Farm business analysis

PLANNING PROFITABLE FARMING SYSTEMS

Five Examples of the use of Linear Programming

by

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F O R E W O R D

The use of linear programming for farm management is no longer a novelty. Many, however, whilst aware that it is associated with electronic computors, have only vague ideas about what can actually be achieved with it. On the other hand some have been so intrigued by its possibilities and by those of the use of computors that they have seen it as the answer to all problems of farm organisation. It is hoped that the account given in this report of the application of linear programming on 5 Yorkshire farms and the following commentary, will both illustrate how linear programming can be used and also what its advantages and limitations are for this class of work.

It should also serve another purpose. Considerable numbers of farm programmes are now being run through computors by different persons and organisations but few of the results are published. Yet programming a farm is a complicated procedure and the would-be programmer can learn much from the methods developed by others. Those followed in this study are explained in detail in the hope that they will provide some assistance to workers who may be experimenting with linear programming for the first time. The procedures used in the five examples presented here are not without their defects - indeed if the investigator were to tackle these farms again he would undoubtedly revise certain of the procedures. It is hoped nevertheless that they will be of value to those who will be developing their own procedures for linear programming farms.

This report would not have been possible without the co-operation of the five farmers whose farms have been used to illustrate the application of linear programming. Their help both in providing the basic data and later in permitting publication of the sections on their farms is very warmly acknowledged. The help given by other members of the Agricultural Economics Section, by Mr.R.Holliday and by the staff of the Electronic Computing Laboratory must also be acknowledged here.

W.Harwood Long

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C O N T E N T S

PLANNING PROFITABLE FARMING SYSTEMS
(5 Examples of the Use of Linear Programming)

1. INTRODUCTION

There are wide variations in the profits achieved by farmers even among those who are occupying farms of a similar size and potential. Partly these variations spring from the fact that some farmers are better than others at the technical jobs of growing good crops, managing livestock efficiently and at marketing. They are however, also a reflection of the many different combinations of stock and crops found on different farms. While it is true that farming systems can be classified into broad general types, it is rare indeed to find even two farmers who are adopting a pattern of cropping and stocking which is identical in all respects. Some systems however, undoubtedly make a more profitable use of the available resources than do others but the problem of identifying these profitable systems for adoption on a particular farm is difficult.

It is not sufficient to locate the farms where high profits are being made and then set these up as examples to be followed, for the opportunities open to individual farmers are not the same, nor are their personal aims. It is admissable in most circumstances, to regard the maximising of the farm profits as the paramount goal of the farmer but it is important to recognise the narrow context within which this goal is sought. The farmer's attitude to risk, breadth of experience, level of education, willingness to depart from traditional methods and other subjective factors all limit the bounds within which he is likely to develop production on his farm, quite apart from the restrictions arising from the availability or otherwise of capital, buildings, equipment and other tangible factors. Once a farmer is established his future plans are likely moreover to be highly influenced by his current system of farming. In spite of these narrow bounds, the choices facing the average farmer when he makes decisions on the crops to grow and the stock to keep are numerous and while the value of ad hoc reasoning should not be minimised, the use of some form of systematic approach to locating the combination likely to be most profitable would seem advantageous.

One such systematic approach is represented by linear programming, a mathematical technique which has found widespread application in economic problems involving the allocation of scarce resources. In using linear programming the assumption is made that there are a limited number of possible enterprises or activities each with a specified unit revenue, which can be considered for inclusion in the system to be adopted on any particular farm. The choice of these activities and their respective levels will be restricted both by the limited resources of that farm and by specific restrictions introduced to ensure a feasible and acceptable plan. Within these bounds there

will be a unique optimum combination which maximises the revenue obtained. The revenue function to be maximised, is normally expressed in terms of gross margins. These represent the gross income less the variable costs which are costs directly linked with the scale of output and include expenditure on items such as purchased feedingstuffs, seeds and fertilisers. Other costs fall into the category of fixed costs and are unlikely to vary significantly in the short run whatever combination of activities is adopted. Such fixed or common costs include regular labour, implement depreciation, rent and the sundry items such as car expenses coming under the heading of general farm expenses. For planning purposes it would be wrong to allocate the fixed costs to specific activities as their magnitude will not by definition be related directly with either the particular combination of activities chosen or by the levels at which such activities are carried on.

The problem to be solved by linear programming is initially set out in the form of a table or matrix such as that given below.

		Barley	Potatoes	Cattle
Gross Margin per Unit	£	32	85	25
Restrictions				
Arable Land	100 acres	1	1	.2
Grass	20 "	0	0	.5
Max.Potatoes	15 "	0	1	0
Labour	5000 hours	11	80	20

This, of course, represents a very simplified example. Here there are three activities to choose from, barley, potatoes and cattle with gross margins per unit of £32, £85 and £25 respectively. There are four restrictions relating to the areas of arable and grassland, potato quota and labour availability, which limit the number of feasible combinations of the three activities. The unit requirements of each activity in terms of the restrictions are set out in the three columns on the right of the table. The data in the table is used as a basis for the calculations which eventually lead to the best solution which is feasible within the restrictions. This maximises the aggregate gross margin.

In actual farm problems the number of rows and columns of data in the initial table is normally considerable and a very large amount of computation is required to reach the optimum solution. For this reason recourse must be had to a high speed electronic computor.

So far in this discussion the term activity has been used synonymously with enterprise but this is not correct. An activity is a specific way of producing a certain commodity resulting in a stated gross margin. Thus a barley activity will refer to barley

grown and harvested by prescribed methods resulting in a specified labour input per acre, and a given expenditure on fertiliser, seed and sprays. Similarly the yield and price received must also be specified. The commodity produced by an activity need not however be something such as barley which is sold off the farm, it can be a product which will enable the scale of another activity to be increased. In the problem set out in the table above, under no circumstances could more than 40 units of the cattle activity enter the final plan since there are only 20 acres of grassland available and each cattle unit utilises half an acre of this. If however a ley activity is introduced as an additional possibility, the cattle limit can be raised by using some of the arable land for leys in order to augment the area of grass. A revised table including the ley activity is given below -

		Barley	Potatoes	Cattle	Ley
Gross Margin per Unit £		32	85	25	- 4
Restrictions					
Arable Land	100 acres	1	1	.2	1
Grass	20 "	0	0	.5	- 1
Max.Potatoes	15 "	0	1	0	0
Labour	5000 hours	11	80	20	2

It will be noted that the ley activity has a negative gross margin of -£4. There is no income from the ley as such so that the gross margin is simply £0 less the variable costs, £4 per acre in this instance. The 1 in the ley column on the arable land row indicates that one unit of ley requires one acre of arable land while the -1 on the grass row indicates that each unit of ley increases the grass area by one acre. The absolute limit on cattle numbers is no longer 40 but 240 as by putting all the arable land down as a ley, the total area of grass can be pushed up from 20 to 120 acres. This of course will not happen unless such a plan results in the highest attainable level of gross margins which would be unlikely.

The concept of setting out in tabular form the constituents of the problem which faces a farmer who has to decide on the form and scale of production and then allowing an electronic computor to take over has an undoubted attraction but it is not without hazard. Once the computor has produced an optimum solution from the data fed to it, there is the temptation to regard this solution as absolute and to forget the imperfections of the data from which it has been derived. It is easy to ignore the many inter-relationships between different forms of farm production and as a result arrive at a false optimum. Elements of risk and uncertainty particularly those due to market fluctuations and variations in weather conditions are hard to resolve. The pace of development in agriculture can rapidly date a plan. Perhaps above all there is the difficulty of setting the initial restrictions so that the