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Impact of the Trade Liberalization of Fluid Milk on the Taiwanese Dairy Industry

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In Taiwan, over 90% of raw milk is used to produce fluid milk, of which half is fresh drinking milk, one quarter is flavored milk and the other quarter is long–life milk and fermented milk. Therefore, there will be an expected influence on the Taiwanese dairy industry caused by the tendency of trade liberalization to result in the import of less costly fluid milk as opposed to the current policy of restricted importation.

The purpose of this study is to analyze and solve the equilibrium demand, supply and the prices of fluid milk in each demand area and supply county of Taiwan under fixed import quantities and given income levels. This was accomplished by incorporating a spatial price equilibrium model that was derived for the maximization problem. Then, we modeled problems associated with three simulated fluid milk import policies – including import quotas, tariff, and complete liberalization – in order to analyze the impact and influence of the policies on consumers, producers and factories (dairy companies), respectively, from 2001 through 2006.

INTRODUCTION

This study is one of our sequential papers researching the Taiwanese dairy industry. Previously, we discussed the relation between dairy farmers and factories relating to the supply and demand for raw milk, and developed a spatial equilibrium model to determine the equilibrium prices for each factory and for regional farmers (Lin and Kawaguchi, 1999). The previous study also examined the role of spatial equilibrium in the allocation of raw milk from farms to the thirty–three milk processing factories located in Taiwan. In order to develop a spatial equilibrium model to get the equilibrium solutions under given conditions of import in the Taiwanese fluid milk industry, we estimated and constructed the linear supply and demand functions presented in the second section. Then, in the third section, we will present the theoretical model we developed and applied to the practical world in order to analyze the results under various import quantities and income levels. Finally, we will discuss the respective import policy and its impact on the Taiwanese fluid milk industry in the fourth and fifth sections.

SPATIAL SUPPLY AND DEMAND ANALYSIS OF FLUID MILK IN TAIWAN

In our previous study (Lin and Kawaguchi, 1999), there was no research discussing spatial analysis in the Taiwanese fluid milk market. However, it would be useful to understand not only the whole market but also the respective area variation for the study of the Taiwanese dairy industry. One of the reasons that so far there has been no research in this field is due to the difficulty of data collection in such areas as the consumption of fluid milk and the supply of fluid milk, and in the various costs of industry and so on. In this study, with the estimation based on available and effective data to overcome the problem, eventually it is reasonably proved that our method of statistical estimation is quite reliable and accurate. According to our estimation, the sum of the estimated fluid milk consumption among eighteen demand areas is nearly equal to the total of the yearly domestic supply and import quantity of fluid milk. On the other side, the sum of the estimated supply among fourteen supply areas is also approximately equal to the total industrial sales of fluid milk.

The spatial price equilibrium model applied in this paper is static and involves partial equilibrium. It assumes perfect competition and a homogeneous product. It also considers that there are no structural changes in supply and demand in the transition from a starting position to the new equilibrium. That is, prices and quantities are determined along supply and demand functions that remain unchanged in the basic model. It should be noted that we consider four cases of the basic model which correspond to four cases of income level.

Applying the theoretical econometric model, both 14–area supply functions and 18–area demand functions of fluid milk can be estimated as follows. Consequently, with linear supply and demand functions as well as the unit transportation cost of fluid milk, the maximization problem to achieve equilibrium becomes a quadratic programming problem. As a result, it is feasible to determine the equilibrium solutions of fluid milk supply, demand, trade flows and prices.

Fluid milk demand functions for the eighteen Taiwanese counties

1. Estimation of fluid milk consumption among the 18 Taiwanese counties

Since the former study (Lin and Kawaguchi, 1999) emphasized the spatial equilibrium analysis of raw milk, this study specifies the product market for fluid milk instead of the material market for raw milk in order to represent the overall view of the dairy industry.

The variables we use are identified as follows (sources are in parentheses).

DQ_N : Fluid milk consumption in Nth demand area (N=1,2,3,..., n), n=18

$DPCA_N$: Real dairy product consumption value per capita in Nth demand area (Report on the Survey of Family Income & Expenditure, Taiwan Province, ROC, Published by Department of Budget Accounting & Statistics, Taiwan Provincial Government R.O.C. 1989–1997)

POP_N : Population in N*th* demand area (Taiwan Annual Statistics Report, Published by Department of Budget Accounting & Statistics, Taiwan Provincial Government, R.O.C. 1989–1997)

CPFD : Consumption value proportion of fluid milk to total dairy product per year (Food Balance Sheet of Taiwan, 1988–1996, Council of Agriculture, Executive Yuan, R.O.C. & Industrial Statistics of Production and Sales for Factories, 1988–1996, M.O.F., Taiwan)

PD : Real fluid milk market price (Industrial Statistics of Production and Sales for Factories, 1988–1996, M.O.F., Taiwan)

The following equation (1) is employed to estimate the respective county's consumption: (1) $DQ_N=(DPCA_N \cdot POP_N \cdot CPFD) \div PD$. Here, the consumption proportion of fluid milk to the total dairy product per year (CPFD) is estimated by the ratio of the

Table 1. Distribution of fluid milk production and consumption in Taiwan in 1996 unit: ton

	North	Middle	South	East	Total
Raw milk processing quantity (1)	116,736	105,590	86,748	5,018	314092
Fluid milk production=(1)×1.34	156755 (37.2%)	141788 (33.6%)	116486 (27.6%)	6738 (1.6%)	421767
Fluid milk consumption	184309 (43.6%)	113168 (26.8%)	107623 (25.5%)	17311 (4.1%)	422411

Source: Taiwan Provincial Department of Agriculture and Forestry

value of fluid milk consumed to the total value of dairy products consumed based on the data of both the Taiwan Yearly Food Balance Sheet and the Statistics of Industrial Production and Sale. In particular, the value of consumed fluid milk is calculated by multiplying the quantity of fluid milk consumption by the fluid market price. In the same way, the total value of consumed dairy products equals the total value of fluid milk consumed plus other dairy products excluding fluid milk.

PD accounts for the fluid milk market price including fresh milk, long-life milk, flavored milk and fermented milk which are estimated by dividing the total amount of fluid milk sales by the total quantity of fluid milk sold. It is assumed that CPFD and PD are unique, respectively, for any area in Taiwan.

Consequently, the result of the above estimation shows that there is an increasing tendency for fluid milk consumption per capita in each particular county from the 1988 to 1996. Compared with the data of dairy factories, there is a similar regional proportion for both fluid milk consumption and fluid milk production, and approximately 70% (table 1) of that is distributed in the north and middle parts of Taiwan in 1996. This means that transportation cost for factories may be efficiently saved (Lin and Kawaguchi, 1998).

2. Fluid milk demand functions for four regional groups

The data estimated from 1988 to 1996 among the eighteen Taiwanese counties is classified into four regional groups according to geographical location (north, middle, south and east). Here, we use the following notations (sources are in parentheses).

DQ^A_N : Fluid milk consumption in Nth county of area A.

PD : Real fluid milk market price (Industrial Statistics of Production and Sales for Factories, 1988–1996, M.O.F., Taiwan)

I^A_N : National real disposable income per capita in N*th* county of area A (Report on the Survey of Family Income & Expenditure, Taiwan Province, ROC, Published by Department of Budget Accounting & Statistics, Taiwan Provincial Government, R.O.C. 1989–1997)

DD^A_B : Dummy variable to measure B*th* county effect in demand equation for area A

For area A, the logarithmic linear equation for fluid milk demand is specified as follows.

(2) $DQ^A_N = F_A\,(PD, I^A_N, DD^A_B, u^A)$,

where A= n: north of Taiwan, N=1～6, B=N, $DD^n_6 \equiv 0$

A= m: middle of Taiwan, N=7～11, B=N–6, $DD^m_5 \equiv 0$

A= s: south of Taiwan, N=12～15, B=N–11, $DD^s_4 \equiv 0$

A= e: east of Taiwan, N=16~18, B=N–15, $DD^{e}_{3} \equiv 0$

The fluid milk consumption (demand) is the endogenous variable and both the real market price and the real disposable income are the predetermined variables for the fluid milk demand equation.

In the study, annual observations for 1988–1996 are used to obtain single equation

Table 2. Fluid milk demand response coefficients for 4 regional groups in Taiwan, 1988–1996
Coefficients for Predetermined Variables

Dependent Variable	*Constant*	*Price Elasticity*	*Income Elasticity*	*DD1*	*DD2*	*DD3*	*DD4*	*DD5*	R^2
DQ^{n}_{N}	1.628	-1.029	0.902	2.055	2.215	1.399	0.704	0.236	0.99
N=1~6	[a](0.45)	(-3.06)**	(4.67)**	(30.23)**	(47.82)**	(28.33)**	(14.18)**	(3.64)**	
DQ^{m}_{N}	12.069	-2.137	0.551	-0.562	-1.488	-1.082	-0.911	–	0.98
N=7~11	(2.41)*	(-4.24)**	(2.17)*	(-6.19)**	(-19.48)**	(-9.30)**	(-10.95)**		
DQ^{s}_{N}	2.597	-1.290	1.043	0.461	-0.685	-2.738	–	–	0.99
N=12~15	(0.60)	(-2.88)*	(4.80) **	(10.19)**	(-14.75)**	(-44.52)**			
DQ^{e}_{N}	-0.657	-0.548	0.912	0.422	0.487	–	–	–	0.92
N=16~18	(-0.08)	(-0.53)	(2.27)*	(4.80)**	(6.88)**				

[a]t–values are in parentheses
Double and single asterisks imply significance at the 1% and 5% levels, respectively.
Logarithmic values of variables (exclude dummy variables) are used for regression analyses.

Table 3. Estimated consumption and market price of fluid milk, and disposable income per capita for Taiwanese 18 counties in 1996

	County	DQ(ton)	PD(NT$/kg)	I (NT$)
1	Kilung	7790	43.75	217400
2	Taipei City	55721	43.75	273850
3	Taipei	67308	43.75	210337
4	Taoyuan	31284	43.75	228184
5	Hsinchu	14278	43.75	230340
6	Miaoli	7928	43.75	193644
7	Taichung	53465	43.75	211200
8	Changhwa	20329	43.75	163970
9	Nantou	8430	43.75	173498
10	Yunlin	14644	43.75	150552
11	Chiayi	16300	43.75	174515
12	Tainan	36522	43.75	192306
13	Kaohsiung	50366	43.75	181452
14	Pingtung	18522	43.75	189243
15	Ponghu	2213	43.75	166889
16	Taitung	3957	43.75	171816
17	Hwalien	6261	43.75	199767
18	Yilang	7093	43.75	189787
	total	422411		

Source: Please refer to the section in the article on the estimation of fluid milk consumption for 18 Taiwanese counties.

Table 4. Fluid milk demand functions for 18 Taiwanese counties in 1996

Unit: 1000 ton, NT$/kg.

DQ_1 =	15.806	−0.1832 PD_1
DQ_2 =	113.058	−1.3106 PD_2
DQ_3 =	136.568	−1.5831 PD_3
DQ_4 =	63.475	−0.7358 PD_4
DQ_5 =	28.970	−0.3358 PD_5
DQ_6 =	16.086	−0.1865 PD_6
DQ_7 =	167.720	−2.6115 PD_7
DQ_8 =	63.772	−0.9930 PD_8
DQ_9 =	26.445	−0.4118 PD_9
DQ_{10}=	45.938	−0.7153 PD_{10}
DQ_{11}=	51.133	−0.7962 PD_{11}
DQ_{12}=	83.635	−1.0769 PD_{12}
DQ_{13}=	115.338	−1.4851 PD_{13}
DQ_{14}=	42.415	−0.5461 PD_{14}
DQ_{15}=	5.068	−0.0653 PD_{15}
DQ_{16}=	6.125	−0.0496 PD_{16}
DQ_{17}=	9.692	−0.0784 PD_{17}
DQ_{18}=	10.980	−0.0888 PD_{18}

We use the following equation to estimate demand equations:
$DQ_N=DQ_0\,(1-\beta)+\beta\,(DQ_0/PD_0)\,PD_N$
Where β : price elasticity,
DQ_0: demand in 1996, PD_0: price in 1996

estimates of fluid milk demand responses for four regional groups (north, middle, south, and east) in Taiwan, respectively. Annual time series data for those regional counties was studied by multiple regression analysis. The result for each region is shown in Table 2. This result shows that the variables contained in the equation (2) can explain at least 92% of the fluid milk demand variations in each regional group during 1988–1996. In the middle region, the average effect of a one percent increase in price has been a 2.14% reduction in fluid milk consumption among the five middle counties, the biggest rate of change among the four regions. In contrast, in the east region there has only been a 0.55% decrease and that is the smallest change. In regard to disposable income, the average effect of a one percent increase in income in the south region has been a 1.04% increase in fluid milk consumption among the four south counties, the biggest rate of change among the four regions. On the other hand, in the middle region there has been a 0.55% increase and that is the smallest change.

3. Linear demand functions of fluid milk for 18 counties

Based upon the data for the demand price elasticities and income elasticities for fluid milk indicated in Table 2, as well as the consumption quantities and market prices of fluid milk for 18 counties in 1996 shown in Table 3, the linear demand functions for those counties at the level of income for 1996 are specified as $DQ_N=\alpha+\beta PD_N$ in Table 4. We assume that the other three income levels are 120%, 140%, and 160% of the 1996 income level for research purposes. Linear demand functions for those income levels are estimated as the equation (demand in θ % level)=(θ/100)^{r}×(demand in 1996 income level), where θ =120, 140, 160 and r refers to the income elasticity of demand for each regional group.

Fluid milk supply functions for fourteen Taiwanese counties

1. Fluid milk supply estimation among fourteen counties

Since it is really difficult to collect the data for fluid milk production costs and quantities from the fluid milk makers in order to develop the fluid milk supply function, we alternatively use the raw milk supply function (Lin and Kawaguchi, 1999, Table 5) among the 14 counties to derive that data. To simplify, we assume that fluid milk production and sales are committed to factories by raw milk producers, so the fluid milk supply price (PS^{f}) is equal to the raw milk supply price divided by the conversion rate (PS^{r}/k) added to the fluid milk production cost (CP) and marketing cost (CM). CP and CM are estimated around 50.98% and 72.3% of PS^{r} according to the data of dairy factories in 1996.

With regard to the estimation of the conversion rate of raw milk into fluid milk: (a) fresh drinking, long–life, flavored, fermented milk and all other uses require 65.30%, 8.44%, 15.38%, 0.94% and 9.94%, respectively, of the total raw milk. And (b) one unit of raw milk is contained in 1.0, 1.0, 2.13, 29.62 units of fresh drinking, long–life, flavored and

Table 5. Supply quantity and price of fluid milk for 14 Taiwanese counties

	County	$SQ^{f}=kSQ^{r}$	$PS^{f}=PS^{r}/k+CP+CM$
1	Taipei	6,988	38.11
2	Taoyuan	27,005	39.14
3	Hsinchu	9,978	39.25
4	Miaoli	20,941	36.43
5	Taichung	10,465	38.58
6	Changhwa	65,053	37.42
7	Nantou	5,214	38.13
8	Yunlin	43,423	37.26
9	Chiayi	29,207	38.98
10	Tainan	96,827	38.84
11	Kaohsiung	30,176	37.85
12	Pingtung	63,790	37.65
13	Taitung	5,274	40.80
14	Hwalien	7,407	38.52
	total	421,748	

$CP=0.5098PS^{r}$ $CM=0.723PS^{r}$

$k=1.34$

(Note) The national average fluid milk price of Table 3 is higher than that of this table. The difference is partly due to an estimation error, and partly due to our simplified assumption.

fermented milk, respectively. Therefore, the conversion rate (k) is equal to approximately 1.34. (65.30% · 1.0+8.44% · 1.0+15.38% · 2.13+0.94% · 29.62)

2. Fluid milk supply functions

As mentioned above, it is assumed that one fixed conversion rate exists between the raw milk supply and the fluid milk supply. Therefore, the fluid milk supply function can be derived as from the following equation (4).

(3) $SQ^r_M = a + b\, PS^r_M$

$PS^f_M = (PS^r_M/k) + CP + CM$

(4) $SQ^f_M = k\, SQ^r_M$

$= k\, [a + b\, k\, (PS^r_M/k)]$

$= k\, [a + b\, k\, (PS^f_M - CP - CM)]$

$= [a\, k - b\, k^2\, (CP + CM)] + b\, k^2\, PS^f_M$

SQ^r_M : Raw milk supply in M*th* producing (supply) area (refer to Lin and Kawaguchi, 1998)

SQ^f_M : Fluid milk supply in M*th* producing area (M=1,2,..., m), m=15

PS^r_M : Real supply price of raw milk in M*th* area

PS^f_M : Real supply price of fluid milk in M*th* area

Where k accounts for the constant of the 1.34 conversion rate, and a and b are both constants, too. As noted previously, CP and CM are constant and equal to 50.98% and 72.3% of PS^r_M in 1996, respectively.

Linear fluid milk supply functions for each area are specified in Table 6 by employing both of the raw milk supply equations (3) and (4) as well as the area price and quantity observations of 1996 shown in Table 5. According to the total fluid milk production of the 14 areas, the figures (421,748 tons) are almost equal to the 1996 total fluid milk sales quantities (419,174 tons) of the dairy industry as a whole (data offered by Dairy Industry Committee). Moreover, the estimated figure of supply is also very close to the above

Table 6. Fluid milk supply equations for 14 producing counties in 1996

Unit: 1000 ton, NT$/kg.

SQ_1 =	-19.9597	+	0.7071	P_1
SQ_2 =	-77.1388	+	2.6610	P_2
SQ_3 =	-28.5013	+	0.9802	P_3
SQ_4 =	-59.8178	+	2.2170	P_4
SQ_5 =	-4.7653	+	0.3947	P_5
SQ_6 =	-29.6216	+	2.5303	P_6
SQ_7 =	-2.3741	+	0.1990	P_7
SQ_8 =	-19.7724	+	1.6961	P_8
SQ_9 =	-13.2994	+	1.0905	P_9
SQ_{10}=	-181.0688	+	7.1548	P_{10}
SQ_{11}=	-56.4291	+	2.2880	P_{11}
SQ_{12}=	-119.2888	+	4.8622	P_{12}
SQ_{13}=	-10.9820	+	0.3984	P_{13}
SQ_{14}=	-15.4218	+	0.5925	P_{14}

$SQ^f = [ak - bk^2(CP + CM)] + bk^2 P^f$

estimated figure of the total fluid milk consumption in Table 3. From this, it is proved that the method of measuring statistics on the side of either supply or demand is really effective and reliable.

THEORETICAL MODEL AND APPLICATION

Theoretical model

The model will be described and started with a simple multi–region, one commodity (fluid milk) world. We assume that there are M supply areas and each of them supplies one given commodity, and there are N regions (counties) that demand this commodity. The supply areas from 1 to 14 represent the domestic suppliers and the area of 15 refers to all overseas suppliers. Since the world market price of fluid milk is supposed to be unique for Taiwan, to simplify the model and consider the policy factor, it is assumed that only one overseas supplier exists and import quantity is parametrically fixed for analysis. Thus, PS_{15} stands for the import price of fluid milk in Taiwan. We omit the superfixe f in this section. The commodity is supposed to be traded freely from any supply area to any consuming region; moreover, traded freely by dealers among consuming regions.

The model presented in this paper uses a price formulation, in which the decision variables are prices (fluid milk supply and demand prices). The Lagrangean multipliers are interpreted as shadow quantities. Alternatively, it can be presented in an equivalent quantity formulation (dual), in which the decision variables are quantities, and the Lagrangean multipliers are interpreted as shadow prices. The price formulation is easier in the presence of a fixed supply. On the other hand, the quantity formulation is easier in the presence of a fixed price.

The model is specified as follows.

Maximize

$$F=\sum_{N=1}^{18}\int\{\alpha_N-\beta_N PD_N\}\,d\,PD_N-\sum_{M=1}^{14}\left[\int\{\gamma_M+\delta_M PS_M\}\,d\,PS_M\right]-\gamma_{15}\,PS_{15}$$

subject to $PD_N-PS_M \leqq t_{MN}$ for all M and N, and all variables are non–negative.

α_N : intercept value of the linear demand function in consuming area N

β_N : slope coefficient of the linear demand function in consuming area N

γ_M : intercept value of the linear supply function in supply area M

δ_M : slope coefficient of the linear supply function in supply area M

SQ_{MN} : the shipped fluid milk quantity from M*th* producing area to Nth consuming (demand) area

t_{MN} :unit transportation cost of fluid milk from supply area M to demand area N. (Source: Tariff of Freight Traffic, Ministry of Communications, Taiwan, R.O.C.)

The Kuhn–Tucker conditions associated with this problem are both necessary and sufficient conditions for an optimal solution, under the assumptions of differentiability and concavity of the objective function, and in the presence of linear constraints. The Kuhn–Tucker conditions are specified as follows.

(5.a) $PD_N-PS_M+sq_{MN}=t_{MN}$, for all M and N

(5.b) $\alpha_N-\beta_N\,PD_N-\Sigma\,SQ_{MN}=-v_{DN}$ for all N

Table 7. Table of Kuhn – Tucker conditions – *Price Formulation*

			PD1	PD2	PD3	⋯	PD18	PS1	PS2	PS3	⋯	PS15	SQ1,1	SQ2,1	SQ3,1	⋯	SQ15,1	SQ1,2	SQ2,2	SQ3,2	⋯	SQ15,2	SQ1,3	SQ2,3	SQ3,3	⋯	SQ15,3	⋯	SQ1,18	SQ2,18	SQ3,18	⋯	SQ15,18
	$-\alpha 1$	V_{D1}	$-\beta 1$										-1	-1	-1	⋯	-1																
	$-\alpha 2$	V_{D2}		$-\beta 2$														-1	-1	-1	⋯	-1											
B	$-\alpha 3$	V_{D3}			$-\beta 3$																		-1	-1	-1	⋯	-1						
	:	:				⋯																						⋯					
	$-\alpha 18$	V_{D18}					$-\beta 18$																						-1	-1	-1	⋯	-1
	$\gamma 1$	V_{S1}						$-\delta 1$					1					1					1						1				
	$\gamma 2$	V_{S2}							$-\delta 2$					1					1					1						1			
C	$\gamma 3$	V_{S3}								$-\delta 3$					1					1					1						1		
	:	:									⋯					⋯					⋯					⋯						⋯	
	$\gamma 15$	V_{S15}										0					1					1					1						1
	t1,1	sq1,1	1					-1																									
	t2,1	sq2,1	1						-1																								
	t3,1	sq3,1	1							-1																							
	:	:	:								:																						
	t15,1	sq15,1	1									-1																					
	t1,2	sq1,2		1				-1																									
	t2,2	sq2,2		1					-1																								
A	t3,2	sq3,2		1						-1																							
	:	:		:							:																						
	t15,2	sq15,2		1								-1																					
	t1,3	sq1,3			1			-1																									
	t2,3	sq2,3			1				-1																								
	t3,3	sq3,3			1					-1																							
	:	:			:						:																						
	t15,3	sq15,3			1							-1																					
	:	:																															
	t1,18	sq1,18					1	-1																									
	t2,18	sq2,18					1		-1																								
	t3,18	sq3,18					1			-1																							
	:	:					:				:																						
	t15,18	sq15,18					1					-1																					

Part A corresponds to formula (5.a), part B corresponds to formula (5.b), and part C corresponds to formula (5.c).
V_{DN}, V_{SM} and sq_{MN} are slack variables.
All variables cannot be nagative, and satisfy the conditions of $PD_N V_{DN}=0$, $PS_M V_{SM}=0$ and $SQ_{MN} sq_{MN}=0$

(5.c) $-\gamma_M - \delta_M PS_M + \Sigma SQ_{MN} = -v_{SM}$ for M=1,2,⋯,14

$-\gamma_{15} + \Sigma SQ_{15N} = -v_{S15}$ γ_{15} is fixed import quantity

(5.d) $PD_N v_{DN} = 0$, $PS_M v_{SM} = 0$ for all M and N

(5.e) $SQ_{MN} sq_{MN} = 0$ for all M and N

Where sq_{MN} and v are explained as slack variables, and all variables are non–negative. Statement (5.a) indicates that the price difference between supply and demand areas is less than or equal to the unit transportation cost. Whenever trade takes place, the price difference is exactly equal to the unit transportation cost (5.e). In each region, production has to be greater than or equal to the domestic use plus exports to other regions (5.c), and consumption has to be less than or equal to domestic production plus imports from other regions (5.b). Statement (5.d) implies that if the demand price in area N is positive, the quantity shipped from all supply areas to market N equals the demand quantity in market N. In addition, if the supply price in area M is positive, the shipped quantity from area M to all demand areas should be equal to the supply quantity in area M.

All these statements taken together characterize an equilibrium solution for the traditional spatial equilibrium problem in a perfectly competitive market. The Kuhn–Tucker conditions in the case of the Taiwanese fluid milk market are formulated as shown in Table 7. The optimal solution is obtained with the Quadratic Programming Method or other equivalent methods.

Application and result analysis

According to the above quantitative method, we can solve the perfectly competitive

Table 8. Unit transportation cost of fluid milk

Unit: NT$/ton

Demand area / Supply area	1 Kilung	2 Taipei City	3 Taipei County	4 Taoyuan	5 Hsinchu	6 Miaoli	7 Taichung	8 Changhwa	9 Nantou	10 Yunlin	11 Chiayi	12 Tainan	13 Kaohsiung	14 Pintung	15 Ponhu	16 Taitung	17 Hwalien	18 Yilang
1 Taipei	1200	1200	1200	1200	1450	1700	1800	1800	2000	2000	2000	2200	2200	2200	2200	2200	2200	1200
2 Taoyuan	1200	1200	1200	1200	1450	1450	1700	1700	2000	1800	2000	2000	2200	2200	2200	2200	2200	1200
3 Hsinchu	1450	1450	1450	1450	1200	1200	1450	1450	1800	1700	1800	2000	2000	2000	2200	2000	2200	1450
4 Miaoli	1700	1700	1700	1450	1200	1200	1450	1450	1700	1700	1700	1800	2000	2000	2200	2000	2200	1700
5 Taichung	1800	1800	1800	1700	1450	1450	1200	1200	1450	1450	1450	1700	1800	1800	2200	1800	2000	1800
6 Changhwa	1800	1800	1800	1700	1450	1450	1200	1200	1450	1200	1450	1700	1800	1800	2200	1800	2200	1800
7 Nantou	1800	1800	1800	1800	1700	1700	1450	1450	1450	1200	1450	1700	1800	2000	2200	2000	2200	1800
8 Yunlin	2000	2000	2000	1800	1700	1700	1450	1200	1200	1200	1200	1450	1700	1700	2200	1700	2200	2000
9 Chiayi	2000	2000	2000	2000	1800	1700	1450	1450	1200	1200	1200	1450	1450	1450	2200	1450	2200	2000
10 Tainan	2200	2200	2200	2000	2000	1800	1700	1700	1450	1450	1450	1200	1200	1200	2200	1200	2200	2200
11 Kaohsiung	2200	2200	2200	2200	2000	2000	1800	1800	1450	1700	1450	1200	1200	1200	2200	1200	2000	2200
12 Pintung	2200	2200	2200	2200	2000	2000	1800	1800	1450	1700	1450	1200	1200	1200	2200	1200	2000	2200
13 Taitung	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2200	2000	2000	2200	2000	2000	2200
14 Hwalien	2200	2200	2200	2200	2200	2200	2000	2200	2200	2200	2200	2200	2200	2200	2200	2200	800	2200
15 Importer	24	54	66	107	139	184	233	209	293	157	128	51	24	54	450	427	329	183

Source: Tariff of Freight Traffic, Ministry of Communications, Taiwan, R.O.C.

spatial equilibrium problem by utilizing estimated supply and demand functions as well as the unit transportation cost of fluid milk (Table 8). The unit transportation cost is calculated by using the data of the tariff for freight traffic combined with the data of the unit transportation cost of raw milk (Lin and Kawaguchi, 1998, Table 4). We apply the model to analyze the equilibrium condition under a given import quantity of fluid milk. Since the future income level is uncertain, the simulated models used to analyze the policy effect will be created with four cases that have different levels of national disposable income: 100%, 120%, 140%, and 160% of the 1996 income level. The result shown in both tables 9–1, 9–2 and in figures 1, 2 indicate the relation between import price and import quantity, as well as import quantity and domestic supply, under four

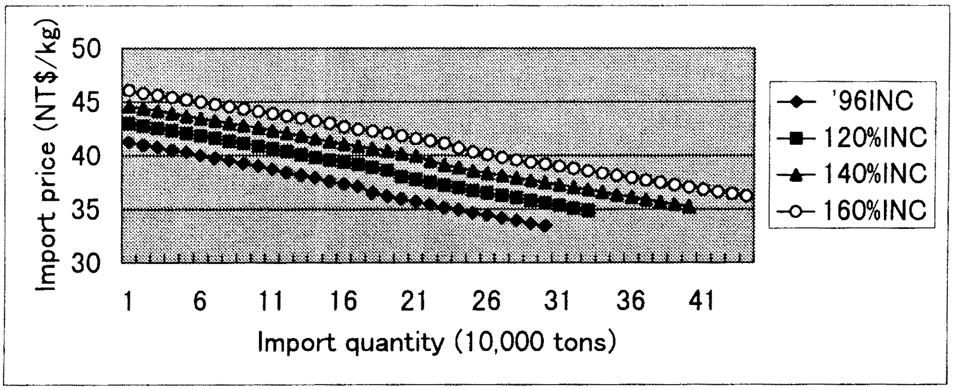

Fig. 1. The relation between import quantity and import price

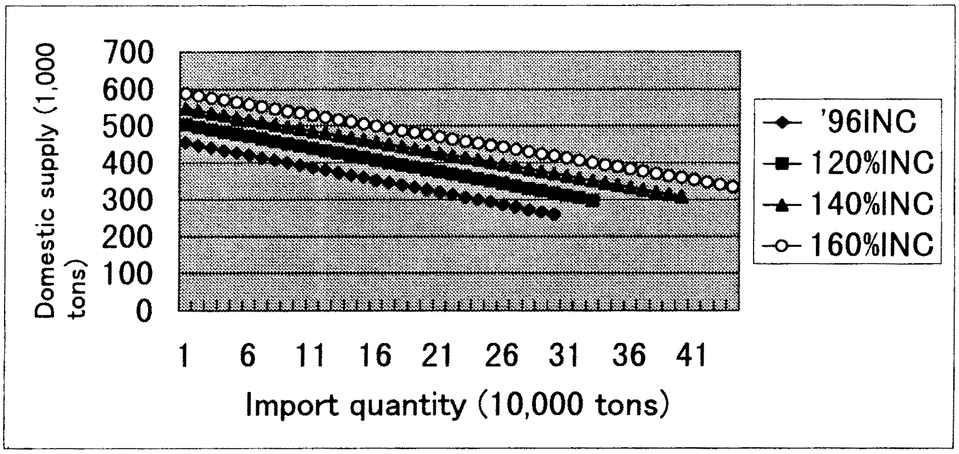

Fig. 2. The relation between import quantity and domestic supply

Table 9–1. Simulation result–composition of import price and quantity

IQ	'96INC	120%INC	140%INC	160%INC
10	41.193	42.977	44.601	46.037
20	40.949	42.745	44.349	45.795
30	40.705	42.513	44.127	45.583
40	40.461	42.281	43.906	45.370
50	40.218	42.049	43.684	45.158
60	39.974	41.817	43.462	44.945
70	39.712	41.585	43.240	44.733
80	39.465	41.341	43.019	44.521
90	39.217	41.097	42.784	44.305
100	38.969	40.861	42.555	44.078
110	38.659	40.625	42.330	43.859
120	38.331	40.327	42.098	43.643
130	38.086	40.052	41.811	43.428
140	37.842	39.780	41.548	43.152
150	37.561	39.548	41.295	42.933
160	37.285	39.316	41.066	42.650
170	37.041	39.084	40.844	42.438
180	36.439	38.808	40.622	42.225
190	36.141	38.550	40.398	42.006
200	35.897	37.994	40.136	41.792
210	35.612	37.677	39.915	41.541
220	35.348	37.445	39.447	41.326
230	35.104	37.175	39.039	41.114
240	34.860	36.919	38.817	40.695
250	34.614	36.687	38.534	40.278
260	34.371	36.455	38.313	40.022
270	34.123	36.223	38.091	39.774
280	33.880	35.991	37.869	39.562
290	33.636	35.757	37.648	39.349
300	33.392	35.525	37.426	39.137
310		35.289	37.204	38.924
320		35.057	36.982	38.712
330		34.825	36.759	38.499
340			36.537	38.287
350			36.312	38.075
360			36.090	37.860
370			35.868	37.648
380			35.647	37.433
390			35.425	37.219
400			35.203	37.007
410				36.795
420				36.582
430				36.370
440				36.157

IQ: Import quantity, unit: 1,000 ton
The other 4 columns indicate the import price (unit: N.T. $/kg.) under four different income levels.

Table 9–2. Simulation result–composition of import quantity and domestic supply

IQ	'96INC	120%INC	140%INC	160%INC
10	453.137	502.705	546.957	586.864
20	446.368	496.259	540.803	580.969
30	439.598	489.813	534.645	575.069
40	432.828	483.368	528.487	569.169
50	426.058	476.922	522.329	563.268
60	419.289	470.476	516.171	557.368
70	412.477	464.031	510.013	551.468
80	405.126	457.599	503.855	545.568
90	398.990	451.138	497.730	539.701
100	392.254	444.728	491.630	533.854
110	385.637	438.318	485.508	528.013
120	378.961	432.035	479.334	522.150
130	372.201	425.658	473.346	516.287
140	365.431	419.247	467.238	510.541
150	358.747	412.801	461.166	504.586
160	351.855	406.356	454.957	498.812
170	345.088	399.910	448.799	492.912
180	338.890	393.600	442.641	487.012
190	332.262	386.999	436.503	481.062
200	325.493	381.104	430.482	475.175
210	318.966	374.918	424.324	469.423
220	312.316	368.473	418.388	463.529
230	305.546	362.262	412.743	457.629
240	298.776	355.965	406.585	452.118
250	292.026	349.519	400.827	446.591
260	285.258	343.073	394.669	440.916
270	278.475	336.628	388.511	435.258
280	271.705	330.182	382.352	429.358
290	264.935	323.760	376.194	423.458
300	258.166	317.314	370.036	417.557
310		310.855	363.878	411.657
320		304.410	357.720	405.757
330		297.964	351.587	399.857
340			345.429	393.957
350			339.259	388.056
360			333.101	382.183
370			326.943	376.283
380			320.784	370.374
390			314.626	364.471
400			308.468	358.571
410				352.670
420				346.770
430				340.870
440				334.970

IQ: Import quantity, unit: 1,000 ton
The other 4 columns indicate the domestic supply (unit: 1000 ton) under four different income levels.

income levels and various import quantity levels. Although the prices of 18 consuming and 14 producing counties – together with their consuming and producing quantities and trade flows among those counties – are also obtained in the result, but we do not show them in this paper due to the limits of available space.

As long as trade takes place between producing area M and consuming area N, the difference between the market price and the supply price is equal to the unit transportation cost. Otherwise, no trade occurs when the price difference is smaller than the unit transportation cost. This kind of price relation is the feature of the perfectly competitive spatial equilibrium.

SIMULATION OF POLICIES AND ANALYSIS OF IMPACTS

It is useful to understand the current and possible future policy concerning the

Table 10. Fluid milk tariff equivalent in 1996

(1)	F.O.B.	16.03
(2)	Transportation	2.18
(3)	Insurance	0.24
(4)	Interest	0.2
(5)	Trader commission	0.48
(6)	Fee of custom clearance	1.43
(7)	Fee of warehouse storage	0.51
(8)	(1)+(2)+(3)+(4)+(5)+(6)+(7) Import price before tariff imposed	21.07
(9)	Fluid milk wholesale price in Taiwan	39
(10)	Tariff equivalent [(9)-(8)]/(8)	85.10%

We assume that the import price of fluid milk before tariff is imposed.
(8) increases 2% every year from 1997.

tariff reduced by 36% during 6 years

Year	Tariff	Import Price (=21.07*1.1*185.10%)
2001	85.10%	42.901
2002	78.97%	42.234
2003	72.84%	41.516
2004	66.71%	40.746
2005	60.58%	39.924
2006	54.46%	39.054

tariff reduced by 15% during 6 years

2001	85.10%	42.901
2002	82.55%	43.079
2003	80.00%	43.236
2004	77.45%	43.371
2005	74.90%	43.485
2006	72.34%	43.574

Table 11. Import policies comparison under four different income levels in 2006

Unit: NT$/kg., 1000ton, %

	Current policy: Import restricted				Policy I: Import quotas							
	(1) 1996 level	120% of (1)	140% of (1)	160% of (1)	(1) 1996 level		120% of (1)		140% of (1)		160% of (1)	
Import price	–	–	–	–	40.917	–	42.715	–	44.320	–	45.768	
Import quantity	0	0	0	0	21.298	–	21.298	–	21.298	–	21.298	–
Domestic supply	459.503	509.147	553.116	592.764	445.489	-3.05%	495.422	-2.70%	540.004	-2.37%	580.203	-2.12%
Total supply	459.503	509.147	553.116	592.764	466.787	1.59%	516.72	1.49%	561.302	1.48%	601.501	1.47%

	Policy II: Import tariff plus tariff equivalents				Policy III: Complete liberalization							
	(1) 1996 level	120% of (1)	140% of (1)	160% of (1)	(1) 1996 level		120% of (1)		140% of (1)		160% of (1)	
Import price	43.574	43.574	43.574	43.574	35.398	–	35.398	–	35.398	–	35.398	–
Import quantity	0	0	54.953	123.217	218.092	–	305.376	–	391.216	–	475.513	–
Domestic supply	459.503	509.147	519.279 (-6.12%)	520.264 (-12.23%)	313.584	-31.76%	313.842	-38.36%	313.877	-43.25%	313.905	-47.04%
Total supply	459.503	509.147	574.232 (3.82%)	643.481 (8.56%)	531.676	15.71%	619.218	21.62%	705.093	27.48%	789.418	33.18%

Interpolation was made from Table 10–1 and 10–2 to get the figures on this table, and a relatively small computational error which can be neglected in practice may be included in those figures.
% indicates the changing rate from current policy to respective policies I, II, and III.

import of fluid milk for the build–up of an econometric model in the next section. In regard to negotiations with the majority of WTO member countries before Taiwan becoming an official member, New Zealand – as the main dairy product exporting country to Taiwan – has made requests to Taiwan on dairy products. For this reason, one of the simulated fluid milk import policies will be in accordance with the results of negotiations with New Zealand. Until now, Taiwan agreed to allow New Zealand to begin a 6–year phased reduction of fluid milk import restrictions. The agreement calls for a 4.5% annual increase in the import quota during the first year over the base year domestic consumption (equal to 10,649 metric tons), then increase that gradually to 9% (equal to 21,298 metric tons) in the sixth year. A 15% tariff is set at the level of import quotas, otherwise a 108% tariff is set over the level of import quotas in the first year, decreasing to 92% in the sixth year. It is expected that Taiwan can become a member of WTO in 2000, therefore, we assume that the agreement will be implemented in the year 2001.

Two alternative policies are also considered to provide comparison with the above policy of import quotas: (a) import tariff plus tariff equivalent from 2001 and (b) complete, immediate liberalization in 2001.

It should be noted here that we assume that the fluid milk can move in international trade in the near future in Taiwan. Although some kind of the fluid milk is not usually considered to move in international trade because of its perishability and product labeling, our assumption will not be unrealistic if mainland China becomes raw milk and fluid milk exporting country in the near future.

The policy of import quotas

If the Taiwanese government follows the agreement with New Zealand, increasing import quotas gradually to 9% (equal to 21,298 metric tons in 2006), the import prices can be estimated as shown in table 11 (the case of policy I) with four cases.

The policy of import tariff plus tariff equivalents from 2001

The method of calculating the fluid milk tariff equivalents is indicated in table 10. If the tariff is reduced by 36% over 6 years like the EU and Canada schedules, the tariff of fluid milk will be reduced to 54.46% and the import price will be 39.054 in 2006. If the tariff is reduced by 15% over 6 years like the USA and Japan schedules, the tariff of fluid milk will be reduced to 72.34% and the import price will be 43.574 in 2006. The composition of the import price and quantity in four various cases is shown in table 11 (the case of policy II).

The policy of complete liberalization in 2001

Complete liberalization of fluid milk imports will push imports to near 305,376 tons in 2006 because of the increased demand for fluid milk by consumers at the substantially lower world prices, if you assume 2% annual increases in income from 1997 (Table 11: the case of policy III). The result of other income levels is also shown in table 11. With complete liberalization, we forecast that the import price will be equal to the world average price of fluid milk plus the import tariff. Here, we assume that the import tariff is the same as the tariff of most Taiwanese imported dairy products, which is 40% of the world average price, as well as assuming that there are 2% annual increases in the world average price of fluid milk from 1997 (FAPRI, 1998; OECD, 1999). Therefore, the import price in 2006 will be $21.07 \times 1.2 \times 1.4 = 35.398$.

Impact of an import quota policy

The result of table 11 shows that if the government chooses the policy of import quotas, the domestic fluid milk supply may decrease at least 2% under all four different income levels. However, domestic fluid milk consumption will increase around 1.5%.

Impact of the policy of import tariff plus tariff equivalents from 2001

The result of table 11 shows that if the government chooses the policy of import tariff plus tariff equivalents, the domestic fluid milk supply may decrease by 6.12% under the case using 140% of the 1996 income level, and by 12.23% in the case using 160% of the 1996 income level. In contrast, domestic fluid milk consumption will increase by 3.82% under the case using 140% of the 1996 income level and by 8.56% in the case using 160% of the 1996 income level.

Impact of the policy of complete liberalization in 2001

The result of table 11 shows that if the government chooses the policy of complete liberalization, the domestic fluid milk supply may decrease by over 30% under the four different income levels. On the other hand, domestic fluid milk consumption will increase more than 15% under those income levels.

No matter which policy we choose, the domestic prices of demand and supply have a negative relation to the import quantity under any above mentioned income level. The more fluid milk we import, the more prices decrease. The simulation results suggest that the effect of the import tariff plus tariff equivalents policy of accelerating the import of fluid milk is much more obvious than that of the import quota policy. However, we are not suggesting that the Taiwanese government select the policy of complete liberalization immediately, because it may cause a large, unfavorable influence on the Taiwanese dairy industry.

However, there is very little trade taking place in less processed dairy products due to the problem of product life, such as that with fresh milk and fluid milk, although the average annual ratio in increasing trade for these items was reasonably high at close to 10 percent (OECD, 1997). In general, tariffs are not reduced more for processed than for basic agricultural products and the reductions are less in many cases. There are some important exceptions, however, with examples of substantial tariff reductions which could stimulate even more rapid trade growth.

REFERENCES

Board of Foreign Trade, M.O.E.A. of Taiwan 1992 *Research Report on Taiwan Becoming a GATT Member*. Taipei, Taiwan

Cramer, Gail L., Eric J. Wailes, and Shangnan Shui 1993 Impacts of Liberalizing Trade in the World Rice Market. *Amer. J. Agr. Econ.*, **75**: 219–226

Customs Import Tariff and Classification of Import & Export Commodities of the Republic of China. 1998 Revised Edition Published by the Directorate-General of Customs, M.O.F. and the Board of Foreign Trade, M.O.E.A. of Taiwan. Taipei, Taiwan

FAPRI 1998 *FAPRI 1998 World Agricultural Outlook*. Food and Agricultural Policy Research Institute, Iowa State University and University of Missouri–Columbia

Grant, Simon and John Quiggin 1997 Strategic Policy under Uncertainty: Sufficient Conditions for the Optimality of Ad Valorem, Specific and Quadratic Trade Taxes. *International Economic Review*, **38–1**: 187–203

Kawaguchi, Tsunemasa and Jong–Sang Lee 1992 On the Uniqueness of Equilibrium Solution in Spatial Equilibrium Analysis. *Sci. Bull. Fac. Agr., Kyushu Univ.*, **46 (3–4)**: 199–210

Krugman, Paul R. and Maurice Obstfeld 1988 *International Economics–Theory and Policy*. Scott, Foresman and Company, Printed in USA

Lin, Lily and T. Kawaguchi 1998 Study on Reducing Raw Milk Transportation Cost in Taiwanese Dairy Industry. *J. Fac. Agr., Kyushu Univ.*, **43 (1–2)**: 269–280

Lin, Lily and T. Kawaguchi 1999 Increase in Raw Milk Demand and Its Long–Run Effects on Dairy Industrial Organization in Taiwan–An Approach with Spatial Equilibrium Analysis. *J. Fac. Agr., Kyushu Univ.*, **43 (3–4)**: 509–529

Lo, Chang–Fa 1994 *Impact on Agriculture of Becoming a GATT Member and the Policy to Deal with it*. Chang Yung–Fa Foundation Institute for National Policy Research, Taipei, Taiwan.

OECD 1996 *Reforming Dairy Policy*. OECD Publications, Printed in France

OECD 1997 *The Uruguay Round Agreement on Agriculture and Processed Agricultural Products*. OECD Publications, Printed in France

OECD 1999 *OECD Agricultural Outlook 1999–2004*. OECD Publications, Printed in France

Wahl, Thomas I., Dermot J. Hayes, and Gary W. Williams 1991 Dynamic Adjustment in the Japanese Livestock industry Under Beef Import Liberalization. *Amer. J. Agr. Econ.*, **73–1**: 118–131