# Support Prices as Policy Tools in Dairy Industry: Issues in Theoretical Modeling

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*Working Paper 96-WP 151*
February 1996

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**ABSTRACT**

*A framework for modeling the dairy sector is developed, emphasizing the complexities unique to this multiproduct industry. Equilibrium conditions among competitive and joint dairy products are specified subject to mass balancing requirements, stable economic relationships and appropriate policy parameters. The model is applied to Canada incorporating the country-specific dairy policy mix.*



**Key Words:** Canada, multiproduct modeling, dairy products, technological constraints, relative prices.

## SUPPORT PRICES AS POLICY TOOLS IN DAIRY INDUSTRY: ISSUES IN THEORETICAL MODELING

Intricate technical and economic relationships among various dairy products pose challenges in modeling the dairy sector because of the possible multiple input, output and intermediate product combinations. Modeling is further complicated because in most major dairy producing countries, especially the industrialized ones, the dairy sector is characterized by pervasive government intervention. These policies that distort production and consumption incentives for milk, as well as its derivative products, have caused substantial trade conflict recently as evidenced by the role of dairy in the overall GATT negotiations (Premakumar et al., 1994). Therefore, models for policy evaluations not only need to incorporate exact technological processing and transformation constraints, but should also impose output and trade restrictions in congruence with the current domestic and world trade policy scenarios.

This paper identifies several issues relating to the multiproduct market structure and how they should be incorporated into a macroeconomic general equilibrium model of the dairy industry that focuses on production, consumption and trade sectors. The next section discusses recent works in the dairy sector modeling and attempts to identify areas of concern. This is followed by a general conceptual framework for modeling the dairy industry, the primary difference from earlier work being the market-level disaggregation of industrial milk supply and use to the respective derivative products. This conceptual model is then applied to the Canadian dairy industry with the specific policy mix unique to that country.

### Issues in Dairy Sector Modeling

Milk is both a final good, consumed as liquid milk, and an intermediate input in manufacturing the primary derivative dairy products, butter and cheese. These manufacturing processes also produce joint products or byproducts with economic value. Skim milk is a byproduct of butter manufacturing from which either NFD (nonfat dry milk, which is the dried solids-nonfat component of milk) or casein (protein component of the solids-nonfat) can be produced. Technical transformation coefficients determine how much of each of these products can be produced per unit of milk. Modeling of the dairy sector for policy analysis has generally been attempted in a supply-demand equalization in standard econometric structural framework as well as in an optimization framework through programming approaches.[1] As pointed out by Bishop et al. (1993), both of these approaches have either been inadequate in their representation of reality, or were infeasible because they failed to adequately or appropriately incorporate the mass balancing constraints implied by these technical transformations.

Several econometric models have been developed to study various aspects of federal regulation of the U.S. dairy industry. These models are generally simplified by estimating aggregate demand for industrial milk as a function of own price, price of substitutes for the final consumption good - generally oils and fats, and income (LaFrance and de Gorter, 1985; Cornick and Cox, 1990; Liu et al., 1990; Liu et al., 1991; Bausell et al. 1992). Implicit in the assumption about the substitutes is that the final consumption goods for which the industrial milk is an intermediate product are the fat derivatives, butter and cheese. Thus, impacts of relative price movements in butter and NFD are not explicit. Further, although fluid (Class I) and industrial (Class II) milk prices are differentiated, such distinction is achieved by an exogenous policy-determined differential or by regressing them on exogenous support prices. These simplifications obscure some of the important price relationships among various products. Since domestic policies are often instituted through support prices for milk and/or dairy products, these relationships may be critical for optimal policy determination. Cluff and Stonehouse (1989) present a policy model for the Canadian dairy sector similar to the quarterly model developed by Stonehouse and Kizito (1990). Their econometric structure disaggregates industrial milk demand as originating from the final demand for butterfat and nonfat solids. Using this model to characterize the quasi-public monopoly structure of the Canadian dairy industry, Stonehouse and Kizito justify the NFD surpluses arising from butterfat self-sufficiency policies.

Alternative programming approaches to model the U.S. dairy industry have, in general, paid close attention to the multiproduct, vertically integrated nature of the industry. Chavas, Cox and Jesse (1993) offer a component pricing, spatial optimization model that characterizes the multiproduct nature of the dairy sector and maximizes overall welfare subject to the necessary technical coefficients. It is set as a multi-regional model, complemented by incorporating differential transshipment costs. Implicit in this objective function maximization approach in a spatial model is the assumption of a single decision

[1] Several national level structural models of the dairy sector have been used in the United States, some specifically developed for dairy policy analysis (National Economic Milk Policy Impact Simulator Model or NEMPIS, Dairy Market Policy Simulator or DaMPS, US Dairy Sector Simulator or USDSS and the Federal Order Simulator or FOS) and others, where the dairy sector is one component of a larger model system (FAPRI trade policy modeling system; USDA's Aggregate Dairy, Livestock and Poultry models under a CGE framework in the inventory-supply management study; and U.S. Forest Service's Impact Analysis for Planning model or IMPLAN, which is really an input-output accounting matrix system incorporating dairy as one of the 3,097 industries covered). Similarly, given the importance of policy interventions in the other major dairy producing countries of the world, a number of models have been used to analyze the dairy sectors of Australia, New Zealand, Canada, the European Union and Japan.

maker, and a notion that consensus exists on the (weighted) unit of surplus measure for aggregation across regions. The model is thus suitable for analyzing regional resource allocation within a country. Emphasis on the need to disaggregate *non-fluid* milk demand and to ensure consistent component balancing is noteworthy.

This paper develops an econometric model to address the supply-demand equalization and price determination of milk and its derivatives at a national level, so that we can then identify international trade implications of alternative policy options. It is developed in a small country, competitive market framework. Policy incorporation is then illustrated for Canada, where substantial domestic support policies have been used and have evolved over time. The Canadian policy impacts have been closely studied and attempts have been made to improve synchronization and fine tuning. We focus on the adequacy and appropriateness of the choice of policy intervention instruments given specific national objectives. More specifically, Canada has had dairy producer support policies in place over the last several years, and has targeted to provide certain minimum income at the national level without overproducing butterfat in order to avoid having to subsidize butter exports. Support prices for butter and NFD are consistent with a predetermined price margin to the milk producer. The result has been a gradual increase in the subsidized NFD surplus that enters the world market and that has met with disapproval from other traditional exporters. Stonehouse and Kizito contend that this is inevitable due to the technical relationship between butter and NFD and the national objective to be self-sufficient in butterfat. In developing our model, we reevaluate the price policy options in order to examine the effectiveness of the present policies. One principal conclusion is that, while these policy instruments are consistent with the policy objectives, they also serve as policy tools for further fine-tuning to counter unintended trade surpluses without compromising domestic income and self-sufficiency policies.

## A Conceptual Framework

The fluid milk supply is a product of the number of cows and per cow milk yield, both of which are modeled as behavioral functions. The number of cows responds to input-output price changes subject to biological constraints.[2] Higher milk prices, relative to feed and beef prices, could be expected to influence dairy herd building. On the other hand, increased beef and feed prices lead to lower female calf retention and earlier culling of cows. These relationships are specified in Equation 1 (Table 1),

[2] Herd building could be determined endogenously by incorporating the time lags between a new calf and heifer as well as between heifers and lactating cows. Although crucial for accurate determination of cycles in the total milk supply, the heifers equation has been left out of the current model for simplicity.

## Table 1. General dairy model structure

| | | |
|---|---|---|
| **A. Milk Supply & Allocation** | | |
| Cow No.: | $n_t = f(n_{t-1}, \frac{P_{m,t}}{P_{E,t}}, \frac{P_{m,t}}{P_{F,t}})$ | (1) |
| Milk Yields: | $\psi_t = f\{\psi_{t-1}, \frac{P_{m,t}}{P_{F,t}}, (n_t - n_{t-1})\}$ | (2) |
| Milk Production: | $y_{m,t} = n_t \bullet \psi_t$ | (3) |
| Distribution: | $y_{m,t} = y^F_{m,t} + y^M_{m,t}$ | (4) |
| Price of Fluid Milk: | $P^F_{m,t} = a_{P_0} + a_{P_1} P^M_{m,t}$ | (5) |
| Average Price of Milk | $P_{m,t} = \frac{P^F_{m,t} \cdot y^F_{m,t} + P^M_{m,t} \cdot y^M_{m,t}}{y_{m,t}}$ | (6) |
| *Endogenous* : $n_t, \psi_t, y_{m,t}, y^F_{m,t}, y^M_{m,t}, P_{m,t}, P^M_{m,t}$ and $P^F_{m,t}$. | | |
| **B. Demand for milk and milk products** | | |
| Standard Fluid Milk: | $d^S_t = f(P^S_{m,t}, P^L_{m,t}, \varpi_t, t)$ | (7) |
| Low fat Fluid Milk: | $d^L_t = f(P^L_{m,t}, P^S_{m,t}, \varpi_t, t)$ | (8) |
| Butter: | $d^B_t = f(P_{B,t}, \varpi_t, t)$ | (9) |
| Cheese: | $d^C_t = f(P_{C,t}, \varpi_t, t)$ | (10) |
| NFD: | $d^N_t = f(P_{N,t}, \varpi_t, t)$ | (11) |
| *Endogenous* : $d^F_t, d^L_t, d^B_t, d^C_t, d^N_t, P^S_{m,t}, P^L_{m,t}, P_{C,t}, P_{B,t}$ and $P_{N,t}$ | | |
| **C. Trends & Technical Relationships** | | |
| Fat Content of Standard Milk: | $\phi_t = f(t)$ | (12) |
| Fat in Low fat Milk: | $\lambda_t = f(t)$ | (13) |
| Butter from Fluid Milk: | $B^F_t = (\phi_t - \lambda_t) \bullet d^L_t$ | (14) |
| Industrial Milk Used in Butter: | $m^B_t = B^M_t / \beta$ | (15) |
| Butter Production: | $B_t = B^F_t + B^M_t$ | (16) |
| Industrial Milk Used in Cheese: | $m^C_t = C_t / c$ | (17) |
| NFD Production: | $N_t = (m^B_t) \bullet \eta$ | (18) |
| *Endogenous:* $\phi_t, \lambda_t, B^F_t, B_t, B^M_t, m^B_t, m^C_t, C_t$ and $N_t$ | | |
| **D. Equilibrium Conditions:** | | |
| Industrial Milk Use: | $y^M_{m,t} = m^B_t + m^C_t$ | (19) |
| Fluid Milk Market Clearing: | $y^F_{m,t} = d^S_t + d^L_t$ | (20) |
| Butter Market Clearing: | $B_t = d^B_t$ | (21) |
| Cheese Market Clearing: | $C_t = d^C_t$ | (22) |
| NFD Market Clearing: | $N_t = d^N_t$ | (23) |
| *Total Endogenous = 27* | | |
| *Exogenous:* $P_E, P_F, \omega_t, t, \beta, c$, *and* $\eta$ | | |

where the number of cows at time $t$ ($n_t$) is modeled as a function of own lag ($n_{t-1}$) and the prices of milk ($P_{m,t}$), beef ($P_{E,t}$) and feed ($P_{F,t}$).

Over the past several years, productivity in the dairy sector worldwide has increased multifold as a result of introduction of new management, veterinary and biological technologies. For example, artificial insemination and embryo transfer procedures, improved quality of feed, improved grasslands management, machine milking, and improved animal disease controls have contributed significantly to the rise in per cow milk production. Milk production has increased by about 22 percent in the Organization for Economic Cooperation and Development (OECD) countries from 1966 to 1992 (OECD 1993). This was achieved by a 49 percent increase in productivity, which more than offset the steady decline in cow numbers over this period. To capture these trends in productivity, the per cow milk yield equation incorporates a dependent lag variable. To account for the economic response to input/output prices, the milk-to-feed price ratio is also included as an explanatory variable. Change in cow numbers in this function is akin to the slippage argument forwarded in the Conservation Reserve Program for crops: accelerated culling can be expected to increase average herd yield, as low yielders are culled first. Conversely, herd building can occur through extended milking life as well as higher rate of heifer retention, both of which would lower the average yield.

Equation 4 is the allocation identity for milk supply, distributed between fluid and industrial uses. The supply of each is balanced by the corresponding demand equation, as shown in the demand and equilibrium blocks of Table 1. Milk used for fluid consumption needs to be fresher than that used for industrial products, and hence, a premium is often paid for fluid grade milk (Equation 5). Average price paid to farmers is calculated in Equation 6 as the weighted price of fluid and manufacturing milk. [3] Note that the milk supply block can be solved separately from the whole system given the information on component prices in Equation 6.

Since each of the dairy products has its own demand schedule that responds to changes in price, income and tastes and preferences, aggregating various manufactured products into one composite product would obscure impacts of relative price movements. In order to better understand the intricate technological and economic relationships among various dairy products, it is imperative to model these markets separately. Equations 7 through 11 represent the demands for standard fluid milk, low fat fluid milk, butter, cheese and nonfat dry milk powder (NFD).

Tastes and preferences for dairy products have changed over time. For example, consumption of low fat milk has been increasing while average fat content of low fat milk has been declining. This,

[3] The weighted price may include several components depending upon the pricing policies prevalent in a given country. For example, the U.S. ***blend price*** includes weighted average of three different prices: fluid grade (Class I), manufacturing grade used for soft products (Class II) and that used for hard products (Class III).

for butterfat output as a byproduct in the fluid industry. These dynamics are accounted for in the model by the trend arguments in demand equations as well as in Equations 12 and 13, which provide for time-varying technical relationships. Equations 14 through 18 specify the other technical relationships to impose the necessary mass balance, taking into account the alternative- and joint-product nature of the dairy products and milk allocation identities.

Using first-order conditions from the processor's optimization problem, a priori specifications of price relationships among the products are derived. Given the processor's profit maximization problem,

$$\pi_t = P_{B,t} \cdot B_t^M + P_{N,t} \cdot N_t + P_{C,t} \cdot C_t - P_{M,t} \cdot (\frac{B_t^M}{\beta} + \frac{C_t}{c})$$

where, $P_{i,t}$ is the price of the $i^{th}$ product ($i$ = butter, cheese, NFD and milk), the first-order conditions would imply:[4]

$$P_{B,t} = \frac{P_{M,t}}{\beta} - P_{N,t} \cdot \theta \quad (24)$$

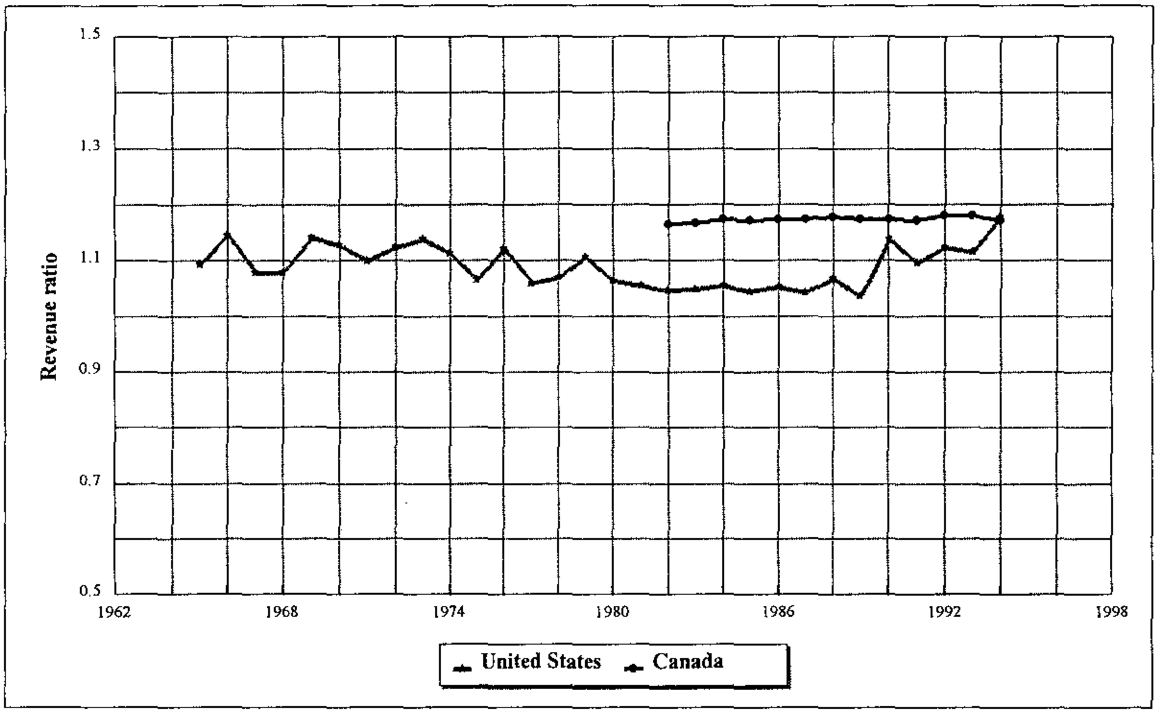
and

$$P_{C,t} = \frac{P_{M,t}}{c} . \quad (25)$$

Here, θ is the butter-NFD ratio specifying the rate of change in NFD production per unit change in butter production. These price relationships, determined by both economic and technical forces, are crucial to this model. Two important points need to be made here. Prices of butter, cheese and NFD cannot be independently fixed by policy: if the NFD and butter price combination makes butter production more profitable than cheese, obviously more milk will flow into the butter industry leading to a downward pressure on butter and NFD prices and an upward pressure on cheese price until equity is achieved in the two manufacturing processes. Historical relative revenue in butter-cum-NFD versus cheese manufacturing for Canada and the United States demonstrates the stability of this relationship. Figures 1 and 2 represent the ratio of revenue from producing cheese versus the total revenue from butter and NFD per unit of milk, at wholesale prices.

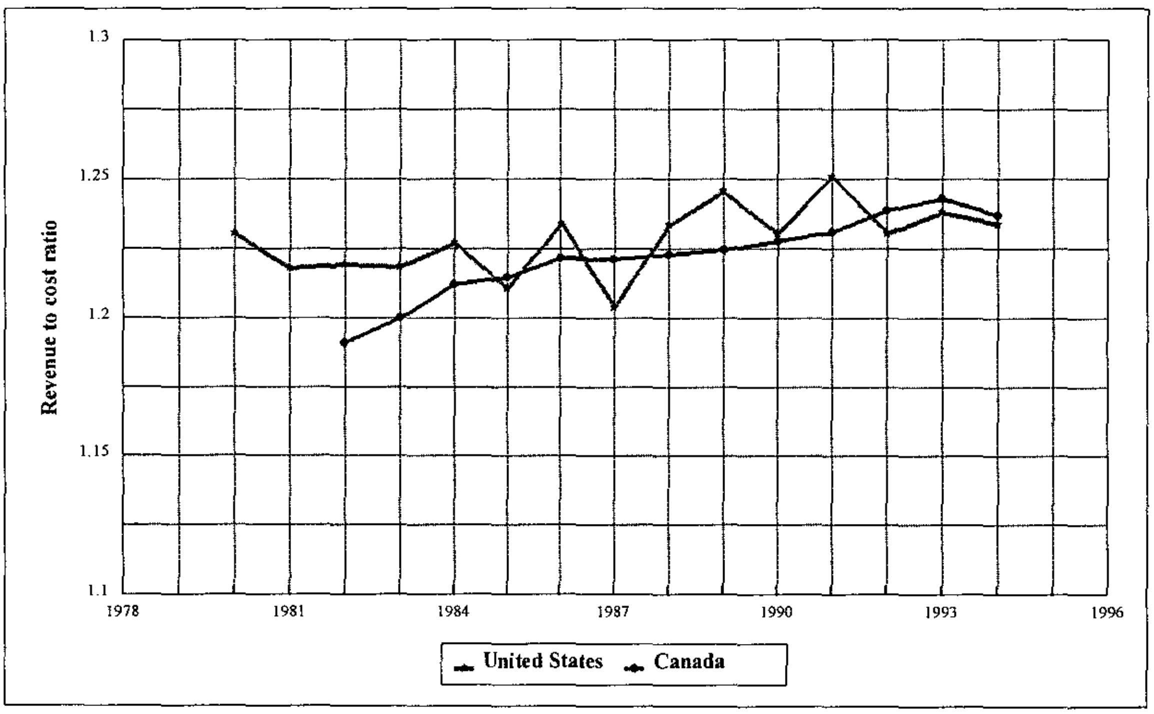
In Canada, where butter and NFD prices are controlled and the price of cheese is not, the data show that cheese price has moved to keep relative profitability very stable. The ratio, which is close to 1.18, implies that cheese manufacturing cost per unit of milk has remained at about 18 percent higher than the cost of butter-cum-NFD manufacturing. In the United States, the ratio is less stable, but long-run stability is evident. The U.S. policy intervention is through administered price support for all three

[4] Since on a micro (single processor) level, the increased use of milk for butter should not influence the overall availability of milk and the increased production of butter should not cause any changes in cheese output or milk used for fluid, this expression can easily be derived by ignoring the cross-effect terms such as $(\partial y^M_t / \partial B_t)$ and $(\partial C_t / \partial B_t)$.




$$\text{Ratio} = \frac{\text{Cheese Price} * \text{Milk-to-Cheese Conversion Factor}}{(\text{Buttter Price} * \text{Milk-to-Butter Conv. Factor}) + (\text{NFD Price} * \text{Milk-to-NFD Conv. Factor})}$$

**Figure 1. Relative revenue from industrial use of milk**




$$\text{Ratio} = \frac{\text{Cheese Price} * \text{Milk-to-Cheese Conversion Factor}}{\text{Industrial Milk Price}}$$

**Figure 2. Relative revenue in cheese manufacturing**

products. It is suggested here that any unstable price relationship imposed exogenously will lead to only a short-run volatility. Perhaps the unintended surpluses and consequent CCC stock changes in the past might have been caused by such forced price relationships. In this respect, the Canadian policy of support prices for only NFD and butter, and free movement of cheese prices, appears to be a more appropriate and consistent policy tool. It must also be noted that such price relationships, jointly determined by technology and economics, will be expected to exist among the other alternative product combinations too (such as cheese to industrial milk, low-fat milk-cum-butter versus whole milk, casein versus NFD, whole milk powder versus butter and NFD, etc.). Another important point to be made here is with regard to the impacts of inappropriate policy price combinations. Attempts to fine tune price policies, without a clear understanding of the intrinsic price relationships, could lead to cyclical proliferation of these policies and volatility in production, consumption, stocks and trade. Given the number of pricing policies in the United States for various classes and subclasses of milk, and the alternative (fat-based and solid-based) methods suggested for milk equivalency measures, the intrinsic price relationships suggested here could provide a sound basis for reexamining these policies for consistency.

The fluid milk can either be sold as the standard milk or converted into low-fat milk and butter. Therefore, in equilibrium, the relationship between the standard milk price and the prices of low-fat milk and butter may be specified as follows:

$$P^{S}_{m,t} = P^{L}_{m,t} \cdot \mu + P_{B,t} \cdot \beta \qquad (26)$$

where, $\mu$ is the milk-to-low fat-milk conversion factor and $\beta$ is the milk-to-butter conversion factor. Equation (26) thus implies that, on the margin, the revenue from standard milk should equal the revenue from fluid milk plus that from the butter component, per unit of milk.

Moreover, the price of fluid milk can be determined as a weighted average of standard milk and low-fat milk prices:

$$P^{F}_{m,t} = \frac{P^{S}_{m,t} \cdot Q_{S,t} + P^{L}_{m,t} \cdot Q_{L,t,N}}{Q_{S,t} + Q_{L,t}} \qquad (27)$$

The model may be closed by introducing market clearing identities for fluid milk and all other dairy products, for a closed economy with no stocks. Government intervention in the dairy industry is introduced in the following section, allowing for stocks and trade in dairy products.

## Modeling Government Intervention and Trade

Agricultural productivity in industrialized countries has been rising since the late 1950s, causing food prices to decline sharply. The rise in productivity and decline in prices of dairy products has been particularly pronounced, especially in industrialized countries. The yield increases in industrialized countries resulted in a steady decline in the number of dairy farms and farm animals. Demand increases for milk and other dairy products have been minimal, if not reversed, due to health concerns. The overall increased output has resulted in sharp declines in dairy product prices amid declining total consumption. Consequently, dairy farmers have experienced decreasing revenues along with increasing productivity, leading to extensive political pressure from this group for increased protection. Lobbying by farming groups as well as the government's concern for maintaining stable supplies of dairy products have contributed substantially to the level of assistance that dairy farmers receive in many of these countries. Governments in most industrialized countries intervene in the dairy product markets by guaranteeing purchases in order to stabilize prices.

The U.S. government stipulates a blend price for milk producers and buys up all surpluses of butter, cheese and NFD at pre-specified prices. The Canadian government adjusts the support (guaranteed purchase) prices for butter and NFD to ensure a set target return over cost to the dairy farmers. Therefore, both private and government stocks add to demand for these products. The government requires a certain percentage of production as a backup stock with the rate contingent upon the current prices. If prices are high, the government holds lower stocks and if the prices are too low, government stocks increase to strengthen prices. Thus the government stock is a supply-reducing policy variable: $S^G_{i,t} = \rho_i \cdot i_t$ where, $\rho_i = f(P_{i,t})$ and $i$ refers to the three dairy products. [5]

The private sector stock demand is profit motivated. The lower the price, the larger the stock level for speculative motives, that is, $S^P_{i,t} = f(P_i, S^P_{i,t-1}, S^G_{i,t})$. Where stocks cannot be differentiated as government and private stocks, stock demand may be modeled as stock share, decreasing with increasing price, and then stock volume can be computed as an identity: $S^H_{i,t} = f(P_{i,t})$ and $S_{i,t} = S^H_{i,t} \cdot i_t$.

The model can be closed by introducing trade at exogenous world prices. For example, three extra equations may be introduced to replace the supply-demand equilibrium conditions by allowing trade in dairy products (excluding milk): $\tau_{i,t} = i_t - d^i_t - S_{i,t}$ where, $\tau_i$ refers to net exports of the $i^{th}$ dairy product. However, each country has a unique set of trade policies, in general, to deter imports or aid exports of the surplus, and the specific policies need to be incorporated. Furthermore, GATT and other common policies impose restrictions on the choice or level of policy intervention for each country.

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[5] For example, $\rho_i = S_i^\rho + S_i^I P_i$ where, $S^I_{i,t} < 0$.

## Application to the Canadian Dairy Sector

Since each country has a unique set of government policy instruments that affect its dairy sector, our general model structure needs to be adjusted accordingly. Moreover, it is imperative to incorporate the policy objectives as well as policy instruments into the model in a way such that the instruments yield the desired objective.

Total demand for milk ($Q^d$) is the sum of demands for milk for fluid consumption ($Q^d_f$) and for industrial purposes ($Q^d_i$), as shown in Figure 3. There is a premium for fluid milk over and above the price of industrial milk.[6] This is represented by a shifted function $Q^{d'}_f$ to denote a price premium over $Q^d_f$, consistent with the notion that such a premium exists in demand but not in the supply of milk.

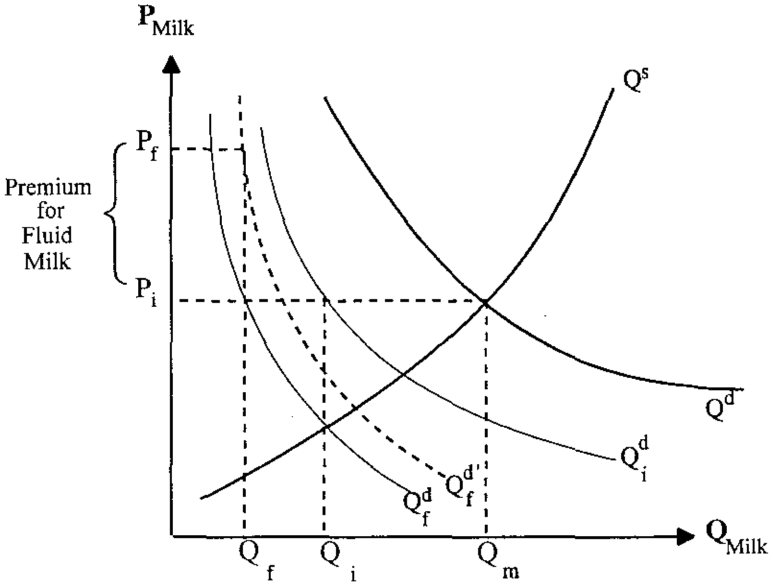


**Figure 3. Aggregate demand for milk**

Milk producers in Canada are supported by a target price (backed by butter and NFD support prices) as well as by a direct subsidy for each unit of milk sold. Target price is set to provide a specific dollar income over cost per unit of milk. This exogenous addition to producers' revenue is represented in the schedule $Q^{s'}$, which is shifted upwards over the supply or marginal cost curve, as shown in Figure 4. (This figure is simplified to represent merely the butter production demand, and can easily be extended to include the other product demands.) Further, the government paid C$1.675 per kilogram of butterfat

[6] Although this is carried out as a policy price, the premium for fluid milk seems reasonable since milk sold as fluid needs to be fresher and produced under stricter sanitary conditions than milk for industrial purposes. This argument is also supported by milk prices that are set according to the uses for which it is intended. For example, while fluid milk is the costliest, milk used to manufacture butter is the cheapest, with milk used for cheese/ice cream, etc. falling in-between these two limits.

to producers during 1991-92, which is equivalent to C$6.03 per hectoliter of milk containing 3.6 kilogram of butterfat (CDC 1992). This subsidy shifts the schedule $Q^d$ upwards to $Q^{d\prime}$. The government sets the milk production quota at $\overline{Q}$ so as to clear the milk market at the target price.[7] This quota can be shown to be consistent with (*a*) self-sufficient butter production achieved by the support price for butter and (*b*) free (domestic) market cheese equilibrium with restricted cheese imports. It is clear that the margin over cost to milk producers remains unchanged by the direct subsidy, although they gain by increased sales. The direct subsidy that increases producer revenue from the target price $P_T$ to $P^*$ in effect lowers the cost to milk processors, and there are welfare gains to processors from the government.

Production above quota is penalized by an over-quota levy to enable exports of unintended overproduction. Given the demand-supply structure of the milk market in this paper, it is evident that there is a supply response at margin to the world price rather than to the target price, at levels over $\overline{Q}$. As in Figure 5, milk supply will be $Q_m$, which is higher than the milk quota by the amount $\overline{Q}Q_m$. The

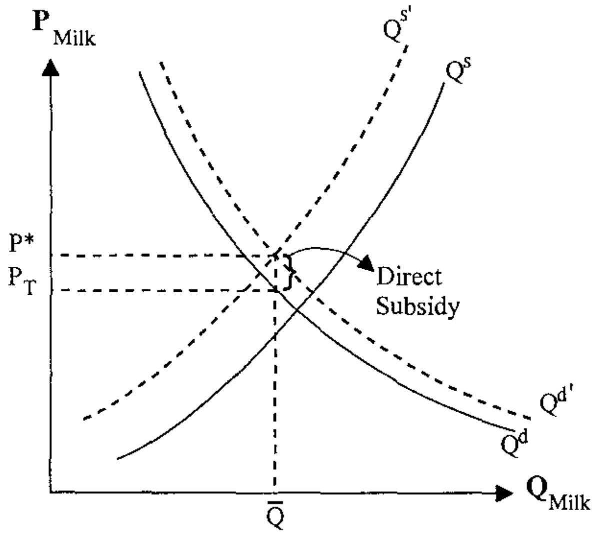


**Figure 4. Target pricing for milk in Canada**

government purchases the extra milk (or dairy products) but levies a penalty on excess production, which effectively reduces the price paid to farmers to the world price level.[8] Producers would receive the policy price $P_T$ for the $O\overline{Q}$ amount of milk and would have to pay the levy ($*L* per unit) on the excess

[7] The Canadian Milk Supply Management Committee (CMSMC) sets the milk quota for each province that, in turn, distribute their shares among the provincial dairy farmers. The support prices for butter and NFD are set by the Canadian Dairy Commission (CDC) so that the milk producers would receive the target price for milk.

[8] Under the National Milk Marketing Plan (a federal-provincial agreement), milk producers assume responsibility for the costs associated with the exports of dairy products. These levies are collected by the Provincial Marketing Boards and are remitted to the CDC on a monthly basis (CDC, 1992, p. 8). Funds collected through levies are used to finance special consumption promotion programs approved by the CMSMC.

amount equivalent to the shaded area in Figure 5. However, producers would benefit from the excess production as long as the world prices are higher than their per unit cost of production - as represented by the supply curve $Q^s$.

## Results and Discussion

The general structure provided in the previous section, along with these policy interventions, were used to develop the Canadian dairy model of the Food and Agricultural Policy Research Institute's (FAPRI) modeling system. The structural coefficients were estimated block-wise using 3SLS nonlinear estimation, over the period 1968 to 1993. Estimation variables are defined in Table 2 and the results from the log-linear estimation are presented in Table 3.

In the 29-equation system representation of the Canadian dairy sector developed here, seven equations are identities. The model was estimated block-wise, using 2SLS and as can be seen in Table 3, most of the equation specifications were validated and a vast majority of the structural parameters were significant. The simulation results were equally encouraging, and detailed results are available directly from the authors. The main contribution of this study however lies not on the significant coefficients and elasticities, but rather on the simple and consistent structural representation. This is useful to identify suitable policy options and assess their implications. Statistical significance of the coefficients and the model validation certainly strengthen our arguments.

The results confirm that in this complex multiproduct sector, technical conversion factors and mass balancing requirements across the total input-output matrix will force certain stable price relationships, characteristic of the market. Technical coefficients in converting milk to its derivative products and the relationship among the products together with the profit maximizing conditions at micro level among competitive producers establish intrinsic price relationship between the alternative product combinations. We wish to draw two policy implications arising from this stable price relationships. First implications is that such intrinsic price relationships limit the available instruments for policy manipulation in directing the sectoral performance. As can be seen in the case of Canada support price announcement for butter and NFD leads to a specific price for industrial milk. Should this milk price be different from the target price, fine tuning can be done by adjusting either or both butter and NFD prices. Further, note that a support price for cheese is not announced, yet through the historical period wholesale price of cheese has changed to retain a stable relationship as suggested by the first

**Table 2. Definitions of variables used in the empirical estimation**

| Acronym | Definition | Acronym | Definition |
|---|---|---|---|
| | ***Endogenous*** | | ***Exogenous*** |
| DMC | Cow numbers | GDP | Gross domestic product |
| DPME | Industrial milk price | BNRATIO | Butter/NFD price ratio |
| DBS_IND | Butter from industrial milk | TREND81 | Dummy variable for 1981 onwards |
| DBS | Total butter supply | MDGTR | Target milk price |
| DMBS | Industrial milk used in butter production | DIRPAY | Direct payment recd. by farmers |
| DMY | Milk yields | BUGSP | Butter support price |
| DCPRET | Cheese retail price | CMK_B | Milk-to-butter conversion factor |
| DBC | Butter consumption | MNGSP | NFD support price |
| DMS | Total milk supply | CMK_N | Milk-to-NFD conversion factor |
| DCC | Cheese consumption | CMK_C | Milk-to-cheese conversion factor |
| DNC | NFD consumption | OTHCRMRT | Other supplies of cream etc. |
| DMFSD | Standard fluid milk consumption | DMOTH | Industrial milk used in other products |
| DMFLD | Low fat fluid milk consumption | DCX | Specialty cheese imports |
| DLFAT | Fat content of low fat milk | POP | Population |
| DBS_LF | Butter from fluid milk | STERPRUS | U.S. Steer price |
| DWFAT | Fat content of whole milk | EXCH | Exchange rate (C$/US$) |
| DNS | NFD production | CPI | Consumer price index |
| CDPWH | Cheese wholesale price | SHFT82 | Dummy variables for 1982 onwards |
| MIPON | Fluid milk price (farm level) | CORNPRUS | U.S. corn price |
| MKPREH | Standard fluid milk retail price | | |
| MFPREH | Low fat fluid milk retail price | | |
| DBPRET | Butter retail price | | |
| DNPRET | NFD retail price | | |
| DMCS | Industrial milk used in cheese production | | |
| DMIS | Industrial milk supply | | |
| DCS | Cheese production | | |
| DBSK | Butter ending stocks | | |
| DNSK | NFD ending stocks | | |
| DCSK | Cheese ending stocks | | |

## Table 3. Results of log-linear model estimation for the Canadian dairy sector

1. LOG(DMC)=0.155+1.01LOG( $DMC_{t-1}$)+0.025LOG(DPME*100/CPI) -0.071LOG(STERPRUS*EXCH *100/CPI)
   (0.66) (25.8) (2.38) (-2.34)

2. LOG(DMY)=-1.086+0.139*SHFT82+0.598LOG($DMY_{t-1}$ )+0.122(DPME/(CORNPRUS*EXCH)) -2.105 LOG (DMC/$DMC_{t-1}$)
   (-1.8) (2.79) (1.94) (-3.13)

3. DMS = DMC * DMY

4. BNRATIO = 0.264 - 0.002 * TREND81 + 0.845 * $BNRATIO_{t-1}$
   () (-0.99) (120.47)

5. LOG(MDGTR-DIRPAY) = LOG (0.825) + 1.004 * LOG(BUGSP*CMK_B+MNGSP*CMK_N)
   (89.53) (344.92)

6. LOG(CDPWH*CMK_C) = LOG(1.257) + 1.029 LOG(MDGTR-DIRPAY)
   (70.73) (266.44)

7. LOG(MIPON) = LOG(0.745) + 1.108 LOG(MDGTR)
   (6.28) (26.48)

8. LOG(MKPREH*100) = LOG (0.457) + 1.381 LOG (MIPON)
   (7.32) (39.65)

9. LOG(MFPREH+(BUGSP*(3.25-1.74)/100) = LOG(1.073) + 0.705 (MKPREH)
   (187.78) (20.00)

10. BNRATIO = BUGSP/MNGSP

11. LOG(DBPRET) = LOG(0.798) + 1.205 LOG(BUGSP)
    (26.17) (45.28)

12. LOG(DNPRET) = LOG(1.25) + 1.61 LOG(MNGSP)
    (9.95) (15.04)

13. LOG(DCPRET) = LOG(0.705) + 1.532 LOG(CDPWH)
    (11.28) (25.09)

14. LOG(DBC/POP) = (-1.013 + 2.111) - 0.551 LOG(DBPRET*100/CPI) +1.277 LOG(GDP/POP) + (-0.125 - 0.925)LOG(YEAR-1974)
    ((-1.59) (5.81)) (-1.34) (5.25) (( -4.78) (-6.09))

15. LOG (DCC/POP) = (-0.02 + 0.428) - 0.524 LOG(DCPRET*100/CPI) + 0.991 LOG(GDP/POP) + (0.132 - 0.136) LOG (YEAR-1974)
    ((-0.02) (2.20)) (-1.46) (4.39) ((3.52) (-2.05))

16. LOG(DNC/POP)=(8.90+7.80)-7.737LOG(DNPRET*100/CPI)-4.113LOG(MIPON*100/CPI)+3.52(LOG(GDP/POP)+(-0.228-3.394)
    (0.29+0.83) (-0.38) (-0.44) (0.73) (-0.19-0.78)
    LOG (YEAR-1974)

17. LOG(DMFSD/POP) = -1.188 - 4.338 LOG(MKPREH/MFPREH)
    (-39.6) (-8.21)

18. LOG(DMFLD/POP) = -0.788 -0.187 LOG(MFPREH*100/CPI) + 0.177 LOG(YEAR-1972)
    (-17.45) (-2.06) (9.83)

19. DLFAT = 0.017 + 0.0004 (YEAR-1972) - 0.00002 $(YEAR-1972)^2$
    (51.95) (6.12) (-7.64)

20. DBS_LF = (CMK_B/(DWFAT/100))*(DWFAT/100-DLFAT)*DMFLD*(1-OTHCRMRT)

21. DBS_IND = DBS - DBS_LF

22. DMBS = DBS_IND / CMK_B

23. DNS = 0.750 (CMK_N * DMBS)
    (47.68)

24. DMCS = DMIS - DMBS - DMOTH

25. DCS = CMK_C * DMCS

26. DCX = -12.095 + 0.087 DCC
    (-3.20) (5.47)

27. DBSK = 44.222 - 13.675 LOG (DBPSUP)
    (1.63) -(0.79)

28. DNSK = 86.805 - 56.893 LOG (DNPSUP)
    (3.72) (-2.59)

29. DCSK = 92.627 - 28.205 LOG (DCPWH)
    (8.02) (-3.88)

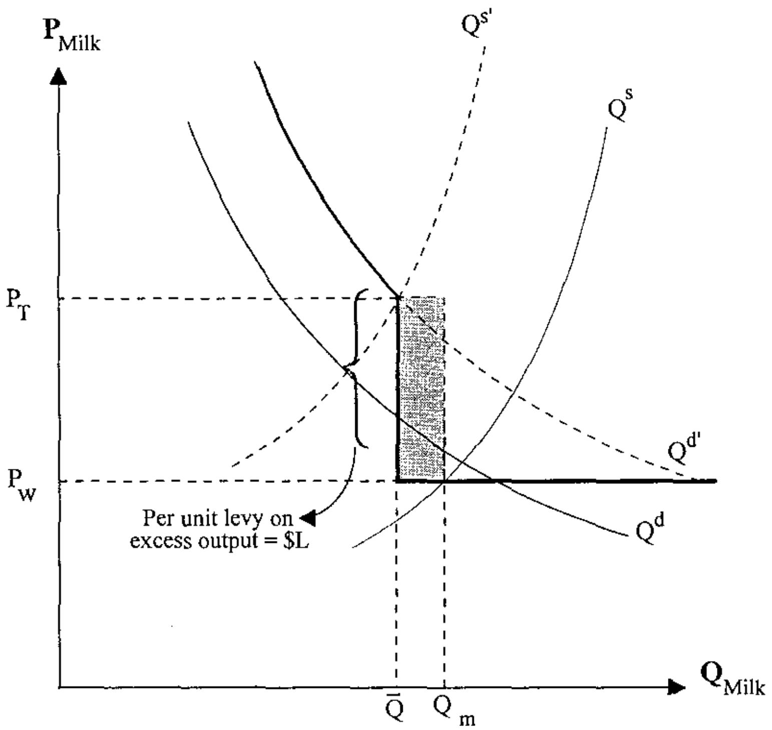


**Figure 5. Dairy policy outcome in Canada**

order conditions of profit maximization. Thus independent support prices for each of the above three products is neither necessary nor sustainable. The U.S. announces support prices for all three products, and the cheese to butter cum NFD revenue ratios have been more volatile than Canada in the short-run. The second implication is that a set target price for milk can be achieved through an infinite number of combinations of butter and NFD prices.

This concept of fine-tuning is illustrated in figure 6. The four quadrants represent price and quantity relationships between butter and NFD. The upper right quadrant relates the two prices. The downward sloping straight line *aa'* represents an iso-revenue line tracing all possible combinations of butter and NFD prices that provide a given level of returns per unit of milk used in manufacturing the joint-products. The opposite quadrant (lower-left) relates the quantity relationship between butter and NFD in production. The technical relationship between the two joint products are thus traced by a ray through the origin. The other two quadrants relate the price-quantity relationship of each of the products, respectively. The curves and $d_{NFD}$ represent the demand for the respective good. The line *aa'* thus represents all combinations of support prices for butter and NFD consistent with a specific target price for milk ($P_T$, less manufacturing margin) as in the case of Canada. Say, the government chooses the price combination $b_1n_1$ to maintain this target price of $P_T$. Self-sufficiency in butter is achieved with $B_1$ level of butter production at Price $b_1$. At this level of butter production, supply of the joint product, NFD, is at $S_1$ while demand is at $D_1$, resulting in a surplus of NFD. It can be similarly shown that, moving to $b_2n_2$ combination of support prices and producing butter to meet self-sufficiency, results in no change in target price level for milk but causes a deficit in NFD. Thus, there is a combination of support prices between the $b_1n_1$ and $b_2n_2$ combinations that would provide self-sufficiency in both commodities, and still be consistent with the given target price of milk.

In the Canadian policy mix, a particular price relationship between the joint products — butter and NFD — was predetermined, and as the target price of milk was revised upwards over time, both NFD and butter prices were proportionally increased (the 50:50 rule) to achieve the target price. Only in 1993-94 was the rule modified to 60:40 in favor of NFD with the goal to reduce the incentive for butter production in order to decrease NFD surpluses. It is also suggested here that various combinations of butter and NFD prices exist that are consistent with any specific target price for milk, and among these, there exists a unique combination that is consistent with exact and simultaneous self-sufficiency in both butter and NFD. The estimated structural coefficients can be used to fine-tune production-consumption levels, in accord with domestic and trade policies.

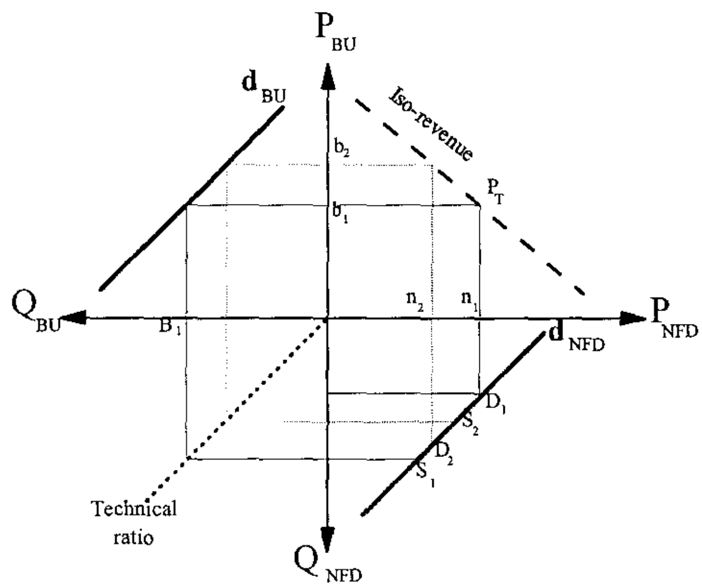


**Figure 6: Fine-tuning support prices for simultaneous self-sufficiency in butter and NFD**

In this regard, we wish to make note of the likely impact of this recent rule change in NFD and butter price setting. Relative strengthening of NFD price relative to butter price by substituting 60:40 rule for the 50:50 rule will theoretically leave processing revenue in the butter industry and hence, the quantity of milk entering butter processing unchanged. Relatively lower priced butter (lower than if 50:50 rule were applied) will result in self-sufficiency at a higher level, increased milk use for butter, and even higher surplus of the relatively higher priced NFD.

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