Trade and welfare effects of dairy price support measures

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Paper prepared for presentation at the American Agricultural Economics Association Annual Meeting, Montreal, Canada, July 27-30, 2003

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Abstract: *Analysis with a stylised model of milk price determination shows that on a dollar for dollar basis it is theoretically possible for milk price support resulting from discriminatory pricing to be as or even more trade distorting than milk price support resulting from explicit trade intervention in dairy product markets. Numerical results suggest that this result depends mainly on the initial trading status of the country in question. However, other parameters, especially the relative elasticities of demand for fluid versus manufacturing milk also matter.*

Key words: price discrimination, trade, dairy, welfare

Introduction

In almost every OECD country, milk producers receive higher prices because governments intervene in the markets for raw milk and dairy products. Estimated rates of milk market price support are among the highest of all commodities the OECD monitors for its Producer Support Estimate (PSE) calculations. (OECD, 2003) Governments intervene to obtain higher producer prices for raw milk using a package of mutually reinforcing domestic and trade policy measures. The typical package includes: 1) a target price for raw milk, 2) support prices for manufactured dairy products necessary to achieve that target price and 3) tariffs, tariff-rate quotas and export subsidies applied to imports or exports of tradable dairy products to defend the support prices. In a few countries, producer prices are further enhanced using extra revenues generated via discriminatory pricing on the domestic market.

Price support achieved through trade measures applied to tradable dairy products, *e.g.* butter, skimmed and whole milk powder, and cheese, results in domestic prices for those products that are higher than their corresponding world market prices. This drives up the prices dairy plants are willing to pay for the raw milk used to make protected dairy products which, through competitive domestic market price determination, then leads to higher prices paid for milk for all end uses. Discriminatory pricing arrangements, administered or sanctioned by the government, lead to prices paid for raw milk for some end uses (typically fresh milk products) that are higher than those paid for raw milk for other end uses (typically manufactured milk products). The additional revenue generated is then transferred back to farmers through a pooled or average price scheme.

Generally speaking, in countries where governments intervene both in traded dairy product markets and via discriminatory pricing on the domestic market the overall level of support may be increased, say, either by increasing trade interventions or by increasing the premium (and any associated tariff) charged domestic fluid milk consumers. The analysis to be reported here comprised comparisons of the effects of marginal changes in one or the other of these two types of intervention.

The remainder of the paper is divided into three parts. The following section describes some general characteristics of milk price discrimination arrangements and their potential effects. It includes a brief review of past work. In the second major section, a stylised model of milk pricing and policy is used to derive some general, qualitative results concerning differences in the market and trade effects of alternative milk price support measures. The third section develops a mathematical version of the model with a view to quantifying differences in the expected trade and welfare effects of the two types of policy measures. The final section concludes by summarizing the analysis.

The price effects of discriminatory pricing, results from previous studies

Price discrimination can lead to an increase in market receipts if buyers can be segregated into distinct groups in which those least responsive to price (*i.e.* those with the lowest price elasticity of demand) are charged the highest price. Segregating consumers and charging them different prices is possible of course only if the seller – whether a private company, co-operative, government agency or quasi-government institution – has market power.

In some countries, the government sets prices for different end-uses of milk by administrative fiat. In others, price premiums and discounts by end-use are determined by a state-trading agency or by a marketing institution (for example a co-operative) granted monopoly power by the government. The way buyers are segregated may also be different in different countries. The most common, and the main focus of this paper, is an arrangement under which domestic consumers are grouped in different demand categories. In other cases the pricing arrangements may lead to differences in prices charged across export markets.

Milk price discrimination and pooling systems exist in a number of countries. In Canada and the United States premiums for various end-uses of milk are determined under a classified pricing system administered by a government agency. In Japan, although the government does not administer any milk prices, it establishes regional marketing zones and regulates the distribution of milk. These regulations ensure that milk from lower cost regions cannot be transported to satisfy demand in higher priced fluid milk regions. Until recently, fluid milk market regulations were also imposed in Australia and the United Kingdom. However, Australia deregulated its fluid milk market in 2000 and the United Kingdom abolished the classified pricing system in 1994.

The impact of price discrimination in domestic milk markets has been analysed in Buxton (1977), Ippolito and Masson (1978), Dahlgran (1980), Helmberger and Chen (1994), Lippert (2001), Cox and Chavas (2001), Australian Bureau of Agricultural and Resource Economics (ABARE) (2001) and the Australian Competition and Consumer Commission (2001). The analytical and empirical studies illustrate that price discrimination reduces fluid milk consumption and increases the amount of milk available for processing. In addition, the average (pooled) price will be higher than the producer price in the absence of a pricing scheme (holding other support measures constant), and therefore leads to higher production levels. Fluid milk consumers who pay higher prices lose from price discrimination, while consumers of manufactured dairy products likely gain as manufacturing milk prices might be reduced by the scheme. However, empirical studies suggest that the higher cost of fluid milk far outweigh any benefit consumers gain from lower prices for manufacturing milk.[1] All these results are conditional on the complexity of a particular market and regulatory framework. Moreover, as price discrimination is usually accompanied by milk distribution restrictions the impact on producers is region specific.

In the majority of the studies discriminatory pricing arrangements are analysed in the context of a closed economy and not much attention has been paid to the impact of these arrangements on trade. Sumner (1999) is one of the very few studies analysing the trade distorting impact of discriminatory milk pricing arrangements. His study, focusing on the US Federal Milk Marketing Order system shows clearly that US exports and imports of manufactured dairy products will vary

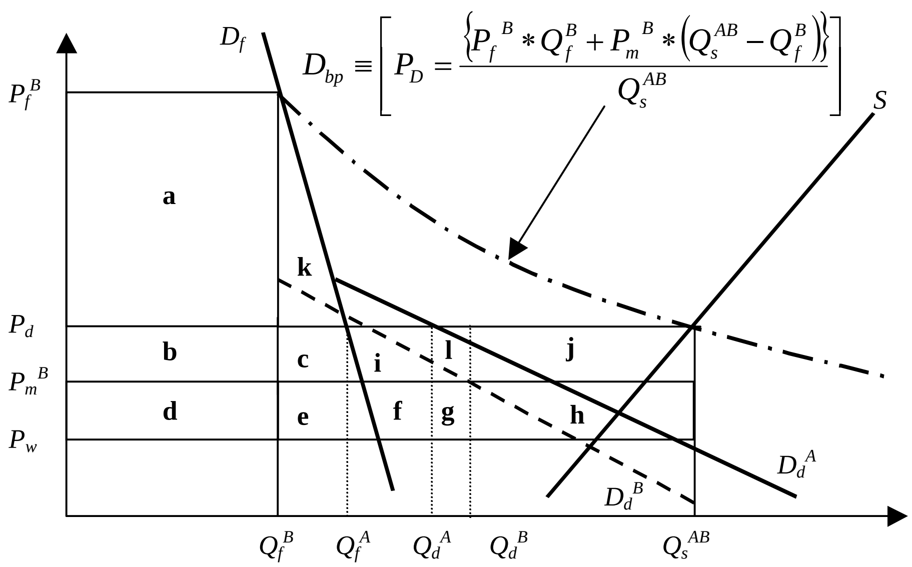
1. For the case of the United States, Ippolito and Masson (1978) estimate that the loss to consumers of fluid milk amounts to about USD 334 million while the gain to manufacturing milk consumers is about USD 120 million. Helmberger and Chen (1994) estimate the loss to fluid milk consumers in the United States to be USD 1000 million and the gain to manufacturing milk to be USD 600 million.

directly with the size of the price premium charged to consumers of fresh milk products. Bouamra-Mechemache *et al.* (2002) evaluated the options for developing a price discrimination policy in the EU dairy sector. Their analysis shows that the EU price discrimination without the EU quota system would significantly affect world prices and trade due to the increase in output resulting from the higher producer price under price discrimination. With the quota in place the impact on trade is considerably less. The authors claim that as long as price discrimination does not involve price discrimination between domestic and export markets, it might be WTO-compatible and, as such, a domestic price discrimination policy could be a partial substitute for more traditional policy measures.

A stylised model of dairy pricing and trade

The standard theoretical framework for analysing the market impacts of government intervention in milk pricing is developed in Buxton (1977), Ippolito and Masson (1978) and more recently in Sumner (1999) and Bouamra-Mechemache *et al.* (2002). Figure 1 constitutes a graphical representation of that framework. In this framework, there are only two end-use milk classes: fluid milk and manufacturing milk. Fluid milk is considered as non-traded with demand supplied exclusively from domestic production. Manufacturing milk is used entirely to manufacture tradable dairy products, the domestic supply of which could be greater (as in this illustration) or less than domestic consumption.

Figure 1 - Market effects of alternative milk price support measures



The line S in the diagram represents the total supply of raw milk (the marginal cost curve for milk production). There are two demand curves, D_f representing the demand for fluid milk and D_d^A representing the combined demand for fluid and manufacturing milk. Demand for manufacturing milk is given by the difference between D_d^A and D_f. Note that the slopes of the demand curves differ, reflecting a demand for fluid milk that is more inelastic than that for manufacturing milk.

To simplify matters, it is assumed that in the absence of government interventions in milk pricing, the price received by producers and paid by purchasers would be the same regardless of whether the milk is to be used for fluid purposes or for manufacturing dairy products.[2] Moreover, under these 'free-market' assumptions the domestic price would be equal (in raw milk equivalent terms) to an appropriately defined world market reference price — labelled P_w in Figure 1. Assume further that the country in question is small enough in world dairy trade to have no or negligible influence on world dairy prices.

Now, suppose there are two policy options for achieving a given producer price for milk — the price labelled P_d in Figure 1.Under the first policy option the government simply sets a flat support price that all purchasers of raw milk must pay. Of course, since that price is above the associated world market price, P_w, the government would have to defend it through the imposition of trade measures — export subsidies (as in the present illustration) and tariffs/tariff rate quotas.[3] The intersection of P_d and S determines the level of total milk production, Q_s^{AB}. The price P_d implies fluid milk consumption and production of Q_f^A. Manufacturing milk processors buy the rest of the milk produced ($Q_s^{AB} – Q_f^A$) also at the price P_d. Part of the manufacturing milk production will be consumed domestically ($Q_d^A – Q_f^A$) and part will be exported ($Q_s^{AB} – Q_d^A$).

If we assume that the quantity exported will have to be sold at the prevailing world price P_w, then the per unit export subsidy will equal (P_d - P_w) and total expenditure on export subsidies would amount to the area 'l' + 'j' + 'g' + 'h'. This is the financial transfer to producers from taxpayers.

2. However, the presence of transportation costs and seasonal payments might generate a market-driven fluid milk premium. The representation of this 'natural' premium would make the graphical analysis intractable. Nevertheless, the analytical framework remains valid if the demand schedules and administered prices as depicted in the diagram are viewed as net of transportation cost and seasonal premiums. (For further discussion see Ippolito and Masson.)

3. Note that applying trade measures [import tariffs, tariff rate quotas (TRQ's) and export subsidies] is analytically equivalent to supporting price by intervention buying.

The financial transfer to producers from consumers is represented by the area 'b' + 'd' + 'c' + 'e' + 'i' + 'f'.

Under the second policy option the government achieves the same targeted producer price P_d by using a combination of a flat support price, P_m^B in Figure 1, and an administratively determined fluid milk premium. This premium, represented in the diagram by the difference between P_f^{B} and P_m^B, is the extra amount that purchasers of raw milk destined for fluid uses must pay. The price producers receive under this arrangement is the weighted average of P_f^{B} and P_m^B where the weights are the quantities of milk going to each of the two end uses. In this example, the manufacturing milk price and administered fluid milk premium are set up such that producers receive the target support price P_d at the level of output Q_s^{AB}.

Since farmers face the same incentive price the level of total milk production is the same Q_s^{AB} in both cases. Under the combined regime the government can increase producer prices either by increasing the fluid milk premium or by increasing the flat support price. This means that with discriminatory pricing, the same desired target price P_d can be achieved with manufacturing milk prices set at the lower level P_m^B as compared to the policy relying only on trade measures. This is because producers under a policy of price discrimination get a part of their price support in consequence of higher prices charged consumers of fluid milk.

The diagram illustrates that in response to the increase in the fluid milk price caused by the introduction of the fluid milk premium, fluid milk consumption will fall to Q_f^B, *i.e.* a decrease of $(Q_f^A - Q_f^B)$. As a result of the higher fluid milk price and the shift in the starting point the combined demand curve D_d^A moves leftward to D_d^B. It follows that by lowering fluid milk consumption, more milk is left for manufacturing purposes $(Q_s^{AB} - Q_f^B)$. At the same time, following the introduction of the fluid milk premium, domestic consumers of manufacturing products will face the lower price P_m^B. Accordingly, the domestic consumption of manufactured products is higher, and is equal to $(Q_d^B - Q_f^B)$. The difference $(Q_s^{AB} - Q_d^B)$ will be exported, attracting a per-unit export subsidy equal to $(P_m^B - P_w)$ and a lower total expenditure on export subsidies - the amount shown by area 'h'. Note that the area 'j' is effectively being *"cross-subsidised"* by domestic fluid milk consumers.

The total transfer to producers from consumers that follows the introduction of the fluid milk premium can be split into two parts: a transfer due to the discriminatory pricing arrangements and a transfer associated with trade measures. In Figure 1, the former is represented as area ‘a’ + ‘b’, and the latter is represented as areas ‘d’ + ‘e’ + ‘f’ + ‘g’. (The financial transfer from taxpayers to producers is represented as area ‘h’.) Note that since P_d is the weighted average of P_f^B and P_m^B, the area ‘a’ is equal to the area ‘c’ + ‘i’ + ‘l’ + ‘j’.[4] The unit market price support created by discriminatory pricing arrangements is now equal to the price gap between P_d and P_m^B. The unit market price support attributable to the flat support price is equal to the gap between P_m^B and P_w.

When milk prices are supported only via trade measures, fluid milk consumers enjoy greater consumer surplus by area ‘a’ + ‘k’ as compared to when the same amount of price support is achieved under discriminatory pricing. Conversely, consumers of manufactured products under discriminatory pricing benefit from greater consumer surplus as compared to the outcome obtained using trade measures alone (a result that is difficult to represent in the graph due to the shift of the demand curve). In effect, price support achieved using discriminatory pricing shifts the associated cost burden from consumers of manufactured dairy products, and taxpayers if the country is a net exporter, to consumers of fluid milk products.

The implications of the two policy alternatives for the volume of trade itself are not as straightforward. Figure 1 is drawn in such a way that less quantity has to be exported under the combined regime. The reduction in exports ($Q_d^B – Q_d^A$) is due to the fact that, in the diagram, the increase in fluid milk price reduces the fluid consumption by less than the decrease in manufacturing milk price boosts the manufacturing milk consumption. However, in general terms, the outcome is ambiguous. In some circumstances, net trade could be greater with the combined regime. The result depends critically on the numerical values of certain economic parameters. Analysis with the algebraic version of the model in Figure 1 permits further insights into these relationships.

4. The area ‘a’ = ‘c’ + ‘i’ + ‘l’ + ‘j’ is equivalent to $(P_f^B – P_d)\, Q_f^B = (P_d – P_m^B)\, (Q_s^{AB} – Q_f^B)$. By rearranging the equation we get $P_d\, Q_f^B + P_d\, (Q_s^{AB} – Q_f^B) = P_f^B Q_f^B + P_m^B\, (Q_s^{AB} – Q_f^B)$. By further simplifying we arrive at the formula for the average producer price that is: $P_d = (P_f^B Q_f^B + P_m^B\, (Q_s^{AB} – Q_f^B))\, /Q_s^{AB}$.

Algebraic version of the model

The supply-demand equations corresponding to the graphical version of the dairy pricing model shown in Figure 1 are as follows:

Raw milk supply: $Q_s = S\,(P_s)$ (1)

Fluid milk demand: $Q_f = D_f\,(P_f)$ (2)

Manufacturing milk demand: $Q^m{}_d = D_m\,(P_m)$ (3)

Weighted average producer price: $P_s = \dfrac{P_f Q_f + P_m (Q_s - Q_f)}{Q_s}$ (4)

Exports: $X = Q_s - Q_f - Q^m{}_d$ (5)

where $S\,(P_s)$ is the milk supply function, $D_f\,(P_f)$ is the fluid milk demand function, $Q^m{}_d$ is the quantity demanded of manufacturing milk, $D_m(P_m)$ is the manufacturing milk demand function and all other symbols have the same meaning given them in discussing Figure 1. Since P_s is the weighted average of P_f and P_m, P_s can be written as equation (4). X is net export of dairy products (milk equivalent term) and it can have a negative value if imports exceed exports. All quantities and prices are considered in liquid units.

Assuming that milk supply and demand functions are of the constant elasticity form, the total differentials of equations (1) through (5) can be written as follows:

$$dQ_s = S'(P_s)dP_s = \frac{\varepsilon Q_s}{P_s} dP_s \qquad (6)$$

$$dQ_f = D_f{}'(P_f)dP_f = \frac{\eta_f Q_f}{P_f} dP_f \qquad (7)$$

$$dQ_d^m = D_m{}'(P_m)dP_m = \frac{\eta_m Q_d^m}{P_m} dP_m$$

(8)

$$dP_s = \frac{Q_f\left(1+\eta_f - \frac{P_m}{P_f}\eta_f\right)}{Q_s\left(1+\varepsilon - \frac{P_m}{P_s}\varepsilon\right)} dP_f + \frac{Q_s - Q_f}{Q_s\left(1+\varepsilon - \frac{P_m}{P_s}\varepsilon\right)} dP_m \tag{9}$$

$$dX = dQ_s - dQ_f - dQ^m{}_d \tag{10}$$

where ε, η_f and η_m are the elasticities of milk supply, fluid milk demand and manufacturing milk demand respectively.

Effects of producer price change

To quantify the relative trade effects and welfare impacts of the two types of government intervention, we examine the effects of a marginal increase in the producer price P_s on: net exports (or imports) of dairy products, producer surplus, and consumer surplus and taxpayers costs. The welfare measures are quadratic approximations based on Taylor series expansion. From equations (1) through (10), these effects can be written as follows:

Change in net exports:

$$\frac{dX}{dP_s} = \frac{dQ_s}{dP_s} - \frac{dQ_f}{dP_s} - \frac{dQ_d^m}{dP_s} \tag{11}$$

Change in producer surplus:

$$\frac{dPS}{dP_s} = \frac{\int_a^{P_s+dP_s} S(x)dx - \int_a^{P_s} S(x)dx}{dP_s} = \frac{\int_{P_s}^{P_s+dP_s} S(x)dx}{dP_s} \approx \frac{\{S(P_s)\}(dP_s) + \frac{S'(P_s)}{2}(dP_s)^2}{dP_s} \tag{12}$$

Change in manufacturing milk consumer surplus:

$$\frac{dCS_m}{dP_s} = \frac{\int_{P_m+dP_m}^{+\infty} D_m(x)dx - \int_{P_m}^{+\infty} D_m(x)dx}{dP_s} = -\frac{\int_{P_m}^{P_m+dP_m} D_m(x)dx}{dP_s} \approx -\frac{\{D_m(P_m)\}(dP_m) + \frac{D_m'(P_m)}{2}(dP_m)^2}{dP_s}$$

$$= -\frac{\left\{Q_d^m + \frac{1}{2}\left(dQ_d^m\right)\right\}(dP_m)}{dP_s} \leq 0 \quad \text{[Since } 0 \leq dP_m;\ dQ_d^m \leq 0;\ \text{and } |dQ_d^m| \leq Q_d^m\text{]} \tag{13}$$

Change in fluid milk consumer surplus:

$$\frac{dCS_f}{dP_s} = \frac{\int_{P_f+dP_f}^{+\infty} D_f(x)dx - \int_{P_f}^{+\infty} D_f(x)dx}{dP_s} = -\frac{\int_{P_f}^{P_f+dP_f} D_f(x)dx}{dP_s} \approx -\frac{\{D_f(P_f)\}(dP_f) + \frac{D_f'(P_f)}{2}(dP_f)^2}{dP_s}$$

$$= -\frac{\left\{Q_f + \frac{1}{2}\left(dQ_f\right)\right\}(dP_f)}{dP_s} \leq 0 \quad \text{[Since } 0 \leq dP_f;\ dQ_f \leq 0;\ \text{and } |dQ_f| \leq Q_f\text{]} \tag{14}$$

Change in taxpayer costs:

$$\frac{dTC}{dP_s} = b\left(\frac{dX}{dP_s}\right) + X\left(\frac{dP_m}{dP_s}\right) + \left(\frac{dX}{dP_s}\right)\left(\frac{dP_m}{dP_s}\right)(dP_s) \tag{15}$$

where dPS is the change in producer surplus; dCS_m and dCS_f are the changes in consumer surplus in the manufacturing milk market and in the fluid milk market respectively; dTC is the change in taxpayer costs[5]; a indicates the point where the supply curve meets the price axis (an arbitrarily small positive value that is less than P_s); and b is the initial price gap between a manufacturing milk demand price and an appropriately defined world market price for raw milk.

From equations (6), (7), (8), (12), (13) and (14), equations (11) through (14) can be rewritten as follows:

$$\frac{dX}{dP_s} = \frac{\varepsilon Q_s}{P_s} - \frac{\eta_f Q_f}{P_f}\left(\frac{dP_f}{dP_s}\right) - \frac{\eta_m Q_d^m}{P_m}\left(\frac{dP_m}{dP_s}\right) \tag{16}$$

$$\frac{dPS}{dP_s} \approx Q_s + \frac{\varepsilon Q_s}{2P_s}(dP_s) \tag{17}$$

5. Taxpayer costs are positive when the country in question is a net exporter of dairy products as the government must pay subsidies to encourage purchases of surplus production. These costs could be negative for a net importing country where the government collects the tariff revenues.

$$\frac{dCS_m}{dP_s} \approx -\left\{\frac{\eta_m Q_d^m (dP_s)}{2P_m}\left(\frac{dP_m}{dP_s}\right)^2 + Q_d^m\left(\frac{dP_m}{dP_s}\right)\right\} \tag{18}$$

$$\frac{dCS_f}{dP_s} \approx -\left\{\frac{\eta_f Q_f (dP_s)}{2P_f}\left(\frac{dP_f}{dP_s}\right)^2 + Q_f\left(\frac{dP_f}{dP_s}\right)\right\} \tag{19}$$

When a trade measure is used to achieve a given increase in P_s the price gap between fluid milk and manufacturing milk (fluid milk premium) is assumed to remain at its initial level such that, $dP_f = dP_m$. In this case, equations (16) through (19) and (15) become as follows:

$$\left.\frac{dX}{dP_s}\right|_{dP_f=dP_m} = \left.\frac{dX}{dP_s}\right|_{trade} = \frac{\varepsilon Q_s}{P_s} - \left(\left.\frac{dP_f}{dP_s}\right|_{dP_f=dP_m}\right)\left(\frac{\eta_f Q_f}{P_f} + \frac{\eta_m Q_d^m}{P_m}\right)$$

$$= \frac{\varepsilon Q_s}{P_s} - \frac{Q_s x}{Q_f y}\left(\frac{\eta_f Q_f}{P_f} + \frac{\eta_m Q_d^m}{P_m}\right) \quad \text{where} \begin{cases} x = 1 + \varepsilon - \dfrac{P_m}{P_s}\varepsilon \\ y = \dfrac{Q_s}{Q_f} + \eta_f - \dfrac{P_m}{P_f}\eta_f \end{cases} \tag{20}$$

$$\left.\frac{dPS}{dP_s}\right|_{dP_f=dP_m} = \left.\frac{dPS}{dP_s}\right|_{trade} \approx Q_s + \frac{\varepsilon Q_s}{2P_s}\left(dP_s|_{trade}\right) \tag{21}$$

$$\left.\frac{dCS_m}{dP_s}\right|_{dp_f=dP_m} = \left.\frac{dCS_m}{dP_s}\right|_{trade} \approx -\left\{\frac{\eta_m Q_d^m (Q_s)^2 x^2 \left(dP_s|_{trade}\right)}{2P_m (Q_f)^2 y^2} + \frac{Q_d^m Q_s x}{Q_f y}\right\} \tag{22}$$

$$\left.\frac{dCS_f}{dP_s}\right|_{dp_f=dP_m} = \left.\frac{dCS_f}{dP_s}\right|_{trade} \approx -\left\{\frac{\eta_f Q_f (Q_s)^2 x^2 \left(dP_s|_{trade}\right)}{2P_f (Q_f)^2 y^2} + \frac{Q_s x}{y}\right\} \tag{23}$$

$$\left.\frac{dTC}{dP_s}\right|_{dP_f=dP_m} = \left.\frac{dTC}{dP_s}\right|_{trade} \approx \left\{b + \frac{Q_s x\left(dP_s|_{trade}\right)}{Q_f y}\right\}\left\{\frac{\varepsilon Q_s}{P_s} - \frac{Q_s x}{Q_f y}\left(\frac{\eta_f Q_f}{P_f} + \frac{\eta_m Q_d^m}{P_m}\right)\right\} + X\left(\frac{Q_s x}{Q_f y}\right) \tag{24}$$

Consider now the case where the supposed increase in P_s is achieved only through an increase in the fluid milk premium without any change in the trade measures, i.e. $dP_m = 0$. In this case, equations (16) through (19) and (15) become as follows:

$$\left.\frac{dX}{dP_s}\right|_{dP_m=0} = \left.\frac{dX}{dP_s}\right|_{DPA} = \frac{\varepsilon Q_s}{P_s} - \left(\left.\frac{dP_f}{dP_s}\right|_{dP_m=0}\right)\frac{\eta_f Q_f}{P_f} = \frac{\varepsilon Q_s}{P_s} - \frac{\eta_f Q_s x}{P_f z} \quad \text{where } z = 1+\eta_f - \frac{P_m}{P_f}\eta_f \qquad (25)$$

$$\left.\frac{dPS}{dP_s}\right|_{dP_m=0} = \left.\frac{dPS}{dP_s}\right|_{DPA} \approx Q_s + \frac{\varepsilon Q_s}{2P_s}\left(dP_s|_{DPA}\right) \qquad (26)$$

$$\left.\frac{dCS_m}{dP_s}\right|_{dP_m=0} = \left.\frac{dCS_m}{dP_s}\right|_{DPA} = 0 \qquad (27)$$

$$\left.\frac{dCS_f}{dP_s}\right|_{dP_m=0} = \left.\frac{dCS_f}{dP_s}\right|_{DPA} \approx -\left\{\frac{\eta_f Q_f (Q_s)^2 x^2 \left(dP_s|_{DPA}\right)}{2P_f (Q_f)^2 z^2} + \frac{Q_s x}{z}\right\} \qquad (28)$$

$$\left.\frac{dTC}{dP_s}\right|_{dP_m=0} = \left.\frac{dTC}{dP_s}\right|_{DPA} \approx b\left(\frac{\varepsilon Q_s}{P_s} - \frac{\eta_f Q_s x}{P_f z}\right) \qquad (29)$$

Quantitative differences in trade and economic impacts

To see the differences in trade and welfare impacts due to trade measures and those due to discriminatory pricing, consider the difference between the set of equations (20) through (24) and equations (25) through (29). Note that $dP_s|_{trade} = dP_s|_{DPA}$, since the increases in P_s via trade measures and discriminatory pricing arrangements are assumed to be the same in this analysis. The results of the calculations are as follows:

$$\left.\frac{dX}{dP_s}\right|_{trade} - \left.\frac{dX}{dP_s}\right|_{DPA} = \frac{\eta_f Q_s x}{P_f Q_f yz}\left[1-\left(\frac{\eta_m}{\eta_f}\right)\left\{\frac{P_m}{P_f}\left(1+\eta_f\right)-\eta_f\right\}\left(\frac{Q_d^m}{X+Q_d^m}\right)\right] \qquad (30)$$

$$\left.\frac{dPS}{dP_s}\right|_{trade} - \left.\frac{dPS}{dP_s}\right|_{DPA} = 0 \qquad (31)$$

$$\left(\left.\frac{dCS_m}{dP_s}\right|_{trade} + \left.\frac{dCS_f}{dP_s}\right|_{trade}\right) - \left(\left.\frac{dCS_m}{dP_s}\right|_{DPA} + \left.\frac{dCS_f}{dP_s}\right|_{DPA}\right)$$

$$= -\frac{Q_d^m Q_s x}{Q_f y}\left[\left(dP_s\right)\frac{\eta_m Q_s x}{2P_m Q_f y}\left\{1+\frac{P_m Q_f \eta_f}{P_f Q_d^m \eta_m}\left(1-\frac{y^2}{z^2}\right)\right\} + \left\{1+\frac{Q_f}{Q_d^m}\left(1-\frac{y}{z}\right)\right\}\right]$$

$$\text{where } dP_s|_{trade} = dP_s|_{DPA} = dP_s \qquad (32)$$

$$\left.\frac{dTC}{dP_s}\right|_{trade} - \left.\frac{dTC}{dP_s}\right|_{DPA}$$

$$= \frac{Q_s x}{\left(X + Q_d^m + Q_f z\right)}\left[\frac{b\eta_f\left(X + Q_d^m\right)}{P_f z}\left\{1 - \frac{\eta_m P_f Q_d^m z}{\eta_f P_m\left(X + Q_d^m\right)}\right\} + \left(dP_s\right)Q_s\left\{\frac{\varepsilon}{P_s} - \frac{x}{Q_f y}\left(\frac{\eta_f Q_f}{P_f} + \frac{\eta_m Q_d^m}{P_m}\right)\right\} + X\right] \tag{33}$$

Relative trade effect

Given that the demand for fluid milk is considered to be relatively inelastic, it may safely be assumed that $-1 \leq \eta_f < 0$. Since our assumptions also imply $0 < P_m \leq P_s \leq P_f$, we may say that $1 \leq x$ and $0 \leq z \leq y$. The relative trade impacts of the two policy measures can then be summarized as follows:

$$\left.\frac{dX}{dP_s}\right|_{trade} \overset{>}{\underset{<}{=}} \left.\frac{dX}{dP_s}\right|_{DPA} \Leftrightarrow \frac{X + Q_d^m}{Q_d^m} \overset{<}{\underset{>}{=}} \left\{\left(\frac{P_f}{P_m}\right)\left(1 + \eta_f\right) - \eta_f\right\}\left(\frac{\eta_m}{\eta_f}\right) \tag{34}$$

The result in (34) shows that while both trade measures and domestic arrangements distort trade, there is no guarantee that one is worse than the other – the result depends on initial conditions and parameter values. The key factors determining relative trade impacts are the initial trading status of the country, $(X+Q_d^m)/Q_d^m$; the initial relative supported prices of fluid and manufacturing milk, P_f/P_m; and the relative magnitudes of the elasticity of demand for fluid versus manufacturing milk, η_m/η_f. The two assumptions: that $(P_f/P_m)>1$ and that $(\eta_m/\eta_f)>1$ yield an unambiguous result for one important special case. It is that market price support resulting from trade measures (tariffs and their equivalent) will always be more trade distorting than market price support due to discriminatory pricing if the country in question is *not* a net exporter of dairy products.

In some other cases though, those two conditions: higher initial prices for fluid milk and a lower elasticity of demand for fluid milk are not enough. And, in particular, for a net *exporting* country, market price support due to discriminatory pricing will be relatively less trade distorting than market price support due to trade measures only if exports represent a small enough share of total manufacturing milk use – as demonstrated in the numerical analysis to follow. Moreover, the higher the initial gap between fluid and manufacturing milk prices the more likely that a marginal change in market price support due to a (further) increase in fluid milk prices will be less trade distorting than an equivalent increase in market price support due to trade measures.

Relative economic costs and benefits

It is clear that the changes in milk supply in the two policy experiments are the same because the increases in Ps through the two policy measures are the same. Equation (31) shows then that the changes in producer surplus in the two policy experiments are equal.

From equations (32) and (33), we may obtain the following (sufficient but not necessary) conditions for determining the relative impacts of consumer surplus and taxpayer costs:

$$\left(\left.\frac{dCS_m}{dP_s}\right|_{trade}+\left.\frac{dCS_f}{dP_s}\right|_{trade}\right)\begin{matrix}>\\=\\<\end{matrix}\left(\left.\frac{dCS_m}{dP_s}\right|_{DPA}+\left.\frac{dCS_f}{dP_s}\right|_{DPA}\right)$$
$$\Leftarrow\left\{1+\eta_f\left(1-\frac{P_m}{P_f}\right)\right\}\begin{matrix}<\\=\\>\end{matrix}\frac{X+Q_d^m}{Q_d^m}\begin{matrix}<\\=\\>\end{matrix}\left(\frac{P_f}{P_m}\right)\left(\frac{\eta_m}{\eta_f}\right)\left[\frac{Q_f\left\{1+\eta_f\left(1-\frac{P_m}{P_f}\right)\right\}^2}{Q_s+Q_f\left\{1+2\eta_f\left(1-\frac{P_m}{P_f}\right)\right\}}\right] \quad (35)$$

$$\left.\frac{dTC}{dP_s}\right|_{trade}>\left.\frac{dTC}{dP_s}\right|_{DPA}\Leftarrow 1<\frac{X+Q_d^m}{Q_d^m}<\left\{\left(\frac{P_f}{P_m}\right)\left(1+\eta_f\right)-\eta_f\right\}\left(\frac{\eta_m}{\eta_f}\right) \quad (36)$$

Propositions in (35) and in (36) reveal that the key factors determining relative economic costs of market price support due to trade measures versus discriminatory pricing are the same as those determining relative trade effects ($(X+Q_d^m)/Q_d^m$, P_f/P_m and η_m/η_f). However, those parameters are embedded in expressions that do not as readily lend themselves to general interpretations. We can make some progress in comparing relative *consumer* costs by using a simpler approximation to the welfare change – one based on the *first-order* Taylor series. In this case, the result in (35) simplifies to:

$$\left(\left.\frac{dCS_m}{dP_s}\right|_{trade}+\left.\frac{dCS_f}{dP_s}\right|_{trade}\right)\begin{matrix}>\\=\\<\end{matrix}\left(\left.\frac{dCS_m}{dP_s}\right|_{DPA}+\left.\frac{dCS_f}{dP_s}\right|_{DPA}\right)\Leftrightarrow\frac{X}{Q_d^m}\begin{matrix}>\\=\\<\end{matrix}\eta_f\left(1-\frac{P_m}{P_f}\right) \quad (35')$$

With this simpler version it is clear that in the case of *net exporters*, the reduction in total consumer surplus due to an increase in trade measures is always less than that due to discriminatory pricing arrangements. (In this case the ratio of exports to domestic consumption of manufacturing milk is positive. The last term in (35′) is unambiguously negative.) In the case of net importers, the reduction in consumer surplus due to an increase in trade measures will be greater than that due to discriminatory pricing only if the ratio of imports to manufacturing milk demand is *large enough*, i.e. greater than $|\eta_f(1-P_m/P_f)|$. Note that if $P_m=P_f$, the relative impact of total consumer surplus is solely determined by the initial trading status. We should not overlook though that these alternative propositions are valid only when we examine an infinitesimal change in P_s, as opposed to propositions in (35). We now turn to some illustrative empirical calculations based on equations (34), (35) and (36).

Numerical estimation of trade and economic impacts

Tables 1 and 2 contain results obtained by plugging into the expressions in equations (35) and (36) some alternative empirical values judged 'plausible' based on supply-demand conditions representative of OECD countries and on elasticities drawn from the literature.[6] Each table contains two major column headings corresponding to the trading status of the country– the ratio of domestic manufacturing milk production to domestic consumption. Table 1 contains results illustrating two *importing* country cases – one corresponding to a country that imports one-half of its consumption of manufactured dairy products, the other to a country that imports only ten percent of its consumption. Similarly, Table 2 contains results illustrating two *exporting* country cases – one for a country that exports ten percent of its consumption of manufactured dairy products, the other a country whose exports are three times domestic consumption. There are three major groups of rows in the table with each group itself containing three rows. The three major row headings correspond to alternative cases for the ratio of the elasticity of demand for manufacturing milk to that for fluid milk. The three minor row headings, repeated for each one of the relative elasticity cases, correspond to alternative initial ratios of fluid milk price to manufacturing milk price. The only other key parameters identified in the above analysis with the algebraic version of the model and not covered in Tables 1 and 2 are the ratios of fluid milk consumption to total milk consumption – the fluid milk share. All the calculations in Table 1 and 2 were based on a fluid milk share of forty percent.

6. The estimations of key parameter values are mainly based on Aglink and PSE database in terms of seven major milk-producing countries in the OECD in 2001: Australia, Canada, European Union, Japan, Mexico, Switzerland and the United States.

The cell entries are all either plus or minus signs. A plus sign indicates that, for the corresponding indicator, the effects of price support due to trade measures are greater than are the effects of price support due to discriminatory pricing. So that, for example, in the columns headed with the label 'Trade volume' a '+' sign indicates that market price support due to trade measures is more distorting to trade than is discriminatory pricing – and vice versa. Likewise, a negative sign in one of the three columns headed 'Consumers cost' (the negative of the change in consumer surplus) indicates that some consumers might prefer trade measures to discriminatory pricing.

The trade volume results confirm the findings obtained with the algebraic version of the model and synthesized in equation (34) and related discussion above. The trade volume effects due to trade measures are always greater than those due to discriminatory pricing if the country in question is a net importer – regardless of the settings of other key parameters. However, the trade volume effects of discriminatory pricing can be less than those due to trade measures if the country in question is a 'large enough' exporter. Note the result in Table 2 for the trade volume indicator for the exporting country whose initial ratio of exports to domestic consumption is 3.0. Likewise, the trade volume indicator for the case of an exporting country exporting only ten percent of its manufacturing milk consumption illustrates the result that for a country exporting a *small enough* percent of production, the trade volume effects due to market price support afforded via trade measures is greater than the trade volume effects of discriminatory pricing – i.e. the same result as for a net importing country. Results for the trade volume indicator for the second country case in Table 2 (Trade ratio=3.0) also reveal that trade measures may be more or less distorting than discriminatory pricing depending on relative elasticities of demand. When the elasticity of demand for milk used to manufacture dairy products is high relative to that for fluid milk, trade measures are relatively more distortive and vice versa.

Table 1. Qualitative comparisons of effects of alternative market price support measures for selected indicators: importing countries

Key parameter values		*Qualitative comparisons for selected indicators* [c]											
		Trade ratio[d] =0.5						**Trade ratio[d] =0.9**					
The ratio of demand elasticity[a]	**Price ratio[b]**	Trade volume	Consumer costs			Taxpayer costs	Social costs [e]	Trade volume	Consumer costs			Taxpayer costs	Social costs [e]
			mnf	*fluid*	*total*				*mnf*	*fluid*	*total*		
3.0	1.4	+	+	–	+	–	+	+	+	–	+	+	+
	1.1	+	+	–	+	–	+	+	+	–	+	+	+
	1.0	+	+	–	+	–	+	+	+	–	+	+	+
2.0	1.4	+	+	–	+	–	+	+	+	–	+	+	+
	1.1	+	+	–	+	–	+	+	+	–	+	+	+
	1.0	+	+	–	+	–	+	+	+	–	+	+	+
1.2	1.4	+	+	–	+	–	+	+	+	–	+	–	+
	1.1	+	+	–	+	–	+	+	+	–	+	–	+
	1.0	+	+	–	+	–	+	+	+	–	+	–	+

(a) The ratio of the demand elasticity for manufacturing milk to that for fluid milk, η_m/η_f.
(b) The ratio of the initial fluid milk price to the initial manufacturing milk price, P_f/P_m.
(c) A plus indicates that the impact of trade measures is greater than that of domestic pricing arrangements; and a minus indicates the reverse.
(d) The ratio of the domestic manufacturing milk production to the domestic demand for manufacturing milk, $(X+Q_d^m)/Q_d^m$.
(e) The change in social costs can be estimated as: $(dTC/dP_s) - (dPS/dP_s) - (dCS/dP_s)$. Since (dPS/dP_s) in the two policy measures are the same, the difference in social costs can be calculated as: $\{(dTC/dP_s\rfloor_{trade}) - (dTC/dP_s\rfloor_{DPA})\} - \{(dCS/dP_s\rfloor_{trade}) - (dCS/dP_s\rfloor_{DPA})\}$. [where: dTC/dP_s = the change in taxpayer costs; dPS/dP_s = the change in producers' surplus; and dCS/dP_s = the change in total consumers' surplus]

Table 2. Qualitative comparisons of effects of alternative market price support measures for selected indicators: exporting countries

Key parameter values		*Qualitative comparisons for selected indicators* [c]													
The ratio of demand elasticity[a]	Price ratio[b]	Trade ratio[d] =1.1						Trade ratio[d] =3.0							
		Trade volume	Consumer costs			Taxpayer costs	Social costs [e]	Trade volume	Consumer costs			Taxpayer costs	Social costs [e]
			mnf	*fluid*	*total*				*mnf*	*fluid*	*total*		
3.0	1.4	+	+	–	–	+	+	+	+	–	–	+	–
	1.1	+	+	–	–	+	+	+	+	–	–	+	+
	1.0	+	+	–	–	+	+	0	+	–	–	+	+
2.0	1.4	+	+	–	–	+	+	–	+	–	–	+	–
	1.1	+	+	–	–	+	+	–	+	–	–	+	–
	1.0	+	+	–	–	+	+	–	+	–	–	+	–
1.2	1.4	+	+	–	–	+	–	–	+	–	–	+	–
	1.1	+	+	–	–	+	+	–	+	–	–	+	–
	1.0	+	+	–	–	+	+	–	+	–	–	+	–

(a) The ratio of the demand elasticity for manufacturing milk to that for fluid milk, η_m/η_f.
(b) The ratio of the initial fluid milk price to the initial manufacturing milk price, P_f/P_m.
(c) A plus indicates that the impact of trade measures is greater than that of domestic pricing arrangements; a minus indicates the reverse; and zero indicates no difference.
(d) The ratio of the domestic manufacturing milk production to the domestic demand for manufacturing milk, $(X+Q_d^m)/Q_d^m$.
(e) The change in social costs can be estimated as: $(dTC/dP_s) - (dPS/dP_s) - (dCS/dP_s)$. Since (dPS/dP_s) in the two policy measures are the same, the difference in social costs can be calculated as: $\{(dTC/dP_s\rfloor_{trade})-(dTC/dP_s\rfloor_{DPA})\} - \{(dCS/dP_s\rfloor_{trade})-(dCS/dP_s\rfloor_{DPA})\}$. [where: dTC/dP_s = the change in taxpayer costs; dPS/dP_s = the change in producers' surplus; and dCS/dP_s = the change in total consumers' surplus]

It is clear that the estimated impacts regarding consumer surplus on the two milk markets are different. The results for this indicator in Tables 1 and 2, confirms that the economic costs paid by manufacturing milk consumers under the policy experiment with discriminatory pricing arrangements would always be less than that with trade measures; while for fluid milk consumers it would always be the other way around. When a trade measure is used, the consumer prices for both fluid milk and manufacturing milk are increased, costing both fluid milk and manufacturing milk consumers. When discriminatory pricing arrangements are applied, on the other hand, the fluid milk price is increased without changing the gap between the manufacturing milk and the world reference prices, imposing costs on just fluid milk consumers.

Despite the ambiguity of results for total consumer costs revealed in analysis with the algebraic version of the model there is a consistent pattern of related numerical results in Table 1. For all the cases examined the result depends only on the initial trading status of the country. If the country in question is a net importer the consumer costs of trade measures are, without exception, greater than those of discriminatory pricing. On the other hand, if the country in question is a net exporter and regardless of the share of exports in total manufacturing milk production, total of consumer costs are less with discriminatory pricing.

While initial trading status seems enough, for the cases examined, to determine comparative consumer costs of trade measures versus discriminatory pricing, this is not the case for taxpayer costs. For an exporting country, as proposition in (36) implies, the taxpayer costs of implicit export subsidies (i.e. financial transfer to producers to taxpayers) mean that trade measures are likely to be more costly than discriminatory pricing arrangements. For an importing country though, this depends - especially on the relative elasticities of demand. When the elasticity of demand for manufacturing milk is low relative to that for fluid milk trade measures are less costly to taxpayers, but not when the difference between those elasticities is high. See the result for the taxpayer cost indicator for the second country case in Table 1. Finally, the total social costs of trade measures generally exceed those of discriminatory pricing except for the large exporter case.

Conclusions

Tariffs, tariff rate quotas and export subsidies are visible interventions leading to distortions in world trade in dairy markets. Discriminatory pricing arrangements create less obvious but analogous effects. This drives us to the question which kind of policy creates the greater effects. Results of our analysis show that there are four key parameters determining the relative effects: the initial trading status; the relative prices of fluid and manufacturing milk; the relative elasticities of demand for fluid and manufacturing milk; and the share of fluid milk in total milk production. Results from numerical analysis strongly suggest that it is the first of these that is most important in determining relative cost and trade effects.

Regarding the relative trade effects, under plausible elasticity assumptions, trade measures applied by an importing country will, for a given amount of price support provided, always be more trade distorting than pricing arrangements. There are possibilities of the reverse happening for an exporting country where the elasticities of demand for fluid and manufacturing milk are close to each other and the initial fluid milk premium is small.

In general, the relative consumer costs (total for manufacturing and fluid milk consumers) of trade measures will be higher than for discriminatory pricing if the country in question is an importer and the other way around if the country in question is an exporter. Comparative taxpayer costs also depend largely on initial trading status but on other key parameters – especially the relative elasticities of demand. Generally speaking, although there are exceptions, the domestic total welfare costs of the two measures depend in the same way as total consumer costs on the initial trading status of the country.

The numerical analysis refers only to a limited number of individual cases developed for illustrative purposes. This limits greatly the generality of the conclusions. A more complete analysis would include Monte Carlo type simulations wherein greater ranges of plausible parameter values could be systematically and jointly considered.

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