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MEASURING THE IMPACTS OF TRADE LIBERALIZATION FOCUSING ON THE EFFECTS OF PROCESSED GOODS ON RAW MATERIAL MARKETS: AN APPLICATION TO THE DAIRY SECTOR IN KOREA

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The paper presents an economic analysis of the effects of trade liberalization on a processed industry focusing on the effects of processed goods on raw material markets. We develop a partial equilibrium model allowing for measuring such indirect effects. The model is applied to analyze the effects of Korea-U.S. FTA on dairy industry in Korea. The simulation analysis provides useful insights on the impacts of Korea-U.S. FTA when measuring the effects trade liberalization on a processed industry is of interest.

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I. INTRODUCTION

In 2007, Korea and the U.S. reached a free trade agreement (FTA),

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which resulted in a huge change in the environment of food markets in Korea. Some research has been conducted to measure the impacts of the Korea-U.S. FTA on the Korean agricultural markets, and some researchers forecast that the FTA will increase the U.S. share of non-processed imported agricultural products in Korea from 31.6% in 2006 to 44.2% in 2023, and the amount of imported non-processed agricultural products from the U.S. will increase to 3.9 billion dollars in 2023 (Choi and Lee, 2007).

However, not much research has been done in evaluating the effect of the Korea-U.S. FTA on the processed food markets in Korea even though most researchers expect that the impact of the Korea-U.S. FTA on the processed food market will be significant. Some studies have revealed that the Korean food market including dairy products, meat, and alcoholic beverages may experience a huge impact from the Korea-U.S. FTA due to a big increase of imported U.S. food in Korea (Kwak, 2007). While the results from these studies can be used as a guideline in evaluating the full impacts of trade liberalization such as FTA between Korea and the U.S., when the industry under scrutiny involves some form of processing like in a food processing industry, it might ignore significant indirect effects taking place in an agricultural sector producing associated raw material. Measuring the full impacts of trade liberalization on a processing industry deserves both theoretical and empirical interests. Nevertheless, a little effort has been devoted to measure the effect of the Korea-U.S. FTA on a food processing industry such as the Korean dairy market taking both direct and indirect effects of trade liberalization into consideration.

This paper attempts to develop a theoretical framework based on a partial equilibrium approach which allows us to measure the impacts of trade liberalization in a food processing industry focusing on indirect effects taking place in raw material markets. We apply the theoretical model developed to the Korean dairy market to measure the full impacts of the Korea-U.S. FTA using numerical simulation analysis. For numerical simulation exercise and econometric estimation, the data from the Korean Ministry for Food, Agriculture, Forestry and Fisheries, Korea Agro-Fisheries Trade Corporation, Korea Dairy Committee, and the Korea Dairy Industries Association are used.

This paper is expected to make contributions to the existing literature on measuring the impact of trade liberalization both theoretically and empirically. We first focus on developing a conceptual framework on the measurement of full impacts of trade liberalization. Next, building on a partial equilibrium framework, we develop a theoretical model allowing for both direct and indirect effects of trade liberalization. Finally, we apply this model to Korean dairy industry, in particular, cheese and butter industry, under the Korea-U.S. FTA scenario, in order to evaluate empirically the effects of tariff reduction in a food processing industry.

II. THE CONCEPTUAL FRAMEWORK

In general, the research on the impacts of trade liberalization such as FTA on an industry has only focused on 'direct effects' taking place in such an industry (Choi, 2006; Kim and Jang, 2008). While this approach is relevant for the most cases, it might ignore "indirect effects" which can be non-negligible when it comes to a processing industry. Linked with the processing industry, these indirect effects of trade liberalization in a processing industry can occur in domestic and/or import raw material markets.

For an illustration purpose, let us consider the impacts of trade liberalization on a food processing industry. In order to capture impacts of trade liberalization in a comprehensive fashion, one needs to consider both direct and indirect effects of trade liberalization in a food processing industry. For indirect effects, there are two paths to be considered. First, there would be negative impacts on domestic raw material markets. The shrinking effects of trade liberalization on a food processing industry due to tariff reduction result in negative effects in an agricultural sector producing associated raw material for a food processing industry. Second, there would be significant impacts on both a food processing industry and domestic raw material markets via the import price reduction of foreign raw material due to a reduction of tariff. While this price reduction of foreign raw material may generate positive impacts on a food processing industry itself, it may produce negative impacts on an agricultural sector linked to domestic raw material markets. The size of these indirect effects depends on a degree to which a food processing industry is related to domestic/ foreign raw material markets.

In summary, we can characterize the full impacts of trade liberalization on a food processing industry (e.g., dairy markets) in the following way.

① Negative direct effects in domestic processed food markets: The tariff reduction on cheese and butter generates a negative direct effect for domestic cheese and butter markets.

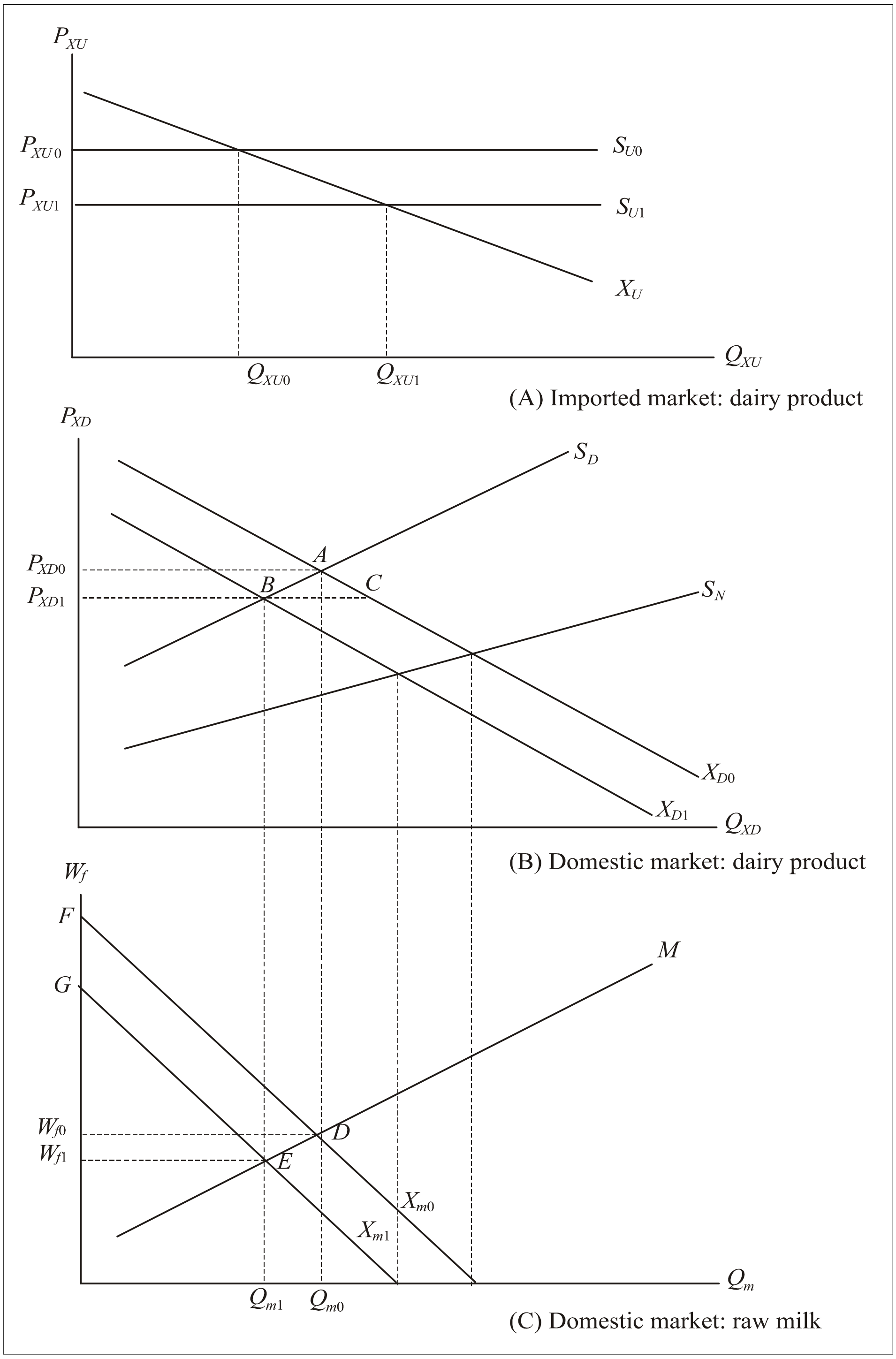
② Negative indirect effects in domestic raw material market due to a decrease of derived demand: The negative direct effects in domestic processed food markets results in the decrease in the production of processed goods. This in turn reduces derived demand of raw material, i.e., milk. Due to this demand decrease, the price of milk will be decreased. Reflecting this price reduction, the supply of milk is expected to be decreased as well. These changes in demand and supply of milk generate welfare changes of producers and consumers (see the following Figure 1 for details).

③ Negative indirect effects in domestic raw material market due to import price reduction of foreign raw material: Due to import price reduction of foreign raw material, substitution from domestic raw material to imported raw material will take place. This implies the decrease of demand of domestic raw material. Anticipating this decrease, the demand and supply of domestic raw material are changed. Again, these changes in demand and supply of domestic raw material generate welfare changes of producers and consumers of domestic raw material.

④ Positive indirect effects: The price reduction of foreign raw material contributes positively to the associated processing industry.

The above discussion on the indirect effects of trade liberalization on raw material markets can be illustrated in Figure 1. Figure 1 describes imported market of dairy product and the structure of domestic dairy product and associated raw milk market. Suppose X_D and S_D represent the demand and the supply function for a domestic dairy product (e.g., cheese or butter), respectively. The market equilibrium of this processed product takes place at point A, in which the market clearing price and quantity of a dairy product are P_{XD0} and Q_{XD0}, respectively. Let S_N represent the marginal cost function for other inputs for a

[Figure 1] Indirect effects of trade liberalization in a food processing industry (e.g., dairy industry)



processed dairy product except raw milk. The line *M*, which is the difference between S_D and S_N, depicts the supply function of raw milk. Suppose the demand function for raw milk can be described as X_{m0}. Before trade liberalization, the equilibrium price and quantity of raw milk market are determined at point *D*, i.e. W_{f0} and Q_{m0}, respectively.

Suppose that the tariff for imported dairy product is reduced due to the Korea-U.S. FTA. As shown in Figure 1, reflecting the tariff reduction, the supply function of an imported dairy product (S_{U0}) will shift down to S_{U1}. As a result, the price of this product is decreased from P_{XU0} to P_{XU1}. This change in an imported dairy product market will affect domestic dairy market. Taking product heterogeneity into consideration, the price of domestic dairy product will be decreased from P_{XD0} to P_{XD1} due to the price decrease of imported dairy product and subsequent increase of the amount of import which can be translated into a shift-down of demand curve in a domestic dairy market (X_{D0} to X_{D1}). Reflecting this increase in import, the demand of domestic dairy product will be decreased, resulting in negative indirect effects in domestic raw milk market. This is due to changes in derived demand associated with a dairy product, which can be represented by the shift of the demand curve for raw milk from X_{m0} to X_{m1}. Finally, because of these changes in derived demand for raw milk, raw milk price decrease is expected from W_{f0} to W_{f1} and the raw milk supply decrease from Q_{m0} to Q_{m1}.

While the dairy-product consumers' surplus increase is given by the area $P_{XD0}P_{XD1}AC$ in Figure 1, the decrease in the dairy-product producers' surplus is equivalent to the area $P_{XD0}P_{XD1}AB$. This corresponds to an increase in net surplus in the dairy product market equivalent to the area ABC. Note that the change of consumers' surplus in raw milk market can be measured as the area $W_{f0}DF$ minus the area $W_{f1}EG$. On the other hand, the decrease of producers' surplus in raw milk market is given by the area $W_{f0}pW_{f1}DE$. Hence, indirect effects represented by a deadweight loss in the raw milk market are equivalent to the area $DEGF$.

III. THE MODEL

Given this conceptual motivation, this paper develops an improved version of an original equilibrium displacement model of the Korean dairy market introduced by Kim and Jang (2008). The original model basically incorporates cheese and butter for analysis. Each dairy product has one demander, Korean dairy consumers, and three suppliers, namely Korean dairy processors, dairy exporters in the U.S., and dairy exporters in other countries. Since Korean consumers can buy dairy products from domestic and/or foreign markets including the U.S. and other countries, the price reduction of U.S. dairy products in Korean dairy markets due to the Korea-U.S. FTA will affect Korean consumers' demand for dairy products. The original model tracked this impact of the Korea-U.S. FTA and measured the changes in the price and quantity of dairy products from Korea, the U.S., and other countries in the Korean market.

However, implications from the original model are found to be restricted in the following sense. First, the original model fails to capture the step-by-step tariff reduction effects following the tariff reduction road map agreed in the Korea-U.S. FTA since it is basically a static model. Second, the original model focuses only on dairy product markets without considering the linkages between dairy product markets and input markets, such as raw-milk market. In contrast to this, the improved version developed in this paper allows us to capture indirect effects taking place in raw material markets.

Building on the original model developed by Kim and Jang (2008), we propose the following improvements. First, taking the market structure where domestic cheese or butter processors who use domestic raw materials (e.g., milk) are competing with foreign processors like the U.S. into consideration, the model needs to capture a potential reduction of domestic milk producers' surplus due to the decrease of domestic cheese and butter demand by the tariff reduction on imported processed goods. Second, the model also incorporates a potential switch from domestic milk to imported raw material (e.g., imported raw cheese material) in producing processed goods like cheese reflecting the price advantages of imported raw material due to the Korea-U.S. FTA. Third, the model should allow for the evaluation of the step-by-step tariff reduction effects following the tariff reduction road map agreed in the Korea-U.S. FTA.

In addition, to make the model empirically tractable, several assumptions need to be made. First, we only allow for the production structure where cheese and butter are produced only from domestic milk. Thus, we rule out the cases where cheese is made from imported raw cheese material (the point ② of the previous section). Second, we maintain small country assumption implying that the changes of market conditions in Korea do not affect world market prices. Third, a perfectly competitive market structure is assumed. Fourth, we rule out the import of milk from foreign countries reflecting high transportation costs of fresh milk. This assumption allows us not to consider import of milk from the U.S. Fifth, the demand is equal to the supply at equilibrium. Finally, dairy products are heterogeneous between domestic and imported products.

Incorporating these assumptions and updates[1], we have

Demand function of the i^{th} domestic dairy product:

$$X_{Di} = d_{Di}(P_{Di}, P_{Ui}, P_{Oi}) \tag{1}$$

Demand function of the i^{th} U.S. dairy product:

$$X_{Ui} = d_{Ui}(P_{Di}, P_{Ui}, P_{Oi}) \tag{2}$$

Demand function of the i^{th} other countries' (except the U.S.) dairy product:

$$X_{Oi} = d_{Oi}(P_{Di}, P_{Ui}, P_{Oi}) \tag{3}$$

Total domestic demand of the i^{th} dairy product:

$$X_{Ti} = X_{Di} + X_{Ui} + X_{Oi} \tag{4}$$

Supply function of the i^{th} domestic dairy product:

$$X_{Di} = s_{Di}(P_{Di}) \tag{5}$$

Domestic price of the i^{th} U.S. dairy product:

$$P_{Ui} = P_{Wi}\omega_i \tag{6}$$

Tariff condition:

$$\omega_i = 1 + \tau_i \tag{7}$$

[1] In general, the equations (8) and (9) impose a restrictive assumption on the production technology, i.e., a CRS production function with one input, implying an infinitely elastic, horizontal supply curve. As such, one should note that the mathematical model developed in this paper describes a special case of the general model represented in Figure 1. However, as captured in equation (5), an upward-sloping supply curve in a processed dairy product market is still feasible when an associated input market (e.g., raw milk) is characterized by a non-competitive market structure. Especially, in Korea, the raw milk market is not considered to be competitive because of entry barriers (e.g., a supply management scheme such as a quota system).

Production function of the i^{th} domestic dairy product:

$$X_{Di} = g_{Di}(M_i) \tag{8}$$

Price of milk used for the production of domestic dairy product:

$$W_i = g_{Mi} P_{Di} \tag{9}$$

Supply function of domestic milk:

$$M = m(W_f) \tag{10}$$

Farmers' price of milk (average price):

$$W_f = (M_i W_i + M_k W_k + M_m W_m) / M \tag{11}$$

Price discrimination of domestic milk for the i^{th} dairy product:

$$W_i = W_m \tag{12}$$

Price discrimination of domestic milk for the k^{th} dairy product:

$$W_k = W_m - MU \tag{13}$$

Adding up conditions for milk:

$$M = M_i + M_k + M_m , \tag{14}$$

where the subscript *i* denotes the i^{th} dairy product (e.g., $i =$cheese, butter), the subscript *f* denotes "farmer", *k* denotes "other dairy product except the i^{th} dairy product", and the subscript *m* means "milk". We use subscript *D* for domestic, *U* for the U.S. and *O* for other countries. The subscript *W* indicates "world" and *T* for "Total".

Equation (1) indicates that the demand of the i^{th} domestic dairy product is a function of its own price (P_{Di}), the import price of diary product from the U.S. (P_{Ui}) and other countries (P_{Oi}). Equation (2) and (3) show that the demand of the i^{th} dairy product imported from the U.S. and other countries is affected by the same arguments as in (1). These three equations capture the effects of the Korea-U.S. FTA on the demand of domestic dairy products through the import price reduction of U.S. dairy product.

Equation (4) describes the total domestic demand for the i^{th} dairy product which is equal to the demand for domestic/ the U.S./ other countries' i^{th} dairy product. The supply function of the i^{th} domestic dairy product is denoted in equation (5). It is assumed to be a function of its own price. The model does not consider the supply function of U.S. dairy products and other country's dairy products. This is because of small country assumption where market conditions of Korean markets cannot affect world market prices. Equations (6) and (7) describe how the changes in the tariff of the i^{th} U.S. dairy product affect the price of the i^{th} U.S. dairy product. After complete tariff removal under the Korea-U.S. FTA is effective, the price of the i^{th} U.S. dairy product is equal to the world price.

The indirect effects described earlier part of this paper can be captured by equations (8) ~ (14). Equation (8) is the production functions that transform milk into i^{th} domestic dairy product. Equation (9) presents the competitive equilibrium condition for milk, stating that the price of milk for i^{th} dairy product is the equal to the value marginal product of milk, where g_{Mi} is the marginal product of milk in i^{th} dairy product. Note that g_{Mi}, the marginal product of milk in i^{th} dairy product, is assumed to be constant reflecting a Constant Returns to Scale nature of production technology in Korean dairy industry.[2] Equation (10) expresses the supply of milk, as a function of the farmer price of milk, which is derived as blend price in equation (11). Equation (12) and (13) capture price discrimination, which raises the price of milk paid by fluid milk processors by a fixed mark-up, *MU*, relative to that paid for dairy product. Equation (14) shows the adding up condition. In particular, the impact of the Korea-U.S. FTA on the market of i^{th} dairy product (direct effects) affects the milk market, which is used as an input to produce i^{th} dairy product, via equation (8) and (9). In equation (8), the change in demand of i^{th} dairy product due to the Korea-U.S. FTA results in the changes of derived demand of milk. Equation (9) shows the linkages between the prices of i^{th} dairy product and milk used as an input.

Considering equations (1) ~ (14) altogether, the effects of the Korea-U.S. FTA on the dairy market in Korea can be numerically analyzed. In order to make this model empirically tractable, all of the equations are written in an elasticity form after total differentiation. They are given in equations (1)' ~ (14)'. Note that '*E*' denotes proportional changes. For

[2] According to diary market experts, Korean cheese and butter processing factories rarely experienced DRS or IRS, because they generally produce within the range where CRS characterizes production technology. In addition, this assumption is consistent with previous research in a dairy market using partial equilibrium models like our model (e.g., see Balagtas, Joseph V. and Sounghun Kim (2007)).

example, EX_{Di} is the changes due to the Korea-FTA with respect to the initial conditions ($= \frac{dX_{Di}}{X_{Di0}}$). Now, the model is given by:

$$EX_{Di} = \eta_{DDi}EP_{Di} + \eta_{DUi}EP_{Ui} + \eta_{DOi}EP_{Oi} \quad (1)'$$
$$EX_{Ui} = \eta_{UDi}EP_{Di} + \eta_{UUi}EP_{Ui} + \eta_{UOi}EP_{Oi} \quad (2)'$$
$$EX_{Oi} = \eta_{ODi}EP_{Di} + \eta_{OUi}EP_{Ui} + \eta_{OOi}EP_{Oi} \quad (3)'$$
$$EX_{Ti} = \psi_{Di}EX_{Di} + \psi_{Ui}EX_{Ui} + \psi_{Oi}EX_{Oi} \quad (4)'$$
$$EX_{Di} = \varepsilon_i EP_{Di} \quad (5)'$$
$$EP_{Ui} = E\omega_i \quad (6)'$$
$$E\omega_i = \varphi E\tau_i \quad (7)'$$
$$EX_{Di} = EM_i \quad (8)'$$
$$EW_i = EP_{Di} \quad (9)'$$
$$EM = \varepsilon_m EW_f \quad (10)'$$
$$EW_f = \upsilon_i(EM_i + EW_i) + \upsilon_k(EM_k + EW_k) + \upsilon_m(EM_m + EW_m) - EM \quad (11)'$$
$$EW_i = EW_m \quad (12)'$$
$$EW_k = EW_m \quad (13)'$$
$$EM = \theta_i EM_i + \theta_k EM_k + \theta_m EM_m, \quad (14)'$$

where η_{DUi} is the price elasticity of demand for the i^{th} dairy product ($= \frac{\partial X_{Di}}{\partial P_{Di}} \frac{P_{Di}}{X_{Di}}$), ψ_{Di} is the proportion of the i^{th} domestic dairy product in total domestic demand of the i^{th} dairy product ($\frac{X_{Di}}{X_{Ti}}$), ε_i is the price elasticity of supply ($= \frac{\partial s_{Di}}{\partial P_{Di}} \frac{P_{Di}}{s_{Di}}$), φ is the proportion of tariff to tariff equivalent ($= \frac{\tau_i}{\omega_i}$), υ_i is the share of milk revenue from the i^{th} dairy product ($= \frac{W_i M_i}{W_f M}$), and θ_i is the proportion of raw milk used for the production of the i^{th} dairy product to total raw milk ($= \frac{M_i}{M}$), and ε_m is the price elasticity of supply for raw milk ($= \frac{\partial M}{\partial W_f} \frac{W_f}{M}$).

The model summarized in equations (1)’ ~ (14)’ can be used to implement simulation analysis of the effects of the Korea-U.S FTA on domestic dairy industry taking indirect effects on raw material markets into consideration. Here, the tariff changes reflected by the Korea-U.S FTA are represented by $E\tau_i$.

IV. PARAMETERS AND A ROAD MAP FOR TARIFF REDUCTION

For a numerical simulation, the values of parameters in the model are taken from previous studies or are calculated from data. First, the estimates of the price elasticity of demand of cheese and butter were taken from the results of Kim and Jang (2008) (see Table 1). The value of supply elasticity was estimated by Song et al. (2005). Other values of parameters were calculated from data obtained from Korea Dairy Industries Association, Korea Dairy Committee, Korea Agro-fisheries Trade Cooperation, and Korean Ministry for Food, Agriculture, Forestry and Fisheries.

[Table 1] Estimates of the Price Elasticity of Demand

Butter				Cheese			
η_{xy}	*D*	*U*	*O*	η_{xy}	*D*	*U*	*O*
D	-1.218	0.135	0.149	D	-0.548	0.135	0.149
U	0.135	-0.808	0.269	U	0.135	-0.684	0.269
O	0.149	0.269	-0.785	O	0.149	0.269	-0.741

Source: Kim and Jang (2008).

The simulations were conducted with the computer package (GAMS), considering the road map for tariff reduction concluded at Korea-U.S. FTA (see Table 2 for details).

[Table 2] Road map for Tariff Reduction due to Korea-U.S. FTA

Year	Butter (%)	Cheese (%)
2009	89.0	36.0
2010	80.1	33.6
2011	71.2	31.2
2012	62.3	28.8
2013	53.4	26.4
2014	44.5	24.0
2015	35.6	21.6

2016	26.7	19.2
2017	17.8	16.8
2018	8.9	14.4
2019	0.0	12.0
2020	-	9.6
2021	-	7.2
2022	-	4.8
2023	-	2.4
2024	-	0.0

Source: Korean Ministry for Food, Agriculture, Forestry and Fisheries.

V. SIMULATION RESULTS AND IMPLICATIONS

The effect of the Korea-U.S. FTA on the Korean dairy market is still a big pending issue for the U.S. as well as Korea. Many U.S. dairy exporters expect to see their market share increase in Korean dairy markets after the Korea-U.S. FTA while Korean dairy processors and milk farmers worry about a decrease in the sales volume of their products. Exporters in other countries who are competing with U.S. exporters in Korean dairy markets are also very interested in the consequences of the Korea-U.S. FTA in terms of changes in their market shares.

The simulation exercises utilizing the above model are expected to produce meaningful results for future discussion evaluating the impact of the Korea-U.S. FTA. In particular, empirically estimating the indirect effects, discussed earlier when a processing industry and its associated raw material market is concerned, would shed light on evaluating a full impact of trade liberalization in terms of changes in the prices and market shares of Korean, U.S., and other countries' dairy products and their indirect effects on raw milk market in Korea.

First, Table 3 shows direct effects of step-by-step tariff reduction in butter market. The quantity and price changes of butter for domestic/ the U.S./ other countries are simulated. The simulation results show that after 10 years of tariff reduction following the road map for tariff removal, the price of butter imported from the U.S. is decreased up to 47.1% and the trade volume is increased up to 61.6% at 2019 when tariff reduction is completed compared to the year of 2010.[3]

On the other hand, the price and quantity of domestic butter is found to be decreased up to 4.1% and 3.2%, respectively. Associated sales volume of domestic butter producers is found to be decreased up to 7.2%, and producers' surplus up to 3.2%, respectively. These correspond to 3,852 Mil. KRW cumulative loss in sales volume and 2,174 Mil. KRW cumulative loss in producers' surplus of domestic butter market in levels. On the other hand, the cumulative gain of consumers' surplus is predicted to increase up to 2,284 Mil. KRW, which is slightly larger than that of cumulative loss of producers' surplus in Korean butter market.[4]

[Table 3] Simulation Results for Butter Market

Unit: Million KRW, %

Year	Quantity Change (%)				Price Change (%)		Production Change (%)	Producers' Surplus Change (%)	Consumers' Surplus Change
	Domestic	U.S.	Other Countries	Total	Domestic	U.S.			
2010	-0.25	3.76	-1.31	-0.55	-0.32	-4.71	-304 (-0.57)	-172 (-0.32)	181
2011	-0.26	3.95	-1.38	-0.57	-0.34	-4.94	-318 (-0.59)	-179 (-0.33)	189
2012	-0.27	4.15	-1.45	-0.60	-0.35	-5.20	-332 (-0.62)	-187 (-0.35)	197
2013	-0.29	4.38	-1.53	-0.62	-0.37	-5.49	-348 (-0.66)	-197 (-0.37)	207
2014	-0.30	4.64	-1.62	-0.66	-0.39	-5.80	-366 (-0.70)	-207 (-0.39)	217
2015	-0.32	4.92	-1.72	-0.69	-0.42	-6.16	-386 (-0.74)	-218 (-0.42)	229
2016	-0.34	5.24	-1.83	-0.73	-0.45	-6.56	-408 (-0.79)	-230 (-0.44)	242
2017	-0.37	5.61	-1.96	-0.77	-0.48	-7.02	-433 (-0.84)	-244 (-0.48)	257
2018	-0.40	6.04	-2.11	-0.82	-0.51	-7.56	-462 (-0.91)	-261 (-0.51)	274
2019	-0.43	6.53	-2.28	-0.88	-0.55	-8.17	-495 (-0.98)	-279 (-0.55)	293
Total	-3.18	61.62	-15.93	-6.67	-4.10	-47.09	-3,852 (-7.15)	-2,174 (-3.16)	2,284

Next, Table 4 shows the simulated indirect effects of step-by-step tariff reduction in butter market on raw milk market. The supply and price

[3] Total change of rates is calculated using the following formula: $\frac{V_{Final}-V_{Base}}{V_{Base}}\times 100$, where V_{Base} is the value of base year and V_{Final} is the value of final year. In Table 3, V_{Base} is the value of price or quantity in 2010 (the value before tariff reduction due to Korea-U.S. FTA) and V_{Final} is the value of price or quantity in 2019 (the value after completing the final tariff reduction).

[4] The values of producers' surplus and consumers' surplus are calculated using formula from Alston, Norton, and Pardey (1995).

changes of raw milk derived by domestic butter market are simulated. The simulation results indicate that when tariff is completely removed, the supply of raw milk for producing butter is found to be decreased up to 3.2% and the price of raw milk is also found to be decreased up to 4.1% in a cumulative sense compared to the year of 2010. Reflecting these changes, sales loss of milk farm due to the demand decrease of domestic butter is found to be 286,707 Mil. KRW which is a 8.2% reduction compared to 2010. Producers' surplus of milk farm is also found to be decreased up to 119,127 Mil. KRW which is a 4.2% decrease compared to 2010.

[Table 4] Indirect Impacts on Raw Milk Market via Butter Market

Unit: Million KRW, %

Year	Raw Milk Supply Change (%)			Raw Milk Price Change (%)				Farm Sales Change (%)	Producers' Surplus Change (%)
	Fresh Milk	Butter	Total	Fresh Milk	Butter	Other	Farm Price		
2010	-0.38	-0.25	-0.28	-0.32	-0.32	-0.32	-0.37	- 22,710 (-0.65)	-9,491 (-0.19)
2011	-0.40	-0.26	-0.30	-0.34	-0.34	-0.34	-0.38	- 23,685 (-0.68)	-9,888 (-0.20)
2012	-0.42	-0.27	-0.31	-0.35	-0.35	-0.35	-0.40	- 24,759 (-0.72)	-10,326 (-0.21)
2013	-0.44	-0.29	-0.33	-0.37	-0.37	-0.37	-0.43	- 25,951 (-0.76)	-10,812 (-0.22)
2014	-0.47	-0.30	-0.35	-0.39	-0.39	-0.39	-0.45	- 27,256 (-0.80)	-11,341 (-0.24)
2015	-0.50	-0.32	-0.37	-0.42	-0.42	-0.42	-0.48	- 28,720 (-0.85)	-11,937 (-0.25)
2016	-0.53	-0.34	-0.40	-0.45	-0.45	-0.45	-0.51	- 30,353 (-0.90)	-12,598 (-0.27)
2017	-0.57	-0.37	-0.42	-0.48	-0.48	-0.48	-0.55	- 32,202 (-0.97)	-13,346 (-0.29)
2018	-0.61	-0.40	-0.46	-0.51	-0.51	-0.51	-0.59	- 34,320 (-1.04)	-14,203 (-0.31)
2019	-0.67	-0.43	-0.49	-0.55	-0.55	-0.55	-0.64	- 36,751 (-1.13)	-15,185 (-0.34)
Total	-4.88	-3.18	-3.65	-4.10	-4.10	-4.10	-4.70	- 286,707 (- 8.18)	-119,127 (-4.23)

Table 5 shows the simulated direct effects of step-by-step tariff reduction in cheese market. The quantity and price changes of cheese for domestic/ U.S./ other countries are simulated. The simulation results show that after 10 years of tariff reduction, the price of cheese imported from the U.S. is decreased up to 26.5% and the trade volume is increased up to 22.5% in a cumulative sense compared to the year of 2010. On the other hand, the price and quantity of domestic cheese is found to be decreased up to 3.1% and 2.4%, respectively. These changes in price and quantity are associated with the decrease of sales volume of domestic cheese producers up to 5.4% and producers' surplus up to 2.4%. In levels, these correspond to 25,848 Mil. KRW cumulative loss in sales volume and 14,587 Mil. KRW cumulative loss in producers' surplus of domestic cheese market. On the other hand, the cumulative gain of consumers' surplus is found to be increased up to 31,044 Mil. KRW, which is larger than that of cumulative loss of producers' surplus in Korean cheese market.

[Table 5] Simulation Results for Cheese Market

Unit: Million KRW, %

Year	Quantity Change (%)				Price Change (%)		Production Change (%)	Producers' Surplus Change (%)	Consumers' Surplus Change
	Domestic	U.S.	Other Countries	Total	Domestic	U.S.			
2010	-0.14	1.18	-0.50	-0.12	-0.18	-1.77	-1,539 (-0.32)	-868 (-0.18)	1,870
2011	-0.14	1.20	-0.51	-0.12	-0.18	-1.80	-1,560 (-0.33)	-880 (-0.18)	1,893
2012	-0.14	1.23	-0.52	-0.12	-0.19	-1.83	-1,584 (-0.33)	-894 (-0.19)	1,919
2013	-0.15	1.25	-0.53	-0.12	-0.19	-1.86	-1,608 (-0.34)	-907 (-0.19)	1,945
2014	-0.15	1.27	-0.54	-0.12	-0.19	-1.90	-1,633 (-0.34)	-922 (-0.19)	1,973
2015	-0.15	1.30	-0.55	-0.12	-0.20	-1.94	-1,659 (-0.35)	-936 (-0.20)	2,000
2016	-0.16	1.32	-0.56	-0.12	-0.20	-1.97	-1,686 (-0.36)	-951 (-0.20)	2,029
2017	-0.16	1.35	-0.57	-0.12	-0.21	-2.01	-1,714 (-0.36)	-967 (-0.21)	2,060
2018	-0.16	1.38	-0.58	-0.12	-0.21	-2.05	-1,743 (-0.37)	-983 (-0.21)	2,091
2019	-0.17	1.41	-0.60	-0.12	-0.21	-2.10	-1,773 (-0.38)	-1,001 (-0.21)	2,124
2020	-0.17	1.44	-0.61	-0.12	-0.22	-2.14	-1,802 (-0.39)	-1,017 (-0.22)	2,155
2021	-0.17	1.47	-0.62	-0.12	-0.22	-2.19	-1,836 (-0.40)	-1,036 (-0.22)	2,191
2022	-0.18	1.50	-0.64	-0.12	-0.23	-2.24	-1,870 (-0.41)	-1,055 (-0.23)	2,228
2023	-0.18	1.53	-0.65	-0.11	-0.23	-2.29	-1,904 (-0.41)	-1,075 (-0.23)	2,265
2024	-0.18	1.57	-0.67	-0.11	-0.24	-2.34	-1,938 (-0.42)	-1,094 (-0.24)	2,300
Total	-2.38	22.45	-8.31	-1.78	-3.07	-26.47	-25,848 (-5.37)	-14,587 (-2.37)	31,044

Finally, Table 6 shows the simulated indirect effects of tariff removal on cheese in the raw milk market. The supply and price changes of raw milk derived by domestic cheese market are simulated utilizing the model described earlier. The simulation results point out that given the complete removal of tariff, the supply of raw milk for producing cheese is found to be decreased up to 2.4% and the price of raw milk is also found to be decreased up to 3.1% in a cumulative sense compared to the year of 2010.

In addition, sales loss of milk due to the demand decrease of domestic cheese is found to be 204,474 Mil. KRW which is a 5.8% reduction compared to 2010. Producers' surplus of milk farm is also found to be decreased up to 85,248 Mil. KRW which is a 2.7% decrease compared to 2010.

[Table 6] Indirect Impacts on Raw Milk Market via Cheese Market

Unit: Million KRW, %

Year	Raw Milk Supply Change (%)			Raw Milk Price Change (%)				Farm Sales Change (%)	Producers' Surplus Change (%)
	Fresh milk	Cheese	Total	Fresh milk	Cheese	Other	Farm Price		
2010	-0.18	-0.14	-0.15	-0.18	-0.18	-0.18	-0.20	-12,191 (-0.35)	-5,095 (-0.10)
2011	-0.19	-0.14	-0.15	-0.18	-0.18	-0.18	-0.20	-12,351 (-0.35)	-5,161 (-0.10)
2012	-0.19	-0.14	-0.16	-0.19	-0.19	-0.19	-0.20	-12,536 (-0.36)	-5,237 (-0.10)
2013	-0.19	-0.15	-0.16	-0.19	-0.19	-0.19	-0.21	-12,723 (-0.37)	-5,313 (-0.10)
2014	-0.20	-0.15	-0.16	-0.19	-0.19	-0.19	-0.21	-12,929 (-0.37)	-5,397 (-0.10)
2015	-0.20	-0.15	-0.17	-0.20	-0.20	-0.20	-0.22	-13,124 (-0.38)	-5,476 (-0.11)
2016	-0.21	-0.16	-0.17	-0.20	-0.20	-0.20	-0.22	-13,335 (-0.39)	-5,562 (-0.11)
2017	-0.21	-0.16	-0.17	-0.21	-0.21	-0.21	-0.22	-13,559 (-0.40)	-5,655 (-0.11)
2018	-0.21	-0.16	-0.18	-0.21	-0.21	-0.21	-0.23	-13,784 (-0.40)	-5,746 (-0.11)
2019	-0.22	-0.17	-0.18	-0.21	-0.21	-0.21	-0.23	-14,022 (-0.41)	-5,842 (-0.12)
2020	-0.22	-0.17	-0.18	-0.22	-0.22	-0.22	-0.24	-14,258 (-0.42)	-5,938 (-0.12)
2021	-0.23	-0.17	-0.19	-0.22	-0.22	-0.22	-0.24	-14,516 (-0.43)	-6,044 (-0.12)
2022	-0.23	-0.18	-0.19	-0.23	-0.23	-0.23	-0.25	-14,784 (-0.44)	-6,154 (-0.12)
2023	-0.24	-0.18	-0.20	-0.23	-0.23	-0.23	-0.26	-15,051 (-0.45)	-6,261 (-0.13)
2024	-0.25	-0.18	-0.20	-0.24	-0.24	-0.24	-0.26	-15,311 (-0.46)	-6,367 (-0.13)
Total	-3.13	-2.38	-2.58	-3.07	-3.07	-3.07	-3.33	-204,474 (-5.83)	-85,248 (-2.71)

The validity of our analysis is discussed by comparing our results with the values of losses from the previous simulation results. Our results identify the total losses due to the tariff removal of U.S. butter and U.S. cheese to be 291 billion KRW and 230 billion KRW, respectively. Thus, the total loss of Korean butter and cheese markets due to trade liberalization could be at least 230 billion KRW, which turns out to be smaller than the values presented by previous research (e.g., Choi (2006): 135 ~ 437 billion KRW, and Choi and Lee (2007): 458 billion KRW).

These simulations results offer several implications. First, the indirect effects of Korea-U.S. FTA are found to be significant. The price reduction of U.S. butter due to tariff reduction, which is called as a direct impact, causes the changes in price and quantities of raw milk. These changes result in farm sales losses (8% decrease compared to 2010) and producers' surplus losses (3%). In the case of butter, in a proportional term, production loss (7.4) and producers' surplus losses (4.2%) of butter processors are similar to those of farm sale losses (8%) and producers' surplus losses (3%) of raw milk farmers, respectively. The simulation analysis for cheese also produces similar results: production loss (5.5%) and producers' surplus losses (3.1%) of cheese processors are found to be larger than those of farm sale losses (6%) and producers' surplus losses (1.7%) of raw milk farmers in a proportional term. Third, the impacts of Korea-U.S. FTA on butter market (production loss: 7.4% and farm sales loss: 8%) is found to be larger than the direct impact of cheese (production loss: 5.5% and farm sales loss: 6%). These larger effects can be contributed to the larger tariff reduction on butter (89%) compared to cheese (36%). Forth, as expected, producers' surplus of dairy processors and dairy farmers is found to be decreased, while consumers' surplus is found to be increased. The comparison of producers' surplus and consumers' surplus changes reveals that the consumer surplus increase overtakes producer surplus decrease in a marginal sense, implying overall increase of social welfare in Korean butter and cheese markets due to the Korea-U.S. FTA.

VI. SUMMARY AND CONCLUDING REMARKS

This paper has investigated the effects of trade liberalization on a food processing industry. By incorporating potential indirect effects of changes in a food processing industry on its associated raw material markets, this paper presents a new and insightful theoretical framework which allows us to evaluate the full impacts of trade liberalization.

We then apply this model to the case of the Korea-U.S. FTA. We empirically evaluate the size of indirect effects of the Korea-U.S. FTA on dairy markets and associated raw milk markets. We found significant amount of indirect effects of the Korea-U.S. FTA on domestic raw milk market in terms of sales volume reduction and producers' surplus decrease. It is noted that if this is ignored in an evaluation package, one tends to underestimate the impacts of trade liberalization which might lead to a biased simulation result in evaluating the impacts of trade liberalization such as the Korea-U.S. FTA. We also found significant consumer-surplus-increasing effects of the Korea-U.S. FTA, which turn out to be outpacing producer-surplus-decreasing effects, contributing to overall increase of social welfare effects of the Korea-U.S FTA in Korean butter and cheese markets. The model developed in this paper can be utilized when a processing industry is the subject of analysis for trade liberalization.

As a next step of our research, the model could incorporate a situation where Korean cheese or butter processors may replace milk by other inputs, such as imported raw-cheese for processing cheese or imported raw-cream for processing butter. This is a plausible scenario since import prices of these inputs will be decreased due to the Korea-U.S. FTA. The model developed in this paper could also be applied to the whole dairy sector, including powdered milk, ice-cream, and yogurt. In doing this application, one should recognize that the model used in this paper is somewhat limited in the sense that it is not a perfectly dynamic model, even though our model tries to follow the road map for tariff reduction due to the Korea-U.S. FTA by taking a snap-shot approach via a year-by-year simulation. Finally, the model could be modified to analyze the impact of trade liberalization on other food processing sectors, such as meat and grain processing sectors.

References

Alston, J. M., G. W. Norton, and P. G. Pardey (1995), Science under Scarcity, CAB International.

Balagtas, Joseph V. and Sounghun Kim (2007), "Measuring the Effects of Generic Dairy Advertising in a Multi-market Equilibrium," *American Journal of Agricultural Economics*, Vol. 89, No. 4.

Choi, Sei-Kyun (2006), Korea-U.S. FTA: Effects and Strategies in the Agricultural Sector, Korea Rural Economic Institute.

Choi, Sei-Kyun and Dae-sup Lee (2007), Study of the effects of Korea-U.S. FTA and Countermeasure, Korea Rural Economic Institute.

Gardner, B. L. (1987), The Economics of Agricultural Polices, New York: Macmillan.

Kim, Sounghun and Dowhan Jang (2008), "Analysis of the Impact of Korea-U.S. FTA on Korean Dairy Market: Focusing on Cheese and Butter Markets," *Journal of Rural Development*, Vol. 31, No. 4, (in Korean).

Kwak, Chang-keun (2007), "Analysis about the effects of Korea-U.S. FTA on Korean Food Industry," Paper Presented at the Seminar of KFRI.

Muth, R. E. (1964), "The Derived Demand Curve for a Productive Factor and the Industry Supply Curve," *Oxford Economic Papers*, Vol. 16.

Song, Joo Ho et al. (2005), A Study on the Analysis of the Milk Demand and Supply Management System in Korea, Korea Rural Economic Institute.

Song, J. and D. A. Sumner (1999), "Dairy demand, supply and policy in Korea: potential for international trade," *Canadian Journal of Agricultural Economics*, Vol. 47, No. 5.

Sumner, D. A., H. Lee, and D. G. Hallstrom (1999), "Implications of Trade Reform for Agricultural Markets in Northeast Asia: a Korea Example," *Agricultural Economics*, Vol. 21.

United States International Trade Commission (2001), U.S.-Korea FTA: The Economic Impact of Establishing a Free Trade Agreement (FTA) Between the United States and the Republic of Korea, USITC Publication.

United States International Trade Commission (2007), U.S.-Korea Free Trade Agreement: Potential Economy-wide and Selected Sectoral Effects, USITC Publication.