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TRANS-TASMAN TRADE IN MANUFACTURED DAIRY PRODUCTS: A MATHEMATICAL PROGRAMMING MODEL OF IMPERFECT SECTORAL COMPETITION

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New dairy arrangements under the Closer Economic Relationship agreement with New Zealand will eliminate existing voluntary restraints on trade in manufactured dairy products. Current marketing arrangements in both the Australian and New Zealand industries may allow the formation of a stable duopoly. A mathematical programming model of a 'Stackelberg' duopoly was used to evaluate the potential incentives for and outcomes of Trans-Tasman trade in manufactured dairy products. The results show that under current Australian dairy export policies, trade in dairy products with New Zealand could result in transfer payments from Australia to the New Zeland dairy industry.

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Introduction

Under the Closer Economic Relationship (CER) agreement with New Zealand, barriers to trans-Tasman trade in dairy products will be eliminated in July 1990. The effects of this agreement on the Australian and New Zealand dairy industries are closely linked to the marketing policies of both industries. Australian domestic marketing policies allow for separation of the domestic and export markets for manufactured dairy products. The New Zealand Dairy Board because of its monopolistic powers has the power to limit the volume of exports sent to the Australian market. A mathematical programming model of the Australian dairy manufacturing industry was used to evaluate the potential implications of trade with New Zealand under these market conditions.

Restrictions on the import of manufactured dairy products has allowed the Australian dairy industry to differentiate prices on the domestic and export markets. Under the 'Kerin Plan', in effect until 30 June 1992, levies on all milk produced are used to support exports. This has had two important effects. First, returns from producing manufacturing milk have been greater than would occur if dairy processors had not received export support payments. Second, as the industry tends to equate the return from both the domestic and export markets, domestic market prices are held above world prices. This creates an incentive for the New Zealand industry to bring in dairy products under CER.

The response of the New Zealand industry to these incentives is under the control of a monopolistic authority, the New Zealand Dairy Board. Under existing Australian export support arrangements, New Zealand exports to the Australian market will displace domestic sales of Australian products to the export market. An increase in the volume of Australian exports will lower the rate of export support and prices in the domestic market. Consequently, New Zealand faces a downward sloping demand for its exports into the Australian market. By limiting the volume of exports New Zealand can take a price leadership role and equate marginal cost with marginal revenue. As Australian producers do not have explicit controls on supplies, they may respond competitively to prices. This leads to a 'Stackelberg' duopoly solution to dairy trade under CER.

The principal design problem encountered in this paper was the development of a mathematical programming model which represented the incentives for production and trade for both industries. This involved the design of an objective function and constraints from the marginal conditions of the duopoly solution. The parameters of the model were then selected in two stages. Where available, demand elasticities and technical parameters were taken from published sources. The remaining parameters were determined so that the model replicated base period values for production, domestic consumption, exports and the prices of manufactured dairy products and manufacturing milk. The model was then used to simulate the effects of liberalisation of trade with New Zealand on the demand for manufacturing milk in Australia and the composition of domestic consumption and exports.

Industry Background

The Australian dairy industry consists of over 17 000 dairy farms, producing nearly 6200 ML of milk a year. Approximately 30 per cent of this production is sold as fresh or market milk. The remaining milk is used to produce manufactured dairy products, of which 60 per cent is consumed on the domestic market. The major dairy products are cheese, milk powders and butter. In total, these products account for about 80 per cent of all milk used in manufacturing. Cheese is the dominant manufactured product in terms of both volume and revenue. Roughly 60 per cent of Australian cheese is of cheddar varieties.

The Australian dairy processing industry is presently operating under the 'Kerin Plan', now in its third year. The plan allows for a transfer of income from the sale of market milk and domestic manufactured products, to the export sector. The principal instruments of the plan are a milk levy and export support payments. The milk levy is collected against all milk produced in Australia. In addition, a levy is collected from the sale of butter and cheddar type cheeses on the domestic market. Support payments are made directly to manufacturers for all products sold on the export market. Given that trade in manufactured products is restricted, manufacturers may equate marginal returns from the domestic and export markets. Consequently, domestic prices are pitched above export prices at the export support rate, plus any additional product levies.

The levy for 1988-89 is set at 45c/kg butterfat or about 2c/L on all milk produced in Australia. Product levies on domestic sales of butter and cheese will average $435/t and $70/t, respectively. The total levy pool for 1988-89 is estimated to be about $150M. The estimated export support rate is about 21 per cent. Product levies will be discontinued after June 1989, as a part of the phased reduction of export support foreshadowed in the Kerin plan. This is estimated to result in about a 20 per cent reduction in moneys available for export support. Under the current plan, regulations governing the all milk levy and export support will remain in place until 1992.

Export support arrangements are administered by the Australian Dairy Corporation (ADC) under the supervision of the federal government. At the beginning of the year the ADC estimates export prices and levy collections and calculates the rate of export support. In addition to the constraint imposed by the amount of available support funds, there is a maximum support rate of 30 per cent. The calculated rate of support is paid on a per unit basis, regardless of the actual export prices received by producers during the year. Support payments are made by the ADC to the exporters once export contracts are confirmed. A surplus or shortfall in the market support fund is carried over into the next year.

New Zealand

The New Zealand dairy industry consists of about 16 000 dairy farms, producing over 7000 ML of milk a year. Over 90 per cent of the milk is used to produce manufactured dairy products. The major products are milk powders, butter and cheese. New Zealand production of manufactured dairy products in 1987-88 was in excess of 350 kt of milk powders, 200 kt of butter and 130 kt of cheese. The large majority of cheeses produced in New Zealand are cheddar varieties.

The New Zealand industry is a strongly export reliant industry, exporting nearly all its production of milk powders and over 80 per cent of its butter and cheese production. The capacity of New Zealand to expand into the Australian market especially in milk powders is evident. However, exports of cheese to Australia may be limited and may depend on the ability of the industry to expand its cheese production. Roughly, one half of New Zealand's 100 kt of cheese exports are sold in Japan and the United States. Sales of cheese in Australia are in excess of 135 kt of which 120 kt are produced in Australia. As New Zealand currently exports 7 thousand tonnes of cheese to Australia and has the infrastructure already in place, the cost of redirecting further cheese exports to Australia will be small.

In contrast to Australia, the export of dairy products in New Zealand is controlled by the New Zealand Dairy Board. The Dairy Board buys all products which are to be exported and markets these products worldwide. The Board may influence the pattern of manufactured product through its purchase prices. The main objective of the Dairy Board is to maximise returns from the international market.

<u>Market structure for manufactured dairy products under CER</u>

The market structure of the Australian domestic market for manufactured dairy products under CER is likely to be characterised by imperfect competition. The New Zealand Dairy Board has monopoly control over dairy exports and may limit the volume of product exported to Australia. While the Australian industry does not have supply controls on manufactured dairy products, the export support scheme can regulate domestic prices in the absence of competing imports. The domestic market for manufactured dairy products in Australia under CER may be characterised as a duopoly.

Economic models of duopoly yield a range of market outcomes depending on assumptions made about the marketing strategies of the competing industries. At one extreme of this range is marginal cost pricing which yields the equivalent of a perfectly competitive market solution. At the other extreme is perfect collusion, which yields a joint monopolist solution, in which the marginal costs of each industry are equated with joint industry marginal revenue. A number of intermediate duopoly solutions have been considered, in which each producer is assumed to anticipate the response of its competitor to a change in the level of production or price. Producers maximise profit subject to the conjectural response of a competitor. In general, there is no theoretical basis for assuming what form this conjectural response will take. However, in the case of dairy trade between Australia and New Zealand, the different sources of market power in each industry may lead to a well defined 'Stackelberg' duopoly. (For a general discussion, see Henderson and Quandt 1980.)

A single product case is illustrated in Figure 1. In Australia, domestic prices are controlled through the level of export support. Individual producers may be assumed to respond competitively to these prices. Domestic demand and supply, in the absence of trade with New Zealand, are illustrated in panel a. Domestic demand and total supply are given by the curves dd and ss, respectively. Over the relevant range, the supply to the domestic market (s1s1) is perfectly elastic at the subsidy rate (s') which just exhausts the moneys collected under the all milk levy. Imports from New Zealand displace domestically produced and consumed products onto the export market. This lowers the rate of export support and prices received in the domestic market by reducing the quantity of product available to support prices. Thus, New Zealand faces a downward sloping demand curve, illustrated by the curve d'd' in panel b. As New Zealand has monopoly controls over quantities exported, profits are maximised when marginal costs are equated with marginal revenue, given by the intersection of mr' an mc in panel b. The prevailing price in all markets is given by p*, imports from New Zealand by q and Australian domestically produced product by q* less q. In the case of multiple products, the demand and marginal revenue curves (d' and mr') are jointly determined by the level of all products exported by New Zealand and prevailing export prices.

Where domestically produced product is completely transferred to the export market, at a subsidy rate of s", the relevant demand schedule for

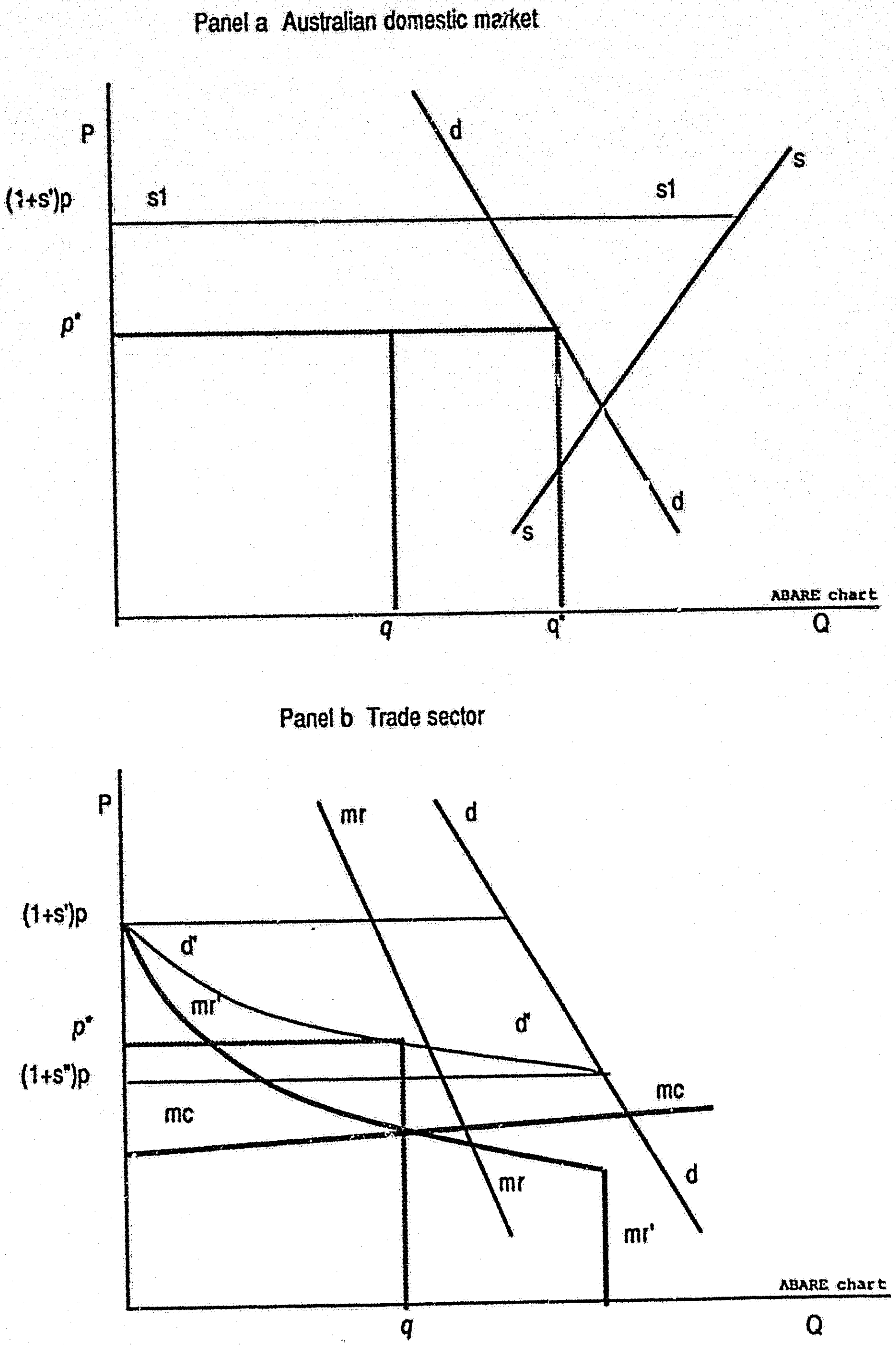

Figure 1 Duopoly dairy trade solution under CER

additional New Zealand exports is given along the curve dd. Marginal revenue takes into account the effect of an increase in quantity on the price of all exported product. Thus, marginal revenue for additional exports falls along the marginal revenue curve associated with the domestic market demand curve (mr).

Model Development

A mathematical programming model of the dairy processing sector was developed to evaluate the effects of trade with New Zealand. The specific objectives were, first, to estimate the demand for manufacturing milk in Australia under alternative trade arrangements and, second, to estimate the composition of domestic consumption and exports of processed dairy products.

The approach taken was to develop a price endogenous programming model with sectors representing Australian domestic consumption, exports, production and trade with New Zealand in processed dairy products. The problem was to design an objective function and a constraint set such that an optimal solution represents the response of Australian producers and the New Zealand industry to the removal of trade restrictions. The objective function of the model is an artificial construct in that it does not represent a value which is of concern to either producers or industry. Under conditions of perfect competition, the objective function of a price endogenous or spatial equilibrium model can be given a welfare interpretation (McCarl and Spreen 1980). However, this interpretation cannot be extended, in general, to programming models of imperfect competition.

The objective function and constraints were derived from the marginal cost and revenue conditions, faced by market participants, that give rise to the duopoly solution outlined in the previous section. Furthermore, the imposition of constraints on New Zealand imports or the level of export support allow for model solutions representing current marketing arrangements or competitive trade. The model is developed for each sector in the following sections.

Domestic returns

As the potential number of sellers on the domestic market is large, pricing on the domestic market is assumed to be competitive. The domestic market component was developed as a quadratic programming model, allowing the simplest representation of endogenous price determination. Marginal returns to domestic sales of each product are given by price, as determined along a demand schedule. A linear demand function is assumed:

$$p_i^d = \alpha_i + \beta_i q_i^d$$

where p_i^d is the domestic price of the ith product, α_i and β_i are parameters of the ith demand function, and q_i^d is the quantity of the ith product sold on the domestic market.

It is further assumed that manufactured dairy products are homogeneous and that access to the Australian market by countries other than New Zealand is effectively restricted by existing quotas and penalty tariffs. Thus, all other imports may be subsumed into the constant parameters of the demand functions. Hence, the demand function may be rewritten:

$$p_i^d = \alpha_i + \beta_i \left[q_i^{dA} + q_i^{NZ}\right]$$

where q_i^{dA} is the quantity of the ith domestic product allocated to the domestic market and, q_i^{NZ} is the quantity of the ith product imported from New Zealand.

Integrating the demand function with respect to the quantities of each country's sales in Australia yields an expression for the domestic sales component of the objective function:

$$(1) \qquad \sum_i (q_i^{dA} + q_i^{NZ}) \left[\alpha_i + \beta_i (q_i^{dA} + q_i^{NZ})/2\right]$$

The expression gives the area under the demand curves and is simply the consumer valuation of domestic sales.

Export returns

A small country assumption was made about the sale of Australian exports on the world market. Thus, marginal revenue to Australia of exports is constant and equal to the export price, p_i^e. However, for an individual exporter, who takes the subsidy rate as given, marginal revenue for the ith product sold on the export market is equal to the export price plus the subsidy rate, s, multiplied by the export price:

$$(1+s)p_i^e$$

If the subsidy rate is implicitly defined, the marginal export return may be re-expressed:

$$\left[1 + \frac{m}{\sum_i p_i^e q_i^e}\right] p_i^e$$

where q_i^e the quantity of ith Australian export and m is the maximum amount of moneys available to subsidise exports. This expression yields the subsidised export curve illustrated in Figure 2. Intergrating this expression with respect to the export quantities yields the export component of the objective function:

$$\sum_i q_i^e p_i^e + m\log\left[\sum_i q_i^e p_i^e\right] \qquad (2)$$

Equation 2 gives the area under the subsidised demand curve. However, it cannot be directly associated with any revenue or welfare measure, although the equation does yield the appropriate marginal export conditions. In Figure 2, export revenues are given by the lightly shaded area while the more heavily shaded area is the subsidy payment. The remaining unshaded area represents the funds required to subsidise each unit of export at the maximum subsidy rate.

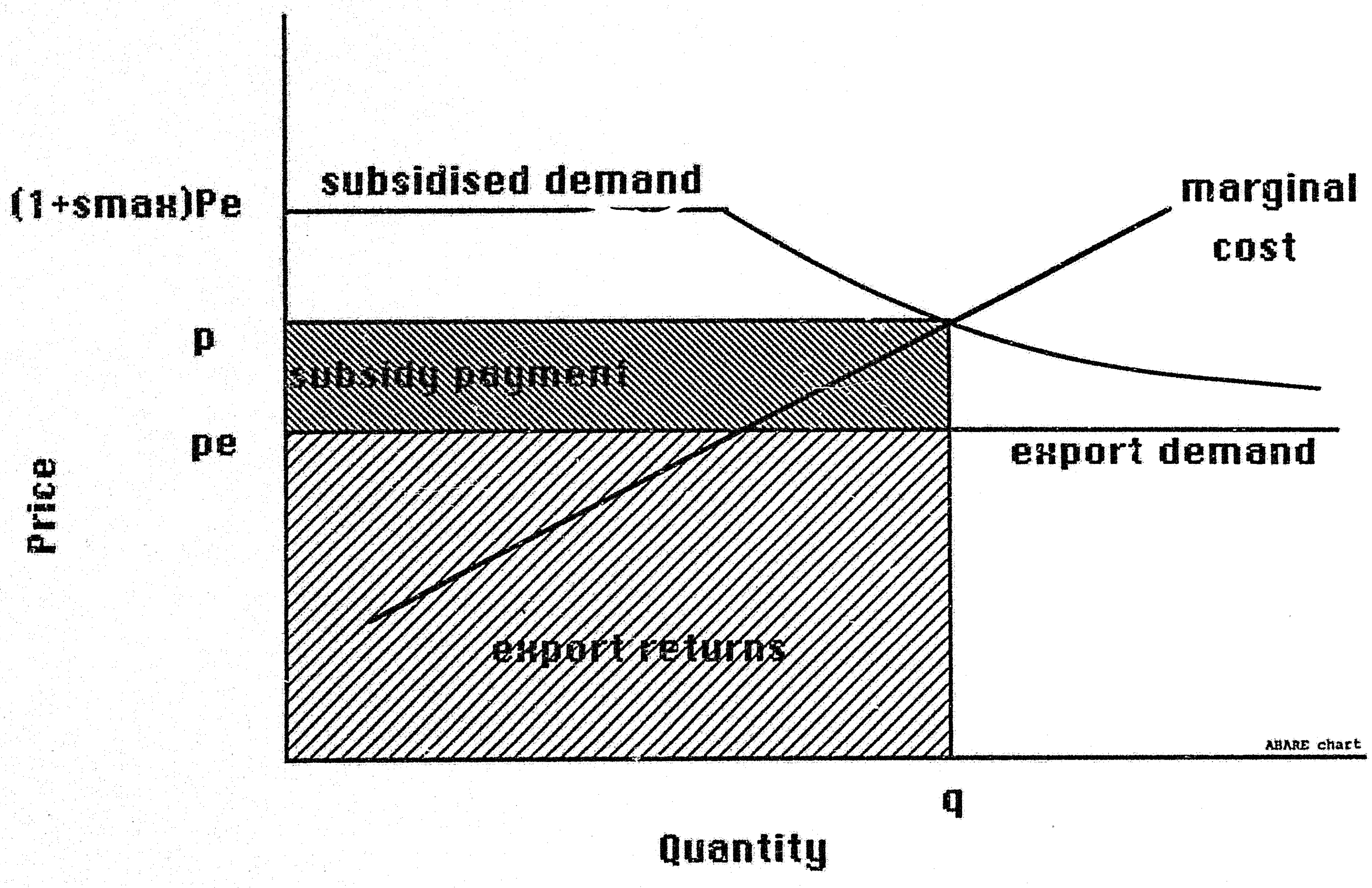

Figure 2 Australian export sector

There are several institutional constraints on the level of export support. Discussion of these constraints will be deferred until after considering the incentive for New Zealand entry into the Australian market.

New Zealand exports

New Zealand exports to the Australian market receive domestic market prices which are, in turn, equal to the subsidised export price. In addition, the marginal return to the New Zealand industry contains the effect of an incremental increase in exports on the export subsidy rate:

$$(1 + s)p_i^e + \delta s/\delta q_i^{NZ} \sum_i p_i^e q_i^{NZ}$$

Thus, marginal revenue for New Zealand exports into Australia may be written:

$$\alpha_i + \beta_i(q_i^{dA} + q_i^{NZ}) + \delta s/\delta q_i^{NZ} \sum_i p_i^e q_i^{NZ}$$

The reduction in the subsidy rate with respect to New Zealand exports is due to the transfer of Australian product from the domestic to the export market. For a unit of export which displaces a unit of Australian product, the derivative may be written:

$$\delta s/\delta q_i^{NZ} = -mp_i^e \left[\sum_i p_i^e q_i^{e*} + \sum_i p_i^e q_i^{NZ}\right]^{-2}$$

where q_i^{e*} is the optimal level of Australian export of the ith product, given that New Zealand does not export to the Australian market.

Jointly integrating the complete set of marginal conditions yields a component of the objective function for New Zealand exports:

$$\sum_i (q_i^{dA} + q_i^{NZ})\left[\alpha_i + \beta_i(q_i^{dA} + q_i^{NZ})/2\right] + m\sum_i p_i^e q_i^{NZ}\left[\sum_i p_i^e q_i^{e*} + \sum_i p_i^e q_i^{NZ}\right]^{-1}$$

$$(3) \qquad - m\log\left[\sum_i p_i^e q_i^{e*} + \sum_i p_i^e q_i^{NZ}\right]$$

The marginal conditions on the ith export are valid only to the point where domestic product is completely displaced. This quantity is given by the intersection of the New Zealand excess demand function with the domestic demand schedule (the intersection of d'd' with DD in panel b of Figure 1). This point corresponds to the kink in the marginal reveune schedule. For exposition, it will be assumed that marginal revenue is negative for all quantities beyond this point. It is demonstrated that this assumption holds, given the parameters of the model, in part one of Appendix A.

The equation for the New Zealand demand schedule is given by:

$$(1+s)p_i^e = \left[1 + m\left[\sum_i p_i^e q_i^{e*} + \sum_i p_i^e q_i^{NZ}\right]^{-1}\right]p_i^e$$

Equating this expression with the domestic demand curve yields an implicit expression for the point of intersection, which can be taken as an [illegible] bound on the level of New Zealand exports to Australia:

$$(4) \qquad 0 \le \alpha_i + \beta_i q_i^{NZ} - \left[1 + m\left[\sum_i p_i^e q_i^{e*} + \sum_i p_i^e q_i^{NZ}\right]^{-1}\right]p_i^e$$

<u>The export support fund</u>

There are several constraints related to the moneys available for export support. First, the total subsidy payment must be less than or equal to the milk levies collected:

(5) $$m \leq r^a\left[x_f + \sum_j x_j\right] + \sum_i r_i^p q_i^{dA}$$

where r^a is the all milk levy rate, x_f is the volume of fluid milk produced for the fresh milk market, x_j is the volume of manufacturing milk used in the jth manufacturing process and, r_i^p is the product levy for the ith product sold on the domestic market.

There are institutional constraints on the maximum all milk and product levy rates:

(6) $$r^a \leq rmax^a$$

(7) $$r_i^p \leq rmax_i^p$$

Lastly, there is an institutional constraint on the maximum subsidy rate:

(8) $$m \leq smax\sum_i p_i^e q_i^e$$

With regard to the first three constraints, the amount of money available for export support is predetermined. However, when the maximum levy constraint is binding, moneys available for export support are linked to the level of Australian exports and domestic sales. The reduced gradient of the objective function, Z, with respect of the level of Australian exports is now given by:

$$(1+s)p_i^e + (\delta Z/\delta m)(\delta m/\delta q_i^e)$$

So long as the maximum levy constraint is not binding, the derivative of m with respect to q_i^e is zero and the derivative of the objective function with respect to m may be arbitrarily positive. However, if the constraint is binding, the derivative of m with respect to q_i^e is positive and the derivative of the objective function with respect to m must be zero.

As stated to this point, the derivative of the objective function with respect to m may be written:

$$\log\left[\sum_{i=1}^{n} q_i^e p_i^e\right] + \sum_i p_i^e q_i^{NZ} \left[\sum_i p_i^e q_i^{e*} + \sum_i p_i^e q_i^{NZ}\right]^{-1} - \log\left[\sum_i p_i^e q_i^{e*} + \sum_i p_i^e q_i^{NZ}\right]$$

Noting that Australian exports are equal to the sum of the pre-optimal exports and New Zealand exports to Australia, this expression may be rewritten:

$$\sum_i p_i^e q_i^{NZ} \left[\sum_i p_i^e q_i^{e*} + \sum_i p_i^e q_i^{NZ}\right]^{-1}$$

This expression is simply the relative value of New Zealand versus Australian exports.

Adding the following term to the objective function:

$$(9) \qquad \left[\text{smax}\sum_i p_i^e q_i^{e*}\right]\log(m) - m$$

ensures that the derivative of objective fucntion with respect to m will be zero when the maximum levy constraint is binding. Consequently, the appropriate marginal conditions on exports will be maintained.

Costs

A linear domestic production technology was assumed. Products are produced jointly under alternative technologies. The production of the ith product may be expressed:

$$(10) \qquad q_i^A = \sum_{j=1}^{m} a_{ij} x_j$$

where a_{ij} is the amount of ith product produced from a unit of milk from the jth technology and, x_j is the amount of milk allocated to the jth technology.

Average costs for a given technology were represented by a linear function of the level of milk input:

$$\delta_j + \gamma_j x_j$$

Average and marginal costs of New Zealand imports were assumed to be equal to a constant import price, p_i^{NZ}.

Total costs are entered into the objective function:

$$(11) \qquad -\sum_{j=1}^{m} x_j\left[\delta_j + \gamma_j x_j\right] - \sum_{i=1}^{n} p_i^{nz} q_i^{NZ}$$

Model application

The objective function of the model is given by equations 1, 2, 3, 9 and 11. The constraint set is given by equations 4, 6, 7, 8 and 10. Two additional constraint sets were incorporated into the model. The first constraint limits the supply of milk available for processing and generates a corresponding shadow price of milk. The second set of constraints pre-empt New Zealand access to the Australian market. When imposed, these constraints generate the pre-optimal levels of Australian exports required for the duopoly solution. Thus, the model is solved sequentially for the pre- and post access solution at each level of milk available for processing.

Demand curves for manufacturing milk can be generated by varying the constraint on milk available for processing. It is important to note that the shadow price associated with the milk constraint includes the effect of the additional levy money collected with an additional unit of milk. This effect must be deducted to obtain a net of levy shadow price on milk, written:

$$p^m = (\delta Z/\delta b) - (\delta Z/\delta m)(\delta m/\delta b)$$

where p^m is the net of levy shadow price for manufacturing milk, Z is the objective function and b is the supply of manufacturing milk available for processing.

There are several additional considerations in specifying the model so that alternative solutions to the duopoly problem can be formulated. These include the restriction of New Zealand access to generate the pre-optimal solutions and the elimination of export support to generate a competitive market solution. These are discussed in Appendix B.

Model parameters

Preliminary estimates for the financial year 1988-89 were used to create a base for selecting the model parameters (Bhati and Barrett 1988). Base prices and quantities are presented in Table A. Model parameters were determined in two stages. First, technical and domestic demand parameters were derived from existing data sources. In the second stage, cost function parameters were obtained by aligning the model to replicate price and quantity outcomes for the base period.

Technical coefficients were obtained for the five major processed products, produced jointly from four alternative technologies. The products are butter, cheese, skim milk powder and wholemilk powder, and casein. The four technologies are the intensive production of cheese, skim milk powder, wholemilk powder and casein, respectively. Butter and skim milk powder are joint products of each technology. The technology matrix is presented in Table 2.

Estimated retail demand elasticities and retail prices were used to determine a slope parameter, β_i, for each product. Wholesale prices and domestic consumption were then used to calculate two sets of intercept parameters. The first, α_i^*, was calculated for the base period in which product levies for butter and cheese were in place. An alternative set of intercept parameters, α_i, were computed to simulate the effect of the

TABLE 1
Prices, domestic consumption and exports of processed dairy products in Australia, 1988-89

Product	Retail price	Wholesale price	Export price	Domestic consumption	Exports	Product levy	NZ transport[b]	NZ access price
	$/t	$/t	$/t	kt	kt	$/t	$/t	$/t
Butter	3580	1950	1500	52	46	434.5	255	1755
Skim milk powder[a]	5206	2508	1929	44	76	-	135	2074
Whole milk powder	5400	2601	2001	13	57	-	164	2165
Cheese	5140	3085	2373	118	65	70.5	257	2630
Casein	-	6522	5017	1	8	-	164	5181

(a) Includes buttermilk powder. (b) Transport costs are in Australian dollars and are the latest figures available - 1987-88.

TABLE 2
Technology matrix and cost parameters for the major processed dairy products

Product line	Product						Cost parameters			
	Butter	Skim milk powder	Whole milk powder	Cheese	Butter milk powder	Casein			Cost per litre AC[b]	MC[c]
	t/ML	t/ML	t/ML	t/ML	t/ML	t/ML	$'000/ML	$'000/ML	c/L	c/L
Skim Milk Powder[a]	54.5	82.4	-	-	5.4	-	-2.21	0.63	4.16	10.53
Casein	54.5	-	-	-	5.4	28.7	-0.50	1.55	3.38	2.98
Cheese	9 8	-	-	104.8	1.0	-	-1.74	0.40	5.26	12.26
Whole Milk Powder	14.9	-	125.9	-	1.5	-	-4.08	1.73	4.81	13.70

(a) Average costs. Source: Dairy Industry Cost Survey, Australian Dairy Corporation. (b) Marginal costs. Refer to text, page 16. (c) Includes buttermilk powder.

removal of product levies. The removal of a product levy results in an increase in domestic consumption which can be represented by a shift of the domestic product demand curves

$$\alpha_i = \alpha_i^* + r_i$$

The demand elasticities and parameters are presented in Table 3.

A synthetic approach was taken to determine the parameters of the cost functions. Cost parameters were obtained through an iterative process which aligned the model solutions for the base period price, quantities and average costs. Average costs of production for a given technology were assumed to be a linear function of production:

$$AC_j = \delta_j + \gamma_j x_j$$

Thus, marginal costs may be written:

$$MC_j = \delta_j + 2\gamma_j x_j$$

The parameters of the cost function may be expressed as a function of average costs, marginal costs and the level of production:

$$\delta_j = 2AC_j - MC_j$$

and:

$$\gamma_j = \left[MC_j - AC_j\right]/x_j$$

Initially, marginal costs for each technology and the level of production were determined by replicating base period quantities of manufactured dairy products at existing prices. These marginal cost levels were subsequently scaled to replicate a shadow price for manufacturing milk equal to the net of levy manufacturing milk price estimated from ABARE survey data (ABARE 1988). The final parameter estimates were then calculated using average production cost estimates

TABLE 3
Domestic demand parameter estimates for processed dairy products

Product	Retail elasticity	Wholesale elasticity			
			$/kt	$	$
Butter	-0.50	-0.27	-138	9110	8676
Skim milk powder(a)	-0.25	-0.12	-473	23330	23330
Whole milk powder	-0.25	-0.12	-.600	24201	24201
Cheese	-0.90	-0.54	-48	8796	8725
Casein	-	-2.00	-6522	9783	9783

obtained from a survey funded by the Australian dairy industry. Average production costs for each product line are presented in Table 1. The cost parameters for the model are presented in Table 2.

The cost of New Zealand imports consists of two parts, New Zealand export prices and trans-Tasman transport costs. Export prices are taken as equal to average Australian export prices because it is assumed both Australia and New Zealand face world prices. Transport costs are the current costs of transporting dairy products between Australia and New Zealand and these costs are presented in Table 1.

Given a range of production where Australia is an exporter of all manufactured dairy products, marginal returns are given by the subsidised export price. Consequently, the elasticity of demand for manufacturing milk is determined, in the absence of subsidy constraints, by the slope of the cost curves. In the short run, costs may increase with increased volumes of production, as capital investment in processing is essentially fixed and the demand for manufacturing milk may be inelastic. Thus, the parameter estimates obtained by aligning the model may be appropriate in the short run. However, in the long run, costs of production may be considerably more elastic, resulting in a more elastic demand for manufacturing milk.

<u>Baseline simulation</u>

The model was solved, using the Minos non-linear programming package (Murtagh and Saunders 1983) over a range of manufacturing milk supplies to simulate a baseline demand for manufacturing milk and the level of domestic consumption. New Zealand access to the Australian market was constrained to zero. Product prices and the all milk levy rate were held at base period levels, while product levies were removed.

The baseline provides estimates of the pre-optimal level of Australian exports, required for the duopoly solution. The results are presented in Table 4. Milk supplies, available for processing, were varied between 1000 ML and 4000 ML. Under the baseline scenario, Australia is an exporter of manufactured dairy products when

TABLE 4

Baseline simulation - removal of product levy on butter and cheese

Milk supply	Milk price	Subsidy rate	Cheese: Domestic sales	Cheese: X	Cheese: M	Cheese: W'sale price	Butter: Domestic sales	Butter: X	Butter: M	Butter: W'sale price	Wholemilk Powder: Domestic sales	Wholemilk Powder: X	Wholemilk Powder: M	Wholemilk Powder: W'sale price	Skim Milk Powder: Domestic sales	Skim Milk Powder: X	Skim Milk Powder: M	Skim Milk Powder: W'sale price
KL	c/L	%	kt	kt	kt	$/t	kt	kt	kt	$/t	kt	kt	kt	$/t	kt	kt	kt	$/t
4.00	17.7	19.0	124.9	79.4	0.0	2823.5	56.4	52.4	0.0	1784.8	13.6	56.7	0.0	2380.9	44.4	60.3	0.0	2295.2
3.58	20.0	21.6	123.6	60.2	0.0	2885.5	56.1	40.3	0.0	1823.9	13.6	51.2	0.0	2433.1	44.3	48.7	0.0	2345.6
3.50	20.4	22.2	123.3	56.6	0.0	2900.5	56.0	38.0	0.0	1833.5	13.6	50.2	0.0	2445.8	44.3	46.5	0.0	2357.8
3.00	23.8	27.9	120.5	35.2	0.0	3034.4	55.4	23.7	0.0	1918.1	13.5	43.7	0.0	2558.7	44.1	32.7	0.0	2466.7
2.50	26.2	30.0	119.5	11.8	0.0	3084.9	55.2	9.2	0.0	1950.0	13.5	37.1	0.0	2601.3	44.0	18.9	0.0	2507.7
2.00	31.7	30.0	112.7	0.0	0.0	3410.8	50.1	0.0	0.0	2640.9	13.5	20.8	0.0	2601.2	44.0	6.1	0.0	2507.7

* Includes buttermilk powder.
X = Exports; M = Imports

manufacturing milk supplies are in excess of 2000 ML. With manufacturing milk supplies falling below 2000 ML exports fall to zero. This was taken as a lower bound on milk supplies for the duopoly simulations considered in the following section.

Policy Simulations

Two policy experiments were conducted. First, New Zealand was allowed free access to the Australian market under current export subsidy arrangements. This experiment yields the duopoly solution for trade in manufactured dairy products with New Zealand. As export support may be eliminated with the termination of the Kerin Plan in 1992, a second experiment was conducted in which export support through the all milk levy is eliminated. This experiment yields a competitive market solution. Results for these experiments are presented in Tables 5 and 6.

Implications of CER in the short term

The rate of adjustment in milk supplies to changes in manufacturing milk prices is likely to be slow. Consequently, the short term implications of CER may be evaluated at current levels of manufacturing milk supplies used in the production of butter, cheese, milk powders and casein (3580 ML). The New Zealand industry may not be able to adjust fully to removal of trade restrictions, despite the fact that the removal of restrictions will not take place until July 1990. Consequently, the results may tend to overstate the level of trade in the short term.

With the introduction of CER, the majority of trade is projected to take place in cheese, milk powders and casein. Transport costs, as a percentage of export prices, for milk powders and casein are low. Consequently, New Zealand exports of milk powders completely displace Australian product from the domestic to the export market. New Zealand exports of cheese displace roughly 25 per cent of Australian product to the export market. Transport costs for butter are sufficiently high to preclude New Zealand exports of butter to Australia at the projected rate of export support. With the elimination of export support, trade does not take place in undifferentiated products.

TABLE 5

Simulation of duopoly

Milk supply	Milk price	Subsidy rate	Cheese: Domestic sales	Cheese: X	Cheese: M	Cheese: W'sale price	Butter: Domestic sales	Butter: X	Butter: M	Butter: W'sale price	Wholemilk Powder: Domestic sales	Wholemilk Powder: X	Wholemilk Powder: M	Wholemilk Powder: W'sale price	Skim Milk Powder: Domestic sales	Skim Milk Powder: X	Skim Milk Powder: M	Skim Milk Powder: W'sale price
ML	c/L	%	kt	kt	kt	$/t	kt	kt	kt	$/t	kt	kt	kt	$/t	kt	kt	kt	$/t
4.00	16.5	14.4	99.8	104.1	27.3	2714.2	56.9	52.2	0.0	1715.7	0.0	70.1	13.7	2285.9	0.0	105.0	44.6	2203.7
3.58	18.4	15.4	96.3	86.9	30.3	2737.3	56.7	40.0	0.0	1730.3	0.0	64.4	13.7	2303.6	0.0	93.4	44.6	2220.7
3.50	18.7	15.6	95.8	83.5	30.8	2742.7	56.7	37.6	0.0	1733.7	0.0	63.3	13.7	2307.6	0.0	91.2	44.6	2224.5
3.00	21.1	17.5	92.8	62.0	32.8	2787.4	56.5	23.2	0.0	1762.0	0.0	56.6	13.7	2339.3	0.0	77.3	44.5	2255.1
2.50	24.0	21.4	95.3	35.2	28.4	2880.8	56.1	8.8	0.0	1821.0	0.0	50.0	13.6	2413.5	0.0	63.3	44.4	2326.6
2.00	25.9	18.7	106.6	0.0	16.9	2879.2	50.5	0.0	4.9	1912.5	2.6	38.5	11.0	2375.2	0.0	49.9	44.5	2276.6

* Includes buttermilk powder.
X = Exports; M = Imports.

TABLE 6

Simulation of free trade

Milk supply	Milk price	Subsidy rate	Cheese: Domestic sales	Cheese: X	Cheese: M	Cheese: W'sale price	Butter: Domestic sales	Butter: X	Butter: M	Butter: W'sale price	Wholemilk Powder: Domestic sales	Wholemilk Powder: X	Wholemilk Powder: M	Wholemilk Powder: W'sale price	Skim Milk Powder*: Domestic sales	Skim Milk Powder*: X	Skim Milk Powder*: M	Skim Milk Powder*: W'sale price
ML	c/L	%	kt	kt	kt	$/t	kt	kt	kt	$/t	kt	kt	kt	$/t	kt	kt	kt	$/t
4.00	12.8	na	134.2	68.5	0.0	2373.0	58.4	51.4	0.0	1500.0	13.9	55.2	0.0	2001.0	45.2	60.6	0.0	1929.0
3.58	14.4	na	134.2	47.8	0.0	2737.0	58.4	39.2	0.0	1500.0	13.9	49.5	0.0	2001.0	45.2	49.0	0.0	1929.0
3.50	14.7	na	134.2	43.8	0.0	2373.0	58.4	36.8	0.0	1500.0	13.9	48.4	0.0	2001.0	45.2	46.8	0.0	1929.0
3.00	16.6	na	134.2	19.2	0.0	2373.0	58.4	22.3	0.0	1500.0	13.9	41.5	0.0	2001.0	45.2	33.1	0.0	1929.0
2.50	18.7	na	132.9	0.0	0.0	2432.0	58.4	6.2	0.0	1500.0	13.9	33.6	0.0	2001.0	45.2	17.3	0.0	1929.0
2.00	22.3	na	116.2	0.0	12.6	2630.0	48.2	0.0	8.4	1755.0	13.9	21.9	0.0	2001.0	45.2	1.2	0.0	1929.0
1.50	24.7	na	85.8	0.0	43.1	2630.0	36.6	0.0	20.0	1755.0	13.9	13.5	0.0	2001.0	38.3	0.0	6.7	2074.0
1.00	26.8	na	58.2	0.0	70.6	2630.0	23.5	0.0	33.1	1755.0	13.9	5.8	0.0	2001.0	23.2	0.0	21.7	2074.0

na Not applicable.
* Includes buttermilk powder
X = Exports; M = Imports.

The rate of export support falls from 21.6 per cent in the baseline solution to 15.4 per cent in the duopoly solution. Domestic prices for manufactured dairy products and export returns fall by about 5.1 per cent. Domestic consumption of cheese increases by about 2.4 per cent. Manufacturing milk prices fall by about 1.5c/L, or 7.5 per cent. This may be compared to the competitive market solution in which domestic prices for manufactured dairy products fall to export parity. With the removal of export support, domestic consumption of cheese increases by roughly 8.6 per cent in comparison to the baseline. Manufacturing milk prices fall by more than 25 per cent, or 5.5c/L.

In the duopoly solution, domestic prices remain well above import parity levels. While CER will result in lower returns to the Australian dairy industry, the industry clearly benefits from the exercise of monopoly power by New Zealand. However, the liberalisation of dairy trade with New Zealand results in short run welfare losses to Australia of around $7m. Gains in consumer surplus from trade, calculated at a retail level, are approximately $21.4m. The effective transfer of support payments to New Zealand is in excess of $28.5m. Milk supplies are assumed to be perfectly inelastic in the short run, thus there is no change in producer surplus. However, total revenue to the Australian dairy industry is projected to fall by about $50m.

The Effect of CER in the longer term

The longer term implications of CER will, for the most part, depend on two factors. The first is the decision as to whether current export support policies will be retained. The second is the supply response of Australian dairy producers to prices under the selected policy option. While the question of supply response was not addressed here, adjustments in manufacturing milk supplies to lower prices will have two effects on social welfare. First, social losses associated with costs of production at subsidised prices for manufactured dairy products and milk will be reduced. Second, gains in consumer surplus due to lower prices will be offset by losses in producer surplus in the dairy industry.

The simulation experiments provide some insights into the effect of alternative policies on the demand for manufacturing milk. The demand o manufacturing milk for the baseline, duopoly and competitive market soulutions is presented in Figure 3. Under existing export support arrangements, the reduction in manufacturing milk demand due to the removal of trade restrictions with New Zealand decreases as quantity of manufactuing milk increases. Conversely, the reduction in manufacturing demand which occurs with the removal of export support increases with quantity. However, industry incentives for retaining export support are substantial over the entire range of production considered. The additional returns on manufacturing milk from export support exceed the amount of the levy. However, this will not be true for individual producers, regions or states of Australia. Producers who supply a large proportion of their production to the fresh milk market would be better off under competitive conditions of trade in manufactured dairy products.

The composition of domestic sales and exports changes with the level of milk supplies. The composition of domestic sales and exports for cheese, milk powders and butter for the duopoly solution are presented in Figure 4. New Zealand exports of milk powders completely displace Australian domestic sales at all level of production considered. Again, this reflects the comparatively low transport costs for milk powders as opposed to butter and cheese. Trade patterns for cheese are complex. At low levels of production, subsidy rates are high but the total amount of money required to subsidise exports is limited. Thus, the rate of return to New Zealand exports is higher but trade volumes are lower. The New Zealand marginal revenue curve is shifted with higher subsidy rates but becomes much more inelastic. As Australian production increases, rates of export support fall and intially trade flows increase along with the increase in funds required to subsidise exports. The New Zealand marginal revenue curve shifts down but becomes relatively elastic. However, as production continues to increase, trade flows eventually begin to fall as the New Zealand marginal revenue curve continues to shift down with lower subsidy rates, but there is little change in the elasticity.

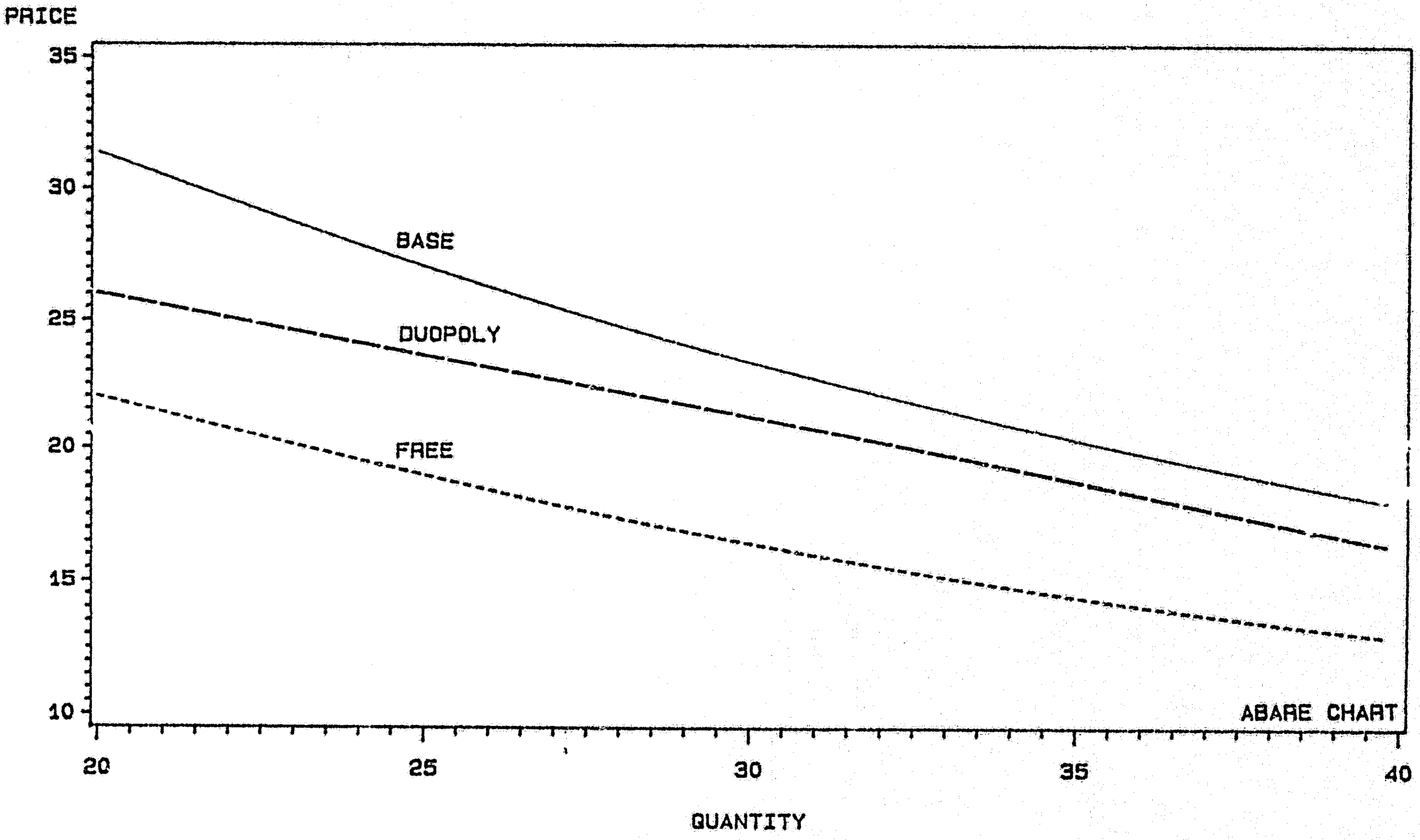

FIGURE3 DEMAND FOR MANUFACTURING MILK

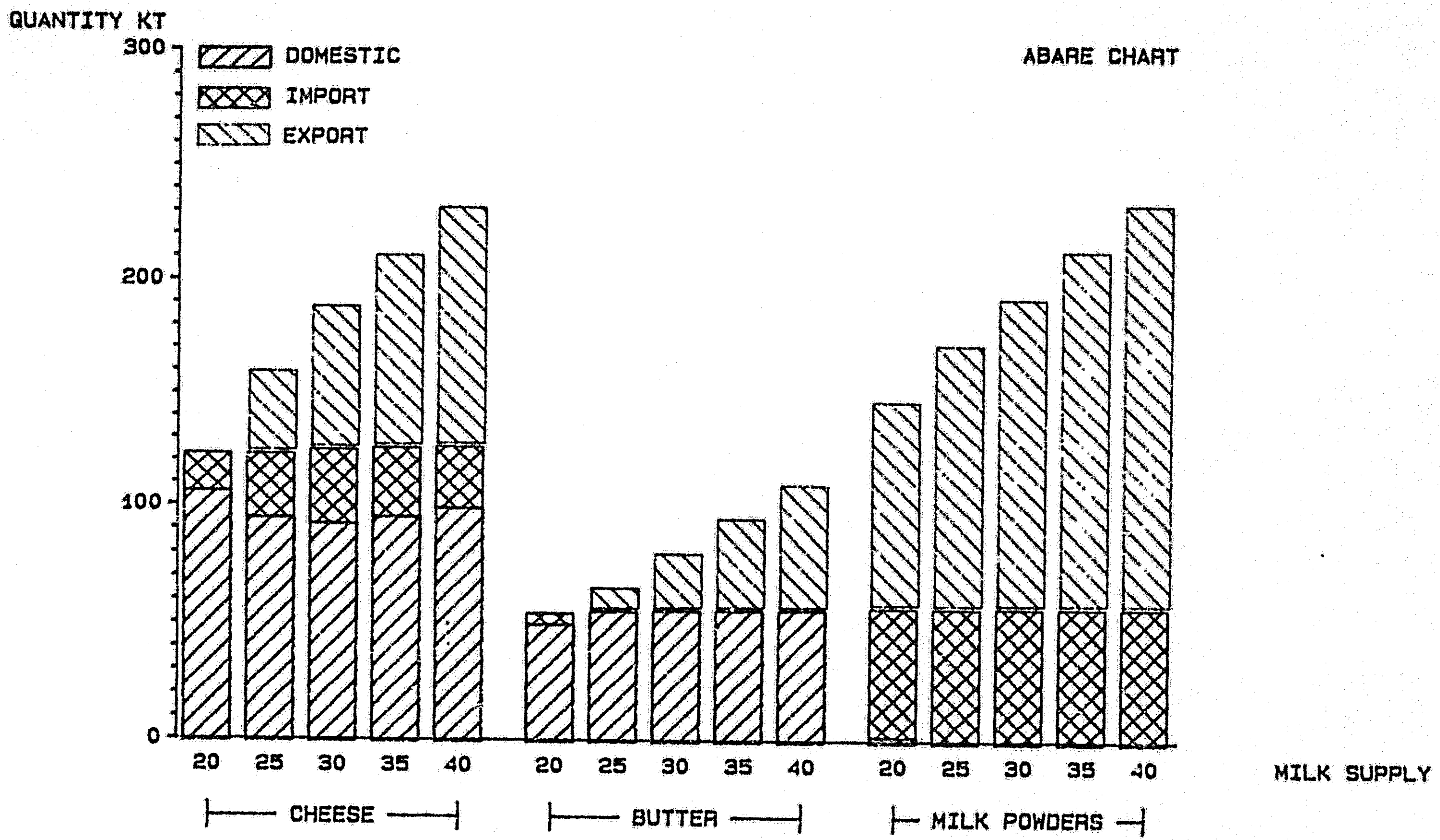

FIGURE 4 DAIRY PRODUCT CONSUMPTION AND TRADE FOR THE DUOPOLY SOLUTION

Conclusions

Trans-Tasman trade in manufactured dairy products is likely to be characterised by imperfect competition. Under current Australian dairy export policies, domestic prices are equated with subsidised export prices. Therefore, the policies create an incentive for the introduction of product from New Zealand under CER. It was shown that these conditions could lead to a stable duopoly under the current industry arrangements. In this situation, New Zealand would extract a subsidised return from the Autralian market and displace sales of Australian product from the domestic to the export market.

A mathematical programming model was developed to evaluate the potential effect of trade with New Zealand on the demand for manufacturing milk in Australia and the composition of domestic consumption and exports of manufactured dairy products. The model was derived from the marginal conditions of a 'Stackelberg' duopoly. It is assumed that Australian producers respond competitively to industry level marketing arrangements, while the New Zealand industry uses its monopoly control over exports to take a price leadership role in the Australian domestic market.

The duopoly solution was compared with two alternatives. In the first alternative, trade with New Zealand was restricted. In the second alternative, export support arrangements in Australia were eliminated. The results of the experiments indicate that the Australian domestic prices for manufactured dairy products are likely to be well above export prices under CER. At current levels of production, the export support rate falls by only about 6 percentage points and domestic prices for manufactured dairy products remain about 15 per cent above corresponding export prices. Consequently, the reduction in demand for manufacturing milk is limited in comparison to a situation in which export support is removed. The industry will retain a strong incentive to preserve existing export support arrangements.

However, in the near term, welfare gains to consumers from lower domestic prices are not sufficient to offset the transfer of export support payments to New Zealand. Under the current Australian export support policy, New Zealand producers could gain over $28m a year in transfer payments. The loss in revenue to the Australian dairy industry is projected to be about $50m. An increase in the funds available for export support would increase industry returns. However, welfare losses to Australia could also increase due to higher prices paid by consumers and increased transfer payments to New Zealand.

The major volume of trade with New Zealand is expected to be in milk powders, reflecting the lower costs of transport for these products. Furthermore, as these products are difficult to differentiate by country of origin the effects of non-price competition would tend to be minimal. New Zealand exports of cheese are limited to about 25 per cent of the Australian market. To some degree, cheese is a differentiable product and some non-price competition between Australian producers and New Zealand is likely to occur. Given current export prices and transport costs for butter, exports of New Zealand butter to the Australian market are expected to be very limited. However, with a relative price change in the landed price of butter, significant exports of butter may occur. New Zealand exports of butter would displace exports of cheese, owing to their joint effect of displacing Australian product onto the export market and lowering the export support rate. Consequently, a change in the composition of New Zealand exports would not have a great effect on the demand for manufacturing milk and domestic prices of manufactured products in Australia.

APPENDIX A

New Zealand Export Constraints

The constraint on New Zealand exports to Australia can be regarded as an absolute upper bound because the marginal return to additional exports is less than marginal cost f… all admissable cases. At the point where Australian domestic sales are totally displaced by New Zealand export, additional New Zealand exports will not affect the subsidy rate. However, in this case New Zealand is a sole monopoly seller in the Australian market and will take into account the direct effect on price of an increase in domestic sales. The appropriate marginal revenue curve for additional exports is then given by:

$$\alpha_i + 2\beta_i q_i^{NZ}$$

The maximum price which can prevail on the domestic market, given Australia is an exporter, may be written:

$$(1 + smax)p_i^e$$

This expression may be equated with the domestic demand curve and solved for the minimum quantity of domestic sales:

$$q_i^d = \left[-\alpha_i + (1 + smax)p_i^e\right]/\beta_i$$

If New Zealand were to completely displace this level of domestic sales, marginal revenue would be given by:

$$-\alpha_i + 2(1 + smax)p_i^e$$

which is less than zero if:

$$\alpha_i > 2(1+smax)p_i^e$$

This condition is comfortably met for all products, given the parameters of the model and current export prices.

APPENDIX B

Alternative Model Specifications

Some minor modifications of the model are required to generate solutions representing dairy arrangements under which New Zealand access to the Australian market is restricted. Further modifications are required to generate solutions representing competitive trade, in which export support payments are eliminated. These are considered in the following two sections.

Restricted access

Given New Zealand access to the Australian market is restricted, the export revenue component of the model corresponing to New Zealand (equation 3) is deleted. However, the derivative of the objective function with respect to moneys available for export support is now given by:

$$\log\left[\sum_{i=1}^{n} q_i^e p_i^e\right]$$

It must be ensured that the derivative of the objective function is zero when the maximum subsidy rate constraint is binding. The term to correct the derivative of the objective function with respect to export support moneys (equation 9) is replaced by:

$$(9.1) \qquad -m\log\left[m/smax\right] + m$$

Competitive trade

To simulate the removal of export support requires modifications to the Australian and New Zealand export components of the objective funtion. The equation for Australian export returns (equation 2) is replaced by the following expression:

(2.1)
$$\sum_i q_i^e p_i^e$$

The equation for New Zealand export returns (equation 3) is replaced by:

(3.1)
$$\alpha_i + \beta_i(q_i^{dA} + q_i^{NZ})$$

The expression for correcting the derivative of the objective funtion with respect to export support monies (equation 9) and the constraint set on New Zealand exports are deleted.

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