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Economies of Size in the England and Wales Dairy Sector

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ECONOMIES OF SIZE IN THE ENGLAND & WALES DAIRY SECTOR [1]

Analyses of size economies in the England and Wales dairy sector have generally been made on the basis of comparisons of input/ouput measures. These measures have been classified according to input use and farm size and have led to conclusions about efficiency and structural change. This paper examines economies of size using econometrically estimated long-run average cost (LAC) functions. From Milk Marketing Board data we estimate and compare two LAC functions, one for 1976/7, the other for 1980/1. The results imply that diseconomies of size will eventually result and that the LAC curve has been shifting to the right and downwards over time.

1. Introduction

Post-war structural change in agriculture has been nowhere more evident than in the dairy sector. Between 1950 and 1982, the number of registered milk producers in England and Wales fell from 196,000 to 52,000 and the average herd size increased four-fold to 65 cows. This trend towards fewer but larger units implies the existence, or at least a belief on the part of farmers, of economies of size. Such economies benefit both public and private interests since they lower unit costs. Britton and Hill (1975), in their analysis of dairy farms in England and Wales for 1972/3, concluded that economies of size were all but exhausted at a herd size of 60 cows, though larger herds did not appear to experience diseconomies. This suggests that, in common with other studies (for example, Lund and Hill, 1979), the long-run average cost (LAC) curve is L-shaped. This contrasts sharply with the traditional, textbook diagram of a U-shaped LAC curve.

In 1976, 73% of all herds in England and Wales, accounting for around 40% of milk production, were of less than 60 cows. By 1980, structural change had reduced the proportion of such herds to 63%. Moreover, their contribution to milk production had fallen by a quarter to around 30%. With technological improvements very much in evidence, resulting in reduced costs, it seems likely that economies of size now extend beyond the 60-cow herd. Accordingly, the aim of this paper is to examine size economies in the dairy sector in England and Wales. We use econometric methods to estimate LAC functions for two samples of cross-section data. The data originate from the Milk Marketing Board's periodic sample of dairy farms: they consist of 488 farms in 1976/7 and 406 farms in 1980/1[2].

In Section 2, we discuss some of the theoretical and conceptual issues relating to LAC functions and economies of size. Section 3 considers the estimation procedures used and Section 4 presents the results. We draw some conclusions in Section 5. A definition and description of the data are contained in the Appendices.

2. Some Concepts and Theory

Economies of size measures the variation in unit costs associated with a variation in some or all of the inputs. Modern textbook analyses of economies in production (for example, Ferguson, 1969, p.80) tend to concentrate on economies of scale, that is, the effect on production of a proportionate increase in all inputs. This is evident from the abundant discussion of homogeneous production functions. Empirical studies of production in agriculture have also tended to concentrate on this concept (for example, Dawson and Lingard, 1982). However, it is unlikely that farms increase all inputs in strict proportion, and hence the concept of economies of scale appears unduly restrictive. Economies of scale is a special case of economies of size, and it is this more general concept that is our concern.

The construct which is of interest in the analysis of size economies is the LAC curve which shows the minimum unit cost of producing every feasible level of output. Traditionally, it is assumed that this curve is U-shaped. The rationale for this assumption can be found in Kaldor (1934) who assumes that management is a factor of production which is fixed, even in the long-run. Kaldor argues that one of the functions of management is to co-ordinate the other inputs:

> "You cannot increase the supply of co-ordinating ability to an enterprise alongside an increase in the supply of other factors, as it is the essence of co-ordination that every single decision should be made on a comparison with other decisions ...; it must therefore pass through a single brain .... [Thus] the supply of 'co-ordinating ability' for the individual firm is 'fixed'." (Kaldor, 1934)

Assuming that input prices and technology are given, the U-shaped LAC curve displays increasing, constant or decreasing economies of size as the curve is decreasing, constant or increasing, respectively.

In contrast with the U-shaped LAC curve of traditional theory, some studies (see for example Britton and Hill, 1975, and Lund and Hill, 1979) have inferred the existence of an L-shaped curve. These suggest that although economies of size may be exhausted at some level of output, diseconomies, resulting in the upturn of the curve, appear not to be in evidence. The presence of an L-shaped curve might be inferred from a two-dimensional scatter diagram of average cost and output, particularly if management is shown to be positively correlated with the latter, that is, if better management is associated wih larger firms. However, this illustrates the danger of trying to infer the shape of the LAC curve whilst ignoring he crucial influence of managerial ability. Greater managerial skills will enable a firm to produce any given output at a lower cost. Hence, each point on the two-dimensional scatter diagram is associated with a given level of managerial ability and consequently, the shape of the LAC curve should not be inferred from this scatter alone.

Let us consider the derivation of the LAC function. Specifically, consider the derivation of a function which specifies the average cost of producing any output level. The existence of such a function must be based on predictions concerning the behaviour of the firm. Moreover, it must be derived from a model in which output is predetermined. In other words, we need to assume that the firm is behaving in some specific way with respect to some arbitrary level of output. If we assume that the aim of the firm is to maximise profit, it necessarily follows that the firm is producing any given output at minimum total cost. A fortiori, profit is total revenue less total cost and maximum profit can only be achieved when cost is minimised.

We can now examine the decision-making process of a farm in any given production period where the aim is to minimise total cost. It is not unreasonable to assume that a dairy farm produces a single, non-negative output, milk. Denote this by Q. The flow of output is produced from the input of non-negative, homogeneous and infinitely divisible flows of n variable inputs X_i (i = 1, ..., n) and one fixed, strictly positive input called management (M). Assume further that the production function, which shows the maximum output obtainable from any input mix, is stochastic. The random error term, u, which exhibits the usual classical properties of zero mean and constant variance, accounts for unpredictable variations in output caused by the weather, disease and so on. For simplicity, assume that the farm's production function is additively separable between all the inputs and the error term[3], that is:

$$Q = f(X_1, X_2, \ldots X_n, M) + u \qquad (1)$$

Assume that (1) is twice differentiable and strictly quasi-concave and that the marginal productivities are everywhere positive for all inputs.

Suppose that the farm faces given and invariant prices of P_i ($i = 1, \ldots, n$) for its variable inputs. The farmer's problem is to minimise the cost (C) of producing a predetermined, expected or planned level of output (Q_p). Noting that E [u] = 0, the problem is:

Minimise: $$C = \sum_{i=1}^{n} P_i X_i \qquad (2)$$

subject to: $$Q_p = f(X_1, X_2, \ldots, X_n, M)$$

Using the envelope theorem (see Silberberg, 1978, pp.275-6) the (indirect) cost function is:

$$C = C^*(P_1, P_2, \ldots, P_n, Q_p, M) \qquad (3)$$

Hence, C^* is the minimum cost associated with the given values of P_1, P_2, ..., P_n, Q_p and M. From (3), the minimum average cost of producing Q_p is:

$$AC = \frac{C^*(P_1, P_2, \ldots, P_n, Q_p, M)}{Q_p} = AC^*(P_1, P_2, \ldots P_n, Q_p M) \quad (4)$$

that is, average cost is a function of input prices, the planned level of output and management. It is this function which is the focus of attention.

3. Estimation Procedure

In this section we consider a statistical derivation of the LAC function. Johnston (1960, pp.29-30) notes that, "The desired range of output observations in the long-run analysis can probably only be obtained from 'cross-section' data for a reasonably large number of firms at some given point in time". This is because such data will discount the possibility of intertemporal variations in input prices. These are assumed constant and the same for all firms. Moreover, cross-section data for a given point in time will view each firm at a different point in its evolution; each firm will have a different amount of the fixed input, management. Hence, given technological and managerial efficiency, cross-section data will provide information on the LAC curve.

A major problem in estimating a LAC function, whose general form is given in (4), is the specification of the unobservable variables, planned output and management. In this paper we use pragmatic methods to quantify both. Let us consider this problem in more detail since it determines the estimation procedure chosen.

Data on planned output can be obtained from actual data on inputs and output by estimating a production function. The estimated values of output correspond to planned levels of output from given sets of inputs. The average cost of producing a planned level of output, that is, the dependent variable in the LAC function, is calculated by dividing total cost by planned output. However, a theoretical problem arises from this procedure. From the duality between production and cost functions, once a functional form has been specified for the former, a functional form has simultaneously been specified for the latter. Hence, in theory, there is no need to estimate both: the parameters of one function are implied by those of the other. But, "...direct derivation of cost functions can become a messy business even for very simple production functions" (Ferguson, 1969, p.163). For more complex production functions the problem is intractable. The two-stage procedure then is a practical way of surmounting this problem. Thus, we are assuming that the estimated production and cost functions are approximations of the true functions and that they are consistant with one another.

The first stage is to specify and estimate a production function. The flexible functional form we employ is the transcendental logarithmic (translog) function which gives a second-order approximation to an arbitrary function. As noted by Vlastuin <u>et al</u> (1982), the translog function involves a minimum of maintained hypotheses and imposes no specific form on economies of scale. Output in the production function is taken to be litres of milk; the inputs are feed costs (F), labour costs (L), capital costs (K), rent (R), and management[4]. Thus, the function to be estimated is:

$$\ell n\, Q = \alpha_o + \sum_i \alpha_i \,\ell n\, X_i + \alpha_M \,\ell n\, M + \tfrac{1}{2} \sum_i \sum_j \gamma_{ij} \,\ell n\, X_i \,\ell n\, X_j + \sum_i \gamma_{iM} \,\ell n\, X_i \,\ell n\, M + u \qquad (5)$$

$$i, j = 1, \ldots, 4$$

where $\gamma_{ij} = \gamma_{ji}$ and $\gamma_{iM} = \gamma_{Mi}$, that is, the parameters are symmetric.

One problem in estimating this production function is the specification of management. Often, the variable is omitted in cross-section production function studies because it is unobservable, but it is a crucial variable in our context and we attempt to find a proxy. However, a caveat is given by Mundlak (1961): "An attempt to substitute some index of management does not solve the conceptual difficulty. It can be regarded as an *ad hoc* procedure as long as no criterion for evaluating its performance is available". After some experiments, the proxy chosen was "margin over feed costs per litre". This gives an *ex post* indication of the farmer's performance.

The second stage of the estimation procedure is to estimate the parameters of the LAC function whose general form is given in (4). The functional form is determined from both theory and *a priori* expectation. First, the theory predicts that average cost is a second-order function in planned output thereby giving the conventional U-shape. Second, we expect that average cost declines as managerial ability increases.

4. Results

The translog production function estimates are given in Table 1. While we are interested in the estimated output levels, heteroscedasticity and multicollinearity are two possible problems. Let us consider each.

Goldfeld and Quandt (G & Q) tests (see Johnston, 1972, pp.218-9) were performed to test for the presence of heteroscedasticity. These were carried out under the six alternative rankings of the observations by output and by the inputs. For the 1976/7 sample, the largest G & Q test statistic, which is that reported at the foot of the first column of Table 1, was obtained for a ranking by feed[5]. Thus, it is hypothesised that the variable feed is the source of the problem. Unfortunately, we do not know the form of the heteroscedasticity so the following procedure is used. Glejser tests (see Johnston, 1972, pp.220) were performed where the absolute values of the residuals, $|e|$, are regressed against various functional forms of feed[6]. From the best regression, the estimated values of $|e|$ are calculated and these are then used to divide the variables in the production function. The translog production function is then re-estimated using weighted least squares (WLS). G & Q tests were again performed but these test statistics were higher than before. We conclude therefore that the source of heteroscedasticity is more complex than our simple functions of feed alone, and consequently we use the original production function estimates. The consequences of this should not be serious since we are interested in the estimated values of output, rather than the parameter estimates and hypothesis testing. For the 1980/1 sample, the highest G & Q test statistic, which is that reported at the foot of the second column of Table 1, is obtined under a ranking of management. Using a similar procedure to that above, the second-round G & Q test statistic (again under a ranking of the observations by management) fell to below the critical value[7]. We use therefore the estimates of this production function to obtain the estimated values of output[8].

Multicollinearity is a problem in both sets of estimates and the Farrar-Glauber tests (see Johnston, 1972, pp.163-4) are all significant, that is, the null hypotheses of orthogonality amongst the explanatory variables in both preferred equations are rejected. But as Johnston suggests (p.164), this will be the case in most, if not all, Farrar-Glauber tests in any econometric analysis. Again, and more importantly, it is not the parameter estimates that are of specific interest, but rather the estimated values of output. Consequently, it is felt that the presence of multicollinearity is not too harmful.

We can now use the estimated values of output from these production functions to estimate the LAC functions. Average cost for each sample is calculated as total cost divided by the planned output derived from the production function estimates. Experiments were carried out on different functional forms. Those preferred, which coincidentally have the same functional form in each of the two years, are presented in Table 2.

Heteroscedasticity is a problem in both equations when estimated by OLS: the largest G & Q test statistics were obtained under a ranking of average cost. Accordingly, it is hypothesised that average cost is the cause of heteroscedasticity in both equations and the procedure outlined above was again carried out. The preferred WLS estimates are given in the second and fourth columns of Table 2[9]. Heteroscedasticity does not now appear to be a problem in the 1976/7 estimates. It is still inherent in the 1980/1 estimates but the problem has been reduced substantially and it was felt not unreasonable to use this result.

The results of our study imply that whilst diseconomies are present at levels of output above the optimum[10], they are far less marked than the reductions in average cost to be gained through expansion of smaller herds. This can be seen by the skewed U-shape of both LAC curves in Figure 1. The implications of the LAC function estimates are presented in Table 3. The optimal output level is 707,000 litres in 1976/7 and 754,000 litres in 1980/1, an increase of 7%. To calculate the optimal herd size for each year it was thought appropriate to use the average yield of those farms with output levels nearest the optimum. Using the mean yield from ten such farms in each sample the optimal herd size is coincidentally, 137 cows in each year[11]. Thus, while the LAC has shifted to the right over the period, increasing the optimal level of output, the optimal herd size remains unchanged. This implies that technological improvements in production over the four years are being reflected entirely in increased yields per cow. This is not so surprising over a relatively short period. Over the longer term it might be expected that improvements in the production process would lead to increases in the optimal size of herd.

The minimum average cost of production, in current prices, given average managerial ability in each sample, is 7.6 pence/litre in 1976/7 and 10.2 pence/litre in 1980/1. In 1980 prices, the minimum cost in 1976/7 is 11.7 pence/litre[12]. Thus, the downward shift in the LAC over the period implies a fall of 13%, or 3% per year, in minimum average cost. Average milk returns were 9.5 pence/litre in 1976/7 (13.1 pence/litre in 1980 prices) and 12.8 pence/litre in 1980/1, showing a fall in real terms of 2%, or 0.5% per year. These changes imply that reductions in average cost have more than offset the fall in the price the farmer receives for milk. With aggregate output of milk increasing over this period, this adds support to the case that dairy farmers are not necessarily acting 'peversely' when seen to be increasing their output in times of a falling product price.

The break-even level of output is where average cost is equal to output price. Assuming that average milk return is equivalent to output price, we can calculate the break-even output levels in each year by substituting the former into each estimated LAC function. The break-even output level for 1976/7 is 84,000 litres while that for 1980/1 is 98,000 litres. Both these correspond to a herd size of about 20 cows.

5. Summary and Conclusions

In this paper, we have sought to provide estimates of the LAC function for the dairy sector in England and Wales for the two years 1976/7 and 1980/1, thereby identifying any economies of size. A simple theory was developed in conditions of output uncertainty. By minimising the cost of producing an expected or planned level of output, it was shown that the relevant LAC function is average cost per unit of expected or planned output. The determinants of this function at any one point in time are planned output and managerial ability. Since both of these variables are unobservable a proxy for management was taken to be 'margin over feed costs', and data on planned output were obtained from production function estimates. The results show that the LAC curve is U-shaped though skewed to exhibit much greater economies than diseconomies of size.

Once a threshold of 20 cows has been reached, economies of size exist up to a herd size of 137 cows. Diseconomies of size will occur at herd sizes above this optimum. However, these diseconomies, while being present, are not great and profits can be made even with the largest observed herd sizes. The results also imply that the LAC curve over the four-year period is shifting both to the right and downwards. Technological advances are acting to increase milk yields and reduce costs. However, they have not led to an increase in the optimal herd size.

The optimal herd size of 137 cows appears to be large when compared with observed herd sizes, but it must be recognised that there are no constraints on input use in a long-run analysis. In practice, farms are operating in successive short-run conditions. Moreover, labour may be indivisible for some farms. Whilst one dairyman can perhaps milk up to 120 cows at any milking, to reach the optimal herd size extra part-time labour is likely to be required. In many cases this may not be available, thus constraining the labour input to a single dairyman. Indivisibility of the labour input therefore may prevent a farmer from achieving the optimal herd size.

Our results show the optimal herd size to have remained constant between 1976 and 1980. Nevertheless, structural change proceeds, as those farmers with below optimal herds seek to reap the benefits of size economies. MMB data show that the number of dairy herds in England and Wales during this period fell from 56,100 to 45,900. Herds of less than 20 cows represented 24% of the total in 1976, but only 15% in 1980. Herds of 100 cows or more increased from 9% to 13% over the four years. These changes are in keeping with the long recognised trend towards fewer but larger herds.

Results of the MMB's Milk Cost Survey for 1984/5, when available, will reveal something of the initial reaction of dairy farmers to the

EEC quota policy introduced in April 1984. Some farmers have responded by reducing their herd size, and, as is widely believed, the use of non-transferable quotas will serve to slow, if not stop, further structural change. Clearly, quotas add a new dimension to the question of structural change in the dairy sector and will need to be incorporated in any studies which examine the post-quota situation. This is an issue which will surely receive attention in future research.

Footnotes

1. We would like to thank Ken Thomson for comments on an earlier draft of this paper.

2. We would like to thank the MMB for making available disaggregated data from their 1976/7 and 1980/1 Milk Cost Surveys.

3. This implies that risk is independent of the inputs.

4. See Appendices for definitions and descriptions of the data.

5. Since both samples are large, it was thought appropriate to use the 99% confidence level for hypothesis testing throughout the analysis.

6. The functional forms used are those suggested by Gujarati (1978), p.204.

7. The preferred Glejser equation is:

$$|e| = \underset{(23.85)}{0.721\ M} \quad ; \qquad R^2 = 0.05$$

8. The estimated values obtained when the production function is estimated by WLS relate to the transformed output. This is then multiplied by the estimated values of $|e|$ obtained from the preferred Glejser equation. This product is the antilogged to give estimated output.

9. The preferred Glejser equations are:

for 1976/7 – $|e| = \underset{(26.11)}{0.938\ AC} \quad ; \qquad R^2 = 0.15$

for 1980/1 – $|e| = \underset{(21.01)}{0.445\ AC} \quad ; \qquad R^2 = 0.003$

10. We will refer to the level of output with the minimum average cost as the 'optimum' output since this represents the optimal capacity of the farm.

11. The average yields for the 10 farms with output levels nearest the optima are 5,177 litres for 1976/7 and 5,500 litres for 1980/1.

12. The cost of production in 1976/7 has been expressed in 1980 prices through the use of a composite inflator calculated by weighting the increases in the price of inputs over the four year period. The weights are based on the average input use across all farms in the 1976/7 data set. The increases in the price of inputs are taken from CSO (1982), MAFF (1981) and Nix (1976 and 1981).

	Weight	Price Increase $\left(\frac{1980}{1976}\right)$
Input:		
Feed	0.65	1.40
Labour	0.13	1.60
Rent	0.13	1.98
Capital	0.09	1.69
	1.00	1.53
Milk	-	1.37

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Appendix I: Definition of Variables

Q = Total output of milk (litres).

F = Total feed costs (£):- purchased, home-grown and imputed grazing costs.

L = Total labour costs (£):- hired and imputed cost for family labour.

R = Gross rent (£):- actual rent and imputed rent for owner-occupier.

MC = Total machinery and equipment costs (£):- running costs, maintenance, depreciation and contract costs.

AHS = Average herd size (cows).

k = Imputed costs of herd replacement per cow (£):- the average over all farms.

K = Capital costs (£) (= MC + [AHS x k])

LO = Livestock output (£):- milk returns, net calf returns and net herd replacement costs.

M = Management proxy (£):- margin over feed per litre $\left(= \frac{LO - F}{Q} \right)$

C = Total costs (£):- (= F + L + R + K).

Appendix II: Description of Data

	Min.	Max.	Mean	S.D.
1976/7				
(n=488)				
Q	16,970	2,098,600	368,810	315,750
F	1,296	130,590	19,948	18,066
L	1,015	24,547	4,320.5	3,035.1
R	156	36,552	3,845.5	4,683.5
K	189.55	19,871	2,613.7	2,246.4
MC	52	14,778	1,597.4	1,535.9
AHS	10.083	480.33	80.657	63.591
k	12.6	12.6	12.6	0
M	0.010088	0.083480	0.050542	0.010628
LO	1,952	219,180	38,508	32,883
C	2,773	211,560	30,728	26,448
1980/1				
(n=406)				
Q	35,123	1,991,000	497,990	384,000
F	2,659	135,650	31,799	24,305
L	1,718	42,101	8,393.5	5,558.0
R	255	54,750	7,030.6	8,085.8
K	812.50	44,664	6,719.7	5,323.0
MC	196	36,668	4,374.9	3,826.8
AHS	11	350.00	94.169	66.456
k	26.6	26.6	26.6	0
M	0.022555	0.12896	0.076528	0.012267
LO	5099	278,260	70,655	54,449
C	7,770.4	230,710	53,943	40,541

Table 1: Production Function Results

Dependent Variable	1976/7 ln Q (by OLS)	1980/1 ln Q (by OLS)	1980/1 ln Q (by WLS)
α_o	7.985 (8.67)	5.226 (3.31)	6.124 (4.32)
α_F	0.917 (4.16)	1.443 (3.91)	1.193 (3.61)
α_L	-0.220 (0.86)	-0.031 (0.1)	-0.185 (0.63)
α_K	0.271 (1.06)	-0.143 (0.43)	0.037 (0.13)
α_R	0.254 (1.82)	0.008 (0.05)	0.106 (0.66)
γ_M	3.076 (9.75)	2.183 (3.65)	2.294 (4.90)
γ_{FF}	0.004 (0.14)	-0.180 (4.09)	-0.138 (3.48)
γ_{LL}	0.027 (0.96)	0.349 (1.44)	0.042 (1.87)
γ_{KK}	0.054 (1.47)	-0.128 (3.19)	-0.109 (3.22)
γ_{RR}	0.002 (0.26)	-0.111 (1.37)	-0.010 (1.33)
γ_{MM}	0.343 (12.64)	0.344 (4.82)	0.324 (6.38)
γ_{FL}	-0.011 (0.27)	0.033 (0.69)	0.004 (0.10)
γ_{FK}	-0.048 (0.86)	0.271 (3.49)	0.226 (3.31)
γ_{FR}	-0.014 (0.59)	0.039 (1.41)	0.025 (0.95)
γ_{FM}	-0.111 (2.00)	-0.088 (0.94)	-0.153 (2.05)
γ_{LK}	-0.011 (0.28)	-0.045 (0.96)	-0.030 (0.72)
γ_{LR}	-0.014 (0.63)	-0.034 (1.61)	-0.020 (1.02)
γ_{LM}	-0.022 (0.41)	0.097 (1.51)	0.069 (1.45)
γ_{KR}	-0.026 (0.97)	0.017 (0.65)	0.013 (0.54)
γ_{KM}	0.106 (1.66)	0.046 (0.52)	0.103 (1.52)
γ_{RM}	0.301 (0.88)	0.016 (0.38)	0.041 (1.14)
R^2	0.99	0.99	0.99
G & Q test	$F_{200,200} = 1.94$	$F_{120,120} = 2.99$	$F_{120,120} = 1.41$

Notes:

1) t-statistics in parentheses;

2) Critical value for t: $t_{99\%} = 2.58$; and

3) Critical value for F: $F_{99\%;200,200} = 1.20$; $F_{99\%;120,120} = 1.53$

Table 2: LAC Function Results

	1976/7		1980/1	
Dependent Variable	ln AC (by OLS)	ln AC (by WLS)	ln AC (by OLS)	ln AC (by WLS)
Constant	5.9824 (7.20)	6.3281 (7.39)	9.8776 (9.31)	8.7722 (7.76)
ln Q	-1.4686 (11.01)	-1.5518 (11.44)	-2.0143 (12.27)	-1.8531 (10.67)
$(\ln Q_p)$	0.05442 (10.13)	0.057606 (10.67)	0.07463 (11.61)	0.068466 (10.19)
ln M	-0.46125 (22.41)	-0.51966 (25.28)	-0.56473 (18.38)	-0.57880 (13.30)
R^2	0.68	0.98	0.71	0.98
G & Q test	$F_{200,200}=3.39$	$F_{200,200}=1.17$	$F_{120,120}=5.89$	$F_{120,120}=1.93$

(see notes for Table 1)

Table 3: Implications of LAC Results *

	1976/7	1980/1
Optimal output (litres)	707,210	753,885
Optimal herd size (cows)	137	137
Minimum average cost (current prices) (pence/litre)	7.64	10.24
Minimum average cost (1980 prices)** (pence/litre)	11.69	10.24
Break-even output*** (litres)	84,060	98,137

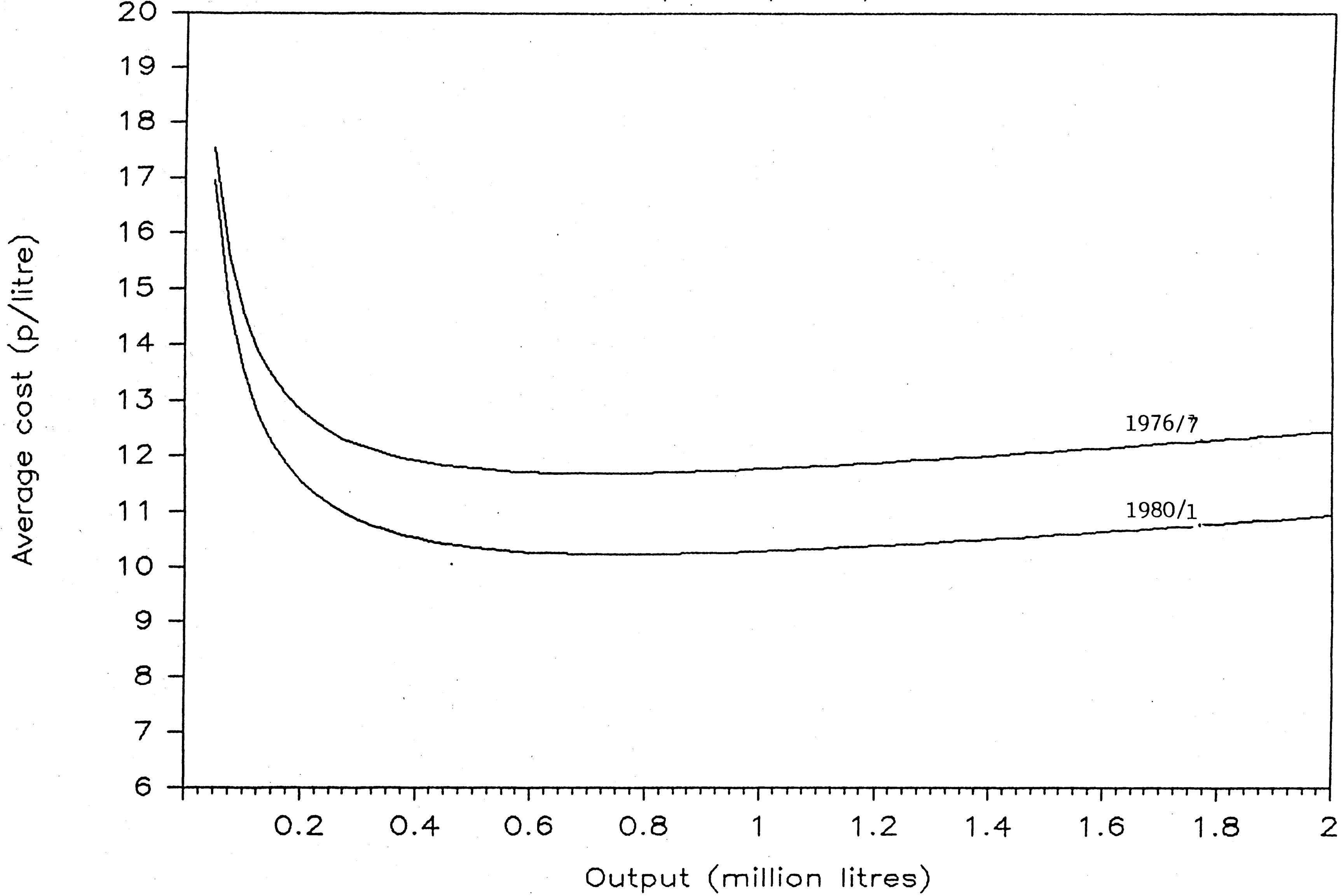
* The results presented relate to the mean level of the management proxy in each year.

** See footnote 11.

*** Average milk returns: 1976/7 - 9.53 pence/litre and 1980/1 - 12.78 pence/litre.

FIGURE 1: LAC Curves at Mean Values of M

(1980 prices)†



† See footnote 11

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