Pf_{t-2}$.

The following system of equations is specified to estimate the intermediate term supply response:

$$y_t = \beta_0 + \beta_m \ln Pm_t + \beta_f \ln pf_t + \beta_b \ln Pb_t + \beta_{d93} D93 + \beta_{d02} D02 + \varepsilon_{yt}$$

$$NC_t = \alpha_0 + \alpha_m \ln Pm_t + \alpha_f \ln pf_t + \alpha_b \ln pb_t + \alpha_{m2} \ln Pm_{t-2} + \alpha_{f2} \ln Pf_{t-2}$$
$$+ \alpha_{d91} D91 + \alpha_{d02} D02 + \varepsilon_{nt}$$

where $D91=1$ if $t \geq 1991$ and $D91=0$ otherwise. The dummy variable D91 is included to capture the effects of the policy which eliminated the price cap for the butter fat premium in 1991. Table 1-3 reports the 3SLS estimation results. All estimated coefficients are statistically significant. The estimated coefficients imply that the number of cows is more sensitive to the feed price than to the milk price. The negative coefficient on the beef price in the equation for NC_t is statistically very significant, implying that the beef price plays an important role in the milk producers' decisions on culling milking cows. Consistent with theory, the effects of all three prices on the number of milking cows are larger in the intermediate run than in the short run. Note that the intermediate term supply response model allows the number of calves to be adjusted, which results in more sensitive responses to changes in variables.

2.4. Calculation of supply elasticity

Table 1-4 presents the supply elasticities with respect to milk, feed, and beef prices. These elasticities are calculated at the mean values of the data. While we know the direction of the effects of these variables, the elasticities reported below provide some sense on the magnitude of these effects. We notice that the intermediate run produces much higher elasticities, indicating that the length of run is important in evaluating the supply response in milk production. Among the three price variables considered, the feed price has the most significant effect on milk supply. It is also interesting to note that the feed price becomes more important in the longer run, when the number of milking cows is allowed to adjust by changing the number of calves. These findings on feed price suggest the venerability of Korean dairy farming to even a small change in the world feedgrain market, given Korea relies its livestock feed supply mostly on foreign sources.

Table 1-1. Data description for estimating supply response

	Milk production	Number of milking cows	Number of calves with age less than 2 years	Feed price	Beef price index	Milk price	CPI	Average production per cow
Year/Unit	Ton	1000 heads	1000 heads	Won/kg		Won/kg		Kg
1980	452327	84		181.85	24.613	266	34.648	4494
1985	1005811	176	70	180.85	40.364	322	49.207	4681
1990	1751758	273	94	165.22	62.084	364	62.056	5372
1995	1998445	286	114	198.5	84.858	414	82.367	5836
2000	2252804	286	119	229.24	100	595	100	6591
2001	2338874	289	120	248.65	116.9	595	104.3	6763
2002	2536648	302	120	248.65	146.2	595	106.7	7017
2003	2366214	278	121	245.53	162.7	595	110.7	7102

Table 1-2. Estimation results of the short term supply response model

	Constant	$\ln Pm_t$	$\ln pf_t$	$\ln pb_t$	NC_{t-1}	$Calf_{t-2}$	D93	D02	D03	R2	D.W.
NC_t	309.49 (273.1)	42.46 (32.57)	-63.08 (31.55)**	-29.01 (17.50)*	0.325 (0.162)**	0.811 (0.315)***	-	25.30 (8.81)**	-25.30 (9.68)***	0.943	2.231
y_t	-10633 (6666)	3641.4 (798.3)***	-2192.5 (625.8)***	1080.3 (438.9)**	-	-	918.34 (106.2)***	358.58 (198.7)*	-	0.934	1.893

Note: Standard errors are in parentheses. Asterisks, *, **, and *** denote statistical significance at 10%, 5%, and 1%, respectively.

Table 1-3. Estimation results of the mid term supply response model

	Constant	$\ln Pm_t$	$\ln pf_t$	$\ln Pb_t$	$\ln Pm_{t-2}$	$\ln Pf_{t-}$	D91/D93	D02	R^2	D.W.
NC_t	2991.5 (344.7)***	120.06 (60.47)**	-332.31 (31.08)***	-205.00 (27.79)***	148.93 (53.38)***	-292.13 (38.62)***	-28.549 (9.997)***	25.232 (12.42)**	0.954	1.880
y_t	-1911.9 (5350.0)	2657.5 (812.7)***	-2391.9 (469.4)***	787.80 (374.7)**	-	-	825.39 (115.0)***	465.58 (206.6)**	0.930	1.509

Note: Standard errors are in parentheses. Asterisks indicate statistical significance at 1% (***) and 5% (**) levels.

Table 1-4. Supply elasticity calculations

	Milk price	Feed price	Beef Price
Supply elasticity with respect to			
Short run	0.2992 (0.0012)	-0.5338 (0.0025)	-0.2318 (0.0019)
Intermediate run	0.7722 (0.0046)	-1.6238 (0.0080)	-0.6884 (0.0030)

Note: Standard errors are in parentheses. The reported elasticities are evaluated at the means.

Part II

Estimating Demand for Dairy Products

Part II consists of two sections. The first section presents the demand estimations of five dairy products and the second section presents the demand estimation of milk powder. We separated the demand part into two, primarily due to the level of data available for empirical estimation. The estimations of the demand for first five products are conducted using annual level data while the milk powder demand estimation uses second part uses quarterly level data.

1. Demand for Five Dairy Products: estimated using Annual Data

1.1. Model specification

Demand for five dairy products including fluid milk, fermented milk, cheese, infant formula and butter was estimated. We assumed that product demand is a function of own price, income, and the household food expenditure share of dairy products. The last two variables are dummy variables. Milk is not part of traditional diet in Korea. However, diet patterns in Korea are changing recently and the consumption of dairy products is particularly sensitive to these changes.

Using a double log form, we estimated the following product demand equation.

(1) $\ln D_t = \alpha_0 + \alpha_1 \ln P_t + \alpha_2 \ln Y_t + \alpha_3 \ln R_t + \alpha_4 B_t + \alpha_5 d1_t + \alpha_6 d2_t + \varepsilon_t$

where D_t is per capita dairy product demand, P_t is the real price of the product, Y_t is the real per capita income, R_t is the average household expenditure share on dairy food in total food expenditure, B_t is the birth rate, $D1_t$ is the time dummy representing the Korean financial crisis (d1=1 for t>1998, d1=0 otherwise), and $D2_t$ is the time dummy representing a discrete change in cheese consumption (d2=1 for t>1987, d2=0 otherwise).

Variables P_t and Y_t appear in all five product demand equations, other variables apply only to certain equations. As alluded to earlier, the dietary change in Korea is an important element for demand for dairy products and to represent these changes, we include the expenditure share variable.[1] However, R_t is omitted in the cheese equation. In Korea, cheese is hardly consumed at home, which indicates that the household expenditure share is not a relevant variable to explain cheese consumption. The birth rate variable, B_t appears only in the enfant formula equation. Enfant formula demand is surely affected by the enfant population, and the birth rate variable is included to represent the increase in the enfant population. Finally, $D2_t$ is used only in the cheese equation. From 1987, cheese was separated into two kinds, natural cheese and processed cheese, and the dummy variable $D2_t$. captures the demand effect of this change.

1.2. Data

The data period includes 1975-2004, with some exception. For price information, we used the price indexes provided by the Statistical Bureau. These price indexes are available at product basis, we converted these indexes to represent real prices (year 2000=100). Consumption information was collected from various issues of the Dairy Statistics published by the Korean Ministry of Agriculture and Forestry. Income data were obtained from the Korean Central Bank, and the expenditure shares of dairy food were collected from the Statistical Bureau.

1.3. Estimation results

Estimation results are provided in Table 2-1. Almost all explanatory variables are statistically significant at least at the 5% level of significance. Since we used the double log form of demand equation, our parameter estimates presented in Table 2-1 can be interpreted directly as elasticities.

Among the five products estimated, fermented milk consumption is found to be most price elastic, and then followed by butter and enfant formula. Cheese

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[1] Song and Sumner used the urbanization index to represent the change in dietary patterns

consumption is least price elastic among the products considered. With respect to income, cheese consumption is most responsive, with its income elasticity at 2.7. Fluid milk consumption is also moderately income elastic, with its income elasticity at 1.2. However, enfant formula has a relatively low income elasticity, 0.37. Income effects are significant at the 1% level for all equation except for enfant formula.

The expenditure share of dairy food is also found to be important. Particularly, butter consumption has the highest elasticity, 3.35, with respect to expenditure share. Enfant formula and fluid milk consumption is also moderately elastic with respect to expenditure share. As expected, the birth rate affects enfant formula consumption positively, but with inelastic consumption responses.

2. Demand for Milk Powder: estimated using quarterly data

In this demand study, we consider a single product that can be viewed as an aggregate of various milk powders. Specifically, this aggregate product includes three major kinds of milk powders that are consumed in Korea, skim milk powder, whole milk powder, and manufactured milk powder. While skim milk powder and whole milk powder consist of only milk substance, manufactured milk powder includes non milk substance such as sugar or food additives.[2]

While skim milk powder and whole milk powder is supplied from either domestic or foreign sources, manufactured milk powder is mostly imported. Manufactured milk powder is used mainly as a substitute for skim milk or whole milk powder, and import demand for manufactured milk powder is created due to the import policy that is differentiated by product. Both skim milk powder and whole milk powder have very small TRQs with highly prohibitive over quota tariffs. On the other hand, manufactured milk powder has relatively a low tariff with no TRQ restrictions (in 2004 the tariff rate applied to manufactured milk powder is 36%).

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[2] Manufactured milk powder is made by mixing whey powder, sugar, or food additives with skim milk powder or whole milk powder.

Milk powder is not usually used as a final consumer product, and rather used as an input in production of other consumer food products. Therefore, milk powder consumption can be considered as derived demand by dairy food manufacturers or other food manufacturers who use milk powder as a food ingredient. When used as a food ingredient, these three powder products can be close substitutes one another.

2.1. Model Specification

Before we begin the empirical estimation of demand for milk powder, it may be useful to overview some aspects of the Korean dairy market that are relevant to our study. We begin by considering the following identity: Total consumption of milk powder at period t can be expressed with the following identity:

(2) $D_t = Q_t - S_{t-1} + I_t - S_t$

where D_t is the total quantity of milk powder consumption, Q_t is milk powder production that is produced domestically, I_t is the import quantity, S_{t-1} is the carry over stock, S_t is the current ending stock, and the subscript t denotes the current period.

For the empirical estimation, we assume the following consumption equation,

(3) $D_t = b_0 + b_1 P_t + b_2 Y_t + b_3 S_{t-2} + b_4 d + \varepsilon_t$

where P_t is the price of milk powder, Y_t is the real disposable income of an urban household, S_{t-2} is leftover from t-2 period, and d is a dummy that represents the financial crisis in Korea (d=1 for the years after 1997, otherwise d=0). P_t is measured by the import price that includes the tariffs. S_{t-2} is included to represent the effect of accumulated stock on consumption.

2.2. Data

In this study, we used the quarterly data, spanning the period from 1996 to 2004. In order to arrive at total consumption data, we obtained data on components based on (2). First, we obtained quarterly data on domestic milk powder production and stock from the Dairy Statistics published by the Korean Ministry of Agriculture and Forestry. For the import data, we obtained monthly import data (by product) from the Korean Ministry of Commerce, and constructed the quarterly data.[3] Given that manufactured milk powder includes non-milk substances, we assume only 70 percent of manufactured milk powder to be milk substance.

Price data are constructed from total import quantities and values published by the Ministry of Commerce. Manufactured milk powder accounts for over 90 percent of milk powder imports in volume, we used the data on manufactured milk powder imports to compute the price data. Our price data are the border price which includes tariffs.

Figure 2-1 provides the trends of domestic production, imports, consumption and stock of milk powder for 1996-2004 on the quarterly basis. It is interesting to observe two different trends: total consumption and imports move together, while domestic production and stock show a similar trend.

2.3. Empirical Results

Estimation results are presented in Table 2-2. All parameter estimates are statistically significant at the 5 percent level (parameters for income and stock variables are significant at the 1 percent level). While negative price and positive income effects are predictable, we find the level of stock has positive effects on consumption, with statistical significance. Further, our results show that the 1977 financial shock has negative effects on milk powder consumption.

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[3] Our import data exclude the amounts imported over the tariff rate quotas. Import data show that the imports of skim milk powder and whole milk powder exceed the tariff rate quota amounts in spite of high over quota tariffs ranging between 180-190 percent. Given the fact that manufactured milk powder has a single tariff ranging between 30-40 percent and is a close substitute for skim or whole milk powder, milk powder imported over the TRQ amount is likely to be used in the production of dairy products that are re-exported later. In the case of re-exporting, the lower tariff rates apply to the amount imported over TRQ.

Based on our parameter estimates, we calculated various elasticities at the sample mean and presented in the table. The price and income elasticities are estimated as -0.5084 and 0.9851, respectively. Previously, Song and Sumner (1999) estimated these elasticities and compared to their -0.80 and 0.64, our estimates are lower with respect to the price and higher with respect to income. Further,

Table 2-1. Estimation results for diary products

	Constant α_0	own price α_1	income α_2	exp. Share α_3	birth rate α_4	time dum D1 α_5	time dum. D2 α_6	$\bar{R}^2$	D.W
Fluid milk	-14.411 (2.285)**	-0.960 (0.437)*	1.211 (0.041)**	1.817 (0.152)**		-0.314 (0.076)**	-	0.988	1.871
Fermented milk	-4.429 (7.657)	-2.159 (0.598)**	0.996 (0.299)**	0.663 (0.311)*		-0.553 (0.121)**	-	0.981	2.0069
Cheese	-42.106 (6.158)**	-0.874 (0.229)**	2.704 (0.342)**	-		0.365 (0.154)*	1.507 (0.205)**	0.991	1.8515
Infant formula	7.342 (4.577)	-1.200 (0.4542)*	0.368 (0.1694)*	1.391 (0.1936)**	0.682 (0.2184)*	-0.284 (0.0749)**		0.949	1.6356
Butter	-12.036 (5.088)*	-1.844 (0.645)**	0.864 (0.227)**	3.350 (0.549)**		-	-	0.952	1.6244

Notes: Statistical significance is denoted by ** at 1% and * at 5%.

Demand for enfant formula is estimated using data between 1975-2002.

Figure 2-1. Milk powder consumption, production, imports, and stock

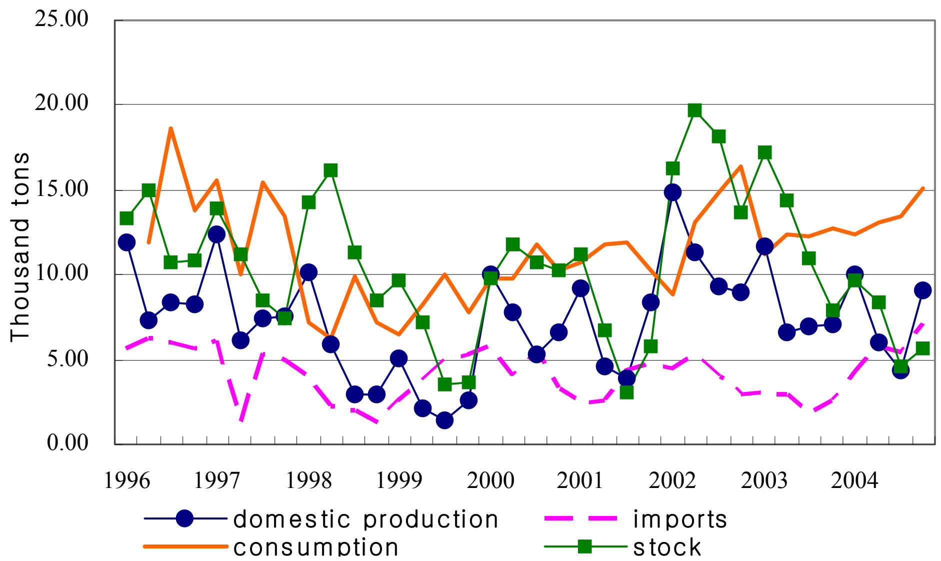

Table 2-2. Estimation results for milk powder demand estimation[1)]

	Constant b_0	Price b_1	income b_2	stock at t-2 b_3	time dum. b_4	$\bar{R}^2$	D.W.
Coefficient	7485.2 (4709)	-1.8718 (0.8306)*	0.0026 (0.0008)**	0.1893 (0.0800)**	-4294.5 (989.4)*	0.6264	2.0152
Elasticity[2)]		-0.5084	0.9851	0.1738			

1) Statistical significance is denoted by ** at 1% and * at 5%. First-order autocorrelation error is corrected

2) Elasticities are calculated at the average values of data period

Part III

A Component Based Investigation of Policy Changes

Part III is organized into seven sections. To set the stage for our simulation work, in the first two sections, we begin with the brief background on the current status of Korean dairy trade and on the DDA negotiation. In the third section, we present the simulation model and the next two sections provide information on parameters and scenarios that are necessary for model calibration. We, then, present the simulation results and conclude Part III.

1. Brief Overview of Dairy Product Trade in Korea

Until 1994, Korea maintained strict import quotas for most dairy products. With the Uruguay Round WTO agreement, Korea formally opened the dairy market, providing minimum access (MMA) quotas, relatively low within-quota tariff rates, and very high over-quota tariff rates. Before implementation of the WTO agreement, annual imports ranged between 4 percent and 9 percent of total domestic consumption. However, when the new WTO agreement was implemented in 1996, imports increased sharply from 9 percent to 19 percent of total raw milk-equivalent consumption. In 2003, about 21 percent of total domestic consumption was supplied from imports (in raw milk equivalent). Imports, consisting mostly of manufactured products, amount to about half of total domestic consumption of manufactured dairy products (Table 3-1).

After the initial increase in imports in 1996, import patterns follow significantly different paths for different products. After 1996, only the imports of cheese and formulated infant powder continued to grow, while the imports of other products either decreased or changed little. Cheese imports grew at an average annual rate of 19 percent from 1995 to 2004. In 2004, cheese accounted for almost 40 percent of all dairy imports by value (Table 3-2).

All imported dairy products are subject to either a single rate of tariff or a two-tier tariff rate quota system (Table 3-2). During the 10-year Uruguay round implementation period (1995-2004), over-quota tariff rates fell each year, but the lower within-quota tariffs did not fall. The tariff rates vary significantly across products. For example, skim milk powder has a tight quota for which the lower tariff of 40 percent and an over-quota tariff of 176 percent applies (in 2004). Butter has an 89 percent over-quota tariff. At the other end of the spectrum, formulated butter (which is about 70 percent milk fat) has a single tariff of 8 percent. Cheese imports have a single tariff of 36 percent. These tariff patterns account for the high imports of cheese and formulated butter relative to the imports of products such as skim milk powder and butter. For example, in 2003, Korea imported only 1,380 tons of butter, but 13,161 tons of formulated butter.

Many important dairy products imported under a tariff rate quota exceeded the quota quantity and had a substantial proportion of imports paying the high tariff rates. This means we can model the import barriers effectively as ad valorem tariffs using the high tariff rate as the marginal rate for the imports of the products that exceed the MMA amount.[4] However, given the tiny quota quantities and high over-quota tariffs, imports of butter and skim milk powder remain small relative to the imports of similar manufactured dairy products and relative to overall consumption. The import volume data suggest clearly that import demand for these high-tariff products shifted to similar products such as formulated butter, whey powder, and mixed powder that face much lower import barriers. With the substitution across products, demand may be best thought of as associated with dairy components such as fat and non-fat solids that are used to manufacture final products, rather than specific final products themselves. Based on this observation, we pursue our simulation modeling on such a component basis.

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[4] However, trade experts indicate that most of over quota imports are not intended for domestic consumption, but for production of export products. f they are re-exported, manufacturers are reimbursed with the payment of the high tariffs. Thus, for some important dairy products (such as butter or skim milk powder) that exceed the TRQs, we did not include the over quota amount in domestic consumptions and used the low tariff as the effective tariff rate.

2. The DDA Round of WTO Negotiations

The DDA framework signed in August in Geneva promises gradual elimination of subsidies on commercial exports, including indirect export subsidies associated with export credit guarantees, state trading enterprises and food aid (WTO, 2004). However, on import access, the DDA framework schedules a less complete liberalization. These agreements and current negotiating positions of important negotiating coalitions suggest that the highest tariff rates will be reduced most with the highest bound tariff rates declining by 50 percent or more (a so-called Swiss formula approach). This approach will be applied in "bands" rather than as a single formula. Tariff rate quota (TRQ) quantities will also be expanded. Doubling of small access quantities under TRQs may be likely outcomes. The access negotiation will consider formula reduction rates and which products belong in which reduction categories.

Smaller tariff cuts and slower expansion of the quota quantities for tariff rate quotas will be allowed for sensitive products. Each country will be allowed to declare a limited number of sensitive products, but these will not be exempted from access improvements. The market access expansion in developing countries is likely to be limited for many commodities. Smaller increases in access will be required for developing countries under the special and differential treatment provisions. Developing countries will also be allowed to declare a limited number of special products for which less access improvement will be required.

Finally, as expected, debate over domestic support programs has raised many issues and proposals and the suggested schemes to deal with these programs are almost as complex as the programs themselves. The bottom line is likely to be some tightening of what payments can be considered exempt from reform (green box) and some allowance for programs that are more than minimally trade distorting yet do not contribute to production as much as full production subsidies (blue box). With those changes, there will likely be limits on overall subsidies in the less distorting category (blue box) and substantial cuts in the category of subsidies that are considered most trade distorting (amber box). Progress on the details of this reform plan is likely to come throughout 2005, with a basic agreement on many specifics by the end of the year and a final deal in 2006. The negotiations and the settlement of the recent WTO dispute over cotton together imply that substantial reductions in trade distorting subsidies will result from the negotiations. The negotiating positions suggest that cuts in the aggregate measure of support by 50 percent or more are likely. In addition, there will be shift of some subsidy programs into less production distorting forms.

3. Simulation Model

The simulation model necessarily abstracts from many details, but we capture essential features of the Korean market and policies. Some of key market features include the following. Fluid milk consumption is supplied only from the domestic source, and processed product components are mostly imported. That means that imports compete with the domestic milk production in excess of fluid use that is available for manufacture of tradable products. There are two domestic raw milk prices—a high government-set price that applies to the raw milk used for fluid consumption and a much lower market price that applies to the milk used for non-fluid consumption. One important innovation of our model is that the manufactured outputs considered in our model are milk components, rather than specific products. Various milk components are aggregated into two components, fat and non-fat-solids.

We begin with three quantities: (1) fluid milk (Q_{fl}) which has the same component composition as raw milk, (2) the fat component of manufactured dairy products (Q_{fat}) and (3) the non-fat-solid (NFS) component of manufactured dairy products (Q_{nfs}). Domestic production of raw milk (*X*) has two uses, fluid use (X_{fl}) and non-fluid use (X_{pro}). Raw milk is sold at the high price, p^H , for fluid use and at the low price, p^L , for non-fluid use. Farmers receive a weighted average of these two milk prices, where the weights are equal to the product use shares. Fixed proportions of fat and NFS are produced from raw milk at the rates of α_j (4% for j=fat and 9% for j=NFS). Domestic uses of fat and NFS include imports that enter the country under the ad valorem tariffs. Imports are the major share of the processed product markets in Korea and, under a small country assumption, the market prices for components, p_{fat} and p_{nfs}, are determined by the import prices, which are exogenous to Korea.

The following system describes the Korean dairy market:

1) $Q_i = D^i(p_i; \boldsymbol{z_i})$, i=*fl, fat, nfs*

2) $p_{fl} = (1+\omega)p^H$

3) $p_j = (1+\pi_j)\hat{p}_j$, j=*fat, nfs*

4) $Q_{fl} = X_{fl}$

5) $Q_j = \alpha_j X_{pro} + M_j$, j=*fat, nfs*

6) $X = X_{fl} + X_{pro}$

7) $p^X(p^H, p^L) = \dfrac{\partial C(\boldsymbol{w}, X)}{\partial X}$

8) $p^L = \sum_j \alpha_j p_j$, j=*fat, nfs*

9) $v_n = \dfrac{\partial C(\boldsymbol{w}, X)}{\partial w_n}$, n=*1,..,N*

10) $w_n = G(v_n; \boldsymbol{h_n})$, n=*1.,···,N*

Equation (1) describes output demand, where $\boldsymbol{z_i}$ represents a vector of demand shifters. Equation (2) determines the market price for fluid milk under the assumption that the fluid milk price is a constant proportion of the price of raw milk that is supplied for fluid use, where ω represents the marketing margin. Equation (3) determines the market prices for components as the product of the imported price, $\hat{p}_j$, times one plus the ad valorem tariff, π_j. Equations (4) and (5) represent the market equilibrium where quantity demanded equals quantity supplied. Note that while milk for fluid use is supplied only from domestic sources, fat and NFS supplies for manufactured products include imports, M_j. Equation (6) is the identity, indicating that domestic raw milk production is the sum of milk for fluid use and manufactured use. In equation (7), with $C(\boldsymbol{w},X)$ denoting the cost of producing X with a vector of input prices, $\boldsymbol{w}$, the marginal cost of raw milk is equated to the milk price (P^X) which is a weighted average of the high and low milk prices (the weights are the sales shares sold at each price). Equation (8) defines the low milk price, indicating that the price of raw milk used for manufactured products equals the sum of component values.[5] (The high price of raw milk used for fluid products is set exogenously by the government.) Equations (9) and (10) together describe the input market equilibrium with a set of derived input demand and supply equations, where v_n and w_n are the quantity and price of input n and $\boldsymbol{h_n}$ is a vector of input supply shifters. Equations (7)-(10) determine raw milk production *X,* together with quantity and price variables related to inputs.

Because Korea is a small country in world dairy trade, component prices, p_{fat} and p_{nfs}, (and thus p^L (by equation (8)), are determined by equation (3), implying that these prices are insulated from any changes in the domestic market. Thus, any domestic shock, for instance, a change in p^H , would affect X, X_{pro}, and M_i, but not p_{fat} and p_{nfs}.

Totally differentiating equations (1)-(10) and using log differentials to convert to elasticity form yields the following linear elasticity model (Muth, 1964; Sumner et al., 1999)

1') $EQ_i = \sum_k \eta_{ik} Ep_k + \boldsymbol{\lambda_i z_i}$, *k=fl, fat, nfs, i=fl, fat, nfs*

2') $Ep_{fl} = Ep^H$

3') $Ep_j = E\hat{\pi}_j$, *j=fat, nfs*

4') $EQ_{fl} = EX_{fl}$

5') $EQ_j = s_j^Q EX_{pro} + (1 - s_j^Q) EM_j$, *j=fat, nfs*

6') $EX = s_{fl}^X EX_{fl} + (1 - s_{fl}^X) EX_{pro}$

7') $Ep^X = \sum_n \gamma_n Ew_n$

8') $Ep^L = s_{fat}^p Ep_{fat} + (1 - s_{fat}^p) Ep_{nfs}$

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5 For simplicity, equation (8) defines that the processed raw milk price equals the value of components. However, it is likely that the component value exceeds the raw milk price in the presence of costs associated with processing raw milk into the components. This implies our estimation may present some systematic bias. That is, under the model specifying processing costs, smaller changes would be realized for the reductions in the processed raw milk price, raw milk production and the share of processed raw milk and for the increases in component imports

9') $$Ev_n = \sum_{k=1,..,N} \gamma_k \sigma_{nk} Ew_k + EX \quad , n=1, \cdots N$$

10') $$Ew_n = \rho_n Ev_n + \boldsymbol{\mu_n} E\boldsymbol{h_n} \, , n=1, \cdots, N$$

Throughout the equations (1')-(10'), the following notation is used: Operator E represents a proportional change; η and λ with an appropriate subscripts represent demand elasticities with respect to the own price and to each demand shifter; $\hat{\pi}_j = (1+\pi_j)$; s with an appropriate subscript and superscript describes a share, that is, s_j^Q is the share of the domestic source in the total component consumption (i.e., $s_{fat}^Q = \alpha_{fat} X_{pro} / Q_{fat}$ and $s_{nfs}^Q = \alpha_{nfs} X_{pro} / Q_{nfs}$), s_{fl}^X $(= X_{fl} / X)$ is the proportion of fluid milk in raw milk production, and s_{fat}^p $(= \alpha_{fat} p_{fat} / p^L)$ is the value share of fat in the price of non-fluid milk; γ_k is the cost share of input k; σ_{nk} is the Allen elasticity of substitution between inputs n and k; ρ_n is the supply elasticity of input n; and $\boldsymbol{\mu_n}$ is a vector of supply elasticities related to the supply shifters of input n.

Our analysis considers effects of trade policy changes after there has been a decade of implementation. Therefore, we consider the impact of reduced import barriers in the year 2015. Of course, with negotiations underway it is impossible to know the date at which policy changes will be fully implemented but based on WTO negotiations so far and we believe this date to be a reasonable estimate (WTO 2005). To obtain baseline projections for 2015, we rely on two sources. We extend by one year published FAPRI baseline projection for Korea (FAPRI 2005) and we apply our own projections, based on analysis of recent Korean data and trends, for required information that is not available from FAPRI.

In order to use the model to examine relevant scenarios, we must specify a set of parameter values including various elasticities and shares related to outputs and inputs as well as policy parameters. Outputs include milk components, fat and NFS, and, of course, neither supply and demand parameters nor quantity and price data are directly available for components. Hence we were required to infer component information from available data and parameters on raw milk and milk products, which is the subject of the next section.

4. Simulation Parameters: Component-Based Parameters

This section describes the construction of various parameters that are required for simulation analysis. Constructing parameters requires a large amount of data. In what follows, we provide the steps involved and the summary of information used in constructing parameters. The resulting parameter values are summarized in Table 3-5.

4.1. Component Consumption Data

Our first task is to calculate the domestic shares of components, s_{fat}^{Q} and s_{nfs}^{Q}. The domestic share of component, for example, fat, can be expressed as s_{fat}^{Q} $=\alpha_{fat}X_{pro}/Q_{fat}$, where Q_{fat} is the total quantity of fat consumed. Realizing Q_{fat} is the sum of domestically produced and imported components, i.e., $(\alpha_{fat}X_{pro}+\sum_{i}F_{i}g_{i})$, where F_i and g_i are the fat ratio and the total imports of product i, we have to obtain the relevant data. First, to obtain the data on imports (F_i and g_i), we considered 13 dairy products based on 2004 import data (Table 3-3). Relying on various sources, we obtained information on component shares, and calculated component imports using multiplying the product import and relevant component ratio. The total component consumption is calculated by simply adding domestic production of component, $\alpha_i X_{pro}$ (i=fat or NFS), to component imports. Note that our X_{pro} excludes milk used to produce fermented milk which has substantial consumption in Korea. We included raw milk used for fermented milk in fluid milk consumption because fermented milk is made directly from raw milk.

However, our simulation requires the projection of Q_{fat} that again requires projections of product imports and domestic non-fluid consumption. We used the projection on X_{pro} directly from FAPRI data. However, we revised the FAPRI figure slightly because FAPRI projections do not include fermented milk consumption in their data. Given that currently fermented milk consumption accounts for about 25 percent of fluid milk consumption in raw milk equivalent terms, we extend the FAPRI projection on X_{pro}, assuming that fermented milk maintains its 25 percent share of all fluid milk in 2015. For the projection on components derived from products, we rely on FAPRI projections. However, FAPRI projects consumption of only four processed products, butter, cheese, nonfat dry milk, and whole milk powder. We converted the quantities of products into those of components and calculated the proportional increase in component consumption between 2004 and 2015. According to the FAPRI projections based on these four commodities, component consumption increases by 17.9 percent for fat and 7.65 percent for NFS between 2004 and 2015. We then applied these rates of change to our 2004 component imports and by adding the projections on domestically produced components to component imports, we obtain Q_{fat}, s^Q_{fat} and s^Q_{nfs}. Table 3-4 provides calculated component shares and some of key data information.

4.2. Derivation of Component Elasticities

The next task involves the construction of component elasticities based on our estimation of product elasticities. To derive component demand elasticities from product demand elasticities, we have used the methodology by Alston et al., which is consistent with underlying demand theory. The component elasticities can be calculated as:

$$\begin{bmatrix} \eta_{fat,fat} & \eta_{fat,nfs} \\ \eta_{nfs,fat} & \eta_{nfs,nfs} \end{bmatrix} = \begin{bmatrix} \sum_{i=1}^{n} \hat{\eta}_{ii} \frac{p_{fat} F_i}{p_i q_i} \frac{F_i}{F} & \sum_{i=1}^{n} \hat{\eta}_{ii} \frac{p_{nfs} N_i}{p_i q_i} \frac{F_i}{F} \\ \sum_{i=1}^{n} \hat{\eta}_{ii} \frac{p_{fat} F_i}{p_i q_i} \frac{N_i}{N} & \sum_{i=1}^{n} \hat{\eta}_{ii} \frac{p_{nfs} N_i}{p_i q_i} \frac{N_i}{N} \end{bmatrix}$$

where $\hat{\eta}_{ii}$ is the own price elasticity of product i, F_i is the fat content in product i, N_i is the NFS content in product i, F and N are total fat and NFS contained in all product (i=1,⋯,n), p_i and q_i are the price and quantity of product i. To obtain the component prices, p_{fat} and p_{nfs}, we used the FAPRI butter price projection for fat and the FAPRI non-fat dry milk price projection for NFS. To obtain the fat value, FAPRI's projected butter price was inflated by the factor (1/0.85) because butter is roughly 85 percent fat and 15 percent water.

4.3. Derivation of Component Tariffs

The important assumption used in the derivation of component tariffs is that component tariffs are the weighted average of effective tariffs on products. Marginal tariffs are used as effective tariffs and component shares are used as weights. Import data in 2004 are categorized into 13 manufactured products. For the products for which high over-quota tariffs are applied, we use over-quota tariffs in the calculation of component tariffs. Therefore, the component tariffs, for example for fat (T_{fat}), can be expressed as: $T_{fat} = \sum_i T_{Xi}\left(\frac{F_i}{F}\right)$, where T_{Xi} is the tariff rate of product X_i. The tariff rate for NFS is calculated similarly. Our calculation results on component tariffs are provided in Table 3-4.

4.4. Other Parameter Specification

Demand elasticity for fluid milk: For the own demand elasticity for fluid milk, we used our own estimate, -0.96. This is highly elastic compared to -0.47 and -0.53 by Park et al. (1996) and -0.63 by Heien and Wessells (1988) who estimated U.S. demand. However, our estimate is in the similar magnitude compared to -1.48 by Shin and Jung (2003) who used Korean data. In specifying the cross demand elasticities, zero substitutions between fluid milk and the components are assumed. Fluid milk is consumed for drinking and equation (1) for fluid milk describes this consumer demand. The milk fat and NFS components are demanded by intermediate firms that manufacture dairy and other food products but not fluid milk. This implies relatively low substitution between the components and fluid milk, and for simplicity, we assumed zero substitution ($\eta_{fl,fat}=\eta_{fl,nfs}=0$) (Heien and Wessells, 1988). We also assume that these output demand elasticities are constant over time and not function of the policy shifts.

Factor related parameters: Factor cost shares, γ_k, are constructed using 2003 input data (MAF and Korea Dairy Committee, 2003). The model also requires parameters for the Allen elasticities of input substitution, σ_{nk}. Unfortunately, little information is available on these values, but we expect little input substitution between feed and other inputs. We therefore set the substitution parameters related to feed relatively low (see Table 3-1).[6]

Finally, the model requires supply elasticities for inputs into dairy production (ρ_n^{-1}). The dairy industry in Korea is a small share of agriculture and we are considering long run adjustments, therefore we may expect relatively elastic input supply curves facing the dairy industry. Consider first the labor input. If the labor input were homogeneous across different industries, adjustment costs were zero and the labor market for farm occupations were competitive, we would expect perfectly elastic supply of labor in the dairy market. The same consideration applies to capital inputs. However, given that adjustment costs may still be significant over a 10-year horizon, we set the input supply elasticities to be 1.5 for labor and 2.0 for capital. We used a relatively large feed supply elasticity of 4.0 facing the dairy industry because Korea is a small country importer and most feed is imported. We assume that the parameters related to inputs do not change over time and are not functions of the trade policies. Table 3-5 summarizes the parameters used in the simulations.

5. Policy Scenarios

We examine the policy regime that allows for additional import access to the Korean market in 2015. We refer to this as “Doha scenario”. In light of our earlier discussion, the relevant Doha scenario for Korea assumes that Korea’s high over-quota dairy product tariffs decline by 50 percent by 2015 and the much lower within quota tariffs and single tariffs decline by 25 percent by 2015. This scenario is consistent with the kind of formulas under discussion in the current negotiations under which the higher tariffs will be cut most (WTO 2005). We also consider the free trade scenario, which is represented with no imposition of tariffs. This scenario is presented only to provide a reference in discussing the simulation results.

The 50 percent tariff cut is consistent with the pledge of substantial reduction of these higher tariffs. It is also consistent with the expectation that

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6 Hoque and Adelaja (1984) estimated the Allen elasticities of input substitution in US milk production. heir estimates were 0.08 for labor and feed, 0.27 for feed and capital, and 2.94 for labor and capital. We used their estimates as guidance.

dairy products will not be considered "sensitive" or special products by Korea and thus will not be allowed to avoid substantial tariff cuts. Korea has several products more important economically and politically than dairy, and as our results show, even relatively large tariff cuts for dairy have modest internal impacts in Korea.

These tariff cuts are based on products. Thus, to apply these policy shocks to our model, we have to convert these tariff cuts into the component based tariff cuts. To do so, we applied the relevant tariff cuts to the effective tariffs. That is, when the effective tariff is a over-quota high tariff, a 50 percent cut is applied and when the effective tariff is a within quota low tariff, a 25 percent cut is applied. Once we obtain the tariffs specific to products, we calculated component tariffs as weighted averages using the ratio of component contents of each product. The resulting component tariffs consistent with the Doha scenario are 20.9% for fat and 25.9% for NFS. This is equivalent to a 31.5 percent decline in the implied tariff for fat and 39 percent decline in the implied tariff for NFS from the current (2004) level of tariffs.

The future directions for domestic policies are also an important issue in Korea. We expect the outcomes of the DDA would impose no major changes in domestic dairy support polices. As a developing country for agriculture, Korea's domestic support commitments will be relatively light and dairy is also a small part of the AMS. Furthermore, with fluid milk consumption solely supplied by the domestic sources, Korea could easily maintain a price discrimination policy.[7] However, with the anticipation of further market opening, the most important domestic policy issue centers around income support for farmers. Various income support policy options are discussed and those include production quotas and support prices. To gain some insight on this issue, we briefly discusses the consequences of alternative domestic policies.

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[7] The Doha Framework agreement (WTO 2004) indicated that the approach will continue to be employed to redu commitments for domestic support. This means that commitments will apply on an agriculture-wide basis and not to individual commodities

6. Simulation Results

Table 3-6 reports the simulation results from the Doha and Free trade scenarios. Results are presented as percentage changes from the baseline projected values. We focus on the Doha scenario, with the free trade scenario provided for comparison. The Doha tariff reductions cause a 7.6 percent reduction of the fat component price and 7.5 percent reduction of the NFS price in Korea. Use of fat for manufactured products increases by 3.7 percent and use of NFS increases by 3.3 percent through equation (1'). The price of raw milk used for manufactured products falls by 7.5 percent as determined by the reduced prices of imported components. Of course, the price of raw milk used in fluid products is set by the government and does not change.

Domestic raw milk production falls only modestly, by 2.1 percent. With constant fluid milk consumption and most domestic milk used for fluid products, the decline in raw milk production implies a significant decline in domestic raw milk used for manufactured products and for the Doha scenario this decline is 18.8 percent. Reduction in raw milk used for manufactured products and increased use of overall milk fat and NFS for manufactured products imply that component imports must increase. Our results indicate that imports of fat increase by 10 percent and imports of NFS increase by 9.3 percent.

Changes in component quantity and price under the Doha scenario indicate that the implied own price demand elasticities for fat and NFS are -0.49and -0.44 (varies little under the free trade scenario). Likewise, the implied raw milk supply elasticity, using the implied changes in the weighted average of raw milk prices, was 2.55, which is elastic, as expected in the long run.

Although our Doha scenario imposes significant tariff reductions, the effects on input market prices and quantities are modest. Use of each input falls by only about 1.8 percent. The model implies a decline of only about one percent in the prices of labor and capital used for dairy production. These inputs are supplied by farmers and price declines imply the magnitude of the impact on farm income. Such modest changes are consistent with the importance of the use of raw milk in fluid products for which there is no price change.

As expected, complete free trade causes larger impacts on the Korean dairy economy than does the partial liberalization of the Doha scenario. Elimination of tariffs from manufactured dairy products implies the price declines of 23.6 percent for milk fat and 23.8 percent for NFS. In this case import of fat rises by 31.4 percent and the import of NFS rises by 29.3 percent. The quantity of raw milk used for manufactured products falls by 59.3 percent and the price of raw milk used for manufactured products falls by 23.7 percent. Despite these large shifts in percentage terms, the quantity of raw milk produced falls by only 6.5 percent. Even in the free trade scenario, the prices of farmer supplied inputs, labor and capital, fall modestly between 1.7 and 4.1 percent.

Various income and policy implications are forthcoming from our results. First, further market opening would surely decrease the income of Korean dairy farmers. With our results of the 18.8 percent decline in processed raw milk quantity and a decline of 7.5 percent of low milk price, this income decline is equivalent to the 25 percent of the farm gate income obtained from processed milk production. Given that the revenue obtained from the production of processed milk constitutes only a small proportion of the farm gate income, the income decrease due to further market opening would not be large. Some rough calculation shows that such a decrease in income would be by 2.5 percent assuming the revenue from processed milk production supported one tenth of income at the farm gate.

One of most important objectives of government policy is income support for farmers. In an anticipation of market opening, this is particularly an important consideration of Korean dairy policy. There is a strong indication that the Korean government may pursue quota based policies to provide income support for dairy farmers. We will examine the situation where the quotas are provided for raw milk designated for fluid and processed use and the government wants to maintain the same level of farm income with the tariff cuts in 2015. Suppose the current level of production is maintained as quota amounts. Then, to maintain the constant income level the low price of milk has to be supported by the government and our results shed some light on the magnitude of this support. Our results of 7.5 percent and 18.8 percent declines of manufactured milk price and quantity indicate that the low price of milk has to be supported by the government by more than 7.5 percent to maintain the income constant. The quantity decline of 18.8 percent implies that to prevent this decline the low milk price has to be above the current level, which again implies that the price support for low price has to be more than to compensate the price decline of 7.5 percent.

7. Concluding Remarks

Korean dairy product consumption has grown rapidly for several decades and this growth is expected to continue. This paper has developed and applied a model of South Korean dairy trade policy reform built upon detailed considerations of Korean dairy data and trends, market institutions, and government policy. The key results are that liberalization would cause significant increases in imports, lower prices of processed dairy products for Korean consumers, but relatively small reductions in returns to resources owned by Korean dairy farmers. Korean dairy farmers are expected to continue to supply the growing market for beverage milk and this helps to reduce the impact of additional import access.

Although a full global dairy model is beyond the scope of this article, it is important to note that the border import prices for milk components would be somewhat higher under the Doha scenario. These higher world prices would be consistent with a model of multilateral liberalization under which EU export subsidies decline, tariff-rate quotas expand, and tariff decline in many restricted markets. Even though we do not explicitly consider this scenario, higher border prices in our model mean smaller price cuts (when tariff cuts are applied) and consequently produce even smaller adjustments in Korea.

Table 3-1. Total consumption of raw milk and its shares by use and by source

Year	Total consumptions of raw milk (1000 tons)	Share in fluid consumption	Share in non-fluid consumption	Non-fluid consumption by source: Domestic	Non-fluid consumption by source: Foreign
1975	162	72%	28%	28%	0%
1976	199	66%	34%	34%	0%
1977	254	64%	36%	36%	0%
1978	326	62%	38%	38%	0%
1979	374	61%	39%	35%	3%
1980	412	68%	32%	32%	0%
1981	558	67%	33%	33%	0%
1982	593	72%	28%	26%	2%
1983	729	72%	28%	26%	1%
1984	834	74%	26%	23%	3%
1985	972	76%	24%	23%	0%
1986	1,162	79%	21%	21%	0%
1987	1,425	78%	22%	22%	0%
1988	1,652	79%	21%	21%	0%
1989	1,642	73%	27%	27%	0%
1990	1,879	71%	29%	29%	0%
1991	1,869	72%	28%	19%	9%
1992	1,920	73%	27%	23%	4%
1993	1,984	71%	29%	22%	7%
1994	2,078	75%	25%	19%	6%
1995	2,144	73%	27%	18%	9%
1996	2,465	66%	34%	15%	19%
1997	2,440	70%	30%	12%	18%
1998	2,286	61%	39%	26%	12%
1999	2,747	47%	53%	36%	17%
2000	2,803	60%	40%	18%	23%
2001	3,026	57%	43%	21%	22%
2002	3,060	54%	46%	24%	21%
2003	2,990	61%	39%	19%	20%
2004	3,074	58%	42%	15%	27%

Note: The numbers are calculated using the raw-milk equivalent data.

Source: Various issues of Dairy Year Book (MAF and Korea Dairy Committee).

Table. 3-2. Imports of dairy products (2003 and 2004) and tariff schedule by product

Product	2003 imports		2004 imports		Single tariff (%)		Two-tier tariff (%)			MMA (tons)	
							Low tariff (within MMA)	High tariff			
	$1000	Ton	$1000	ton	1995	2004	2004	1995	2004	1995	2004
Milk	0	0	0	0	46.3	36	–	–	–	–	–
Skim milk powder	7866	4560	8729	4389	–	–	20	215.6	176	621	1,034
Whole milk powder	2972	1660	3190	1512	–	–	40	215.6	176	344	573
Condensed milk	125	53	295	190	–	–	40	98	89	78	130
Whey	25035	39582	26334	35861	–	–	20	94.1	49.5	23,000	54,233
Butter	3003	1380	8774	4055	–	–	40	98	89	250	420
Formulated butter	21891	13161	35348	17411	8	8	–	–	–	–	–
Cream	2113	2030	7276	5286							
Cheese	93829	35782	120197	41351	39.6	36	–	–	–	–	–
Lactose	9287	15770	9678	14672	–	–	20	94.1	49.5	15,000	9,400
Mixed powder[1]	25000	12713	63593	29612	39.6	36	–	–	–	–	–
Infant formula	13597	3035	16959	2995							
Casein	23977	5236	34411	6179	24.8	22.5	–	–	–	–	–

1. Mixed powder was imported under the MMA restriction until 2000 (26,415 tons in 2000), but since then there is no MMA restriction.

Source: Dairy Year Book (2004)

Table 3-3. Fat and non-fat-solid contents of various dairy products

	Fat (%)	Non-fat solid (%)
Fluid milk[1)]	0.04	0.09
Cream[1)]	0.35	0
Butter[2)]	0.85	0
Manufactured butter[3)]	0.68	0
Skim milk powder[1)]	0	0.99
Whole milk powder[1)]	0.302	0.678
Mixed milk powder[4)]	0.02	0.68
Whey[5)]	0.055	0.9
Cheese[6)]	0.33	0.27
Lactose[1)]	0	1
Casein[1)]	0	1
Condensed milk[7)]	0.6	0.22
Fermented milk[8)]	0.215	0.485
Infant formula[9)]	0	0.60

1) The component ratios are based on Lee (1997).
2) The component ratios are based on the minimum requirements provided in the "Guideline for dairy product components and processing, 2001" published by the Korean National Veterinary Research and Quarantine Service.
3) Given the fat content of manufactured butter varies, to arrive at the representative fat ratio of manufactured butter, we used the price ratio, i.e., the ratio of the price of imported manufactured butter to the price of imported butter.
4) The primary ingredient of mixed milk power is skim milk power and it also contains various food additives such as sugar, soybean oil, milk protein and whey etc. We assume that 70% of mixed milk power is milk substance and 2% of this 70% is fat.
5) The component ratio is based on "International Ingredient Corporation" (http://www.iicag.com/cheesewhey.php)
6) Cheddar cheese is used as a representative, and the component information is obtained from the "National Dairy Council" (http://www.nationaldairycouncil.org/nutrition/products/table13.pdf)
7) The component ratio is based on the minimum requirements of the "Guideline of dairy products components and processing, 2001" published by the Korean National Veterinary Research and Quarantine Service.
8) Fermented milk is assumed to contain 70% of milk substance.
9) We use the ingredient information contained in infant formula "Similac". The ingredient include nonfat milk, lactose, vegetable oil, whey protein and other food nutrients (less than 2%) such as vitamins.

Table 3-4. Fat and Non-fat-solid consumption

		Total consumption	Domestic production	Imported	Share of import	Import price1)	Tariff
			ton	ton	ton	$/kg	%
2000	FAT	35723.91	11127.81	24596.10	0.69	2.48	26.16
	NFS	107281.56	25037.58	82243.99	0.77	1.66	34.97
2001	FAT	38670.00	15601.81	23068.19	0.60	2.36	27.79
	NFS	114835.18	35104.07	79731.11	0.69	2.21	33.69
2002	FAT	50827.22	26227.76	24599.46	0.48	2.43	25.89
	NFS	138051.54	59012.47	79039.07	0.57	1.69	33.45
2003	FAT	39000.34	13725.76	25274.58	0.65	2.56	27.55
	NFS	109013.21	30882.97	78130.24	0.72	1.74	31.56
2004	FAT	44975.78	11314.29	33661.49	0.75	2.55	30.90
	NFS	113198.26	25457.16	87741.10	0.78	2.01	31.34
Average	FAT	41839.45	15599.49	26239.96	0.63	2.48	27.66
	NFS	145594.94	43873.56	101721.38	0.88	2.33	33.00

1) To construct component prices, we used the butter price for fat and the skim milk powder for NFS.

Table 3-5. Parameter specification and baseline projections

Output and raw milk related parameters			
Output demand elasticity matrix (η)			
	Fluid	Fat	NFS
Fluid	-0.96	0	0
Fat	0	-0.458	-0.032
NFS	0	-0.053	-0.382
Quantity shares			
	$S^{Q}_{fat} = 0.2184$	$S^{Q}_{nfs} = 0.2139$	$S^{X}_{fl} = 0.89$

Value shares		
s^{p}_{fat} =0.311		

Input related parameters		
Factor cost shares (γ)		
Labor = 0.18	Feed = 0.50	Capital = 0.32
Input substitution (σ)		
Labor/feed = 0.1	Labor/capital = 1.0	Capital/feed = 0.3
Input supply inverse elasticity parameter (ρ)		
Labor = 0.67	Feed = 0.25	Capital = 0.5

2003 benchmark and 2015 projected baseline data		
	Year 2004[1]	Year 2015
Raw milk production (tons)	2,255,450	2,641,000
Fluid milk consumption (tons)	1,973,593	2,351,440
Fat component consumption (tons)	44,976	53,027
NFS component consumption (tons)	113,198	121,858
Price for fat ($/ton)		$2,450
Price for NFS ($/ton)		$2,400
Tariff for imported fat	30.9%	30.9%
Tariff for imported NFS	31.3%	31.3%

1 Data under 2004 are reported when they are relevant to the construction of the baseline data.
Sources: Authors' econometric estimates, MAF data, authors' parameter choices based on prior literature and FAPRI projections.

Table 3-6. Effects of border liberalization on the Korean dairy economy

	Variables	Proportional change in 2015	
		Trade reform with no change in domestic policy	
		Doha scenario[1]	Free trade scenario[2]
Quantity use	Fluid milk	0	0
	Fat	0.037	0.116
	NFS	0.033	0.103
Prices	Fluid milk	0	0
	Fat	-0.076	-0.236
	NFS	-0.075	-0.238
Raw milk quantity and prices	Raw milk production	-0.021	-0.065
	Raw milk for fluid use	0	0
	Raw milk for processed use	-0.188	-0.593
	Low price of raw milk	-0.075	-0.237
Component imports	Fat	0.100	0.314
	NFS	0.093	0.293
Input demand	Labor	-0.019	-0.061
	Feed	-0.021	-0.067
	Capital	-0.020	-0.065
Input prices	Labor	-0.013	-0.041
	Feed	-0.005	-0.017
	Capital	-0.010	-0.032

High over-quota dairy product tariffs decline by 50 percent and the much lower within quota tariffs and single tariffs decline by 25 percent by 2015.
Zero tariffs are imposed.

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