THE USE OF PARAMETRIC LINEAR PROGRAMMING TECHNIQUE FOR THE DETERMINATION OF VIABLE, PARITY AND OPTIMUM SIZES OF FARMS [1]

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ABSTRACT

In the paper an attempt is made to determine, by using the parametric lineara programming (p. 1. p.) technique, certain sizes of farm which could provide the farm family with given income targets set by pre-determined criteria. In particular, three sizes are examined: viable, parity and optimum sizes.

Firstly, the pre-determined income targets of the farm family and the alternative methods for specifying the three different sizes of farm are briefly described. Among the methods, p.l.p. is chosen as the best one to be used for seeking solution to the problem under examination. Its basic merits are primarily pointed out from the farm planning point of view.

Secondly, an application of this method is made on a particular type of farming, namely the family-type sheep farms in the Epirus region of Greece[2]. On the one hand the procedure is fully explained and, on the other, the particular results are presented. Then the usefulness of these results is discussed in both methodological and practical terms.

1. The material of this work is basically derived from my Ph. D. thesis, submitted to Wye College-University of London in 1981.

2. Epirus covers an area of 9204 sq. km., which is 7% of the total land area of Greece.

Thirdly, an assessment of the p.l.p. method is made in connection with other methods and with its static character.

Finally, the paper examines the practical possibilities for and the importance of utilising the empirical results.

INTRODUCTION

There are a number of alternative methods that can be employed in order to determine viable, parity and optimum farm sizes. Basically these are methods that are widely used in tackling farm management problems, particularly those with an emphasis on the allocation and reallocation of resources available to the farmer with the objective of improving the economic efficiency of his farm. Here the parametric linear programming technique is selected for application.

The results presented in this paper are based on a representative sample of family-type sheep farms in the Epirus region of Greece, taken from a farm management survey in 1979.

The purpose is mainly to describe and discuss the problems and the procedures, which can be applied to any type of farming anywhere.

The basic concepts used in this paper are defined in Appendix I.

1. METHODOLOGY

1.1. Income targets of the farm family

In order to apply the procedure for determining viable, parity and optimum farm sizes first comes the extremely important task of establishing the relevant income targets of the farm family.

(i). Viability level of income: By this term we mean that level of farm family income which corresponds to the minimum viable farm size. The minimum viable level of income was determined as being 188,000 drs a year, in order to provide a basic minimum standard of living for the typical farm family in Epirus, on the basis of the annual average household expenditure.

The relevant data were collected directly from the farmers. This procedure of calculation has previously been used by a number of researchers (Kitsopanidis, 1968, India, Uttar Pradesh Agricultural University, 1971, Banerjee and Sirohi, 1975, Marothia 1977) .

(ii). Parity level of income: By this term we mean that level of farm family income which corresponds to the parity income (or parity size) farm. The parity level of income was determined at 292,000 drs a year, which was the average figure per adult person derived from the annual average earnings of employees in industrial and handicraft occupations. This income relates to an adult person working 2,140 hours a year (N.S.S.G., 1978). The so determined parity figure assumes that there is only one wage earner in the non-farm family and that this is the Sole source of income.

(iii). Maximum possible level of income: This level of income corresponds to an optimum farm size and it clearly cannot be predetermined. In this case, by definition, there is no income ceiling as an objective, the maximum possible income being sought.

1.2. Searhcing alternative methods for determining viable, parity and optimus fata sizes

(i). Empirical method

An empirical approach is first examined which might provide rough approximations to «solutions». However, the methodology is so simple that it could hardly be described as a «technique».

As a first step, those farms which are at a viable and parity level of income and those which are not can be identified. This can be done easily once these income levels have been determined.

A further step could then be to determine the required sizes based on a sample of farms, using their average level of performance and incomes. This can be done by dividing the pre-determined income targets by the average farm family income as calculated per unit of farm size. This approach is based on the existing technical and economic efficiency of the farms in the sample. Whether or not the sizes thus determined are above or below the existing size of the average farm, the percentage contribution of the various enterprises remains the same. A substantial assumption in using this approach is that approximately constant returns to scale exist. This may be true within a relatively small range of farm size or change therein.

However, an optimum farm size can hardly be determined empirically, mainly because there is no maximum (optimum) level of income which can be pre-determined. Only if survey data showed that total farm income fell beyond a certain size could an assessment be made, but, again, this would still only be based on existing levels of performance and, more importantly, combinations of enterprises.

(ii). Functional relationships

An attempt can be made to employ functiolal relationships of an explicit mathematical form as away of seeking solutions to the problem under investigation. Such a relationship may clearly be of some value if a statistical significance exists concerning the estimated parameters of any of the mathematical functions used. To do this, a regression analysis procedure is used by the least-squares method.

For the determination of minimum viable as well as parity farm sizes an attempt can be made by seeking a functional relationship between income and size.

As for determining the optimum size, the power function known as the Cobb-Douglas production function can be employed. After estimating such a function the objective function is set to achieve maximum profit. This objective function can give an optimum size, subject to the constraints, by inserting the Cobb-Douglas function. The main reasons why this production function is selected are that :

(a) It is the most popular in farm- firm analyses and it has historically proved to be the best in depicting the physical production relationships in agriculture as it takes into account diminishing returns to scale between inputs and outputs; in other words it expresses the logic or basic mechanics of the agricultural production process.

(b) It very often provides an adequate fit of the data.

(c) It has the advantage of computational feasibility.

(d) Finally, this algebraic model provides sufficient degrees of freedom unused to allow for statistical testing (Beringer, 1956; Heady and Dillon, 1961, p. 228; Yotopoulos, 1967).

The above two techniques, empirical and functional, can be used both for individual enterprises independently and for the farms as a whole. They can give «practical» or «positive» sizes as they rely on the existing farm organisation. However, the determination of optimum sizes by the Cobb-Douglas production function is considered to be a «normative» rather than a «positive» approach (Heady, 1971).

(iii). Programming techniques

Following the use of the preceding techniques, certain programming techniques, namely linear programming (l.p.) and parametric linear programming (p.l.p.), can be employed. These techniques have focussed attention not only on analysing the present farming cropping and stocking policies but also on planning the best possible reorganisation of the farm as a whole.

The main differences between these programming techniques and the previous two techniques are:

(a) The programming techniques take into account, in full detail, the combination of all the alternative possible enterprises and the resources available for the farm as a whole: there is no aggregation, as is the case with the other two methods, and no planning procedure is applied to a single enterprise: and

(b) The programming techniques seek to achieve optimum combinations of enterprises, i.e. they are «normative» techniques and as such they can be used for determining «normative» farm sizes (minimum viable, parity or optimum), given the optimum reorganisation of the farm.

A brief reference to these programming techniques is made below.

Linear programming

L.p. can produce optimum farm plans for different sizes of farm. Each solution for each size of farm is unique, i.e. for each size of farm a different solution has to be derived, which will probably be different in terms of the proportionate choice of enterprises. The method, therefore, can be applied in steps of various farm sizes to obtain the optimum farm organisation and the income level at each step. By this means it is possible to approximate and determine certain sizes which provide certain pre-determined income levels, bearing in mind that such sizes are associated with the optimum farm organisation in each case.

Parametric linear programming

P.l.p. is a variant on conventional 1. p. Its advantage compared with l.p. is that it produces a series of optimum plans over a continuous range of availability of a resource, e.g. land area or capital. Hence this method is also known as «variable resource programming» (or «variable price programming») (Candler, 1956: 1957,1959, Bolton, 1964, Kitsopanidis, 1965, Barnard and Nix, 1979, p. 241).

It is possible, as an alternative to p.l.p., to re-run a l.p. matrix with several different discrete levels of availability of one or more resources. However, a parametric program has the merit of giving continuously, at any point within the range of the resource being varied, the different optimum farm plans, and thus saves time. This technique has a greater potential application in modal than in individual farm planning (Barnard and Nix, 1979, p. 421).

In this paper the p.l.p. technique is used to investigate possible solutions to the problem of determining minimum viable, parity and optimum farm sizes, bearing in mind that the farms have at the same time the optimum combination of enterprises. It is the merit of the method, we should expect, that these solutios will be obtained more easily, quickly and precisely than by using l.p. The results obtained by p.l.p. should be seen to be extremely important and useful in both methodological and practical terms.

2. APPLICATION OF PARAMETRIC LINEAR PROGRAMMING TECHNIQUE

2.1. Assumptions and Constraints - Data used

The main assumptions made in this study are as follows:

(i) The farmers' objective is to maximise their income, subject to a number of constraints (e.g. personal preferences, physical conditions, crop rotations, labour available, etc.). In addition, normative behaviour and perfect knowledge on the part of the farmers is assumed.

(ii) «Technological homogeneity» exists on all farms, i.e. each farm has the same production possibilities, the same type of resources and constraints, the same levels of technology and the same level of managerial ability. It is further assumed that only family labour is available for operating the farm.

(iii). All farmers are faced with the same prices for both outputs and inputs, which means that perfect competition is assumed to exist between them in both output and input markets.

(iv) With regard to income levels, there is no income from any source other than farming.

Most of these assumptions are reasonably realistic as long as we are dealing with a particular type of farming in a homogeneous area.

The main c o n s t r a i n t s imposed on the sheep farms of Epirus are: (a) climate, topography, soil type and the knowledge and skills of the farmers; these allow only a limited number of enterprises to be selected by the farmers in the region; and (b) the present area of land per farm, both irrigated and non-irrigated, and the existing amounts of labour used in farming; these have to be taken as the maximum supply of each available on the farms: however, a maximum resource supply does not apply to capital, particularly working capital.

The d a t a u s e d in this paper are based on a representative sample of 23 family-type sheep farms in the mountainous zone of the Epirus region of Greece, taken from a farm management survey in 1979. Epirus is located in the north-western part of Greece. It covers 7 % of the total land area of Greece and it is the most mountainous region among the ten large administrative regions of the country. The region is to some extent homogeneous, particularly with respect to each geographic zone (plain, semi-mountainous, mountainous), as regards soil type, type of farming, narrow area ranges of farms, farmers' educational level, family members' composition, etc. Small family farms prevail in the whole area and there is a traditional dominance of sheep-t6 e farms. These farms, while sheep represent the main enterprise, tend to combine both crop and livestock production in a farming system which secures advantages of technical, biological and economic nature.

Table 1 depicts the main characteristics of the sample of farms at the average level. The average farm size of the sample, in terms of arable land, is close to the overall average of full-time farms in Epirus.

As well as the arable land, the farmers utilise mainly common land pastures for grazing sheep. In general, sheep are kept outdoors for approximately seven months of the year (usually from mid-March to mid-October) grazing in flocks on the pastures and indoors during the remainder of the year, when they are fed on hay and concentrates. Common land pastures are of primary importance in securing a favourable economic result for the traditional livestock enterprises in Greece, particularly sheep (Zioganas and Papanastasis, 1979).

TABLE 1 Family composition and farm enterprises (averages per farm)

Items	Mountainous area (23 farms)
Family members	
Total number	4.83
Adult males working on farm (1)	1.22
Adult females working on farm (1)	0.85
Farm enterprises (str.)	
Lucerne irrigated	4.50
Maize irrigated	0.30
Potatoes irrigated	0.80
Lucerne	10.70
Barley	3.50
Wheat	1.70
Tobacco	-
Vines	-
Forage	15.50
Total crop	37.00
Sheep (no.)	188
Irrigated land (%)	15.00
Number of parcels of arable land	4.74

(1) by working members are meant adults with a normal efficiency. The available labour of one member is 2300 hours, or 287.5 SMDs a year.

Although the productivity of pastures is small relative to the arable land, they provide the basis for making sheep farming profitable.

As far as income criteria are concerned, the most realistic approach is to consider farm family income. Farm income as a criterion shows the «potential» sizes, if all the factors of production used belonged to the farmer.

2.2 Description of the technique

The technique has already been referred to earlier (Section 1.2), as a tool that can be used to help determine optimal farm reorganisation. The most important point, to repeat, is that the technique is basically l.p., differing only in that it is possible to vary a resource (parameter) and, consequently, obtain a continuous series of optimum plans corresponding to the successive levels of that resource, when all other constraints are assumed to remain fixed. This modified simplex method may be described as continuous, or variable resource, programming and has the advantage that all optimum plans can be determined as the supply of one scarce resource varies continuously from zero to the maximum economically rational amouny (Headt and Candler, 1958, p. 233: Bolton, 1964). By varying one resource the enterprise mix of the farm changes, until no addition to total net revenue is obtained from further increases in that resource, or until no additional plans are required. All relationships between any two concecutive optimum plans obtained are linear. Therefore, any plan for any point between two computed plans can easily be determined by interpolation. At any point the enterprise mix is determined from the previous optimum and the magnitude of each enterprise is determined by the rate of change between the preceding and the succeeding optimum plan. Total net revenues can be calculated on the same basis.

In this work arable land is the variable resource, and the results achieved by varying the quantity of this resource over a wide range, with other constraints remaining fixed, will be shown. The objective is to specify optimum plans for sheep farms in the Epirus region, where these farms, except for their area of arable land, are to a substantial extent homogeneous. Here p.l.p. is applied to farms in the mountainous zone (which covers 76 % of the total region of Epirus), on the basis of a sample of 23 representative farms.

The matrix for operating p.l.p., which is basically the same as l.p., is presented in Table 2. This matrix is at the level of two men labour available for the average situation and with the average farm's gross margin and labour requirements per sheep. These items are modified on the basis of App. II (Tables 1 and 4). A major

TABLE 2 Linear programming marrix for the average farm in the mountainous area for parametrising arable land

					1	2	3	4	5	6	7	8	9
	Activities:				LUC IRR STR	MAIZE STR	POTATOES STR	LUCERNE STR	BARLEY STR	WHEAT STR	FORAGE STR	SHEEP HD	LANDTR STR
	Net Revenues:				2877.00	2916.00	10222.00	1562.00	634.00	700.00	571.00	1649.00	0.0
	Constraints												
1. LAND TOT	STR	37	≥		0	0	0	0	0	0	0	0	1.00
2. LANDTIE	STR	0	≥		1.00	1.00	1.00	1.00	1.00	1.00	1.00	0	-1.00
3. IRCROPST	STR	0	≥		1.00	1.00	1.00	0	0	0	0	0	-0.15
4. LUCIRTIE	STR	0	≥		1.00	0	0	0	0	0	0	0	-0.11
5. MAIZETIE	STR	0	≥		0	1.00	0	0	0	0	0	0	-0.08
6. POTATTIE	STR	0	≥		0	0	1.00	0	0	0	0	0	-0.05
7. LUCTIE	STR	0	≥		0	0	0	1.00	0	0	0	0	-0.71
8. LAB JAN	HR	270	≥		0	0	0	0	0	0	0	2.20	0
9. LAB FEB	HR	280	≥		0.80	0	0	0.30	0.40	0.50	0	2.10	0
10. LAB MAR	HR	360	≥		0	1.50	0.50	0	0.40	0.50	0.20	2.20	0
11. LAB APR	HR	400	≥		1.70	2.00	1.50	0.30	0.30	0.40	0	2.20	0
12. LAB MAY	HR	450	≥		5.50	3.10	8.20	1.50	0	0	3.80	1.70	0
13. LAB JUNE	HR	450	≥		6.50	5.60	21.60	2.30	0	0	0	1.70	0
14. LAB JULY	HR	450	≥		6.90	5.90	23.50	2.30	0.80	1.40	4.30	1.60	0
15. LAB AUG	HR	450	≥		6.60	2.50	16.70	2.20	0	0	0	1.60	0
16. LAB SEPT	HR	450	≥		4.50	1.30	5.50	1.50	0	0	0	1.60	0
17. LAB OCT	HR	400	≥		0.90	5.00	28.00	0.30	0	0	0	1.60	0
18. LAB NOV	HR	360	≥		0	0.30	0	0	1.10	1.10	0	1.60	0
19. LAB DEC	HR	280	≥		0	0	0	0	0	0	0	2.20	0
20. FORAGTIE	STR	0	≤		0	0	0	0	0	0	1.00	0	-0.22
21. SHEEP	HD	25	≤		0	0	0	0	0	0	0	1.00	0

Footnote: (1) N.R. in drs; drs=drachmas, where 1 dr. is equivalent to approximately 0.67 pence or £1 is equivalent to approx. 150 drs.
(2) STR=stremmas; 1 STR is equivalent to 1,000 sq. metres or 0.1 hectares or 0.2471 acres.

assumption is that, except for sheep, all enterprises have the same gross margin and input-output coefficients per unit (stremma) through the complete size (arable land) variation.

In the matrix all the crop land constraints were varied proportionally to any given arable land size by connecting them by tie-lines to a land transfer activity (an extra column in the matrix). Another point worth mentioning is that the farms are assumed to be operated by the farm family itself, so that a maximum size can be specified which the farm family can manage. Moreover, as has been said, in the plans obtained the best utilisation of any given amount of arable land is achieved, as wound be determined with conventional l.p. This is extremely important, because arable land is the scarcest resource in the region and is difficult and highly expensive either to buy or to rent. It should be borne in mind that the two men farms are those most likely to be met in the region.

23 Building the linear programming model

On the basis of the analysis of technical and economic data of the surveyed farms in Epirus, the l.p. model has been specified for the average farm of the mountai nous area in order to obtain optimum farm plans. This made] is in the form of matrix, as presented in Table 2. As for any l.p. matrix, four types of information were required (Nix, 1967), as follows:

(i). Resources and constraints: These are the limitations within which the farm plan must be operated. Two types of constraints were used here.

First, the maximuum resources available were decided. These refer to total arable land, irrigated arable land and hours of labour per month; for this purpose the average obtained from the sample farms were used, which can be said to relate to the «average farm». Labour is assumed to include only family labour and the relevant figures in the matrix refer to an average of two men labour equivalent, on the basis of App. II (Table 1).

Secondly, the other constraints are mainly rotational, to ensure a minimum degree of crop rotation consistent with maintaining soil productivity, for it is assumed that the farm is a going business» and as such is expected to continue in operation for a long period of years (McPherson and Faris, 1958). The explanation of these constraints is contained in App. II (crop rotation constraints). The remaining constraints relate to a minimum number of sheepe, owing to the type of farming, and to a minimum of forage land in the mountainous area, since no more that half the present average area of forage (approximately 16 str.) can in fact be cultivated with crops in that area.

No maximum constraints are placed on sheep, barley, wheat or forage. Finally, no constraint is placed on circulating capital which can relatively easily be borrowed from the Agricultural Bank of Greece when requested-at least up to the maximum levels likely to be required on these farms.

(ii). Enterprises: As seen from the matrix (Table 2), 8 enterprises are available for selection. The irrigated crops are lucerne (irrigated), maize and potatoes, while all the other crops are non-irrigated. All the above enterprises were found on the average farm and are the usual ones found on the sheep type of farm in the region. All crops and sheep are considered independently on the supposition that their inputs are bought and their products are sold, i.e. no intermediate ties are examined, particularly between sheep and those crops which provide foodstuffs for sheep (maize, barley, lucerne and forage). This has been done deliberately for the following reasons. First, there are so many alternative ways of connecting the sheep with the above crops (i.e. alternative methods of feeding, or combination of feeds) that it becomes an extremely complex problem to include them all in the matrix. Second, apart from this being a much simpler way of tackling the problem (indeed the alternative may have proved to be virtually impossible), it also allows us to consider more clearly the opportunity costs and to produce more readily the most profitable, optimum combination of enterprises. Third, a great deal of foodstuffs are in fact bought for sheep. Finally, the purchase prices of some of the foodstuffs (maize and barley) are very low compared with their sale prices, since they were subsidised by the State.

Any differences in profit obtained by feeding sheep with homegrown foodstuffs can be worked out after the optimum combination of enterprises has been selected by l.p.

(iii). Net revenues: These are simply the gross margins, i.e. enterprise outputs minus variable costs per unit of each activity as shown in the matrix and in App. II (Table 2). Thegross margin per unit for each enterprise is taken as the average of the surveyed farms.

(iv). Resource requirements: These, also called «input-output coefficients», are presented in the matrix. The labour requirements in hours per month are shown in App. II (Table 3). The most appropriate labour hours required and gross margin achieved per sheep in relation to the number selected are approximated by trial and error, through re-running the l.p. matrix until the right «fit» was obtained in each case. The relevant figures are shown in App. II (Table 4). An attempt was made to achieve the same result by including different size-groups as separate activities in the matrix, in order to tackle the problem of economies of scale, but this was found not to work as expected.

2.4. Empirical results

Table 3 presents the optimum plans with arable land varying upwards from 1 str. The maximum area reached, without breaking the proportion of irrigated

TABLE 3 Optimum plans of two men sheep farm in the mountainous area with arable land area varying

Arable land, enterprises and economic efficiency factors		1	2	3	4	5	6
I.	Total arable land (str.)	1.00	60.70	62.10	65.52	84.80	94.20
II.	Enterprises (str. or no.)						
1.	Lucerne irrigated	0.02	1.19	-	-	-	-
2.	Maize irrigated	0.08	4.86	4.91	1.31	5.92	1.07
3.	Potatoes irrigated	0.05	3.04	3.10	3.27	-	-
4.	Lucerne	0.63	38.26	40.43	46.52	60.21	66.88
5.	Barley	-	-	-	-	0.02	5.53
6.	Forage	0.22	13.35	13.66	14.42	18.65	20.72
	Total (str.)	1.00	60.70	62.10	65.52	84.80	94.20
7.	Sheep (no.)	123	123	123	123	123	123
III.	Econ. effic. factors (drs)						
1.	Gross margin	204289	318386	319368	320556	324346	325285
2.	Farm family income	172198	267585	268207	268272	268288	268720
3.	Farm income	195551	297245	297943	297951	297988	298022
4.	MVP(1) of land (drs/str.)	1912	717	348	197	100	0
5.	MVP to rent (2) of land ratio	4.61	1.73	0.84	0.47	0.24	0
6.	Gross margin per man	102145	159193	159684	160278	162173	162643

(1) Marginal value product.
(2) Average rent of land: 415 drs/str.

crop land constraint, is 94.20 str. There are 6 different plans with their corresponding combinations of enterprises as well as the most important economic efficiency factors in the table. The graphical presentation of the crop mix is shown in Figure 1.

Gross margin, farm family income and farm income are also presented graphically in Figure 2, and the marginal value product of arable land in Figure 3.

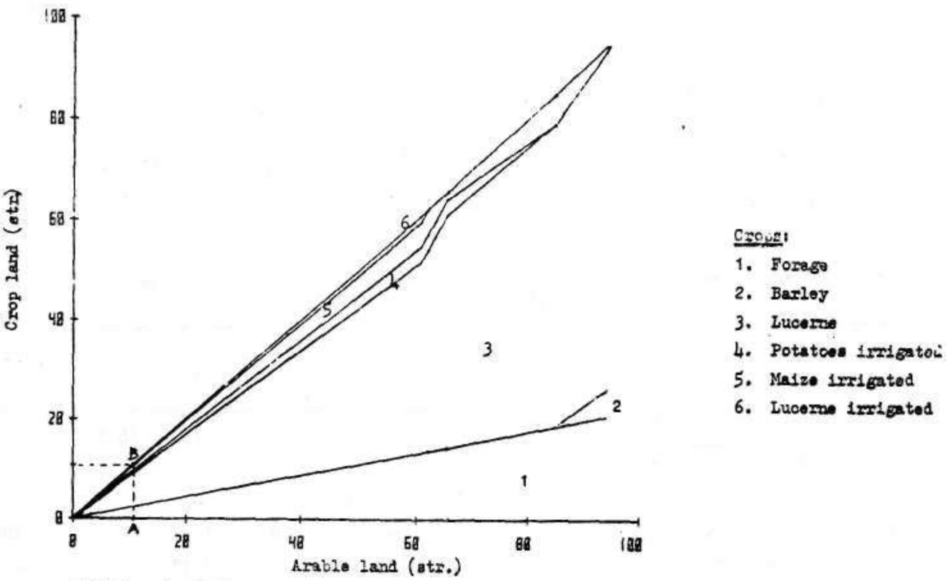

FIGURE 1 Optimum crop combinations of two men sheep farm in the mountainous area with arable land area varying.

As the area of arable land varies, the optimum combination of enterprises thus changes at 6 levels. As might be expected, when the farm size is small, labour intensive crops (potatoes, maize) are selected, since the gross margins of these crops per land unit are higher than the other crops and thus they utilise more effectively the land resource, which is very limited in relation to the other resources As the size increases, less labour intensive crops (forage, lucerne, barley) gradually appear in the enterprise mix, substituting for the above crops. This is because arable land is no longer so limiting, whereaslabour becomes relatively more limiting and thus those enterptises are selected which give higher margins per labour unit. Sheep are not shown in Figure 1; this enterprise is constantly selected at a number of 123 through all size variations. This expresses the strong competitiveness of sheep against crops and their high economic efficiency. The maximum labour constraints in certain months prevent the selection of more sheep at the expense of arable land.

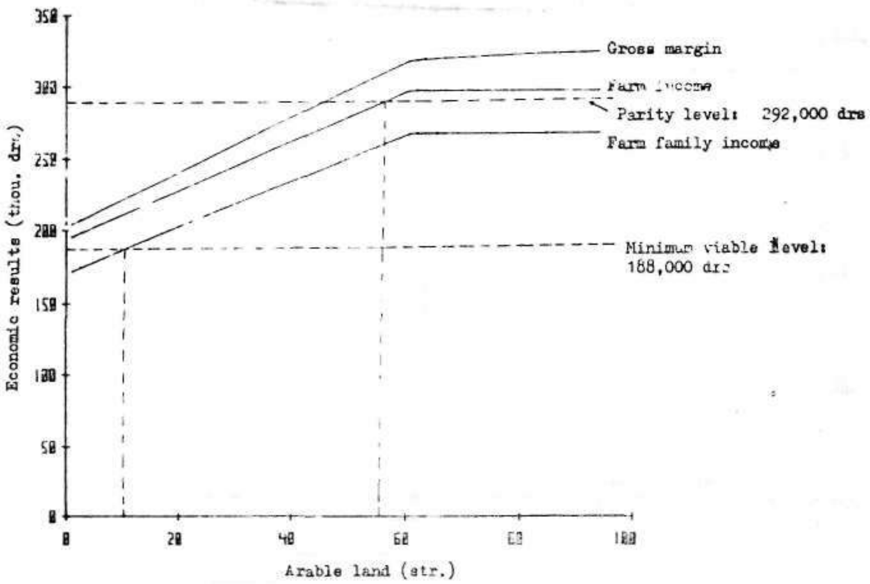

FIGURE 2 Economic results of two men sheep farm in the mountainous area with arable land area varying.

The economic measures shown in Figure 2 continuously increase but at a decreasing rate. In other words, after each change in the optimum plans, the (upward) slopes of the lines decrease. The slope of the «curve» (i.e. each linear segment of line) reflects, or records, the change in income per unit of resource (land) change; that is, it corresponds to the marginal productivity of land. It could be said that the curves correspond to the law of diminishing returns, even at linear discrete intervals here, owing to the linearity assumption. The marginal value product of land (Table 3 and Figure 3) falls in steps, i.e. by linear segments, due to the fact that the marginal value product between any two consecutive optimum plans is constant (again because of the linearity assumption).

Next, the minimum viable, parity and optimum sizes can be determined.

Minimum viable size: As we have seen, the minimum viable size should provide the income target of 188,000 drs. Based on the data in Table 3 and Figure 2 this level of income lies between optimum plans 1 and 2 when thefarm family income criterion is used and before plan 1 (i.e. with 120 sheep alone) when the farm income criterion is used. The corresponding minimum viable size and plan is determined by interpolation and presented in Table 4.

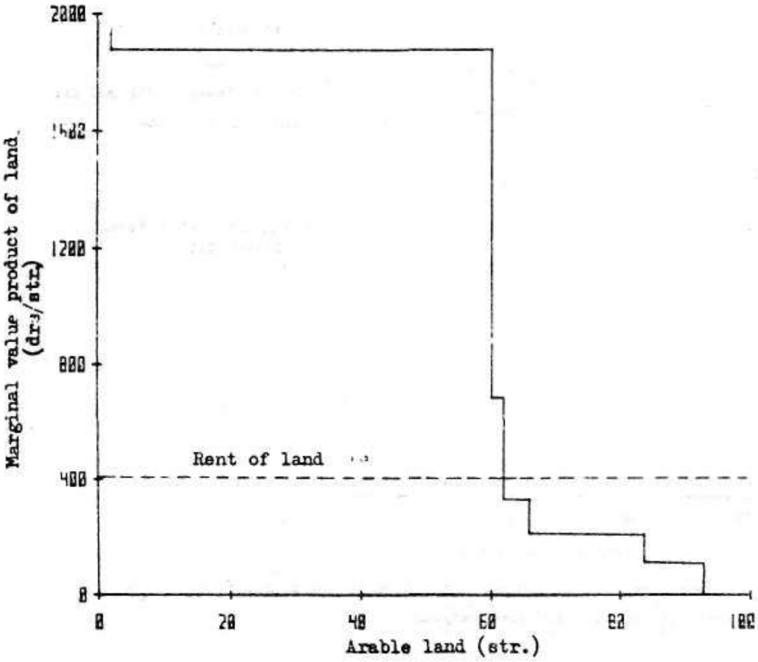

FIGURE 3 Marginal productivity of arable land of two men sheep farm in the mountainous area with arable land area varying.

TABLE 4

Minimum viable size of two men sheep farm in the mountainous area

Enterprises (str. or no.)	F.F.I. criterion
1. Lucerne irrigated	0.21
2. Maize irrigated	0.87
3. Potatoes irrigated	0.55
4. Lucerne	6.86
5. Forage	2.40
Total (str.)	10.89
6. Sheep (no.)	123

They are also presented graphically (in terms of only arable land, i.e. excluding the sheep) in Figure 2. Also in Figure 1 a graphical solution is presented, as an example, on the basis of the farm family income criterion, where both the total area of arable land and the areas of the separate enterprises contained in the optimum are shown. These are given by projecting onto the vertical axis horizontal lines from the points where the vertical line AB cuts the crop lines.

Parity size: This sizes is not reached with the farm family income cririon but only with the farm income criterion, as can be seen in Table 3 and Figure 2. The relevant results for parity size with the farm income criterion are presented in Table 5.

TABLE 5

Parity size and parity ratio of two men sheep farm in the mountainous area

Enterprises (str. or no.)	F. I. criterion
1. Lucerne irrigated	1.13
2. Maize irrigated	4.61
3. Potatoes irrigated	2.89
4. Lucerne	36.32
5. Forage	12.67
Total (str.)	57.62
6. Sheep (no.)	123
Working hours	3705
Parity ratio	0.58

The parity ratio shows that labour in sheep farming earns far less per hour than the average of labour employed in the other sectors of the economy. This implies that farmers must increase their efficiency of production and / or must be given higher product prices than at present, in order to reach or at least approximate to a unity parity ratio on a per hour of work basis.

Optimum size: As can be seen in Table 3, the maximum farm size that two men can manage to farm is 94.20 str. of arable land, plus 123 sheep. However, an optimum size cannot be determined regardless of the level of marginal productivity. The optimum size should be at tha of arable land is equal to the rent of the land prevailing in the area. The rent is an opportunity cost for the owner-occupier and an actual cost for the tenant. According to Table 3 and Figure 3, the optimum farm size is plan 3, which consists of 62.10 str. arable land and 123 sheep, the particular crop mix being:

Maize irrigated	4.91	str.
Potatoes irrigated	3.10	str.
Lucerne	40.43	str.
Forage	13.66	str.
Total	62.10	str.

Above this size the marginal productivity of land is lower than the rent (415 drs). This means that it does not pay two men farmers to rent or buy extra land beyond the above size (assuming the annual cost of buying land is equal to annual rents), and that those already having more land than this (and without the opportunity of employing more labour) are likely to be able to rent or sell their surplus land at prices in excess of its intrafirm marginal value productivity.

2.5 Practical usefulness of the results-Farm models proposed to the farmers

It can be said that a farm model consists of a model plan which indicates the economically optimum enterprises and production processes for a farm with predetermined resources, constraints and techniques (OECD, 1965, p. 98).

All the relevant results have already been presented. These results can, of course, be considered for application in relation to any particular farm case. They can be utilised to obtain the optimum farm plan at any level of arable land area (str.).

However, optimum plans obtained in this way may require modification for a particular individual farm case to fit the particular conditions, namely the resources and other constraints that exist and the techniques used (e.g. the proportion of irrigatable arable land, the soil fertility, crop varieties etc.). Such modifications may be worked out by the use of budgeting, particularly partial budgeting, in which case no computer facilities are necessarily needed. In this context, budgeting can play the role of a tool which is complementary to mathematical programming techniques, such as p.l.p., in order to produce the necessary changes on a particular farm, i.e. those which will lead to the plan likely to be most profitable.

However, it is worthwhile concentrating attention on some of the results to be taken as farm models: those which represent the most common farming conditions in the region. Two different aspects will be examined: one concerning farm models to meet farmers' income objectives, and the other concerning farm models at different levels of arable land area.

(i). Farm models to meet farmers' income targets

For this purpose the farm family income criterion is considered to be more realistic at present than the farm income criterion. Also, the farm models used are those which represent the optimum allocation of resources. The solutions are the minimum viable, parity and optimum sizes of farms with their optimum organisation of resources and enterprises as determined by p.l.p.. the most common amount of labour available being equivalent to two men. These are the farm models, which those sheep farmers with labour available equal to two men, should plan to achieve according to the different income objectives- if, that is, land availability were flexible.

It is assumed that most farmers in Epirus have as their target the achievement of the maximum possible level of income from operating their farms, given the resources at their disposal. This objective corresponds to the optimum farm size suggested by p.l.p.

However, a minimum objective is simply to survive and remain in farming. This relates to the minimum viable size of farm. Above that minimum any farm can be considered to be viable.

It could possibly be argued that a parity income farm is the fairest objective from the social (national or regional) point of view, for in that case the income level is comparable to that obtained in other sectors of the economy outside agriculture.

To repeat, the optimum size, given by p.l.p., is the most profitable level of production of the farm, and therefore neither the minimum viable nor the parity size can normally exceed that size, unless extra labour is used.

(ii). Farm models at different levels of arable land area

The relevant farm plans were presented (given two men labour availability) for the mountainous zone in Table 3. Of great importance are the farms with up to 30 stremmas of arable land, since nearly 80 % of all the farms in Epirus have less than this.

On the basis of that table the computed and presented optimum plans at certain levels of arable land area can be used directly for farms that have approximately the same area of arable land, and, furthermore, any optimum plan can be obtained by interpolation at any level of arable land area. The combination of enterprises can be specified from the previous optimum plan, the magnitude of each enterprise being calculated on the basis of the rate of change between the preceding and the succeeding optimum plan. To take one example: to calculate the area of lucerne (in str.) in the optimum plan at the level of 25 str. arable land from Table 3. This lies between optimum plans 1 and 2 computed at the levels of 1 str. and 60.70 str. respectively. Lucerne is 0.63 str. in plan 1 and 38.26 str. in plan 2, i.e. it increases. In this case the calculations are: ((38.26 - 0.63) x (25 - 1) ÷ (60.70 — 1) = 15.12. Then 0.63 + 15.12 = 15.75 str. of lucerne. Instead of «plus» the last calculation will be «minus» if the magnitude of an enterprise decreases from the preceding towards the succeeding computed plan.

It should be emphasised that the arithmetic is simple and can be followed by agricultural advisors to specify farmers' particular optimum plans at any level of arable land area.

3. AN ASSESSMENT OF THE ALTERNATIVE METHODOLOGY

The particular areas of concern in this section are the comparison between the various methods and an evaluation of the static character of the whole approach.

3.1. Combarison between the alternative methods - which is the most appropriate methodology ;

The methods which can be applied refer either to the existing farm plans, i.e. prior to any whole-farm adjustments, or to optimally reorganised farm plans, i.e. after whole-farm changes. The former relate to the determination of «practical» or «positive» sizes (at minimum viable, parity or optimum levels), whereas the latter relate to the determination of «normative» sizes (at the three levels). The two cases will now be examined separately.

Methods determining «positive» sizes: The problem for the farm as a whole, particularly regarding the sheep type of farming examined in the present study, becomes complicated. The complication lies in the farm size measure on the one hand and in the combination of the different enterprises constituting the farm on the other.

Using the empirical method, when assuming that constant proportions govern the changes in all the magnitudes of the farm's inputs and outputs, it is possible to reach solutions, but these can of course only be considered to be rough approximations, not reflecting a precise confrontation of the problem. Size is determined as a combination of arable land area and sheep numbers, the arable land consisting of certain constant combination of crop enterprises.

Using functional relationships between total income and farm size, the problem may be far more difficult. In the first place, farm size is expressed in terms of stremmas of «adjusted arable land», by combining arable land and sheep into a single measure, through converting sheep into an equivalent area of arable land. However, even though total income proves to be highly correlated to «adjusted arable land» (farm size), the problems remain as to how to divide the latter between arable land area and sheep and what combination of crops should be grown on the arable land in order to give a clear description of what in fact constituted either a minimum viable or parity farm. This problem is met by applying constant proportion on the basis of the average farm as there appears to be no alternative. However, the weakness of this «solution» is obvious. Thus it fails to identify and describe at any level of farm size the appropriate combination of the different enterprises. In other words, the relationship between income and farm size is calculated by estimating the best fit equation, whereas linear relationships are assumed between income and the levels of the different enterprises on the farm.

It is, therefore, reasonable to conclude that the results obtained by the empirical method are more realistic than those given by functional relationships.

With regard to optimum sizes, the data obtained from the farms do not enable their determination by either empirical method or functional relationships, unless perhaps the available data do reach a size level beyond which total farm income begin to decline.

Methods determining «normative» sizes: Entirely different methods are used for determining «normative» sizes. These are: the Cobb-Douglas production function, l.p. and p.l.p. The first is used for determining optimum sizes, the second for determining minimum viable and parity sizes, and the third for determining minimum viable, parity and optimum sizes all together.

As a method to specify an optimum farm size, the Cobb-Douglas production function has two major weaknesses. First, the constraint of keeping fixed total costs at the average farm's level means that the method has very limited value compared with determining optimum sizes without such a constraint, as with the application of either l.p. or p.l.p. Second, apart from any points for or against this method in an aggregate form, it does not specify the optimum allocation of resources within the particular enterprises nor desirable changes in the enterprise mix. Therefore, the method should be seen as providing only some orientation towards, or preliminary indication of, the optimum size. It is far from perfect in terms both of defining at all precisely total farm size or the required enterprise combination. As such it can only be recommended either as a preliminary stage (not at all always necessary, however), followed by a complete programming technique, or when the input and output data are only available in an aggregate form (i.e. unsuitable for building programming models). However, in the latter case too, the results would still only have an indicative value and could be entirely misleading, unless the results are statistically significant. The method might have a greater value at the regional or national level than at the individual farm level, in terms of indications of potentially worthwhile changes in resource use on a larger scale, but this would only be a matter of degree.

L.p. only gives approximate figures when determining minimum viable and parity sizes in the sense that at those levels the enterprises might differ somewhat from being at an optimum combination. But is is not expected that such differences are substantial in practical terms.

Finally, p.l.p. has two advantages compared with l.p. as far as the purposes of this study are concerned. One is that not only minimum viable and parity sizes but also optimum sizes are determined. The second is that the optimum combination of enterprises is specified precisely at all of these sizes. Since the same data are required for these two programming techniques and the same basic matrix is constructed (with only minor changes for computational purposes) it would appear always preferable to use p.l.p., for the reasons stated above. Only if there seemed to be any practical difficulty about implementing the optimal plans would there be any doubt, but this should have been taken into account in constructing the matrix.

To summarise, both programming techniques are much better and more successful than the empirical and functional relationship methods. They are precise mathematical techniques, which determine in detail the optimal enterprise mix at each farm size level required. The most appropriate method is p.l.p.

3.2. Dynamic versus static approach

(i). The dynamic situation and its relevance to the present study

The present study is «static» as far as its alternative types of methodology is concerned. It simply refers to the manipulation of one year's data obtained in the past, though the findings should certainly have for the present and the near future. The methodology applied here is indeed static in nature, whereas the farm is operating in a dynamic framework. First, viable, parity or optimum farm sizes must all contain a dynamic element, since they are varying and evolving continuously over time according to many factors, such as changing cost /price levels, economic conditions of agriculture, the introduction of new production techniques, changes in social trends, stages of economic growth and development and, generally speaking, the overall state of the economy (Carter, 1968, p. 15; Bergmann, 1969, p. 115; Heady, 1969, p. 570; Heady, 1971, p. 17). Moreover, the dynamic element is combined with a time-lag between starting production and ultimately selling the product, uncertainty as to the future in general, weather variability, etc. (Barnard and Nix, 1979, p. 42). Especially during these years of inflation prices of both input materials and products are rapidly changing. All these characteristics of a dynamic nature threaten to undermine a static study, and their neglect in tackling it may be considered as being a serious drawback of the methods used.

(ii). The feasibility of following a dynamic procedure

With the use of static methods of analysis and planning it is always a problem as to how the resource base, the production systems and the investment patterns, as well as the ultimate economic results, can be modified to accommodate rapidly changing economic conditions. In tackling these problems dynamic (or dynamic linear) programming techniques might be preferred (Throsby, 1968). However, these dynamic techniques tend to involve many difficulties with regard to the data (Carter, 1963; Merrill, 1965; Kingma and Kerridge, 1977). Thus one could argue, without intending to minimise the importance of such techniques, that in the meantime current problems cannot wait until practical dynamic procedures have been improved sufficiently to incorporate into empirical research studies. Furthermore unforeseen economic and technical changes could also upset results obtained from dynamic programming and dynamic linear programming.

As Barnard and Nix (1979, p. 307) underlined, when referring to possible future changes in farmers' plans, «In the longer term additional information is required, such as: the lines of development of most interest to the farmer, his long-term aspirations, his attitudes to the employment of more or less labour, the availability of capital for the acquisition of additional resources and the availability of labour and housing in the vicinity». In discussing dynamic linear programming and dynamic programming (pp. 424 - 429), they also described a number of difficulties and limitations concerning both methodological routine and data requirements (mainly future expectations). The static programming techniques (linear and parametric) do not have such difficulties and limitations. In other words, it appears that at least in practical terms there are still serious difficulties in applying dynamic programming techniques.

(iii). Justification of the validity of the applied static methods

Referring to the above discussion, it becomes clear that instead of using long - term (dynamic) planning techniques (whether «formal», i.e. programming, or «informal», i.e. budgeting), where many factors cannot be foreseen, it is preferable to use a short - term (one year), or static, technique. Furthermore, a series of short - term plans, when applying 1. p. and p. 1. p. methods in such cases can to a large extent incorporate the dynamic element in farming. Such short - term plans can be considered as a valid approach and can be readily applied (Barnard and Nix , 1979, p. 305).

The results in the present study already refer back to the year 1979. Strictly speaking,modifications might be needed every year to keep pace with the dynamic changes in various factors. However, even if these are not made, (and it was not possible to do here) it would be fair to say, knowing the farming of the region, that the results obtained concerning minimum viable, parity and optimum sizes will retain a considerable validity for a least several years ahead, since changes in costs and returns caused by price changes are likely to alter largely in proportion to one another, leaving net incomes in real terms at a similar level to those which exist at present.

4. PRACTICAL IMPLICATIONS OF THE STUDY - EXPANSION FROM THE MICRO - LEVEL (FARM - UNIT) TO THE MACRO- LEVEL (AREA)

It would next be of interest to discuss the importance of and the possibilities for extending the proposed optimum organization and sizes of farms to the area as a whole on the basis of the farm models describet in a preceding section.

4.1. The importance and feasibility of reorganising the sheep farms in general.

In fact, the sheep farms in Epirus comprise a high proportion (approximately 45 %) of the total number of farms in the whole region, while sheep themselves contribute approximately 42 % of the total value of livestock production and 25 % of the total value of crop and livestock production combined.

Therefore, an extension of the optimum reorganisation of sheep farms to the whole region would clearly have a significant impact on increasing income levels not only of individual farmers but also on the income level of the whole region, thus substantially contributing to the improvement of the total economy of Epirus.

As the optimum farm plans mainly and consistently favour expansion of the sheep enterprise, this is in line with the existing agricultural programme for Epirus, which places emphasis on expanding sheep production, and at the same time stresses and confirms the comparative advantage of the region for sheep production, consisting as it does mainly of pasture land. An increase in supply would have no impact on the level of farmers' prices.

It would be reasonable to argue that the value to be gained from studying farm management problems by means of farm models, as proposed above, is in fact enhanced by the fact that these models embrace a section of farming which produces a significant proportion of the agricultural output of the region (Barnard and Weston, 1963, p. 8).

On the basis of the sample of farms used in this work, the aim was to identify the major characteristics of the sheep farms and then, by analysis and planning, to enable generalisations to be made at the regional level relating to possible adjustments to farming policy which would improve incomes. The sample of farms represents a satisfactory degree of representativeness of the sheep-type of farming.

Normally, generalisations concerning the application of optimum farm plans to a whole region are of value provided any aggregation bias in static l.p. models is avoided. According to Day (1963), three requirements should be met to avoid aggregation bias:

(a) «Technological homogeneity» should exist, i.e. each farm should have the sane production possibilities, the same type of resources and constraints, the same level of technology and the same level of managerial ability.

(b) Individual farmers in a group should hold expectations about net revenues per enterprise which are proportional to average expectations.

(c) The constraint vector of the programming model for each individual farm should be proportional to the aggregate constraint vector.

But even if these requirements were wholly met, it would be too much to claim with certainty that aggregation bias can be totally avoided (Buckwell and Hazell, 1972; Barnard and Weston, 1963). No single solution could be expected to cover all farms however carefully the basic model had been synthesised. Instead, a series of solutions is normally required to cover the variations likely to be found on the farms under study. On the latter point, the different farm models proposed above go some way towards facing the problem, bearing in mind always that a particular farm might need to be modified with the aid of budgeting.

4.2. The role of the agricultural advisory services

The findings of this research, especially the optimum reorganisation of sheep farms as given by the above farm models, could only be utilised in practice through the involvement of agricultural advisory services. They should be able to use the results presented in trying to find the necessary «bluprints», or basic guidelines, for giving advice to farmers. In other words, agricultural advisors can be considerably assisted by the solutions offered in the present study to provide a more effective and therefore successful service. It is virtually impossible to conceive that information of this kind could be directly addressed to farmers. Thus the role of the agricultural advisory services is extremely important in helping farmers to meet these major management problems of agricultural adjustment.

Nowadays the management of any farm should involve decision-making in the application of technology, the choice of a proper combination of crop and levestock enterprises and effective business administration and control of the farming operations. Thus the agricultural advisory services should place emphasis on the farm management problems facing the farmers. In particular, their involvement is necessary to advise farmers in the process of planning and developing future operations to attain the full potential of the land, labour and capital resources available and to improve the economic efficiency of their farms.

5. CONCLUSIONS

The minimum viable, parity and optimum sizes of the family-type sheep farms in the Epirus region of Greece have been determined, using the parametric linear programming technique. Also, some other alternative methods have been outlined as fairly applicable.

It is believed, however, that there are many other methods that might have been considered for selection, but the choice made took into account the information available and the feasibility of analysing the results.

This study was kept within the sphere of static considerations and perfect competition in both output and input markets. However, future research might be useful to examine the application of dynamic techniques and techniques relating to risk and uncertainty for answering similar questions.

It should be emphasised that parametric linear programming is an extremely useful technique for attempting to determine all three farm sizes (minimum viable, parity, optimum), not merely in methodological but also in practical terms. In fact no other method seems to be capable of achieving all these results at the same time and to be so specific as regards the optimum plans. Moreover, the parametric linear programming results enable the optimum farm plan to be readily obtained for any farm size.

The results have showed that sheep are clearly very competitive and profitable, as they are constantly selected at high numbers. Thus the «sheep type» of farm in Epirus does not require a fundamental change in system that would essentially change the type of farming practised. The sheep are extremely important, as they strengthen the economic position of this type of farming and reduce considerably the area of arable land required to achieve the levels of viability, parity and optimality. Even without any arable land a farm could become viable by keeping a number of sheep above some minimum level. Sheep utilise large areas of poor pasture and this is the basic reason why they are profitable. Consequently, from the agricultural policy point of view, every effort should be made to support the sheep enterprise in the region.

REFERENCES

Banerjee, B.N. and Sirohi, A.S. (1975): «Identificationof Small Farmer in Chandavli Tehsil, district Varanasi» , Indian Journal of Agricultural Economics, 30 (3) : 185-191.

Barnard, C.S. and Nix, J. S. (1979): «Farm Planning and Control», Cambridge University. Press.

Barnard, C.S. and Weston, W.C. (1963): «A Design for Farming», Report No. 61, Farm Economics Branch, University of Cambridge.

Bergmann, T. (1969): «Factors Influencing Optimum Size and Decision—making on Co—operative Farms», Sociologia Ruralis, 9 (2): 114-133.

Beringer, C. (1956): «Estimating Enterprise Production Functions from Input-Output Data on Multiple Enterprise Farms», Journal of Farm Economics, 38 (4): 923 - 930.

Bolton, B. (1964): «Variable Resource Programming for Appraising Farm Adjustment Opportunities», Agricultural Economics Research, 16 (1): 12-22.

Buckwell, A.E. and Hazell, P.B.R. (1972): «Implications of Aggregation Bias for the Construction of Static and Dynamic Linear Programming Supply Models», Journal of Agricultural Economics, 23: 119 -134.

Candler, W. (1956): «A Modified Simplex Solution for Linear Programming with Variable Capital Restrictions», Journal of Farm Economics, 38 (4): 940-955.

Candler. W. (1957): «A Modified Simplex Solution for Linear Programming with Variable Prices», Journal of Farm Economics, 39 (2): 409-428.

Candler. W. (1959): «A New Look at Budgeting from the Standpoint of Linear Programming», Australian Journal of Agricultural Economics, 3: 46-54.

Carter, H.C. (1963): «Representative Farms-Guides for Decision Making», Journal of Farm Economics, 45 (5): 1448 - 1455.

Carter, P.G. (1968): «Small Farm Viability - Its Estimation and Relevance to Structural Policy», M. Se. dissertation, University of Cambridge.

Day, L.M. (1963): «Use of Representative Farms in Studies of Interregional Competition and Production Response», Journal of Farm Economics, 45 (5): 1438-1445.

Heady, E.O. (1969): «Agricultural Policy under Economic Development», Iowa State University Press, Ames, Iowa, U.S.A.

Heady, E.O. (1971): «Optimal Sizes of Farms under Varying Tenure Forms, Including Renting, Ownership, State and Collective Structures», American Journal of Agricultural Economics, 53 (1): 17-25.

Heady, E.O. and Candler, W. (1958): «Linear Programming Methods», Iowa State College Press.

Heady, E.O. and Dillon, J.L. (1961): «Agricultural Production Functions», Iowa State University Press, Ames.

India, Uttar Pradesh Agricultural University (1971): «Problems and Prospects of Small Farmers in two Regions of Uttar Pradesh in 1969 - 70», Pantnagar, Uttar Pradesh, India, Agro-Economic Regional Survey (1971), No. 2.

Kingma, O.T. and Kerridge, K.W. (1977): «Towards an Analytical Base for Studying Farm Adjustment Problems — A Recursive Stochastic Model of the Farm-Firm», Quarterly Review of Agricultural Economics, 30 (2): 91 -116.

Kitsopanidis, G. (1965): «Parametric Programming — An Application to Greek Farming», Athens.

Kitsopanidis, G. (1968): (Productivity of Agriculture in Macedonia and Thrace», Athens.

Madden, J.P. (1967): «Economics of Size in Farming», Economic Research Service, U.S. Dept. of Agriculture, Washington.

Marothia, D.K. (1977): «Relative Economic Efficiency of Small Farms in Capital Intensive Economy», Financing Agriculture, 8 (4): 22-25, India.

Merrill, W.C. (1965): «Alternative Programming Models Involving Uncertainty», Journal of Farm Economics, 47 (3): 595 - 610.

McPherson, W.W. and Faris, J.E. (1958): «Price Mapping of Optimum Changes in Enterprises», Journal of Farm Economics, 40 (4): 821-834.

N.S.S.G. (1978): «Statistical Yearbook of Greece», Athens.

Nikolitch, R. (1965): «The Adequate Family Farm-mainstay of the Farm Economy», Agricultural Economic Research, 17 (3): 84-89.

Nix, J. (1967): «Linear Programming», Farm Management, 1 (2): 4-13.

O.E.CD. (1965): «Advisory Work in Farm Management», Series 77, Paris.

Throsby, CD. (1968): «Dynamic Programming, Activity Analysis and the Theory of the Firm», Review of Marketing and Agricultural Economics, 36 (1): 20 - 27.

Yotopoulos, P. (1967): «Allocative Efficiency in Economic Development», Centre of Planning and Economic Research, Athens.

Zioganas, CM. and Papanastasis, V.P. (1979): «Contribution of the Common-use Rangelands to the Profitability of Certain Livestock Enterprises and Importance of their Improvement and Proper Management», Geotechnica, No 3, p. 25-31.

Zioganas, C (1931): «The Determination of Viable, Parity and Optimum Sizes of Family-Type Sheep Farms in the Epirus Region of Greece», Ph. D. thesis, Wye College, University of London.

APPENDIX I

DEFINITIONS OF BASIC CONCEPTS

Some basic definitions have been determined, following a critical examination of the relevant literature, as follows.

Fair standard of living: This is taken as the averags living expenditure of farm families in a certain area, taking into account also the standard of living in other occupations, expected movements in prices and some accumulation of capital. However, it has to be recognised that it is extremely difficult to determine precisely a «fair» standard of living as so defined. What seems to be the most important from a practical point of view is to be able to determine a minimum (acceptable) standard of living, which is based on the average expenditure criterion; (the average expenditure of farm families in Epirus is so low, being 188000 drachmas in 1979, that anything less is considered to be unacceptable). Above that minimum a considerable range of what constitutes a «fair» standard of living could be argued.

Family farm: This is defined as a farm on which all the management is provided by the farm family, mainly the head of the family, and almost all the labour required is supplied by the family itself.

Viable farm size: The «family needs criterion» is employed here as the best and the most pragmatic basis for the definition. This is in accordance with the definition given by Nikolitch (1965, p. 84), Madden (1967, p. 8) and Carter (1968, p. 15), with only a small amendment. Thus a viable farm size is considered to be that size of a farm which yields sufficient income to: (a) provide a fair standard of living, (b) meet all farm expenses, including depreciation, maintenance, insurance and interest paid on fixed capital (i.e. excluding interest on farmer's own fixed capital) and (c) provide enough capital growth for new farm investments required to keep in step with technological advance and rising standards of living. However, taking into account what has been said above about determining what is a «fair» standard of living, it would also be difficult to determine precisely a single «viable» farm size. Thus what has been attempted is the determination of a minimum viable farm size, which would provide a minimum level of income sufficient to meet a minimum standard of living and the items (b) and (c) above. Beyond the so-determined minimum viable farm size any size is viable.

Parity income (or parity size) farm: This is a farm which provides the farm family with approximately the same level of income as the non-farm family, on average, in the same region.

Optimum farm size: A farm is considered to be of an optimum size at that size where it produces the maximum possible income, given a certain level of fixed resources, particularly family labour, devoted to the farm. This a definition with a clear objective from the farmer's point of view.

All the above definitions, as bases for determining the corresponding real figures, take on far more meaning when we come to deal with a particular type of farming in a homogeneous area.

Farm family income: This represents the sum available to remunerate the farmer's labour and that of his family, together with the use of his own land and own capital invested. It is obtained after subtracting from the gross output (farm) or enterprise output (enterprise) all costs of production, excluding the value of family labour and the reward (rent and interest) for the farmer's own land and capital. Another way of obtaining the farm family income is by subtracting from the gross margin the fixed costs, excluding the same items as above.

The importance of this economic measure is that it represents the «pure» income the farm family is able to take from the farm. It has been found highly appropriate, particularly in Greek farming, because the labour is provided almost entirely by the family and the farmers are mainly owners-occupiers on family-type farms. It is the level of this income which determines the family's standard of living. In fact, it determines the maximum level of consumption by the farm family without affecting the farm property. Moreover, the farm family has to rely on the farm family income in order to meet living expenses and to provide the source for any savings , investment and increase in net capital, assuming there are no other sources of income. This concept has been used for determining the minimum viable and the parity income size of farm needed to provide the corresponding levels of income, as previously defined.

Farm income: This represents the amount available to remunerate the family and hired labour and the use of the land and capital, whether rented or borrowed or not. It is obtained after subtracting from the gross output (farm) or enterprise output (enterprise) all costs of production, except the reward (wages, rent, interest) for the factors of production (labour, land, capital) employed in the farm, or after subtracting from the gross margin all fixed costs, except the same items as above.

This income concept expresses the total remuneration for all the factors of production employed' When all the factors of production are provided by the family, the «farm income» and the «farm-family income» are the same. These two concepts are the best measures of comparative profitability between family farms. (It is to be noted that «farm income», as defined above, differs markedly from «net farm income», as used in the U.K.).

APPENDIX II

DATA CONCERNING APPLICATION OF PROGRAMMING TECHNIQUES

TABLE 1

Monthly labour hours available by one full-time adult man

J	F	M	A	M	J	J	A	S	O	N	D	Year
135	140	180	200	225	225	225	225	225	200	180	140	2300

Source: Greek Ministry of Agriculture.

Crop rotation constraints

Irrigated lucerne: 5 years «in» followed by 2 years «out», so the maximum is 5/7 of the irrigated arable land.

Maize (irrigated): Can be cultivated every second year, so the maximum is 1 *(2* of the irrigated arable land.

Potatoes (irrigated): Should be cultivated only once in three years, so the maximum is 1 /3 of the irrigated arable land.

Lucerne (non-irrigated): As for irrigated lucerne; thus 5 /7 is the maximum but of the total arable land.

TABLE 2

Gross margins of enterprises in the mountainous area

Enterprises	Enterprise output	Variable costs	Gross margin
A. Crops (drs /str.)			
Irrigated lucerne	3868	991	2877
Maize	5070	2154	2916
Potatoes	19226	9004	10222
Lucerne (non-irrig.)	2669	1107	1562
Barley	1872	1238	634
Wheat	2010	1310	700
Forage	921	350	571
B. Sheep (drs /hd)	2657	1008	1649

TABLE 3

Monthly labour - hour requirements (per str. or head) in the mountainous area

Enterprises	Months												year
	J	F	M	A	M	J	J	A	S	O	N	D	
Irrig. lucerne	—	0.8	—	1.7	5.5	6.5	6.9	6.6	4.5	0.9	—	—	33.4
Maize	—	—	1.5	2.0	3.1	5.6	5.9	2.5	1.3	5.0	0.3	—	27.2
Potatoes	—	—	0.5	1.5	8.2	21.6	23.5	16.7	5.5	28.0	—	—	105.5
Lucerne (non-irrig.)	—	0.3	—	0.3	1.5	2.3	2.3	2.2	1.5	0.3	—	—	10.7
Barley	—	0.4	0.4	0.3	—	—	0.8	—	—	—	1.1	—	3.0
Wheat	—	0.5	0.5	0.4	—	—	1.4	—	—	—	1.1	—	3.9
Forage	—	—	0.2	—	3.8	—	4.3	—	—	—	—	—	8.3
Sheep	2.2	2.1	2.2	2.2	1.7	1.7	1.6	1.6	1.6	1.6	1.6	2.2	22.3

TABLE 4

Gross margin achieved and labour hours required per sheep by group-size (no. of sheep) in the mountainous area

Items	Group-sizes (no. of sheep)							
	50	100	150	200	250	300	350	400
A. Gross margin[1]								
(drs)	2211	1809	1608	1479	1386	1315	1258	1210
B. Labour hours[2]								
1. January	3.7	2.6	2.1	1.8	1.6	1.5	1.4	1.3
2. February	3.5	2.5	2.0	1.7	1.5	1.4	1.3	1.2
3. March	3.7	2.6	2.1	1.8	1.6	1.5	1.4	1.3
4. April	3.7	2.6	2.1	1.8	1.6	1.5	1.4	1.3
5. May	2.8	2.0	1.6	1.4	1.2	1.1	1.0	1.0
6. June	2.8	2.0	1.6	1.4	1.2	1.1	1.0	1.0
7. July	2.7	1.9	1.5	1.3	1.2	1.1	1.0	0.9
8. August	2.7	1.9	1.5	1.3	1.2	1.1	1.0	0.9
9. September	2.7	1.9	1.5	1.3	1.2	1.1	1.0	0.9
10. October	2.7	1.9	1.5	1.3	1.2	1.1	1.0	0.9
11. November	2.7	1.9	1.5	1.3	1.2	1.1	1.0	0.9
12. December	3.7	2.6	2.1	1.8	1.6	1.5	1.4	1.3
Total hours	37.4	26.4	21.1	18.2	16.3	15.1	13.9	12.9

1. According to the equation: $\hat{Y}=6879.16\,X^{-0.2901}$ where $\hat{Y}$ = gross margin (drs/sheep) and X = no. of sheep.

2. According to the equation: $\hat{Y} = 269.20\,X^{-0.5076}$ where $\hat{Y}$ = labour hours per sheep and X = no. of sheep.

(Estimations made elsewhere; Zioganas, 1981).