"SOME NOTES ON 'DYNAMIC' LINEAR PROGRAMMING": COMMENT

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C. D. Throsby's paper [1] presents a worked example of a "dynamic" linear programme for a Cowra farm which could prove highly misleading to uninitiated readers. The practical man may be led to reject the solution because it is technically unsound, but the technique should not be judged by the results of technical absurdities which could be removed by more accurate specification. The more experienced analyst may wonder why the technique was used on such a problem at all.

As an example of the technical errors referred to, the solution has sheep carried for twelve months without feed, and cutting eleven or twelve pounds of wool as well as rearing a fat lamb, before they are twelve months of age! Such errors are clearly not the fault of the method.

Turning to matrix design, no provision is made for the carry-forward of capital to later years, although borrowing is permitted with some startling results.

The use of gross profit as a criterion for selection of enterprises is to be avoided. One reason for this rule can be seen from the final plan, which shows both sheep and capital "slack", or surplus, in year three. Thus any activity which uses sheep and capital, but not land or machinery, would enter the plan in year three. For example, supplementary feeding of sheep, using £1 of capital to produce 1s 0d. gross revenue, would find a place in the "optimum" plan.

SUGGESTED IMPROVEMENTS IN SPECIFICATION

Endeavouring to visualize the practical outcome of following the computed plan, an "agistment" or "cold storage" activity seems urgently needed. The property commences conveniently understocked, but what becomes of the seventy sheep to be grazed on newly sown wheat-with-improved pasture before the crop is harvested in year two? Clearly four additional constraints, at least, are required to ensure that the property is not overstocked at the time of lowest feed availability in each year.

There is no feed available for the "slack" sheep in years two and three. A carrying capacity constraint would prevent their inclusion. It is interesting to trace the implications of the existence of these "slack" sheep. What occurs in the solution suggested is this:—Money is borrowed in year two in anticipation of income in year four, and ewes are purchased with this money. These ewes produced a certain number of additional sheep in year four, at a lower cost than such sheep could be purchased at that

[1] This *Review*, Vol. 30, No. 2 (June, 1962), p. 119.

time, even allowing for the interest charge on this borrowed money over the intervening two years. Since these sheep can reproduce without feed, why waste good money growing pastures!

Household expenditure is defined as a fixed cost, hence the eight vectors devoted to it may be wasted. A negative basis entry of 2,500 against capital in each year should suffice to produce the desired result that £2,500 per year (if available[2]) is devoted to household and other fixed expenditures.

The matrix space so gained could be devoted to a "carrying capacity" constraint and a "sheep sell" activity for each year. Sheep sell would supply slightly less capital than required by "sheep buy". Sheep revenue would be brought into account through "sheep activity" columns and the $z_j—c_j$ of pasture columns would require to be adjusted accordingly. Such a formulation would ensure that sheep were bought according to economic criteria rather than as an inescapable consequence of there being forage available for their use.

Although consideration of the fifth and subsequent years is purposely ignored by Throsby, it is of interest that consideration of net worth at the end of the fourth year might cause a farmer to replace wheat in year three by wheat plus improved pasture. By so doing about £4.3 of net cash revenue per acre is foregone over 200 acres, but the operator completes the four years possessed of an additional (0·462 x 200) sheep from natural increase in the fourth year, and 200 acres of pasture at its most productive stage (with a definite sale value), instead of 200 acres of stubble on land which has grown two successive wheat crops.

General Comment

The worked example illustrates two features of "dynamic" linear programming which severely limit its application in farm management studies.

The first is a high requirement for computer space, which multiplies specification and scaling problems as well as costs. Despite the deliberately restricted objectives of Throsby's study a 27 x 29 matrix is involved. Such a matrix is too large to contemplate solving by hand, and would cost between £6 and £30 to solve by computer at custom rates on Australian computers, yet the solution obtained is inexact because of incomplete specification.

The second difficulty stems from the first. Coalition of activities, unless performed with considerable finesse, commonly leads to the specification of joint input relationships which do not apply in real life. As an example, Throsby's model *requires* that pastures be stocked to capacity each year. In real life, pastures are unlikely to be damaged if moderately understocked, and there should be scope to manage a combination of pastures of different ages to minimize any possible loss from understocking. The problem could be formulated better, using a "sheep-husbandry" activity as suggested earlier, so that sheep are not purchased when capital would be better spent on sowing wheat or additional areas of pasture, or carried forward to future years.

[2] Vide W. V. Candler, "Reflections on Dynamic Programming Models", *Journal of Farm Economics,* Vol. 42, No. 4 (November, 1960), p. 920.