RISK, UTILITY AND STOCKING RATE*

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A simple utility-based model of risky wool production is presented. Evaluation of the model indicates the effect on optimal stocking rate of changes in the degree of risk aversion, farm area, variable cost, fixed cost, wool cut, wool price, variance of wool price, climatic variability and tax rate. It is shown that the utility hypothesis implies a lower optimal stocking rate than does expected profit maximization and hence implies a discrepancy between private and public optimal resource use which it is suggested, might be mitigated by a progressive bounty on wool production.

Introduction

Compared to earlier work with its tendency to emphasize technical efficiency, more recent discussions of 'optimal' grazing rates have generally recognized the primacy of economic considerations.[1] A variety of approaches to economic evaluation have been elaborated. These range from simple methods such as the maximization of gross returns, e.g. [2, 20, 33], or some measure of net income or gross margin, e.g. [28, 29, 31], to the more complicated approaches of systems analysis [9, 34], simulation [35] and decision theory [7, 18, 32]. As well, production function models [13, 14, 15], linear programming [19, 27] and inventory analysis of drought fodder reserves for different stocking rates [10, 22] have received some attention.

To date, the contributions of Byrne [5], Chisholm [6] and Lloyd [16] are perhaps most useful in providing the basis for the economic determination of optimal stocking rates. Their work indicates that the optimal stocking rate may fall quite markedly as account is progressively taken of price effects, drought costs and risk aversion, as illustrated in Figure 1. Lloyd [16], for example, relative to a particular context, estimated an optimal stocking rate of 6·5 sheep per acre for maximum profit in the average season; 5·5 sheep per acre if drought costs were included; 5 sheep per acre if additional fencing and fertilizer costs needed at higher stocking rates were included; and 4 sheep per acre if the farmer was moderately averse to risk. Such effects have been reflected in farmer behaviour. In general, and to the dismay of some scientists, farmers have stocked their properties below the rates suggested as optimal by field researchers and extension officers.

In a relatively informal way this paper shows that such conservative stocking rate behaviour by farmers is explainable in terms of utility analysis[2], i.e., by the hypothesis that farmers seek to maximize utility

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[1] An extensive review of the literature on stocking rate choice has been presented by McArthur [17].

[2] The essence of (Bernoulli or von Neumann-Morgenstern) utility analysis is that the utility of a risky profit π with frequency distribution $f(\pi)$ is given by the expected utility of the risky profit, i.e.

$$U(\pi) = \int U(\pi) f(\pi) d\pi$$

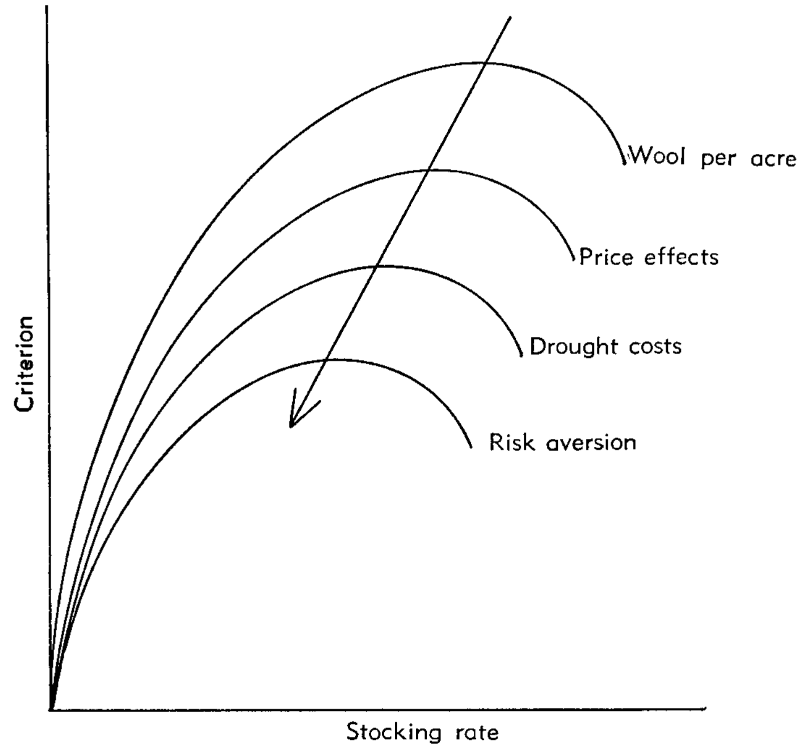

FIG. 1—Progressive influence of economic considerations on optimal stocking rate.

rather than expected profit.[3] Furthermore, it is shown that this hypothesis implies stocking rate choice is also influenced by the level of fixed costs and property size—factors which so far have not been recognized as having any *logical* influence on stocking rate choice.

Utility Model of Wool Production

Assuming a given acreage of uniform quality, a set rate of stocking, no handfeeding, and revenue solely from wool sales, annual net income for a viable wool-producing firm is given by the expression

$$(1) \qquad \pi = A\{S(WR-C)-F\}, \quad WR-C > 0,$$

where A is area in acres;
S is stocking rate in sheep per acre;
W is annual wool cut in lb. per sheep;
R is wool price in \$ per lb., net of marketing expenses;
C is annual variable production cost in \$ per sheep; and
F is annual fixed cost in \$ per acre.

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where $U(\pi)$, fixed only up to a positive linear transformation, is the decision maker's utility function [21]. Once $U(\pi)$ and $f(\pi)$ are established, input levels influencing π may be chosen so as to maximize $U(\pi)$—at least to the extent that inputs are variable and controllable.

[3] Some evidence supporting the hypothesis for Australian farmers has been presented by Officer and Halter [24] and, in a stocking rate context, by Officer, Halter and Dillon [25].

Following Byrne [5], who showed the approach to be satisfactory, the relation between wool cut per sheep and stocking rate can be expressed as

(2) $$W = M - (dS/c)$$

where M is maximum possible wool cut per sheep in lb.;
d is the reduction in lb. wool per sheep as stocking rate increases by one sheep per acre; and
c is a climatic index defined as the ratio of feed produced per acre in a given year to feed produced per acre in the average year and distributed with mean $E(c) = 1$ and subjective variance $V(c) = \sigma_c^2$.

Substituting equation (2) into equation (1) and taking the relevant expectations, expected net income is given by[4]

(3) $$E(\pi) = A\{S([M - dS]R - C) - F\}$$

and the variance of net income is given by[5]

(4) $$V(\pi) = (dAS^2R)^2\sigma_c^2.$$

Assuming a quadratic utility function

(5) $$U(\pi) = \pi - b\pi^2, \quad b \geqslant 0,$$

and making use of the fact that $E(\pi^2) = [E(\pi)]^2 + V(\pi)$, the utility of risky net income can be expressed as

(6) $$U(\pi) = E(\pi) - b\{[E(\pi)]^2 + V(\pi)\}.$$

This equation indicates that for a risk indifferent farmer ($b = 0$) utility maximization is equivalent to expected profit maximization, while for a risk averse farmer ($b > 0$) the utility maximizing level of profit is necessarily less than maximum expected profit.

Substitution from equations (3) and (4) gives utility as a quartic function of stocking rate, viz.:

(7) $$\begin{aligned} U(\pi) = &-bd^2A^2R^2(1 + \sigma_c^2)S^4 + 2bdA^2R(MR - C)S^3 \\ &-A[dR + 2bdARF + bA(MR - C)^2]S^2 \\ &+A[(MR - C)(1 + 2bAF)]S - (bA^2F^2 + AF). \end{aligned}$$

Inspection of this equation shows that all the parameters of the model, i.e. A, C, F, M, R, d, σ_c^2 and b, enter non-linearly with respect to S and therefore influence the level of stocking rate which maximizes utility.

2? 4? 6? 8? What Sheep Stocking Rate?

Because of its quartic form, iterative rather than analytical assessment of equation (7) is the easiest way of determining both the level of stocking rate which maximizes utility and the influence of changes in the other parameters on optimal stocking rate.[6] As a starting point for such evaluation, the following set of basic parameter values is used on the assumption that they constitute a reasonable set of values relative to many farm situations in the high rainfall and wheat-sheep zones:

[4] Using $E(1/c) \simeq 1/E(c) = 1$. See Deming [8, p. 372].

[5] Using $V(1/c) \simeq V(c) = \sigma_c^2$. See Deming [8, p. 393].

[6] Analytic assessment of equation (7) is outlined in McArthur [17, pp. 44-47] who shows that for the range of relevant parameter values, $\partial U/\partial S = 0$ has a single real root corresponding to a maximum of expected utility. See also Turnovsky [30] for an analytic discussion of the influence of factor price uncertainty.

b, coefficient of risk aversion, of 0·00001;
A, farm area, of 1,000 acres;
C, variable production cost, of \$2·00 per sheep;
F, fixed cost, of \$4·00 per acre;
M, maximum possible wool cut per sheep, of 12 lb.;
R, wool price net of marketing expenses, of \$0·45 per lb.;
d, reduction in wool cut per sheep as stocking rate is increased by one sheep per acre, of 0·60 lb.; and
σ_c^2, index of climatic variability, of 0·10.

Unless otherwise specified, the above values are used throughout the following analyses.

Risk Aversion

Utility values for a range of stocking rates and for three different degrees of risk aversion ($b = 0$, 0·00002 and 0·00005) are shown in Figure 2. Respectively these b values[7] imply an optimal stocking rate of approximately 6·3, approximately 6·0, and approximately 5·0 sheep per acre reflecting the general rule that the more averse a farmer is to

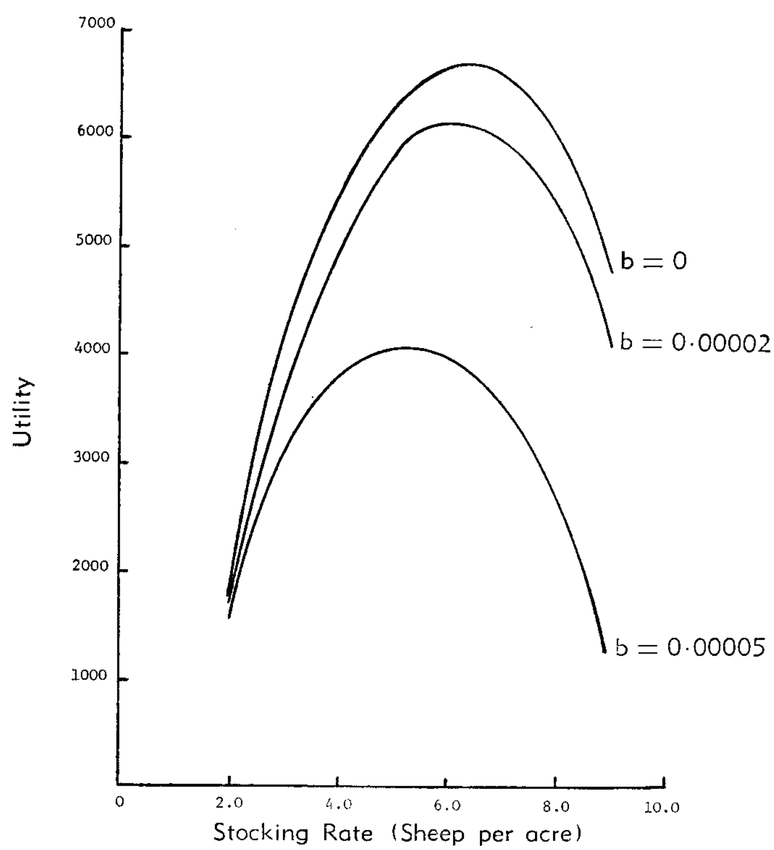

FIG. 2—Utility for a range of stocking rates.

[7] A b value of zero implies its owner would be indifferent between a 50-50 gamble for \$0 or \$10,000 and a sure payment of \$5,000. For b values of 0·00001, 0·00002, and 0·00005 the sure payments for indifference are respectively \$4,700, \$4,375, and \$2,930.

risk, the lower should his stocking rate be. Some empirical evidence in this regard has been presented by Officer, Halter and Dillon [25].

Farm Area

Equation (3) implies that expected income increases linearly with farm area, A. Thus the criterion of maximizing expected income will treat farm area as irrelevant to the choice of stocking rate. That this may be far from the case if choice is based on utility maximization is illustrated by Figure 3. The larger the area a farmer operates, the lower his optimal rate of stocking for a given degree of risk aversion. The reason is that, if risk aversion prevails, the utility of A times $\$X$ is less than A times the utility of $\$X$, i.e. $U(AX) < A[U(X)]$, so that utility does not increase linearly with farm area and the stocking rate which produces maximum utility decreases as farm area increases. As well, the greater the degree of risk aversion, the more the optimal stocking rate falls as farm size increases.

Particularly because of variation in land quality, enterprise mix and farmers' risk attitudes, empirical evidence clearly supporting the utility

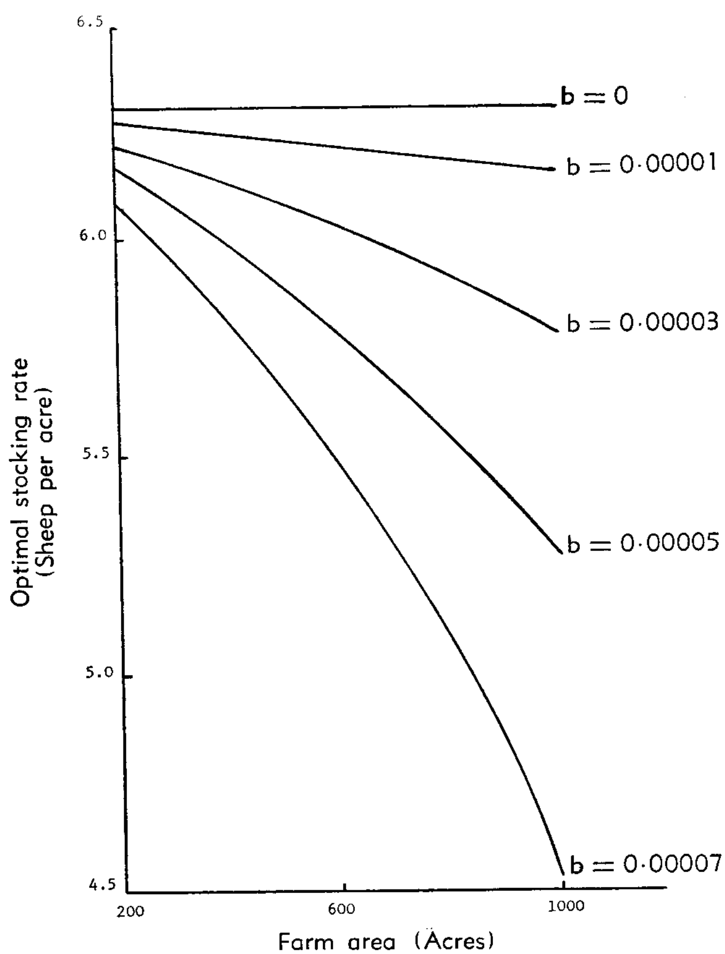

FIG. 3—Effect of farm area and degree of risk aversion on optimal stocking rate.

hypothesis of lower stocking rates on bigger farms may be difficult to obtain. Data for the pastoral zone presented in Table 1 perhaps give some support to the hypothesis. Likewise Gruen [11], in a survey of a fairly homogeneous area, noted that stocking rate tended to be highest on smaller farms. Parish and Dillon [26] noted a similar effect in a survey of stocking rates and found 'differences in area to overshadow differences in the other factors affecting rate of stocking'.

TABLE 1

Property Size and Stocking Rate in the Pastoral Zone

Number of sheep on the property	Average property size in acres	Sheep equivalents per 1,000 acres
1,000 to 1,999	7,814	297
2,000 to 4,999	25,785	189
5,000 to 9,999	67,215	150
10,000 to 19,999	153,119	104
20,000 and over	219,971	132

Source: B.A.E. [3, Tables A5 and A8].

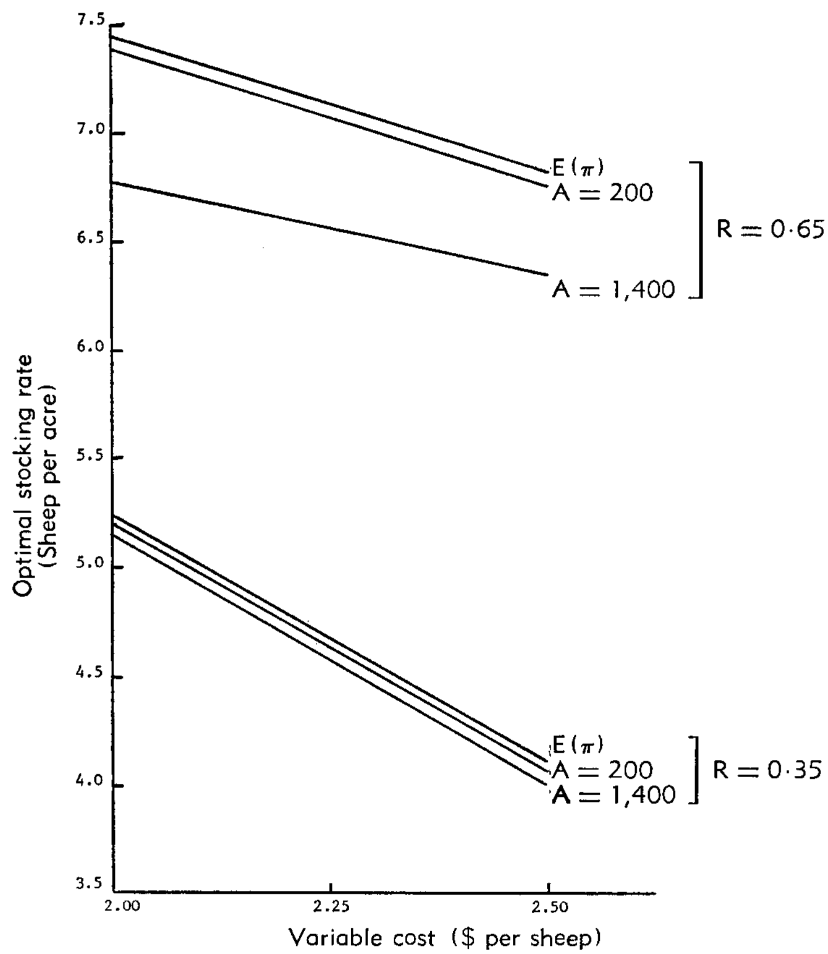

FIG. 4—Effect of variable cost on optimal stocking rate under alternative farm areas and wool prices.

Variable Cost

From Figure 4 it can be seen that an increase in the level of variable costs has the effect of reducing optimal stocking rate, both for the utility and the expected income criterion. In fact, it is only at high wool prices and relatively large farm size that variable costs cause a marked divergence in optimal stocking rate as determined by the two criteria.

Fixed Cost

As Figure 5 indicates, the utility hypothesis implies an increase in stocking rate, with consequent lessening of the difference between the profit and utility maximizing rates, as fixed cost increases. The explanation lies in the fact that an increase in fixed cost implies a relative cheapening of variable factors. For a moderate degree of risk aversion (say $b = 0{\cdot}00001$), changes in the level of fixed costs have almost no effect on optimal stocking rate as given by utility maximization. The greatest effect occurs for a high degree of risk aversion and a low level of fixed cost.

Although the effect of fixed cost on stocking rate choice may not normally be large, the effect is interesting because fixed costs are usually ignored in the determination of 'optimal' stocking rate via such procedures as gross margins analysis and expected profit maximization. For example, the optimal stocking rate calculated on the basis of maximization of expected income is 6·3 sheep per acre for all the various combinations of area, fixed cost and risk aversion coefficient of Figures 3 and 5. As these diagrams show, the existence of risk aversion may lead to an optimal stocking rate well below that which would maximize expected profit.

Wool Cut

The data of Figure 6 show that as maximum possible wool cut per sheep increases, or as the reduction in wool cut per unit increase in stocking rate decreases, optimal stocking rate rises. This effect is as expected from equation (2) since an increase in M or a decrease in d implies a clear gain in the technical efficiency of wool production. However, as Figure 6 indicates, it is only under the favourable conditions of high M and low d values that the utility criterion gives markedly different results from the expected profit criterion, although of course the discrepancy increases as the degree of risk aversion becomes greater.

The parameters M and d are the major carriers of technology in the model of equation (7) (or in the model of equations (1) and (2) if utility is ignored). Data presented by the B.A.E. [4] indicates the average sheep stocking rate in Australia has increased from 1946 to 1967. This suggests that the influence of improved technology in raising optimal stocking rate has outweighed the effect of the cost-price squeeze in reducing it.

Wool Price

Optimal stocking rate increases with wool price but more slowly the greater the degree of risk aversion or the larger the farm area. Figure 7 presents pertinent data.

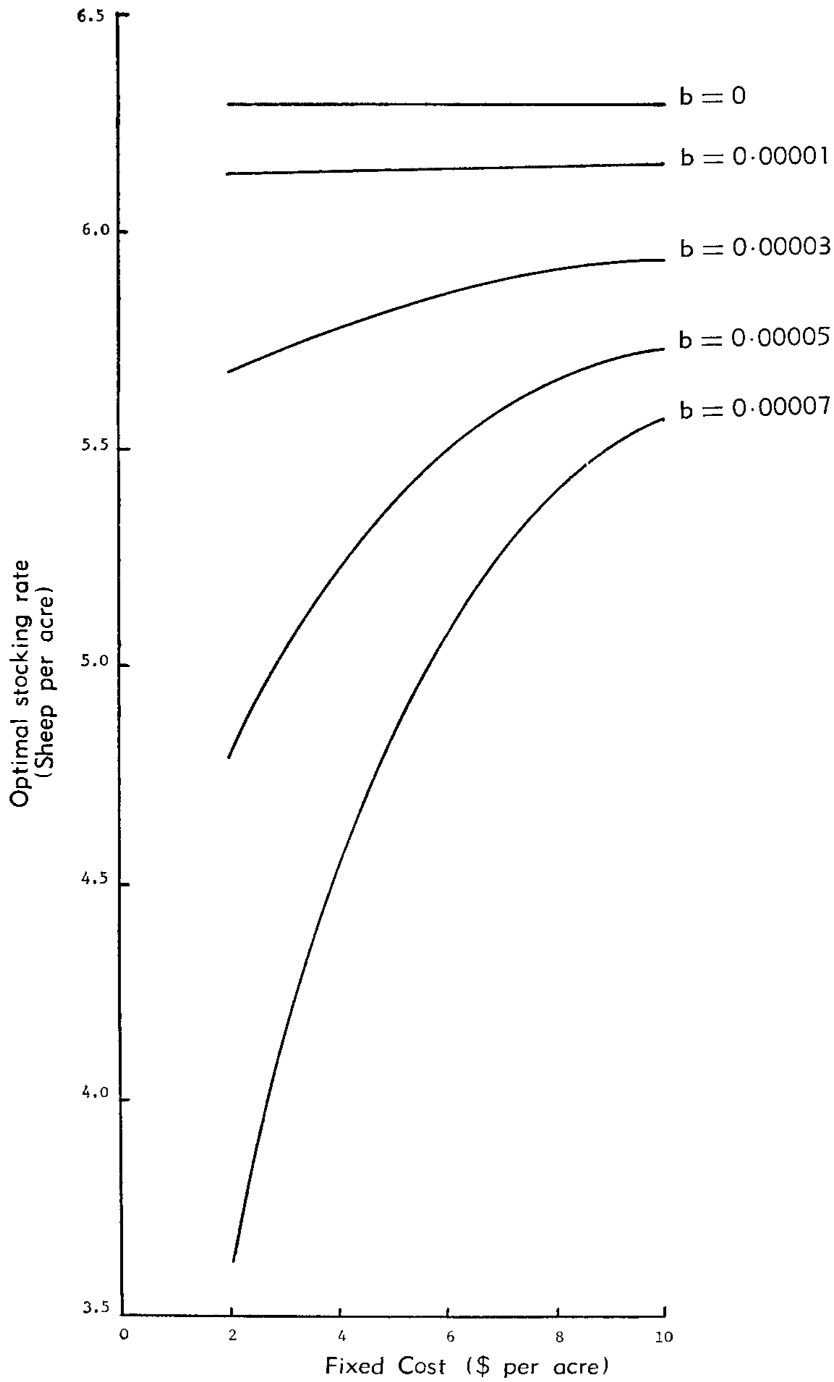

FIG. 5—Effect of fixed cost and degree of risk aversion on optimal stocking rate.

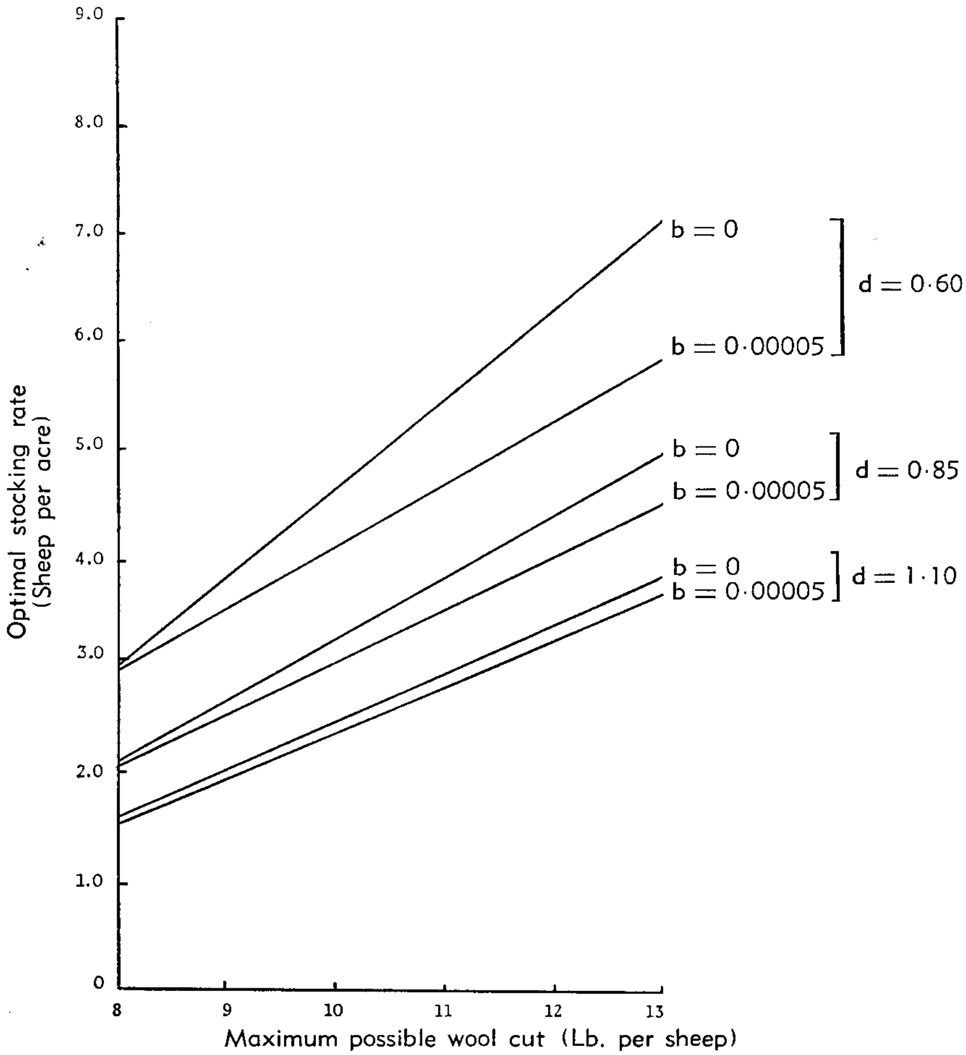

FIG. 6—Effect of wool cut per sheep and degree of risk aversion on optimal stocking rate.

Wool Price Uncertainty

If wool price R is uncertain, with subjectively estimated mean μ and variance σ^2, and is independent of the climatic index c, equations (3) and (4) become[8]

(8) $$E(\pi) = A\{S([M-dS]\mu - C) - F\}$$

(9) $$V(\pi) = (ASM)^2\sigma^2 + (dAS^2)^2[\sigma^2 + \mu^2\sigma_c^2].$$

Substitution of these extended specifications for $E(\pi)$ and $V(\pi)$ into equation (6) gives a revised utility equation analagous to equation (7) which allows for the influence of wool price uncertainty. Data from the evaluation of this revised model are presented in Figures 8 and 9. From Figure 8 it can be seen that the more variable a farmer believes wool price to be, the lower will be his optimal stocking rate for utility

[8] Using, in equation (9), $V(R/c) = \sigma^2 + \mu^2 \sigma_c^2$ as per Deming [8, p. 393].

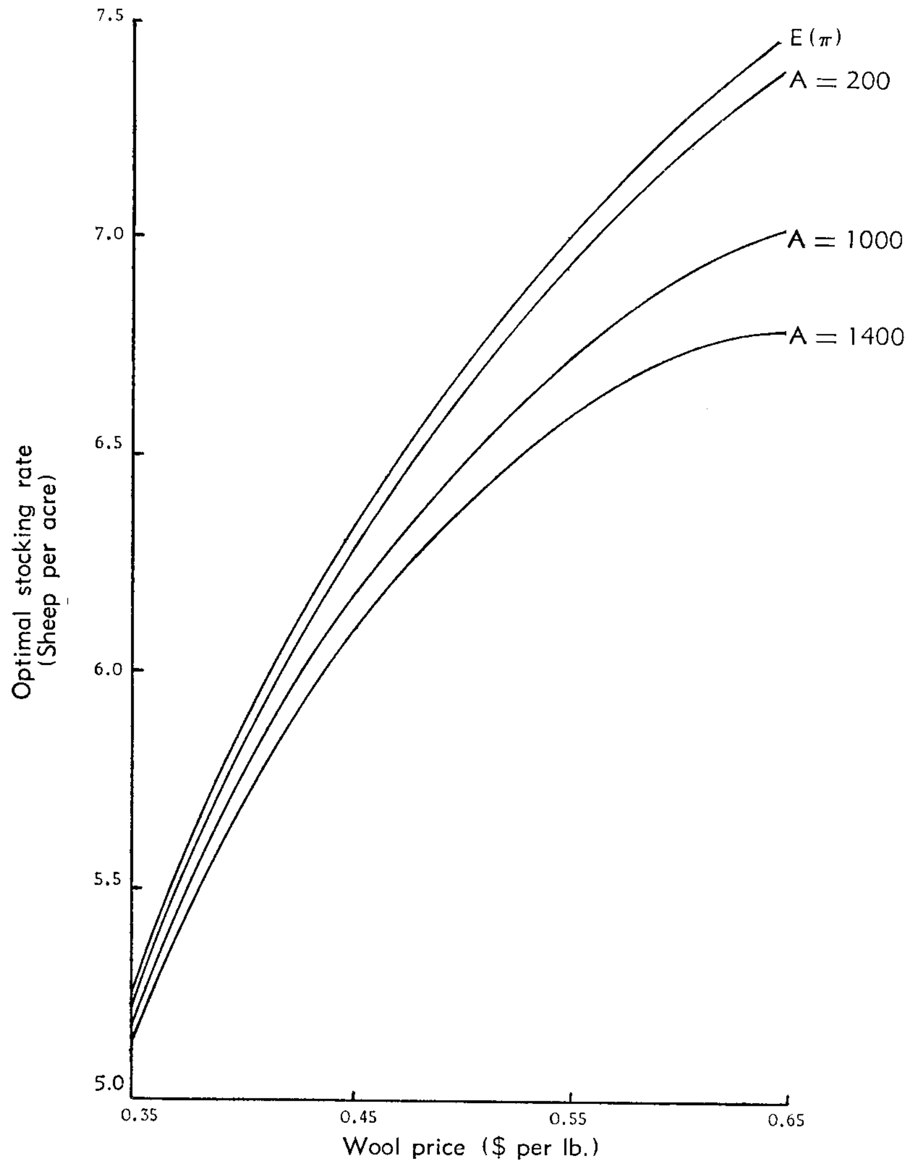

FIG. 7—Effect of wool price on optimal stocking rate under alternative farm areas.

maximization. Figure 9 indicates a similar effect on stocking rate the lower the expected wool price. Both effects are enhanced as risk aversion increases.

Climatic Variability

In the present utility framework, σ_c^2 represents the year to year variability of pasture production about the mean value of annual pasture production. Figure 10 shows that if M (the maximum possible wool cut per sheep) is taken as a measure of the quality of the environment, then the better the environment, the more will the utility maximizing stocking rate be reduced if there is variability associated with this

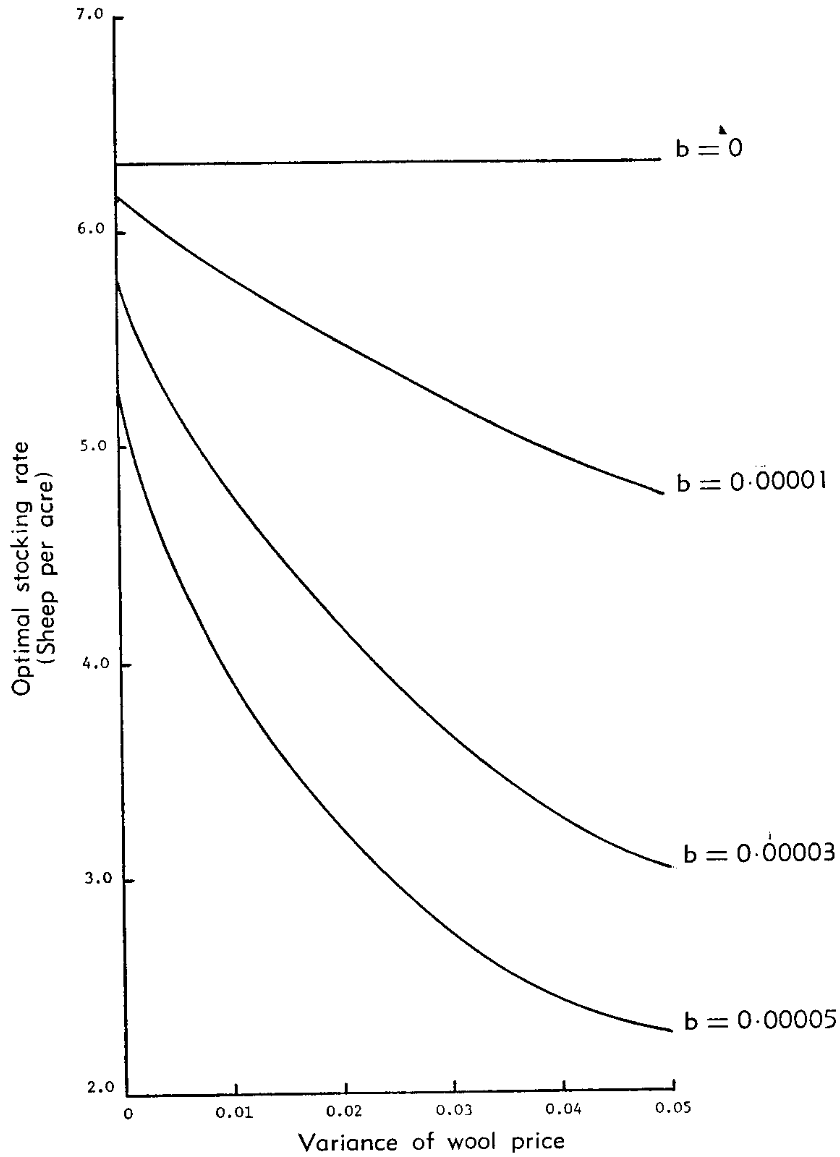

FIG. 8—Effect of wool price uncertainty and degree of risk aversion on optimal stocking rate.

'good' environment. In a 'bad' environment—where M is relatively low—optimal stocking rate will be largely unaffected by climatic variability.

Income Tax and Drought Bonds

Progressive income tax is analogous to a declining price (or an increasing variable cost) per unit of product as production increases. The effect of tax is thus to reduce the optimal stocking rate and this effect, given utility maximization, will be greater the higher the tax rate, the greater the degree of risk aversion, the larger the property, and the more variable the economic and technical environment.

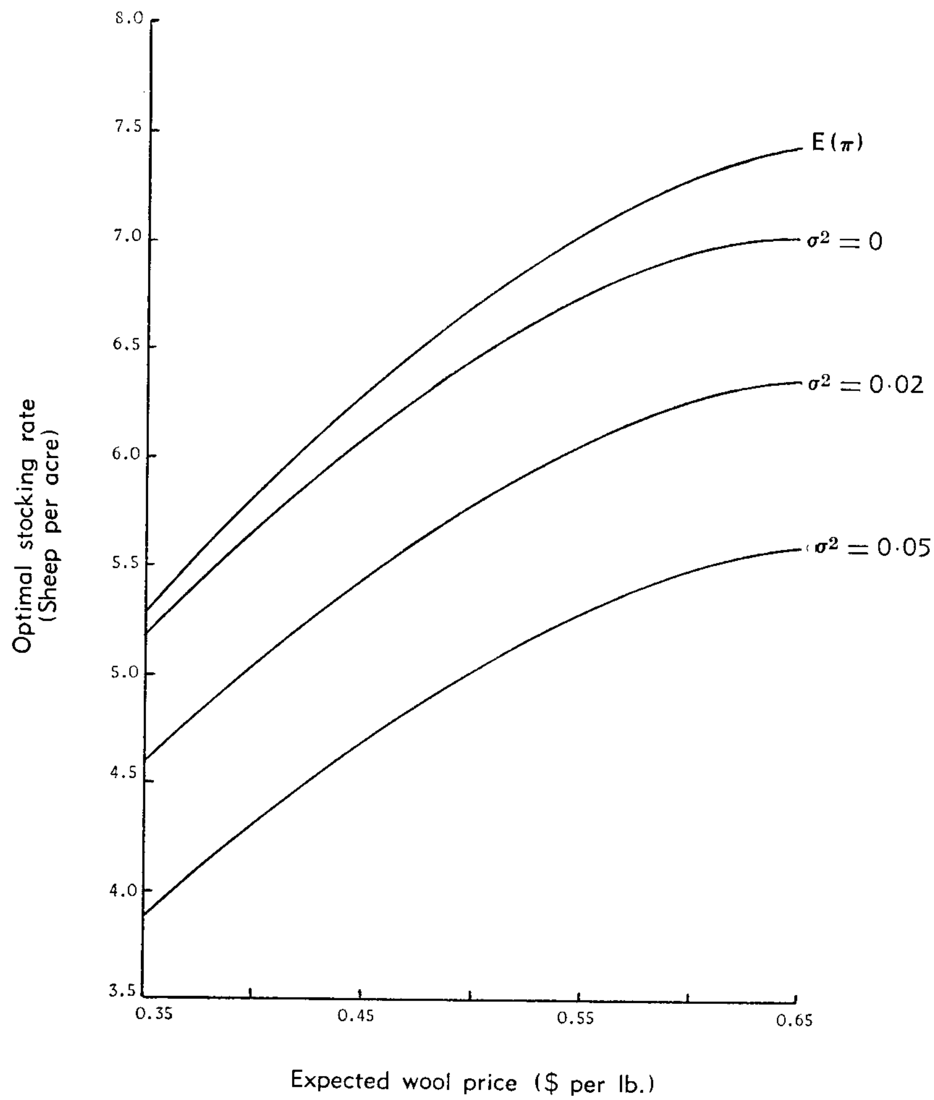

FIG. 9—Effect of wool price mean and variance on optimal stocking rate.

Provisions for income averaging and drought-bond insurance, in so far as they reduce the variance of net income, will diminish the effect of basic income tax and climatic variability in leading to lower optimal stocking rates than would otherwise prevail. Concomitantly, the greater a farmer's degree of risk aversion, the greater will be his willingness to purchase drought bonds.

Summary of Results

The results presented above are summarized in Table 2 under a *ceteris paribus* assumption. It is noteworthy that, compared to the hypothesis of expected profit maximization, utility analysis implies that a variety of additional factors are relevant to stocking rate choice. More-

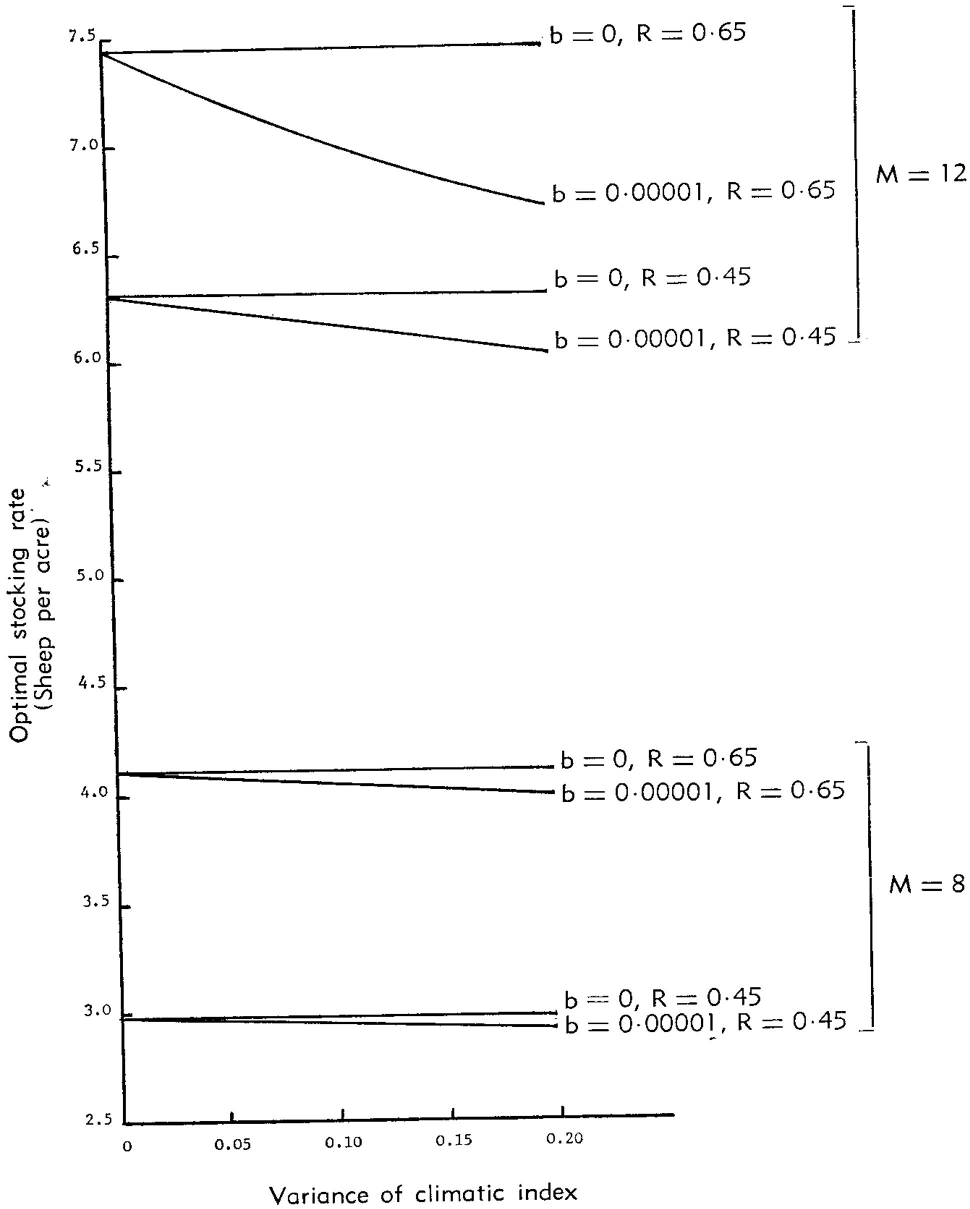

FIG. 10—Effect of climatic variability and degree of risk aversion on optimal stocking rate under alternative wool prices and technical environments.

over, in those cases where a parameter is relevant to both criteria, its effect on utility-based stocking rate is greater than its effect on expected profit-based stocking rate.

The listings in Table 2 are suggestive of a variety of investigations that might be conducted to test the hypothesis of utility maximization. Such tests, however, will be difficult in so far as the *ceteris paribus* condition fails to hold in the real world.

TABLE 2

Effect of an Increase in Various Parameters on the Optimal Stocking Rate of a Risk Averse Producer

Parameter increased *ceteris paribus*	Effect on optimal stocking rate as determined by:	
	Utility maximization	Expected profit maximization
Degree of risk aversion, b	Decrease	Nil
Farm area, A	Decrease	Nil
Variable production cost per sheep, C	Decrease	Decrease
Fixed cost per acre, F	Increase	Nil
Wool cut per sheep, W	Increase	Increase
Maximum possible wool cut per sheep, M	Increase	Increase
Reduction in wool cut per unit increase in stocking rate, d	Increase	Increase
Wool price, R	Increase	Increase
Variance of wool price, σ^2	Decrease	Nil
Variability of climate, σ_c^2	Decrease[a]	Nil
Rate of income tax	Decrease[a]	Decrease

[a] This effect will be partly diminished the more freely income averaging provisions and drought insurance are available.

Risk Aversion and Resource Use

If, as common judgement holds to be true, wool producers are mainly risk averse[9] and do in fact attempt to maximize utility, their allocation of resources will be suboptimal relative to that implied by expected profit maximization. In particular, their stocking rate will be less than that judged optimal in monetary terms.

From a national point of view, however, resource allocation based on expected profit maximization is desirable since, by its nature, the State can logically take a long-term view and be indifferent to risk, especially risk relevant to only a part of G.N.P.[10] This being so, it could be rational for the State on economic (as distinct from welfare) grounds to pay producers a bounty at a progressive rate on their wool production.[11] Appropiately chosen, such a supplement to wool price would lessen the gap between the individual's utility maximizing resource allocation and the allocation that would be optimal, from the State's viewpoint, in terms of expected profit maximization. To a degree, any such risk-induced gap is already being lessened (unwittingly) by the provision of fertilizer price subsidies, income averaging, drought bonds and State-supported research aimed at increasing wool cut per sheep.

[9] The little evidence available indicates risk aversion to be generally true with respect to money gains. Officer [23] in an intensive study of New England wool producers' utility functions over the range of money gains from $0 to $10,000 found 5 producers out of 5 to be risk averse. As reported by Anderson [1], Francisco, Anderson and Dillon in a study of N.S.W. Western Division wool producers' utility functions over the range of money gains from $0 to $40,000 found 18 producers out of 21 to be risk averse.

[10] The logic of such use of expected profit rather than utility has been outlined by Halter and Dean [12, pp. 66-67].

[11] A product bounty rather than an input subsidy on sheep is suggested since sheep are only one of the inputs used in wool production and all inputs will be influenced by risk considerations.

Compared to a progressive production bounty, however, all these mechanisms suffer from the disadvantage of being discriminatory between producers in their availability. Of course, whether or not there is a significant risk-induced discrepancy between publicly and privately desired resource use in the grazing industry, and whether it might profitably be influenced by government action given wool's terms of trade, is a question for further research.

References

[1] Anderson, J. R. *Risk, Production Theory and Extensive Woolgrowing,* unpublished Ph.D. thesis, University of New England, Armidale, 1970.

[2] Arnold, G. W., and McManus, W. R., 'The Effects of Stocking Rate and Grazing Management on Fat Lamb Production', *Proc. Aust. Soc. An. Prod.* IV: 129, 1962.

[3] B.A.E., *The Australian Sheep Industry Survey 1963-64,* Canberra: Bureau of Agricultural Economics, 1967.

[4] B.A.E., *Selected Rural Statistics for the Sheep Industry: By Zones: 1946-47 to 1966-67,* Canberra: Bureau of Agricultural Economics, 1969.

[5] Byrne, P. F., *An Evaluation of Different Stocking Rates of Merino Sheep,* Wool Economics Research Report No. 13, Canberra: Bureau of Agricultural Economics, 1968.

[6] Chisholm, A. H., 'Towards the Determination of Optimum Stocking Rates in the High Rainfall Zone', *Rev. Mktg. Agric. Econ.,* 33 (1): 5, 1965.

[7] Dean, G. W. 'Decision Theory Models in Range Livestock Research', *Development and Evaluation of Research in Range Management Decisions,* Western Agricultural Economics Research Council, Report No. 5: 111, 1963.

[8] Deming, W. E., *Sample Designs in Business Research,* New York: Wiley, 1960.

[9] Dillon, J. L., and Burley, H. T., 'A Note on the Economics of Grazing and its Experimental Investigation', *Aust. J. Agric. Econ.* 5 (2): 123, 1961.

[10] Dillon, J. L., and Lloyd, A. G., 'Inventory Analysis of Drought Reserves for Queensland Graziers: Some Empirical Analytics', *Aust. J. Agric. Econ.* 6 (1): 50, 1962.

[11] Gruen, F. H., 'Stocking Rates in the Berriquin and Wakool Irrigation Districts', *Rev. Mktg. Agric. Econ.* 21 (2): 113, 1953.

[12] Halter, A. N., and Dean, G. W., *Decisions Under Uncertainty with Research Applications,* Department of Agricultural Economics, Oregon State University, Corvallis, 1969.

[13] Heady, E. O., 'Economic Concepts in Directing and Designing Research for Programming Use of Range Resources', *J. Farm Econ.* 38 (5): 1604, 1956.

[14] Hopkin, J. A., 'Economic Criteria for Problem Solution in Research Relative to the Use and Development of Range Resources', *A Methodological Anthology,* Western Agricultural Economics Research Council, Report No. 1: 35, 1957.

[15] Jensen, B. C., and Thomas, D. 'Determining Grazing Fees on National Forests', *Range and Ranch Problems, Policy Implications and Alternatives for Future Research,* Western Agricultural Economics Research Council, Report, No. 9: 47, 1967.

[16] Lloyd, A. G., 'Economic Aspects of Stocking and Feeding Policies in the Sheep Industry of Southern Australia', *Proc. Aust. Soc. An. Prod.* VI: 137, 1966.

[17] McArthur, I. D., *Risk, Utility and Stocking Rate Choice,* University of New England, Farm Management Bulletin No. VI, Armidale, 1970.

[18] McConnen, R. J., 'Decision Theory, Climatic Variability and "Best" Short-Run Management Strategies', *J. Farm Econ.* 43 (5): 1340, 1961.

[19] McConnen, R. J., McCorkle, C. M., and Caton, D. D., 'Feed-Livestock Relationships: A Model for Analysing Management Decisions', *Agric. Econ. Res.* 15 (2): 41, 1963.

[20] McManus, W. R., Arnold, G. W., and Paynter, J. R., 'Studies in the Wool Production of Grazing Sheep', *J. Exptl. Agric. An. Hus.* 4 (15): 404, 1964.

[21] Marschak, J., 'Scaling of Utilities and Probability', in Shubik, M. (ed.), *Game Theory and Related Approaches to Social Behavior*, New York: Wiley 1964, Ch. 5.

[22] Mauldon, R. G., and Dillon, J. L., 'Droughts, Fodder Reserves and Stocking Rates', *Aust. J. Agric. Econ.* 3 (2): 45, 1959.

[23] Officer, R. R., *Decision Making Under Risk.* Unpublished M.Ag.Ec. thesis, University of New Engand, Armidale, 1967.

[24] Officer, R. R., and Halter, A. N., 'Utility Analysis in a Practical Setting', *Am. J. Agric. Econ.* 50 (2): 257, 1968.

[25] Officer, R. R., Halter, A. N., and Dillon, J. L., 'Risk, Utility and the Palatability of Extension Advice to Farmer Groups', *Aust. J. Agric. Econ.* 11 (2): 171, 1967.

[26] Parish, R. M., and Dillon, J. L., 'Estimation of Stocking Rates by Multiple Regression Analysis', *Rev. Mktg. Agric. Econ.* 23 (4): 215, 1955.

[27] Rickards, P. A., and Anderson, J. R., 'The Influence of Technical Productivity and Availability of Carry-over Finance on Optimum Post-Drought Recovery', *Farm Mgt.* 3 (1): 1, 1967.

[28] Sims, H. J., and Webb, C. J., 'Sheep Management Studies at Walpeup', *J. Dept. Agric. Vic.* 44 (11): 489, 1946.

[29] Tribe, D. E., and Lloyd, A. G., 'Effect of Stocking Rate on the Efficiency of Fat Lamb Production', *J. Aust. Inst. Agric. Sci.* 28 (4): 274, 1962.

[30] Turnovsky, S. J., 'The Behaviour of a Competitive Firm with Uncertainty in Factor Markets', *N.Z. Econ. Papers* 3 (1): 52, 1969.

[31] Walters, D. V., 'The Most Profitable Sheep Stocking Rate', *Farm Mgt.* 4 (3): 13, 1968.

[32] Walther, T. A., 'Statistical Decision Theory Applied to Western Range Problems and Ranch Management Decision-Making", *Development and Evaluation of Research in Range Management Decision-Making,* Western Agricultural Economics Research Council, Report No. 5: 37, 1963.

[33] Weston, R. C., 'Higher Production from Fat Lambs', *Wool Technol. Sheep Breeding* XII (4): 41, 1965.

[34] Wright, A., *Systems Research and Grazing Systems: Management Oriented Simulation,* University of New Engand, Farm Management Bulletin No. V, Armidale, 1970.

[35] Zusman, P., and Amiad, A., 'Simulation: A Tool for Farm Planning Under Conditions of Weather Uncertainty', *J. Farm Econ.* 47 (3): 574, 1965.