INVENTORY ANALYSIS OF DROUGHT RESERVES: A NOTE ON THE VALUATION OF CARRYOVER*

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In a recent paper, Dillon and Lloyd give a brief account of a detailed study which they made of fodder reserves for Queensland graziers.[1] This work was based on an inventory model using what the authors have termed a "rolling planning strategy".[2] Briefly, such a strategy consists of selecting a planning period sufficiently long to cover the longest drought which might reasonably be expected to occur (with probability 0.999). With the effluxion of time, this planning period continually slides forward, so that its end is never reached. Such periods ranged from 14 to 36 months in the regions studied.[3] All decisions are then based on the expected profit and loss account for the planning period, as well as upon variance considerations over the same period. It is shown in this note that the value placed on fodder unused at the end of the planning period by Dillon and Lloyd — namely, replacement cost — is inappropriate if one is concerned with decisions which are optimal for the somewhat longer run; i.e., for periods of length greater than the specified planning periods.

To put the problem in perspective, it ought to be noted that the use made by Dillon and Lloyd of a single planning period was intended by these authors as a computationally feasible approximation to a more sophisticated model involving a planning period of greater length. No criticism of this procedure as such is intended, since the (seemingly insuperable) computational problems involved in multi-period models are all too familiar to the author. However, when a model with a single, relatively short planning horizon is used, it is well to keep in mind the more comprehensive analytical structure which it is desired to approximate. The danger is that expected net income will be maximised in the current planning period only at the expense of income in later years.

This comment would lose some of its cogency if the behavioural assumptions of the Dillon-Lloyd procedure were satisfied. In particular, if at the end of every planning period the grazier concerned sold his carryover at the prevailing market rates, and then started all over again, he might well maximise net income within individual planning

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1. John L. Dillon and Alan G. Lloyd, "Inventory Analysis of Drought Reserves for Queensland Graziers: Some Empirical Analytics", this *Journal,* Vol. 6, No. 1 (September 1962), pp. 50-67.

2. *Ibid.,* p. 51.

3. *Ibid.,* p. 60.

periods (if indeed he followed the guides[4] set out by Dillon and Lloyd). But since the end of his planning horizon is never reached under a rolling planning strategy, it cannot be concluded with certainty that he will in fact maximise net revenue over the planning period. Moreover, even if successful in this goal, the difficulty remains that in so doing, the grazier may fall far short of maximising the sum of net incomes (appropriately discounted) over the course of several planning periods. A formal solution — not very helpful computationally — has been given to this problem by Dvoretzky, Kiefer and Wolfowitz.[5] If in fact graziers wish to base their decisions on planning periods longer than those used by Dillon and Lloyd, the fodder carried over at the end of a planning period ought to be valued at its value productivity as inventory input. This value cannot be determined *ex ante*, since, strictly speaking, it is determined by the inventory rule followed. However, it is not difficult to set up a convergent process which ensures consistency and optimality. The steps of such a procedure are:

1. Make an intelligent guess as to what the approximate value of $E(y^*)/y^*$ ($=\lambda$, say) might be.[6]
2. Placing this approximate value on carryover, compute the optimal inventory, y^*.
3. Compute λ: go back to 2. Continue until λ approaches an asymptote.

What is the net effect of this procedure? Its beauty is that the value which the grazier attributes to carryover is just what it will be worth to him in the next planning period if he follows the drought planning guides based on this procedure. Moreover, it can easily be shown that for certain probability distributions of demands,[7] this procedure ensures that expected net revenue as a function of fodder supply is bounded from above, whereas using replacement cost valuation of carryover results in an unbounded function and an absurd inventory rule.

To what extent do these conclusions invalidate the results given by Dillon and Lloyd? A simple test is provided by referring to their Table IV, which gives data on y^* and $E(y^*)$, as well as other items, for the Barcaldine region. For those 17 cases in which $y^* \neq 0$, the ratio λ can be computed. For ten price and stocking rate regimes this is found to be less than replacement cost (k_1). In the case of another six regimes λ is found to be greater than k_1. In one case the valuation is approximately correct.

In the ten cases where the optimal fodder supply, y^* (as computed

4. More comprehensive drought planning guides than those given in Dillon and Lloyd (*op. cit.*) are to be published by these authors for the benefit of graziers.

5. "The Inventory Problem: I. Case of Known Distributions of Demand; II. Case of Unknown Distributions of Demand", *Econometrica*, Vol. 20, No. 2 (April 1952), pp. 187-222; and No. 3 (July 1952), pp. 450-466.

6. The notation follows Dillon and Lloyd, *op. cit.*, p. 59. $E(y^*)$ *is expected* net revenue when fodder supply in months per sheep, y, attains its expected-profit-maximising value, y^*. Replacement cost could be used as a starting value for a computer program.

7. The author has demonstrated this mathematically for uniform and 2-step forms of the probability frequency function of drought lengths (unpublished memo, Department of Economics, Adelaide University, September 1962).

by Dillon and Lloyd) is zero, it is still possible in most cases to use this test. Since the computational treatment is discrete, the exact value of y^* may lie anywhere in the interval [0, 1). Bounds for λ can hence be computed. Whenever $E(y^*)$ is negative (i.e., in five cases) it follows that λ is negative also, and hence the valuation placed on carryover is too high. Of the remaining five cases where $E(y^*)$ is positive, in one instance the test is inconclusive, but in the other four the carryover is undervalued.

In summary, then, of twenty-six price and stocking rate regimes for which the test is conclusive, in fifteen cases carryover is overvalued, in ten cases undervalued, and in one case approximately correctly valued. This very likely implies that in fifteen cases the stock length maximising expected net revenue is overestimated, in ten under-estimated, and in one case is about right.

Finally, it is to be noted that none of these conclusions would gainsay the authors' prescription that "the best drought policy for most Queensland graziers would be to keep zero or very small reserves of harvested fodder."[8] Rather, the results given here would add force to this conclusion, since in all the cases where the Dillon-Lloyd solution underestimates optimal fodder supplies, this corresponds to wool prices not less than £0.35 per pound greasy — far in excess of current expectations.

8. Dillon and Lloyd, *op. cit.*, pp. 66-67.