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ON THE GROWTH OF THE AGRICULTURAL FIRM*

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Theoretical problems involved in the reconciliation of the assumption of constant returns to scale with determinacy of firm size are discussed with particular reference to Australian farms. Various techniques for examining changes in the size distribution of firms are examined and their use demonstrated. The work is stochastic rather than deterministic. B.A.E. sheep industry survey data is used and flock size is used as the measure of farm size. The results do not suggest that inequality in the distribution of farm sizes is increasing. Growth differs between flock sizes within the same region and for the same flock size between regions. Profitability seems to be relatively larger in the medium flock sizes.

In conventional static theory, the firm is assumed to be operating under a given state of technology and with profit maximization as its objective. If the market structure is one of perfect competition in both commodity and factor markets then an individual firm may sell any amount of output and may buy any amount of inputs at given market prices. At the same time decisions are made under perfect knowledge. These decisions have traditionally involved the choice of inputs to meet least cost criteria, the optimal mix of products in a multi-product firm and lastly the level of operations. When the state of technology was specified as being embodied in a production function with constant returns to scale the existence of an indeterminacy in the case of a firm in perfect competition was realized. Since the demand for the output of such a firm was horizontal and long-run average costs were constant there were three possible outcomes. If price exceeded long-run marginal cost then the firm would expand indefinitely; or, price would be less than long-run average cost so no output would be produced; or, price would be equal to long-run marginal cost and an individual firm would be indifferent to the actual level of output.

Confronted with this indeterminacy between long-run static equilibrium and the existence of perfect competition various suggestions were made for overcoming the dilemma. Indivisibilities of a technical, mar-

* Presidential address, Australian Agricultural Economics Society, Canberra, 1968. In preparing this address I have benefited from reading in draft form, *Profitability, Growth and Valuation* by A. Singh, G. Whittington and H. T. Burley, Cambridge University Press, 1968.

keting or financial nature[1] may pose difficulties in the proportionate increase of all inputs but these indivisibilities are either temporary or inconsistent with perfect competition. Technical indivisibilities, for instance, may arise through the lumpiness of some machinery inputs and over a certain range of output average costs may rise. However, as output expands still further, average costs will fall as the lumpy input is spread over a greater output. Marketing indivisibilities may arise through the lumpiness of certain types of expenditure. For example, expenditure on promotion may, if lumpy, and if spread only over relatively few units of output cause average costs to rise but, again, the effect of the indivisibility on costs would be reversed as output expands. Financial indivisibilities might arise if the cost of borrowing is a decreasing function of the size of the firm, but this would be inconsistent with perfect competition in factor markets. If we extend the notion of the production function to include credit as an input, then decisions with respect to the financing of operations should be added to the input and output decisions previously mentioned.

Once indivisibilities as a source of increasing costs are no longer accepted one must look for some other input which might be regarded as fixed—in the long run—so that diminishing marginal returns as a consequence of the fixed input might occur. Typically, the major contender for this role has been the entrepreneurial input. Marshall in this context argued that a firm cannot continue to grow indefinitly because, after a certain time, progress for a single entrepreneur would be arrested 'by the decay, if not of his faculties, yet of his liking for energetic work'.[2] The growth could be prolonged if the firm were handed down to a successor equally as energetic as the original proprietor but Marshall seemed to think that entrepreneurial decay was rather pervasive and the supply of entrepreneurs capable of exploiting any possible scale economies was limited. In a perfect knowledge situation it is difficult to conceive of management skill being a limiting factor to growth.

Following Kaldor,[3] the entrepreneurial function may be interpreted as consisting of the bearing of uncertainty and of the performance of the managerial function of supervision and co-ordination. Uncertainty bearing implies an imperfect knowledge situation and is inconsistent with a perfectly competitive model. With a given constellation of prices and technology, once optimal decisions with respect to inputs, outputs and financing are made, then the supervisory role is a purely routine one. As such, the input of supervisors could be increased proportionately along with the other productive factors. If the given constellation of prices and technology changes the co-ordinating function will decide what the new decisions are to be. However, once these decisions are made there is no further need of the co-ordinating function until the parameters (prices and technology) change again. The co-ordinating function then is most important if the parameters are changing frequently, or are likely to do so.

According to Kaldor[4] it is the supply of this co-ordinating function

[1] See G. J. Stigler, *The Theory of Price*, Macmillan, New York, 1947, pp. 134-138.

[2] Alfred Marshall, *Principles of Economics* 9th ed. Macmillan, 1961, p. 286.

[3] N. Kaldor, 'The Equilibrium of the Firm', *Economic Journal*, Vol. 44, 1934, pp. 60-76.

[4] Kaldor, *ibid.*, p. 69.

which is the limiting factor, for the individual firm. On this argument, if the supply of these managerial skills could be increased, then—for a firm in perfect competition with no restrictions to growth coming from the product demand side—increases in growth and increases in size would continue. The growth of specialized management services not only in the developed southern part of Australia but more dramatically in the northern part should then result in increases in the size of farms. In Kaldor's model it would be necessary to leave a static world and enter a dynamic one before co-ordination problems would pose a barrier to continued growth of the firm.

On the problem of co-ordination, Williamson[5] in a recent article has given precision to some positive theories of bureaucratic behaviour with what he calls the 'control-loss' phenomenon in discussing (quasi) static limitations to firm size. Put briefly, and hence inadequately, the control-loss phenomenon arises because as an organization becomes larger there is a loss of control over its actions by those at the top. As successive hierarchies of control build up in the organization information must be transmitted across more and more levels to reach the top decision maker and from him down. In the process of transmission the information becomes subject to 'noise' at each transmission level and there is a deterioration in the quality of the information and this is the control-loss. This control-loss is cumulative over the levels at which information is sent and the loss eventually imposes a limitation on firm growth.

The control-loss phenomenon probably has restricted applicability to owner-operated firms where the bulk of the labour input and the managerial function are embodied in the one man. However, owner-operated farms are not the only form of economic organization found in agriculture. Scattered bits of evidence would suggest to me that multiple farm ownership, often of geographically separate units, is increasing with the introduction of another level in the hierarchy of control. Moreover, we have had in Australia ever since our earliest days pastoral companies operating a number of properties which have most of the organizational features of a modern industrial corporation. It would be an interesting exercise to examine the growth rates of these forms of agricultural organization in comparison with the owner-operated form.

While still operating within the framework of perfect competition, Baumol[6] has developed a model where the growth rate of the firm is a decision variable. That is, the firm chooses that growth rate which maximizes the discounted stream of profits. Profits are defined as the difference between discounted net revenues and the discounted costs of further expansion. Two sorts of costs are distinguished; those arising from current levels of production and these costs are used in obtaining net revenues and those arising specifically from expanding levels of output.[7] In such a model the necessary condition for the optimal rate of

[5] Oliver E. Williamson, 'Hierarchical Control and Optimum Firm Size', *Journal of Political Economy* Vol. 75, No. 2, April, 1967, pp. 123-138.

[6] W. Baumol, 'On the Theory of Expansion of the Firm', *American Economic Review*, December, 1962, pp. 1078-1087.

[7] The role of expansion costs, in particular the notion that these costs tend to increase with the firm's rate of growth was first developed by Edith Penrose, *The Theory of the Growth of the Firm*, Blackwell, Oxford, 1963, and Robin Marris, *The Economic Theory of Managerial Capitalism*, Macmillan, London, 1964.

growth is given by equality of the marginal net revenue from additional growth and the marginal cost of such growth. In the case of the agricultural firm, if the marginal net revenue from additional expansion is fairly constant but the marginal costs of expansion rise rapidly, the optimal rate of growth may be very low.

Once we leave the case of perfect competition and simple profit maximization, the firm's objective function becomes multi-dimensional and there are a number of restraints the firm must include in its decision making. Williamson,[8] for a corporate form of organization, has investigated the differences in behaviour for firms attempting to maximize profits or growth or sales. While the analysis may have restricted applicability to an owner-operated form of organization, it does indicate the need for the development of theories of maximizing behaviour for the agricultural firm. For such firms the value of the objective function may depend not only on the level of profits and the rate of growth but also on the values of other variables arising from firm-household interactions characteristic of owner-operated farms. The restraints will depend on available resources, either owned or borrowed; and imperfections, particularly in factor markets serving agriculture, may limit the growth rate a firm can achieve.

Many, but not all, such imperfections arise from incomplete information. This is particularly the case in the capital market. For farm firms, almost all external finance used is of a fixed interest nature whether borrowing is from institutional sources (banks, pastoral houses, etc.) or non-institutional sources. As is known, a high gearing ratio (total capital to equity capital) yields particularly high profit rates on equity in the case of success. On the other hand, a high gearing ratio leads to particularly severe rates of loss in the case of failure[9] and either internal or external capital rationing may result from the possibility of such losses.[10]

When we confront the theoretical constructs we have so far discussed with actual data a number of problems immediately arise. We know in a general imprecise way that the real world is characterized by firms of different sizes but some ambiguity attaches to a measure of size. The size of a firm has a number of dimensions although in practice we will tend to concentrate our quantitative analysis on only one dimension. For farm firms a number of measures suggest themselves. Probably the best single measure of economic size is income generated within the firm. At the aggregate level, the size distribution of incomes among Australia's primary producers relies heavily on taxation returns and the income measured tends to be confounded with special depreciation and investment allowances. Cross-section data, especially when available on a continuing basis, would permit a more precise analysis of change in size

[8] John Williamson, 'Profit, Growth and Sales Maximization', *Economica*, February, 1966, pp. 1-16.

[9] See M. Kalecki, 'The Principle of Increasing Risk' in *Essays in the Theory of Economic Fluctuations*, Allen and Unwin, London, 1939, pp. 95-106, and J. Steindl, 'Capital Enterprise and Risk', *Oxford Economic Papers*, No. 7, March, 1945, pp. 21-45.

[10] The effects of capital rationing on firm's decision making is discussed in C. B. Baker, 'Limited Capital as a Restraint on Agricultural Development' in *Economic Development in Agriculture*, Iowa State University Press, Ames, Iowa, 1965, pp. 118-131.

using income as a measure. However, such data involve some sampling problems over and above the usual ones in any sample survey.

If we have continuous observations on the same group of firms, the sample is unaltered over time but the population of firms may be changing as births of new firms and deaths of existing ones (both perhaps of small size) change the composition of the population. The second measure of size, and the most easily obtained, is gross receipts or sales. Since there is relatively little processing of farm products at the farm level and vertical integration—whether forward by farmers or backward by food processors—is relatively unimportant in Australia, sales, while not as satisfactory a measure of size as income, do have the advantage of being easily measured. In intertemporal comparisons, however, it has the disadvantage that increases in size as measured by sales may simply reflect a rise in prices.

A further dimension is assets or net worth. If there were no differences in productivity between firms, assets and income would be expected to be proportional. In fact, productivity does differ between firms and for the owner-operated firm these differences in productivity may reflect differences in managerial skills which may be at the centre of any explanation of the size distribution of farm firms. Size comparisons between firms in different industries, for example between sheep raising and dairying, using assets as a measure of size, point up certain difficulties about this measure. The first is that of valuation; which prices are to be used, historical or replacement? The second has to do with the time path of accumulation of the assets, that is whether the accumulation has been affected over the most recent years or reflects a slow continuing process over many years.

In some exploratory empirical work I have looked at some changes in the size distribution of farm firms. The first procedure which usually occurs to any economist in measuring inequality in the distribution of any variable is the familiar Lorenz curve widely used in measuring inequality in the distribution of income. The National Council of Wool Selling Brokers has published information for two years only on the size distribution of wool clips sold at auction in Australia. This use of clip sizes and number of growers ignores the possibility of a single grower selling under different account names. If this practice were widespread, particularly amongst larger growers, it would tend to distort the distribution in its upper reaches. There is very little, if any, evidence on how widespread the practice is. In addition the data do not incorporate wool sold under private treaty which may bias the 1956-57 figures. In this case we are equating the size of the firm and the size of the clip. Size of clip is one remove from the value of sales with prices as the connecting variable and so the distribution of clip sizes may be a less satisfactory measure than the distribution of sales receipts. For the years 1943-44 and 1956-57 the basic data for the construction of the Lorenz curves are given in Table 1.

The two Lorenz curves are shown in Fig. 1. If all observations fell on the diagonal, perfect equality in the distribution of clip sizes would exist. That is, the percentage of growers and the percentage of wool sold would be the same. Apart from its descriptive use the Lorenz curve can yield a coefficient of inequality. This coefficient—the Gini co-

TABLE 1

Distribution of Clip Sizes 1943-44, 1956-57

Size of Clip (Bales)	1943-44 Per cent of growers	1943-44 Per cent of total clip	1956-57 Per cent of growers	1956-57 Per cent of total clip
1-4	21·2	1·4	19·8	1·1
5-9	17·4	3·5	12·6	2·3
10-29	34·7	17·0	32·4	15·7
30-49	11·1	12·0	15·6	15·7
50-99	8·7	17·0	11·8	20·9
100-199	4·3	16·7	5·2	18·6
200-299	1·3	8·7	1·4	9·0
300-399	0·5	5·4	0·6	5·0
400-499	0·3	4·0	0·2	2·7
500 and over	0·5	14·3	0·4	9·0

Source: Wool Review, 1944-45, 1956-57. National Council of Wool Selling Brokers.

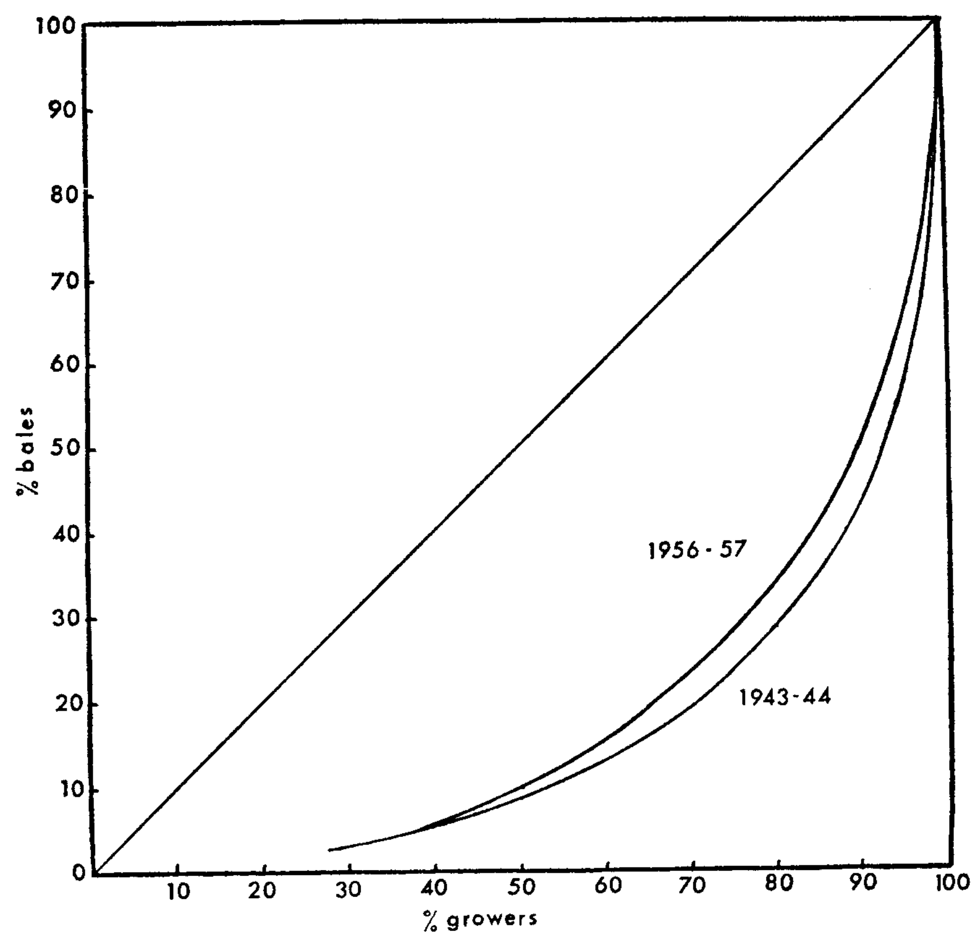

FIG. 1—Lorenz Curves.

efficient—can be measured by the ratio of the area between the diagonal and the Lorenz curve to the whole area. As can be seen from Fig. 1 there is some suggestion that there has been a reduction in the inequality of clip sizes between the two periods.

Unfortunately the data are only available for the two years and while the Lorenz curve serves as a useful graphic descriptive device it throws little light on the process generating the observed distribution of firm sizes and changes in this distribution. Moreover, the Lorenz curve has a number of limitations which arise from the number of firms being analysed. For example, 100 firms each with 1 per cent of total sales would show perfect equality on the Lorenz curve. But the same result would hold if there were two firms each with 50 per cent of total sales. From the policy aspect where one of our concerns may be any tendency for big farms to get bigger the inferences one might draw from this information would differ substantially. Similarly, if over the course of the trade cycle, small farms increase as non-farm employment opportunities decline while the number and size of the largest farms remain constant, the larger units would tend to become a relatively smaller fraction of all units.

To overcome this sensitivity of the Lorenz curve to changes in the number of firms the Herfindahl Index has been suggested as an alternative to the Lorenz curve. If X is the market share of the i-th firm expressed as a ratio and n is the number of firms then the Herfindahl Index is defined as $I = \sum_{i=1}^{n} X_i^2$. If $X_i = X_i - \overline{X}$ then the index can be rewritten as $I = \sum X_i^2 + \frac{1}{n}$. The index then increases as market shares become more dispersed about the average market share and as the number of firms declines.[11] However, in the absence of data on individual growers this index cannot be applied to the data in Table 1 and we are left with the imperfections of the Lorenz curve.

The Lorenz curve is basically a description at a point in time of the size distribution of some variable but it provides no indication of the mechanism underlying changes in the distribution over time. Hart and Prais[12] have argued that the log-normal distribution will yield a symmetrical Lorenz curve and they postulate this frequency distribution as a simple stochastic model of the size distribution of firms. Gibrat[13] explained the derivation of the log-normal distribution with a Law of Proportionate Effect. In its simplest form the law states that growth in proportion to size is a random variable with a given distribution which is constant in time. In other words, the probability of growing by x per cent is the same for large and small firms. Other stochastic models par-

[11] For the use of this index in a manufacturing context see I. M. Grossack, 'Towards an Integration of Static Dynamic Measure of Industrial Concentration', *Review of Economics and Statistics*, Vol. 47, No. 3, August, 1965, pp. 301-308.

[12] P. E. Hart and S. J. Prais, 'The Analysis of Business Concentration: A Statistical Approach', *Journal of Royal Statistical Society*, Series A, Vol. 119, Part II, 1956, p. 157. In the discussion on this paper D. G. Champernowne and M. G. Kendall both point out that other frequency distributions besides the log-normal are consistent with symmetrical Lorenz curves.

[13] R. Gibrat, *Les Inegalites Economiques*, Sirey, Paris, 1931.

ticularly the Markov chain and Simon's birth and death process are discussed in Steindl.[14] Of these the Law of Proportionate Effect and the Markov chain will be in this address.

The empirical work I have done so far has essentially been stochastic rather than deterministic. A rough distinction often made between these two types of models is that in the former, the economist looks at economic magnitudes only and responses to changes in these magnitudes are automatic, that is the responses are determined by the economic variables deemed relevant. It is true that econometricians do introduce stochastic elements into their deterministic equations but these stochastic elements usually take the form of an appendage additive disturbance which is needed to enable the estimation of the parameters of the model to proceed.

For a stochastic process, probability considerations are at the basis of the model although, it must be confessed, it is sometimes difficult to see the connection between optimizing economic behaviour in the conventional sense and the particular stochastic process used in economic analysis. In the case of the log-normal distribution of the size of firms, the economic rationale for this model is usually that the size of a firm at any moment of time represents the cumulative effect of many small independent factors; for example, retention rates, profitability, gearing ratios, availability of funds, weather, level of management, time of selling, product and input mixes and so on down to the quality of lunches preceding the Board of Directors' meetings. If size can be taken as the sum of many small independent variables identically distributed then appeal to the Central Limit Theorem will justify the assumption of normality for the distribution of firm size.[15]

The basic data used were derived from the Bureau of Agricultural Economics Sheep Industry Survey. Continuous observations on flock sizes were available for each year from 1952-3 to 1962-3 on 345 farms. Of these 345 farms, 135 were in the Wheat-Sheep zone, 130 in the High Rainfall zone and 80 in the Pastoral zone. Flock size is used as the measure of farm size. This measure does not seem to be too wide of the mark for the Pastoral zone and High Rainfall zone. For the former over 90 per cent of total returns originate in the sheep enterprise and 74 per cent in the High Rainfall zone. The measure does understate size for the Wheat-Sheep zone with only 51 per cent of farm returns originating in the sheep enterprise.[16] In the absence of an income measure for each individual farm, flock size is, *faute de mieux,* used.

The first of the stochastic processes to be looked at is Gibrat's Law of Proportionate Effect. A simple first test of the law is to examine whether growth is related to size. A simple regression

$$Y = a + bX$$

was fitted; where X is flock size in 1952-3 and Y is the percentage change in flock size between 1952-3 and 1962-3. The results are shown in Table 2.

[14] J. Steindl, *Random Processes and the Growth of Firms,* Griffin, London, 1965, Ch. I.

[15] For a fuller description, see J. Aitchison and J. A. C. Brown, *The Log-Normal Distribution,* Cambridge, 1957.

[16] These figures are three year averages 1960-1 to 1962-3 from, *The Australian Sheep Industry Survey,* Bureau of Agricultural Economics, Canberra, 1965.

TABLE 2

Regression of Percent Growth on Opening Size

Zone	*b*	*r*	*t*
Pastoral	—0·044	—0·25	26·98***
Wheat-Sheep	—0·011	—0·16	1·82*
High Rainfall	—0·010	—0·22	2·60***

* Significant at the 10 per cent level.
*** Significant at the 1 per cent level.

This preliminary testing suggested that although the simple correlation between opening size and percentage growth is low the estimates of *b* all suggest that there is a negative relationship between opening size and percentage growth with the relationship most marked for Pastoral zone properties. The low correlation coefficients (r) occasioned some surprise but are perhaps suggestive that a simple linear model is not a good approximation to the underlying growth model. In any event, this first simple testing does seem to cast doubt on the validity of the Law of Proportionate Effect.

In order to examine the regression results in more detail, the percentage change in size for different size classes was tabulated. These figures are shown in Table 3. For the Pastoral zone, the average per cent change declines with increasing size of flock and the same result holds, although less markedly, for the High Rainfall zone. For the Wheat-Sheep zone the relationship is not as systematic and may reflect, in part, the inadequacy of flock size as a measure of farm size in the Wheat-Sheep zone. Further inspection of the results in Table 3 suggested that the variability of the percentage change in flock sizes was not the same for all flock sizes. The standard deviation declines systematically with increasing flock sizes in the case of the Pastoral zone. This lack of homogeneity of variances is also in conflict with the Law of Proportionate Effect.[17] I tested the homogeneity of variances using Bartlett's approxi-

TABLE 3

Per Cent Change (1952-3 to 1962-3) in Flock Numbers for 3 Zones

Initial	Pastoral			Wheat-Sheep			High Rainfall		
Flock Size	N	$\bar{X}$	s	N	$\bar{X}$	s	N	$\bar{X}$	s
200-499	–	–	–	13	10·9	48·4	22	73·6	64·6
500-999	4	141·0	231·9	51	57·5	83·8	45	69·6	74·6
1000-1999	12	70·5	114·5	44	37·0	71·2	39	53·2	57·7
2000-3999	31	29·9	41·9	25	8·9	27·1	18	28·9	46·2
4000-7999	18	28·9	46·4	2	34·3	27·8	6	23·1	36·0
8000-15,999	13	17·5	51·7	–	–	–	–	–	–
16,000 and over	2	—27·2	23·8	–	–	–	–	–	–

N is the number of farms.

$\bar{X}$ is the average per cent change in flock size, where the averaging is over the farms in each size class.

s is the standard deviation of the per cent changes in each size class, corrected for the degrees of freedom in each class.

[17] J. Steindl, *op. cit.*, p. 30.

mate Chi-square test.[18] The hypothesis of equal variances for the various class sizes was strongly rejected at the 1 per cent level for both the Wheat-Sheep and Pastoral zones. The same hypothesis was rejected at the 10 per cent level, but not at the 5 per cent level, for the High Rainfall zone.

In view of the evidence of heterogeneity in the variances the Aspin-Welch test[19] which does not assume homogeneous variances was used to test the significance of the differences between the mean percentage change in flock size for the size groupings in Table 3. In cases where the sample sizes were less than those tabulated by Aspin, the approximation suggested by Welch based on 'Student's' t distribution was used. The test was a one tailed test of the null hypothesis against the alternative that the mean in one class was significantly greater than the mean in another. Pairwise comparisons of the means for each class in each zone were made. For the Pastoral zone, for instance, this means fifteen comparisons. Because of the large estimated variances in the Pastoral zone in Table 3 the test only produced a significant (at the 5 per cent level) result in 4 classes. The 1000-2000, 2000-4000, 4000-8000, and 8000-16,000 classes all had mean percentage changes in flock size significantly greater than the 16,000 and over class. These results must be interpreted with considerable caution since the average per cent change in the 16,000 and over class was negative, but based on only two properties although both showed declines in flock size. However, the test yielded inconclusive results when the means of the four classes 1000-2000 to 8000-16,000 were tested among each other.

In the case of the Wheat-Sheep zone, the 500-1000 class showed a significantly larger growth rate than both the 200-500 class and the 2000-4000 class. At the same time the 1000-2000 class also tested significantly larger than the 2000-4000 class. For the High Rainfall zone, the 200-500 class showed a significantly larger growth than both the 2000-4000 class and the 4000-8000 class and similar results were obtained for the 500-1000 class. The 1000-2000 class showed a significantly larger growth rate than the 2000-4000 class. For the Wheat-Sheep zone, then, the centres of most rapid growth were in the two classes above the smallest class and in the three smallest for the High Rainfall zone.

In order to gain some further idea of the relative mobility of firms in the three zones Kendall's rank correlation coefficient was computed.[20]

Firms were ranked by flock size in both 1952-3 and 1962-3. The rank correlation coefficient indicates the extent of mixing—firms changing their position in the initial size ordering—and can be interpreted as a measure of mobility. The calculated coefficients were 0·70, 0·64, 0·61 for the Pastoral, High Rainfall and Wheat-Sheep zones respectively. These estimates suggest that mixing was greatest for the High Rainfall and Wheat-Sheep zones and least for the Pastoral zone.

[18] M. S. Bartlett, 'Properties of Sufficiency and Statistical Tests', *Proceedings of Royal Society of London*, Series A, Vol. 160, 1937, p. 273.

[19] Alice A. Aspin with Appendix by B. L. Welch, 'Tables for Use in Comparisons Whose Accuracy Involves Two Variances Separately Estimated', *Biometrika*, Vol. XXXVI, 1949, pp. 290-296.

[20] M. G. Kendall, *Rank Correlation Methods*, Griffin, London, 1948.

The rank correlation coefficient gives us some idea of the mixing of flock sizes which has occurred between the opening and closing years. However, it would be interesting to know whether the mixing which has occurred is the result of above-average size flocks interchanging with each other and similarly for below-average size flocks or whether the interchange has been between below-average and above-average size flocks. A measure due to Grossack[21] is helpful in this regard. Using the same data on flock sizes from the three zones it is possible to get the proportional contribution of each farm to the sample total sheep numbers in 1952-3 and 1962-3. Since the data are sample data one must bear in mind that any inferences to the total Australian sheep population are influenced by the representativeness of the sample farms. Suppose X_i is the proportion of the *i*-th farm in 1952-53 and Y_i is that same farm's share in 1962-3. If x_i and y_i represent deviations from the relevant means then $b = \Sigma x_i y_i / \Sigma x^2_i$ where b is the estimate of the simple regression of Y_i on X_i. It can be shown that

$$b = 1 + \Sigma w_i \left[\frac{y_i - x_i}{x_i}\right]$$

where $w_i = \frac{x^2_i}{\Sigma x^2_i}$

The w_i give a relatively greater weight to those farms whose share is further from the mean share in the initial year. Since the mean market share is the reciprocal of the number of farms, this mean will get smaller as the number of farms increases, approaching zero in the limit. With a large number of farms it will be the larger firms in the opening year which will contribute most to the determination of b. An increase in the share of an above-average size farm allied with a decrease in the share of a below-average size farm will tend to give a value of $b > 1$. If firms' shares tend to regress towards the mean share, which would be the case if the share of an above-average size farm tended to fall while the share of a below-average size farm tended to increase, then the value of b will tend to be < 1.

The simple regressions of opening shares on closing shares for each of the three zones were run. The estimates of b were 0·76, 0·81 and 0·84 for the Pastoral, High Rainfall and Wheat-Sheep zones respectively. The interpretation of these estimates is that, for example, for the Pastoral zone the larger farms of 1952-3 had lost on average some 24 per cent of their share in total sheep numbers of 1962-3. The larger farms for all three zones were, on average, unable to retain their shares with the fall most marked in the Pastoral zone and least marked in the Wheat-Sheep zone.

Apart from between zone comparisons of mobility it would be interesting to have some idea of the relative mobility of different flock sizes. The proportion of farms moving from one flock size to another between 1952-3 and 1962-3 is shown in Table 4. For example, in the Wheat-Sheep zone 61·5 per cent of the farms in the 200-500 size category were still in that same category in 1962-3. 38·5 per cent of farms in the 200-500 category in 1952-3 had moved to the 500-1000

[21] I. M. Grossack, *op. cit.*, pp. 302-304.

TABLE 4

Per Cent of Farms in Different Size Classes, 1952–3 *and* 1962–3

Wheat-Sheep Zone

1962–3 / 1952–3	200–500	500–1,000	1,000–2,000	2,000–4,000	4,000–8,000	8,000–16,000	Number of Farms 1952–3
200– 500	61·5	38·5					13
500– 1,000	2·0	41·1	49·0	5·9	2·0		51
1,000– 2,000	2·3	6·8	61·4	20·4	9·1		44
2,000– 4,000			13·0	73·9	13·1		23
4,000– 8,000						25·0	4
8,000–16,000							0
Number of farms (1962–3)	10	29	55	29	11	1	135

High Rainfall Zone

1962–3 / 1952–3	200–500	500–1,000	1,000–2,000	2,000–4,000	4,000–8,000	8,000–16,000	Number of farms 1952–3
200– 500	27·3	63·6	9·1				22
500– 1,000	4·4	24·4	62·2	9·0			45
1,000– 2,000		2·6	48·7	43·6	5·1		39
2,000– 4,000		5·5	—	66·7	27·8		18
4,000– 8,000				20·0	—	80·0	5
8,000–16,000						100·0	1
Number of farms (1962–3)	8	27	49	34	7	5	130

Pastoral Zone

1962–3 / 1952–3	500–1,000	1,000–2,000	2,000–4,000	4,000–8,000	8,000–16,000	Over 16,000	Number of farms 1952–3
500– 1,000	50·0	—	25·0	25·0			4
1,000– 2,000		41·7	41·7	16·6			12
2,000– 4,000		7·4	59·3	33·3			27
4,000– 8,000			5·9	70·6	17·7	5·8	17
8,000–16,000				13·3	66·7	20·0	15
16,000 and over					40·0	60·0	5
Number of farms (1962–3)	2	7	23	26	15	7	80

category by 1962-3.[22] The diagonal entries for each of the three zones can be interpreted as a measure of immobility and 100 minus the diagonal element can be interpreted as a measure, for each size class, of mobility. Such measures are shown in Table 5.

TABLE 5

Per Cent of Farms Not in the Same Size Class in 1962-3 as in 1952-3

Size Class	Wheat-Sheep		High Rainfall		Pastoral	
	N	%	*N*	%	*N*	%
200-500	13	38·5	22	72·7	–	–
500-1000	51	58·9	45	75·6	4	50·0
1000-2000	44	38·6	39	51·3	12	58·3
2000-4000	23	26·1	18	33·3	27	40·7
4000-8000	4	25·0	5	100*	17	29·4
8000-16,000	–	–	1	0**	15	33·3
16,000 and over	–	–	–	–	5	40·0

* Of the 5 farms in this size class in 1952-3, 4 had moved to the next highest class and the other had moved down a class.

** There was only 1 farm in this class in 1952-3 and it was in the same class in 1962-3.

N is the number of farms in each size class in 1952-3.

For example, for the 200-500 class and the 500-1000 class, farms in the High Rainfall zone showed a relatively greater propensity to move into other classes than for the same size classes in the other two zones. However, firms in the Pastoral zone in the 1000-2000 class and 2000-4000 class were relatively most mobile. A detailed analysis of changes in flock size composition using a simple Markov chain has been written by Scobie and Rowe[23] and their detailed analysis tends to support the exploratory results presented here.

Apart from any theoretical interest the question of what factors are relevant in determining the rate of growth of the farm firm has important policy implications. Low income farms are characteristically small size farms. If the low income problem is transient in the sense that small size farms will grow to a sufficient size to ensure an adequate income then policy makers may regard the low income problem as a less pressing one than if small farms were to show no growth at all. Apart from the question of whether growth takes place or not, the rate at which growth occurs is also relevant for policy decisions. At the other end of the size spectrum there has developed an Australian ethic that 'large' properties are, in some sense, undesirable. While the motivations underlying this ethic are undoubtedly complex, deriving from the

[22] The entries in Table 4 for each of the three zones can be interpreted as rough estimates of the transition probabilities used in a Markov process. They are rough in the sense that only 1952-3 and 1962-3 observations were used in estimating them. Had year to year movements in flock sizes been used the number of observations would have increased and the efficiency of estimation improved. See, G. G. Judge and E. W. Swanson, 'Markov Chains, Basic Concepts and Suggested Uses in Agricultural Economics', *Australian Journal of Agricultural Economics*, Vol. 6, No. 2, December, 1962, pp. 49-61.

[23] G. M. Scobie and A. H. Rowe, 'Trends in the Size Distribution of Australian Sheep Flocks', *Quarterly Review of Agricultural Economics*, Vol. XX, No. 3, July, 1967, pp. 127-141.

whole history of land settlement in Australia, a number of propositions might be made.

The first is that inequality in the size distribution of farms is indicative of large inequalities in the distribution of both wealth and income and that a reduction in this inequality is socially desirable. Moreover, there often seems to be an underlying suspicion that 'large' farms are growing relatively faster than 'small' farms despite the efforts at closer settlement so that the inequality in the distribution of farm sizes is in fact increasing. The tentative results presented here would not support this contention. Allied with these equity based arguments are arguments about efficiency and profitability in relation to size. If our criterion of the most efficient farm is that which produces commodities at the lowest possible cost, then comparisons of the relative efficiency of various farm sizes will have to be based on the analysis of costs. Such comparisons are admittedly difficult because of differences in the product mix between firms and the difficulties of allocating overhead costs; differences in geographical location may affect the level of costs and this may make the problem of imputed costs, particularly for labour inputs, even more hazardous than usual. Despite these difficulties, only a thorough study of the relative costs of different size farms would permit a firm basis for inferences about any possible relationship between size and efficiency.

Profitability is usually measured as a rate of return on capital or on net worth. Since profit is a residual item it, like costs, is subject to many difficulties of measurement. As Osborn[24] points out in commenting on some Federal Trade Commission studies, '. . . although the largest and most fully integrated companies had by far the lowest accounting costs, the medium-size firms were the most profitable in terms of return on net worth'. Information on rates of return on capital by flock sizes from the Bureau of Agricultural Economics Sheep Industry Survey are given in Table 6.

TABLE 6

Rates of Return (%) on Capital; By Size of Flock
(Average three years 1960-1 to 1962-3)

Zone	Flock Size						
	200-499	500-999	1000-1999	2000-4999	5000-9999	10,000-19,999	20,000 and over
Pastoral	–	—0·4	5·3	6·7	7·2	7·4	5·9
Wheat-Sheep	1·2	5·6	6·6	6·7	9·9	7·6	–
High Rainfall	—2·0	2·6	4·2	5·1	5·0	4·6	–

Source: The Australian Sheep Industry Survey, Bureau of Agricultural Economics, Canberra, 1965.

These figures are certainly not definitive but they do raise some interesting questions in the same vein as those raised by Osborn. Averaged over states for these three particular survey years all three zones show a decline in rates of return on capital for the largest flock sizes with flock sizes in the medium ranges being most profitable and—apart from the Wheat-Sheep zone—negative rates of return for the smallest flock sizes.

24 Richard C. Osborn, 'Efficiency and Profitability in Relation to Size', *Harvard Business Review*, Vol. 29, No. 2, March, 1951, pp. 82-94.

However, the sheep industry is not a homogeneous entity and the averaging procedure used gives no consideration to the fact that the largest flocks tend to be concentrated in remote areas of high weather risk with special management problems. Individual producers in the largest flock size stratum in all zones achieve rates of return to capital of 17% and upwards in all but the most adverse years.[25]

I hope in this address I have raised some of the questions about the growth of the farm firm that seem relevant. In a perfectly competitive world where prices and technology are changing very rapidly, even though still known with certainty, the problems of co-ordination may limit growth. The difficulty of co-ordination is more likely to be a pressing one with a corporate form of organization with a long chain of command than for the owner-operated form of organization which characterizes much of Australian agriculture. If the problems of co-ordination provide no barrier to growth in a farm firm but there are costs specific to expansion, for example, the learning of new techniques or the acquisition of new skills, then the usual marginal analysis will yield the optimal growth rate as a decision variable.

In a purely competitive world where firms are faced with some uncertainty, e.g. with respect to prices, then the firm has a number of decision criteria from which it may choose. For instance, the firm may maximize expected profits, it may minimize its maximum losses, or maximize its minimum profits or a variety of other criteria. Moreover, the objective function may involve not only the expected level of profits but also their variability and we become involved in questions of a trade off between the level of expected profits and their variance. However, we know very little about the implications of choosing a particular decision criterion for the growth of the firm.

If the managerial input is relegated to a minor role and emphasis is placed on capital accumulation and growth then we need to know much more about the investment decision at the farm level. For a firm-household complex the ability of the firm to retain profits for investment depends on the demands for consumption arising from the household. For a corporation the fear of a take-over may limit the retention of profits for capital accumulation, but for a farm, the requirements of the household may prove an even more effective barrier to growth. If further expansion is financed externally, then imperfections in the capital market will prevent the optimal rate of growth being achieved.

The empirical work I have presented here throws no light on the optimal size of firm, even assuming that this is a meaningful concept. Still less have I attempted to provide a single explanation, either in terms of managerial inputs or capital formation, of the growth of the farm firm. However, the empirical results do suggest that growth differs both between flock sizes within the same region and for the same flock size between regions. Moreover, profitability seems to be relatively larger on the medium flock sizes but I have done little more than scratch the surface of the question of 'What determines the growth of the farm firm'.

[25] B.A.E. private communication.