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# Evading Farm Support Reduction via Efficient Input Use: The Case of Greek Cotton Growers

Christos J. Pantzios, Stelios Rozakis, and Vangelis Tzouvelekas

The present paper examines the importance that efficient resource use may have for cotton growers under the current EU policy regime. To that end, input-oriented technical and scale efficiency scores for a sample of 172 cotton-growing farms are empirically quantified. The results suggest that cotton farms in the sample are not efficient mainly due to the nature of the policy regime governing the sector throughout EU. By becoming efficient, the co-responsibility levy will be reduced by 18.3% and farms may increase their profits by 50.1% on the average.

*Key Words:* co-responsibility levy, cotton farms, goal programming, Greece, scale and technical efficiency, stochastic frontier model

**JEL Classification:** D24, Q12, Q16, C61

The measurement of productive efficiency in farming activities has become the focus of a rapidly expanding body of agricultural economics literature.<sup>1</sup> Recently, this research has

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<sup>1</sup> Battese and Bravo-Ureta and Pinheiro provide a detailed review of the relevant efficiency studies in agriculture.

also been extended to the closely related issue of scale efficiency—that is, the deviation of a farm's productivity from the maximum attainable one (e.g., Karagiannis and Sarris 2006; Jaforullah and Whiteman; Wadud and White; Featherstone, Langemeier, and Ismet; Llewellyn and Williams). Naturally, the empirical measurement of technical and scale efficiency is an attractive research theme on its own, as a primary objective in production economics is optimal resource utilization. However, there may be cases where achievement of optimal resource use may also be advisable for additional reasons. One case may be policy regimes where financial support is offered only for a predetermined output level. Productive units operating under such regimes may find that pursuing optimal resource use may help them to not only utilize their resources optimally but also to preserve the support they enjoy under the policy regime.

Agricultural policies are a typical example of regulated regimes with provisions of maximum output levels for which farm support is available. Within the European Union (EU),

provisions referring to ceilings of output produced (or area cultivated) are included in many EU regulations. As farm support (usually in the form of intervention prices) naturally functions as a signal to individual farmers to boost output, the actual way in which such ceilings are imposed becomes a crucial issue, for both farmers and policy makers in the EU member states. Greek cotton production is an illustrative case. The current EU policy regime imposes a production quota at the country level for all cotton-producing member states. Exceeding this aggregate quota results in a reduction in the intervention cotton price for all farmers. This mechanism, however, has failed to restrain Greek cotton production. Acting as price takers, individual producers conceived the demand for their produce as perfectly elastic and arranged their production only according to the EU intervention price, *not* the aggregate production quota. As a result, Greek cotton production has boomed over the last twenty years despite the quota, which in turn activated reductions in cotton intervention prices. This has provoked loud protests by the Greek cotton growers about shrinking farm incomes over the last five years.

According to FADN (Farm Accountancy Data Network) statistics, farm incomes have gradually deteriorated from 1,200–1,500 €/ha in the 1990–92 period to 650 €/ha in 1997–99. According to the Greek Ministry of Agriculture, almost 60% of this reduction was due to the fall in world cotton prices. World cotton prices' reflection on Greek cotton growers fluctuated around a stable trend during the 1990s. On the contrary, subsidies have dropped more than 40%, whereas yield has stabilized (outlier appearing in 1996 reflects an exceptionally bad year for cotton cultivation). Farm income decrease (in Thessaly, from more than 2,000 per ha to about 700 per ha) is due to a 33% decrease in total sales (constant values 1992) and to a 40% increase in total costs. These trends continue until today according to Eurostat statistics.

Both EU and United States cotton policies that are both based on a subsidy scheme have provoked significant protests, particularly in

Brazil and in West African countries. Brazil, which filed a complaint within the context of World Trade Organization (WTO) in September 2002, claimed that the United States cotton regime and in particular Step 2 of the farm's law Three-Step Competitiveness Program encouraged U.S. farmers to increase their production, resulting in lower cotton prices worldwide. Specifically, according to Brazilian claims, the estimated \$3 billion in U.S. dollars in annual subsidies provided to 25,000 U.S. cotton growers have resulted in losses of about \$1.5 billion U.S. dollars per year to producers in Benin, Burkina-Faso, Mali, and Chad (Laws; Institute for Agriculture and Trade Policy). These four West African countries, which produce better quality cotton than their U.S. and EU counterparts at a lower cost, requested the abolition of such subsidies as well as of smaller ones paid to European (mainly Greek and secondly Spanish) producers. They also requested compensation for losses incurred (mentioned in the Cancun draft communiqué). African states have been supported by Brazil, which is demanding recognition of the importance of cotton to the economic development of the LDC and that developed countries decrease to zero protection at the frontier, subsidies to farmers and export support (three zero request). Right after the Common Agricultural Policy (CAP) review in 2003, a main decision about subsidies decoupling came to respond to WTO conference. Especially concerning cotton, Greece exercised the right to moderate decoupling by keeping 65% of cotton support in price subsidy form and only 35% decoupled.

The implementation of the EU cotton policy regime on a more disaggregated basis (i.e., further allocating the country-level production quota down to the county or even to the farm level) could offer a natural settlement of this problem, at least domestically (Karagiannis and Pantzios). As a matter of fact, such an arrangement implemented after 2001 by the Greek Ministry of Agriculture (triggered by Regulation 1051/01, which replaced previous regulations strengthening the stabilizer mechanism thus causing a sharp drop in the support payable for all production) involved high ad-

ministrative cost and even political conflicts, making its application difficult. This paper offers an additional suggestion that could also help Greek farmers to evade reductions in cotton intervention prices if the actual production scale is above the optimal level: the improvement of their technical and scale efficiency. In the past, high EU-guaranteed cotton prices have influenced the scale of production on Greek cotton farms (Sapounas; Fousekis et al.) by encouraging farmers to: (i) invest in modern equipment and expand production, (ii) use water and chemical fertilizer excessively, and (iii) divert even marginally productive land to cotton farming.

On the other hand, high support prices relative to cost of production have assured healthy returns for cotton-growing farms, including those located in marginal areas operating in an inefficient way. Nonetheless, although high support prices in the form of a unit subsidy do not eliminate variability in prices and therefore risk, they do increase the expected returns to the farmers. This in turn has resulted in willingness to produce more for both risk-averse and risk-neutral producers. That production growth in a vertical market system like cotton was translated in increased demand for inputs and probably into inefficiency related to their allocation in the production process. Under these circumstances, pursuing technical and scale efficiency may assist Greek cotton growers in two complementary ways. First, it may yield substantial cost savings, which could compensate for the reduced intervention prices caused by exceedingly high production levels. Second (and more importantly), scale efficient production may result in lower output levels, which in turn may mitigate or even eliminate reductions in the EU-guaranteed cotton prices if the actual production scale is above the optimal level.

In this context, the objective of the present paper is to provide empirical evidence on how optimal resource use may mitigate the income losses that cotton growers in the county of Karditsa (a representative cotton-producing area in Central Greece) have suffered during the last five years. To that end, recent methodological developments in efficiency analysis

suggested by Atkinson and Cornwell and extended later on by Ray and Reinhard, Lovell, and Thijssen have been used to provide farm-specific estimates of input-oriented technical and scale efficiency in the context of a flexible translog specification of the production frontier model. These measures are used to estimate average cost savings that could accrue to farmers if they were technically and scale efficient. Then, utilizing a goal programming model we attempt an estimation of the output reduction that could have been achieved in the broader area of our survey if farms had been operating under these optimal efficiency levels. Finally, this finding is used to compute how much this lower production might have reduced the penalty per ton that cotton farmers have suffered in the period examined.

The rest of the paper is organized as follows. A brief overview of the Greek cotton sector is provided in the next section. The theoretical underpinnings for the estimation of input-oriented technical and scale efficiency, as well as the goal programming model used to generalize these estimates for the whole county of Karditsa, are developed in the third section. Section 4 presents the data and discusses the empirical results. The policy implications that emerged from our study are offered in the fifth section. Concluding remarks follow in the last section.

### **The Greek Cotton Sector**

Traditionally, cotton growing has been a prominent farming activity in Greece providing the primary input to a major domestic processing industry (cotton ginners). During the last two decades the sector has shown an impressively rapid expansion. The acreage cultivated with cotton almost doubled during the 1980s, reaching 240,000 ha in 1991, from only 120,000 ha in 1981 (i.e., year of the Greek Accession into the EU), and kept expanding during the 1990s to reach 430,000 ha in 1996. The volume of cotton production swelled, according to the Greek Cotton Board, from only 290,000 tons in 1981 to about one million tons in 1996. Within the EU, Greece has thus become the largest cotton producer, accounting

for about 70% of the total EU cotton production.

The sector's rapid enlargement has mainly been the result of past high support mechanisms of the EU cotton regime. Until 1986, the EU cotton policy was a typical deficiency payment scheme: the price received by cotton farmers was based on a target price (higher than the world price) predetermined annually by EU authorities. Faced with high financial costs, however, since 1987 the EU has replaced this policy regime with an intervention mechanism consisting of: (i) an intervention price, (ii) an aggregate production quota, called *maximum quantity guaranteed* (MQG), which is set at the country level, and (iii) a reduction in the intervention price, called the *co-responsibility levy*, which is applied to all cotton farmers when the actual cotton production of the country exceeds the predetermined maximum quantity guaranteed.

As a result of the initial favorable CAP measures, cotton cultivation gradually became the primary farm activity (and source of income) for a growing number of agricultural households (OTEX cotton oriented farms rose from 2.5% of the total number of Greek farms in 1987 to 6.3% in 1995). Farmers diverted even marginally productive land to cotton cultivation; invested in equipment (such as cotton harvesters, irrigation systems, and water drillings) and, in general, largely expanded their scale of operation. Naturally, negative environmental effects started to emerge as cotton ranks high on the list of heavily polluting crops; high levels of fertilizer residues have been measured in cotton fields and the excessive use of irrigation water appears to have reduced underground water supplies to alarming levels.

In the wake of the latest reform in the CAP cotton regime, production expansion is no longer associated with corresponding increases in farm revenues. However, as the production quota was imposed at the country level, individual cotton growers routinely ignored it and kept expanding their own production. Recently, cotton growers played a leading role in loud farmer protests against the EU-imposed cotton production quota claiming that it dras-

tically shrinks their farm income in the face of ever increasing production costs.<sup>2</sup>

### Methodological Framework

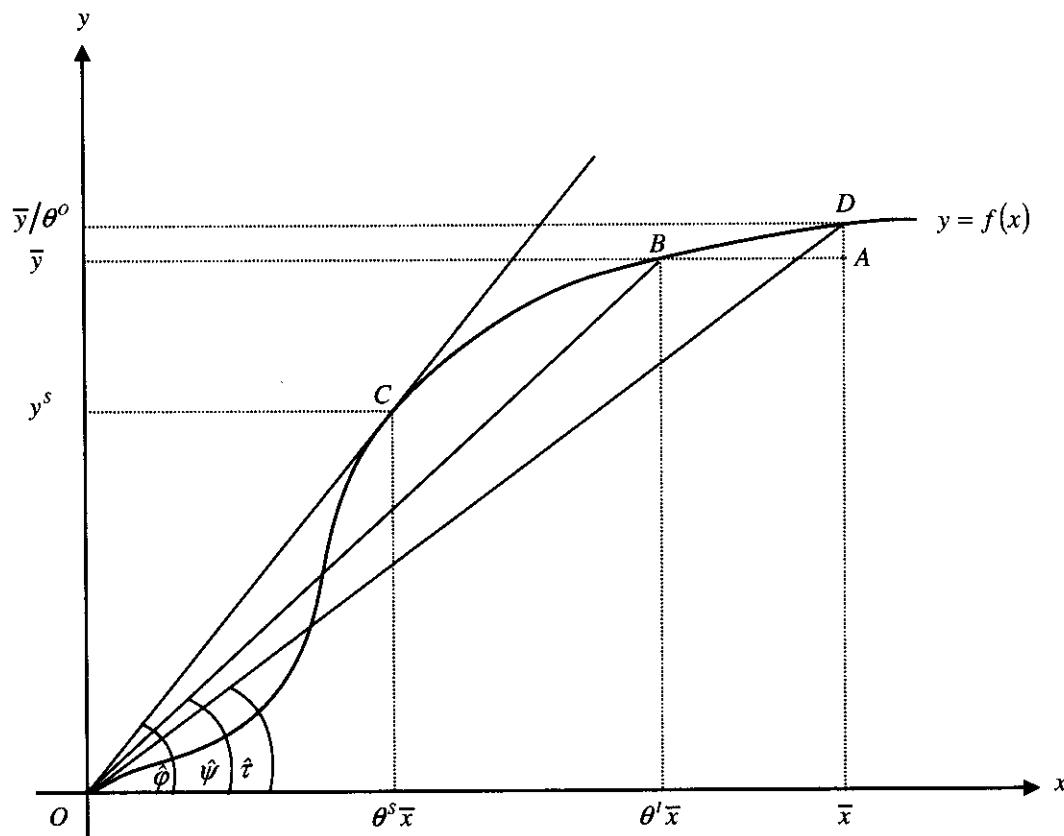
For the measurement of efficiency in production, two indices of technical inefficiency can be defined radially according to whether one adopts an output-expanding or an input-conserving approach (Kumbhakar and Lovell, pp. 46–48). The first one is the output-oriented *Debreu-type* index, defined as the ratio of the observed to maximum feasible output, given the production technology and the observed factor use. The second one is the input-oriented *Shephard-type* index, defined as the ratio of minimum feasible to observed factor use, given the production technology and the level of output produced. Figure 1 illustrates both indices of technical inefficiency geometrically in the single-input, single-output case. Let us assume that farm  $i$  uses  $\bar{x}$  amount of factor  $x$  to produce  $\bar{y}$  level of output at point A. In that sense the farm in question is technically inefficient as it does not operate on its production frontier, given by  $y = f(x)$ . The output-oriented index of this technical inefficiency is defined as the ratio of the observed to the maximum attainable output given at point D, that is  $\bar{x}A/\bar{x}D$  or  $\bar{y}/(\bar{y}/\theta^o)$  with  $0 < \theta^o \leq 1$ . Analogously, the input-oriented index of technical inefficiency is given by the ratio of optimum (point B) over the actual factor use, that is  $\bar{y}B/\bar{y}A$  or  $(\theta^i\bar{x})/\bar{x} = \theta^i$  with  $0 < \theta^i \leq 1$ .

Both indices of technical efficiency can be obtained from the econometric estimation of the stochastic production frontier (SPF) model introduced independently in 1977 by Aigner, Lovell, and Schmidt and Meeusen and Van der Broeck. In this analytical framework the agricultural output is treated as a stochastic production process of the following general form

$$(1) \quad \bar{y}_i = f(\bar{x}_i; \beta) \exp(v_i - \theta_i^o)$$

where  $f(\cdot)$  is approximated by a translog production function

<sup>2</sup> According to FADN data, unit cost of production of cotton growers increased during the 1990–2000 period in Greece by 18.3%.



**Figure 1.** Measurement of Technical and Scale Efficiency in the Single-Input Single-Output Space

$$(2) \quad \ln \bar{y}_i = \beta_0 + \sum_{j=1}^n \beta_j \ln \bar{x}_{ji} + \frac{1}{2} \sum_{j=1}^n \sum_{k=1}^n \beta_{jk} \ln \bar{x}_{ji} \ln \bar{x}_{ki} + \varepsilon_i$$

where  $\bar{y}$  is the actual output produced by the  $i$ th farm,  $\bar{x}_{j(k)i}$  is the actual quantity of the  $j(k)$ th input used by the  $i$ th farm, and  $\beta$  is a vector of parameters to be estimated. The component  $v_i$  is a symmetric *iid* error term representing random variation in output due to random exogenous factors, measurement errors of the dependent variable, omitted explanatory variables, and statistical noise. The component  $\theta_i^o$  is a nonnegative error term representing the stochastic shortfall of the  $i$ th farm's output from its production frontier due to the exis-

tence of output-oriented technical inefficiency.<sup>3</sup>

Estimation of input-oriented technical efficiency is possible within the above model specification using the approach suggested by Atkinson and Cornwell and extended later on by Ray and Reinhard, Lovell, and Thijssen (1999). In summary, the scale factor  $\theta'$  must be calculated such that the bundle  $(\theta' \bar{x}, \bar{y})$  be-

<sup>3</sup> Farm-specific estimates of output-oriented technical inefficiency in the context of the SPF model can be obtained using the conditional expectation of  $u_i$  given  $\varepsilon_i$  and the predictors developed either by Jondrow et al. or Battese and Coelli (1988). To do so, one must assume a specific statistical distribution for the one-sided error term. As pointed out by Greene, neither the ranking nor the composition of the top and bottom efficiency score deciles are sensitive to that choice. In addition, Ritter and Simar suggest the use of a relatively simple distribution such as the half-normal that was adopted in our empirical study.

comes a feasible and efficient projection of the observed bundle  $(\bar{x}, \bar{y})$  on the production frontier (point B in Figure 1). In the context of a translog specification assuming that  $\theta_i^0 = 0$ , we get

$$(3) \quad \ln \bar{y}_i = \beta_0 + \sum_{j=1}^n \beta_j (\ln \bar{x}_{ji} + \ln \theta_i^j) \\ + \frac{1}{2} \sum_{j=1}^n \sum_{k=1}^n \beta_{jk} (\ln \bar{x}_{ji} + \ln \theta_i^j) \\ \times (\ln \bar{x}_{ki} + \ln \theta_i^k) + v_i.$$

Since under weak monotonicity output-oriented technical efficiency should imply and must be implied by input-oriented technical efficiency, we set Equation (3) equal to the output-oriented specification in Equation (2) (Reinhard, Lovell, and Thijssen 1999).<sup>4</sup> Then solving for  $\theta_i^j$ , farm-specific estimates of input-oriented technical efficiency can be obtained. According to Ray, in the context of the translog specification,  $\theta_i^j$  can be obtained from the following relation (p. 191):

$$(4) \quad \theta_i^j = \exp\left(\frac{-E_i + \sqrt{E_i^2 - 2B\theta_i^0}}{B}\right)$$

where  $E_i = \sum_j [(\partial \ln \bar{y}_i)/(\partial \ln x_{ji})]$  is a local measure of the returns to scale for the  $i$ th farm and  $B \equiv \sum_j \sum_k \beta_{jk}$  is the sum of the second-order parameters of the translog production frontier in Equation (2). The input-oriented technical inefficiency index obtained directly indicates cost savings that are possible through the elimination of these inefficiencies (Kopp, p. 490).<sup>5</sup> Specifically, the cost of production at the technically efficient point B would be

$$(5) \quad C_i^l = \theta_i^l \sum_{j=1}^J w_j \bar{x}_{ji}$$

where  $C_i = \sum_j w_j \bar{x}_{ji}$  is the observed cost at

point A. These cost savings are actually translated into profit increases given that farmers maintain the same level of output produced and thus face the same intervention price:

$$\Delta\pi = C_i - C_i^l = (1 - \theta_i^l) \sum_j w_j \bar{x}_{ji}.$$

The definition of scale efficiency is based on the axiomatic approach of production economics.<sup>6</sup> In the multiple-input multiple-output case, it is measured as the ratio of the ray average productivity at the technically efficient input scale relative to what is attainable (using Frisch's terminology) at the *technically optimal scale*<sup>7</sup> of production. In terms of Figure 1, the technically optimal scale of production is obtained at point C, where average factor productivity is maximized. For an input-oriented measure of scale efficiency, we need to compare average factor productivity at the technically efficient point B with that at point C.<sup>8</sup> That is

$$(6) \quad SE^l = \frac{\hat{\phi}}{\phi} = \frac{\bar{y}/\theta^l \bar{x}}{y^s/\theta^s \bar{x}} = \frac{\bar{y}\theta^s}{y^s\theta^l}.$$

If the underlying technology is approximated by a translog specification, Ray (p. 189) has shown that:

$$(7) \quad \theta_i^s = \exp\left(\frac{1 - E_i}{B}\right)$$

and (p. 191)

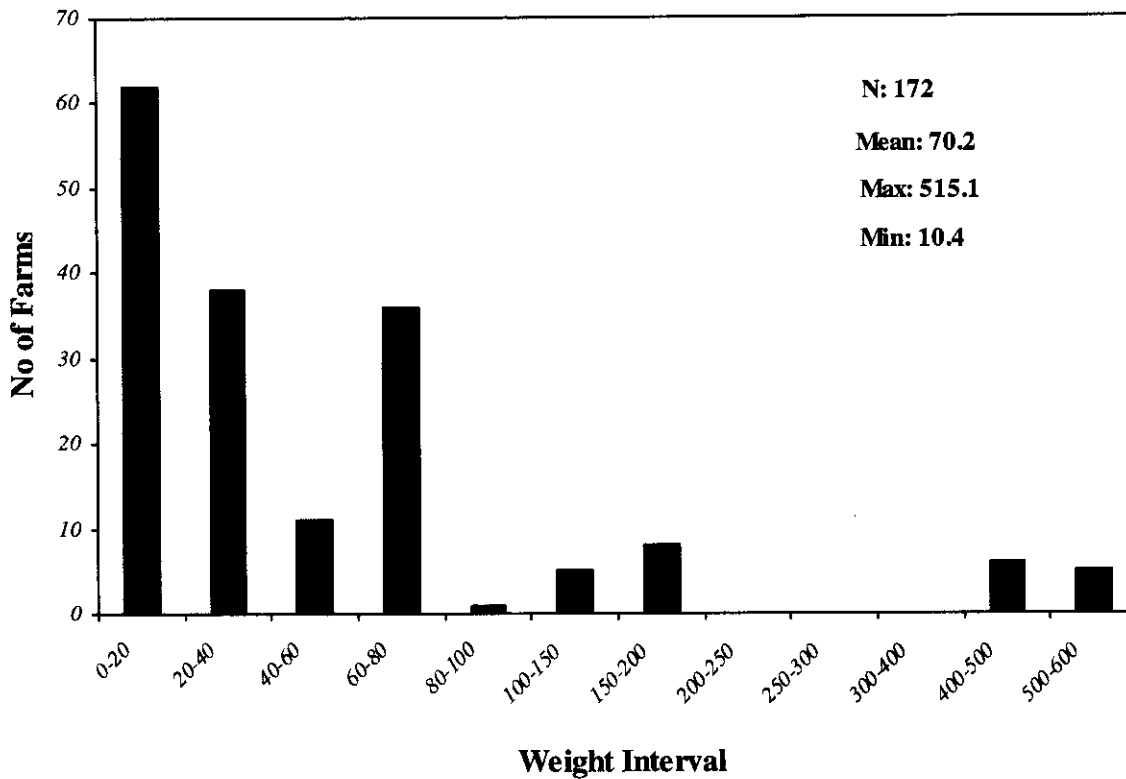
<sup>6</sup> Excellent discussions on the axiomatic approach in production economics are provided by Färe, Grosskopf, and Lovell (1983) and Banker, Charnes, and Cooper.

<sup>7</sup> In Data Envelopment Analysis (DEA) literature the point of maximum ray average productivity is called the *most productive scale size* (MPSS). It can be easily proved that at this point, returns to scale equals unity (Ray, pp. 184–186). Färe, Grosskopf, and Lovell (1988) and Førsund provide a thorough discussion of this issue, as well as of the relation between scale efficiency and scale elasticity.

<sup>8</sup> Similarly, for an output-oriented measure of scale efficiency, one needs to compare average factor productivity at the output-oriented technically efficient point D with that attained at point C. That is,  $SE^o = \hat{\tau}/\tau = \bar{y}\theta^w/y^s\theta^o$ .

<sup>4</sup> For a detailed discussion of the properties of efficiency indices, see Russell (pp. 30–41) and Kumbhakar and Lovell (pp. 44–46).

<sup>5</sup> This dual relationship between the input-oriented technical efficiency index and total cost of production is not valid for the output-oriented technical efficiency index except in cases where linear homogeneity in all inputs holds (Färe and Lovell).



**Figure 2.** Precipitation Map of Greece and Karditsa County and area of study in Thessaly plain. All municipalities in the sample fall within 400–600 rainfall range

$$(8) \quad SE_i^f = \exp \left[ \frac{(1 - \sqrt{E_i - 2B\theta_i^p})^2}{2B} \right]$$

If the matrix  $|\beta_{jk}|$  is negative definite, then  $B < 0$ . This in turn implies that if the farms in the sample exhibit decreasing returns to scale, which is probably the case of the Greek cotton farms, then making them scale efficient would result in a reduction in their total cotton produced, as  $\theta_i^s < 1$ .

The input-oriented scale efficiency index does not possess a dual relation with cost of production as does the corresponding technical efficiency index. However, using relations (4), (6), and (7) we can compute the output level ( $y_i^s$ ) at the scale efficient point, from an input conservation perspective.<sup>9</sup> If indeed diminishing returns to scale prevail, then it should hold that  $\theta^s \bar{x} - \theta^s \bar{x} > 0$  and  $\bar{y} - y^s > 0$ . These output

reductions will reduce the corresponding co-responsibility levy imposed on all cotton growers by the relevant Common Market Organization (CMO). In order to compute the decrease in the amount of co-responsibility levy, we generalize the findings obtained from our sample survey to the whole county of Karditsa.

To do so, each individual farm in the sample has been weighted according to its representation in the county of Karditsa on the basis of its crop mix. These weight-coefficients are defined through a goal programming model that was formulated based on the ideas developed by Ogryczak and Lahoda and Williams. First, the whole county of Karditsa was divided into six homogeneous subregions (groups of municipalities in Figure 2), according to farm characteristics such as average size of farms, labor force available, irrigated land percentage, and crop mix. In each one of these six subregions, a goal programming model was applied to assign to each farm in the sam-

<sup>9</sup> Alternatively, we can compute  $y_i^s$  by inserting  $\theta_i^s \bar{x}_{ji}$  into the production frontier model in (1) under a translog specification.



ple its relative weight coefficient so that all other farms in the subregion are adequately represented. Weights are calculated so that observed aggregate data on the farm's crop mix are reproduced as closely as possible by the model's aggregate estimates. The goal programming model has the following mathematical form:

$$(9a) \quad \text{Min}(\max \lambda - \min \lambda)$$

$$(9b) \quad \text{s.t.} \quad \sum_i \sum_l \lambda_i s_{ilh} + d_h^- - d_h^+ = s_h^R \quad \forall h \in H$$

$$(9c) \quad d_h^- \leq p^d s_h^R \quad \forall h \in H$$

$$(9d) \quad d_h^+ \leq p^d s_h^R \quad \forall h \in H$$

$$(9e) \quad \min \lambda \leq \lambda_i \quad \forall i \in N$$

$$(9f) \quad \lambda_i \leq \max \lambda \quad \forall i \in N$$

where  $i \in N$  are the farms in the sample,  $h \in H$  is the farm crop group index in the subregion,  $l \in L_h$  is the individual crop within group  $h$ ,  $s_{i,l}$  is the value of crop  $l$  that belongs to the corresponding group  $h$  for farm  $i$ ,  $s_h^R$  is the observed value of crop  $l$  in group  $h$  in the subregion, and parameter  $p^d$  is the percentage of tolerated deviation from regional crop mix. The positive variables are the weight coefficients for each farm ( $\lambda_i$ ), the maximum and minimum weight values ( $\max \lambda$ ,  $\min \lambda$ ) applied to all farms, and deviations ( $d_h$ ) for each group at the subregion level.

The elements  $h$  used to define farm groups were limited by the availability of aggregate data at the subregion level. In the present model, we used the total area under cotton cultivation, the total area under cereals cultivation, and the total irrigated and nonirrigated acreage. For each of these elements an additional set of constraints described in (9b) through (9d) was included in the model. The optimization of the model actually minimizes the distance between maximum and minimum weight coefficient, aiming at weights of the same order of magnitude. In optimizing the model, there is a compensation between the deviation tolerance and the difference between maximum and minimum weights. For instance, if we aim at a minimal deviation of 1% in the surface observed at the subregional level for each element  $h$ , then the model will be compelled to assign higher weights to some

farms and to almost ignore others with a crop mix different from the average subregional crop mix. The minimal deviation used in this model is set at 5%. In other words, the total acreage cultivated by crop or group of crops ( $h$ ) after multiplication of individual acreages by the weight coefficients should not deviate more than 5% from the subregional acreage cultivated by the same crop or group of crops ( $h$ ).

Once the reduction in the amount of the co-responsibility levy is obtained, we can compute thereafter the anticipated changes in the surveyed farm's total profits using the following relation:

$$(10) \quad \pi_i^s = [p_w - (p_c - p_c^s)]y_i^s - \theta_i^s \sum_{j=1}^J w_j \bar{x}_{ji} \\ = [(p_w - p_c)y_i^s + p_c^s y_i^s] - \theta_i^s \sum_{j=1}^J w_j \bar{x}_{ji}$$

where  $p_w$  is the intervention cotton price,  $p_c$  is the amount of the current co-responsibility levy arising from excess cotton production above the maximum quantity guaranteed imposed by the relevant CMO, and  $p_c^s$  is the reduction in the amount of that co-responsibility levy arising from the decrease in cotton production in the county of Karditsa if farmers operate at the technically optimal scale size. The first term on the right-hand side is the total revenues for cotton growers under the current intervention price reduced by the amount of the actual co-responsibility levy. It is the same price at the observed level multiplied by the reduced level of cotton produced attained at the technically optimal scale size. The second term is the additional revenues due to the reduction of the co-responsibility levy. Finally, the last term measures the cost of production by moving in the technically optimal scale size point.

## Data and Estimation

### Data

The data used in this paper arise from a questionnaire survey of 172 cotton farms in the county of Karditsa, located in the region of Thessaly in Central Greece, for the 1997–98

**Table 1.** Summary Statistics of the Variables

Variable	Mean	SD	Minimum	Maximum
Output (kg)	22,736	17,139	2,000	94,500
Labor (hours)	1,728	1,587	131	8,574
Capital (*C)	3,655	1,232	675	12,354
Seeds (kg)	551	142	101	1,698
Land (stremmas <sup>a</sup> )	60	45	15	260
Specialization <sup>b</sup> (%)	90.9	14.2	42.3	100
Age (years)	53	7	37	70
Education (years)	8	0.39	7	10
Total assets (*C)	6,046	1,670	2,036	26,824
Land fragmentation (number of plots)	5.1	3.9	1	18
Off-farm income (*C)	2,320	1,371	0	3,657

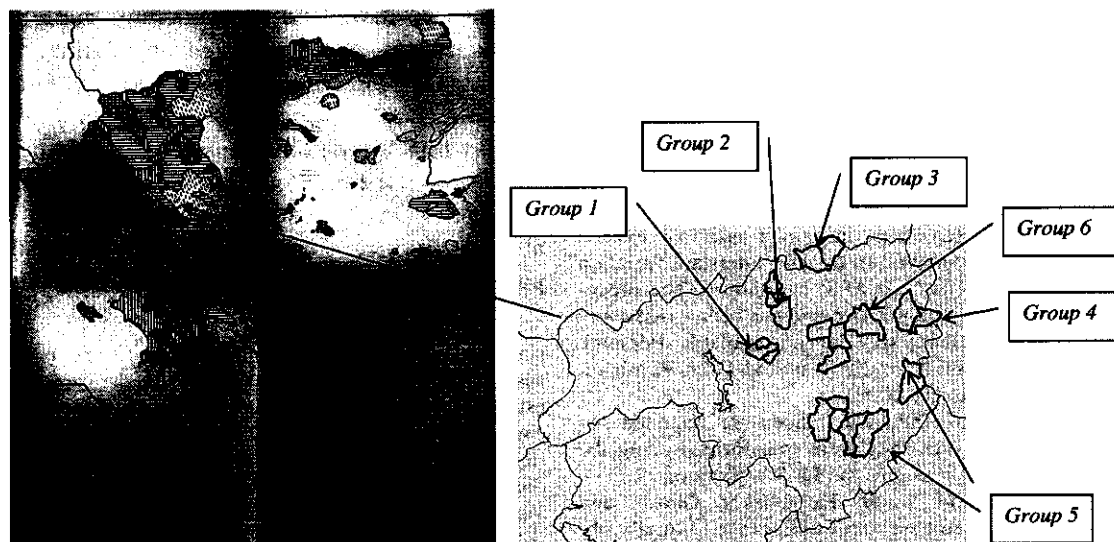
<sup>a</sup> One stremma equals 0.1 ha.

<sup>b</sup> Measured using a Herfindhal index.

cropping year. Thessaly is one of the major agricultural regions of the country and historically it has been a prime area for cotton farming. Summary statistics of the key variables of the surveyed farms used in the empirical analysis appear in Table 1. The surveyed farms belong to 20 communities in the greater area of Karditsa plain. These communities were selected to adequately represent plain and semi-mountainous areas of the region (Figure 2). The 172 farms actually surveyed represent a total of 16,260 farms situated in the plain and semi-mountainous communities of Karditsa.

That is, on the average each farm in the sample represents about 100 farms. After the implementation of the goal programming model explained in the previous section and the estimation of their relative weights, we found that some of them represent 500 farms (maximum weights) while others only 10 farms (minimum) in the greater area of Karditsa. The detailed picture of the weights per farm is presented in the form of a frequency distribution in Figure 3.

In the stochastic production frontier model in Figure 2, the dependent variable is the total



Precipitation map of Greece.

Area of study : all groups in 400-600 rainfall range.

**Figure 3.** Farm Weight Frequency Distribution for the Surveyed Cotton Farms

annual cotton production measured in kilograms, while the independent variables include: (a) total labor, that is, hired and family (paid and unpaid) labor related to cotton production, measured in hours; (b) farm land devoted to cotton cultivation, measured in stremmas (one stremma equals 0.1 ha); (c) total amount of seeds used in cotton production, measured in kilograms; and (d) total value of purchased inputs (fertilizers and pesticides) and cost of machinery repair used in cotton cultivation, measured in euros.

In order to investigate the sources of input-oriented technical and scale efficiency differentials among farms in the sample, we have regressed, in a second stage, their corresponding efficiency scores against a set of relevant demographic and economic variables using a simple OLS as follows:<sup>10</sup>

$$(11) \quad \ln Eff_i = \delta_0 + \sum_p \delta_p \ln z_{ip} + \omega_i$$

where  $Eff_i$  is the efficiency index<sup>11</sup> (technical or scale) for farm  $i$ ,  $z_{ip}$  is the  $p$ th variable for the  $i$ th farm used to explain efficiency differentials,  $\delta$  are the corresponding parameters to be estimated, and  $\omega$  is a usual *iid* error term. It should be noted here that since both efficiency measures are calculated rather than estimated in the first stage, it is permissible to use them as explanatory variables in a second stage under the assumption that the  $z$  variables are uncorrelated with conventional inputs of production (Reinhard, Lovell, and Thijssen 2002, p. 1056; Karagiannis and Sarris).<sup>12</sup>

<sup>10</sup> The second approach has gained greater popularity among researchers, inasmuch as it has existed since Timmer attempted to explain interstate variation in technical efficiency in U.S. agriculture. The procedure is now common practice and has been extensively used when sufficiently rich data are available (Forsund, Lovell, and Schmidt, p. 23; Tian and Wan; Reinhard, Lovell, and Thijssen, 2002).

<sup>11</sup> Since both efficiency indices are bounded between zero and one, they were transformed using the logarithm function before the OLS estimation of (11).

<sup>12</sup> Deprins and Simar; Kumbhakar, Ghosh, and McGuckin; and Battese and Coelli (1995) initially objected to the use of technical efficiency scores as a dependent variable in a second-stage regression. However, although their argument is valid for output-oriented technical efficiency that is estimated in a first

For the purpose of the present study the variables used to explain efficiency differentials among cotton growers in Karditsa are: (a) the age of the farmer measured in years; (b) the value of the farm's total assets (comprised of the value of mechanical equipment, cultivated land and infrastructure) measured in euros; (c) the formal education of the farmer measured in years of schooling; (d) the land fragmentation measured as the number of plots cultivated with cotton in each farm; (e) the "specialization" of the farm measured by means of a *Herfindhal* index calculated as  $H_i^{sp} = \sum_m (y_m^s)^2$  with  $y_m^s$  being the share of product  $m$  of the farm's total production; (f) the total off-farm income measured in euros; and (g) five subregional dummies in order to capture differences in the environmental and physical conditions of cotton farms in the sample.<sup>13</sup>

### Estimation Results

The ML parameter estimates and their corresponding standard errors of the translog production frontier in (2) are presented in Table 2. The majority of the estimated parameters (11 out of 15) in the production frontier are found to be statistically significant at least at the 5% level. The estimated production frontier satisfies all the regularity conditions, namely positive and diminishing marginal productivities, at the point of approximation. Specifically, monotonicity conditions are satisfied since all the marginal products are positive, while the determinants of the principal minors of the bordered Hessian matrix alternate their signs indicating diminishing marginal productivities. The estimated variance-ratio parameter,  $\gamma$ , is positive and statistically sig-

stage, it is not true for input-oriented technical and scale efficiencies that are calculated from the parameter estimates of the stochastic frontier model. This is because output-oriented technical efficiency is assumed in the first stage to be independently and identically distributed, which contradicts its use as a dependent variable in a second stage having a functional relationship with the  $z$  explanatory variables. However, no such assumption has been made for the calculation of input-oriented technical and scale efficiency scores.

<sup>13</sup> All variables except the regional dummies are expressed in natural logarithms.

**Table 2.** Parameter Estimates of the Translog Stochastic Production Frontier for Cotton Farms

Parameter	Estimate	SE
Constant	-0.1378	(0.0612)**
Labor	0.2833	(0.1039)*
Capital	0.2862	(0.1244)**
Seeds	0.1616	(0.0545)*
Area	0.1544	(0.0454)*
Labor $\times$ capital	-0.0506	(0.0930)
Labor $\times$ seeds	0.2333	(0.0920)**
Labor $\times$ area	-0.2103	(0.0883)**
Labor $\times$ labor	0.0591	(0.0266)**
Capital $\times$ seeds	-0.4328	(0.1608)*
Capital $\times$ area	0.1245	(0.1448)
Capital $\times$ capital	0.1984	(0.0526)*
Seeds $\times$ area	0.1889	(0.0912)**
Seeds $\times$ seeds	-0.0828	(0.1268)
Area $\times$ area	0.0926	(0.1211)
$\sigma^2$	0.1993	(0.0354)*
$\gamma$	0.9369	(0.0502)*
$\ln(\theta)$	-16.516	

\* Significant at the 1% level.

\*\* Significant at the 5% level.

nificant at the 1% level;<sup>14</sup> its value implies that 84.35% of output variability is explained by the corresponding differences in output-oriented technical inefficiencies of the cotton farms examined. Statistical testing further supports this argument, as the average production function model was rejected at the 5% level of significance using the likelihood ratio test.<sup>15</sup>

Partial input elasticities with respect to output, and the returns to scale (RTS), were computed for each farm in the sample. Their average value and descriptive statistics are reported in Table 3. Inspection of the table reveals that *ceteris paribus*, capital seems to have the largest impact on cotton production,

**Table 3.** Production Elasticities and Returns to Scale of Green Cotton Farms

	Mean	SD	Minimum	Maximum
Labor	0.2777	0.0512	0.1270	0.4332
Capital	0.2992	0.0813	0.0063	0.5533
Seeds	0.1300	0.1009	0.0171	0.4169
Area	0.1715	0.0791	0.0319	0.4351
RTS	0.8784	0.0386	0.7846	0.9716

followed by labor, acreage cultivated, and seeds used. All farms in the sample exhibit decreasing RTS ranging from 0.9716 to 0.7846; the average RTS is found to be 0.8784. Statistical testing confirms the existence of decreasing returns to scale at the 1% level of significance (the value of the respective LR-test is 46.23 with 5 degrees of freedom). This is due to the relevant policy regime governing the sector, which induced an increase in the cultivated area beyond the capabilities of the existing production technology of Greek cotton farms. As also stated at the outset, the EU cotton regime has induced cotton growers to divert even marginally productive land to cotton farming.

#### *Input-Oriented Technical and Scale Efficiency*

Input-oriented technical and scale efficiency scores of the farms examined are shown in Table 4, in the form of a frequency distribution within a decile range. The table reveals that the cotton farms in the sample show considerable technical but only slight scale inefficiency. This implies that, primarily, Greek cotton growers have not been successful in optimally utilizing their inputs under the existing technology. More specifically, the computed input-oriented technical efficiency has an average value of 74.6%, implying that the farms examined could have produced the observed cotton quantity using on the average, about 25% less input quantities within the current state of technology. Moreover, technical efficiency scores vary considerably across farms, ranging from a minimum of 55.2% to a maximum of 94.6%. Of the 172 farms in the sample, only 65 (i.e., less than 40% of the

<sup>14</sup> It should be noted here that  $\gamma$  is not equal to the ratio of the variance of the technical inefficiency effects to the residual variance. This is because the variance of  $u$  is equal to  $[(\pi - 2)/\pi]\sigma_u^2$  not  $\sigma_u^2$ . The relative contribution of the inefficiency effects to the total variance term is equal to  $\gamma^* = \gamma/[\gamma + \{(1 - \gamma)\pi/(\pi - 2)\}]$  (Greene, p. 101).

<sup>15</sup> The value of the likelihood ratio test is 34.65, well above the corresponding critical value of the chi-squared distribution obtained from Kodde and Palm (Table 1).

**Table 4.** Frequency Distribution of Input-Oriented Technical and Scale Efficiency

Efficiency (%)	Input-Oriented Technical Efficiency	Input-Oriented Scale Efficiency
<20	0	0
20–30	0	0
30–40	0	0
40–50	0	0
50–60	16	0
60–70	51	0
70–80	40	0
80–90	51	1
>90	14	171
<i>n</i>	172	172
Mean	74.69	98.56
Minimum	52.21	89.75
Maximum	94.62	99.99

farms examined) achieved input-oriented technical efficiency above 80%. This means that the majority of the sample participants face severe technical inefficiency problems.

Regarding input-oriented scale efficiency, the average value is found to be 98.5%, ranging from 89.7% up to 99.9%. In fact, only one of the farms in the sample has a scale efficiency score lower than 90%. This implies that the average ray productivity of the cotton farms examined would deviate from the maximum attainable one by about 1.5%, *if they operated under full technical efficiency*. Moreover, for individual farms in the sample, the deviation of ray productivity from the maximum attainable one would range from zero up to 10.3%.

#### *Sources of Technical and Scale Efficiency Differentials*

The results of the second-stage OLS regression used to explain technical and scale efficiency differentials among sample participants are reported in Table 5. Since both the dependent and the explanatory variables (except for the regional dummies) are expressed in natural logarithms, these parameter estimates coincide with the relevant elasticity values.

A positive relationship is found between

technical and scale efficiency indices and the farmers' age. This is in accordance with the notion that years of hands-on experience and learning by doing are critical factors in determining individual performance, particularly in crop production.<sup>16</sup> However, the impact of age on the degree of technical or scale efficiency need not be monotonically increasing: that is, young cotton producers may well be expected to become more efficient over time, up to a point where the relationship between age and efficiency levels off; as they approach retirement age, microeconomic performance declines. This notion of decreasing returns to human capital is captured by the negative relationship found between technical and scale efficiency and age-squared (the relevant parameter estimates are  $-0.0857$  and  $-0.0231$ , respectively). A positive relationship is also found between a farmer's education and the efficiency scores of his farm. This lends support to Welch's hypothesis about the "worker effect" of education, that is, the notion that education is a strong complement to most of the inputs utilized in the production process. Moreover, schooling may enhance the information acquisition process and the efficiency in the use of the acquired information and thus in the utilization of current agricultural technology.

Farm size (approximated by farm's total assets) ended up with a statistically insignificant estimate in both equations. This implies that farm size was not significant in explaining the level of technical or scale inefficiency. Similar findings concerning the possible relationship between farm size and efficiency levels are reported by other authors, although there are studies reporting contradictory results (e.g., Kalaitzadonakes, Wu, and Ma; Romain and Lambert; Amara et al.; Giannakas, Schoney, and Tzouvelekas). It seems, therefore, that this relationship is subject to the particular traits of the sector under study. On the other hand, farm specialization, measured by means of a

<sup>16</sup> However, Weersink, Turvey, and Godah argued that inexperienced farmers tend to acquire knowledge about recent technological advances more easily than their older counterparts.

**Table 5.** OLS Regression Results of Input-Oriented Technical and Scale Efficiencies on Specific Farm Characteristics

Variable	Technical Efficiency		Scale Efficiency	
	Estimate	SE	Estimate	SE
Farmers' age (years)	0.5417	(0.1587)*	0.8547	(0.2069)*
Farmers' age squared (years)	-0.0857	(0.0105)*	-0.0231	(0.0024)*
Total assets (*C)	0.0007	(0.0011)	-0.0009	(0.0010)
Farmers' education (years)	0.2058	(0.0487)*	0.4058	(0.1036)*
Specialization (Herfindhal index)	-0.7193	(0.3285)**	-0.2695	(0.2369)
Land fragmentation (number of plots)	-0.2047	(0.0625)*	-0.3698	(0.0852)*
Off-farm income (*C)	-0.0012	(0.0006)**	0.0069	(0.0093)
Regional dummies				
RD <sub>1</sub>	0.0418	(0.0054)*	0.0087	(0.0021)*
RD <sub>2</sub>	0.0152	(0.0061)*	0.0285	(0.0206)
RD <sub>3</sub>	0.0036	(0.0026)	-0.0013	(0.0019)
RD <sub>4</sub>	-0.0052	(0.0136)	0.0305	(0.1036)
RD <sub>5</sub>	-0.0036	(0.0012)*	-0.0021	(0.0009)**
$\bar{R}^2$	0.4698		0.4305	

\* Significant at the 1% level.

\*\* Significant at the 5% level.

*Herfindhal* index,<sup>17</sup> was found to be negatively related with technical efficiency but not with scale efficiency levels (i.e., the corresponding parameter estimate ended up with a nonsignificant value in the scale efficiency equation). This finding implies that cotton farms that also diversify to other farming activities appear to be more technically efficient than farms highly specialized in cotton production. This may also reflect the fact that for farmers relying almost exclusively on cotton, actual production volumes basically shape their farm income; thus they may tend to use inputs excessively in their effort to achieve as large a crop as possible.

Land fragmentation, measured as the number of cotton plots on each farm, seems to negatively affect both efficiency indices. Specifically, the higher the degree of farm

fragmentation into many plots, the lower the scale and technical efficiency levels attained by individual farmers. This negative relation is however more in evidence for scale rather than for technical inefficiency (the corresponding parameters are -0.2047 and -0.3698, respectively). Off-farm income is associated with low technical efficiency scores but is not related with scale efficiency levels. This finding seems to support the hypothesis that off-farm income reduces producer incentives to generate the highest possible income from farming. Finally, three out of five and two out of five regional dummies are statistically significant in the technical and scale efficiency regression equations, respectively. Given that our sample is highly localized, these regional dummies can serve as a good proxy for the general environmental conditions in each particular area of Karditsa. Therefore physical factors, such as soil quality and weather conditions, affect individual technical and scale efficiency levels. Since environmental conditions in the first two regions are favourable for cotton cultivation and unfavourable in the fifth region, the signs of the corresponding coefficients ( $RD_1, \dots, RD_6$ ) are rather expected.

<sup>17</sup> By construction, the *Herfindhal* index assigns high values to farms specialized either in cotton or in any other crop. However, our sample consists of farms highly specialized in cotton production in the sense that more than 60% of their total gross revenues is earned exclusively from cotton farming. Hence, the interpretation of our empirical findings refers exclusively to cotton specialization and not farm specialization in general.

**Table 6.** Potential Profits Gains for Cotton Farms in Karditsa under Optimal Resource Use

	in €	in €/Stremma
Actual Profits ( $\pi^A$ ):	12,584	210.4
$TR^A = (p_w - p_c)\bar{y}$	26,747	447.3
$C^A = \sum_j w_j \bar{x}_j$	14,163	236.8
Profits at Technical Efficient Input Use ( $\pi^I$ ):	16,147 (128.3)	270.0
$TR^I = (p_w - p_c)\bar{y} = TR^A$	26,747 (100)	447.3
$C^I = \theta^I \sum_j w_j \bar{x}_j$	10,600 (74.8)	177.3
Profits at Scale Efficient Input Use ( $\pi^S$ ):	18,883 (150.1)	315.8
Potential Revenues ( $TR^S$ ):	26,504 (99.1)	443.2
$(p_w - p_c)y^S$	25,675 (94.5)	422.7
$p_c^S y^S$	829 (4.5)	13.8
$C^S = \theta^S \sum_j w_j \bar{x}_j$	7,621 (53.8)	127.4

One stremma equals 0.1 ha. Numbers in parentheses are the corresponding percentage values relative to the observed level of profits, revenues and cost.

#### Potential Profit Gains for Cotton Farms

The average input-oriented technical efficiency score of 74.7% implies that on the average the observed cotton output levels could have been produced with 25.3% lower production costs without altering the existing production technology. Table 6 presents a detailed report on the potential cost reductions and thus profit gains from eliminating both input-oriented technical and scale inefficiency from the cotton farms in the sample. Actual cost of production for the sample participants is calculated on the average to be 14,163, and total revenues 26,747. As a result actual profits for cotton growers in the sample are estimated to be 12,584. If, however, cotton farms in Karditsa become technically efficient from an input-conserving perspective (i.e., reducing input use while maintaining the same level of output), their potential total profits will be increased by 28.3%. This increase will arise exclusively from the associated reduction in the cost of production, as total revenues will be the same; cotton produced and thus intervention price will remain unchanged. Specifically, total cost of production will be decreased by 3,563 and thus total profits would be 16,147. Therefore, reducing technical inefficiency could substantially improve the economic viability of cotton farms.

If farms, apart from being technically efficient, also attain scale efficiency, their total profits will be further changed. That change will stem from three sources: (a) the further reduction in the cost of production (in terms of Figure 1 input use and thus production cost will be decreased from  $w \cdot \theta^I \bar{x}$  to  $w \cdot \theta^S \bar{x}$ ); (b) the reduction in the total output produced (under decreasing returns to scale, by moving to the technically optimal scale of production, output produced will be decreased); and (c) the increase in cotton intervention price as total cotton produced will exceed by a lesser amount the maximum guarantee quantity imposed at the country level. Thus, there are two positive effects and one negative effect on farm's total profits. If the production technology is well-behaved (i.e., positive and diminishing marginal products), as it is in our case, the positive effects will always outperform the decrease in total revenues due to reduced farm output level.

In order to compute the change in the penalty imposed on all Greek cotton growers our results are extrapolated for the whole county of Karditsa using the goal programming method described in the previous section. According to these results, in the period 1997–98, cotton output would have been reduced by 55,422 metric tons if all cotton-producing farms in Karditsa County had been both technically and scale efficient. The potential re-

**Table 7.** Potential Co-Responsibility Levy Reduction for All Greek Cotton Growers, 1997–1998

Variable	Actual Data	Estimates If Karditsa Cotton Growers Operate at Technically Optimal Scale Size
Actual cotton production	1,085,488 Mt	1,030,065 Mt (–5.1%)
Production quota (MQG)	782,000 Mt	782,000 Mt
Co-responsibility levy	0.15 αC/kg	0.12 *C/kg (–18.27%)

duction of the co-responsibility levy (faced, however, by all Greek cotton growers) is computed in Table 7. In 1997–98, actual cotton production in Greece was 1,085,488 metric tons; the country's production quota was set at 782,000 metric tons; the target price was 0.97 €/kg; and the co-responsibility levy was 0.15 €/kg. In percentage terms, this co-responsibility levy represents an 18.3% reduction in the target price.

The actual Greek production exceeded the predetermined production quota by 38.8% in 1997–98; it would have exceeded the production quota by 31.72%, if the Karditsa county cotton growers had been technically and scale efficient. Since the actual exceeding of the production quota by 38.8% resulted in an 18% drop in the intervention price, simple algebraic calculations suggest that if the Karditsa County cotton growers had been technically and scale efficient, the intervention price (the co-responsibility levy) would have been 0.12 €/kg in the period 1997–98. In other words, if *only* the Karditsa cotton growers had been both technically and scale efficient, the financial penalty (the co-responsibility levy) for *all* Greek cotton growers would have been smaller by 0.03 €/kg.

Using this penalty reduction we have estimated the potential profits for the sample participants; the results are presented in the lower panel of Table 6. According to these estimates, potential profits for the surveyed farms would be 18,883, 6,299 higher than those currently realized by cotton growers. More analytically, 28.3% (3,563) of these additional profits would stem from being fully technically efficient and the remaining 21.8% (2,736) from moving to the technically optimal scale of production (i.e., being scale efficient). Specifical-

ly, potential revenues would be slightly decreased to 26,504, of which 829 would arise from the reduction in the co-responsibility levy due to the reduction of cotton produced in the whole county of Karditsa. On the other hand, total cost of production would be 7,621, decreased by 46.2% from its actual level. Of this reduction, 25.2% arises from the corresponding decrease in inputs use by moving to the technically efficient point of production (point B in Figure 1), while the remaining 21.0% from moving to the technically optimal scale of production (point C in Figure 1). This significant decrease in the cost of production outweighs the relevant reduction in total revenues resulting in the final increase of farm profits by 50.1%. In absolute terms potential profits at the technically and scale efficient point of production will be 315.8 per stremma, which is 105 higher than those currently enjoyed by the sample participants (210.4).

### Policy Implications

Our analysis indicates that the benefits the Common Agricultural Policy offered to Greek cotton producers have come at a rather significant opportunity cost. Specifically, the satisfactory farm income that the EU cotton regime secured in the past for cotton growers (via administrative prices, set well above world levels) allowed them to disregard efficiency considerations in the way in which they apply their production technology. Nowadays, however, the resulting efficiency distortion is becoming a critical factor for Greek (and other EU) cotton growers, for at least two reasons. First, the EU itself has taken a course of gradual reduction of its costly farm programs; thus, ways to achieve cost savings are becoming in-



creasingly important for the economic viability of farming operations. Second, further liberalization of the world agricultural markets will only intensify competition, thus making efficiency a major determinant for the survival of cotton producing farms.

The considerable technical and scale inefficiency in Greek cotton farming also becomes important in light of the attitude Greek cotton farmers have exhibited against the CAP cotton regime: as already mentioned, they have repeatedly protested, claiming that their revenues are severely reduced by the current EU regime (outlined in section 2). This study indicates, however, that instead of blindly demanding higher prices to secure their income, cotton farmers could achieve a similar result via cost savings stemming from the reduction of their technical and scale inefficiency.<sup>18</sup>

Thus, the primary policy suggestion derivable from our study calls for Greek policy planners to complement the current EU cotton regime with structural policies that explicitly induce cotton farmers to improve the technical and scale efficiency of their operations. Such measures can effectively address the difficulties associated with the prospects facing Greek cotton growers, outlined above. First, they can implicitly induce Greek cotton farmers not to exceed (or at least to exceed by less) the EU-imposed, cotton production quota (MQG), thus maintaining the level of EU support currently available to them, and their farm revenue. Second (and perhaps more importantly), such measures may prepare Greek cotton growers to cope with future support reductions in light of current and future CAP reforms and increasingly integrated world agricultural markets.

Specific measures of such complementary

structural policies may include those to improve resource allocation skills of Greek cotton growers. Our second-stage regression results suggest that human capital variables (such as age and education) positively affect the efficient use of a farm's resources. According to human capital theory, innovative ability is closely related to a farmer's level of education, experience, and information accumulation—these characteristics are associated with the resource allocation skills of farm operators (Schultz). These resource allocation skills are acquired or learned rather than innate. Certainly policy measures cannot modify a farmer's level of education or the years of his hands-on experience. Instead policy instruments can be designed to alter farmers' allocative ability through the continuous transfer of the necessary knowledge to those farmers that require it most. This can be done through on-farm extension visits, demonstrations, vocational training, informative leaflets, and so on, which can considerably improve farms' human capital and thus their economic performance.

Incentives are a second measure for cotton growers to adjust the excessive scale of their farm operations. According to our second-stage results, human capital variables seem to play an important role. However, what is also important from a policy point of view is the negative effect of the land fragmentation variable on scale efficiency levels. In fact, it is the most important determinant, apart from human capital variables exhibiting a high elasticity value. This finding suggests that a potential reallocation of land in the county of Karditsa could contribute to that direction. As shown in Table 1, on the average each farm in Karditsa cultivates cotton in five different plots, which may be located far away from each other. Contrary to other European countries, the existing legislative framework in Greece allows the breakup of agricultural land among family members, which through the years has resulted in considerable fragmentation of farm operations throughout the country. Land reallocation is a feasible rural structural measure, which in turn could considerably

<sup>18</sup> In a different analytical framework Karagiannis and Pantzios show that full compliance with (rather than consistent violation of) the country-level production quota imposed by the current EU cotton regime would make Greek cotton farmers better off. The empirical results of the present study lend additional support to the view that Greek cotton farmers can maintain their farm income by fully abiding to production controls and reducing production costs via efficiency improvements rather than persistently demanding ever higher administrative prices.

improve individual farmers' performance and specifically their scale of operation.

In addition, cotton farmers can indirectly face the land fragmentation problem by sharing equipment with adjacent farms through the "grouping of farms" procedure that is eligible for financial aid by the current CAP structural funds. In Greece, informal forms of cooperation based on extended family relationships have prevailed and—administrative inertia notwithstanding—the aforementioned possibility has rarely been exploited. However, these days several factors converge to activate this option in Greece—the time to replace equipment bought during the golden era of the 1980s has come. New investments can best be undertaken by a group of farmers when funded through submitted business plans. In addition, the new availability of funds directed to market support or compensation payments and the Rural Development Initiatives are making funding such actions feasible.

Another possibility is using measures to favor balanced cotton farming operations by discouraging occasional or marginal cotton growers, but also farmers who base their farm income on diversified farm production. Product diversification and not farm pluriactivity can improve the economic performance of Greek cotton growers. The policy regime that governed the sector until the early 1990s induced cotton growers to convert even marginally and low productive areas into cotton production and to invest in modern equipment inappropriate for cotton production, subsidized at a significant cost by both the EU and the Greek government (Sapounas). The recent reform of the CAP towards decoupling farm incomes, as well as the early retirement programs adopted recently throughout Greece, will certainly positively affect the future course of the sector. In line with that, Greek authorities can help cotton growers in diversifying their farm operations towards a more balanced growth of the rural economy of Karditsa County.

Immediately following the last CAP review in 2003, the main decision about subsidies decoupling came in response to the WTO conference. Especially concerning cotton, Greece

exercised the right to moderate decoupling by keeping 65% of cotton support in price subsidy form and only 3% decoupled. This means that the overproduction problems will persist in the near future, as Greek cotton growers will continue to base their decisions on the price support scheme. Nevertheless, there is scope for significant improvement through the use of Rural Development Programs to restructure the sector in the coming years. Specifically, within the context of Rural Development Regulation 1257/1999 as amended by Regulation 1783/2003, several measures (2nd Pillar) can be undertaken towards the restructuring of farm operations to diminish their difficulties in achieving high efficiency and/or productivity levels. In addition, the recent CAP reform towards decoupled farm incomes can also provide a positive framework for the future development of cotton farming throughout the EU.

However, since Member States have different options regarding implementation, the degree of decoupling and the use of national envelopes will have an impact on cotton growing. Hence, Member States who wish to support cotton farming should consider the factors affecting farmers' performance when implementing the new rules. The existence of national envelopes gives the opportunity to each Member State to deal with its own peculiarities and structural difficulties regarding farm operations so that cotton farming is maintained as a significant source of income in rural areas (CEC).

### Concluding Remarks

Productive units operating with decreasing returns to scale under policy regimes where financial support is offered only for a predetermined output level may find that pursuing technical and scale efficiency is a decisive factor for the support level they enjoy. Greek cotton production under the EU cotton regime is an illustrative case. This paper examines the importance that input-oriented technical and scale efficiency may have for the support Greek cotton farmers receive, in the context of the current EU cotton policy. For this purpose

we estimated econometrically the technical and scale efficiency levels of a sample of cotton growers in the representative, cotton-producing county of Karditsa, located in Thessaly in Central Greece, for the period 1997–98. In addition, by utilizing goal programming we computed the cotton output of Karditsa County if all cotton farming operations in the county were both technically and scale efficient.

Our empirical findings suggest that, in general, the cotton farms examined are technically and scale inefficient. The high support policies of the EU in the 1980s appear to have considerably contributed to the inefficiencies observed. Our analysis indicates that elimination of these inefficiencies could result in considerable gains; the cotton farmers examined could reduce production costs by 50.1% by becoming both technically and scale efficient. Additionally, we estimate that if cotton farms in the area examined were technically and scale efficient, the intervention price reductions (co-responsibility levy) imposed by the EU for excessive cotton production would be smaller for all Greek cotton growers. Policy recommendations derivable from our study suggest that Greek policy planners should complement the current EU cotton regime with structural policies that explicitly induce cotton farmers to improve the technical and scale efficiency of their operations. Such measures can effectively mitigate the amount by which Greek cotton farmers exceed the EU imposed cotton production quota, thus maintaining the level of EU support currently available to them, and their farm revenue. Second, and perhaps more importantly, such measures may prepare Greek cotton growers to cope with future support reductions in light of future CAP reforms and increasingly integrated world agricultural markets.

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