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SHORT-RUN COSTS AND THROUGHPUT VARIABILITY FOR A NSW ABATTOIR

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The demand for abattoir services in Australia has fluctuated considerably over the past fifteen years (AMLC 1981; IAC 1983). Several abattoirs have ceased operating and there have been calls for industry rationalisation. The purpose here is to provide some empirical evidence on the short-run costs of the abattoir once operated by the New England (Abattoir) County Council in Guyra, NSW, giving particular emphasis to the implications of fluctuating throughput.

This abattoir represents an interesting case study. It was established in 1965 following an initiative of the NSW Government to replace small slaughterhouses by central facilities in order to ensure satisfactory hygiene and inspection standards (IAC 1983). Finance was entirely from loan funds totalling $1.83m (Anon. 1965). Like most county council abattoirs, it did not trade in meat on its own behalf; rather, it slaughtered cattle, sheep and pigs on a fee-for-service basis. In 1981, following several months of unprofitable operations the abattoir was 'moth-balled'. Interestingly, however, the facility was re-opened in 1985 under private ownership to operate, once again, as a service abattoir.

The focus of attention here is on the cost structure of the abattoir as it existed prior to ceasing operations. What, if any, aspect of the cost structure led to difficulties in covering variable costs? Was the plant well-suited to coping with the fluctuating throughput levels characteristic of livestock slaughter operations? These are the key questions of interest.

This case study should be of interest to individuals involved with the economics of meat processing, especially those concerned with industry rationalisation. Some of the empirical evidence can be compared with results from earlier cross-sectional studies (Cassidy, McCarthy and Toft 1970; Parsons and Guise 1971; IAC 1983). However, some of the evidence can be interpreted only in qualitative terms because of a lack of suitable benchmarks.

The demand for the services of the case-study abattoir over the period of the study reflected the national demand during the period. The Australian Meat and Live-stock Corporation (1981) estimates that, between 1977 and 1980, cattle capacity utilisation in abattoirs declined from 84 to 60 per cent nationally and from 92 to 58 per cent in NSW. The decline in sheep meat capacity utilisation between 1976 and 1981 was from 83 to 66 per cent nationally and from 86 to 77 per cent in NSW. Relatedly, between 1977 and mid-1981, 22 abattoirs ceased operations in Australia (AMLC 1981).

The discussion in the remainder of the note is in four sections:

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description of the estimated cost function; cost levels and discussion of the pattern of cost variability; analysis of the sensitivity of cost to fluctuations in throughput; and conclusions.

Estimated Cost Function

The authors obtained weekly cost data for the case-study abattoir covering 225 weeks from November 1976 to January 1981, a period during which plant size remained fixed except for an addition to freezer capacity. These costs were categorised into fixed and variable components. As was the case in the Industries Assistance Commission (1983) cost study, discretion had to be used in categorising the costs. However, the system used here was similar to that used by the Commission. Further details can be found in the broader study (Small 1982) on which this note is based. It should be pointed out that the data used here (and presumably those used by the Industries Assistance Commission and other authors) came from accounting records. As such, the data may not reflect accurately economic costs figured on the basis of the 'opportunity cost' principle. Moreover, given the information available, it was not possible to partition fixed costs into 'avoidable' and 'unavoidable' components (see Friedman 1962, p. 101). These features of the data should be recognised as a limitation of cost analyses of the present type. Other limitations of statistical cost analyses of the present type are discussed by French (1977).

The output variable for the analysis was weekly throughput measured in cattle equivalents. As pointed out by the Industries Assistance Commission (1983), there are differing views within the meat processing industry on the appropriate ratios to use in converting the throughput of various livestock categories to cattle equivalents. The ratios used in this study were calculated using similar procedures to those used by Parsons and Guise (1971) and they fall within the range of values quoted within the industry. It was estimated that the cost of processing one head of cattle was equivalent to that associated with 8.3 sheep or lambs, or 6.9 pigs.

When the throughput ratios were applied to data from the case-study abattoir, the mean weekly throughput level was 1295 cattle equivalents with a range from 381 (71 per cent below the mean) to 223 (72 per cent above the mean). The coefficient of variation was 35 per cent. While some of this variability would have been predictable (for example, seasonal variability), the overall extent of the variability is considerable. An important implication of throughput variability is addressed later.

Cost data were deflated by appropriate indexes which varied across different cost items, while revenue data were deflated using the consumer price index. Ordinary least squares regression was applied to the deflated cost data to estimate the average variable cost relationship. A quadratic functional form was chosen on the basis of data plots and consistency with economic theory.

The estimated average variable cost function is reported below (estimated standard errors in parenthesis)[1]:

[1] Econometric estimates of the relationship between throughput and variable cost components (labour, utilities and 'other') are provided in (Small 1982). It was found that

$$AVC = 61.996 - 0.036Q + 0.944(10^{-5})Q^2 \qquad \bar{R}^2 = 0.749$$
$$(1.707) \quad (0.0003) \quad (0.114)(10^{-5})$$

where AVC = average variable cost ($/week); and
Q = throughput (cattle equivalents per week).

This estimate was regarded as acceptable on the basis that signs were as expected, estimated regression coefficients were well in excess of twice the corresponding standard errors, $\bar{R}^2$ was satisfactory and there was no evidence of autocorrelation.

Cost Levels and Pattern of Cost Variability

The ability to cover variable costs is the economist's criterion for short-run plant viability. Based on the estimates of variable costs and weekly revenue, it was estimated that the abattoir covered variable costs about 70 per cent of the time during the study period. It was also found that the mean weekly throughput level (1295) was 32 per cent below the throughput level corresponding to minimum average variable cost (1907), while the observed maximum throughput level (2230) was 17 per cent above the minimum average variable cost throughput level.

Setting aside the historical record, how difficult was it for the abattoir to cover variable costs given the estimated cost structure? Some data relevant to this question are provided in Table 1. One indicator of the degree of difficulty a firm could expect in trying to cover its variable costs given a fluctuating output rate is simply the range of viable output rates for a given average revenue function. The narrower the range of

TABLE 1

Critical Weekly Throughput Rates Corresponding to Various Fee-for-Service Levels

Fee-for-service per cattle equivalents	Viable range[a]	Minimum throughput[b]	Elasticity of minimum throughput[c]
$		Cattle equivalents	
28	372	1721	−4.70
30	993	1410	−2.27
32	1354	1230	−2.04
34	1637	1088	−2.02
36	1878	968	−2.10
38	2092	861	−2.24
40	2286	764	−2.43
42	2464	675	−2.68
44	2630	592	−2.99
46	2787	513	−3.14

[a] Difference between highest and lowest throughput rates for which average variable costs are covered.
[b] Lowest throughput rate at which average variable cost is covered.
[c] Point elasticity of minimum throughput rate with respect to the fee-for-service.

labour was the principal contributor to variable costs over all throughput levels and its importance relative to utilities and other variable cost components increased as weekly throughput increased.

viable output rates, the greater the difficulty the firm could expect in trying to cover variable costs. Values of the viable range of throughput levels for the case-study abattoir are reported in the second column of Table 1 for various levels of the fee-for-service, which is assumed to be a 'flat rate' charge invariant to throughput. The range seems large even for fee-for-service levels only slightly above the minimum level of average variable cost (approximately $28 per cattle equivalent). Nevertheless, it has to be considered against an observed range in throughput of 1849 cattle equivalents.

Another indicator of the difficulty a firm could expect in trying to cover average variable costs is the minimum output rate necessary to cover these costs for various levels of the average revenue function. This information for the case-study abattoir is provided in the third column of Table 1. The point to note from this information is that the minimum viable throughput level is less than the observed mean weekly throughput level (1295) once the fee-for-service is in excess of $31 per cattle equivalent.

Also shown in Table 1 (last column) is the point elasticity of the minimum viable throughput level with respect to the fee-for-service. For the range of fee-for-service figures shown, a 1 per cent increase in the fee-for-service is accompanied by at least a 2 per cent reduction in the minimum viable throughout level. The corollary of this, of course, is that reductions in the fee-for-service are accompanied by more than proportionate increases in the minimum viable throughout level. There is no published benchmark against which these elasticity figures can be compared, although they might be meaningful to meat processing firms that have tried to monitor the relationship between plant viability and fee-for-service. If the economist's benchmark value of unity is used to distinguish between a relatively elastic versus a relatively inelastic response, then the minimum viable throughput is clearly in the former category.

The authors did not attempt to estimate a demand function for the services provided by the abattoir. However, the authors believe that the scenario which probably applied was one of a highly inelastic weekly demand for services (because of a lack of substitutes) over a range of the fee-for-service, with this range being determined by proximity to other slaughter facilities and the level of the fee-for-service at these facilities. If this were the case, then increases in the fee-for-service during periods in which throughput levels were generally low may well have been a relatively effective means of ensuring that variable costs were covered. This view results from the finding that the viable range of throughput levels increased rapidly with increases in the fee-for-service. The fee-for-service set by the abattoir varied from about $30 to $45 (estimated cattle equivalent figures) over the study period. Although the minimum figure is slightly above minimum average variable cost, in particular weeks the throughput levels were sufficiently small that variable costs were not covered by the fee-for-service. However, decisions about the extent of increases in the fee-for-service would have had to have been taken after considering the extent of the abattoir's spatial monopoly power. Perhaps the management considered this power to be very limited.

Plant Flexibility

One aspect of abattoir operations which has received much publicity is the degree of fluctuation in throughput levels. An implication of fluctuating throughput is that management might opt for a flexible plant, defined as one which is characterised by (acceptably) low unit costs for processing the expected level or range of throughput but which, at the same time, does not result in steeply rising units costs either side of the expected throughput level. Such a plant might not offer the lowest unit costs for processing the expected level of throughput (see Pasour and Bullock 1975) and such a plant might have its lowest unit costs at a throughput level other than the expected throughput level (the latter would be true in the presence of scale economies).

How flexible was the plant operated by the case-study abattoir? Readers might have reached the view that the plant was flexible on the basis of the results already presented in Table 1. Further evidence in support of this view is presented in this section.

One measure of plant flexibility used was the point elasticity of average and total variable costs with respect to throughput. Computed elasticities are reported in Table 2. There are no industry benchmarks against which these figures can be assessed. However, the authors' qualitative conclusion is that, over the observed throughput levels, variable costs were not very sensitive to variations in throughput.

In Table 3 some crude comparisons of plant flexibility between the case-study abattoir and those studied by Parsons and Guise (1971) and the Industries Assistance Commission (1983) are presented. Assumed increases in plant capacity utilisation are shown in the first column of the table and percentage reductions in average variable costs estimated in the three studies are shown in subsequent columns. The definitions of

TABLE 2

Point Elasticity of Average and Total Variable Costs with Respect to Throughput Level[a]

Weekly throughput in cattle equivalents[b]	Elasticity of average variable costs	Elasticity of total variable costs
400	−0.23	0.77
600	−0.34	0.66
800	−0.43	0.57
1000	−0.48	0.52
1200	−0.50	0.51
1400	−0.45	0.55
1600	−0.32	0.68
1800	−0.13	0.87
2000	0.13	1.13
2200	0.43	1.43
2400	0.75	1.75

[a] For a quadratic average variable cost function, the elasticity of total variable costs with respect to throughput is equal to one plus the elasticity of average variable costs with respect to throughput. At the minimum average variable cost throughput level these elasticities are equal to one and zero, respectively.

[b] The mean observed throughput was 1295 and the minimum average variable cost throughput was 1907.

TABLE 3

Comparisons of Plant Flexibility

Assumed increase in capacity utlisation (per cent)	Percentage reduction in average variable costs[a]		
	This study	Parsons and Guise (1971)[b]	IAC (1983)[c]
From 25 to 45	21.14	26.49	—
From 45 to 65	16.19	36.03	—
From 60 to 100	6.73	—	6.67

[a] The greater the reduction in average variable cost for a given increase in capacity utilisation, the lower the degree of plant flexibility.
[b] Computed using their zero variability in throughput option.
[c] Computed from their cost data for a 'small' abattoir (that is, annual throughput of less than 100 000 cattle equivalents which is equivalent to a weekly capacity throughput of 2000 for a 50-week year; this approximates the observed maximum weekly throughput of 2230 for the case-study abattoir).

'capacity' used by Parsons and Guise and by the Industries Assistance Commission are quite similar, both relating to the maximum attainable throughput level as assessed by management. For the case-study abattoir, 'capacity' was assumed to be the observed maximum weekly throughput (2230 cattle equivalents) during the study period, a measure similar to the observed peak annual capacity used by the Australian Meat and Live-stock Corporation (1981). This measure probably gives a lower estimate of capacity than the 'management-assessed' measure. Based on the data in Table 3, the case-study abattoir was more flexible than the sample of abattoirs in the Parsons and Guise study and about as flexible as the abattoirs surveyed by the Industries Assistance Commission.

The effect of fluctuating throughput on the level of annual total variable costs was examined through a simulation experiment described in the Appendix. At the mean throughput level (1295) and actual coefficient of variation of throughput experienced by the abattoir (35 per cent), the cost increase from fluctuating throughput compared with stable throughput was negligible. Indeed, at the mean throughput level there was very little increase in total variable costs resulting from fluctuating throughput irrespective of the degree of fluctuation. This result can be attributed to the fact that the mean throughput level (1295) was close to the throughput level corresponding to minimum marginal cost (1271) or the inflection point of the total variable cost function. It supports the authors' view that the plant was flexible over the range of observed throughputs. Had the mean throughput level been greater and if throughput levels had been more unstable, then the cost of fluctuating throughput levels would have been much more significant.

Conclusions

The fact that the case-study abattoir was purchased recently by a private firm to be operated once again as a service facility is some indication that perhaps the abattoir has the potential for economic viability. The authors' view, based on the statistical evidence presented here, is that the County Council may have covered variable costs more often had it adjusted the fee-for-service in response to changes in throughput. Management of the abattoir was not delegated authority to vary fees without Council's approval. By the time of the study period, the Council's decision making had become dominated by the magnitude of the debts accumulated since the abattoir commenced operations. These were in the region of $5m. Debts had increased in all but one year of the abattoir's operation, and the Council was concerned to have these waived, in part or in whole, to alleviate the burden of servicing them. Adjusting fees for service was perceived to be risky and of marginal benefit at best (V. T. Wright, personal communication, 1986).

In early 1985 the state Government waived, in effect, about $6m of the debt (which was almost $7m by this time) on the condition that the licence to slaughter was surrendered (Anon. 1985*a*). The abattoir was purchased for around $0.8m by its current owner (Anon. 1985*b*).

A striking feature of the operations of the case-study abattoir was that, for most of the study period, it appeared to be operating at throughput levels for which the average variable cost was falling. The existing plant was used inefficiently in the sense that it was usually operated at less than its minimum cost throughput level. Nevertheless, as shown by Piggott, Dumsday, Wright and Small (1985), the existing plant may have been optimal in the sense that no other scale of plant would have resulted in lower unit costs for the observed throughput levels. Such could have been the case in the presence of economies of size.

Even if some other scale of plant would have resulted in lower unit costs for the mean throughput level, it would not necessarily have resulted in lowest unit costs for throughput levels considerably below or above the mean throughput level. The authors' view is that the plant owned by the case-study abattoir seemed flexible in the sense of being able to handle a wide range of throughput levels without significant increases in unit costs. However, this view is based on qualitative interpretations of various flexibility measures and limited comparisons with results from other studies.

Underutilisation of capacity, among other things, has been mentioned as one of the main reasons for abattoir closures (AMLC 1981; IAC 1983). This view needs some qualification in the light of the evidence presented here. First, if meat slaughtering is characterised by economies of size, the cheapest way to process a target level of throughput may be to operate a plant at less than its optimal throughput level, where 'optimal' throughput is synonymous with the minimum short-run average cost throughput level. Second, for the case-study abattoir, there seemed to be a considerable range of throughputs (at each level of the fee-for-service) over which variable costs would have been covered and, hence, over which the abattoir would have minimised its losses by operating. The fact that the abattoir is estimated to have failed to cover variable costs for about 30 per cent of the study period should be attributed in part to extreme shortfalls in throughput but also, perhaps, to a lack of upward adjustment in the fee-for-service in times of low throughput levels.

These conclusions need to be considered with the limitations of the study in mind. Apart from the general shortcomings of statistical cost analysis discussed by French (1977), in the case of this study it could be argued that the choice of functional form pre-conditioned some of the statistical results although the choice seemed reasonable. It should also be kept in mind that cost accounting data were used in the study and they might not be an accurate reflection of the economist's concept of opportunity costs.

APPENDIX

Simulated Effects of Fluctuating Throughput on Annual Total Variable Costs

In order to determine the effect of fluctuating throughput levels on the annual level of total variable costs, the following simulation experiment was undertaken:

(a) weekly throughput levels were assumed to be normally distributed over the year with mean μ and variance σ^2;
(b) values of μ were chosen ranging from 500 to 2500 and for each value of μ the value of σ^2 was varied to give a range of values for the coefficient of variation of throughput from 15 per cent to 55 per cent;
(c) for each μ, σ^2 combination, 50 random weekly throughput levels were generated and the 50 associated cost levels were calculated and converted to an equivalent annual total variable cost figure;
(d) the throughput levels generated in (c) were summed to give the annual throughput level which was assumed to be uniformly distributed over the year (that is, 50 equal weekly throughputs) and (equivalent) annual total variable costs were computed;
(e) the total variable cost from (d) was subtracted from that in (c) and the difference expressed as percentage of (c); and
(f) for each μ, σ^2 combination, the experiment was replicated 100 times to give 100 percentage cost differences which were then averaged.

The results of this experiment are shown in Table A.1, with the figures in the body of the table being the average of the percentage cost differences between fluctuating and constant weekly throughput patterns. Negative figures indicate that the equivalent annual total variable costs under fluctuating throughput levels are less than those under stable throughput levels.

The case-study abattoir frequently operated at throughput levels for which marginal costs were falling (that is, up to 1270 cattle equivalents per week). These corresponded to throughput levels for which the total variable cost function was 'concave from below'. In this situation, as shown in Table A.1, fluctuating throughput levels resulted in lower variable costs than stable throughput levels and the cost reduction from fluctuating throughput increased with the degree of throughput fluctuation. The reverse was true for throughput levels over which marginal cost increased.

In assessing the results shown in Table A.1, it needs to be kept in mind that, *had* it been envisaged the abattoir's mean weekly throughput and/or the variability in throughput would differ markedly from those observed, perhaps a different plant would have been constructed.

TABLE A.1

Simulated Percentage Differences in Annual Total Variable Costs: Fluctuating versus Constant Weekly Throughput Levels[a]

Mean weekly throughput in cattle-equivalent units	Coefficient of variation of weekly throughputs (per cent)				
	15	25	36[b]	45	55
500	−0.41	−1.14	−2.24	−3.72	−5.20
750	−0.48	−1.33	−2.62	−4.36	−6.02
1000	−0.38	−1.06	−2.11	−3.52	−4.66
1250	−0.05	−0.15	−0.32	−0.57	−0.26
1295[c]	0.04	0.10	0.15	0.21	0.90
1500	0.56	1.55	2.98	4.85	7.74
1750	1.46	4.02	7.82	12.81	19.34
1907[d]	2.13	5.88	11.43	18.76	27.92
2000	2.56	7.06	13.76	22.59	33.35
2250	3.74	10.33	20.17	33.15	48.33
2500	4.84	13.42	26.22	43.17	62.39

[a] If the difference is negative then annual total variable costs are smaller under fluctuating throughput than under constant throughput.
[b] Observed coefficient of variation.
[c] Observed mean.
[d] Minimum average variable cost throughput level.

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