An Assessment of Deficiency Payments to Milk Producers in Japan

Nobuhiro Suzuki and D. H. Judson

This article represents an econometric assessment of the role that deficiency payments have played in developing the Japanese fluid and manufacturing milk markets and the potential effects of reducing deficiency payments on these milk markets. Principal findings are: (*a*) an historical simulation of the model without deficiency payments and import quotas indicates that these measures have reduced the variation in milk prices that would have otherwise occurred under this model, and price supports through these measures have resulted in greater milk production than would have accrued without price supports; and (*b*) a reduction in deficiency payments beginning in 1988 results in a decrease in milk prices and manufacturing milk supply and an increase in fluid milk supply and dairy imports, but fluid milk prices soon stop declining. The policy implications of such a decline in deficiency payments are discussed.

Key words: deficiency payments, price supports, dairy supply, milk pricing.

The objective of this report is to quantitatively analyze two problems. The first is to determine the role that deficiency payments to producers of milk for manufacturing into dairy products played in developing the Japanese dairy industry, analyzing the effect of payments over the period 1966–87. The second is to assess the effects of reducing the guaranteed milk price on the Japanese dairy industry and milk market. A nonlinear simultaneous equations model of the Japanese milk market was developed to analyze these policies.

The "temporary" law of deficiency payments to producers of milk for manufacturing came into being in 1966.[1] This system was designed to compensate farmers for the difference between their guaranteed price and the trade-basis manufacturer's purchase price. The guaranteed price is set by the government based on farm production costs, while the trade-basis or "standard" manufacturer's purchase price is set by the government as the price payable to farmers for milk used for manufacture, based on market prices of dairy products and manufacturers' processing and selling costs.

This law was not applied to milk sold fluid but only to milk for manufacturing. The former is little affected by overseas milk supplies because of its perishability and the high unit cost of transportation. On the other hand, the manufacturer's payable price to farmers for milk used for manufacturing is affected by imports of overseas dairy products and is much lower than farmers' production costs. Therefore, it was necessary for the Japanese government to compensate for this differential in order to encourage the development of the Japanese dairy industry. This guaranteed price encouraged a sharp increase in milk production

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[1] The law has been in effect since 1966, although it is labeled "temporary." It is labeled "temporary" because it was supposed to be terminated if one of two scenarios developed. First, payments would stop if the bulk of the Japanese milk supply was sold as fluid milk, although a trigger for stopping payments was not set. The Japanese government originally thought that the growth rate in demand for fluid milk would be much higher than the available supply. This means that most manufactured dairy products would have been provided by imports. Second, payments would have been terminated when the improving productivity in Japanese dairy farming reduced the differential between the farmers' production costs and the manufacturer's price. However, neither of these situations has been realized.

in the Hokkaido prefecture. Over 80% of Hokkaido milk production is used for manufacturing. Moreover, it is important to recognize that the high guaranteed price of milk for manufacturing has played a role in protecting milk production in Tofuken (areas of Japan other than Hokkaido) by keeping the bulk of Hokkaido milk off of the fluid milk market.[2] Nearly 90% of Tofuken milk production is used for fluid purposes (e.g., drinking and cooking).

Deficiency payments to dairy farmers have played an important role in developing Japanese dairy farming. This policy and related measures to develop large-scale dairy farms in Japan enabled the average scale of Japanese dairy farms to equal those in the European Economic Community. However, under the recent situation of increasing production capacity and stagnant milk demand, the maintenance of a high guaranteed price is contributing to a chronic milk surplus.[3] Some researchers say that the main reason for the persistent milk surplus is the increase in the number of large-scale, full-time farmers (Kajii). Indeed, such farmers intend to maintain milk production levels even if the milk price is reduced, because they have no income source other than milk sales and their fixed costs and debts are extremely high. However, even large-scale farmers must reduce their production if milk prices decline substantially. This viewpoint, which emphasizes the effects of an increasing production capacity, overlooks the effects of the rigid guaranteed price.

Moreover, the rigidity of the guaranteed price in Japan, together with the high appreciation of the yen and low prices of overseas dairy products, is enlarging the differences between domestic and foreign dairy product prices.

Producers' cooperatives have been making efforts to regulate supplies by installing their own supply management programs through the use of production quotas. This was in response to payment quotas which were introduced in 1979 in order to reduce the cost of the program to government. A policy of production quotas can bring short-term benefits to sellers of commodities with inelastic demands. Kaiser, Streeter, and Liu demonstrated that farmers are better off under a voluntary supply control program. As mentioned by some researchers, the drawback would be that imposing rigid and equal quotas for each farm will prevent larger farms from realizing scale economies, and administrative costs for the policy are large (Ohtsuka). As long as the rigidity of guaranteed prices contributes to milk surpluses, one of the possible policy options is to reduce guaranteed prices gradually in order to make milk prices reflect market conditions.

The Japanese government reduced the guaranteed price in 1986, 1987, and 1988 in order to reduce the government's financial burden and to reduce the differential between domestic and foreign milk price. From the viewpoint of reducing milk surpluses, however, it was not a reduction in real terms because milk production costs declined much more due mainly to a reduction in imported mixed feed prices.

Theoretical Background

Several econometric models of the Japanese milk market have been developed (Ohtsuka; Matsubara; Ministry of Agriculture, Forestry, and Fisheries; Yuize). In all of them fluid milk prices are thought to be determined in part by the monopolistic power of milk marketing boards with fluid milk demand being determined by a set price and the supply of milk used in manufacturing considered to be a residual after the fluid milk demand is subtracted from the total milk supply, with no relation to the guaranteed price for milk used in manufacturing. Such a modeling procedure overlooks the fact that there is competition between producers in Hokkaido and the rest of Japan (known as the "Civil War"). By neglecting the relationship between Hokkaido and the rest of Japan and considering manufacturing milk supply to be a mere residual with no relation to the guaranteed price, these models may not effectively estimate the effects of the guaranteed price reduction.

The Japanese milk marketing boards do not have monopolistic power like the England and Wales Milk Marketing Board (EWMMB). Indeed, EWMMB adopts a high price for fluid milk in order to maximize total revenue under

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[2] If fluid milk prices in Tofuken are equal to the guaranteed price plus the transportation costs from Hokkaido to Tofuken, Hokkaido will not send its milk to Tofuken as long as the manufacturing milk supply in Hokkaido is within payment quotas.

[3] By "surplus" we mean large stockpiles of dairy products. For example, the dairy product stocks in 1979 enlarged five times as much as those in 1975. After 1979 producers' cooperatives installed their own production quotas in response to government-introduced payment quotas. The reduced production should also be considered milk surplus.

the assumption that the price elasticity for fluid milk demand is smaller than that for manufactured milk demand. The theory of price discrimination cannot be applied to the whole Japanese milk market (as in the case of the EWMMB) because the Japanese milk marketing board[4] is independent in each prefecture and there is no national milk marketing board. Therefore, considering the competition between Hokkaido and Tofuken in the Japanese milk market, it is assumed in the current model that the ratio of manufactured milk to total supply is determined by the relative price of manufactured milk to fluid milk. Given a certain guaranteed price for milk used in manufacturing, fluid milk demand, supply, price, and manufactured milk supply are determined simultaneously. This system will allow simulation of the effects of guaranteed price reduction.

Structure of the Model

This model consists of 36 behavioral equations, where there are 15 structural equations and 21 definitional identities, as given in tables 1 and 2.

Most of the structural equations are specified in double logarithmic form with constant elasticities and estimated by the Ordinary Least Squares (OLS) method.[5] The observation period spans the fiscal years 1966–87. It is assumed that the structure of the Japanese milk market remained relatively stable for 22 years after the introduction of deficiency payments. This assumption is somewhat tenuous, but there is supporting statistical evidence in that all of the computed equations have high coefficients of determination as well as generally acceptable Durbin-Watson d statistics or Durbin's h statistics.

Figure 1 represents a simplified flow chart of this model. Milk production is determined by a lagged weighted average price for both fluid and manufactured milk. How much milk is destined for each end use is determined by the relative price of fluid and manufactured milk. Demand for fluid milk is determined by fluid milk price, and fluid milk price is determined at a market clearing level. That is, quantity demanded or supplied for fluid milk and fluid milk price are solved simultaneously. Demand for manufactured milk is determined by both the standard purchase price of manufacturers and the imported dairy product price converted into raw milk equivalents. Since domestic manufacturing supply, including the decrease in dairy product stocks sent into the market, cannot satisfy the demand for manufactured milk, the shortfall is imported. In this model, dairy import prices and dairy product stocks are considered as exogenous variables.

That is, the basic structure of the model is explained by following equations (a) through (h):

(a) *Milk supply* = f_1 (*Blend price*),
(b) *Manufacturing milk supply* = f_2 (*Fluid milk price*, ***Guaranteed price***),
(c) *Fluid milk supply* = *Milk supply* − *Manufacturing milk supply*,
(d) *Fluid milk demand* = f_3 (*Fluid milk price*),
(e) *Fluid milk demand* = *Fluid milk supply*,
(f) *Manufacturing milk demand* = f_4 (***Standard purchase price***, ***Dairy import price***)
(g) *Dairy imports* = *Manufacturing milk demand* − *Manufacturing milk supply* − ***Decrease in stocks***, and
(h) *Blend price* = [*Fluid milk supply*∗*Fluid milk price* + ***Payment quota***∗*Guaranteed price* + (*Manufacturing milk supply* − ***Payment quota***)∗***Standard purchase price***]/*Milk supply*.

Boldface variables are the exogenous variables in this system. Equation (e) determines fluid milk price. This system can be solved because there are eight endogenous variables and eight equations.

Equations (1)–(4) (table 1) represent the reproduction cycle of milk cows. Equations (1) and (2) determine the number of adult dairy cattle (*ABT*, *ABH*) which are two years old and older. The sum of the price parameters is nearly zero [.26 − .19 − .09 in equation (1) and .16 − .07 − .07 in equation (2)], which means that these equations are approximately zero-order homogeneous expressions with respect to prices. Dairy beef price (*MBMP*) is considered as an opportunity cost of an animal in milk production. Half of two-period-lagged

[4] The milk marketing board in each prefecture is the designated producers' cooperative which gathers almost all of the milk produced in the prefecture, sells it, and pays each producer a weighted average price (or blend price) for both fluid and manufactured milk.

[5] The application of nonlinear simultaneous estimation methods does not provide significantly different results and takes much more time to compute. Hence, we present the OLS results.

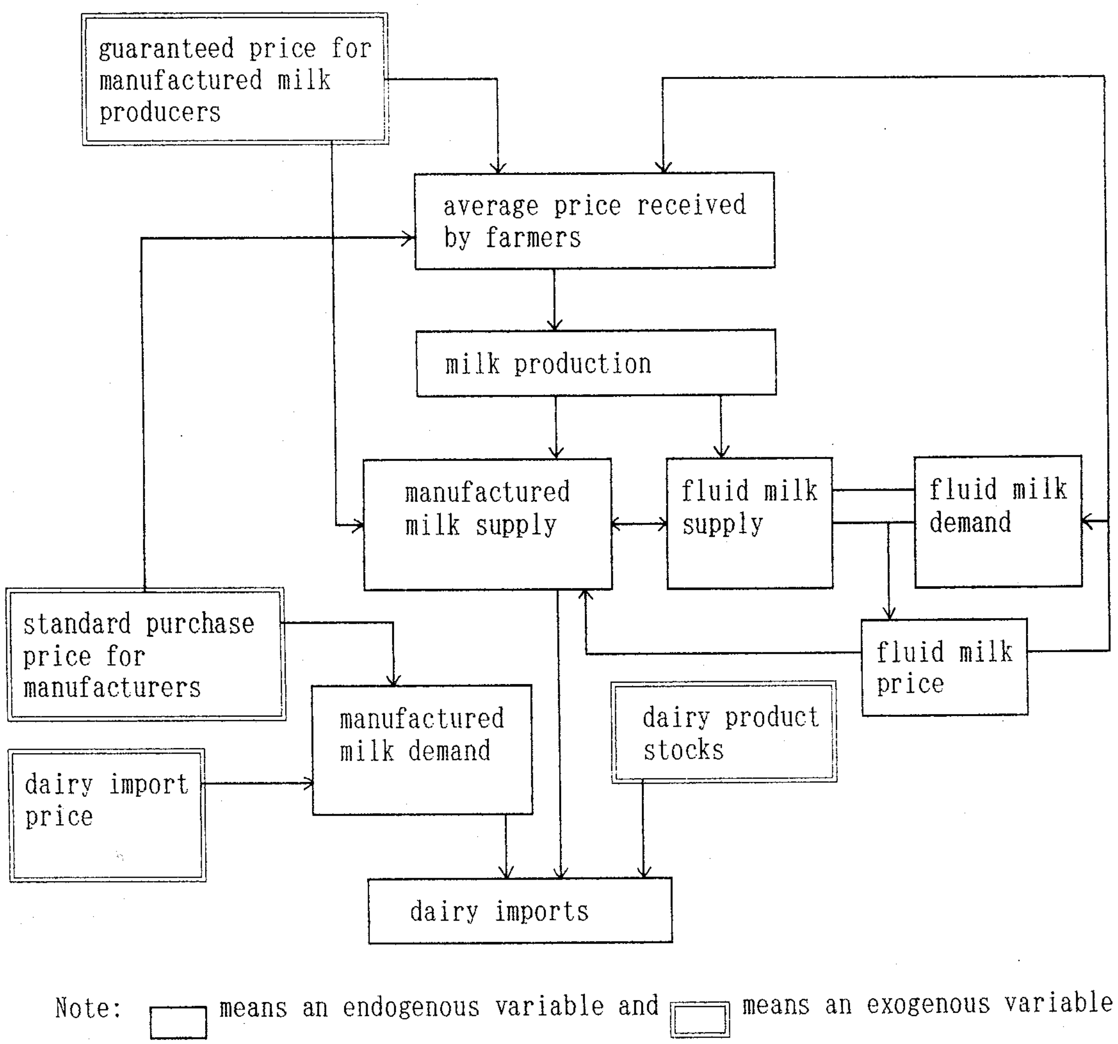

Figure 1. Basic structure of the milk market model—simplified flow chart

milk cow numbers ($MBT_{t-2}/2$, $MBH_{t-2}/2$) represents the number of female calves which were born two years ago. This variable and lagged dependent variables (ABT_{t-1}, ABH_{t-1}) are added in order to avoid multicollinearity problems.

*DY*72 is one of the livestock industry crisis indicators. During the years 1972–74, farmers were anxious about a sharp rise in feed prices and slaughtered excess numbers of cows. *DY*7274 takes on the value one in the years 1972–74 and zero in other years. *DY*8687 is one of the production quota indicator variables. Production quotas have been in effect since 1979. During the years 1979–85, these quotas were gradually enlarged each year. However, in 1986–87, the quotas were set less than the previous years. In this model, effects of production quotas are measured by introducing these indicator variables.[6] Clearly, the quota does not have the same effect in every year. Therefore, many combinations of periods were tried and only periods for which estimated effects were significantly different from zero were chosen. As a result, *DY*79, *DY*80, *DY*81, *DY*82, *DY*8085, *DY*86, *DY*87, and *DY*8687 are used in this model.

[6] An alternative method would be to take the quotas as given. However, in that case, we would need to use only the years before 1979 to estimate price elasticities of milk production.

Equations (3) and (4) determine the number of milking cows (*MBT, MBH*). The number of milking cows is given as a stable ratio of the number of adult dairy cattle (*ABT, ABH*) for several years.

The sign of each parameter of (1)–(2) is consistent with the a priori expectations. That is, a rise in the average milk price received by farmers brings an increase in cow numbers,[7] a rise in feed prices brings a decrease in cow numbers, and a rise in dairy beef carcass prices brings a decrease in cow numbers due to an increase in cow slaughter. Supply response in both regions is very inelastic and Hokkaido parameters are smaller than those for Tofuken. This may reflect the fact that the reactions to price change by large-scale, full-time farmers, which predominate in Hokkaido, are rigid due mainly to fixed cost effects.

In (5) and (6), milk production per cow is determined by cow numbers, mixed feed prices, and time trends. As a decrease in cow numbers means a decrease in the number of low-producing cows through slaughter, an increase in milk production per cow results. A decline in mixed feed prices also brings an increase in milk production per cow because more mixed feeds are given to cows. As a proxy for technological advancements in milk production per cow, we use a time-trend variable. In this equation, a semilog function is adopted because it is assumed that future technological advancements will decline because of the biological limits of cows. However, it might not decline in the short run. Technological advance will depend in part on improvements in fertilization and other technology.

Milk production is calculated by multiplying cow numbers by milk production per cow, as in (11) and (12).

Equations (13) and (14) show milk quantity for farmers' own use, for nursing calves and other uses. This quantity has been only approximately 2% of total milk production. Milk supply is calculated by subtracting this quantity from milk production, as in (15) and (16).

Milk supply is divided into fluid milk supply and milk supply for manufacturing. How much milk farmers will divert to each use is determined by the relative price between fluid and manufactured milk, as in (18)–(21).

[7] Decreasing cow numbers through slaughter takes less time than increasing them. That is, the effects of price decline and rise are not symmetric. Further research should be done in order to realize this asymmetry in the model.

Fluid milk demand is determined by (24). This is not final consumers' demand but processors' derived demand. Explanatory variables are milk price, consumption expenditure, temperature, and the ratio of persons 0–14 years old to total population. In Japan, it is said that people drink more milk when it is warm, in the same fashion as people in the U.S. drink greater quantities of soda pop.

Equation (25) indicates the milk market equilibrium condition, wherein fluid milk price is determined at a market clearing level and where demand and supply for fluid milk are equal. In model simulations, this equilibrium price is found by means of the Gauss-Seidel solution technique.

Manufactured milk demand is determined by (27). This demand includes domestic manufacturing supply, imported dairy products converted into raw milk equivalents, and a decrease in dairy product stocks. Therefore, explanatory price variables include both standard purchase prices for domestic manufactured milk and imported dairy product prices represented by natural cheese prices including the tariff converted into raw milk equivalents. Equation (27) also includes an income variable, proxied by private consumption expenditures.

Equation (31) shows the relationship between average prices received by farmers in Tofuken and those in Hokkaido. For the past 22 years, Hokkaido's price has been approximately 17% lower than Tofuken's price. In (31) it is assumed that transportation costs are determined at a rate proportional to milk prices. This assumption may not be valid when applied to cases where milk prices decline significantly.

The model was estimated using MICRO AGNESS, which is a computer package program for econometric analysis developed by Inaba.

Case I: Comparison of the Model with Historical Data

Table 3 indicates the results of testing this model against historical data. In the test, given the exogenous variables, values for endogenous variables are determined in a fully dynamic simulation by means of the Gauss-Seidel solution technique for the estimation period 1966–87.

Table 1. Equations of the Milk Market Model

*(1) $\ln(ABT) = 2.40 + .26 \cdot \ln(FPT) - .19 \cdot \ln(MFI) - .09 \cdot \ln(MBMP)$
(3.9) (3.2) (−2.5) (−1.9)
$+ .67 \cdot \ln(ABT_{t-1} + MBT_{t-2}/2) - .06 \cdot DY72 - .08 \cdot DY8687$
(6.9) (−1.9) (3.1)

$R^2 = .92$ R^2 adjusted = .88 D.W. = 1.83

*(2) $\ln(ABH) = 1.00 + .16 \cdot \ln(FPH) - .07 \cdot \ln(MFI) - .07 \cdot \ln(MBMP)$
(4.8) (2.3) (−1.1) (−1.8)
$+ .82 \cdot \ln(ABH_{t-1} + MBH_{t-2}/2) - .06 \cdot DY72 - .04 \cdot DY8687$
(14.0) (−2.1) (−1.4)

$R^2 = .99$ R^2 adjusted = .99 D.W. = 2.25

*(3) $MBT = .77 \cdot ABT$
(420.0)

$R^2 = .99$ R^2 adjusted = .99 D.W. = .72

*(4) $MBH = .69 \cdot ABH$
(228.2)

$R^2 = .99$ R^2 adjusted = .99 D.W. = .55

*(5) $AMSFT = -7.62 - 1.18 \cdot \ln(AMBT) - 1.52 \cdot \ln(MFI/WPIF) + 4.90 \cdot \ln(TR)$
(−4.8) (−3.1) (−6.6) (10.2)

$R^2 = .97$ R^2 adjusted = .97 D.W. = 1.55

*(6) $AMSFH = -38.93 - .74 \cdot \ln(AMBH) - 1.55 \cdot \ln(MFI/WPIF) + 11.38 \cdot \ln(TR)$
(−9.0) (−1.4) (−3.7) (7.0)

$R^2 = .98$ R^2 adjusted = .98 D.W. = 1.32

*(7) $AAMBT = 16.11/(1 + 8.50 \cdot e^{-.17 \cdot TR})$
(52.8) (55.5) (−49.3)

$R^2 = .999$ R^2 adjusted = .999 D.W. = .83

*(8) $AAMBH = 26.67/(1 + 5.80 \cdot e^{-.16 \cdot TR})$
(63.9) (62.9) (−50.0)

$R^2 = .999$ R^2 adjusted = .999 D.W. = .71

(9) $AFNT = AMBT/AAMBT$

(10) $AFNH = AMBH/AAMBH$

(11) $MSFT = AMBT \cdot AMSFT$

(12) $MSFH = AMBH \cdot AMSFH$

*(13) $\ln(FOFT) = .46 + .66 \cdot \ln(AFNT) + .13 \cdot \ln(ST) + .15 \cdot DY79 + .21 \cdot DY8085$
(2.4) (29.7) (6.6) (4.2) (9.0)
$+ .58 \cdot DY8687$
(18.4)

$R^2 = .99$ R^2 adjusted = .99 D.W. = 2.04

*(14) $\ln(FOFH) = 1.01 + .31 \cdot \ln(AFNH) + .29 \cdot \ln(ST) + .56 \cdot DY80 + .71 \cdot DY81$
(1.0) (2.1) (3.0) (3.9) (5.1)
$+ .35 \cdot DY82 + .69 \cdot DY86 + .88 \cdot DY87$
(2.6) (4.8) (5.7)

$R^2 = .90$ R^2 adjusted = .84 D.W. = 2.06

(15) $MSRFT = MSFT - FOFT$

(16) $MSRFH = MSFH - FOFH$

(17) $MSRF = MSRFT + MSRFH$

*(18) $\ln(FDFH) = .98 + .63 \cdot \ln(PP/WPIF) - .46 \cdot \ln(WMPT/WPIF)$
(5.3) (2.8) (−2.3)
$+ .89 \cdot \ln(FDFH_{t-1})$
(35.7)

$R^2 = .99$ R^2 adjusted = .98 D.W. = 1.47 h-statistic = 1.05

(19) $FMFH = MSRFH - FDFH$

*(20) $\ln(FDFT) = 1.16 + 1.93 \cdot \ln(PP/WPIF) - 1.40 \cdot \ln(WMPT/WPIF) + .88 \cdot \ln(FDFT_{t-1})$
(1.5) (4.2) (−3.7) (7.2)
$- .23 \cdot DY75 - .28 \cdot DY8687$
(−2.8) (−4.7)

$R^2 = .85$ R^2 adjusted = .81 D.W. = 2.65 h-statistic = −1.93

Table 1. Continued

(21) $FMFT = MSRFT - FDFT$

(22) $FMF = FMFT + FMFH$

(23) $FDF = FDFT + FDFH$

*(24) $\ln(DFMFNF) = \underset{(3.0)}{.61} - \underset{(-4.7)}{.19}\cdot\ln(WMPTH/WPIF) + \underset{(33.8)}{90}\cdot\ln(CF/NF) + \underset{(1.4)}{.001}\cdot ANN + \underset{(4.7)}{2.38}\cdot NR014 - \underset{(-7.0)}{.07}\cdot DY7274$

$R^2 = .995$ R^2 adjusted = .994 D.W. = 2.10

(25) $WMPTH = WMPTH\cdot DFMF/(MSRF - FDF)$

(26) $WMPT = (WMPTH\cdot FMF - (FPH\cdot MSRFH - ADMH\cdot PP - (FDFH - ADMH)\cdot SP))/FMFT$

*(27) $\ln(FDIMNF) = \underset{(21.7)}{1.82} - \underset{(-2.2)}{.24}\cdot\ln(SP/WPIF) - \underset{(-3.4)}{.25}\cdot\ln(CMPT/WPIF) + \underset{(9.5)}{.51}\cdot\ln(CF/NF)$

$R^2 = .96$ R^2 adjusted = .95 D.W. = 1.21

(28) $DPIM = FDIM - (FDF + ST_{t-1} - ST)$

(29) $FP = (FMF\cdot WMPTH + ADM\cdot PP + (FDF - ADM)\cdot SP)/MSRF$

(30) $FPT = (FMFT\cdot WMPT + ADMT\cdot PP + (FDFT - ADMT)\cdot SP)/MSRFT$

*(31) $FPH = \underset{(147.2)}{.83}\cdot FPT$

$R^2 = .99$ R^2 adjusted = .99 D.W. = .69

(32) $GV = (PP - SP)\cdot ADM$

(33) $FDIM = FDIMNF\cdot NF/1{,}000$

(34) $DFMF = DFMFNF\cdot NF/1{,}000$

(35) $AMBT = (MBT + MBT_{t-1})/2$

(36) $AMBH = (MBH + MBH_{t-1})/2$

Note: Numbers in parentheses are t-statistics. R^2 is the coefficient of determination. R^2 adjusted is the coefficient of determination adjusted for the number of parameters estimated. D.W. is the Durbin-Watson d-statistic for auto correlation. * indicates structural equation, while others are definitional identities.

The results indicate that the dynamic properties of this model are reasonably good. In particular, the fact that all performance indicators of fluid milk price are favorable supports the assumption that fluid milk price is determined as a market equilibrium price. However, in the cases of Hokkaido's fluid milk supply and dairy product imports, the mean absolute percent error is large and Theil's U-statistic is over one. This is because the two variables are calculated as residuals of the total values by definitional equations and their percentages to total Hokkaido milk supply and total manufactured milk demand have been rather small in past years.

Case II: No Deficiency Payments and No Import Quotas

After FY 1966, if there had been no deficiency payments and no import quotas, what would have happened in the Japanese milk market? We simulate such a situation by adding two equations, $PP = SP$ and $SP = CMPT$, into this model and eliminating the production quota indicator variables, where PP = guaranteed price, SP = standard purchase price, and $CMPT$ = imported dairy product price converted into raw milk equivalents as represented by the imported natural cheese price including the tariff. In the last two years (1986, 1987), $CMPT$ was less than half of SP. This means there is a large differential between domestic and overseas milk prices, but in FY 1982, $CMPT$ was about 80% of SP. Thus, $CMPT$ is fluctuating widely due to changes in both international dairy product prices and exchange rates.

Results of this historical simulation were remarkable and are shown as Case II in table 4. Price supports through deficiency payments and import quotas have been keeping Japanese milk cow numbers larger than would occur without price supports by at least 20–30% (compare the observations with Case II values of table 4). The expression "at least" is used for two reasons. First, as previously men-

Table 2. Variables of the Milk Market Model

Symbolic Names	Definitions	Time Period	Unit	Source
AAMBH	Number of milk cows per farm (Hokkaido)	FY	head/farm	*AMBH/AFNH*
AAMBT	Number of milk cows per farm (Tofuken)	FY	head/farm	*AMBT/AFNT*
ABH	Number of dairy cattle two years old and over (Hokkaido)	Feb. 1	1,000 head	Livestock Statistics, MAFF
ABT	Number of dairy cattle two years old and over (Tofuken)	Feb. 1	1,000 head	Livestock Statistics, MAFF
*ADM**	Volumes for which deficiency payments were provided (all Japan)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
*ADMH**	Volumes for which deficiency payments were provided (Hokkaido)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
*ADMT**	Volumes for which deficiency payments were provided (Tofuken)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
AFNH	Average number of dairy farms (Hokkaido)	FY	1,000 farm	$(FNH_{t-1} + FNH)/2$
AFNT	Average number of dairy farms (Tofuken)	FY	1,000 farm	$(FNT_{t-1} + FNT)/2$
AMBH	Average number of milk cows (Hokkaido)	FY	1,000 head	$(MBH_{t-1} + MBH)/2$
AMBT	Average number of milk cows (Tofuken)	FY	1,000 head	$(MBT_{t-1} + MBT)/2$
AMSFH	Milk production per cow (Hokkaido)	FY	ton/head	*MSFH/AMBH*
AMSFT	Milk production per cow (Tofuken)	FY	ton/head	*MSFT/AMBT*
*ANN**	Averate temperature (Tokyo)	CY	0.1°C	Meteorological Agency
*CF**	Total private consumption expenditures (in CY 1980 price)	FY	0.1 billion yen	Annual Report on National Accounts, Economic Planning Agency
*CMPT**	Imported natural cheese price including tariff converted into raw milk equivalents	CY	yen/kg	CIF price•1.35/13.43 from Japan Exports and Imports, Ministry of Finance
DFMF	Fluid milk demand	FY	1,000 ton	Food Balance Sheet, MAFF
DFMFNF	Fluid milk demand per capita	FY	kg/person	*DFMF/NF*•1,000
DPIM	Dairy imports converted into raw milk equivalents	FY	1,000 ton	Food Balance Sheet, MAFF
*DY*7274*	Livestock industry crisis panic indicator	FY	72–74 = 1 other = 0	*DY*72, *DY*75 are similar
*DY*8687*	Production quota indicator	FY	86–87 = 1 other = 0	*DY*79, *DY*80, *DY*81, *DY*82, *DY*8085, *DY*86, *DY*87 are similar
FDF	Manufactured milk supply (all Japan)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
FDFH	Manufactured milk supply (Hokkaido)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
FDFT	Manufactured milk supply (Tofuken)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
FDIM	Manufactured milk demand	FY	1,000 ton	Food Balance Sheet, MAFF
FDIMNF	Manufactured milk demand per capita	FY	kg/person	*FDIM/NF*•1,000
FMF	Fluid milk supply (all Japan)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
FMFH	Fluid milk supply (Hokkaido)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
FMFT	Fluid milk supply (Tofuken)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
FNH	Number of dairy farms (Hokkaido)	FY	1,000 farm	Livestock Statistics, MAFF

Table 2. Continued

Symbolic Names	Definitions	Time Period	Unit	Source
FNT	Number of dairy farms (Tofuken)	FY	1,000 farm	Livestock Statistics, MAFF
FOFH	Milk quantity for farmers' own use, for nursing calves and others (Hokkaido)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
FOFT	Milk quantity for farmers' own use, for nursing calves and others (Tofuken)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
FP	Average price received by farmers (all Japan)	FY	yen/kg	Statistics of Prices and Wages in Rural Area, MAFF
FPH	Average price received by farmers (Hokkaido)	FY	yen/kg	Statistics of Prices and Wages in Rural Area, MAFF
FPT	Average price received by farmers (Tofuken)	FY	yen/kg	(*FP*•*MSRF* − *FPH*•*MSRFH*)/*MSRFT*
GV	Amount of deficiency payments	FY	million yen	(*PP* − *SP*)•*ADM*
MBH	Number of milk cows (Hokkaido)	Feb. 1	1,000 head	Livestock Statistics, MAFF
MBT	Number of milk cows (Tofuken)	Feb. 1	1,000 head	Livestock Statistics, MAFF
*MBMP**	Wholesale milk cow beef carcass price at Shibaura market (average of all grades)	CY	yen/kg	Meat Marketing Statistics, MAFF
*MFI**	Price indices of compound concentrated feed for cattle	FY	1985 = 100	Statistics of Prices and Wages in Rural Area, MAFF
MSFH	Milk production (Hokkaido)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
MSFT	Milk production (Tofuken)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
MSRF	Milk supply (all Japan)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
MSRFH	Milk supply (Hokkaido)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
MSRFT	Milk supply (Tofuken)	FY	1,000 ton	Milk and Milk Products Statistics, MAFF
*NF**	Average population	FY	1,000 persons	Annual Report on National Accounts, Economic Planning Agency
*NR*014*	Ratio of persons aged 0–14 to total population size	Oct. 1	total = 1	Japan Statistical Yearbook
*PP**	Manufactured milk guaranteed price for farmers	FY	yen/kg	Milk and Milk Products Statistics, MAFF
*SP**	Standard purchase price for manufacturers	FY	yen/kg	Milk and Milk Products Statistics, MAFF
*ST**	Ending stocks of dairy products converted into raw milk equivalents	FY	1,000 ton	Estimated from Food Balance Sheet, etc.
*TR**	Time trend	FY	FY	FY-1900 (for example, 70 means FY 1970)
WMPT	Fluid milk price (Tofuken)	FY	yen/kg	(*FPT*•*MSRFT* − *ADMT*•*PP* − (*FDFT* − *ADMT*)•*SP*)/*FMFT*
WMPTH	Fluid milk price (all Japan)	FY	yen/kg	(*FP*•*MSRF* − *ADM*•*PP* − (*FDF* − *ADM*)•*SP*)/*FMF*
*WPIF**	Wholesale price indices (all commodities)	FY	1985 = 100	Wholesale Price Indices, The Bank of Japan

Note: * means an exogenous variable in the model; MAFF = Ministry of Agriculture, Forestry, and Fisheries.

tioned, developments in Japanese dairy farming were achieved through deficiency payments as well as related measures for large-scale dairy farming under the price support system, for example, rangeland development. These related measures would not have been carried out effectively if there had been no price supports. However, there are no variables representing these measures in this model. Therefore, the role of deficiency payments in this

Table 3. Final Test of the Model

Endogenous Variables	Mean Absolute % Error	Theil's *U*-Statistic	Turning Point Error 1	Turning Point Error 2
(1) *ABT*	1.90	0.5784	33.33	20.00
(2) *ABH*	1.85	0.3623	0.00	0.00
(3) *MBT*	1.97	0.5218	33.33	33.33
(4) *MBH*	1.97	0.3388	0.00	5.56
(5) *AMSFT*	0.92	0.7619	6.25	6.25
(6) *AMSFH*	1.53	0.6970	21.05	6.25
(7) *AAMBT*	1.08	0.1622	0.00	0.00
(8) *AAMBH*	1.20	0.1300	0.00	0.00
(9) *AFNT*	1.91	0.2046	(a)	(a)
(10) *AFNH*	1.68	0.2965	(a)	(a)
(11) *MSFT*	2.05	0.4780	20.00	25.00
(12) *MSFH*	2.50	0.3541	5.00	0.00
(13) *FOFT*	2.35	0.3109	40.00	40.00
(14) *FOFH*	7.07	0.6761	27.27	27.27
(15) *MSRFT*	2.08	0.4701	13.33	13.53
(16) *MSRFH*	2.62	0.3564	5.00	0.00
(17) *MSRF*	1.80	0.4084	10.53	0.00
(18) *FDFH*	3.64	0.5085	21.05	6.25
(19) *FMFH*	25.50	1.3786	25.00	20.00
(20) *FDFT*	6.39	0.5634	41.67	12.50
(21) *FMFT*	2.03	0.4387	0.00	5.00
(22) *FMF*	1.12	0.4499	5.00	0.00
(23) *FDF*	4.72	0.5635	31.25	0.00
(24) *DFMFNF*	1.12	0.5563	11.11	5.88
(25) *WMPTH*	2.90	0.6208	23.08	23.08
(26) *WMPT*	2.26	0.4396	23.08	23.08
(27) *FDIMNF*	2.87	0.9273	6.67	17.65
(28) *DPIM*	12.36	1.5755	30.00	46.15
(29) *FP*	1.86	0.4259	15.38	15.38
(30) *FPT*	1.85	0.3855	15.38	21.43
(31) *FPH*	3.19	0.5790	15.38	21.43
(32) *GV*	0.00	0.0000	0.00	0.00
(33) *FDIM*	2.87	0.8037	11.76	11.76
(34) *DFMF*	1.12	0.4501	5.00	0.00
(35) *AMBT*	1.80	0.3570	18.18	30.77
(36) *AMBH*	1.88	0.2640	0.00	0.00

Note: (a) means that there are no turning points in both observed and simulated values. Mean absolute percent error is defined as $\Sigma\, |(Y_t' - Y_t)/Y_t|/n \cdot 100$ and Theil's *U*-statistic is defined as $[\Sigma\, \{(Y_t' - Y_{t-1}')/Y_{t-1}' - (Y_t - Y_{t-1})/Y_{t-1}\}^2/\Sigma\, \{(Y_t - Y_{t-1})/Y_{t-1}\}^2]^{1/2}$, where Y_t' = solution value and Y_t = actual value. Turning point percent error 1 is the percentage of values which are turning points in the simulation, while their observed values are nonturning points. On the other hand, turning point percent error 2 is the percentage of values which are nonturning points in the simulation, while their observed values are turning points. Our definition of Theil's *U*-statistic is based on Inaba.

model considers only direct effects through price supports and does not consider indirect effects through related measures.[8]

A second reason why the model may be underestimating the effect of price supports is the assumption that fluid milk prices are not affected by overseas fluid milk prices. Under a situation of no import quotas, not only dairy products such as butter and skim milk powder but also much cheaper Long-Life Milk (LL Milk) may be imported. In such cases, imported LL Milk may gain some market share in Japan. This is a factor which can lead to a decline in domestic fluid milk prices. Moreover, a decline in prices for various milk beverages (including chocolate milk) due to cheaper skim milk powder imports may also have some influence on fluid milk because various milk beverages have some substitutability. These downward pressures on fluid milk prices under a no import quota scenario are not taken into account in this model.

Without deficiency payments and import quotas, domestic manufacturing milk supply would have almost vanished and dairy imports would have increased by a factor of three to four. Japanese dairy farmers would have survived depending on the fluid market alone. Fluid milk supply would have increased by about 10%, and fluid milk price would have declined by 30–50%.

As shown in table 5, the coefficients of variation of milk prices without price supports are larger than those with price supports. This is caused by the fact that price elasticities in both supply and demand are small, and imported dairy product prices have a rather large fluctuation.

Case III and Case IV: Reducing Guaranteed Price by 3% Annually and Reducing Standard Purchase Price by 1% Annually versus Maintaining FY 1987 Levels of Price Supports

If the guaranteed price had been reduced gradually after FY 1988, what changes would have occurred in the Japanese milk market? Case III is the situation wherein every year after FY 1988 the guaranteed price (*PP*) is reduced by 3% and the standard purchase price (*SP*) is reduced by 1%.[9] These reduction rates were

[8] The indirect effects of related measures are being captured, in part, by the price support variables.

[9] An alternative case, in which the guaranteed price is reduced by 6% annually and the standard purchase price is reduced 3% annually, was also considered. The differences between this alternative and Case III were only a matter of degree; average prices in Hokkaido and Tofuken dipped lower around FY 1989–2005, but eventually converged to the same level. Other results were similar.

Table 4. Comparison of Observations with Case II (No Deficiency Payments and No Import Quotas)

		1970	1975	1980	1985	1987
Number of milk cows (Tofuken)	Observation (1)	678	657	744	743	698
(1,000 head)	Case II (2)	502	513	513	506	503
	(2)/(1)*100	74	78	69	68	72
Number of milk cows (Hokkaido)	Observation (1)	234	271	331	356	345
(1,000 head)	Case II (2)	179	205	224	234	230
	(2)/(1)*100	77	75	68	66	67
Fluid milk supply	Observation (1)	2,651	3,181	4,010	4,307	4,598
(1,000 ton)	Case II (2)	2,942	3,532	4,432	4,882	5,166
	(2)/(1)*100	111	111	111	113	112
Manufacturing milk supply	Observation (1)	1,963	1,709	2,311	3,015	2,656
(1,000 ton)	Case II (2)	697	485	299	255	192
	(2)/(1)*100	35	28	13	8	7
Dairy imports	Observation (1)	561	979	1,027	1,139	1,352
(1,000 ton)	Case II (2)	2,143	2,397	3,642	4,516	4,695
	(2)/(1)*100	382	245	355	396	347
Fluid milk price (Tofuken)	Observation (1)	53	102	112	110	100
(yen/kg)	Case II (2)	30	69	67	62	53
	(2)/(1)*100	58	68	60	57	53
Manufacturing milk price	Observation (1)	44	80	89	90	83
(yen/kg)	Case II (2)	21	43	41	37	26
	(2)/(1)*100	58	74	64	52	39
Blend price (Tofuken)	Observation (1)	49	97	107	105	98
(yen/kg)	Case II (2)	30	69	67	62	53
	(2)/(1)*100	61	71	62	59	54
Blend price (Hokkaido)	Observation (1)	45	80	87	88	75
(yen/kg)	Case II (2)	25	57	56	52	44
	(2)/(1)*100	56	71	64	59	58

chosen because they are actual reduction rates in nominal terms from FY 1985 to 1986. In this case, after the year when $PP < SP$, $PP = SP$. This situation is realized by adding the following two equations into this model:

$$PP = (1 - 3/100)*PP_{t-1}$$

and

$$SP = [|(1 - 1/100)*SP_{t-1} + PP| - |(1 - 1/100)*SP_{t-1} - PP|]/2.$$

As a comparison case for Case III, we examined a situation where PP and SP remain unchanged at the FY 1987 level into the future. This is given as Case IV in table 6.

In both Case III and Case IV, the assumptions about the other exogenous variables in these cases are as follows: private consumption expenditures are increased by 3% per annum, which was the average growth rate during FY 1980–87; population increases by .64% per annum, which was also the average growth rate during FY 1980–87; mixed feed prices, cow beef carcass prices, the wholesale price index, ending stocks of dairy products, temperature, ratio of persons aged 0–14 to population size,

Table 5. Coefficient of Variation of Milk Price

	With Deficiency Payments and Import Quotas	Without Deficiency Payments and Import Quotas
Standard purchase price for manufacturers	.08	.15
Guaranteed price of manufactured milk for farmers	.09	.15
Fluid milk price in Tofuken	.10	.12

Note: Calculated from FY 1967 to FY 1987; each milk price is deflated by the wholesale price index.

Table 6. Comparison of Case III with Case IV

		1990	1995	1997	2001	2005
Number of milk cows (Tofuken)	Case IV (1)	770	819	830	845	859
(1,000) head)	Case III (2)	748	735	721	699	696
	(2)/(1)•100	97	90	87	83	81
Number of milk cows (Hokkaido)	Case IV (1)	360	382	389	399	409
(1,000 head)	Case III (2)	353	350	345	334	330
	(2)/(1)•100	98	92	89	84	81
Fluid milk supply	Case IV (1)	4,904	5,571	5,869	6,515	7,228
(1,000 ton)	Case III (2)	4,971	5,783	6,138	6,881	7,655
	(2)/(1)•100	101	104	105	106	106
Manufacturing milk supply	Case IV (1)	3,112	3,374	3,370	3,258	3,056
(1,000 ton)	Case III (2)	2,912	2,468	2,150	1,477	894
	(2)/(1)•100	94	73	64	45	29
Dairy imports	Case IV (1)	1,327	1,484	1,667	2,155	2,761
(1,000 ton)	Case III (2)	1,559	2,485	3,013	4,238	5,431
	(2)/(1)•100	118	167	181	197	197
Fluid milk price (Tofuken)	Case IV (1)	99	103	104	105	107
(yen/kg)	Case III (2)	92	84	81	78	79
	(2)/(1)•100	93	82	78	74	74
Guaranteed price	Case IV (1)	83	83	83	83	83
(yen/kg)	Case III (2)	76	65	61	54	48
	(2)/(1)•100	91	78	74	65	58
Blend price (Tofuken)	Case IV (1)	97	99	100	102	104
(yen/kg)	Case III (2)	90	82	80	77	79
	(2)/(1)•100	93	82	80	76	76
Blend price (Hokkaido)	Case IV (1)	80	83	83	85	87
(yen/kg)	Case III (2)	75	68	66	64	65
	(2)/(1)•100	93	82	80	76	76

Note: Case III = reducing guaranteed price by 3% annually and reducing standard purchase price by 1% annually; Case IV = maintaining FY 1987 levels of price supports. FY 1997 is the year when the guaranteed price and the standard purchase price are projected to be at the same level in Case III. FY 2001 is the year when fluid milk prices and the average price received by farmers are projected to rebound in Case III.

and imported natural cheese prices converted into raw milk equivalents are all fixed at the FY 1987 level. The volumes for which the deficiency payments are provided are the whole quantity which is earmarked for milk for manufacturing.

These simulation results are shown as Case III (reducing guaranteed and standard purchase prices) and Case IV (prices fixed at FY 1987 level) in table 6. As all price levels are unchanged in real terms in Case IV, price variables are almost constant and quantity variables seem to follow reasonably parallel trajectories from empirical trends during the forecasting years.

In Case III, the guaranteed price (*PP*) and the standard purchase price (*SP*) are projected to be at the same level, 61 yen per kilogram in FY 1997 and 48 yen in FY 2005. This means that deficiency payments would vanish by 1997. Corresponding with these reductions in guaranteed price, manufacturing milk supply is predicted to be 71% smaller than in Case IV in FY 2005 while fluid milk supply is predicted to be 6% larger than in Case IV in FY 2005. As a result, fluid milk price should decline and in FY 2001, the average price received by farmers is projected to be 77 yen in Tofuken, or 25% lower than in Case IV, and 64 yen in Hokkaido, also 25% lower than in Case IV. However, such reductions should cease at this level, and after FY 2001 the average price received by farmers will begin to rise. Dairy imports should be about two times larger than in Case IV in FY 2005. Cow numbers in FY 2005 are predicted to be 19% smaller in both Tofuken and Hokkaido, as compared with Case IV.

One of the important findings in this simulation is that the blend price received by farmers is expected to stop declining even if the guaranteed price continues to decline. The ratio of fluid milk to total domestic milk supply is predicted to be 90% by FY 2005. Eighty-six percent of manufacturing milk demand will be provided by dairy imports in FY 2005.

Summary and Conclusions

Price supports through deficiency payments and import quotas have resulted in Japanese milk production at least 20–30% greater than it would have been without price supports. Also, price supports have kept milk price fluctuations smaller, in terms of the coefficient of variation, than they would have been in a free market and as a result contributed to stabilizing the operation of both dairy farms and milk manufacturing firms.

A gradual reduction in the guaranteed price will make the ratio of fluid milk to total milk supply rise, and the temporary deficiency payment act can be repealed. In this case, as total fluid milk supply in Japan increases, fluid milk prices should fall, but are expected to stop falling at some level and rebound, if recent price and income elasticities for demand and the growth rate of the population and income remain unchanged. It is estimated that the lowest average prices received by farmers will be 64 yen in Hokkaido and 77 yen in Tofuken, if the annual average reduction rate in the guaranteed price is 3%. A guaranteed price reduction in the future means that the majority of Japanese dairy farmers will have to survive by depending on the fluid market.

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