# The Beef Cattle Transportation and Processing Industry of Northern New South Wales.

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## Introduction

The focus of this paper is on changes in the total variable processing costs associated with the processing of beef cattle and the variability in the transportation and other costs associated with the assembly and throughput of beef cattle for export licensed abattoirs in a northern region of New South Wales. The chosen region produces over 11 per cent of Australia's beef cattle. The effects of changes in regional supplies on abattoir activity can have significant impacts on regional economies and therefore an understanding of the connection between changes in supply and the activity of abattoirs is of some significance.

The seven export licensed abattoirs located in the Northern and North Coast Statistical Divisions of New South Wales were examined for the effects of changes in the supply of fat cattle available for processing. The focus of the paper is on the transportation costs associated with the movement of the cattle from the saleyards within the region and the variable costs, operating costs and the opening and closing costs associated with the processing of the animals over six consecutive four week periods. The time horizon of six months, assuming a month to be four weeks, will enable seasonal fluctuations to be considered and also keep the size of the model within reasonable proportions. That is, from a period of high supply to a period of low supply, and vice versa.

## Background on the Beef Processing Sector

After a peak of 29.8 million beef cattle in Australia in 1976, numbers steadily declined to a minimum level of 19.4 million in 1984. Over the same period, similar changes in the number of beef cattle being slaughtered in Australia and New South Wales were observed. In 1976/77 the number of cattle slaughtered in Australia peaked at 10.33 million and dropped to 5.61 million by 1983/84 (Australian Meat and Livestock Corporation 1982, 1989). The decline in the number of beef cattle slaughtered in New South Wales dropped from 3.31 million to 1.28 million over the same period. As a consequence 11 export licensed abattoirs closed in New South Wales and 5 of these were located in the two Statistical Divisions covered by this study.

To some extent, the livestock transportation industry has considerable flexibility to adjust to such changes in that different types of animals can be transported by a prime mover and truck. Such trucks can be easily converted or connected to other trailers in order to transport other goods (Bureau of Transport Economics 1982). However, in the beef processing sector such flexibility is not as pronounced. A decrease in the supply of beef cattle for slaughter is not easily substituted for by slaughtering and processing of other livestock. This is because the size of the animals and the nature of the equipment and facilities used in the processing plants. Consequently, a reduction in the regional supply of cattle could necessitate processing plants sourcing cattle from further afield and therefore being subject to increased transportation costs. Alternatively, a processing plant could process fewer cattle which will increase the average total processing cost and the average variable processing cost. This would be likely to reduce profits since individual export licensed processing plants can generally be considered to be price takers.

Therefore, it is important to understand the impact and the effect that changes in beef cattle supply can have on the cost of individual processing plants in terms of the variation in transportation costs and the variation of average variable processing costs due to a change in throughput. Such an understanding has implications for the survival of individual processing plants and the stability of the beef meat processing industry as a whole. Also, in order to plan development of additional processing plants or extend existing plants, changes in supply and the associated changes in costs and capacity utilisation need to be understood.

## Approach to the Analysis

Variability in both supply and demand factors has effects on the transportation and processing sectors of the beef industry. An example of the variability is shown in Table 1. By reducing the costs of processing and transportation, a more efficient transportation and processing sector is possible. Also, if the costs of investment and disinvestment could be reduced then returns to producers may be increased. Similarly, if the marketing margin between the farm gate and the final overseas consumer can be narrowed through greater efficiency then the final product is also likely to be cheaper in comparison to other beef meat producing countries. This has the potential to enhance Australia's competitive advantage in beef meat production relative to other countries. It would therefore seem worthwhile examining whether or not selective closure of plants during periods of low supply leads to a reduction in overall costs and at what point plants should be closed. In examining this possibility it is recognised that there are costs involved in closing down and starting up a plant.

TABLE 1

*Statistics on Four Weekly[a] Variation in the Supply of Fat Cattle from Selected Saleyards, July 1988 to June 1989.*

| Saleyard | Average | Standard deviation | Maximum number | Minimum number |
|---|---|---|---|---|
| Armidale | 2977 | 1217 | 5193 | 1323 |
| Casino | 6362 | 2900 | 12550 | 3133 |
| Gunnedah | 7130 | 1428 | 9417 | 5390 |
| Inverell | 4380 | 780 | 6137 | 3505 |
| Tamworth | 5184 | 1584 | 9574 | 3612 |
| Tenterfield | 1559 | 876 | 2804 | 336 |

[a]Based on data from the New South Wales Meat Industry Authority and excludes the Christmas period.

To examine plant closure policies a multi-period plant location model was used, incorporating nonlinear functions for the processing costs and integer (binary) variables to designate whether a processing plant is open or closed in each time period. Cattle were treated as a homogeneous product despite the fact that Crom (1970), Freebairn and Rausser (1975), MacAulay (1976), Martin (1983), Mues, Harris, Horton and Baskerville (1991) and others have shown that differences exist in the nature of supply and demand response for different quality cattle and meat. The reasons for treating cattle as a homogeneous product are that:

a) there is a high correlation between low and high quality beef prices (Saepung 1986);

b) there is limited information available from the abattoirs on the classes of animals slaughtered; and

c) the modelling approach should be such as to keep the study within manageable proportions.

For purposes of the analysis, data from the 1988/89 financial year were used to construct a model of the transportation network and the set of seven processing plants in the region. By allowing plants to open and close the costs were then compared with the situation that all processing plants were in continuous operation at similar levels of capacity utilisation. The average variable processing cost and average cost of transporting the live animals were compared for each abattoir in order to assess the impact on abattoirs of opening and closing in response to changes in supply. This was followed by a sensitivity analysis based on raising and lowering the average variable processing cost functions for individual processing plants, altering the operating cost functions of all plants and changing the additional costs of opening and closing a plant.

*The Region Selected for Investigation*

The region selected for the study is shown in Figure 1. It is defined as the area contained in the three statistical divisions of New South Wales of the Mid-North Coast, Northern and the Richmond-Tweed region. The area selected contains seven export licensed processing plants. These account for approximately 52 per cent of the livestock slaughtered in New South Wales that are destined for the export market (Faunt 1990). The region also has the necessary resources to support alternative enterprises including crops, wool and lamb in the interior and dairy and semi-tropical agriculture on the coastal strip. The region is also subject to drought and other causes of variability in supply described above. The number of beef cattle in the region from 1985 to 1988 has varied between 42.5 per cent and 44.6 per cent of the total New South Wales beef herd (NSW Department of Agriculture & Fisheries 1987a, 1987b, 1989a and 1989b).

In summary, the particular region was chosen for the following reasons:

a) there is a wide range of agricultural activities that compete for resources within the defined region;

b) there is susceptibility to drought, especially in the Northern Statistical Division;

c) there is a concentration of export licenced meat processing plants facing limited competition from large-scale domestic processing plants;

d) the availability of data from processing plants and from the major saleyards, six of which are reported on a weekly basis by the New South Wales Meat Industry Authority; and

e) there were limited complications in terms of alternative transportation methods, that is, there is no rail transport of livestock in the region due to the fact that there is no rail line crossing the Great Dividing Range.

*Plant Location Models, Processing Costs and Variability*

It was necessary to construct a model since:

a) detailed data were not available from processing plants on the exact costs incurred at various levels of operation; and

b) it is difficult to observe the change in costs for individual plants when they open and close since closure is a rare event (Inverell was the only plant to shut down in August and September in 1989 due to a lack of slaughter cattle within a reasonable distance).

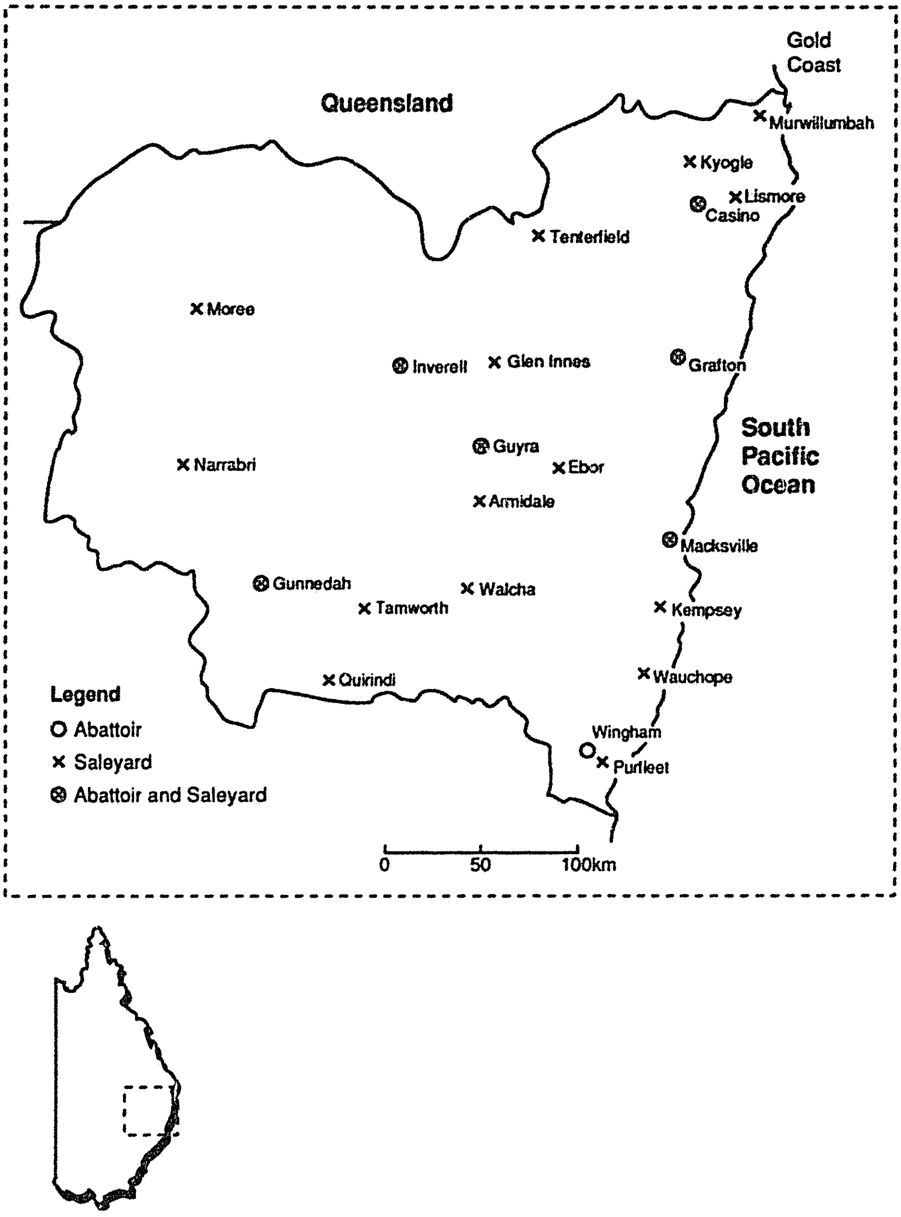


Figure 1 - The region selected for study.

The relationship between different spatial models is detailed in MacAulay (1986) and the various forms of plant location models and forms of the cost functions are described in Brown (1986) and Marlor (1990). The methods of estimating of cost functions are presented by French (1977) in Martin (1977) and the complications of data collection as highlighted in Johnson (1960) are still valid. The model in this paper is based on a non-linear cost function for each plant with binary variables used to represent the status of each processing plant. The average variable processing cost function was assumed to be quadratic in nature in the short run in keeping with the findings of the Industries Assistance Commission (1983) and Trewin *et al.* (1987) and thus the total variable processing cost function will be cubic. Furthermore, the total variable processing cost curve is assumed to be a continuously increasing function hence the marginal variable cost and the average variable processing cost functions cannot be negative (Figure 2).

The non-linear processing cost function coupled with the assumed linear nature of the cost function for transporting cattle from the saleyards to processing plants (abattoirs) forms the basis of the model described below.

## The Structure of the Model

The objective function of the model for this study is the minimisation of the sum of the transportation costs, processing costs, operating costs and the additional costs incurred when a plant opens or closes. The main reason for such an objective function is that any reduction in the cost of beef cattle transportation or beef meat processing will result in a reduced marketing margin. Therefore, depending on the relevant supply and demand conditions at each stage of the beef meat process, the distribution of benefits between producers, processors and consumers could be estimated.

The model is not driven by a need for the industry to satisfy a specific demand, although this would be possible if the orders, quantity demanded, or expected orders were known for each plant, plus such details as expected average carcase weight and other specific details of the orders or contracts. Instead, it is assumed that the processing sector is supply driven and whatever number of beef cattle are available and suitable for the export market during any particular month will be processed through the export licensed processing plant regardless of demand. The operating status of each plant, as open or closed, is the link between each month and is represented by the binary variables, $S_{pt}$.

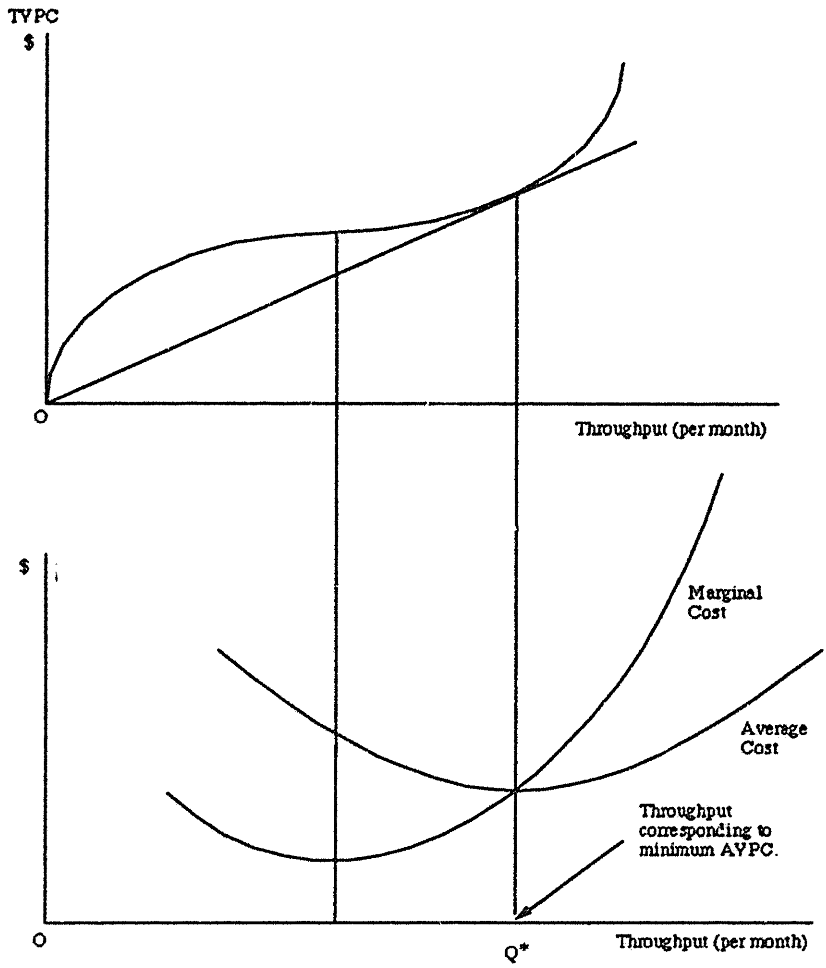


Figure 2 - A possible total variable processing cost curve and corresponding average variable processing cost curve and marginal cost curve for a processing plant.

Mathematically the model is:

$$\text{Minimize} \quad COST = \sum_{i=1}^{21}\sum_{p=1}^{7}\sum_{t=1}^{6}(r_{ipt}X_{ipt}) + \sum_{p=1}^{7}\sum_{t=1}^{6} f_{pt}(A_{pt})$$
$$+ \sum_{p=1}^{7}\sum_{t=1}^{6}(S_{pt}OPER_{pt}) + \sum_{p=1}^{7}\sum_{t=1}^{5}(\eta_{c(pt)}CLO_{pt})$$
$$+ \sum_{p=1}^{7}\sum_{t=1}^{5}(\eta_{o(pt)}OPE_{pt}) \quad \ldots\ldots (1)$$

where $\eta_{c(pt)} = \eta_{c(pt)}(S_{pt}, S_{p(t+1)})$ $= \begin{cases} 1 & \text{if plant p has closed between periods t and t+1} \\ 0 & \text{otherwise} \end{cases}$

where $\eta_{o(pt)} = \eta_{o(pt)}(S_{pt}, S_{p(t+1)})$ $= \begin{cases} 1 & \text{if plant p has opened between periods t and t+1} \\ 0 & \text{otherwise} \end{cases}$

subject to

(supply) $\sum_{p=1}^{7} X_{ipt} \le Q_{it}^{S}$ for each saleyard i and time t, ....(2)

(throughput) $A_{pt} - \sum_{i=1}^{21} X_{ipt} = 0$ for each plant p and time t,........(3)

(processing) $\sum_{p=1}^{7} A_{pt} \ge \sum_{i=1}^{21} Q_{it}^{S}$ for each time period t,.............(4)

(capacity) $A_{pt} - S_{pt}Cap_{pt} \le 0$ for each plant p and time t,........(5)

where $S_{pt} = \begin{cases} 1 & \text{if plant p is open in time t} \\ 0 & \text{if plant p is closed in time t} \end{cases}$

(meat output) $-w_{pt}A_{pt} + Qout_{pt} \le 0$ for each plant p and time t,........(6)

(buying limit 1) $\sum_{d=1}^{4}\sum_{i=1}^{21}(\rho_1 X_{ipt}) - 0.4A_{pt} \le 0$ for each plant p and time t,........(7)

where $\rho_1 = \rho_1(d,i,t)$ $= \begin{cases} 1 & \text{if i has a sale on day d in time t} \\ 0 & \text{otherwise} \end{cases}$

(buying limit 2) $\sum_{d=1}^{3}\sum_{i=1}^{21}(\rho_2 X_{ipt}) - 0.6A_{pt} \le 0$ for each plant p and time t,........(8)

where $\rho_2 = \rho_2(d,i,t)$ $= \begin{cases} 1 & \text{if i has a sale on day d or d+1 in time t} \\ 0 & \text{otherwise} \end{cases}$

(status change) $S_{pt} - S_{p(t+1)} - \eta_{c(pt)} + \eta_{o(pt)} = 0$ for each plant p and time t, ....(9)

(throughput req) $A_{pt} \ge MIN_{pt}$ for each plant p and time t,...... (10)

(order) $Qout_{pt} \ge REQ_{pt}$ for each plant p and time t,...... (11)

$r_{ipt}, X_{ipt}, A_{pt}, f_{pt}(A_{pt}), Q_{it}^{S}, MIN_p, REQ_p \ge 0$ for all t, i and p.

$S_{pt}, \eta_{c(pt)}$ and $\eta_{o(pt)} = 0$ or 1 for all t and p.

where $r_{ipt}$ = assembly costs ($ per head) from saleyard i to plant p in month t;

$f_{pt}(A_{pt})$ = total variable processing costs in dollars of plant p in month t;

$X_{ipt}$ = number of head of cattle transported from saleyard i to plant p during month t;

$A_{pt}$ = number of head of cattle processed at plant p during month t;

$OPER_{pt}$ = the operating cost in dollars of having abattoir p operating during month t;

$CLO_{pt}$ = additional cost in dollars due to closing at the end of month t;

$OPE_{pt}$ = additional cost in dollars due to opening at the end of month t;

$Cap_{pt}$ = the capacity in throughput of cattle per month of plant p during month t

$Q_{it}^{S}$ = number of head of cattle in saleyard i destined for slaughter;

$w_{pt}$ = the average carcase weight of the animals processed in plant p during month t,

$Qout_{pt}$ = the quantity of meat in tonnes from plant p during month t,

$S_{pt}$ = the status of plant p in time t; 0 = closed and 1 = open,

$\eta_{c(pt)}$ = 1 if plant p is closed between months t and t + 1; 0 otherwise,

$\eta_{o(pt)}$ = 1 if plant p is opened between months t and t + 1; 0 otherwise,

$MIN_{pt}$ = the minimum economic, or management set, throughput level needed for plant p during month t,

$REQ_{p}$ = the quantity of meat on order, or expected to be ordered, for plant p during month t.

*The objective function and constraints*

(1) COST — The objective is to minimise the total cost of transporting the animals from saleyards to processing plants ($r_{ipt}X_{ipt}$), the variable processing costs ($f_{pt}(A_{pt})$), the operating costs of a processing plants when it is open ($S_{pt}OPER_{pt}$) and the cost of opening and/or closing processing plants between periods ($OPE_{pt}$ and $CLO_{pt}$ respectively).

(2) supply — the number of animals transported from any saleyard must be less than or equal to the number available.

(3) throughput — all animals arriving at a processing plant must be processed

(4) processing — all the animals considered as available to be used by export abattoirs must be processed.

(5) capacity — the number of animals processed by an abattoir cannot exceed its capacity when it is open (i.e. $S_{pt} = 1$).

(6) meat output — a measure of the quantity of meat produced by each abattoir

(7) buying limit 1 — limiting the quantity an abattoir can purchase on any one sale day to 40 per cent of its monthly throughput.

(8) buying limit 2 — limiting the quantity an abattoir can purchase on any two consecutive sale days to 60 per cent of its monthly throughput.

(9) status change — assessing whether an abattoir has closed or opened between two consecutive time periods, or vice versa.

(10) throughput — summary information on the throughput of animals through each abattoir. It can also be set in conjunction with additional constraints, to satisfy certain MINimum throughput levels.

(11) orders — summary information on how much meat has been produced by each abattoir. It can also be set, in conjunction with additional constraints, to satisfy certain known order REQuirements.

An important point to note is in equation (9), in that only $S_{pt}$ and $S_{pt+1}$ are actually defined as integers and can take on the values of 0 or 1 representing a processing plant being open, 0, or closed, 1, in month t and t + 1. The variables (functions) $\eta_{c(pt)}$ and $\eta_{o(pt)}$, indicating a penalty cost for closing or opening between periods, are forced to either 0 or 1 by constraining the equation to be equal to zero. So, for a plant p, the following possibilities exist:

| $S_{pt}$ | $-S_{pt+1}$ | $-\eta_{c(pt)}$ | $\eta_{o(pt)}$ | Result |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | 0 |
| 1 | 0 | 1 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 |

Note that the opening penalty is incurred when the plant changes from closed to open (0 to 1) and the closing penalty is incurred when the plant changes from open to closed (1 to 0).

*Diagrammatic Representation*

The structure of the model is clarified in Figure 3 in terms of the objective function, the time periods and the how the constraints link the relevant time periods. An attempt to further clarify the structure is presented in Figure 4 where a representative sub-model is used to show the relevant coefficients and links between two consecutive time periods.

*Transport costs*

The published charges for transporting livestock and the average capacity were used to obtain a cartage rate per kilometre for three different sized vehicles (Figure 5).

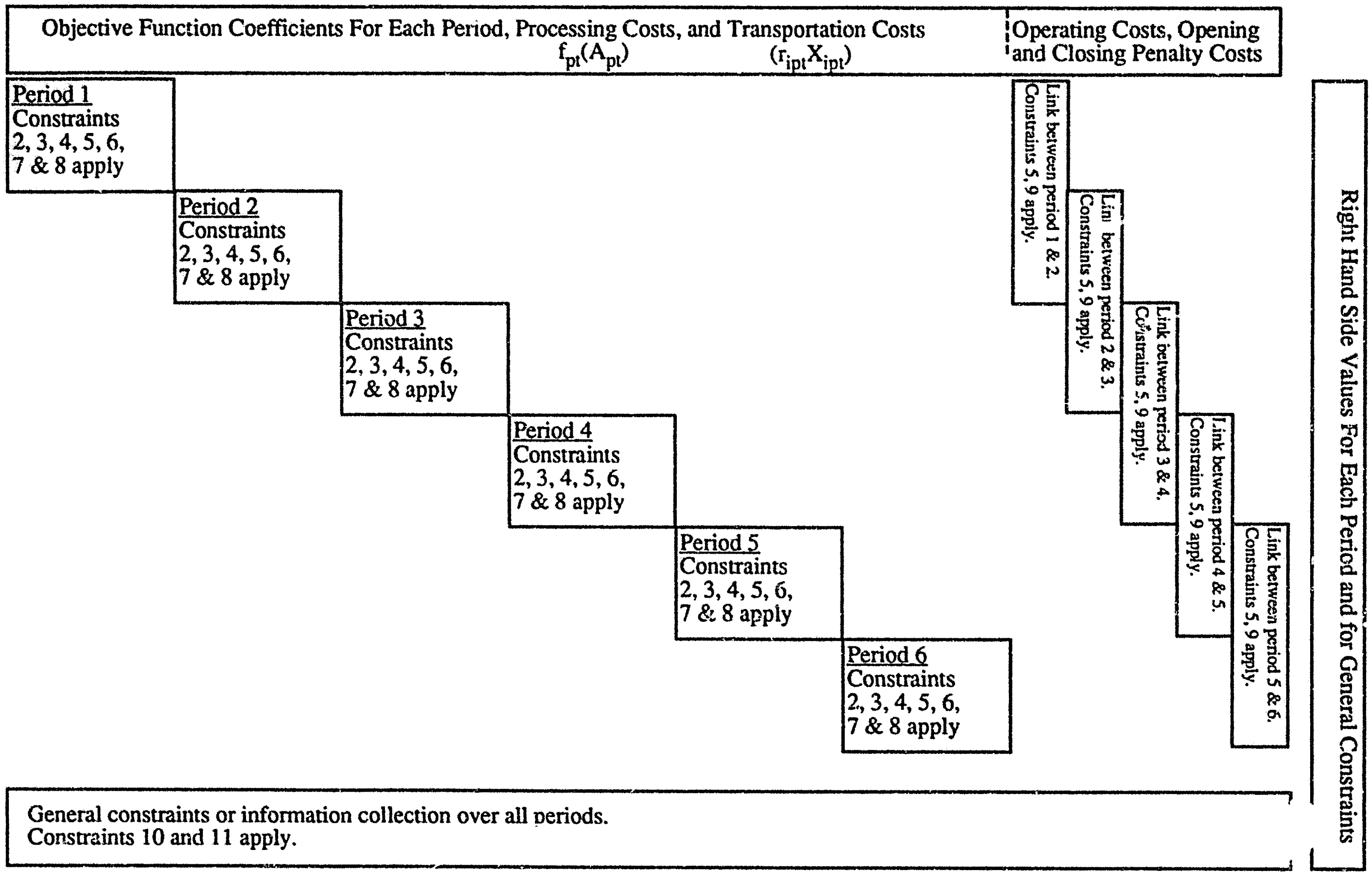


Figure 3 - Diagrammatic Representation of The Multi-period Non-linear Plant Location Model

| | Transportation Section | | | | | | Processing Cost Section | | Meat Produced | | Status Period t | | Status Period t+1 | | Opening/Closing Penalty Plant 1 | | Opening/Closing Penalty Plant2 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vars | $X_{11t}$ | $X_{12t}$ | $X_{21t}$ | $X_{22t}$ | $X_{31t}$ | $X_{32t}$ | $A_{1t}$ | $A_{2t}$ | | | $S_{1t}$ | $S_{2t}$ | $S_{1,t+1}$ | $S_{2,t+1}$ | $\eta_{c(1t,t+1)}$ | $\eta_{o(1t,t+1)}$ | $\eta_{c(2t,t+1)}$ | $\eta_{o(2t,t+1)}$ | | |
| Rows / Coeff | $r_{11t}$ | $r_{12t}$ | $r_{21t}$ | $r_{22t}$ | $r_{31t}$ | $r_{32t}$ | $f_{1t}(A_{1t})$ | $f_{2t}(A_{2t})$ | 0 | 0 | $OP_{1t}$ | $OP_{2t}$ | $OP_{1t+1}$ | $OP_{2t+1}$ | $CLO_{1t,t+1}$ | $OPE_{1t,t+1}$ | $CLO_{2t,t+1}$ | $OPE_{2t,t+1}$ | | RHS |
| $SUPF_{1t}$ | 1 | 1 | | | | | | | | | | | | | | | | | ≤ | $Q^S_{1t}$ |
| $SUPF_{2t}$ | | | 1 | 1 | | | | | | | | | | | | | | | ≤ | $Q^S_{2t}$ |
| $SUPF_{3t}$ | | | | | 1 | 1 | | | | | | | | | | | | | ≤ | $Q^S_{3t}$ |
| $NUM_{1t}$ | -1 | | -1 | | -1 | | 1 | | | | | | | | | | | | = | 0 |
| $NUM_{2t}$ | | -1 | | -1 | | -1 | | 1 | | | | | | | | | | | = | 0 |
| $MEAT_{1t}$ | | | | | | | $-w_1$ | | 1 | | | | | | | | | | ≤ | 0 |
| $MEAT_{2t}$ | | | | | | | | $-w_2$ | | 1 | | | | | | | | | ≤ | 0 |
| $ANIMALS_t$ | | | | | | | 1 | 1 | | | | | | | | | | | ≥ | $\sum_i Q^S_{it}$ |
| $MOND_{1t}$ | 1 | | 1 | | | | -0.4 | | | | | | | | | | | | ≤ | 0 |
| $TUES_{1t}$ | | | | | 1 | | -0.4 | | | | | | | | | | | | ≤ | 0 |
| $MOND_{2t}$ | | 1 | | 1 | | | | -0.4 | | | | | | | | | | | ≤ | 0 |
| $TUES_{2t}$ | | | | | | 1 | | -0.4 | | | | | | | | | | | ≤ | 0 |
| $MOTU_{1t}$ | 1 | | 1 | | 1 | | -0.6 | | | | | | | | | | | | ≤ | 0 |
| $MOTU_{2t}$ | | 1 | | 1 | | 1 | | -0.6 | | | | | | | | | | | ≤ | 0 |
| $LIMTA_{1t}$ | | | | | | | 1 | | | | $-C_{1t}$ | | | | | | | | ≤ | 0 |
| $LIMTA_{2t}$ | | | | | | | | 1 | | | | $-C_{2t}$ | | | | | | | ≤ | 0 |
| $PEN_{1,t,t+1}$ | | | | | | | | | | | 1 | | -1 | | -1 | 1 | | | = | 0 |
| $PEN_{2,t,t+1}$ | | | | | | | | | | | | 1 | | -1 | | | -1 | 1 | = | 0 |
| $PEN_{1,t+1,t+2}$ | | | | | | | | | | | | | 1 | | for the next | | | | = | 0 |
| $PEN_{2,t+1,t+2}$ | | | | | | | | | | | | | | 1 | time period. | | | | = | 0 |

Where $S_{pt}$, $S_{p,t+1}$, are integer varaibles equal to 0 or 1, $\eta_c$ $\eta_o$ also take values of 0 and 1 but are not defined as integer variables (see Section 4.1.1), $SUPF_{it}$ is the supply from saleyard i during time period t, $NUM_{pt}$ is the number of head of cattle that will be processed at abattoir p, $MEAT_{pt}$ is the quantity of meat output from plant p, $ANIMALS_t$ is the total number of animals that are destined for slaughter in abattoirs 1 and 2 during time t, $MOND_{pt}$ & $TUES_{pt}$ restrict abattoir p to purchasing 40 per cent of its throughput from saleyards selling on Monday and Tuesday respectively, during time t, MOTU restricts abattoir p to purchasing a maximumof 60 per cent of its throughput from those saleyards that sell on either Monday and Tuesday, $LIMT_{pt}$ is the capacity constraint of abattoir p during time t, and $PEN_{p,t,t+1}$ is constraint for calculating a change in the operating status of abattoir p from time t to time t+1.

Figure 4 - Matrix of A Representative Sub-model For Time Period t

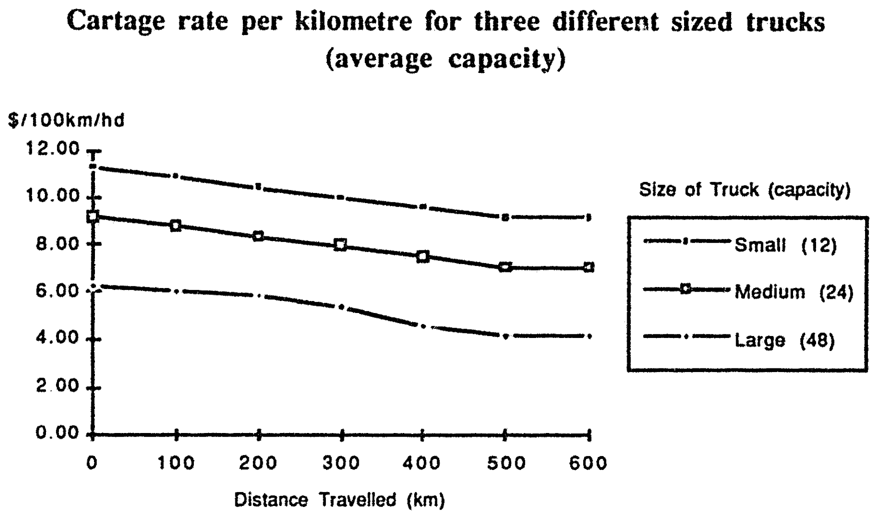


Figure 5 - Cartage rate per kilometre for three different sized vehicles

Since the medium sized vehicle is approximately an average of the large and small this size vehicle was used to for calculating the transportation cost by fitting an equation to the line of 'best-fit'.

The distances between saleyards were estimated from a map printed by the Central Mapping Authority of New South Wales (1984). The location of saleyards and processing plants in relation to the towns were taken into account either through personal knowledge or from town maps supplied by the Central Mapping Authority of New South Wales (1984) by adjusting the distance figure before applying the above formula. The rate per kilometre decreases up to 500 kilometres and from then on the rate does not vary. The greatest distance that can be travelled from a saleyard to a processing plant in the region under consideration is 645 kilometres from Moree to Wingham. By using the above formula, any transport cost calculated this way will understate the actual transport cost but the likelihood of cattle being transported across the extremes of the region is very small. Transport between saleyards and processing plants n the same town are zero because animals are walked between the two establishments. Contrary to this, a charge is made for the movement of cattle from Inverell saleyard to the Inverell processing plant because it is not possible to walk the cattle between the two locations.

*Processing cost function estimation*

There are a number of major differences between the seven export licensed processing plants that are included in the region that is under consideration. As a result, the assumptions made in relation to the processing plants are:

a) all cattle slaughtered are considered as destined for the export market;

b) no distinction is made between private works or Government works;

c) the transfer of resources between cattle slaughter to slaughtering of other species in those processing plants where more than one species is processed are ignored; and

d) each processing plant has cost minimisation as a major objective.

The three different costs required to be estimated for each of the processing plants were:

1) the total variable processing cost (TVPC),

2) the operating cost of having a processing plant open, and

3) an estimate of the additional maintenance cost of closing down and the additional preparation cost of re-opening a plant.

*Total variable processing cost function*

If, by assumption, the average variable processing cost (AVPC) is quadratic by nature then the total variable processing cost (TVPC) is cubic as indicated in Figure 2. The minimum average variable processing cost occurs at the point indicated and this level of throughput will be assumed to be equivalent to the cost minimising level or 100 per cent capacity utilisation level for each plant. It is possible for a processing plant to exceed this throughput level, especially when prices for meat are high and there is and incentive to provide a greater quantity of meat to the market or there are contracts that have to be met. However, it is the supply of cattle available for slaughter that meet the requirements of a contract and the cost of transporting these cattle to the processing plant that determines the level of throughput that can be achieved by a processing plant. Contracts are often quite stringent and becoming more so as buyers set particular standards and specific requirements for the product they are purchasing. This further complicates the task of management. This restrictive assumption of limiting a processing plant to the throughput level corresponding to the minimum average variable cost could be relaxed to allow plants to exceed their capacity by a small amount if desired.

Generally, it can be assumed that processing plants of different capacities have different variable processing cost curves for particular throughputs. Initially, the basic assumption is that plants operating at the same level of capacity utilization will have the same average variable processing cost no matter what their size along similar lines to the assumption of Brown (1986). Thus, given a single average variable processing cost curve and or a total variable processing cost function, it is possible to derive an estimate of the average variable processing cost function and total variable processing cost function for any other processing plant provided the throughput level corresponding to the minimum average variable cost or 100 per cent capacity utilisation of the other plant is known.

In Brown (1986) three types of plant were specified and all plants in each category were assumed to face the same average variable processing cost if they were operating at the same level of capacity utilisation. In this study, no categorisation of the processing plants is made. Instead the average variable processing cost curves are raised or lowered according to information comparing the characteristics of the plant whose cost functions are known with characteristics of the processing plant whose cost details are unknown. Additional characteristics to the differences described earlier, that were taken into account include: respective size of the two plants; age of the plants; past operating record; proportion of throughput destined for export; main markets; and, personal communication with a number of people in the industry.

In Figure 6 the average variable processing costs and total variable processing cost for plants A and B have been drawn to represent a particular cost structure. A 100 per cent utilization of capacity (minimum of the average variable cost curve) for plant A is 3840 head of cattle per month and for plant B 7680 head of cattle per month. Note, that these capacity levels lie on the same ray OX and that both plants have the same minimum average variable processing cost, $c_1$, when operating at 100 per cent capacity. If both plants are operating at a capacity of 62.5 per cent as shown by the intercept of the ray OY and the respective total variable cost curves (throughputs of 2400 and 4800 per month respectively) then both will have the same average variable processing cost at the 62.5 per cent level of capacity utilization level, say $c_2$. Note the gradients at the intercept of any ray OY from the origin and the total variable processing cost function for both plants A and B will have the same gradient, hence the same average variable processing cost for the same level of capacity utilisation.

Each abattoir will process different breeds and sizes of animals depending on the contract they are currently filling or expect to fill. This, plus the availability of quantity and quality of animals at any time will generate variability in the carcase weights. Consequently, an average caracase weight has been assumed for all abattoirs in the region. This average caracase weight is assumed to be the regional average for all processing plants and no variability due to seasonal variation, export versus local contract or any other factor affecting carcase weight is taken into account due to data availability. However, if the relevant data were available the differences could be included in the model.

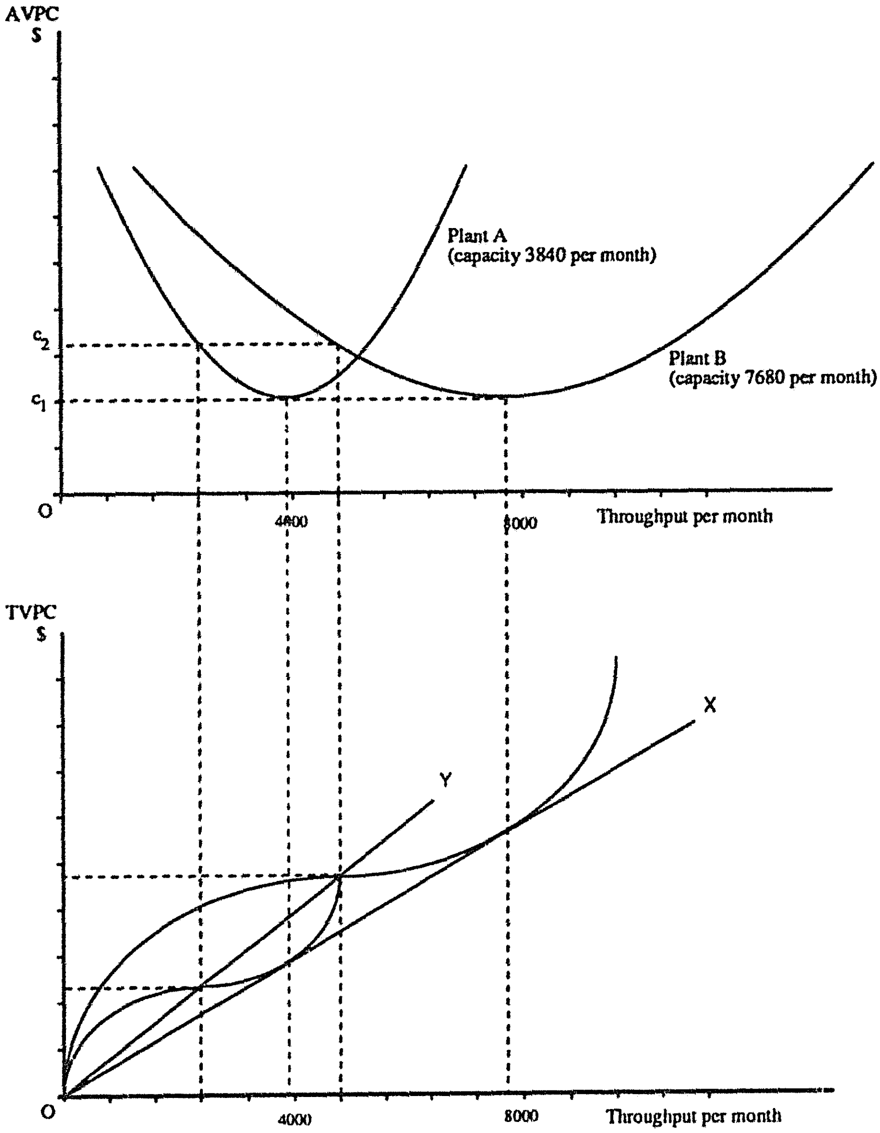


Figure 6 - Graphical relationship between the AVPC and TVPC of two processing plants of different capacities.

It is also assumed that the output of meat from each abattoir can be summed to give a single monthly figure as to the quantity of meat produced by the 7 export abattoirs. Also, contracts have become more specific with regard to the breed of animal required, age of the animal, fat score, grade score, the type of cuts of meat, depth of fat coverage and the type of packaging. Since cattle are being considered as a homogeneous product the variability in the requirements of such contracts has been ignored.

*Operating cost for a processing plant*

Operating cost is defined as those costs incurred with the operation of the plant that are not directly attributable to fixed costs or variable costs. Such costs include: general maintenance; insurance; electricity used in offices; telephone; rates; rent of office equipment and so on. It was not possible to obtain accurate estimates of these costs because the information was considered confidential, commercially sensitive or did not appear as a separate item in the accounting records.

Due to limited time and lack of reliable information, an estimate has been based on some limited information for a processing plant, $P_A$, and it was assumed that other processing plants experienced a similar operating cost, proportional to their size compared to the cost estimated for processing plant, $P_A$. A variation of ± 50 per cent of these costs was examined as part of a sensitivity analysis.

*Costs of opening or closing a plant*

When a processing plant is opened after a period of closure there is a need for additional maintenance to ready the plant for operation. Also there is the possibility of hiring additional staff if previous staff have found alternative work or left the area in search of work. If a processing plant is closing down for a period of time then there is need for equipment to receive additional maintenance in order to avoid damage and minimise the possibility of break down when, and if, the plant re-opens in the future. Also, there could be costs involved in laying off workers such as severance pay, holiday pay, and so on, but it was not possible to obtain any estimates of these costs. Costs such as pay for management and senior staff may continue to be incurred and thus, these would come under the heading of fixed costs and not part of the opening and closing additional costs.

As above with operating costs, these cost are either considered confidential, commercially sensitive or are not specifically separated out in the calculation of the accounting costs of running an abattoir. The time required to obtain accurate data was limiting and consequently, these figures had to be estimated from very limited knowledge and the assumption that the closing down costs and reopening cost are in proportion to the size of the processing plants has also been made. A variation of ± 50 per cent of these costs was examined as part of a sensitivity analysis.

**Results**

The six period model was run with two sets of representative supply data. The first data set (data set 1), was based on supply from the saleyards for the six month period (6 by 4 weeks) from July 1988 to December 1988 and the second (data set 2), was based on supply from the saleyards for the six month period from January 1989 to June 1989. The availability of beef cattle for slaughter in the second data period was generally higher than in the first. This may have been due to over estimating supply in April and May as a result of underestimating the number of 'store cattle' sold through the saleyards.

*First Data Set (July 1988 to December 1988)*

The summary results for the first data set, allowing processing plants to open and close, are presented in Appendix A1 and the summary result with all plants remaining open and operating at similar capacity utilisation levels are presented in Appendix A2. The difference between the total transportation costs for the two alternatives is approximately $30 000 and the corresponding difference between the average transport costs is $0.21 per head. The transport cost when allowing plants to open and close is higher than the situation where all plants remain open as a result of having to transport stock greater distances due to the closest abattoir being closed in some cases.

The average variable processing cost is reduced by $9.73 per head although this does not take into account the additional costs of opening and closing particular processing plants. The estimated costs of opening and closing the processing plants are shown in Table 2. The total additional cost of opening and closing processing plants is $40 500 which is approximately $0.14 per animal slaughtered during the 6 months.

TABLE 2

*Additional Costs of Opening and Closing Processing Plants*
*Data Set 1 - July 1988 to December 1988.*

| Additional Closing Costs | | Additional Opening Costs[a] | |
|---|---|---|---|
| Grafton | $3 000 | Grafton | $3 600 |
| Guyra | $1 600 | Guyra | $2 000 |
| Inverell | $5 200 | Inverell | $6 300 |
| Macksville | $3 700 | Inverell | $6 300 |
| | | Macksville | $4 400 |
| | | Macksville | $4 400 |
| Total | $13 500 | Total | $27 000 |

[a] Note: Inverell and Macksville were opened and closed twice.

The additional costs associated with opening and closing plants would have to exceed $2.8 million before there would be no benefit to producers or consumers. However, the additional costs do not take into account the regional costs associated or the flow-on effects with the closure of a processing plant. Also, the uncertainty of regular employment, due to the possibility of processing plant closure is likely to result in qualified and experienced labour moving away from the region.

It should also be noted that Wingham does not open at all according to the results in Appendix A1. As noted in the two-period model, there are fewer saleyards with high throughput levels of slaughter cattle in the Wingham area according to the special nature of the region. Although the average transport costs to Wingham are exceeded by the average transport costs to Grafton and Macksville when all plants remain open the difference in cost is insufficient to justify transporting cattle to Wingham in preference to other processing plants. When Wingham is closed there is actually a decrease in the average transport cost to Grafton. Given the closed nature of the region being studied it is not likely that Wingham will open in preference to Macksville because it is further south and it will be in direct competition for livestock with Gunnedah and Macksville. The exception to this situation in terms of the model, would be if Kempsey, Purfleet and Wauchope had significant increases in the number of livestock passing through the saleyards.

Assuming an average carcase weight of 215 kilograms (Australian Meat and Livestock Corporation 1990) and ignoring the additional costs incurred by opening and closing processing plants, the reduction in processing cost of $9.73 per head is equivalent to a reduction of $0.045 per kilogram of meat produced during the six month period. If producers bear more than half the costs of an increase in the marketing margin (Bureau of Transport Economics 1972), then presumably they would benefit by a similar amount if costs were reduced. Therefore, an increase in the saleyard price of beef cattle of up to 2.5 cents per kilogram carcase weight, or $4.50 per head for an average animal, could be expected if processing plants opened and closed in response to the variability in supply.

*Second Data Set (January 1989 to June 1989)*

The summary results for the second data set allowing processing plants to open and close are presented in Appendix A3 and the summary results with all plants remaining open and operating at similar capacity utilisation levels are presented in Appendix A4. The difference between the total transportation costs for the two alternatives is approximately $40 000 and the corresponding difference between the average transportation cost of $0.11 per head. As above, in data set 1, the transportation cost is less when all processing plants remain open.

The average variable processing cost was reduced by $3.78 per head although again this does not take account of the additional costs of opening and closing particular processing plants. The estimated costs of opening and closing the processing plants are shown in Table 3. The total additional cost of opening and closing processing plants is $31 100 which is approximately $0.05 per animal slaughtered during the 6 months.

TABLE 3

*Additional Costs of Opening and Closing Processing Plants*
*Data Set 2 - January 1989 to June 1989.*

| Additional Closing Costs | | Additional Opening Costs[a] | |
|---|---|---|---|
| Guyra | $1 600 | Guyra | $2 000 |
| Inverell | $5 200 | Inverell | $6 300 |
| Macksville | $3 700 | Macksville | $4 400 |
| Wingham | $1 600 | Macksville | $4 400 |
| | | Wingham | $1 900 |
| Total | $12 100 | Total | $19 000 |

[a] Note: Macksville opened once and closed twice.

The additional costs associated with opening and closing plants would have to exceed $1.3 million before there would be no benefit to producers or consumers. As before, no consideration has been given to the regional impact of closing a processing plant. With the exception of the one month where the supply exceeds the capacity of the other six processing plants, Wingham is closed. As before, the closed spatial nature of the region and the location of the Wingham processing plant near the southern border is the major problem.

Assuming an average carcase weight of 215 kilograms and ignoring the additional costs of opening and closing processing plants, the reduction in processing cost of $3.78 per head is equivalent to a reduction of less than $0.02 per kilogram of meat produced during the six month period. As above, producers could expect an increase of approximately 1 cent per kilogram or $2.00 per head.

*The Variation in Transportation Costs*

The smaller the number of processing plants that are operating in any one month the greater the average transportation cost for moving the animals from the point of purchase to the processing plant (see Appendices A1 to A4). Therefore, any reduction in the number of processing plants operating due to reduced supply will increase the total cost of transporting the animals to the processing plants. The greater the reduction in the number of processing plants operating, the greater the increase in the average transportation cost suggesting a relationship of the form:

$$\text{Transport cost per head} = f\left(\frac{1}{\text{Number of plants}}\right)$$

Since cattle have been treated as a homogeneous product, cattle for slaughter will be sourced from the nearest saleyard that has sales taking place on the appropriate day or days when the processing plant requires cattle. In the case of a processing plant that buys its own slaughter stock, the cost of transportation is important since it is the plant that pays the cost of transport and the wages of the buyer. For service works, such as Casino or Gunnedah, the cost of transport is not borne by the works but by the contractor who is contracting the service works to slaughter the stock. If transport charges were to rise, then nearly all of the burden of the increase would be on the producer, except in the case of the contractor using service works who could reduce transport costs by reducing the distance the animals are moved and use a closer processing plant.

In summary, if the number of 'fat cattle' destined for slaughter in export licensed processing plants is low and some processing plants close then the cattle will be transported greater distances and the cost of transport will rise by a relatively small amount.

*Benefits and Costs of Closing and Opening Processing Plants in Response to Monthly Supply Changes*

Firstly, ignoring the additional costs of opening and closing processing plants, and changes in the distribution of 'fat cattle' available for slaughter, reductions would appear to be possible in the average variable processing costs of processing slaughter cattle destined for export. The saving is greater the lower the supply of cattle as evidenced in the difference between the two data sets. The benefit to the individual Australian producer would be small. If the whole saving of $2.8 million was passed on to producers in the first case, this would average out at less than $10 per slaughter cow sold at the sale yard, or equivalently, less than $0.05 per kilogram dressed weight for the average animal. The number of cattle processed in the case of the first data set, (July 1988 to December 1988), was approximately 64.8 per cent of the total slaughter capacity of the 7 processing plants included in the model. In the second case, the capacity utilisation level was 78.8 per cent and the reduction in the average variable processing cost from opening and closing plants was significantly less than in the first case and the flow-on to the producer would therefore also be less.

From a cost perspective, if the processing plants were to open and close in response to supply variability the direct cost to each processing plant would be the costs involved in closing down the operation and starting it up when required. As these cost are not known, or accurately estimated the exact saving for a processing plant to open and close is difficult to estimate. However, the cost to a regional economy in terms of jobs lost and the loss of revenue to a town or area could be quite significant.

The average cost per month incurred by the processing plant as a result of closing for one month, as compared to a longer closure or seasonal closure of 3 months or more, maybe higher when averaged over the time period in question. For example, administrative costs of closing down and opening up are likely to be similar no matter what the period of closure. However, a short period of closure, say one month, would not impact as much on the regional economy as would a longer period of closure. In the case of regular seasonal closure, as happens in North Queensland, such effects would be expected.

*Sensitivity Analysis*

A selection of cost coefficients and saleyard supply estimates were adjusted as part of a sensitivity analysis. The operating costs (coefficients of the status, or STAT, variables in the objective equation) were increased and decreased by 50 per cent for both sets of data and there was no change in the processing plants shown as opened and closed in each month.

The additional cost associated with closing or opening a processing plant are indicated by the coefficients of the CLO (close) and OPE (open) variables in the objective equation. These coefficients were increased and decreased by 50 per cent. Again, there was no change in the pattern of opening and closing of processing plants.

The above results were expected since the magnitude of the estimated operating costs and the estimated additional costs of opening or closing processing plants were small compared to the total variable processing cost for each processing plant. Also, since it was assumed that the operating cost and additional cost of opening or closing a processing plant were proportional to the capacity or size of the processing plant the results are not surprising. Ideally, more accurate information on the actual costs incurred and whether or not economies of size existed would be useful. Ultimately, a closing down cost, inclusive of an estimate of the cost to the regional economy of a closure of a processing plant, would be the best estimate for use in the model.

A selection of processing plant cost functions were adjusted as part of the sensitivity analysis. The average variable processing cost functions of individual processing plants were raised or lowered, one by one, by $4.00 per head, that is, approximately 2.5 per cent. Those raised by $4.00 per head were those that were open throughout the six month period and those lowered were the processing plants that were closed for most of the six month period. No significant changes in the pattern of opening and closing of plants was found.

It would appear that the proximity of saleyards with an appropriate quantity of 'fat cattle' with respect to the location of a processing plant is the important issue. As it is not possible to physically move saleyards or processing plants some small variations in the quantity of 'fat cattle' in a selection of saleyards was undertaken. Of particular interest was the effect of increasing the availability of livestock at Inverell, Moree and Glen Innes by 100 head of cattle in the first month of the first data set. That is, an increase in the July 1988 supply. This was tried because the capacity of the four processing plants that were open would be insufficient to cope with this increase. The result was that Grafton remained open for all 6 periods instead of closing and that Inverell was open for the first and second month, but closed in the third month.

The model was found to be very sensitive to supply variability in saleyards. For example, an increase in the availability of 'fat cattle' from a saleyard that was matched by a decrease in another would result in a different pattern of opening and closing processing plants but there was very little change in the total variable processing cost and average variable processing costs. The difference was as low as $0.02.

## Summary and Concluding Comments

The indication from the results is that there are some savings that can be made in the beef meat processing industry if processing plants are opened and closed in response to the available supply. Although the magnitude of the savings is quite large when supply is relatively low, that is at about 65 per cent of the slaughter capacity, the actual increase in the price received by the farmer for the stock would be less than $10.00 if all the savings were passed on to the producer.

The act of opening or closing processing plants has very little effect on the cost of transporting the cattle to the processing plants A slight increase in the costs were observed since cattle would have to be transported greater distances.

The costs associated with all processing plants operating at similar levels of capacity utilisation, were compared against the cost of processing plants opening and closing in response to the availability of 'fat cattle' for slaughter. It was found that there was a reduction in the number of processing plants operating in any particular month which resulted in a nominal increase in the average transportation cost of transporting 'fat cattle' from the saleyards to the export licensed processing plants. In contrast, the average variable processing cost decreased for a fixed supply in any particular month when processing plants closed in times of reduced supply.

Over the two six monthly periods investigated, when the available 'fat cattle' averaged approximately 65 per cent of the slaughter capacity the reduction in processing cost was $9.73 per head. If all this saving were to be passed on to the producer an expected increase in the saleyard price of 2.5 cents per kilogram, or $9.73 per head, could be expected. Compared to the impact of occasional closures of processing plants on the regional economy, such a saving would not appear to be significant. However, if the supply of 'fat cattle' was to drop below the number required to maintain the 'rule of thumb breakeven capacity utilisation level of 60 per cent' (Industries Assistance

Commission 1983) then the reduction in average variable processing cost may be significant and possibly advisable in order for processing plants to minimise losses.

A major assumption in this study is that the processing plants are supply driven. That is, the export licensed processing plants will process all the slaughter cattle that are available for slaughter at any particular time. The implication is that processing plants will continue to operate even if they do to have any orders to fill. The limiting factor is the freezer storage space. If, on the contrary, the beef meat processing industry is demand driven, a demand shift will increase the price the processing plants receive. The processing plant will therefore be able to pay more for slaughter cattle. If the processing plant is a service works then the contractors using the service will demand a greater as they perceive an opportunity to increase there profits and consequently the contractors will offer a higher price when purchasing cattle. An increase in price at the saleyard due to increased demand may not increase supply in the short run. In fact, supply often falls in the short run as producers retain breeding stock in order to increase the size of the herd. In order to maintain throughput in times when supply is low processing plants will need to source slaughter cattle from greater distances thus eroding any additional short run profit that was present in the event of an increase in demand.

There are a number of limitations with the model. The first is the fact that the region is not completely closed in nature. Two processing plants are disadvantaged in terms of the model since the model does not enable processing plants to source from outside the region. A possible solution to this problem would be to include representative saleyards outside the region or ideally expand the size of the model to examine a larger area. Secondly, the model is very sensitive to the distribution of the 'fat cattle' among the saleyards within the region. For example, a reduction of less than 3 per cent in the availability of 'fat cattle ' close to a processing plant which is offset by a similar increase in another area may result in a change in the pattern of plants opening and closing over the six month period, and a saving of less than $10 000 in a total transportation and variable processing cost of more than $25 million.

A further limitation of the model is that the data used were based on past data. It is unlikely that such supply values of 'fat cattle' would be available when considering whether or not certain processing plants should close or open during some future period. The actual total transportation cost will also be underestimated by the model, because of the assumption that cattle are a homogeneous product. In order to overcome this, the model would need to be a multi-product model in terms of the raw product, 'fat cattle'. However, it may be extremely difficult to obtain supply data for saleyards that distinguished between cattle breed as well as grade and fat score. Finally, the absence of a fixed cost component and the unreliability of the operating cost and additional costs incurred by opening or closing a processing plant could have an effect on the accuracy of any results obtained. In order to make models such as this reliable, it is important that the data required are either made available or accurate estimations possible. However, the required data continues to be 'commercially sensitive' or confidential and approximations must suffice.

An area for further study would be an extension of this model to incorporate the costs to regional economy that would occur if processing plants were to open and close in an attempt to minimise there costs. If processing plants were to experience closures then an appropriate policy of compensation for employees laid off during such periods would be required. Given that individual export licensed processing plants are essentially price takers and the generally 'flat' nature of the average variable processing cost curve, it is unlikely that individual processing plants would strive towards minimising their average variable processing cost only. The main reason for this is because, in order to do so, the processing plant must be prepared to purchase a greater quantity of slaughter cattle, and in doing so, pay a higher price for the raw product thus raising the average variable processing cost curve. Therefore, if there were to be any policy of processing plant utilisation in periods of low supply of aimed at reducing average variable processing costs by selective closure and thus increasing returns for the producer, Government intervention would be required.

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Appendix A1

Summary Results for Data Set 1, July 1988 to December 1988, Processing Plants Able to Open and Close

| Processing Plant | Period 1 | Period 2 | Period 3 | Period 4 | Period 5 | Period 6 | Total |
|---|---|---|---|---|---|---|---|
| Casino | | | | | | | |
| Number of Cattle | 15 990 | 14 210 | 14 887 | 12 773 | 14 180 | 14 164 | 86 204 |
| Ave. Transport Cost | $15.58 | $9.78 | $12.66 | $15.94 | $10.77 | $9.63 | $12.41 |
| Ave. Processing Cost | $66.52 | $67.58 | $66.92 | $69.98 | $67.61 | $67.63 | $67.64 |
| Grafton | | | | | | | |
| Number of Cattle | 9 201 | 8 303 | 0 | 8 040 | 8 318 | 8 306 | 42 168 |
| Ave. Transport Cost | $14.58 | $13.30 | closed | $14.30 | $11.74 | $11.77 | $13.16 |
| Ave. Processing Cost | $66.45 | $67.26 | closed | $67.81 | $67.24 | $67.26 | $67.18 |
| Gunnedah | | | | | | | |
| Number of Cattle | 13 600 | 13 000 | 13 352 | 13 035 | 12 564 | 12 295 | 77 846 |
| Ave. Transport Cost | $4.92 | $4.36 | $5.58 | $6.21 | $4.82 | $4.16 | $5.02 |
| Ave. Processing Cost | $70.46 | $70.62 | $70.48 | $70.60 | $70.95 | $71.24 | $70.72 |
| Guyra | | | | | | | |
| Number of Cattle | 4 900 | 4 548 | 4 841 | 4 632 | 0 | 4 481 | 23 402 |
| Ave. Transport Cost | $6.59 | $10.61 | $10.61 | $7.17 | closed | $9.78 | $8.93 |
| Ave. Processing Cost | $67.43 | $68.01 | $67.47 | $67.80 | closed | $68.22 | $67.78 |
| Inverell | | | | | | | |
| Number of Cattle | 0 | 13 685 | 15 020 | 0 | 13 691 | 13 582 | 55 978 |
| Ave. Transport Cost | closed | $11.34 | $11.64 | closed | $12.00 | $11.78 | $11.69 |
| Ave. Processing Cost | closed | $71.30 | $69.83 | closed | $71.29 | $71.46 | $70.94 |
| Macksville | | | | | | | |
| Number of Cattle | 0 | 0 | 0 | 8 688 | 0 | 0 | 8 688 |
| Ave. Transport Cost | closed | closed | closed | $17.83 | closed | closed | $17.83 |
| Ave. Processing Cost | closed | closed | closed | $72.73 | closed | closed | $72.73 |
| Wingham | | | | | | | |
| Number of Cattle | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ave. Transport Cost | closed | closed | closed | closed | closed | closed | closed |
| Ave. Processing Cost | closed | closed | closed | closed | closed | closed | closed |
| Total | | | | | | | |
| Number of Cattle | 43 691 | 53 746 | 48 100 | 47 168 | 48 753 | 52 828 | 294 286 |
| Total Transport Cost | $ 482 507 | $ 509 456 | $ 489 239 | $ 587 684 | $ 475 198 | $ 489 110 | $3 033 195 |
| Total Processing Cost | $2 963 616 | $3 721 868 | $3 312 907 | $3 305 244 | $3 385 467 | $3 668 790 | $20 357 892 |
| Ave. Transport Cost | $11.04 | $9.48 | $10.17 | $12.46 | $9.75 | $9.26 | $10.31 |
| Ave. Processing Cost | $67.83 | $69.25 | $68.88 | $70.07 | $69.44 | $69.45 | $69.18 |

Appendix A2

Summary Results for Data Set 1, July 1988 to December 1988, All Processing Plants Open

| Processing Plant | Period 1 | Period 2 | Period 3 | Period 4 | Period 5 | Period 6 | Total |
|---|---|---|---|---|---|---|---|
| Casino | | | | | | | |
| Number of Cattle | 9 134 | 11 238 | 10 057 | 9 862 | 10 193 | 11 045 | 61 529 |
| Ave. Transport Cost | $7.66 | $8.17 | $9.49 | $9.46 | $9.70 | $7.81 | $8.71 |
| Ave. Processing Cost | $82.24 | $74.07 | $78.29 | $79.08 | $77.76 | $74.70 | $77.50 |
| Grafton | | | | | | | |
| Number of Cattle | 5 252 | 6 460 | 5 781 | 5 670 | 5 860 | 6 350 | 35 373 |
| Ave. Transport Cost | $13.74 | $15.40 | $15.40 | $15.40 | $15.54 | $13.90 | $14.91 |
| Ave. Processing Cost | $82.20 | $74.03 | $78.26 | $79.04 | $77.72 | $74.66 | $77.46 |
| Gunnedah | | | | | | | |
| Number of Cattle | 8 205 | 10 090 | 9 032 | 8 855 | 9 155 | 9 918 | 55 255 |
| Ave. Transport Cost | $4.36 | $4.36 | $4.36 | $4.36 | $4.36 | $4.36 | $4.36 |
| Ave. Processing Cost | $83.92 | $76.15 | $80.11 | $80.87 | $79.59 | $76.73 | $79.38 |
| Guyra | | | | | | | |
| Number of Cattle | 2 830 | 3 483 | 3 116 | 3 057 | 3 160 | 3 425 | 19 071 |
| Ave. Transport Cost | $7.09 | $9.68 | $10.43 | $9.32 | $11.35 | $10.89 | $9.86 |
| Ave. Processing Cost | $83.21 | $75.02 | $79.26 | $80.03 | $78.70 | $75.62 | $78.45 |
| Inverell | | | | | | | |
| Number of Cattle | 9 134 | 11 237 | 10 057 | 9 862 | 10 192 | 11 045 | 61 527 |
| Ave. Transport Cost | $10.02 | $9.84 | $10.12 | $9.79 | $9.92 | $10.11 | $9.97 |
| Ave. Processing Cost | $85.24 | $77.08 | $81.29 | $82.08 | $80.76 | $77.70 | $80.50 |
| Macksville | | | | | | | |
| Number of Cattle | 6 394 | 7 867 | 7 040 | 6 904 | 7 135 | 7 731 | 43 071 |
| Ave. Transport Cost | $13.85 | $14.15 | $14.44 | $13.90 | $14.64 | $13.86 | $14.14 |
| Ave. Processing Cost | $84.18 | $76.00 | $80.23 | $81.01 | $79.70 | $76.63 | $79.44 |
| Wingham | | | | | | | |
| Number of Cattle | 2 740 | 3 370 | 3 017 | 2 958 | 3 058 | 3 313 | 18 456 |
| Ave. Transport Cost | $14.04 | $14.04 | $14.04 | $13.43 | $14.04 | $13.84 | $13.91 |
| Ave. Processing Cost | $85.22 | $77.06 | $81.27 | $82.06 | $80.73 | $77.68 | $80.48 |
| Total | | | | | | | |
| Number of Cattle | 43 689 | 53 745 | 48 100 | 47 168 | 48 753 | 52 827 | 294 282 |
| Total Transport Cost | $ 416 446 | $ 538 261 | $ 502 186 | $ 480 021 | $ 514 319 | $ 519 652 | $2 970 884 |
| Total Processing Cost | $3 657 274 | $4 064 072 | $3 837 882 | $3 800 315 | $3 864 083 | $4 027 074 | $23 250 699 |
| Ave. Transport Cost | $9.53 | $10.02 | $10.44 | $10.18 | $10.55 | $9.84 | $10.10 |
| Ave. Processing Cost | $83.71 | $75.62 | $79.79 | $80.57 | $79.26 | $76.23 | $79.01 |

Appendix A3

Summary Results for Data Set 2, January 1989 to June 1989, Processing Plants Able to Open and Close

| Processing Plant | Period 1 | Period 2 | Period 3 | Period 4 | Period 5 | Period 6 | Total |
|---|---|---|---|---|---|---|---|
| Casino | | | | | | | |
| Number of Cattle | 15 096 | 14 765 | 14 778 | 14 337 | 15 228 | 15 186 | 89 390 |
| Ave. Transport Cost | $8.54 | $6.15 | $12.45 | $6.29 | $6.80 | $9.43 | $8.29 |
| Ave. Processing Cost | $66.78 | $67.02 | $67.01 | $67.43 | $66.71 | $66.73 | $66.94 |
| Grafton | | | | | | | |
| Number of Cattle | 8 726 | 8 420 | 8 809 | 8 240 | 8 752 | 8 786 | 51 733 |
| Ave. Transport Cost | $12.63 | $12.94 | $15.0 | $13.36 | $13.32 | $11.76 | $13.18 |
| Ave. Processing Cost | $66.68 | $67.06 | $66.60 | $67.38 | $66.65 | $66.62 | $66.83 |
| Gunnedah | | | | | | | |
| Number of Cattle | 12 760 | 13 218 | 13 600 | 12 333 | 13 075 | 12 735 | 77 721 |
| Ave. Transport Cost | $8.48 | $4.36 | $5.80 | $7.61 | $6.70 | $9.54 | $7.04 |
| Ave. Processing Cost | $70.78 | $70.52 | $70.46 | $71.20 | $70.58 | $70.80 | $70.72 |
| Guyra | | | | | | | |
| Number of Cattle | 4 708 | 4 551 | 0 | 4 450 | 4 725 | 4 740 | 23 174 |
| Ave. Transport Cost | $11.58 | $10.93 | closed | $12.17 | $11.78 | $11.32 | $11.55 |
| Ave. Processing Cost | $67.64 | $68.00 | closed | $68.33 | $67.61 | $67.59 | $67.83 |
| Inverell | | | | | | | |
| Number of Cattle | 14 447 | 14 328 | 0 | 13 973 | 14 955 | 14 617 | 72 320 |
| Ave. Transport Cost | $11.45 | $10.49 | closed | $9.98 | $9.46 | $11.20 | $10.51 |
| Ave. Processing Cost | $70.31 | $70.44 | closed | $70.88 | $69.88 | $70.15 | $70.32 |
| Macksville | | | | | | | |
| Number of Cattle | 0 | 9 759 | 10 408 | 9 484 | 10 058 | 0 | 39 709 |
| Ave. Transport Cost | closed | $12.96 | $15.63 | $13.23 | $15.72 | closed | $14.42 |
| Ave. Processing Cost | closed | $69.83 | $68.84 | $70.43 | $69.31 | closed | $69.58 |
| Wingham | | | | | | | |
| Number of Cattle | 0 | 0 | 0 | 0 | 4 300 | 0 | 4 300 |
| Ave. Transport Cost | closed | closed | closed | closed | $12.24 | closed | $12.24 |
| Ave. Processing Cost | closed | closed | closed | closed | $70.40 | closed | $70.40 |
| Total | | | | | | | |
| Number of Cattle | 55 737 | 65 041 | 47 595 | 62 817 | 71 093 | 56 064 | 358 347 |
| Total Transport Cost | $ 567 191 | $ 583 984 | $ 557 934 | $ 613 237 | $ 715 667 | $ 585 397 | $3 623 410 |
| Total Processing Cost | $3 827 476 | $4 486 706 | $3 251 712 | $4 362 477 | $4 886 381 | $3 846 159 | $24 660 911 |
| Ave. Transport Cost | $10.18 | $8.98 | $11.72 | $9.76 | $10.07 | $10.44 | $10.11 |
| Ave. Processing Cost | $68.67 | $68.98 | $68.32 | $69.45 | $68.73 | $68.60 | $68.82 |

Appendix A4

Summary Results for Data Set 2, January 1989 to June 1989, All Processing Plants Open

| Processing Plant | Period 1 | Period 2 | Period 3 | Period 4 | Period 5 | Period 6 | Total |
|---|---|---|---|---|---|---|---|
| Casino | | | | | | | |
| Number of Cattle | 11 852 | 13 687 | 9 950 | 13 718 | 15 075 | 11 763 | 76 045 |
| Ave. Transport Cost | $5.97 | $5.81 | $6.06 | $5.95 | $6.68 | $6.14 | $6.12 |
| Ave. Processing Cost | $72.25 | $68.29 | $78.72 | $68.25 | $66.80 | $72.50 | $70.62 |
| Grafton | | | | | | | |
| Number of Cattle | 6 701 | 7 819 | 5 721 | 7 552 | 8 665 | 6 748 | 43 206 |
| Ave. Transport Cost | $15.18 | $15.51 | $15.30 | $15.10 | $13.66 | $14.87 | $14.89 |
| Ave. Processing Cost | $72.76 | $68.38 | $78.68 | $69.19 | $66.74 | $72.52 | $70.88 |
| Gunnedah | | | | | | | |
| Number of Cattle | 10267 | 12125 | 8937 | 11207 | 12949 | 10449 | 65 934 |
| Ave. Transport Cost | $8.36 | $4.36 | $4.36 | $6.80 | $6.61 | $9.57 | $6.66 |
| Ave. Processing Cost | $75.59 | $71.46 | $80.51 | $73.10 | $70.65 | $75.05 | $74.02 |
| Guyra | | | | | | | |
| Number of Cattle | 3 612 | 4 214 | 3 084 | 4 070 | 4 677 | 3 663 | 23 320 |
| Ave. Transport Cost | $11.61 | $11.25 | $6.72 | $11.55 | $11.59 | $11.55 | $10.87 |
| Ave. Processing Cost | $73.75 | $69.36 | $79.67 | $70.18 | $67.70 | $73.28 | $71.83 |
| Inverell | | | | | | | |
| Number of Cattle | 11 653 | 13 599 | 9 950 | 13 135 | 14 864 | 11 720 | 74 921 |
| Ave. Transport Cost | $9.40 | $9.74 | $9.76 | $9.29 | $9.39 | $9.54 | $9.51 |
| Ave. Processing Cost | $75.81 | $71.43 | $81.72 | $72.25 | $69.94 | $75.62 | $73.98 |
| Macksville | | | | | | | |
| Number of Cattle | 8 158 | 9 518 | 6 965 | 9 193 | 10 405 | 8 206 | 52 445 |
| Ave. Transport Cost | $16.54 | $12.80 | $12.41 | $15.99 | $15.95 | $16.02 | $15.02 |
| Ave. Processing Cost | $74.73 | $70.35 | $80.66 | $71.17 | $68.85 | $74.54 | $72.90 |
| Wingham | | | | | | | |
| Number of Cattle | 3 495 | 4 080 | 2 985 | 3 940 | 4 460 | 3 515 | 22 475 |
| Ave. Transport Cost | $12.24 | $14.04 | $12.04 | $12.24 | $12.24 | $12.24 | $12.54 |
| Ave. Processing Cost | $75.79 | $71.40 | $81.70 | $72.22 | $69.90 | $75.60 | $73.95 |
| Total | | | | | | | |
| Number of Cattle | 55 738 | 65 042 | 47 592 | 62 815 | 71 095 | 56 064 | 358 346 |
| Total Transport Cost | $ 587 608 | $ 612 624 | $ 426 981 | $ 636 118 | $ 719 023 | $ 601 216 | $3 583 569 |
| Total Processing Cost | $4 144 343 | $4 560 397 | $3 817 435 | $4 451 385 | $4 884 507 | $4 158 396 | $26 016 463 |
| Ave. Transport Cost | $10.54 | $9.42 | $8.97 | $10.13 | $10.11 | $10.72 | $10.00 |
| Ave. Processing Cost | $74.35 | $70.11 | $80.21 | $70.87 | $68.70 | $74.17 | $72.60 |