The Effects of Policy Changes on the Production and Sales of Milk in New South Wales

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Regulation of the New South Wales dairy industry creates inefficiencies and raises the cost of production. In this study, the industry is modelled by adapting an ABARE subregional programming model, and using spatial equilibrium linear activity analysis to examine the effects on the production of market and manufacturing milk within different regions of New South Wales of alternative policies. The output generated by the model includes regional market and manufacturing milk production levels, prices and quantities of market milk sold in each period and region, and market and manufacturing milk transfers between regions. The model also generates details of farm-level activities for each of the representative farms used in the construction of the model.

Broadly speaking, the results generated by the model are consistent with economic theory and previous studies, and point to higher social welfare levels under a less regulated industry structure. However, with respect to the regional structure of the industry, some of the results generated by the model contradict earlier research. In a further series of experiments, the policy scenarios are re-examined after the model has been adjusted to correspond more closely with a long-run situation. Under these circumstances, the opportunity costs of land used in dairying heavily influences the long term structure of the industry. Differences in results between the long-run and short-run cases highlight the need for caution in interpreting the output from complex mathematical programming models.

1. Introduction

The dairy industry in New South Wales is highly regulated. Regional quotas on market milk have existed since 1938 and individual farm quotas were introduced in 1955. The quotas were introduced to induce producers to supply milk year-round, thereby ensuring consumers had access to an adequate supply of fresh milk. In the past, non-transferability of market milk quotas led to inefficiencies and raised the cost of production since quota holders had to produce market milk at a given level all year-round, even when their marginal costs exceeded those of manufacturing milk producers.

Increased competition from Victoria, where no quotas exist, and the introduction of free trade in dairy products between Australia and New Zealand in July 1990 under the Closer Economic Relations (CER) Agreement have led to a number of reforms within the New South Wales dairy industry. These include the introduction of negotiable quotas in July 1990, the incorporation of a market force component within the automatic price fixing mechanism contained in the Dairy Industry (Pricing) Regulation, 1984 (NSW), the merging of a number of farmer co-operatives and the portability of quotas with vendors.

Previous studies have modelled the effects of policy changes at both the regional level (for example Williamson *et al.* 1988b) and the farm-level (Tozer 1993) assuming fixed milk prices. This study uses spatial equilibrium analysis to examine the effects of different policies on the regional production and sales of market and manufacturing milk within New South Wales, allowing for market milk price changes. The model used is based on a subregional linear programming model developed by the Australian Bureau of Agricultural and Resource Economics (ABARE) (Williamson *et al.* 1988b; Lembit *et al.* 1988). ABARE's model was extended by adding regional milk demand functions. In this form, the model can be used to examine the short- run effects of a range of policy alternatives from a relaxation in the transferability of quotas to

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their total removal. The effects of three policies are reported here: the maintenance of fixed quotas (which are still relevant given restrictions on quota transferability under the new system), a system of negotiable quotas, and total deregulation of the industry. Although the aggregate level of market milk production is fixed under the first two policies, it can be redistributed between farms and regions in the latter case. Under deregulation, output of market milk depends on demand. With further modifications (constraint relaxation) to the ABARE model, the model can indicate the likely influence of these policies on the structure of the industry over the longer term.

In the original ABARE model, supply was modelled regionally, but it was assumed that demand for market milk was perfectly inelastic and based solely in Sydney. The extended model allows for regional demands, and for the quantity of milk demanded to be responsive to price. There are four specified demand centres in the model, representing the same regions as those used in the ABARE subregional programming model of supply: the North Coast, the Metropolitan (Sydney) region, the Riverina, and the South Coast. The regions are linked by a set of milk transportation activities. The model covers the calendar year and is divided into four time periods to capture seasonality effects.

The spatial equilibrium analysis provides useful information for policy makers and dairy farmers alike. The price of market milk in each region, the production and sales of market and manufacturing milk in each region, and the inter-regional transfers of market and manufacturing milk are all calculated for each period of the year. Details of aggregate transportation costs, production costs and resource usage levels, which may be of some use in other areas of study, are also calculated, but are not reported in this study.

1.1 Spatial Equilibrium Analysis

Spatial equilibrium problems arise where two or more regional markets with known supply and demand functions produce and consume a homogeneous product. The regions are separated but not isolated by known product transfer costs. Product will move from the market where its value is lower to the market where its value is higher, until the difference in values is not larger than transportation costs. The spatial equilibrium problem is to determine the equilibrium levels of production, supply, consumption, prices and trade flows between regions (Martin 1981). A full discussion of the nature of the spatial equilibrium problem can be found in Takayama and Judge (1971) or Tomek and Robinson (1991).

For two regions, the nature of the equilibrium is clear and it can be identified graphically (Martin 1981, pp. 22-24). For multi-region problems, the equilibrium position is most easily found as the solution to a mathematical optimizing problem (Samuelson 1952, p. 285; Takayama and Labys 1985) in which the value of net social pay-off is maximized. The general form of the problem is set out below:

$$(1) \quad \text{Max } \phi(y,x,z) = \sum_i \int_0^{y_i} D_i(\varepsilon_i)\,d\varepsilon_i - \sum_i \int_0^{x_i} S_i(\theta_i)\,d\theta_i - \sum_i \sum_j t_{ij} z_{ij}$$

subject to

$$(2) \quad \left.\begin{array}{l} y_i - z_{1i} - z_{2i} - \dots\dots\dots \leq 0 \\ -x_i + z_{i1} + z_{i2} + \dots\dots\dots \leq 0 \end{array}\right\} \text{ for all } i$$

and

$$(3) \quad \left.\begin{array}{l} y = (\ y_1\ ,\ y_2\ , \dots)\ \geq\ 0 \\ x = (\ x_1\ ,\ x_2\ , \dots)\ \geq\ 0 \\ z = (\ z_{11}\ , z_{12}\ , \dots)\ \geq\ 0 \end{array}\right\}$$

where $D_i(.)$ and $S_i(.)$ denote the demand and supply functions in the i^{th} region; y is a vector of regional demands for the commodity; x is a vector of regional supplies of the commodity; t_{ij} is the cost of transporting the commodity from producers in region i to consumers in region j; and z is a vector of commodity shipments with z_{ij} being the amount of the commodity transferred from region i to region j. The constraints in (2) ensure that there is no excess demand in any region. The conditions in (3) represent standard non-negativity constraints.

The function ϕ (y, x, z) represents the sum of consumer and producer surplus with trade, less transportation costs. When the supply and demand functions are either linear or stepped, the objective function reduces to a quadratic function and the solution (the market equilibrium) can be found by quadratic programming. Provided the demand curve is not upwards sloping, and the supply curve is not downwards sloping, second order conditions are automatically satisfied.

2. The Model

2.1 Regional Supply Functions for the New South Wales Dairy Industry

Rather than explicitly specifying the supply functions, the ABARE subregional programming model was used to define implicit regional supply functions (see Williamson *et al.* 1988; and Williamson, Topp and Lembit 1988a). The programming representation was used for two reasons. First, past regional supply data are not readily available for econometric analysis, and such functions are unlikely to reflect the supply responses under substantially altered policies. Second, linear programming is flexible enough to incorporate the complex linkages and supply response opportunities on a dairy farm under alternative policies. The implicit supply function in a programming method has the form of a rising step function (Blyth 1982, p. 141; Stovall 1966).

The ABARE subregional programming model divides New South Wales into four regions with three farm types in each region using data provided by the 1984-85 and 1985-86 Dairy Industry Surveys. The three farm types are defined as follows. Type 1 farms are 'quota' farms producing a high proportion of market milk and a low proportion of manufacturing milk, and are characterised by high feed and total costs. Type 2 farms exhibit a seasonal pattern of output producing more milk in winter months than the other farms, and exhibit some comparative advantage in the production of winter milk. Type 3 farms are the extreme, having a strongly seasonal pattern of production with less milk in winter and more in late spring, summer and early autumn.

Structurally, the ABARE subregional programming model has five major components (Williamson *et al.* 1988, p. 6):

- eleven subregional technology matrices (each farm type in each region, except for a type 1 farm in the Riverina);
- a market milk revenue submatrix, which is constrained by equalities to supply a specific amount of market milk to Sydney;
- a transport submatrix, which includes the cost of transporting market milk to Sydney, and manufacturing milk in other regions;
- four manufacturing milk revenue submatrices which are constrained by regional demand quantities that vary temporally in accordance with historical trends; and
- an accounting submatrix to provide convenient access to aggregate cost and production estimates.

The marginal cost of milk production is largely determined by feed supplies during different times of the year (Hill and Freshwater 1988, p. 35). For this reason, the year is divided into four periods designed to reflect as accurately as possible the seasonality of pasture growth in New South Wales.

2.2 Demand for Market Milk in New South Wales

Market milk has relatively few uses, a small number of substitutes and represents a small proportion of most families' expenditure (Bewley 1987a, p. 97). Therefore, demand for market milk is expected to be relatively inelastic. Studies undertaken by Ratnam and Speilman (1972), Street (1974), Nelson (1977) and others confirm this expectation for market milk in New South Wales, Australia and overseas (see Table 1). A recent estimate of the retail demand elasticity for milk is given by Bewley (1987a). Using cross-sectional data on own price, income, population and age structure, the own-price elasticity of market milk demand was estimated to be around - 0.13.

Assuming that the retail demand for market milk in New South Wales is linear, the demand function may be derived from knowledge of the retail price of market milk, the corresponding quantity of market milk consumed, and the elasticity at that price-quantity point. For the purposes of this study it is assumed that a typical quantity of market milk demanded by consumers in New South Wales is 393,054,800 litres per annum (see Williamson, Topp and Lembit 1988a), at a retail price of 85c per litre, this being the price consumers paid in October 1989 (New South Wales Dairy Corporation 1990, p. 58). Assuming that milk is consumed evenly over the year, the demand function is then given by:

$$(4) \quad P = 7.38846154 - 6.6539949 \times 10^{-8} Q$$

where Q is quantity in litres per quarter, and P is price in dollars per litre.

Assuming that marketing margins are constant, the derived demand for milk at the farm-level can be

Table 1: Elasticities Of Market Milk Determined In Previous Studies

Study	Location	Factors influencing demand	Own-price elasticity of demand
Ratnam & Speilman (1972)	Hawaii	Household size, habit, acceptability, and own price	Inelastic
Street (1977)	Sydney	Price, age distribution, lagged milk prices	-0.2
Nelson (1977)	New South Wales & Queensland	Price and age distribution	Inelastic Inelastic
Tedesco (1979)	New South Wales	Price, population, and seasonal factors	Inelastic
Collins (1981)	Australia	Price, income, age, seasonal factors	Inelastic
Bewley (1987b)	New South Wales & Victoria	Price and income	-0.1
Davidson, MacAulay & Powell (1989)	New South Wales, Victoria & Queensland	Own price, income, and cross prices	NSW -0.00 VIC -0.28 QLD -0.00
Bewley (1987a)	New South Wales	Price, income, population, and age structure	-0.13

found by deducting the margin from the intercept term in (4). The margin is assumed here to be 43.82 cents per litre (New South Wales Dairy Corporation 1990, p. 58). Thus the derived demand for market milk is:

$$(5) \quad P = 6.9502615 - 6.6539949 \times 10^{-8} Q$$

To be consistent with the scaling factors used in the ABARE model the demand function is re-expressed in units of 10^7 litres:

$$(6) \quad P = 6.9202615 - 6.6539949 \times 10^{-1} Q$$

where Q is now quantity in 10^7 litres per quarter, and P is price in dollars per litre.

Equation (6) now represents the aggregate farm-level demand equation for market milk per quarter in New South Wales.

2.2.1 Regional demand functions

The aggregate market milk demand curve is the horizontal summation of the individual market milk demand curves for each of the regions. Assuming all consumers have the same demand function, then each region's market milk demand curve can be found by dividing the slope coefficient of the aggregate market milk demand curve by the proportion of the total state population in that region. This approach was applied using census data from Australian Bureau of Statistics (1990). The quarterly market milk demand functions for each region are:

(7) North Coast $P = 6.9502615 - 6.926865Q$

(8) Metropolitan $P = 6.9502615 - 0.8585057\,Q$

(9) Riverina $P = 6.9502615 - 14.944201\,Q$

(10) South Coast $P = 6.9502615 - 7.888881\,Q$

Note that the elasticity of demand at any given price is the same in all regions.

In comparison with ABARE's original model, an additional 12 market milk selling activities are needed to allow for the expanded number of demand regions (3 regions by 4 time periods). Similarly, a further 12 aggregate market milk pools are also required. Thus, the modified model contains 16 demand equations incorporated into the model through the 16 regional market milk selling activities.

2.3 Transport Activities

In the original ABARE model, market milk could only be transported to Sydney from each of the regions, though manufacturing milk could be shipped between any of the regions. Since each region in the extended model can now sell its market milk in any of the four regions, an additional 12 transportation activities were required. An additional market milk transportation sub-matrix was built and the accounting sub-matrix enlarged to enable total transport costs for each route to be summed to facilitate policy analysis.

The costs of transporting market and manufacturing milk were assumed to be equal since both require the same transport and handling procedures. The inter-regional transportation costs are set out in Table 2.

The original ABARE model used a theoretical basis of \$0.01 per litre per 125km to estimate the cost of transporting milk between regions. While determining the intra-regional costs not set out in Williamson, Topp and Lembit (1988), the theoretical inter-regional transportation values set out therein were checked with specific processing factories. On the basis of these inquiries, the costs of transporting milk between the Metropolitan and Riverina regions were increased from 5.1c per litre to 6.25c per litre. Similarly, transport costs between the North Coast and South Coast were increased from 5.1c per litre to 5.5c per litre. The cost of transporting milk within the Metropolitan region was reduced from 2c per litre to 1c per litre.

Table 2: Inter-regional Transportation Costs

Region		Transportation cost
Source	Destination	($ per litre)
North Coast	Metropolitan	0.0425
	North Coast	0.015
	Riverina	0.085
	South Coast	0.055
Metropolitan	Metropolitan	0.01
	North Coast	0.0425
	Riverina	0.0645
	South Coast	0.026
Riverina	Metropolitan	0.0645
	North Coast	0.085
	Riverina	0.011
	South Coast	0.051
South Coast	Metropolitan	0.026
	North Coast	0.051
	Riverina	0.051
	South Coast	0.012

2.4 Demand for Manufacturing Milk in New South Wales

The demand for manufacturing milk is assumed to be perfectly elastic based on the notion that manufacturing milk faces world prices and Australia is a relatively small producer of dairy products. The manufacturing milk prices for each region are given in Table 3. These values are the same as those used in ABARE's model.

Table 3: Manufacturing Milk Prices

Region Price	($ per litre)
North Coast	0.2163
Metropolitan	0.2102
Riverina	0.1748
South Coast	0.2081

3. Model Results

The results generated by the model include regional market and manufacturing milk production levels, and price and quantity data on sales of market milk broken down by region and period. Details of market and manufacturing milk transfers between regions are also produced. On a farm-level, activities for each of the representative farms and aggregate regional and industry costs can also be examined in relation to given policy changes by virtue of the accounting matrix. None of the latter results are reported in this paper, but the results are available from the authors on request.

3.1 Changes in Milk Production

3.1.1 Effects on market milk production

The specific impact on the production of market milk under fixed quotas, negotiable quotas and total deregulation are reported in Table 4. Partial deregulation is not examined since it has little policy application.

Table 4: Changes in Market Milk Production

	Volume (10s ML)	Change from fixed quota (10s ML)	Change from fixed quota (%)	Change from negotiable quotas to deregulation (%)	State production (%)
North Coast					
Fixed quotas	9.9479				25.3
Negotiable quotas	3.7714	-6.1765	-62.09		9.6
Deregulation	3.8718	-6.0761	-61.08	1.01	9.6
Metropolitan					
Fixed quotas	15.4394				39.3
Negotiable quotas	23.4121	7.9727	51.64		59.6
Deregulation	23.8298	8.3904	54.34	2.71	59.1
Riverina					
Fixed quotas	2.3105				5.9
Negotiable quotas	1.7608	-0.5497	-23.79		4.5
Deregulation	1.8073	-0.5031	-21.78	2.01	4.5
South Coast					
Fixed quotas	11.6077				29.5
Negotiable quotas	10.3612	-1.2465	-10.74		26.4
Deregulation	10.8419	-0.7658	-6.60	4.14	26.9

With the introduction of negotiable quotas, the major change is a shift in production from the North Coast to the Metropolitan region. There is a similar but smaller shift from the Riverina and South Coast to the Metropolitan region. It is likely that the strong demand for market milk in the Metropolitan region and the relatively high transportation costs between regions contributes to these changes. Thus under a negotiable regime, production moves to areas which are the most efficient given the transportation costs, that is, where the marginal costs of production are the lowest. This reallocation of production between regions improves efficiency.

Under total deregulation, there will be little further relocation of production beyond that for negotiable quotas since the most efficient regions are then producing market milk. The major change that will occur will be an increase in the level of market milk production until economic rents associated with the quota are eroded away, that is, until the prices for market milk fall to a level where marginal costs equal marginal revenue. The model results indicate that market milk production increases under deregulation and that little further regional production redistributions occur. Levels of market milk production in each region under deregulation are up to four per cent higher than the negotiable policy case.

3.1.2 Effects on manufacturing milk production

Manufacturing milk production levels are not directly affected by market milk quotas, except to the extent that a fixed surplus amount should be produced to prevent under supply of quota require-

Table 5: Changes in Manufacturing Milk Production

	Volume (10s ML)	Change from fixed quota (10s ML)	Change from fixed quota (%)	Change from negotiable quotas to deregulation (%)	State production (%)
North Coast					
Fixed quotas	10.4606				23.0
Negotiable quotas	14.0139	3.5533	33.97		32.8
Deregulation	13.9134	3.4528	33.01	-0.96	33.7
Metropolitan					
Fixed quotas	15.0826				33.1
Negotiable quotas	7.1099	-7.9727	-52.86		16.6
Deregulation	6.6922	-8.3904	-55.63	-2.77	16.2
Riverina					
Fixed quotas	7.1571				15.7
Negotiable quotas	7.8071	0.6501	9.08		18.3
Deregulation	7.7606	0.6035	8.43	-0.65	18.8
South Coast					
Fixed quotas	12.8236				28.2
Negotiable quotas	13.7885	0.9649	7.52		32.3
Deregulation	12.9073	0.0837	0.65	-6.87	31.3

ment. However, the results (Table 5) indicate that manufacturing milk production levels are affected indirectly in that where a region increases its market milk production the quantity of manufacturing milk produced in that region will decline, more or less maintaining total milk production. This result is not all that surprising since milk production will be determined by marginal costs and prices, and manufacturing milk prices have not changed for most farm types. As expected, the major result is that under negotiable quotas and deregulation, more manufacturing milk will be produced in the North Coast, Riverina and South Coast regions, and less in the Metropolitan region.

If total deregulation were to occur, a reduction in the production of manufacturing milk occurs in all regions, as farms produce more market milk. These reductions are only minor in the North Coast and Riverina and are most substantial for the South Coast.

3.1.3 Effects on total milk production

The total level of milk production for each region is reported in Table 6. Generally total milk production in each region remains similar under each policy with the main exception being the North Coast, where the decline in market milk production is only partially offset by an increase in the production of manufacturing milk. This may be partly accounted for by the fact that the North Coast has a larger proportion of higher cost farms.

Table 6: Changes in Total Milk Production

	Volume (10s ML)	Change from fixed quota (10s ML)	Change from fixed quota (%)	Change from negotiable quotas to deregulation (%)	State production (%)
North Coast					
Fixed quotas	20.4085				24.1
Negotiable quotas	17.7852	-2.6232	-12.85		21.7
Deregulation	17.7852	-2.6232	-12.85	0.00	21.8
Metropolitan					
Fixed quotas	30.5221				36.0
Negotiable quotas	30.5221	0.0000	0.00		37.2
Deregulation	30.5221	0.0000	0.00	0.00	37.4
Riverina					
Fixed quotas	9.4675				11.2
Negotiable quotas	9.5679	0.1004	1.06		11.7
Deregulation	9.5679	0.1004	1.06	0.00	11.7
South Coast					
Fixed quotas	24.4313				28.8
Negotiable quotas	24.1497	-0.2816	-1.15		29.4
Deregulation	23.7492	-0.6821	-2.79	-1.64	29.1

3.2 Changes in Market Milk Prices

Prices are determined by the quantities of market milk sold in each region, in each time period. Table 7 indicates the percentage changes in the price of market milk in each period under the different policy scenarios considered. In summary, the results show that the fixed quota and negotiable quota policies hold the price of market milk at higher levels than in the deregulated market due to supply restrictions.

3.3 Comparison of Objective Values

Studies undertaken indicate that the introduction of negotiable quotas or deregulation will lead to an improvement in industry efficiency (for example Lembit and Bhati 1987). The analysis carried out by Williamson *et al.* (1988b) found that increased efficiencies associated with the introduction of the system of non-negotiable quotas would allow each dairy farm to be 'given' a payment of $1000 from the industry. The potential net gain to the industry would be in the order of $2.8 million per annum (Lembit *et al.* 1988, p. 258). Studies by the Industries Assistance Commission (1983) and Purtill and Skinner (1987), have also highlighted some of the inefficiencies inherent in the dairy marketing system.

The objective function in the quadratic programming models is a social welfare measure, namely the sum of consumer and producer surplus net of transport costs. The changes in the objective function values associated with the optimal solutions under various policies provide an indication of the

Table 7: Policy Effects on the Prices of Market Milk

	(1) Price under fixed quota ($/L)	(2) Price under negotiable quotas ($/L)	Price change from (1) to (2) (%)	(3) Price under total deregulation ($/L)	Price change from (1) to (3) (%)
North Coast					
January-March	0.391	0.425	8.76	0.245	-37.16
April-June	0.391	0.417	6.71	0.245	-37.16
July-September	0.391	0.411	5.28	0.245	-37.16
October-December	0.391	0.425	8.76	0.245	-37.16
Metropolitan					
January-March	0.418	0.413	-1.32	0.233	-44.21
April-June	0.418	0.415	-0.77	0.244	-41.75
July-September	0.418	0.416	-0.53	0.250	-40.17
October-December	0.418	0.413	-1.32	0.233	-44.21
Riverina					
January-March	0.365	0.377	3.54	0.198	-45.68
April-June	0.365	0.369	1.32	0.198	-45.68
July-September	0.365	0.364	-0.25	0.198	-45.68
October-December	0.365	0.377	3.54	0.198	-45.68
South Coast					
January-March	0.404	0.409	1.19	0.230	-43.19
April-June	0.404	0.401	-0.79	0.230	-43.19
July-September	0.404	0.402	-0.54	0.236	-41.58
October-December	0.404	0.409	1.19	0.230	-43.19

efficiency losses sustained by following sub-optimal policies. The objective values under each policy are given in Table 8.

Table 8: Objective Values for Each Policy Modelled

Policy	Objective function value ($\$1x10^7$ /year)
Fixed quotas	139.504
Negotiable quotas	139.888
Total deregulation	139.979

As expected, social welfare levels are highest under total deregulation. The increase in the objective value is greater for the movement from fixed to negotiable quotas than the movement from negotiable quotas to total deregulation. This is to be expected since greater adjustments in regional production of market milk and manufacturing milk occurred in the first policy change. Relocation of market and manufacturing milk production under a freer environment is thus the main cause of the gains. This occurs because farmers with lower costs of production and advantages in relation to market locality are able to produce more market milk. The model results are therefore consistent with previous expectations that the removal of fixed quotas would improve efficiency.

3.4 Comparison With Other Research

In terms of the production of market milk, some of the results presented here contradict the results of earlier ABARE work (see Williamson *et al.* 1988b; Lembit *et al.* 1988; De Saram 1991). Subsequent ABARE work analysing the effects of deregulating the New South Wales, Victorian and Queensland milk industries, and allowing free interstate trade of milk, has generated results more consistent with the outcomes presented in this paper (see Lembit *et al.* 1991). In particular, both Lembit *et al.* (1991) and the present study point to a likely increase in the production of market milk in the Metropolitan region, though the increase is more dramatic in the present study. Similarly, both studies show large and quantitatively similar reductions in the production of market milk in the North Coast region. The Murray-Riverina region is characterised by a cessation of market milk production in Lembit *et al.* (1991) and a sharp reduction in the present study.

One difference between the results obtained here and those in Lembit *et al.* (1991) is that in the present study, the South Coast region produces slightly less market milk under deregulation than under fixed quotas, while Lembit's analysis suggests the region will produce substantially more. The reason for the *increase* in the production of market milk in the South Coast region in Lembit's paper is attributed to relative market proximity and production costs (p. 36). The outcome in the current paper may simply be a result of the displacement of South Coast-sourced market milk by Metropolitan-sourced milk. It may also be associated with the use of a lower intra-region transport cost for the Metropolitan region in this study than in Lembit *et al.* (1991) (1c per litre compared to 2c per litre). Either way, both Lembit *et al.* (1991) and the current paper suggest that the major sources of market milk under deregulation will be the Metropolitan and South Coast regions.

De Saram (1991) reports on the actual outcome of trading in milk quota for the six month period after July 1990. At a factory level, the Southern region gained quota milk evenly distributed over various quota periods. This result is consistent with the outcome in Williamson *et al.* (1988b) and Lembit *et al.* (1991). It does not correspond to the results from the current model. Conversely, the trading outcome for the Northern region, namely disposal of quota, corresponds to the results of both the present paper and Lembit *et al.* (1991). No trends were evident for the Riverina region at the time De Saram did her analysis.

In terms of manufacturing milk, both the present analysis and Lembit *et al.* (1991) point to increased production in the North Coast and Riverina regions. The results for the Metropolitan and South Coast regions do not correspond qualitatively or quantitatively, though this is probably accounted for partly by the fact that the Lembit *et al.* model allows for the inter-state trade of milk.

3.5 Long Run Outcomes

Given the presence of resource constraints in programming models, such models are inherently short-run in nature. Both the original ABARE model and the extended model outlined above are distinctly so. In particular, the models assume that individual farm types are endowed with given amounts of land, stock and capital at zero opportunity cost. There is no competition for these resources outside of the type of farm which currently has them. It is not surprising then to find that the total milk production in each region does not decline significantly as milk prices fall under deregulation, and that the change due to deregulation is essentially one of more rational sourcing of market milk. Only by relaxing resource constraints can longer-run scenarios be modelled.

To gain an idea of the longer-run structure of the industry, the policy experiments described above were re-run after making a number of alterations to the model. In particular, the initial farm holdings of land and stock were reduced to zero, as was the value of the capital pool. As a result, the farms could only engage in milk production by borrowing capital at an appropriate interest rate and purchasing the necessary land, cattle and equipment.

Table 9: Milk Production under Deregulation in the Long Run

Region	Market milk production	Manufacturing milk production
North Coast	4.4686	0.0000
Metropolitan	0.0000	0.0000
Riverina	8.6632	0.0000
South Coast	26.8011	0.0000

These resources were assumed to be available at the same prices as for expansion opportunities in the short-run models. While a full set of results are available, results given in Table 9 are only for the regional production of market and manufacturing milk under full deregulation.

The results presented in Table 9 can be compared to those generated under deregulation in the short-run model described previously. The most noticeable feature of the longer-run solution is the elimination of market milk production in the Metropolitan region, coupled with a large increase in production in the South Coast region and to a lesser extent, in the Riverina. The explanation for this change lies principally with the high land prices in the Metropolitan region. Given the opportunity costs of land, it is uneconomic to carry on dairying in that region and deregulation would see the transfer of Metropolitan dairying land to alternative uses. Although land in the Riverina and South Coast regions has an opportunity cost, the reduced aggregate production of milk and the rise in market milk prices to as high as 33 cents litre is sufficient to warrant expansion of dairying in these regions. The total absence of manufacturing milk production throughout the State reflects the uneconomic nature of such activity in the face of alternative uses for land. It is to be noted that even with fixed quotas, the introduction of opportunity costs on land and capital would lead to the elimination of the manufacturing milk sector. It is not surprising that processors then have to use various 'carrots' and 'sticks' (for example minimum production levels to maintain quotas; rising marginal price schedules for manufacturing milk) to coerce farmers to produce manufacturing milk. Deregulation would eliminate one of the 'sticks' for maintaining manufacturing milk production.

Some caution should be attached to the interpretation of these longer-run results as they too suffer from some of the problems associated with the short-run model. In particular, no allowance is made for possible changes in land prices and other resources in the face of altered demand by the dairying sector. Any large-scale fall in demand (as is indicated for the Metropolitan region) may cause the regional price of land to fall. Conversely, land prices could rise in the South Coast and Riverina. Such changes would act to temper the milk production changes, and it is possible that some milk production would continue in the Metropolitan region, and that manufacturing milk production would not cease totally.

The very different results in the longer-run case from those in the short-run case highlight the need for caution in interpreting the output from complex mathematical programming models. The assumptions in these models can be critical to the results.

4. Areas for Further Research

The implications of milk supply from regions outside of New South Wales have not been considered in this analysis. In particular, no allowance has been made for Victorian-sourced milk, or for New South Wales production to flow into Victoria. While it is true that, given current production and transport costs and market milk arrangements, Victorian imports are unlikely to substantially challenge New South Wales sourced milk, inter-state flows may occur were there large falls in the price of milk under deregulation (Lembit *et al.* 1991, p. 35-37). This may be particularly so if the full opportunity costs of resources used in dairying are considered.

In New South Wales, manufacturing milk prices determine production at the margin. Hence the demand function for manufacturing milk is important, particularly under deregulation. Some form of demand equation for manufacturing milk, other than a perfectly elastic one, should be incorporated into the model. It may be useful also to incorporate the processing sector more explicitly and fully into the model. Rational location of processing factories may be an extended policy analysis under such a model.

The assumption of constant per unit transport (and processing) costs could be relaxed allowing the average cost curves of transformation to be specified in, say, a quadratic form creating a cubic programming model. MacAulay, Batterham and Fisher (1989) describe the use of cubic programming methods in spatial trading systems.

Further sensitivity analysis should also be undertaken. Given the reliance on fixed prices for manufacturing milk in each region and on the fixed transportation costs of milk between regions, the model needs to be examined for stability in its solution given a range of prices and costs. Given that fact that the Riverina region had a much smaller production in the short-run results here compared to other studies, some sensitivity analysis was undertaken on the cost of transporting milk from the Riverina . From the limited number of sensitivity runs undertaken, it was found that there were practically no changes to the results for the first one cent per litre drop in transportation costs from the Riverina to Sydney. A more extensive study is needed to confirm the stability of this solution.

5. Conclusions

The general effect of negotiability and deregulation on the production of market and manufacturing milk is significant, and can be observed readily within Tables 4 to 8 for the short-run case. The results indicate that the North Coast will produce much less market milk while the Metropolitan region will increase its production significantly under both negotiable quotas and deregulation. The major effect deregulation has in addition to the policy of negotiable quotas is that large falls in prices will occur in all regions. The price decline will far outweigh the additional production of market milk and farm revenues will decline.

Manufacturing milk production levels adjust such that total milk production levels tend to remain unchanged for each region. Since production is restricted to a level where marginal costs equal marginal revenue, and marginal revenue is set by the price of manufacturing milk, little change in total production will occur under deregulation. This explains the large reductions in manufacturing milk production in the Metropolitan region as more market milk is produced under both negotiable quotas and deregulation. Despite large increases in the production of manufacturing milk in the North Coast region, total production of milk will decline in that region.

Contrary to Williamson *et al.* (1988b), and to some other market participants' beliefs (dairy farmers' comments), but consistent with Lembit *et al.* (1991), the Riverina seems to have a small part to play in the production of market milk for consumption in New South Wales in the short-run. Importantly, this result implies that distance to market is important and that as such, Victorian producers may not be able to compete with producers in New South Wales. If this is the case for the negotiable-quota scenario, where prices are relatively high, it will be more pronounced if total deregulation occurs, since prices will be much lower. In the long run however, an increase in production in the Riverina is indicated.

The movement in New South Wales to a policy of negotiable quotas should increase efficiency in the industry. Deregulation will take producers to an even more competitive position but it will have detrimental effects, in aggregate, on producers' income levels. Farmers should therefore argue against total deregulation, as should processors. Consumers should pursue the case for deregulation, since they could be expected to benefit from lower prices.

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