MEASURING EFFICIENCY IN GREEK AGRICULTURE[1]

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1. Introduction

The aim of this article is to examine whether the resources employed in agriculture in a Greek region are used efficiently, and to ascertain which type or size of farm uses these resources the most efficiently. Such knowledge is of great importance in the formation of agricultural policy, since once identified the more efficient farmers can be encounraged to expand and the less efficient ones given incentives to discontinue farming or to adopt the practices of the efficient farmers.

The article is based on data obtained from a random sample of farmers, covering approximately 10.0 per cent of the farms of the region, and refered to the year 1977/78.

2. The Concept of Efficiency

«Economics is in many ways a science of efficiency» [Sampath (1979)1, but the concept of economic efficiency is an «elusive» one in which the economist, the engineer, and the policy maker all have great stakes» [Lau and Yotopoulos (1971)|.

The concept, «economic efficiency», is used at macro and micro level in two main ways:

a) Synonymously with that of productivity [Lund and Hill (1979)1, and a common measure of efficiency is the output per a single input, (eg. yield per cow, output per unit of land or labour, etc.), or, the ratio of output to the total cost; and b) As a ratio of the actual to some potential output, or of the proximity to some optimum [Domar (1962)], and therefore, the efficiency could be measured through a

1. This article draws heavily on a part a ph. D. thesis under the title «Farm Planning and Policy in Greece» presented by the writer to the School of Economics, University of Leeds, UK in 1981.

mathematical functon, [for examples see Yotopoulos and Nugent (1976)], or through the formation of a linear programming model [eg. Sampath (1979)|.
In the first case efficiency is the ratio of actual output to the output expected by an optimum combination of inputs, (when the marginal productivity of each factor is equal o its price), while in the second case, efficiency is the ratio of actual output received by individuals to the output expected by a profit maximising solution.

Other aspects related to economic efficiency are its components.
Farrell (1957), Lau and Yotopoulos (1971), and others divide economic efficiency into two components, namely technical efficiency and price efficiency. Technical efficiency refers to the proper choice of production function. On the other hand, price efficiency refers to the proper choice of input combination.

Regardless of the definition of economic efficiency and its components a major interest of economics is the relative efficiency between groups of entrepreneurs or sectors of the economy (eg. small and large farms, agriculture and industry and so on.) An entrepreneur in any sector is more efficient than another, when with the same amount of inputs, he produces a higher output, or the same output with lower inputs. However, the measurement of relative efficency is a difficult task and the existing methods of measurement are weak both in their assumptions and in the inclusion of all the components of efficiency.

Aware of the deficiencies of the existing methods of measuring efficiency multi-method approach is adopted for this study.

Raising the level of efficiency is very important from the point of view both of individuals and the economy as a whole. Such an increase can result in growth without any corresponding increase of inputs, or, in what Yotopoulos and Nugent (1976) call, «manna from heaven».

The benefits from increased efficiency would be:
1) For the economy as a whole, higher output with the same resources in a sector, or, the same output with less resources and consequently the freeing of resources to be used for other sectors.
2) For individuals, higher returns to their resources and therefore higher incomes.

There is, of course, an argument regarding the latter, that the increase of efficiency will not always mean an increase in the incomes of individuals, because the surplus created by greater efficiency is transferred to other sectors, especially for industrialisation. On the other hand, the objective of individuals is profitability (difference between output and costs), and not efficiency (ratio of output to costs) [Britton and Hill (1975)1.

3. Methods of Measurement of the Efficiency

There are three categories of methods used for the measurement of efficiency of an individual or of a group of individuals namely:
a) Simple methods.

b) Mathematical functions.
c) Linear programming.

This article deals with the first two. More precisely, the folowing methods are used for measuring the relative efficiency between groups of farms:

a) Simple methods.
1) Indices of partial productivity
— value added per worker
— value added per work hour
— value added per unit of land.
2) Index of total productivity
— output per 100 drachmas of inputs.

b) Production functions for the estimation of marginal products and for testing the relative efficiency at the level of the geometric mean of each group of farms.

The two types of methods are used to test the relative efficiency between:
(a) Tobacco growing farms, and
(b) General gropping farms
between
(a) General cropping farms owning machinery (large farms)
(b) General cropping farms hiring machinery (small farms).

4. Simple Methods of Measuring Efficiency

a. Indices of partial productivity

Partial productivity indices are the simplest measures of economic efficiency, but being partial, they cannot be regarded as adequate measures. According to these indices output is compared with one input at a time. The most common examples of this kind of measurement of efficiency are:
(1) Output per unit of land.
(2) Output per unit of labour, and
(3) Output per unit of capital.
[See Lau and Yotopoulos (1971), Paglin (1965, 1967)1.

Although the indices of partial productivity are inadequate measures, the fact that these indices can be estimated easily, makes then very useful, especially when interest in policy is confined to one or two factors of production, such as: productivity of farm labour for social purposes, productivity of land (when there is a surplus of labour and no alternative employment), productivity of capital.

b. Index of total productivity

The average or total index of productivity refers to the ratio of the value of total output to the cost of total inputs.

Examples of using the ratio of output to cost as a measure of efficeincy are: the study made by Kendrick (1961), which refers to the whole economy of the United States, the study by Britton and Hill (1975,1978), which refers to British agriculture, and many studies on Indian agriculture.

This approach has the following disadvantages:

i) The costs of some inputs, such as managerial effort are difficult to quantify in determining total input costs.

ii) It is an empirical technique not well grounded by theory [Yotopoulos and Nugent (1976)|.

However, this approach has the advantages both of making a direct comparison of output to cost, and there are fewer assumptions than in other methods.

5. Tests of Efficiency Using Simple Methods.

a. Assumptions

Agricultural policy in most countries has as its main targets, both the improvement of farm incomes and the economic efficiency of agricultural production. An improvement in labour productivity should lead to an improvement of farm incomes. Therefore, the improvement of labour efficiency is a crucial factor for economic development and social welfare. This increase can be obtained either by the increase of output per unit of land or by the production of the same output with decreased labour.

Bearing this in mind, the following yardsticks of economic efficiency are used:

1) Value added per farm worker, or work hour: Value added per farm worker, is very important for regions without significant alternative employment to agriculture, while value added per work hour is of great importance for regions providing alternative choices of employment, besides agriculture. In the first case each unit of labour is solely devoted to agriculture, while in the second case, part of the work hours per unit can be used productively outside agriculture.

Measurement is made under the following assumptions:

(a) Value added is defined as the return to all factors of production (owned and hired).

(b) Prices of products and inputs are at actual market prices (taking alternatively the cases of inluding and excluding subsidies), and

(c) Comparisons are based on mean values of each group of farms.

Moreover, correlations between area per farm, (regardless of type of farming in each region), and value added per worker and work hour are used. The correlation coefficients are estimated using the form:

$$r = \frac{\sum_{i=1}^{n} (\chi_i - \bar{\chi})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n} (\chi_i - \bar{\chi})^2 \sum_{i=1}^{n} (y - \bar{y})^2}}$$

where

Xi = Observations of variable χ

yi = Observations of variable y

η = Number of farms

$$\bar{\chi} = \frac{\sum \chi_i}{n} = \text{mean of variable x}$$

$$\bar{y} = \frac{\sum y_i}{n} = \text{mean of variable y}$$

2) Value added per unit of land:

The increase of value added per unit of land results in an overall increase of value added in agriculture and consequently in an increase of the contribution of agriculture to the whole economy. However, the existence of quotas (especially in very productive enterprises) gives a false impression about the relation of efficiency and area of land per farm. That is so, because in each type of farming almost all farmers, regardless of area farmed, enjoy the quotas provided by the governments, but as the area per farm increases, less productive, non-quota enterprises have to come intro the farm plans.

In measuring the value added per unit of land, the same assumptions as in measuring value added per worker and work hour are used.

3) Ratio of total output to costs:

The fact that output is the result of more than one input, (which can be substituted), dictates the need for seeking a more objective method of measuring relative efficiency, than that of output per factor of production. Therefore, a ratio of output with an aggregate representing the sum of the costs of all measurable inputs is the most appropriate yardstick.

In this studw, the ratio of output to total costs is used to compare the efficiency between different types of farming under the following assumptions:

(a) Output is equal to produced quantities of products multiplied by the market prices, (both including and excluding subsidies).

(b) Costs are equal to those for purchased inputs plus the estimated depreciation of fixed inputs, plus an inputed cost for family labour and rent of owned land, plus a.cost of owned capital, (6-8 per cent for fixed capital, and 9 per cent for liquid capital, which are the actual rates of interest paid by farmers).

(c) The cost of managerial labour is not inputed, and

(d) All calculations are based on mean values of each group of farms. Moreover, correlations between area per farm and ratios of output to cost are used, regardless of type of farming.

b. The results

Table 1 has been drawn up in order to provide information about alternative simple tests of relative efficiency between different types of farming and size of farms in each type; on the other hand, table 2 shows the correlation between area per farm and indices of efficiency in each region.

Assordingly, it can be said: Tobacco growing farms, (which are labour intensive farms), have a better performance than general cropping farms, in the ratio of output to total cost, value added per worker and value added per unit of land, but they have a poorer performance in value added per work hour (table 1). Moreover, tobacco growing farms take a higher amount of subsidies per unit of land than general cropping farms. Within the general cropping group, farms owning machinery, (which are at the top level of size) have a slightly better performance than the farms which hire machinery, (the difference is not significant, at the level of 0.05) using as measure of efficiency the ratio of output to cost.

However, the only substantial difference in favour of large farms, (owning machinery), is the value added per worker. On the other hand, small farms absorb fewer subsidies per unit of land than the large farms.

With reference to the correlation between the area of land per farm and the indices of efficiency (table 2), it can be suggested that-.the land area per farm is positively correlated with the indices of productivity, apart from the index of value added per unit of land. However, the correlation of area per farm with value added both per worker and work hour are very strong.

On the other hand, the correlation between area of land and subsidies per unit of land is negative.

c. The importance of increasing the relative efficiency in the region.

If the gap between the efficiency of different types of farming or sizes of farms

*General cropping farms represent 63.3% of the total number of farms and the rest are tobacco growing. Their average output is 308682 drs, and the average family farm income is 177956 drs. while for the average farm of the region the respective figures are 325170 and 198169 drs.

TABLE 1

INDICES OF EFFICIENCY OF DIFFERENT TYPES OF FARMING.
(drachmas)

	Average size	Output per 100 drs. input		Value added per worker		Value added per work hour		Value added per stremma		Subsidies per
	(stremmas)	A	B	A	B	A	B	A	B	Stremma
T										
1) Tobacco growing farms.	57.8	119	108	126272	108288	T 72	62	4369	3747	622
2) General Cropping Farms	T 82.6	106	T 97	T 96063	T 78931	104	87	2286	1901	384
a) Owning machinery	128.5	108	T 98	118010	T 96962	106	87	2296	1886	409
b) Hiring Machinery	52.7	105	T 96	T 80097	T 67172	102	87	2280	1912	368
T										

NOTE: A=including subsidies
B= excluding subsidies

TABLE 2

CORRELATION MATRIX BETWEEN AREA PER FARM AND INDICES OF EFFICIENCY

Indices of efficiency T / Area per farm T		Output per 100 drs of cost	Value added per worker	Value added per work hour	Value added per stremma	Subsidies per stremma
Region (60 farms)	Stremmas per farm	0.1361 (0.150)	0.6837 (.001)	0.3395 (.004)	-0.3222 (0.006)	-0.2293 (0.039)

Note: Figures in parenthesis stand for level of significance.

could be bridged, it is expected that increases of national output could be obtained and farm incomes could be increased.
Therefore national resources could be used more productively. For instance:

If the index of total productivity, (output per 100 drs of cost) in general cropping farms increased from the existing 106 to that of tobacco growing farms (value at 119), the output in general cropping farms would be increased by 12.3 per cent, (or on average by 37844 drs per farm), and family farm income by 21.3 per cent. Weighing this increase against the total number of farms in the region*, the total output will increase by 7.4 per cent, and family farm incomes by 12.1 per cent. Within the general cropping farms the difference in total eficiency between large and small farms is not significant.

6. The Use of Production Functions in Measuring Efficiency

a. Introduction

This approach differs in three ways from the previous methods.
Firstly, it indirectly relates costs to output, secondly, it measures efficiency as a ratio of obtained output to an optimum one, and thirdly it examines the efficiency with which the individual factors of prduction are used. However, this method uses some assumptions which are not always realistic. These are the following: (i) The inputs available to individual farmers are not in fixed supply.
(ii) Production takes place under a common technology and two farms using equal quantities of inputs will produce equal quantities of outputs.

Therefore, in a group of farms following the same production function, (eg. having the same fixed inputs), differences in efficiency could be attributed to:
(i) Different degrees of control over resources, (eg. hired or owned resources),
(ii) Market imperfection (different prices); and (iii) Different objectives (managerial or neutral technology).
In measuring the relative efficiency of two groups of farms the folowing procedures can be adopted :-

1) Fitting one production function for both groups of farms: Assuming that all farms follow a production function:

$$Y = F(Xi,u)$$

where Y = output

Xi = inputs

u= unmeasurable factors.

If all factors of production are incorporated in a production function and the only unmeasurable factor, (not introduced into the production function), is managerial ability .and if managerial ability is considered as a measure of efficiency, then a way of introducing this in a production function is by using a dummy variable. This dummy variable (D) can take a value of one, for one group of farms and a value of zero for the other group of farms.

A value of b_d(coefficient of D), different from zero would suggest a difference in efficiency between the two groups of farms.

Mundlak (1961), Hoch (1955), Massel (1967), and others give example of the use of dummy variables in the production function to quantify differences, in efficiency between groups.

(2) Fitting separate production functions for each group: Supposing the existence of two groups of farms: group A=i and group B=j.

Ten, for the first group it will be:

$$Yi = F(KiLi) \qquad (1)$$

where Yi = output (physical units)

Ki = input I (physical units)

Li = input II (physical units)

Then if Pi = price of output

ri = price of input I

Wi = price of input II, and

Πi = profit

$$\Pi i = PiYi - \lambda\ (Ki\ ri + Li\ wi) \qquad (2)$$

Profit (Πj) takes its maximum value *when.*

$$P_i \frac{\theta Y}{\theta K_i} = r_i \qquad (3)$$

ανδ,

$$P_i \frac{\theta Y}{\theta L_i} = w_i \qquad (4)$$

or in other words when the marginal productivity of each variable resource is equal to its price and consequently, efficiency is at maximum.

Assuming that when allocative efficiency is at maximum, the output is equal to Y, then efficiency for this group can be measured as

$$E_i = \frac{Y_i}{Y} \tag{5}$$

or the ratio of actual output to the optimum, (that expected when the marginal productivity of each resource is equal to its price).
Similarly, it could be found that for group B:

$$E_j = \frac{Y_j}{Y} \tag{6}$$

The ratio of Ei to Ej (equations (5) and (6), is a measure of relative efficiency between the two groups. The higher the E, the more efficient the group.

b. Selection of a functional form

Supposing there exists a production function, then the next step is to choose the appropriate algebraic form for it. ·

Three decision rules appear to be relevant in chosing among the numerous alternative forms [Yotopoulos (1967)].

1) Logic or the mechanics of the production process
2) Theoretical fruitfulness; and
3) Feasibility, criteria and computational manageability.

Taking into account the wide use of Cobb-Douglas production function in agricultural economic problems, its ease in handling the logarithmic transformation, and its economic properties, it is assumed that:
a Cobb-Douglas function expresses the production transformation adequately. Having selected this function on a «priori» basis, then it can be improved by the appropriate choice of variables.

The general form of the function is:

$$Y = aX_1^{b_1} X_2^{b_2} \ldots X_n^{b_n} \cdot u$$

where Y = output

$X_1, X_2, \ldots X_n$ = inputs

$b_1, b_2, \ldots B_n$ = transformation vectors

a = constant deriving from the solution of the equation

u = stochastic term incorporating the effects of unknown and unexplained variables

c. Specification of the model

The final form of the model is linear

$$\text{Log } Y = \log a + b_1 . \log X_1 + b_2 . \log X_2 + \ldots\ldots B_n . \log X_n$$

and the results are taken at the geometric mean.

The following tests are made:

1) The R^2 indicates the extent to which the specified independent variables (X), explain the variation in the dependent variable (Y).

2) The estimated «b» s, are individually tested for significance (t test), and a joint significance test (F test) is applied to all coefficients.

3). Correlations between residuals and each independent variable (X) are tested by the Spearman rank correlation test [Koutsoyiannis (1973)1.

4) Durbin — Watson test is used to test for autocorrelation

5) Tests of multicollinearity used are the:

— Zero — order correlation matrix

— Klein's test

— Confluence analysis or bunch map analysis iLeser (1974)!.

6) If the sample consists of several identifiable groups, then the total variation in Y is the sum of variation between classes and the variation within classes. In order to identify these differences the following procedures are used:

(i) Computing the equation (3) by assuming common intercept and slores for all farms,

(ii) Introducing P — 1, dummy variables (where p= number of classes) in equation (3) to allow each class to have a different intercept intercept and slopes for all farms, so:

$$\log Y = \log A + b_1 . \log X_1 + \ldots\ldots \log X_n + di.Di$$

Where D= 1 for one of the ρ -1 classes and

D = a for all the other classes

d = estimated coefficient of each class dummy; and

(iii) Fitting separate regressions for each class, in order to allow both intercepts and slopes coefficents to vary,

d. *Specification of variables*

The following variables are included in the models:

1) Gross output (Y): Value, (in Greek drachmas) of crop and livestock products and by-products produced.
2) Land A: Stremmas of irrigated land.
3) Land B: Stremmas of non-irrigated land.
4) Services of own machinery and equipment assuming 20 per cent depreciation rate, (value in Greek drachmas).
5) Hired machinery services in drachmas.
6) Purchases of inputs (seed, fertilisers etc.) in drachmas.
7) Hired labour: Standard man work hours of labour casually hired for farm work durng the year.
8) Used family labour: Standard man work hours of labour actually used for farm work during the year.

9) Alternative factors of management such as:
   (i) Number of years attending school by farmer,
   (ii) Age of farmer

10) Fragmentation: Number of plots in a 100 stremmas of land.
    The last two variables are not real variables being inconsistent with the theory of production, but are rather factors of labour and land quality respectively, so they are not used in the basic equation.

7. Interpretation of the Results of Production Functions

The solution of the models has been obtained by using the SPSS (Statistical Package for Social Sciences) programme for multiple regression analysis, on the computers of both Leeds and Manchester Universities. This programme estimates the coefficient of the production function using the method of least squares Nie at al (1975).

The analysis is for the total number of farms, (excluding two extreme cases, so reducing the number from 60 to 58) and by types of farming. The existence of a high level of intercorrelation between capital used for purchases and capital used for machinery services makes necessary the aggregation of the two types of capital (dropping one of the two forms of capital as an alternative solution gives similar results). Therefore in the final function four independent variables are included namely: Irrigated land, non-irrigated land, labour and total capital. However, the variable non-irrigated land proved to be not significant (high standard errors), and for general cropping farms which hire machinery has a negative sign, which is inconsistent with the assumption of economic rationality. Examining all the combinations between the dependent variable and the 4 independent variables, it is found that: the introduction of irrigated land, labour and capital substantially raises the value of R^2 while the inclusion of non-irrigated land does not and in some cases (eg. general cropping farms owning machinery) the value of R^2 decreases. So this variable is superfluous or detrimental [Leser (1974]. Taking into account this fact, and that irrigated land and non irrigated Ian are two non-homogeneous factors, it was decided to drop this variable.

The exlusion of non-irrigated land from the equation does not significantly change the value of the other coefficients, consequently this regression (R_2) is chosen as the basic regression to test the differences between groups of farms, level of fragmentation and the management variables.

The main findings from the estimation of the function are the following:

1) The dummy variable D_2 (table 3), has a negative value, significant at the level 0.05 (at least), and the D_3 a positive sign, but it is not significant. The value of D_2 suggests that general cropping farms hiring machinery, (which are the smallest

farms), are less efficient than the other farms. (The D_2 takes value 1 for general cropping farms hiring machinery and zero for the other farms).
Moreover, the fact that R^2 increases substantially, (when D_2 is introduced) and that the constant coefficient (a) changes insignificantly suggest that difference between general cropping farms hiring machinery and the other farms, is in the slopes and not in the intercepts.

2) Fragmentation has a negative effect on the productivity of farms (regression R, tables 3 to 6). However, in tobacco growing farms the coefficient of the factor of fragmentaton (number of land plots in 100 stremmas) is very low and the value of R^2 remains almost unchanged, so this variable is a rather superfluous variable in this type of farming.
3) The introduction of the age of the farmer or of number of years of his attendance at school, as measures of management, suggests that both these measures positively affect the productivity of farms. However, the coefficient of the age of the farmers is very low and insignificant, while the use of the school attendance of farmers as a measure of management seems to be a superfluous variable: apart from tobacco growing farms, where it is significant and contributes to the increase of R^2 from 0.957 to 0.975.
4) The correlation matrices of the variables introduced in the models (tables 7 to 9), suggest that there is a high level of inter-correlation between the independent variables. However, these inter-correlations are not high enough to create serious problems of multicollinearity [Yotopoulos and Nugent (1976), and Klein (1965)1.
5) The sum of elasticities of production in the equation, which includes all the factors of production acceptable from the theoretical point of view (regression R, for the 3 types of farming) suggests diminishing returns to scale for tobacco growing farms, constant returns to scale for general cropping farms owning machinery, and increasing returns to scale for general cropping farms hiring machinery. However, in assessing these results it must be appreciated that the sum of elasticities does not differ significantly from the value of 1 at the level of 0.5*. Therefore, the assumption of constant returns to scale for all types of farming is the most appropriate.
6) The marginal analysis (table 10 — 12), suggests that: For all types of farming, capital is the factor with a ratio of marginal productivity to opportunity cost**

The significance of difference is tested by

$$t = \frac{\Sigma b_i - 1}{S \ \Sigma b_i}$$

Opportunity cost is represented by the alternative earnings of each factor of production in agriculture, (eg. rent, wage) or in other sectors of the economy (e.g. interest of capital) and it is estimated at the geometric mean of those estimated for each farm of the sample.

higher than one, which means that the use of capital at a level higher than the present, is warranted, especially on labour intensive farms (eg. toacco growing farms).

Tobacco growing farms seem to use land and labour very effectively, as their ratios of marginal productivity to opportunity cost, are nearly equal; (table 10).

On general cropping farms, land compared with capital and labour employed, is misused, as in those farms which own machinery, the marginal productivity of land is very high (table 11), while in farms which hire machinery the marginal productivity is very low (table 12). Therefore, the transfer of land from the small farms (farms hiring machinery), to the large farms (farms owning machinery) would seem justified; while in small farms an increase of land must follow an increase of labour and capital.

The low productivity of land on general cropping farms hiring machinery can be attributed to the fact that many of these farmers are part-time farmers and relatively old. For this type of farming, age is a negative factor of productivity (but at low level of significance) (table 6).

7) For the regression used in the estimation of the marginal productivities of factors of production, a test of homoscedasticity (or that the variance of each error (u) is the same for all values of the explanatory variables) is used, the Spearman rank correlation test between each independent variable and 's', using the form:

$$r'_{ux} = 1 - \frac{6\sum D_i^2}{n(n^2 - 1)}$$

and its level of significance is estimated by the form:

$$t = \frac{r'\sqrt{n-2}}{\sqrt{1 - r'^2}}$$

where r' = Spearman Rank Correlation
u = residuals
X = variable tested
D = difference between the ranks of corresponding pairs of TX and residuals u
η = number of cases

8) The total factor efficiency is tested by the form of a ratio of the value of actual output to the ratios of production elasticities to opportunity costs are equal for all

inputs, assuming that all inputs are transofrmable and the total cost is unchanged; therefore:

$$E = \frac{Y_\alpha}{Y_o} \quad (1)$$

where E = efficiency
Ya = actual output
Yo = optimum output

Yo derives from the relation:

$$\frac{b_1}{x_1} = \frac{b_2}{x_2} = \frac{b_3}{x_3} \quad (2)$$

where b_1, b_2, b_3 = production elasticities
x_1, x_2, x_3 = optimum combination of inputs
If $x_1 + x_2 + x_3$ = C = present cost

Then the equation (2) can be transformed as:

$$\frac{b_1}{X_1} = \frac{b_2}{X_2} = \frac{\Sigma b3}{X_3} = \frac{\Sigma b_i}{X_1+X_2+X_3} = \frac{\quad}{C} \quad (3)$$

From the equation (3) the X_1, X_2, and X_3 can be estimated.
Then by solving the original equation (paragraph 6c) with the optimum X_i, the optimum output is derived.

The ratio of actual to optimum output is 0.91 for tobacco growing farms, 0.98 for general cropping farms owning machinery and 0.84 for general cropping farms hiring machinery (tables 10-12).

These ratios give thought for speculations about potentials of increasing the output in the region as follows:
— For tobacco growing farms by 9.9. per cent
— for general cropping farms owning machinery by 2.0 per cent
— for general cropping farms hiring machinery by 19.0 per cent or an overall increase of output by 8.0 per cent (weighted arithmetic mean).

This increase, which appears to be rather small, is short term assuming that the existing techniques of production will be unchnaged.

8. Summary and Conclusions

This article is devoted to the measurement of efficiency of different types of farming. These are:-

TABLE 3

PRODUCTION COEFFICIENTS AND RELATED PRODUCTION FUNCTION STATISTIOS. ALL FARMS

		R_1	R_2	R_6	R_3	R_4	R_5
1. Number of farms		58	58	58	58	58	58
2. Elesticities of production							
T Irrigated land	(x_1)	0.159	0.156	0.140	0.123	0.155	0.169
		(0.042)	(0.039)	(0.038)	(0.040)	(0.040)	(0.038)
Non-irrigated land	(X_2)	0.006 c					
		(0.243)					
T Labour	(X_3)	0.430	0.426	0.298	0.439	0.434	0.432
		(0.036)	(0.036)	(0.054)	(0.035)	(0.037)	(0.035)
Capital	(X_4)	0.466	0.475	0.545	0.436	0.481	0.418
		(0.063	(0.051)	(0.054)	(0.052)	(0.052)	(0.056)
T Dummy D_2				−0.107			
				(0.032)			
				0.016 c			
Dummy D_3				(0.035)			
Fragmentation	(X_5)				−0,109		
Age of farmers	(X_6)				(0,045)	0.089**c**	
						(0.680)	
Education	(X_7)						0.214
3. Sum of elasticities		1.061	1.057		0.889	1.159	1.233
4.	a	1.973	1.940	1.944	2.236	1.744	2.006
		(0.230)	(0.186)	(0.187)	(0.216)	(0.345)	(0.182)
5.	F	245	333	248	274	247	270
6.	$R^{\underline{013}}{}_2$	0.945	0.946	0.956	0.950	0.945	0.950
7.	DW	1.546	1.531	1.585	1.777	1.555	1.430

Note: (1) Level of significance of 't' = 0.05
except **a** = 0.05 − 0.1 **b** = 0.1 − 0.4, **c** = 0.5 − 0.9
(2) Figures in parenthesis are standard errors.

TABLE 4

PRODUCTION COEFFICIENTS AND RELATED STATISTICS, TOBACCO GROWING FARMS

		R_1	R_2	R_3	R_4	R_5	
1. Number of farms		21	21	21	21	21	
2. Elasticities of production							
Irrigated Land	(X_1)	0.127 **a**	0.120 **a**	0.118 **b**	0.110 **b**	0.073 **b**	
		(0.074)	(0.075)	(0.078)	(0.094)	(0.058)	
Non-irrigated land	(X_2)	0.038**c**					
		(0.033)					
Labour	(X_3)	0.352	0.320	0.331	0.326	0.373	
Capital	(X_4)	0.379	0.444	0.432	0.452	0.367	
		(0.103)	(0.087)	(0.096)	(0.099)	(0.069)	
Fragmentation	(X_5)			-0.023 **c**			
				(0.069)	0.032 **c**		
Age of farmers	(X_6)				(0.176)		
Education	(X_7)					(0.076)	0.285
3. Sum of elasticities		0.896	0.884	0.858	0.920	1.098	
4. Constant	a	2.590	2.409	2.463	2.321	2.474	
		(0.238)	(0.184)	(0.249)	(0.531)	(0.139)	
5.	F	115	150	107	106	202	
6.	$\bar{R}$	0.958	0.957	0.955	0.955	0.975	
7.	DW	2.195	2.247	2.273	2.247	2.051	
T							

Note: (1) Level of significance of 't' = 0.05
except **a** = 0.05 –0.1, **b** = 0.1 – 0.4, **c** = 0.5 – 0.9
(2) Figures in parenthesis are standard errors.

TABLE 5

PRODUCTION COEFFICIENTS AND RELATED PRODUCTION FUNCTION STATISTICS. GENERAL CROPPING FARMS (OWNING MACHINERY)

		R_1	R_2	R_3	R_4	R_5
1. Number of farms		15	15	15	15	15
2. Elasticities of production						
T Irrigated land	(X_1)	0.419	0.423	0.551	0.425	0.416
		(0.99)	(0.094)	(0.109)	(0.094)	(0.097)
Non-irrigated land	(X_2)	−0.013**c**				
		(0.035)				
T Labour	(X_3)	0.153 **a**	0.147 **a**	0.164	0.131 **b**	0.163 **a**
		(0.087)	(0.082)	(0.075)	(0.082)	(0.087)
Capital	(X_4)	0.437	0423	0.425	0.456	0.397
		(0.104)	(0.094)	(0.085)	(0.099)	(0.103)
T Fragmentation	(X_5)			-0.076**a**		
				(0.041)	0.122	
T Age of farmers	(X_6)				(0.117)	0.072 **c**
Education	(X_7)					(0.105)
3. Sum of elasticities		0.996	0.993	1.064	1.134	1.048
4. Constant	a	2.311	2.369	2.036	2.032	2.414
		(0.385)	(0.340)	(0.356)	(0.469)	(0.354)
5.	F	26	38	35	29	27
6.	$\bar{R}^2$	0.878	0.887	0.908	0.888	0.881
7.	DW	2.393	2.484	2.119	2.488	2.656

T

Note: (1) Level of significance of 't' = 0.05
Except **a** = 0.05 − 0.1, **b** = 0.1 − 0.4, **c** = 0.5 − 0.9
(2) Figures in parenthesis are standard errors.

TABLE 6

PRODUCTION COEFFICIENTS AND RELATED PRODUCTION FUNCTION STATISTICS, GENERAL GROPPING FARMS, (HIRING MACHINERY)

		R_1	R_2	R_3	R_4	R_5
1. Number of farms		22	22	22	22	22
2. Elesticities of production						
T Irrigated land	(X_1)	(0.061**b**	0.093**a**	0.066**b**	0.091**a**	0.111
		(0.055)	(0.048)	(0.043)	(0.050)	(0.051)
Non-irrigated land	(X_2)	-0.037**b**				
		(0.033)				
Labour	(X_3)	0.267	0.266	0.270	0.261	0.266
		(0.077)	(0.078)	(0.067)	(0.087)	(0.077)
Capital	(X_4)	0.788	0.735	0.680	0.737	0.691
		(0.103)	(0.092)	(0.082)	(0.097)	(0.101)
T Fragmentation	(X_5)			-0.170		
Age of farmers	(X_6)				-0.036**c**	
					(0.248)	
Education	(X_7)					0.182**b**
						(0.175)
3. Sum of elasticities		1.079	1.094	0.846	1.053	1.250
4. Constant	a	0.901	1.074	1.507	1.136	1.108
		(0.359)	(0.326)	(0.329)	(0.540)	(0.328)
6.	$\bar{R}^2$	0.954	0.953	0.965	0.951	0.953
7.	DW	1.354	1.579	1.944	1.580	1.498

T

Note: (1) Level of significance of 't' = 0.05
Except **a**= 0.05 – 0.1, **b** = 0.1 – 0.4, **c** = 0.5 – 0.9
(2) Figures in parenthesis are standard errors.

TABLE 7

SIMPLE CORRELATION COEFFICIENTS BETWEEN VARIABLES IN FITTED PRODUCTION FUNCTION. TOBACCO GROWING FARMS

	X_1	X_2	X_3	X_4	X_5	X_6	X_7
X_1	1						
X_2	0.609	1					
X_3	0.588	0.569	1				
X_4	0.775	0.761	0.775	1			
X_5	-0.550	-0.496	T-0.351	T-0.575	1		
X_6	T-0.086	T-0.195	T-0.608	T-0.501	0.242	1	
X_7	0.634	0.539	T-0.440	0.633	T-0.458	T-0.101	1

T

TABLE 8

SIMPLE CORRELATION COEFFICIENTS BETWEEN VARIABLES IN FITTED PRODUCTION FUNCTION, GENERAL CROPPING FARMS. (OWNING MACHINERY)

	X_1	X_2	X_3	X_4	X_5	X_6	X_7
X_1	1						
X_2	0.016	1					
X_3	T-0.189	0.454	1				
X_4	0.376	0.504	0.511	1			
X_5	T-0.689	T-0.194	0.012	T-0.338	1		
X_6	T-0.223	0.015	0.004	T-0.328	0.170	1	
X_7	0.353	T-0.365	T-0.108	0.354	T-0.097	T-0.215	1

T

TABLE 9

SIMPLE CORRELATION COEFFICIENTS BETWEEN VARIABLES IN FITTED PRODUCTION FUNCTION, GENERAL CROPPING FARMS, (HIRING MACHINERY)

	X_1	X_2	X_3	X_4	X_5	X_6	X_7
T							
X_1	1						
X_2	T-0.167	1					
X_3	0.608	0.207	1				
X_4	0.628	0.338	0.802	1			
X_5	T-0.488	0.225	T-0.437	T-0.523	1		
X_6	T-0.412	0.112	T-0.352	T-0.352	0.327	1	
X_7	T-0.012	0.285	0.421	0.420	T-0.258	0.072	

TABLE 10

MARGINAL ANALYSIS, TOBACCO GROWING FARMS

	Output	Irrigated land	Non-irrigated land	Labour	Capital
	Y	X_1	X_2	X_3	X_4
1. Sample means: (log)	5.462	1.473	1.043	2.435	4.715
2. Sample means: (antilog)	289734**c**	29.7**a**	11.0	272.2**b**	51880**c**
3. Marginal Productivity		1170**d**		340**e**	2.40**f**
4. Opportunity Cost		1125**d**		371**e**	1.09**f**
5. Ratio of marginal productivity to opportunity cost		1.04		0.92	2.27
6. Optimum combination of resources	317680**c**	22.5**a**		182.0**a**	93728**c**
7. Spearman Correlation Coefficients		0.112 (0.314)**g**		0.140 (0.273)	0.143 (0.269)

Note: **a** = stremmas, **b** = work days, **c** = drachmas, **d** = drachmas per stremma, **e** = drachmas per work day, **f** = drachmas per drachma, **g** = figures in parenthesis show level of significance
E=0.91

TABLE 11

MARGINAL ANALYSIS, GENERAL CROPPING FARMS
(OWNING MACHINERY)

	Output	Irrigated land	Non-irrigated land	Labour	Capital
	Y	X_1	X_2	X_3	X_4
1. Sample means (log)	5.670	1.926	1.477	2.340	5.063
2. Sample means (antilog)	467735c	84.3a	29.9a	218.8b	115611c
3. Marginal productivity		-2347d		314e	1.71f
4.Opportunity cost		1197d		350e	1.09f
5. Ratio of marginal productivity to Opportunity cost		1.96		0.90	1.57
6. Optimum combination of resources	475938c	104.3a		124.0b	124859c
7. Spearman Correlation Coefficients		0.005 (0.493)g		0.204 (0.233)	-0.064 (0.410)

Note: a=stremmas, b = work days, c = drachmas (drs), d= drs per stremma, e = drs per day, f= drs per dr, g = figures in parenthesis stand for significance.
E=0.98

TABLE 12

MARGINAL ANALYSIS, GENERAL CROPPING FARMS.
(HIRING MACHINERY)

	Output	Irrigated land	Non-Irrigated land	Labour	Capital
	Y	X_1	X_2	X_3	X_4
1. Sample means: (log)	5.122	1.385	0.838	1.832	4.671
2. Sample means (antilog)	132434**c**	24.3**a**	6.8	67.9**b**	46880**c**
3. Marginal Productivity		507**d**		518**a**	2.08**f**
4. Opportunity Cost		1293**d**		359**c**	1.09**f**
5. Ratio of marginal productivity to opportunity cost.		0.39		1.44	1.91
6. Optimum combination of resources	157580**c**	6.8**a**		69.5**b**	68961**c**
7. Spearman Correlation Coefficients		-0.036 (0.441)**g**		-0.236 (0.146)	-0.193 (0.194)

Note: **a**= stremmas, **b** = work days, **c** = drachmas, **d** = drs per stremma, **e** = drachmas per day, **f** = drs per dr **g** = figures in parenthesis mean level of significance
E=0.84.

Tobacco growing farms which are labour intensive farms.
General gropping farms, owning machinery which are also characterised by their high ratio of land per man (large farms) and the smaller general cropping farms hiring machinery.

The use of simple methods of measuring efficiency suggests that:

1) The farms in the region are efficient as the ratio of cutput to total costs is higher than 'One'. However, without subsidies this ratio falls below 'One', especially for small farms, but this fall does not bring the ratio of efficeincy far below the value of 'One'.
2) With reference to relative efficiency between types of farming, the labour intensive tobacco farms are more efficient than the general cropping farms, and the larger farms are more efficient than the small farms.
3) The correlations between area of land and the efficiency indices (apart from value added per unit of land) are positive. However, the relatively poor correlation between area of land and output per unit of cost, and the negative correlation between area of land and value added per unit of land should be noted. The last named is due to the distortion created by quotas, and it does not necessarily invalidate the hypothesis, that larger farms are more efficient.
4) The hypothetical improvement in efficiency that could be obtained, if all farmers were at the level of the most efficient group, suggests an increase of output by 7.4 per cent.

The use of production functions in measuring efficiency suggests that:

On small farms, land is misused, and for all types of farming, an increase of capital employed on farms is warranted. On large farms irrigated land is very productive .

Fragmentation of land is a negative factor of production.

The ratios of actual to optimum output are 0.91, 0.98 and 0.84 for tobacco growing farms, general cropping farms owning machinery and general cropping farms hiring machinery respectively. These ratios suggest that the farms are fairly efficient and that the larger farms are more efficient.

On the other hand, the potential increase of output is 8.0 per cent.

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