THE ALLOCATION OF RESOURCES IN THE WOOLGROWING INDUSTRY

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I. *Introduction*

This paper presents a selection of the results of a larger study than is reported here. In the larger study, estimates of farm production functions have been obtained for sheep-raising areas of three types, the pastoral areas (that is, dryland grazing areas) in Queensland, New South Wales and South Australia, the high rainfall areas in New South Wales, Victoria and Tasmania, and the areas in New South Wales, Victoria, South Australia and Western Australia where sheep are grazed in association with cereal cropping, mainly wheat.[1]

Representative of results of the study as a whole are the results from the pastoral and the high rainfall zones of New South Wales. The former area includes, although is not identical with, the Western Division of that State, and is typical of the extensive merino woolgrowing areas in the dryland sheep country of Queensland, New South Wales, South Australia and Western Australia. The latter area includes parts of the Tablelands of New South Wales and is characterised by an intensive form of production, in which fat lambs, in addition to wool and store sheep are produced. In this zone substantial areas have been improved by sowing improved species. The high rainfall areas of New South Wales, and of the other States, are the areas which are generally regarded as having the greatest potential for development and for an expansion of wool output.

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1. These areas are defined following the procedures of the Bureau of Agricultural Economics in *The Australian Sheep Industry Survey*, Canberra, 1957 and in *The Australian Wheatgrowing Industry*, Canberra, 1960. The assistance given the author by the Bureau of Agricultural Economics in the collection of data is gratefully acknowledged.

The general aim of this study is to provide estimates of marginal value productivities of resources for use in making decisions regarding the areas in which agricultural expansion is to be encouraged and in making farm management decisions. To enable a comparison of results for all the areas covered, it was found necessary to select 1954-55 as the year for which to obtain estimates, as it was only for this year that data were available for all areas.

II. *Some Methodological Considerations*

For each area, the average whole-farm production function has been estimated. It has been assumed that this is a function of the form

$$Y_t = c \prod_{i=1}^{n} X_{it}^{b_i} U_t \qquad ,$$

that is, a Cobb-Douglas function, where

Y_t is a measure of the output of the t^{th} farm,
X_{it} are resource categories, measured usually in value terms,
U_t are random error terms, the logarithms of which are assumed

to be normally distributed with zero mean and constant variance.[2]

The properties of the Cobb-Douglas function of immediate interest here are

(i) The b_i in the above equation are elasticities of production, and, where an individual b_i is less than unity, the function shows diminishing returns to the corresponding resource.
(ii) The sum of the b_i, under certain conditions,[3] gives a measure of returns to scale.[4]
(iii) From the fitted function, it is a simple matter to compute estimates of the average marginal products of resources.

The Cobb-Douglas function has been used in a large number of studies, and there has developed an extensive literature concerning its properties,

2. Various algebraic forms for the production function have been considered, tired, and rejected by the author. The Cobb-Douglas function has proved uniformly satisfactory in this study when the conditions for its use have been satisfied.

3. F. G. Jarrett, " Estimation of Resource Productivities as Illustrated by a Survey of the Lower Murray Valley Dairying Area ", the *Australian Journal of Statistics*, Vol. I, No. 1 (April, 1959), pp. 3-11, points out that, if it is assumed that no variables have been omitted from the analysis, a test of whether the sum of coefficients differs significantly from unity can be considered a test of returns to scale. Alternatively, if constant returns are assumed, the test can be interpreted as a test for the inclusion of all relevant variables.

From a statistical point of view, it is possible to make statements about the sum of the coefficients even when it is known that variables have been excluded, provided that information is available concerning the relationship between the omitted and the included variables. See Z. Griliches, " Specification Bias in Estimates of Production Functions ", *Journal of Farm Economics*, Vol. 39, No. 1 (February, 1957), pp. 8-20.

4. When the sum of the coefficients is equal to unity, is less than unity, is greater than unity, then constant, diminishing and increasing returns to scale are claimed.

economic and statistical.[5] Space does not permit the consideration of some important issues raised by a number of recent papers.[6]

In the process of empirical estimation of farm production functions, it is necessary to aggregate resources into resource categories. In this study, an attempt has been made to aggregate resources in the way suggested by Plaxico.[7] The variables finally entering the analyses are described below :—

Pastoral Zone

X_0 = gross farm income, net of " marketing expenses ". The " marketing expenses " subtracted from gross returns are shearing costs, including cost of bales etc., wool selling and freighting expenses, and commission on livestock sales. In 1954-55, 96.7 per cent of gross returns was derived from the sheep enterprise, 2.9 per cent, from cattle, 0.3 per cent from cereal cropping and other enterprises, making a total of approximately 99.7 per cent of gross returns from the two livestock enterprises. Because of the preponderance of the sheep enterprise, the analysis was performed assuming a single enterprise.

X_1 = annual charge on watering facilities for livestock. The annual charge includes depreciation, interest at 6 per cent and repairs.

X_2 = annual charge on fencing, computed similarly.

X_3 = annual expenditure on labour. What is measured here is labour available, rather than labour used. If the ratio of labour used to labour available does not show a trend with other inputs, as seems reasonable to suppose, then no bias in the regression coefficient for the labour input is expected. An under-estimate of the average marginal productivity, however, is expected.

X_4 = annual expenditure on machinery operations. This input includes fuel, oil, repairs, and a quantity of labour. The partial correlation coefficient between this variable X_4 which includes only current factor inputs, and a variable X_6, annual charge on capital invested in

5. See R. M. Parish and J. L. Dillon, " Recent Applications of the Production Function in Farm Management Research ", *Review of Marketing and Agricultural Economics*, Vol. 23, No. 4 (December, 1955), pp. 218-236, and F. G. Jarrett, " Resource Productivities and Production Functions ", *The Australian Journal of Agricultural Economics*, Vol. 1, No. 1 (February, 1957), pp. 65-76.

6. H. S. Konijn, " Estimation of an Average Production Function from Surveys ", *Economic Record*, Vol. XXXV, No. 70 (April, 1959), pp. 118-125 and " Production Functions : A Further Remark ", *ibid.*, Vol. XXXVI, No. 75 (August, 1960), p. 423 ; C. S. Soper, " Production Function and Cross-Section Surveys ", *ibid.*, Vol. XXXIV, No. 67 (April, 1958), pp. 111-117 and " Production Functions : A Reply to Dr. Konijn ", *ibid.*, Vol. XXXV, No. 72 (December, 1959), pp. 434-5 ; I. Hoch, " Simultaneous Equation Bias in the Context of the Cobb-Douglas Production Function ", *Econometrica*, Vol. 26, No. 4 (October, 1958), pp. 566-578 ; and J. R. Hildebrand, " Some Difficulties with Empirical Results from Whole-Farm Cobb-Douglas-type Production Functions ", *Journal of Farm Economics*, Vol. 42, No. 4, (Nov. 1960), pp. 897-904.

7. J. S. Plaxico, " Problems of Factor-Product Aggregation in Cobb-Douglas Value Productivity Analysis ", *Journal of Farm Economics*, Vol. XXXVII, No. 4 (November, 1955), pp. 664-675.

machinery (depreciation and interest) was 0.51 (logarithmic data). This suggests that the intensity of machinery used varied widely among sample farmers ; that is, that the two inputs are not complementary or, alternatively, that farmers did not tend to operate near the optimum ratio of capital to current factor inputs. Hence, the variables were not aggregated. The regression coefficient corresponding to X_6 was found not to be significantly different from zero, and was dropped from the analysis.[8]

X_5 = annual charge for the use of land. Interest at 6 per cent was charged on the unimproved capital value of land, assuming freehold valuations.

High Rainfall Zone

X_0 = gross farm income " net of marketing expenses ". Livestock products again accounted for the major part of farm income (sheep products, 89.9 per cent ; beef, 6.6 per cent ; livestock products, 96.5 per cent). Wool alone accounted for approximately 80 per cent of gross returns, so that it is reasonable to treat the area as having only a single enterprise.

X_1 = acres under improved pastures. This input includes only areas which had been improved by a method involving some cultural treatment of the soil (that is, natural pastures top-dressed with seed and fertiliser were excluded) and which were recorded as being established by or during 1952-53. Newly-sown pastures do not add greatly to production, and thus were not included in the measure of pasture improvement.

X_2 = annual charges on fencing.

X_3 = annual expenditure on labour.

X_4 = annual expenditure on land.

The coefficients for the variables, watering points, expenditure on machinery operations, and machinery capital charges were all found to be non-significant, and were excluded from the analysis. In an earlier analysis, an attempt was made to estimate the production elasticity of

8. An explanation for this low elasticity of production (it was, in fact, very close to zero, and negative) is that farmers had over-invested in machinery during the years of boom prices for wool to the extent that some idle machinery capacity existed. Adapting the method of analysis developed by Griliches (cited above) to this case, let

$$Y_t = C_t^{a_c}(q_tM_t)^{a_m}U_t \quad \text{.........(1)}$$ be the true production function,

where C_t is some resource, say labour, M_t is the total capital invested in machinery, and q_t is the proportion of that machinery which is actually used in production. q_t is not observed and so (1) is not estimated. Instead,

$$Y_t = C_t^{b_c}M_t^{b_m}V_t \quad \text{.........(2)}$$ is estimated.

Then $$Eb_c = a_c + p_c a_m$$

and $$Eb_m = a_m + p_m a_m$$

where the p's come from

$$q_t = c_t^{p_c}M_t^{p_m},$$ the " auxiliary regression " of the omitted variable q_t on the included variables, C_t and M_t. Other things held constant, it is expected that a low value of q_t would be associated with a high value of M_t and hence, expect p_m to be negative. Thus, the expected value of b_m, the estimated machinery coefficient, is less than the value to be expected if no idle capacity existed, or if it were measurable, and accounted for in the analysis by the estimation of (1) rather than (2)

superphosphate. Although various methods of allowing for the lagged effect of this input were tried, it was found that it was not possible to obtain an estimate of its elasticity because of the high correlation of superphosphate inputs with the acreage of improved pastures. For instance, the correlation coefficient between pasture improvement and superphosphate expenditure in 1954-55 was found to be 0.80.

III. *Results and Conclusions*

The estimated production function for the pastoral zone is

$$X_0 = 1.463 X_1^{\cdot 196}\, X_2^{\cdot 248}\, X_3^{\cdot 330}\, X_4^{\cdot 146}\, X_5^{\cdot 366}$$

$$R^2 = 0.813$$

Further information concerning this function is presented in Table I, II and IV in the Appendix. In Table I are presented the average marginal value products of resources used in this region.

TABLE I.

Pastoral Zone, 1954-55 : *Marginal Value Products*

Variable	Geometric Mean	Marginal Value Product	" Optimum " Level
	£	£	£
X_1 : Watering Points	351	4.64	642
X_2 : Fencing	514	4.01	813
X_3 : Labour	1,109	2.48	1,082
X_4 : Machinery operations	768	1.58	479
X_5 : Land inputs	1,474	2.07	1,200

All figures in the table are given as annual inputs, so all are on a comparable basis. The entries in the fourth column represent that combination of resources which will maximise income, given the production function, and given that the total of resources used is the sum of the geometric means from column two.[9] Given the existing level of resources from the table,[10] it appears that, on the average, the sample farms were fairly close to equilibrium positions in the inputs of land and labour, were using excessive machinery inputs and had not allocated sufficient of their

9. J. H. Duloy, " Resource Allocation and Fitted Production Function ", *The Australian Journal of Agricultural Economics*, Vol. 3, No. 2 (December, 1959), pp. 75-85.

10. The total level of resources on the properties was, in fact, higher than that indicated in the table, as machinery and buildings have been excluded from the analysis.

resources to watering points and fencing, both of which show very high average marginal value products.[11]

The estimated production function for the high rainfall zone is

$$X_0 = 6.599\, X_1^{.102}\, X_2^{.164}\, X_3^{.264}\, X_4^{.436}$$
$$R^2 = 0.786$$

Further information concerning this function is presented in Tables I, III and V in the Appendix. The marginal productivities and " optimum " levels of resources (presented with the same *caveat* as applied to those in Table I) are contained in Table II.

TABLE II.

High Rainfall Zone, 1954-55 : *Marginal Value Products*

Variable	Geometric Mean	Marginal Value Product	" Optimum " Level
	£	£	£
X_1 : Improved Pastures	215	1.83	277
X_2 : Fencing	270	2.34	444
X_3 : Labour	941	1.08	713
X_4 : Land inputs	1,184	1.41	1,177

The results entered in Table II suggest that the sample farms in the area are, on the average, with available resources, fairly close to equilibrium in the size of the property, and that they could profitably shift resources from hired labour to increased fencing and pasture improvement. It should be noted that the entries in Table II have been computed using an overall figure of £2 per acre annual charge for improved pastures.[12] It could be argued that a higher figure, £3 per acre, say, is more appropriate. In this case, the estimate of the average marginal value product of pasture improvement falls from £1.83 per £1.00 invested to £1.22.

11. The very high marginal value products for watering points and fencing show up also in the analyses for the other two pastoral zone areas studied, Queensland and South Australia. If stock watering facilities worth £1,000 are established in a paddock hitherto without water, and sheep will travel 2 miles from water to graze, then an increase of £1 annual expenditure on watering points will open up approximately 40 acres of grazing land.

12. No accurate valuations of the improvements to pastures being available, the procedure adopted was to measure the pasture improvement input in acres. To compute an estimate of a mean marginal value product, the use of some valuation figure is necessary. The figure used is based on estimates collected by F. H. Gruen, " Economic Aspects of Pasture Improvement in the Australian Wool Industry ", *The Economic Record*, Vol. XXXVI, No. 74 (April, 1960), pp. 220-241 and especially Table I on p. 224.

Even this latter figure represents a rate of return at the margin somewhat higher than 20 per cent, an estimate which is rather greater than that usually ascribed to pasture improvement.[13] The difference is probably due to the fact that, in this study, only improved pastures established for at least two years were considered, so that the productivity of relatively mature pastures was estimated.

The main point of interest in these results is the marked difference in the overall level of marginal returns between the two regions. Marginal returns are very much higher in the pastoral than in the high rainfall zone. At first sight, it is tempting to conclude that the "average farmer"[14] in the pastoral zone is very far from being *homo oeconomicus*, that the current emphasis on pasture improvement is misplaced, and the teams engaged in oil exploration should be diverted from oil and set to drilling for water in the Western Division !

However, at least part of the difference is explicable in economic terms. Probably a considerable part of the difference is due to the difference in production uncertainty between the regions. The high rainfall zone is a relatively safe area, which is not subjected to very severe droughts. The pastoral zone, on the other hand, is a very "risky" area.[15] So extreme is the climatic variability in the pastoral zone that graziers are subjected to the risk of loss of capital, not only of income, during adverse seasons. Under these conditions, graziers could be expected to adopt a substantial "safety margin" in their use of resources, holding the input of factors short of the optimum appropriate to an average season. The marginal products of resources, then, are likely to be very high, particularly in a better than average season, such as the year for which estimates were obtained.

Another major difference between the two areas is in the type of land tenure existing. In the high rainfall zone, most land is held freehold with full security of tenure and full rights of transfer. This is not so in the pastoral zone.

Most of the pastoral zone falls within the Western Division of New South Wales. Most land in the Division is grazed on leasehold subject to the restrictions imposed by the Western Lands Act of 1901. Among the restrictions are restrictions on property transfers, and particularly, the Act provides that the lessee

> ". . . shall not overstock or permit or allow to be overstocked the said land, and the decision of the Commissioner as to what constitutes overstocking shall be final, and the lessee shall comply with any directions of the Commissioner to prevent or discontinue overstocking."[16]

The Commissioner can obtain information on stocking rates by virtue of his powers to require the lessees to furnish him with "such returns or statements as the Commissioner may from time to time require" in con-

13. F. H. Gruen, "Pasture Improvement—The Farmers' Economic Choice", *The Australian Journal of Agricultural Economics*, Vol. 3, No. 2 (December, 1959), pp. 19-44. Gruen notes that the rate of return ranges from 6 per cent to 25 per cent in the cases he studied.

14. Rather than that much-derided concept, the "average man", we mean here, rather, the "geometric mean man".

15. During the 1944-45 drought, for instance, sheep numbers fell by about 12 per cent from 31st March, 1944 to 31st March, 1946, in the Tablelands Division and by about 42 per cent in the Western Division.

16. Paragraph (v) of Section 18D of the Act.

nection with a wide range of matters including stocking rates, improvements and so forth.[17]

The very high marginal returns estimated for the pastoral zone compared with those estimated for the high rainfall zone seem to be associated with uncertainties of climate, of tenure, and by the existence of restrictions on stocking policy. However, the two inputs for which estimated marginal returns were particularly high (watering points and fencing in the pastoral zone), are among the inputs which can lead to a reduction in the impact of production uncertainty. Thus, uncertainty considerations do not supply a very satisfactory explanation for the relatively small investment in those particular inputs. The observed disequilibrium both between and within the regions has not been fully accounted for. Research directed at elucidating the reasons for this inefficient use of resources and at overcoming it may yield high returns to the wool industry.

17. Paragraphs (g) and (h) of Schedule A to the Act.

APPENDIX

TABLE I

Elasticities of Production

Area	Variable	Elasticity	Standard Error	Level of Significance
Pastoral Zone	X_1: Watering Points	0.196	0.0623	0.005
	X_2: Fencing	0.246	0.1130	0.02
	X_3: Labour	0.330	0.0932	0.005
	X_4: Machinery Operations	0.146	0.0867	0.05
	X_5: Land inputs	0.366	0.0790	0.005
High Rainfall Zone	X_1: Improved Pastures	0.012	0.0298	0.005
	X_2: Fencing	0.164	0.0815	0.05
	X_3: Labour	0.264	0.1108	0.02
	X_4: Land inputs	0.436	0.0906	0.005

TABLE II

Correlation Matrix : Pastoral Zone
(Data in logarithms)

	X_1	X_2	X_3	X_4	X_5
X_1	1.00				
X_2	0.61	1.00			
X_3	0.50	0.62	1.00		
X_4	0.63	0.58	0.55	1.00	
X_5	0.45	0.59	0.61	0.54	1.00

TABLE III

Correlation Matrix : High Rainfall Zone
(Data in Logarithms)

	X_1	X_2	X_3	X_4
X_1	1.00			
X_2	0.42	1.00		
X_3	0.54	0.58	1.00	
X_4	0.43	0.66	0.66	1.00

TABLE IV

Analysis of Variance : Pastoral Zone

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
Regression	51.928	5	10.386	51.287[a]
Error	11.950	59	0.203	
Total	63.878	64		

(a) Significant at 0.001 level

TABLE V

Analysis of Variance : High Rainfall Zone

Source	Sum of Squares	Degrees of Freedom	Mean Square	F
Regression	30.012	4	75.031	55.897[a]
Error	8.188	61	0.134	
Total	38.200	65		

(a) Significant at 0.001 level