# SEARCHING ALTERNATIVE METHODS FOR THE DETERMINATION OF VIABLE, PARITY AND OPTIMUM SIZES OF FARMS*

By
CHRISTOS ZIOGANAS
Greek Ministry of Agricultrure

This paper presents and assesses some alternative methods for determining viable, parity and optimum sizes of farms. These have been applied to family-type sheep farms in the Epirus region of Greece (Zioganas, 1981). A few of the results are presented, but the purpose here 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.

## 1. SEARCHING ALTERNATIVE METHODS

There are a number of alternative methods that can be employed in order to determine minimum 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. The methodology used is described below.

### 1.1. 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».

* This paper is based on a Ph. D. thesis submitted to Wye College (University of London) in 1981.

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 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.

### 1.2. Functional relationships

An attempt has been made to employ functional relationships of an explicit mathematical form as a way 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 so called least-squares method.

For the determination of minimum viable as well as parity farm sizes an attempt has been made by seeking a functional relationship between incone and size.

As for determining the optimum size, the power function known as the Cobb-Douglas production function has been 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 in 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, are 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 sonsidered to be a «normative» rather than a «positive» approach (Heady, 1971).

### 1.3. Programming techniques

Following the use of the preceding techniques, certain programming techniques, namely linear programming and parametric linear programming, have been 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.

#### 1.3.1. Linear programming

Linear programming 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.

### 1.3.2. Parametric linear programming

Parametric linear programming is a variant on conventional linear programming. Its advantage compared with linear programming 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 parametric linear programming, to rerum a linear programming 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 study the arable land area of the sheep farms is the resource which is allowed to vary continuously over a certain range of sizes.

## 2. PRESENTATION OF FINAL RESULTS

The results presented in this paper are based on a representative sample of 70 family - type sheep farms in the Epirus region of Greece, taken from a farm management survey in 1979.

These results refer to the three geographic areas, i.e. plain, semi - mountainous and mountainous, with samples of 23, 24 and 23 farms respectively.

Geographically, 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 main administrative divisions of Epirus include four prefectures (Nomos) : Arta, Ioannina, Preveza and Thesprotia.

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 - type 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.

## 2.1. Individual enterprises on the sheep farms

The following enterprises are examined: sheep, irrigated lucerne, non-irrigated lucerne, maize (irrigated) and barley (non - irrigated). These are the most important enterprises on the sheep farms. Table 1 summarises the results as regards minimum viable and parity sizes.

For both minimum viable and parity sizes, only estimated functional relationships t between size and income gave acceptable and valid solutions, whereas results obtained using the empirical method should only be considered as rough approximations to acceptable figures. As far as income criteria are concerned, the most realistic approach is to consider farm family income.[2] Farm income as a criterion shows the «potential» sizes, if all the factors of production used belonged to the farmer.

The parity ratios show that labour used for sheep production and crop production (except barley) is paid much less than the average of labour employed in the other sectors of the economy. This implies that farmers should either increase their efficiency of sheep and crop production or that they should be given higher product prices than at present if they are to reach or at least approximate a unity parity ratio on a per hour of work basis.

Optimum sizes were determined in terms of maximising the profit at the average level of total costs on the farms surveyed. No statistical significance was found as regards optimum sizes, and so the results (not presented in Table 1) have only an indicative value. Furthermore, optimum sizes obtained in this way

1. 2. The results of Table 1 are based on these.

**TABLE 1.** Comparative basic results between enterprises: Minimum viable and parity sizes (str.*).

| Results | Sheep | | | Irrigated lucerne | | | Non-irrigated lucerne | Irrigated maize | Barley |
|---|---|---|---|---|---|---|---|---|---|
| | Plain area | Semi-mountainous area | Mountainous area | Plain area | Semi-mountainous area | Mountainous area | | | |
| Minimum viable size (1) prior to adjustments (str) | 27.9 | 41.0 | 64.4 | 155.6 | 104.6 | 135.8 | 208.9 | 78.4 | 226.5 |
| Minimum viable size (2) after adjustments (str) | 26.7 | 36.7 | 59.3 | 149.5 | 100.6 | 131.0 | 208.9 | 78.4 | 226.5 |
| Parity size (3) prior to adjustments (str) | 52.4 | 87.8 | 151.8 | 247.5 | 162.9 | 216.3 | 325.8 | 122.1 | 350.0 |
| Parity size (4) after adjustments (str) | 50.2 | 78.1 | 140.3 | 237.8 | 156.7 | 208.7 | 325.8 | 122.1 | 350.0 |
| Parity ratio prior to adjustments | 0.68 | 0.62 | 0.46 | 0.89 | 0.60 | 0.30 | 0.61 | 0.64 | 2.07 |
| Parity ratio after adjustments | 0.69 | 0.64 | 0.48 | 0.92 | 0.62 | 0.31 | 0.61 | 0.64 | 2.07 |

(1) Corresponding number of sheep: 90, 114, 140
(2) Corresponding number of sheep: 86, 102, 129
(3) Corresponding number of sheep: 169, 244, 330
(4) Corresponding number of sheep: 162, 217, 305

* 1 str (= 1 stremma) is equivalent to 0.1 hectares or 0.2471 acres.

have only a limited value compared with optimum levels derived without such restrictions, as will be discussed and calculated in the next section.

The results give an idea of what sizes of each individual enterprise could provide certain income targets for the farmer, if it were assumed that the farmer could specialise entirely in a single enterprise. Although this is only rarely likely to be possible or acceptable to the farmer, this detailed enterprise analysis was felt to be worthwhile as a preliminary stage and a possibly valuable precursor to the whole - farm analysis.

**2.2. Sheep farms as a whole**

Minimum viable, parity and optimum sizes of sheep farms have been determined, using different methods, as shown in Tables 2, 3 and 4. All these sizes are given in terms both of arable land area and sheep numbers. The income criteria are the same as for the single enterprises above. Of the «positive» sizes, the most realiltic are those determined by empirical methods. Of the «normative» sizes, those determined by parametric linear programming are the more precise.

As discussed above, when referring to the individual enterprises, the parity ratios (not presented in Table 3) here again showed 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.

With regard to optimum sizes, it has only been feasible to determine «normative» sizes. Of the two methods used, the parametric linear programming solutions undoubtedly form the only precise approach, the Gobb - Douglas method having several weaknesses.

It has, of course, to be remembered that all the sizes presented in Tables 2, 3, 4 assume that the land is distributed between the different crops in a certain manner shown in detailed tables (Zioganas, 1981) but not included in the present paper.

## 3. AN ASSESSMENT OF THE ALTERNATIVE METHODOLOGY

So far the alternative types of methodology have been decided upon and applied to sheep farming in order to find solutions to the problem of determining viable, parity and optimum sizes for this type of farming. One of the objectives of this study has been to examine and test alternative methods which could give

TABLE 2. Minimum viable sizes od sheep farms determined by different methods

| Methodology | Area | Farm size | |
|---|---|---|---|
| | | Land (str.) | Sheep (no.) |
| A. Prior to whole farm alterations (i.e. "positive" sizes) | | | |
| 1. Empirical methods | Plain | 29.2 | 63 |
| | Semi-mount. | 22.8 | 97 |
| | Mount. | 26.2 | 133 |
| 2. Empirical methods after enterprise adjustments | Plain | 28.3 | 61 |
| | Semi-mount. | 20.8 | 89 |
| | Mount. | 24.3 | 124 |
| 3. Functional relationships | Plain | 9.8 | 21 |
| | Semi-mount. | 17.7 | 70 |
| | Mount. | 17.6 | 84 |
| B. After whole farm alterations (i.e. "normative" sizes) | | | |
| 1. Linear programming (av. farm at two men labour) | Plain | 26.9 | 53 |
| | Semi-mount. | 22.6 | 72 |
| | Mount. | 30.2 | 100 |
| 2. Parametric linear programming (two men farm) | Plain | A(1) | A (90) |
| | Semi-mount. | A | A (114) |
| | Mount. | 10.9 | 123 |

(1) A = All sizes (i.e. including the smallest) are above a minimum viable size. These cases do not have any arable land but only sheep, given in brackets, as they have been determined by functional relationships for the sheep enterprise.

TABLE 3. Parity sizes of sheep farms determined by different methods

| Methodology | Area | Farm size | |
|---|---|---|---|
| | | Land (str.) | Sheep (no.) |
| A. Prior to whole farm alterations (i.e. "positive" sizes) | | | |
| 1. Empirical methods | Plain | 45.4 | 98 |
| | Semi-mount. | 35.4 | 151 |
| | Mount. | 40.7 | 207 |
| 2. Empirical methods after enterprise adjustments | Plain | 43.9 | 95 |
| | Semi-mount. | 32.3 | 138 |
| | Mount. | 37.7 | 192 |
| 3. Functional relationships | Plain | 39.0 | 83 |
| | Semi-mount. | 35.0 | 139 |
| | Mount. | 51.0 | 245 |
| B. After whole farm alterations (i.e. "normative" sizes) | | | |
| 1. Linear programming (av. farm at two men labour) | Plain | 41.7 | 82 |
| | Semi-mount. | 35.1 | 112 |
| | Mount. | 46.9 | 156 |
| 2. Parametric linear programming (two men farm) | Plain | 21.4 | 93 |
| | Semi-mount. | 35.2 | 112 |
| | Mount. | N (1) | N |

(1) N = The parity size is not reached.

solutions to the same problem. The methods chosen were those considered to be the most appropriate for use in this particular type of study, after taking into account the data available from a survey of a sample of farms as well as the feasibility of analysing the relevant results.

TABLE 4. Optimum sizes of sheep farms determined by different methods

| Methodology | Area | Land (str.) | Sheep (no.) |
|---|---|---|---|
| After whole farm alterations (i.e. "normative" sizes) | | | |
| 1. Cobb-Douglas production function | Plain | 46.5 | 106 |
| | Semi-mount. | 58.9 | 149 |
| | Mount. | 29.3 | 188 |
| 2. Parametric linear programming (two men farm) | Plain | 126.5 | 91 |
| | Semi-mount. | 82.2 | 112 |
| | Mount. | 62.1 | 123 |

This section consists of a critical assessment of the different techniques applied. The particular areas of concern are the comparison between the methods used and an evaluation of the static character of the whole approach.

### 3.1. Comparison between the alternative methods

#### 3.1.1. Which is the most appropriate methodology?

First it is considered necessary to examine the two basic alternatives, namely, the single enterprise approach and the whole-farm approach.

(i) The single enterprise approach: The assumption in this case was that the farm had only one enterprise. Minimum viable and parity sizes of the main enterprises found on the sheep farms were determined by two methods, namely, empirical method and functional relationships.

On an a priori basis, in the first (i.e. empirical method), constant returns to scale are assumed between total income and size of enterprise. The approach might also be considered to be a «straight-line method», because a linear equation is in fact assumed, of the form $Y=aX$, where $Y$=total income $X$ = size of enterprise and $a$=income per size unit of enterprise (constant term). It should be emphasised, however, that this linearity assumption on the one hand simplifies the problem, enabling a solution to be easily found, but on the other hand it can hardly be accepted as an entirely precise and justifiable technique. Thus the approach gives only a rough, approximate estimate of either a minimum viable size or a parity size of an enterprise. As such it might be recommended for use occasionally, where either few data are available, or computational facilities or time are very limited, bearing in mind, of course, that the specification of the above sizes using this approach is only a rough estimation, and that one does not even know what degree of approximation is achieved.

With regard to the second method, functional relationships were established between enterprise size and income for determining both minimum viable and parity sizes. These functional relationships are expressed in an explicit mathematical form (equation), (though they have also been presented graphically). To estimate such equations a regression analysis by the least-squares method was carried out for each enterprise. For this application the cross-sectional farm management survey data, referring to a number of cases (observations) of each particular enterprise, were fitted and statistically estimated and tested for significance. In this particular case the power equation $Y= aX^b$ for the sheep enterprise and the linear equation $Y = a+bX$ for the crop enterprises had the best fit, where $Y$ = income (either farm family income or farm income), $X$= enterprise size (number of sheep or stremmas of crops), $a$ = estimated constant term (i.e. the intercept on the $Y$ axis) and $b$ = estimated regression coefficient. This approach, by estimating the best fit equation between income and size, is perhaps the only way of seeking a reasonable, acceptable and feasible solution to the problem under examination, on condition that the estimates are statistically significant. The higher the degree of statistical significance, the more precise and reliable are the results.

Undoubtedly, this second method is much more precise and mathematically sophisticated, and thus preferable, compared with the first method, provided, of course, that a satisfactory degree of statistical significance is proved to exist in the estimated parameters of the best fit mathematical model. This methodology is valuable when a considerable number of farms within a wide range of sizes is examined and when exact and reliable data are collected.

As far as optimm size is concerned, the present survey data did not enable its determination by using either empirical methods or functional relationships between income and size, as they did not reveal any decrease in total farm income beyond a certain size. It is believed, however, that an optimum size of an enterprise could in fact be specified within a particular area with technological and managerial homogeneity and with the same maximum amount of labour available, if the data collected covered a sufficiently wide range of sizes. This could of course provide another field for further research.

An attempt was in fact made in this study to determine an optimum size, given an optimum combination of resources, by the use of the Cobb - Douglas production function. «Optimum size», using this technique, means in terms of maximising the profit at the average level of total costs on the farms surveyed. However, optimum sizes obtained in this way clearly have only a limited value compared with optimum levels derived without such restrictions.

(ii) The whole - farm approach: The methods which have been applied for the farms as a whole 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: These are the same methods as were used for individual enterprises, as outlined above. Here again, on the basis of the same procedures, an attempt was made to determine minimum viable and parity sizes. The problem, however, for the farm as a whole, particularly regarding the sheep type of farming examined in the present study, becomes far more complicated than in the case of an individual enterprise. 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 has been 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 relationship between total income and farm size the problem proved to be far more difficult. In the first place, farm size was 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 proved to be highly correlated to «adjusted arable land» (farm size), the problems remained 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 was met by applying constant proportion on the basis of the average farm as there appeared to be no alternative. However, the weakness of this «solution» is obvious. Thus it failed 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 was calculated by estimating the best fit equation, (here the power equation), whereas linear relationships were assumed between income and the levels of the different enterprises on the farm.

The results obtained from functional relationships tended to overestimate substantially the income level in relation to size, without justifying this by defining the combination of enterprises needed to achieve It. is therefore, reasonable to conclude that for the farm as a whole the results obtained by the empirical method were more realistic than those given by functional relationships .This is perhaps another field for further research.

With regard to optimum sizes, here again, as for individual enterprises, the data obtained from the farms surveyed did not enable their determination by either empirical method or functional relationships, simply because the available data did not reach any size level beyond which total farm income began to decline. Once more, further research might be helpful in this connection.

Methods determining «normative» sizes: Entirely different methods were used for determining «normative» sizes, whether minimum viable, parity or optimum. These were: the Cobb-Douglas production function, linear programming and parametric linear programming. The first was 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, as already mentioned above for individual enterprises, 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 linear programming or parametric linear programming. 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 worth while changes in resource use on a larger scale, but this would only be a matter of degree.

Linear programming 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 it is not expected that such differences are substantial in practical terms.

Finally, parametric linear programming has two advantages compared with linear programming as far as the purposes of this study are concerned. One is that non 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 parametric linear programming, 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 for the farms as a whole is parametric linear programming.

### 3.1.2. Data requirements for the procedure to be applied

In order to apply the procedure described in this study for determining viable, parity and optimum farm sizes, there are two main requirements : first, income targets of the farm family have to be established, and, second, appropriate technical and economic data from a sample of farms have to be obtained. However, the first requirement does not apply to determining optimum sizes ; in this case, by definition, there is no income ceiling as an objective, the maximum possible income being sought. And now these two requirements are briefly analysed below.

(i) Income targets of the farm family: As we have seen these income targets are two-fold : the viability level of income and the parity level of income. (In this study these were 188000 and 292000 drachmas respectively).

Viability level of income: This should be determined as a minimum standard of living. This corresponds to the minimum viable farm size. Two sources of information may be, or become, available : either data collected directly from the farmers as part of farm management survey data, or existingjdata from official national statistics about household expenditure surveys on agricultural households. The former normally have the advantages of being relatively recent and relating to specific regions or localities, but they have to be collected. The latter are often not recent data, because such surveys are not carried out in Greece every year ; but on the other hand they are already available for use. In fact they could be utilised by updating the figures using a consumer price index. It should be borne in mind, however, that revising the figures does not completely meet the problem, because changes in the standard of living are not taken into account. It must be emphasised that the minimum viable level of income or minimum standard of living is an important income target and the dividing line between viable and non - viable levels needs to be constantly reviewed.

Parity level of income: This income target obviously needs to be determined if a parity income size of farm is to be specified. This level of income has been defined in this study as the average annual earnings per employee in industrial and handicraft establishments. It appears that the only reliable source of information for such figures is the official national statistics, if any. Again, such figures need to be updated to keep pace with changes in earnings.

(ii) Technical and economic data of farms: To be precise, the single enterprise and the whole farm situations need to be considered sepa-

The case of a single enterprise: When there is only one enterprise on a farm and its minimum viable or parity size needs to be determined, a relatively large number of such farms with a wide size range needs to be surveyed. Detailed and precise data must be collected concerning technical (or physical) and financial performances referring to both outputs and inputs, in order to be able to use them to derive the farm family income and farm income figures, and then to proceed, if possible, to the estimation of the proper functional relationship (equation) correlating income and size, for, ultimately, the satisfactory determination of a minimum viable or parity size. It should be pointed out that the above has most practical value when it refers to a certain relatively homogeneous area and the technology applied in the specific enterprise is also by and large homogeneous.

The case of the whole farm: Here we can describe two areas : first, when «positive» sizes are to be determined, and second, when «normative» sizes are to be determined. With regard to the first, as with a single enterprise, all types of information for the whole farm are required. However, no allocation of inputs is necessary to the individual enterprises on the farms. This also applies to the «normative» optimum size obtained using the Gobb - Douglas production function.

For the «normative» sizes, whether obtained by linear programming or parametric linear programming, some extra information is needed compared with the methods referring only to «positive» sizes. Such extra information refers to each individual enterprise on the farm. It includes specification of enterprise outputs and enterprise variable costs, to derive the enterprise gross margins, and allocation to the enterprises (per unit) of different input requirements (input- output coefficients), such as labour, working capital, building space, etc., in order to be able to build the linear programming model (matrix).

A complete survey of a sample of farms is also required for determining minimum viable, parity and optimum sizes for the farms as a whole. This survey should relate to an homogeneous area and to a specific type of farming and, in addition, representative farms should be selected. Only under such conditions would an attempt at determining such sizes be considered worthwhile and capable of producing useful and realistic results.

All the requirements described above, whether for an individual enterprise or for whole farms with a mixture of enterprises, relate to the typical situation in an area and are based on a sample of farms. It might be possible, however, for applying linear programming or parametric linear programming, to avoid a large survey of farms and select a typical, or modal, farm (Upton, 1978 p. 201). There is no doubt of course that the only reliable way of collecting information relating to a large number of farms of a particular type is by a survey of a representative sample of them. But this requires a lot of effort and staff and is costly compared with the modal farm approach. The latter is a variation of the case study approach. There is of course the difficulty of how to select the modal farm. Such a farm needs to be identified with great care : the researcher should have previous knowledge of the area and substantial experience to make a successful selection of one single farm which will represent all the farms of a certain type in that area. If such knowledge ledge is lacking, a survey must be carried out in the first place in order to find the modal farm. Whatever the case, it would normally be very difficult to find a farm typical in all respects. On the other hand, this approach is much easier, quicker and less expensive than the farm survey approach. It could be useful if one wished to apply programming techniques to more than one type of farming in an area at the same time, by identifying typical farms for each group.

Conclusions : When the requirements outlined above are met, any of the methods applied in this study could be employed in order to determine the required sizes. These procedures can be applied at University level or nationally (and, in Greece, more practically) by agricultural advisory services personnel, provided there are farm management specialists available. Undoubtedly, the methods which have been applied in this study could bemused for solving similar problems for any type of farming. It is believed, therefore, that the work contained in this study could be useful and applicable not only to Greece but to any other country.

**3.2. Dynamic versus static approach**

3.2.1. 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. Each method simply refers to the manipulation of one year's data obtained in the past, though the findings should certainly have value 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 de velopment 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 dynamic nature threaten to undermine a static study, and their neglect in takling it may be considered as being a serious drawback of the methods used.

### 3.2.2. 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, dynamic techniques tend to involve many difficulties with regard to 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.

### 3.2.3. 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 acceptable and perhaps even preferable to use a short-term (one year), or static, technique. Furthermore, a series of short-term plans, when applying linear programming and parametric linear programming, 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 so in this study), 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 at 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. CONCLUSIONS

In order to determine the minimum viable, parity and optimum sizes of the family - type sheep farms in the Epirus region of Greece, it was not intended to use simply one method but all those methods as described above in turn, since one of the objectives of the study was to investigate and test the alternative methods which could give an answer to the same problem. By so doing it has been possible to throw some additional light on the various possibilities that exist, comparing them according to their apparent validity and practical usefulness. In this way it became possible to make suggestions as to which of the methods might best be applied when seeking anwers to similar problems under differing conditions.

It cannot be claimed, of course, that the methods outlined in the present work are the only ones that exist and can be used in considering the question of determining certain farm sizes. There are many other methods that might have been used, 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. It is an example of the application of procedures which might usefully be applied for solving similar problems for any type of farming.

It should be emphasised that parametric linear programming is an extremely useful technique for attempting to determine certain farm sizes, not merely in methodological but also in practical terms.

However, future research might be useful to examine the application of dynamic techniques and techniques relating to risk and uncertainty for answering similar questions.

# APPENDIX

**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 average 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 à minimum (acceptable) standard of living, which is based on the average expenditure criterion ; (the average expenditure of farm families in Èpirus 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 is 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 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 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.).

## REFERENCES


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

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.

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.

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

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.

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

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

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

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

Uptom, M. (1978) : «Farm Management in Africa-The Principles of Production and Planning», Oxford University Press.

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

Zioganas, C. (1981) : «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.