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THE RESOURCE COSTS OF BLENDED MILK PRICING IN VICTORIA

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Victorian dairy farmers receive an average of the fresh and manufacturing milk prices for each litre of milk they produce. A regional linear programming model was used to estimate milk production in Victoria under average or 'blended' pricing, as well as under marginal pricing. The results indicate that milk production in Victoria under blended pricing is 31 per cent more than it would be using marginal pricing. Resource costs of this excess production were estimated to be around \$9m under blended pricing. The extent of extra production under blended pricing increases as the gap between the two milk prices widens. The introduction of free trade in dairy products with New Zealand in 1990 may reduce manufacturing milk prices and therefore a review of the blended pricing scheme in Victoria could be warranted.

Research on this project was supported by a grant from the Dairy Research Council.

The Australian dairy industry is facing changes in its marketing environment. The changes in trade arrangements are, perhaps, the most significant since the industry lost access to the British butter market when Britain joined the European Community in the early 1970s. It will be important for the industry to adapt to this new environment. State regulations governing the pricing and production of milk will need to be examined to ensure that appropriate market signals are received by producers and that resources committed to dairying are used efficiently.

The restriction of imported dairy products has allowed the Australian dairy industry to differentiate between domestic markets and export markets. Producer levies on all milk, and product levies on cheese and butter have been used to subsidise exports and extract a higher return from the domestic market. After 1990, the introduction of freer trade with New Zealand under the Closer Economic Relations (CER) agreement will introduce a greater degree of competition in the domestic market for processed dairy products in Australia. Furthermore, the termination of subsidies after June 1992 will effectively eliminate any remaining price differentiation between domestic and export products in Australia. With a fall in processed dairy product prices, prices received by farmers for manufacturing milk will decline.

A mathematical programming model of the Victorian dairy industry - which supplies almost 70 per cent of manufacturing milk in Australia - has been developed to evaluate the effects of blended versus marginal pricing on production and industry returns. Using the model, the costs of blended pricing given current prices are compared with costs under a range of alternative manufacturing milk prices.

The Victorian Industry

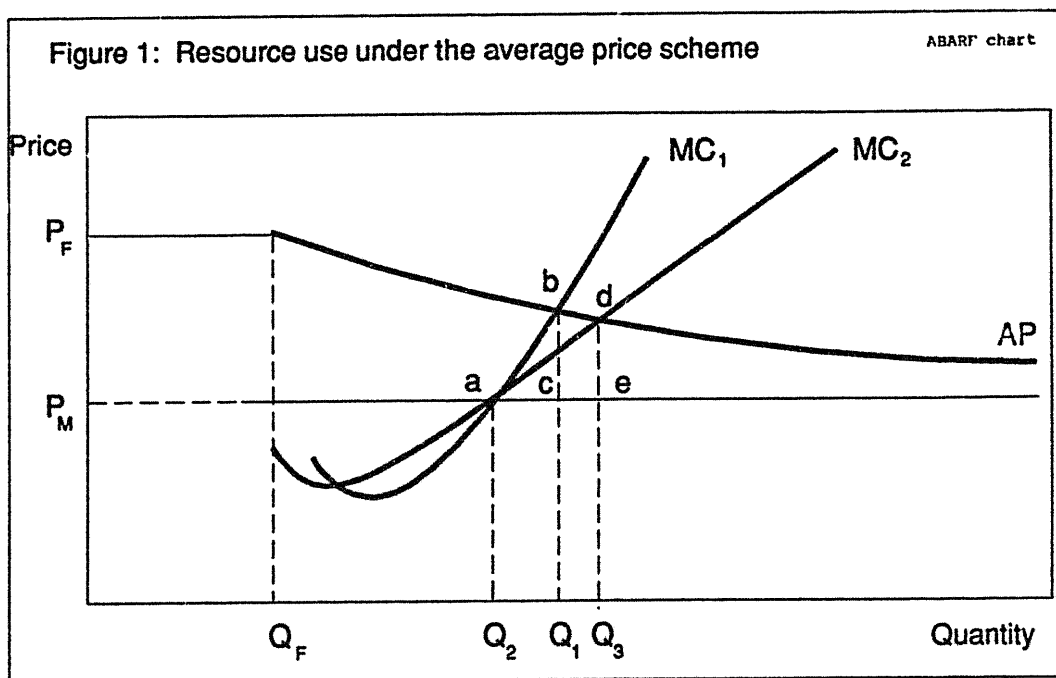
Market milk policy in Australia has been characterised by entitlement schemes. Until 1977 the Victorian industry ensured market milk deliveries by contracting selected farmers to deliver milk to the Victorian market. These farmers received a premium for producing their contracted quota of milk. In 1977 Victorian milk policy changed. Factories rather than individual farmers were contracted to supply market milk. The quantity they supply is based on the amount of milk each factory collects from its contracted farms.

Prices for market milk are set by the Victorian Dairy Industry Authority, which administers market milk policy in Victoria. Returns from the fresh market are pooled and each farmer receives payment depending on the percentage of milk used for market milk in each month. For example, if 10 per cent of total Victorian milk production in a particular month is sold as fresh milk, then each farm will be paid the fresh milk price on 10 per cent of its production for that month. The costs associated with delivering milk are also shared across all farms. The price paid for fresh milk is about twice the price for milk used for the manufactured product. The fresh milk price and manufacturing milk price are blended so that farmers actually receive an average of the market and manufacturing price for each litre of milk produced. Blended prices have been approximately 2c/L greater than manufacturing milk prices. An extra litre of milk produced by a farmer will therefore return the average milk price per litre and a fall in the price of manufacturing milk will widen the gap between blended and marginal prices.

Marginal versus average pricing

The blended or average price scheme in Victoria causes an inefficient use of resources dedicated to milk production in Victoria. The extent of the

inefficiency depends on the cost structure for Victorian farms. This is illustrated in Figure 1.



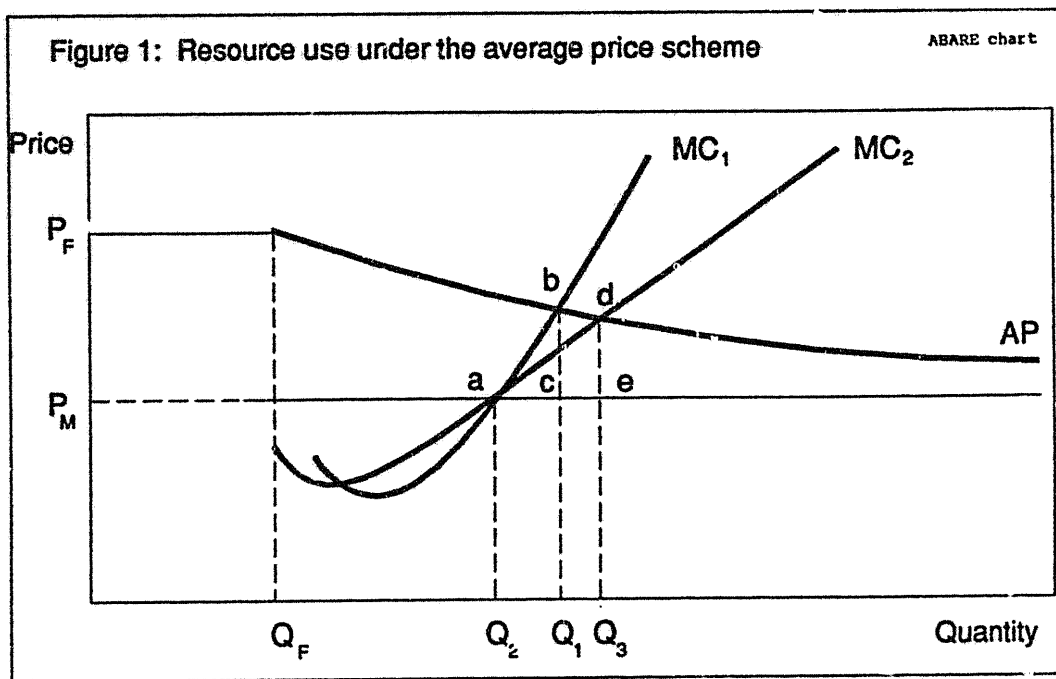
The average price curve is shown as AP. Up to Q_F the fresh milk price P_F is paid for each litre of milk produced. After Q_F , farmers marginal return is a function of the quantities sold in each of the fresh and manufacturing milk markets. The average price is calculated by the formula:

$$AP = \frac{P_F Q_F + P_M Q_M}{Q_F + Q_M}$$

where Q_M is the amount sold on the manufacturing milk market. The marginal price for the industry is P_M because the industry receives the manufacturing price for all units sold above Q_F . Profits to the industry will be maximised when marginal costs (MC_1 or MC_2) equal industry marginal return (P_M), that is, at point a. However, individual farms will maximise profits when marginal costs equal marginal returns for farmers. Marginal return for farmers will be a value on AP for any given quantity of production, because farmers receive the average price for all milk sold. If marginal costs on farms are similar to MC_1 , the level of overproduction ($Q_2 - Q_1$) will be much lower than if marginal costs are represented by the flatter curve MC_2 (overproduction will be $Q_3 - Q_1$). The cost to the industry increases from abc to ade. Therefore, if the price elasticity of supply in Victoria is high, the extent of inappropriate resource use due to excess production will be high.

The level of inefficiency of an average price scheme versus a marginal price scheme will also depend on prices. If either manufacturing prices fall or fresh milk prices increase, the difference between the average and marginal prices for the industry will increase. This occurs as a result of an increase in the weighting given to the fresh milk price in the average

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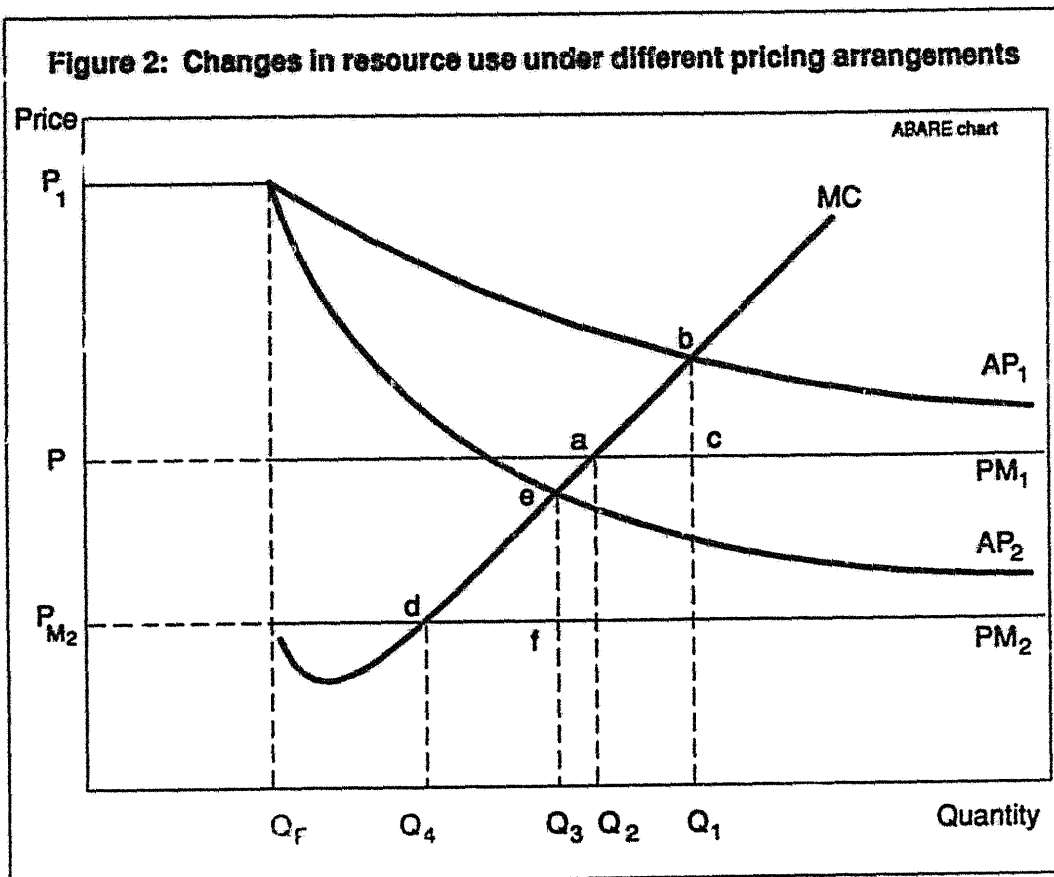
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price equation. As the two prices diverge the amount of extra production under the average price scheme will increase. This situation is illustrated in Figure 2.



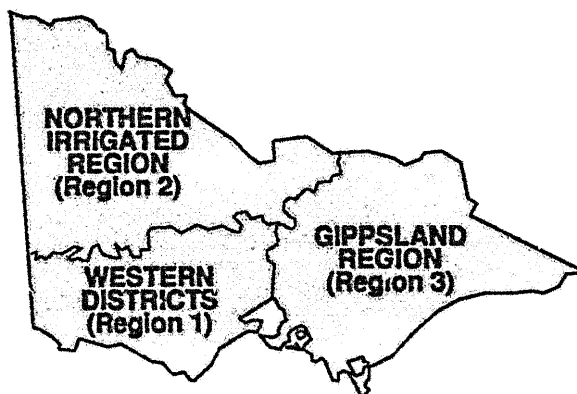
Marginal costs on farms are shown as MC. When the manufacturing milk price is PM₁ and the average price is AP₁ the amount of extra production will be Q₁ - Q₂. The excess resource use will be abc. If the manufacturing milk price then falls to PM₂, the average price will become AP₂. Extra production in this example will be Q₃ - Q₄, and a quantity, def, of resources will be lost to society. Therefore, if prices were to fall significantly as a result of Closer Economic Relations with New Zealand or the reduction of export subsidies, the use of resources in the Victorian dairy industry would become less efficient due to the divergence of the average and marginal price curves. An increase in the fresh milk premium will have a similar result.

An Overview of the Model

The model of the Victorian dairy industry is a regional model of representative farms solved using linear programming techniques. The model comprises three regional technology submatrixes, a market milk revenue submatrix and a manufacturing milk revenue submatrix. The regional technology submatrixes contain all the activities associated with selling milk into the two markets and are linked into both milk revenue submatrixes.

rows. The model optimises a linear objective function which maximises net profits.

Figure 3: Australian dairy industry survey: survey regions, Victoria



ABDAL CHART

Regional delineation in the model was achieved by using the three existing Australian dairy industry survey (ADIS) regions in Victoria (Figure 3). Some minor adjustments to boundaries were made to allow such factors as climate, soil and water availability to be taken into account. For convenience, a number of minor changes were made to the ADIS regional classification. Six irrigated dairy specialist farms in ADIS region 3 were reclassified as region 2 farms. One irrigated dairy specialist farm in region 3 was deleted from the sample. This meant that all the dairy farms located in region 2 were irrigated dairy specialists, while regions 1 and 3 contained dryland dairy specialist farms only. Resource levels for each regional representative farm were calculated using averages computed from the survey data with the new regional classification. Representative farms for each region were then modelled using these resource levels. Technical coefficients for each regional matrix were either calculated from Bureau survey data or obtained from the Victorian Department of Agriculture and Rural Affairs.

A diagram of the model structure is shown in Figure 4. Details of the model including technical coefficients and resource constraints are included in a related technical paper by Topp, Williamson and Lembit (1989).

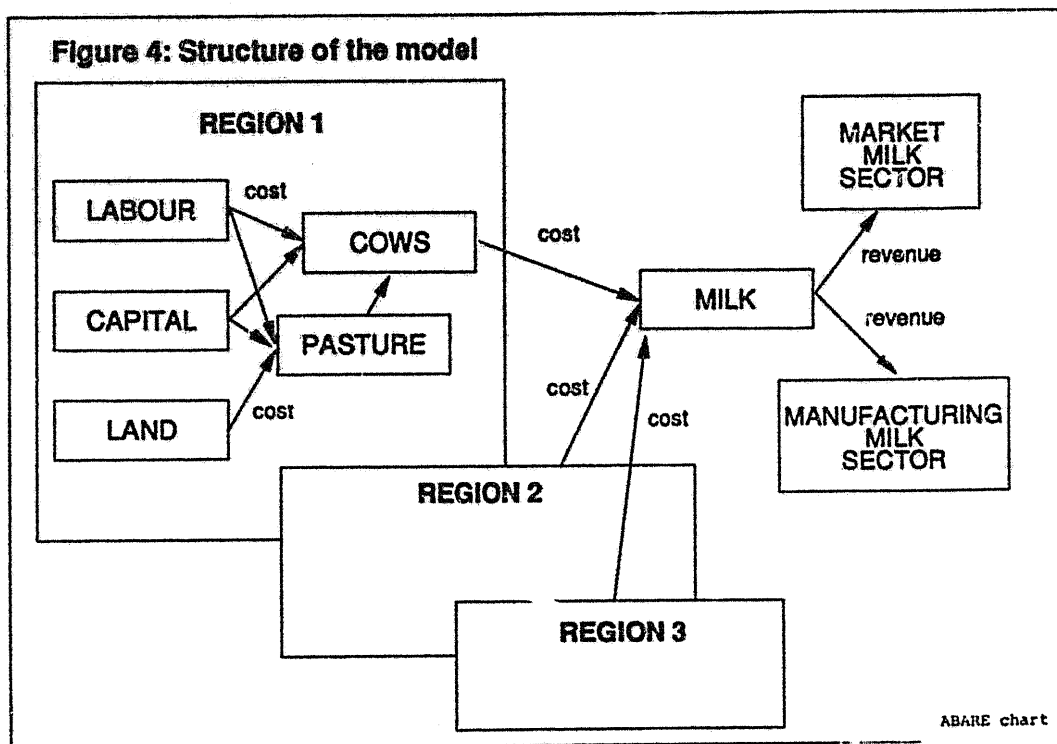
Design aspects

In any period, the marginal cost of milk production is heavily dependent on the availability of quality native and improved pastures. These are the cheapest and most productive feeds available for milk production. The quarterly periods outlined below generally coincide with the pattern of pasture growth in each of the three regions. Period 4 has the highest pasture growth, while period 3 includes the lowest pasture growth months.

- Period 1: January - March
- Period 2: April - June
- Period 3: July - September
- Period 4: October - December

Technical and economic information used in the model was obtained from researchers, extension officers, processors and farmers. Further information

Figure 4: Structure of the model



ABARE chart

on the level of resources available to each region was obtained from ADIS dairy specialist data. All financial data used were either 1986-87 data or earlier data inflated to 1986-87 prices using price indexes estimated by the Bureau.

Dairy production in each region was modelled for a representative farm. Within the farm technology matrix, dairy activities draw on regional resources, with management practices represented by regional norms. For example, capital costs were estimated on a per cow basis and reflect average regional investment in dairy facilities, fencing and other farm machinery. Alternative enterprises were not included in the model. Thus, land and capital stock may be regarded as fixed inputs into dairy production. Adjustments in land and capital stock occur only as the marginal costs of dairying exceed marginal returns. As a result, adjustments within the dairy industry to changes in dairy returns will be understated at both a state and regional level. Furthermore, in the context of total agricultural production, the predicted response in variable inputs is likely to be overstated (LeChatelier principle).

Subject to the limitations on land and capital stock, a model solution represents a long run equilibrium. The time horizon for major shifts in dairy production may extend from five to ten years, based on simulations of the Bureau's econometric model of Australian broadacre agriculture (EMABA) (Dewbre, Shaw, Corra and Harris 1985). Furthermore, all measures of adjustment are based on the assumption that the initial conditions, on which the model is aligned, represent a stable equilibrium.

Each submatrix includes a farm's land, labour, capital (including stock) and pasture production activities. The technical coefficients corresponding to these activities differ between the three regions.

Total arable land for each region was calculated from ADIS dairy specialist data. An assumption was made that not all of this arable land was

of the same quality or productivity of pasture. To allow for some of these differences, the total arable land available in each region was divided into three types on the basis of a cluster analysis of the ADIS sample farms. These farms were separated into three groups on the basis of their total costs per litre of milk, and the resulting proportions of high, medium and low cost farms were used to divide total arable land into the three types. The first type of arable land could be used for the production of high yield/low cost pastures, the second type could be used for the production of lower yielding pastures only, and the third type of land is used for the production of intermediate yielding pasture. Of the total arable land area available, the proportion of each land type in each region is shown in the paper by Topp, Williamson and Lembit (1989).

In regions 1 and 3 there are two perennial pasture activities, one giving a higher yield than the other and at a lower cost. As mentioned above, the high yielding pasture can only be grown using the first quality arable land. Region 2 also has two perennial pastures as well as two annual pastures, again with one yielding greater feed energy at a lower cost. The annual pastures produce less total energy than the perennial pastures, but produce energy at different times during the year and at a lower cost.

The price of arable land was determined using 1986-87 ADIS survey data. Additional land purchases are assumed to be limited to no more than 50 per cent of the existing land areas. Land selling activities were excluded from the model.

Regional dairy cow numbers and dairy cow breed composition were obtained from ADIS dairy specialist data. This information was used to obtain an accurate representation of cow productivity (defined as energy required per unit of milk production) for each regional matrix. To allow for herd expansion or contraction, each regional farm has activities to buy and sell cows. Dairy herd costs include a dairy cow replacement cost, direct variable costs per dairy cow, and a measure of the indirect variable costs associated with cows, such as pesticides and agistment. These were obtained by regressing ADIS variable costs for dairy specialists against dairy cow numbers.

For the purposes of milk production, cows are assumed to follow the standard lactation curve (Wood 1969). After calving, which may occur at the beginning of any of the four periods, milk production rises from day 0 to day 30 and then declines by 10 per cent a month until day 300 when production ceases altogether. This means that each cow will produce milk in the model over 3 1/3 periods. Lactation yields for each region in each period were obtained by multiplying the proportion of lactation in each period by the annual average lactation yield per cow.

Using 1986-87 ADIS dairy specialist data, each region was allocated a representative pool of both capital and labour from which it could draw. A labour requirement coefficient was obtained by regressing total farm labour against the number of cows in each region. Similarly, a capital requirement per cow was obtained by regressing total capital stock against the number of cows. A hire labour activity exists to account for any expansion in output or, conversely, a representative farm may sell the unused portion of its pool of labour. Possible capital acquisitions such as extra land or cows are accounted for by activities to borrow capital, the price of which is set at the opportunity cost of capital, 9 per cent. There is no provision in the model to sell capital.

In the blended price model, an amount of fresh milk equal to the amount produced by the 1986-87 ADIS dairy specialists must be produced before any manufacturing milk activities can be brought into the model. There is no restriction on which region or regions the fresh milk must come from, so the model will produce this milk from the region with the lowest marginal costs.

The precision of the model was evaluated by an historical simulation, using prices, costs and resource levels set to 1986-87 values from ADIS data. The milk supply generated by the model was then compared with regional manufacturing milk supply estimates from the ADIS production data. The model was aligned to replicate actual milk production in 1986-87 by adjusting pasture productivity and pasture costs between regions.

The blended price model was constructed with the intention of representing milk production in Victoria under the existing pricing structure, as accurately as possible. This would allow the analysis of alternative price and production levels under constant institutional arrangements.

A second programming model has also been constructed to enable the simulation of milk production in Victoria under an alternative manufacturing milk pricing structure. In this model, farms are paid the marginal price for their milk. Farms effectively receive two separate payments for their milk - one for the higher priced market milk, and one for the cheaper manufacturing milk. For every litre of manufacturing milk produced, farms are paid an amount equal to the predetermined marginal manufacturing milk price. This compares with the current blended price scheme for milk, where farms receive an average price for all of their milk.

This 'marginal price' model is identical to the original model except for the manufacturing milk revenue submatrix. This submatrix has been modified to reflect a constant price for all manufacturing milk. Regional transport costs for market milk have not been included. Market milk prices are assumed to be equal to market milk prices in the blended price model.

Manufacturing milk supply curves for each of the two models were generated by reducing the price of milk, and then optimising to obtain the level of production. The 'blended price' model was programmed parametrically to simulate a shift in the blended price curve as marginal manufacturing milk prices fell. In the 'marginal price' model, the manufacturing milk price was simply reduced by a constant amount (0.5c/L) for each simulation and then re-solved.

Results

With a 1986-87 price for market milk of 31.95c/L, and a price for manufacturing milk of 15.74c/L, the model's estimate of manufacturing milk production in Victoria under the 'blended' or average price scheme is 2841 ML. Under this pricing scheme, with the above prices for market and manufacturing milk, farms are actually responding to an average price of around 17.56c/L when producing manufacturing milk.

The production of 2841 ML under the blended price scheme compares with manufacturing milk production of 1951 ML under a straightforward marginal price scheme, with the manufacturing milk price again set at 15.74c/L. The difference in milk production between the two models of around 31 per cent can be said to result from the distortion in marginal milk price which occurs under a blended price scheme. Production distortions arising from the

average pricing policy result in estimated resource costs of approximately \$9m. As the price of manufacturing milk falls the rate of decline in industry profits increases substantially. For example, if the price of manufacturing milk falls by 3.5c/L to 12.24c/L, estimated resource costs increase to about \$24m.

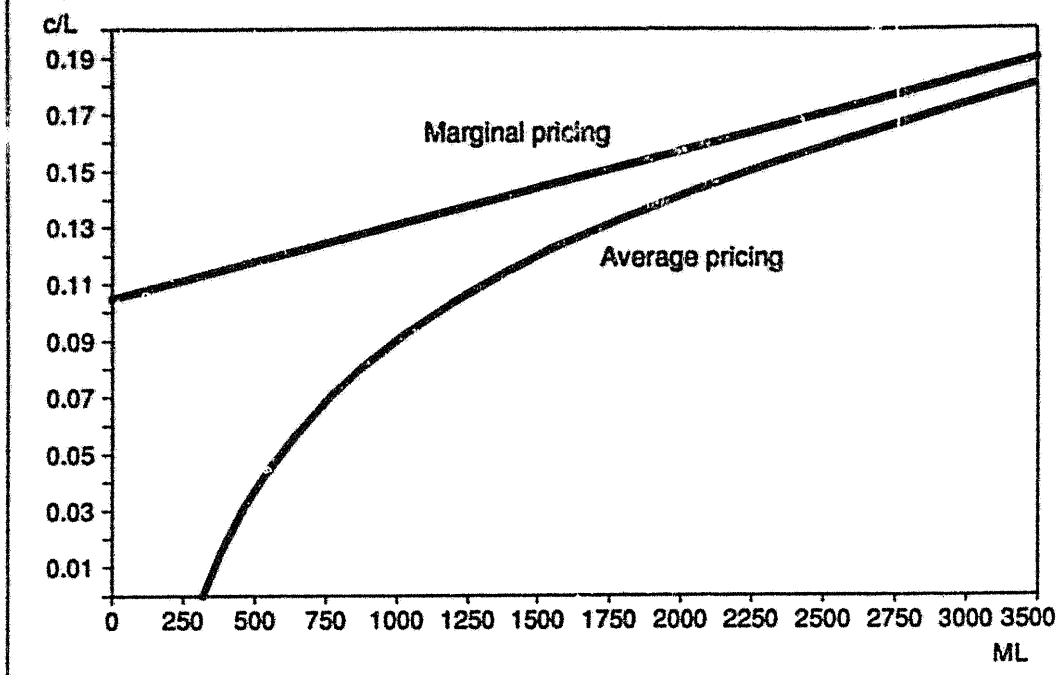
The extent of overproduction of manufacturing milk in the blended price model is exacerbated as the marginal price of manufacturing milk falls relative to the market milk price. In the marginal pricing model, manufacturing milk production decreases as price decreases. In the blended price model, however, the average price for manufacturing milk does not fall at the same rate as the marginal price for manufacturing milk, so that even at quite low marginal manufacturing milk prices, the average price for all milk is still high enough to induce manufacturing milk production. At a marginal milk price of 10.24c/L, estimated manufacturing milk production in the marginal pricing model has fallen to zero. In the blended price model, however, estimated manufacturing milk production is still 1601 kL. Moreover, the blended price model produces an estimated 482 ML of manufacturing milk even when the marginal price of this milk is as low as 1c/L, simply because the average price is still around 14c/L.

The predicted decline in dairy production after a shift to a marginal pricing scheme may also be underestimated. This is because the model has been specified to include dairyfarming activities only, and no account can be taken of resource shifts out of dairying and into more profitable enterprises. Within the model, resources are allocated out of dairy production when the marginal cost of the dairy enterprise exceeds marginal returns. However, more resources may in fact be allocated out of dairy production as the marginal return to dairying falls relative to alternative enterprises. Thus, the results represent a lower limit on the reduction in dairy supplies which is likely to occur under marginal pricing.

The two supply curves shown in Figure 5 illustrate the difference in production under the two price schemes. As can be seen, the marginal price supply schedule is more elastic than the blended price supply schedule, and indicates an efficient response in resource use by producers to changing manufacturing milk prices. The graph also shows how the two supply schedules converge as manufacturing milk production increases relative to market milk production, and as the blended price approaches the marginal price. Conversely, as the marginal price for manufacturing milk falls and production contracts, the difference between the blended and marginal prices widens, and the two supply schedules diverge. The blended price schedule depicts production at levels significantly above marginal price levels when marginal milk prices are lower.

Figure 5: Manufacturing milk supplies in Victoria

ADAGE chart



Conclusions

The results from this research provide guidance for the future direction of the Victorian dairy industry. The current objective of milk policy in Victoria is to provide an equitable return for all farmers (IAC 1983). The results of this analysis indicate that there is a cost of meeting this objective. The resource cost at the 1986-87 level of production and prices is estimated to be around \$9m or 3.6 per cent of net industry returns. In the long run the current blended price scheme leads to 30 per cent extra production at 1986-87 prices in Victoria. The resources dedicated to the extra production may be used more profitably in other enterprises providing that alternative activities are subject to competitive pricing conditions. It is the costs associated with this extra production that reduce industry profits.

Currently, export markets are relatively buoyant and domestic manufacturing milk prices are increasing to reflect this. However, with the advent of the new arrangements under the Closer Economic Relations agreement and the possible removal of the All Milk Levy in the 1990s, the fresh and manufacturing milk prices may diverge further. Under these circumstances, and with the continuation of average pricing, the extent of excess production in Victoria will increase. In the light of this it is important to note that a reduction in marginal prices will result in a larger reduction in costs under the marginal price scheme relative to average pricing.

The blended pricing system results in an inefficient allocation of resources, and for this reason should be subject to review. Furthermore, under the blended pricing system a fall in manufacturing milk prices relative to market milk prices results in an increase in the social welfare loss. As such a change in relative prices is likely under CER, the need for a review of the current pricing system in Victoria is further justified.

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PROGRAMMING MODEL OF THE VICTORIAN DAIRY INDUSTRY:
A TECHNICAL DOCUMENTATION

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A detailed documentation of the structural components of a regional linear programming model of the Victorian dairy industry is presented in this paper. Included are the complete technical and financial details of model activities, resource levels and input-output coefficients as well as data derivation and sources. This documentation presents the foundation on which an ongoing effort to model the Australian dairy industry will be based.

The second stage of the development of an Australian dairy industry programming model is presented in this paper. A regional dairy programming model was developed to quantify the impact on the Victorian dairy industry of Closer Economic Relations (CER) with New Zealand. Two separate papers have been prepared. The purpose here is to provide a detailed description of the structural components of the model. The other paper, 'The resource costs of blended milk pricing in Victoria' (Topp, Williamson, Lembit and Beare 1989), contains a general discussion of the theoretical structure of the model, the modelling approach and summary results.

This documentation contains a complete technical and financial description of the structural components of the model. First, details of the model structure and a general algebraic formulation of the model are presented. Technical information such as dairy costs and feed demand and supply are included next. Derivation of the labour and capital requirements and other cost and resource data make up the balance of the documentation. An extension of this technical documentation is planned, to take account of future model development.

Model Structure

There are three component parts which make up the general physical structure of the model:

- . a market milk revenue submatrix,
- . a manufacturing milk revenue submatrix, and
- . three regional technology matrixes.

The market milk revenue submatrix is constrained by equalities to produce a specific amount of market milk equal to the 1985-86 market milk production represented by the dairy specialist component of the Australian dairy industry survey (ADIS).

The manufacturing milk submatrix is a linear approximation of a blended price curve, and is constrained by quantities reflecting differing average price levels. This submatrix can be programmed parametrically to simulate the shift in the blended price curve as the marginal price for manufacturing milk rises or falls. The three regional technology submatrixes are independent of one another and are linked into the market milk and manufacturing milk submatrixes by transfer rows. Aggregate resource levels, available in each region, act as production constraints on each of the three submatrixes.

General algebraic formulation of the model

The purpose of the model is to maximise a linear objective function of the form:

$$Z = \sum_{j=1}^n C_j x_j - \sum_{k=1}^n C_k x_k$$

where C_j is equal to the revenue (net of transport and levies) obtained for the sale of one unit of x_j (market and manufactured milk), and C_k is equal to the cost associated with operating a unit of x_k (pasture, cows, etc.).

Subject to a set of linear constraints:

$$\sum_{j=1}^n a_{ij}x_j + \sum_{k=1}^n a_{ik}x_k \leq b_i$$

where a_{ij} 'yield' and a_{ik} are the 'resource requirement' coefficients, respectively. The b_i are constraint bounds on resources, product pools and marketing. In addition, there are non-negative restrictions on the activities.

The model is solved with a parametric objective function to generate a supply curve for manufacturing milk. In this case, the objective function is redefined as:

$$Z = \sum_{j=1}^n (C_j + \alpha d_j)x_j - \sum_{k=1}^n C_k x_k$$

where the parameter α varies from 0 to ∞ .

Technical Coefficients and Costs

Dairy cow costs

Dairy cow costs (Table 1) can be grouped broadly into three categories: a dairy herd maintenance cost, direct variable costs, and indirect variable costs. These costs are in 1986-87 prices.

A dairy herd maintenance cost was determined in the following manner. Assume that in any one year there will be 1 in 8 dairy cows being sold as culls and 1 in 8 springer cows being brought in to replace the cull cows sold. The cost per head of maintaining a current herd number is therefore

$$(\text{cost of springer} - \text{revenue from cull}) / 8 = \$30.39.$$

Direct variable costs consisted of costs associated with artificial insemination, herd recording, teat dipping, mastitis treatment, milk fever, sundry antibiotics and herd health. Data sources included Olney and Falconer (1985) and personal communication with the Victorian Department of Agriculture.

Indirect variable costs consisted of agistment, contracts, sprays and pesticides, administrative costs, repairs and maintenance, and other materials and were obtained using dairy specialist data from the Bureau's Australian dairy industry survey (ADIS). The six indirect variable costs were collectively regressed against dairy cow numbers and a significant coefficient of \$128.48 per head, with a standard error of \$11.02, was obtained for all farms in Victoria.

Energy supply and demand

(a) Energy demand

The energy requirements of dairy cattle producing a known milk yield are well documented. A standard lactation curve is rarely observed as the shape

TABLE 1
Annual Dairy Cow Costs

Item	Cost
	\$/head
<u>Dairy herd maintenance cost</u>	
Sale of cull cow (500 kg cow at \$0.82/kg)	410.00
<u>Less</u> commission (10 per cent of sale price)	41.00
<u>Less</u> freight	2.08
Total	366.92
Purchase price of dairy cow	600.00
<u>Plus</u> transport	10.00
Total	610.00
Net cost of new cow	243.08
Annual cost over eight years	30.39
<u>Dairy cow direct variable costs</u>	
Mastitis treatment	
- during lactation	1.21
- dry cow treatment	5.60
Artificial insemination	14.00
Herd recording	4.00
Teat dipping	1.00
Milk fever	0.34
Sundry antibiotics	1.00
Herd health	7.10
Total	34.25
<u>Dairy cow indirect variable costs</u>	128.48
<u>Total dairy cow cost</u>	162.73

of the lactation curve may be affected by environmental factors, notably age, fertility, and season of calving. Wood (1969) in a UK study of 860 Friesian cows in 1964 and 1965 found that lactation curves for the same cow vary widely with a change in calving time from one year to the next. The results from Wood's study were used to obtain an approximation of the standard lactation curve, which is used in this analysis (Table 2). The regional average milk yields (region 1 - 3066 L/cow, region 2 - 3856 L/cow, region 3 - 3771 L/cow) in each quarter of the year are apportioned using the approximation of the standard lactation curve in Table 2.

TABLE 2

Proportion of the Total Lactation in Each Period for a Dairy Cow Calving in Period 1

Period	Proportion
Period 1 January-March	0.4600
Period 2 April-June	0.3118
Period 3 July-September	0.1814
Period 4 October-December	0.0468

Table 3 is a feeding table adapted from Olney and Falconer (1985) showing the amounts of energy required for maintenance and milk production of Friesian and Jersey cows. Allowance is made for major influences affecting nutrient requirements such as body size, expected growth rate, lactation status, and the cow's breeding status.

TABLE 3

Energy Requirements of Dairy Cow Calving in Period 1

Item	Period 1	Period 2	Period 3	Period 4
	MJ	MJ	MJ	MJ
<u>Friesian dairy cattle</u>				
Daily maintenance requirement	49.89	49.89	53.35	56.71
<u>Plus</u> adjustment due to liveweight change	-7.69	8.60	15.32	19.08
Adjusted maintenance	42.20	58.49	68.67	75.79
<u>Plus</u> additional requirement per litre of milk yield	5.29	5.29	5.29	5.29
Quarterly requirement	3 840.2	5 322.6	6 248.5	6 897.1
<u>Jersey dairy cattle</u>				
Daily maintenance requirement	42.35	42.33	45.27	48.12
<u>Plus</u> adjustment due to liveweight change	-6.53	7.30	13.00	16.19
Adjusted maintenance	35.82	49.63	58.26	64.31
<u>Plus</u> additional requirement per litre of milk yield	5.29	5.29	5.29	5.29
Quarterly requirement	3 258.4	4 516.2	5 301.8	5 852.1

Source: Adapted from Olney and Falconer (1985).

The annual lactation yields were used in association with Tables 2 and 3 to determine dairy cow energy requirements in each quarter. The energy requirements were weighted by the breed ratio in each of the three regions in the model.

(b) Energy supply

. Constituents of feeds in Victoria

Dairy cows in most areas of Victoria rely heavily on pasture feed. However, there are large areas in Victoria where pastures on their own will not supply enough high quality feed throughout the year. In order to achieve desired levels of milk production, some reliance is placed on other feeds and supplements. The data included in this section have been obtained by personal communication with the Victorian Department of Agriculture and Rural Affairs officers throughout Victoria.

All feeds contain fibre, energy and protein. Because energy is the most limiting factor, all other constraints on feed constituents were considered redundant and were not included in the model.

. Pasture

There is essentially one type of pasture activity in the model: that being improved pastures which range from perennial white clover/ryegrass pastures in the summer to annual ryegrass/subclover pastures in the winter. Because of their high productivity and high degree of permanency, these pastures are characterised by low unit costs of production.

To estimate the availability of pasture a method derived from Olney and Falconer (1985) was used. Pasture dry matter available (A_x) for grazing in period (P_x), where x is 1, 2, 3 or 4, is derived from potential pasture production Y_x in period P_x according to the following equation:

$$A_x = G_x (Y_x)$$

where G is the grazing efficiency in period P_x . Grazing efficiencies, defined as the proportion of total pasture ingested by the cow, ranged from 60 to 80 per cent depending on the region and time of year. Potential pasture production in each period is based on growth rates in kilograms per hectare per day of dry matter for each month (assuming pasture management practices outlined below). Growth rates are assumed to be a measure of the change in dry matter of total above-ground parts in an area excluded from grazing.

During winter, pastures are assumed to be well managed and intensively grazed. Little feed carryover and a minimum deterioration in pasture quality would be expected. Estimates of energy quality were therefore made on the assumption that pastures were between the early and late vegetative stages at grazing. In spring, summer and autumn, pasture growth was assumed to be greater and consequently less well grazed. The possibility of feed carryover in spring and summer and natural deterioration in quality in late summer and autumn result in the estimates of energy content being based on the assumption that pastures were between the late vegetative and late bloom stages of growth.

The estimated amount of pasture available and the corresponding gross margins for 1986-87 are presented in Tables 4 and 5.

TABLE 4
Pasture Production

Pasture and month	Dry matter production per month	Grazing efficiency	Net dry matter availability per month	Net dry matter availability per quarter	Energy value per quarter
	kg/ha		kg/ha	kg/ha	MJ/kg
REGION 1					
<u>Perennial pasture</u>					
January	465	0.8	372		
February	280	0.8	224	720	7632
March	155	0.8	122		
April	690	0.8	552		
May	558	0.8	446	1262	13886
June	330	0.8	264		
July	186	0.8	149		
August	279	0.8	223	1044	11902
September	960	0.7	672		
October	2480	0.6	1488		
November	2550	0.6	1530	3886	42746
December	1240	0.7	868		
REGION 2					
<u>Annual pasture</u>					
January					
February	140	0.8	112	732	8 345
March	775	0.8	620		
April	990	0.7	693		
May	1 023	0.7	716	1 829	20 119
June	600	0.7	420		
July	620	0.7	434		
August	1 085	0.7	760	2 274	25 014
September	1 800	0.6	1 080		
October	2 015	0.6	1 209		
November	1 050	0.6	630	1 839	19 493
December					
<u>Perennial pasture</u>					
January	1 860	0.6	1 116		
February	1 400	0.7	980	2 964	32 604
March	1 240	0.7	868		
April	900	0.7	630		
May	310	0.8	248	1 118	12 298
June	300	0.8	240		
July	310	0.8	248		
August	620	0.8	496	1 689	19 255
September	1 350	0.7	945		
October	2 170	0.6	1 302		
November	1 950	0.6	1 170	3 681	40 491
December	2 015	0.6	1 209		
REGION 3					
<u>Perennial pasture</u>					
January	729	0.8	583		
February	470	0.8	376	1093	11583
March	167	0.8	134		
April	699	0.8	559		
May	620	0.8	496	1319	14511
June	330	0.8	264		
July	186	0.8	149		
August	372	0.8	298	1130	12876
September	975	0.7	685		
October	2533	0.6	1520		
November	2664	0.6	1598	4160	45760
December	1488	0.7	1042		

Source: Victorian Department of Agriculture and Rural Affairs (personal communication, 1988).

TABLE 5

Pasture Gross Margins

Item	Cost
	\$A
REGION 1	
<u>Perennial pasture</u>	
Fertiliser	
- super-potash mixture 453 kg/ha at \$200/t	90.50
- urea 100 kg/ha at \$350/t	35.00
Gross margin	125.50
REGION 2	
<u>Annual pasture</u>	
Fertiliser	
- super-potash mixture 375 kg/ha at \$200/t	75.00
- urea 100 kg/ha at \$350/t	35.00
Irrigation 8.37 ML/ha at \$12.00/ML	100.44
Gross margin	210.44
<u>Perennial pasture</u>	
Fertiliser	
- super-potash mixture 500 kg/ha at \$200/t	100.00
- urea 200 kg/ha at \$350/t	70.00
Irrigation 13.41 ML/ha at \$12.00/ML	160.92
Gross margin	330.92
REGION 3	
<u>Perennial pasture</u>	
Fertiliser	
- super-potash mixture 453 kg/ha at \$200/t	90.50
- urea 100 kg/ha at \$350/t	35.00
Gross margin	125.50

Source: Victorian Department of Agriculture and Rural Affairs (personal communication, 1988).

Supplementary feeding

Hay making and grain feeding are methods of balancing feed supply and livestock nutrient demand. In the model, the level of hay making and grain feeding activity is selected on a year-in-year-out basis, that is, all silage, hay and grain are used and not held over as insurance against poor seasons or drought.

Hay making

Hay can be made from any pasture activity in periods 1, 2 and 4 only. Hay can be fed out in any quarterly period; 0.25 hours labour per tonne are required in feeding out, and 0.25 hours labour per tonne are required to carry and store hay. Using contractors, hay making costs \$36/t for rectangular bales. A 15 per cent loss incurred in making the hay and a 15 per cent loss in feeding it out are assumed. This assumption, however, refers only to a minimum hay making loss for all regions. Using ADIS dairy specialist data as a guide, adjustments were made to the productivity of hay making activities in each region to reflect the region's ability to produce hay.

Since the quality of pasture hay is less than that of freshly grazed pasture (on an energy value to dry matter basis), energy values of grazing pastures used for hay making were adjusted downwards by a factor of 0.75. The reducing factor was calculated from the ratio between the energy value for hay assumed as 7.61 MJ/kg of dry matter, and the average energy value for fresh pasture, of 10.15 MJ/kg of dry matter.

Grains

Grain prices remain constant over the year but differ between regions according to ADIS data (region 1 - \$140.94/t, region 2 - \$136.94/t, region 3 - \$140.94/t). Feeding of grains was limited to the recommended maximum ratio of 60 per cent concentrate to 40 per cent forage (Broster 1983).

(c) Irrigation

Irrigation on dairy farms provides a way of increasing milk supply (through the production of pasture over an area above that produced under a natural rainfall environment). From ADIS data, region 2 was found to contain significant areas of irrigation. For this region, the option of using irrigated pastures was included in the regional representative farm.

Flood irrigation is the dominant system of irrigation in region 2. A technique presented in Lacy, Cregan and Thompson (1987) was used with data from the Bureau of Meteorology to estimate water requirements for pastures in region 2 (Table 6). A water charge of \$12/ML is assumed to apply to all irrigation water used.

Farm labour

To estimate the amount of labour required for each dairy cow a regression approach was taken. Using ADIS data for the three years ended 1985-86 total farm labour was regressed against dairy cow numbers, beef cow numbers and area of field, vegetable and other crops. Significant parameter estimates were obtained for all regions (Table 7).

Farm capital

The amount of capital needed for each farm was estimated using a regression technique. Using ADIS data for the three years ended 1985-86 total farm capital (excluding operator's house) was regressed against dairy cow numbers, beef cow numbers and area of field, vegetable and other crops. Significant parameter estimates were obtained in all regions (Table 8).

TABLE 6
Irrigation Water Requirements

Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<u>Region 2</u>												
Rainfall	30	29	31	30	43	40	42	45	41	45	30	27
Estimated effective rainfall	21	20	22	21	30	28	29	32	29	32	21	19
Evaporation	260	210	175	110	60	55	35	60	85	110	170	230
Evapotranspiration	247	200	149	94	51	47	30	51	72	94	145	196
Irrigation requirement	226	170	127	73	21	19	1	19	43	62	124	177
Effective irrigation	283	225	159	91	26	24	1	24	54	78	155	221

Source: Bureau of Meteorology; long term average rainfall and evaporation data provided by Victorian Department of Agriculture.

TABLE 7
Farm Labour Per Dairy Cow

Region	Labour per cow	t-statistic for parameter = 0
	weeks	
1	0.212481	2.388
2	0.344237	5.943
3	0.212481	2.388

TABLE 8
Farm Capital Required Per Dairy Cow

Region	Capital per cow	t-statistic for parameter = 0
	\$	
1	1442.2	7.000
2	1390.6	9.548
3	2227.1	7.686

Land values

The land values in the model were derived from ADIS data for 1986-87 (region 1 - \$1152/ha, Region 2 - \$1306/ha, Region 3 - \$2809/ha). In the survey, farms are valued by the Commonwealth Development Bank according to the type of land on each farm.

Milk prices and transport costs

The costs of transporting market milk to the Melbourne market are equalised across Victoria for all producers. The equalised transport cost is implicit in the milk price received by Victorian producers and therefore not separately identified in the model.

Prices for manufacturing milk (Table 9) and market milk are derived from ADIS data for 1986-87 within each region. A policy of milk pooling across all Victorian producers results in producers responding to the average price rather than the marginal price. In order to simulate the supply response resulting from this policy, an average 'all milk' price curve was used in the model as a pricing mechanism for both market and manufacturing milk. The curve had a non linear functional form and was approximated in a linear form as a falling stepped linear function.

TABLE 9

Prices for Manufacturing Milk
(Net of Transport and Levies)

Region	Price
	c/L
1	0.172435
2	0.152011
3	0.147880

Source: ADIS 1986-87.

Resource Levels

Using ADIS dairy specialist data, an industry level of resources was allocated to the representative farm in each region. The allocations were weighted according to the each farm's proportional representation in the dairy specialist population (Table 10).

TABLE 10

Resource Levels in the Model

Right hand sides	Unit	Region 1	Region 2	Region 3
Milk herd	No.	170 109	338 574	244 775
Operator labour pool	weeks	144 202	263 568	265 842
Capital pool	\$	313 793 961	657 410 926	1 126 197 536
Arable land (grade 1)	ha	118 933	46 896	54 990
Arable land (grade 2)	ha	20 988	57 090	46 307
Arable land (grade 3)	ha	0	99 909	43 413

Source: ADIS 1986-87.

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