Economic Efficiency in Organic Farming: Evidence from Cotton Farms in Viotia, Greece

Vangelis Tzouvelekas, Christos J. Pantzios, and Christos Fotopoulos

ABSTRACT

Using recent advances in the stochastic production frontier framework, this paper presents an empirical analysis of technical, allocative and economic efficiency of a sample of organic and conventional cotton farms located in Greece. The results suggest that both farm types in the sample examined are technically, allocatively and economically inefficient. Farmer’s age and education and farm size are important factors in explaining differentials in efficiency estimates. In comparative terms, organic farms exhibit lower efficiency scores vis-à-vis their conventional counterparts in terms of technical and economic efficiency; regarding allocative efficiency both farm types are almost equally inefficient. Low efficiency scores in both types of farming may be attributed to the respective intervention policies of the last 20 years.

Key Words: cotton, efficiency, organic farming, stochastic production frontier.

Introduction

Cotton farming has been one of the most dynamic agricultural enterprises in Greece, characterized by high output value, high farm income and compelling export performance. However, since the mid 1990s, cotton farming in Greece has slipped into a worrying recession triggered by record-high levels in both domestic and world supply and drastic reductions in the support policy of the European Union (EU). With most of the agricultural sectors across EU facing similar recessions, exclusive reliance on traditional protective policies is no longer possible. Alternative strategies are urgently needed to ensure the survival of agricultural enterprises. Such an alternative strategy may be to introduce differentiation among varieties of agricultural products on the basis of their quality characteristics. Relatively recently, the European Commission has encouraged products of designated origin (PDO) and products of geographical indication (PGI) as ways of promoting agricultural product differentiation. Additionally, a prominent alternative of product differentiation, which received considerable attention within the EU over the last 15 years, is the use of organic farming practices in agricultural production. Within the EU the differentiation between organically and conventionally produced commodities has already been institutionalized, as the European Commission introduced in the early 1990s a specialized framework (EU Reg-
quota. The perspective of a trade liberalization in the world agricultural markets (already initiated at the latest Uruguay agreement on international trade) is expected to put additional pressure on this EU cotton policy. In this rapidly changing environment (characterized by drastic reductions in price support, increasing competition and liberalization of trade flows), the quality-based differentiation of cotton becomes an appealing alternative for dealing with fluctuating prices and surplus production.

In principle, it is suggested that the differentiation of cotton via organic cultivation techniques could lead to considerable economic as well as environmental benefits. In particular: (i) organically produced cotton and its subsequent use in textile may lead to the development of niche markets and the differentiation of its price relative to the price of conventionally produced cotton, (ii) the elimination of expensive chemical inputs from cotton cultivation may lower production costs and reduce extremely high yields, and (iii) organic cultivation of cotton may result in favorable environmental effects as it is well-known that conventionally cultivated cotton ranks high in the list of heavily polluting crops. However, the application of organic techniques in cotton growing is currently facing considerable difficulties since the respective knowledge (organic fertilizing, biological control techniques, etc.) is incomplete or experimental. These difficulties are reflected in the minimal percentage of organically cultivated land that is devoted to cotton growing. Specifically, the organically utilized agricultural land (OUAL) in Greece reached about 5270 ha in 1996, accounting for 0.13 percent of total agricultural land. Of the annual organic crops, cotton showed a promising start as it was grown in about 370 ha (31 percent of OUAL) in 1994. Although this acreage plummeted to only 9 percent of OUAL (i.e., 153.6 ha) in 1996, the acreage of fully organic cotton fields shows a steady growth, rising from 2.5 ha in 1994 to 7.1 ha in 1995 and 16.5 ha in 1996. These changes indicate that despite the aforementioned difficulties in organic cotton cultivation methods a core of persistent organic cotton growers has formed in Greece.

Regarding the policy on organic cotton farming, it should be stressed that Greek organic farmers face the same regime as conventional farmers; this means that, at the minimum, they receive the price of conventional cotton (which via the EU intervention price is set higher than the world price). Any price premiums they may receive are above the price for conventional cotton. In addition, organic farmers receive financial aid in the form of acreage-based subsidies via the EU Regulation 2076/92. The basic idea behind such "organic" subsidies is to help farmers cope with lower yields and provide them with an incentive to reduce intensive farming. Eligible for this "organic" financial aid are all organic farmers irrespective of the state (in-conversion or fully organic) of their farm operations.

Methodological Framework

The current interest in efficiency measurement finds its origin in Farrell who explored the concepts of the production frontier. In his influential paper, Farrell showed that productive efficiency can be broken down into two coherently components: the pure technical or physical component and the allocative or price component. The former refers to the ability of producers to avoid waste of inputs by producing as much output as the inputs at their disposal permit under the current state of technology; the latter refers to the ability of producers to contrive an optimal allocation of the inputs available in light of the prevailing output and input prices. Thus, technical inefficiency arises when actual or observed output from a given input mix is less than the maximum possible; allocative inefficiency arises when the input mix is not consistent with cost-minimization.

In recent years considerable progress has been made towards refining the production

3 In other words, the "organic" financial aid subsidizes the acreage devoted to organic cultivation not the volume of actual production as is the case with subsidizing prices.
ations 2092/91 und 2078/92) that allows the certification—via inspecting organizations—of commodities labeled organic. As a result, organic practices in the cultivation of various crops have spread across EU member-states, while organic produce is becoming appealing to consumers with food safety and environmental concerns. Although organic farming is a conceptually attractive alternative to conventional farming, in practice the actual economic performance of organic agricultural enterprises remains largely an empirical question.

On the other hand, the importance of productive efficiency in overall farm productivity, economic performance, and competitiveness has been increasingly recognized, especially in the course of gradually liberalizing agricultural markets. Although efficiency studies have been published for several primary sectors in various countries, similar research on organic farming practices is generally lacking. However, such empirical research is certainly warranted. Typically yields are known to decrease (causing income losses) during several years after converting into organic; thus, it is suggested that organic cotton growers should receive an almost 40-percent price premium over conventional cotton prices to cover such income losses (International Cotton Advisory Committee). Therefore, if organic farming practices are socially and politically desired, then research efforts to help organic farmers improve their economic performance can have important implications for their economic survival.

More exactly, if organic farm operations exhibit considerable inefficiencies, their effort, at least in the short-run, should be to increase farm output (and thus farm income) by improving the utilization of their inputs and their allocation in the production process. On the other hand, one cannot neglect the potential improvements that could arise from narrowing the gap of the technological disadvantage between organic and conventional farming practices. Still, studying the efficiency of organic farms today can provide policy makers with useful indications of the potential future changes in the technological conditions of such farms. This is because, irrespective of the kind of technology adopted by the farmers, it is equally important that this technology is utilized efficiently.

The Greek Cotton Sector

Cotton growing has shown an impressive expansion in Greece during the last 20 years. The sector's rapid enlargement has been mainly the result of the early high support-mechanisms of the Common Agricultural Policy (CAP) of the EU. The acreage cultivated with cotton was almost doubled during the 1980s reaching 250 thousand ha (2.4 million hectares) in 1991, from only 120 thousand ha in 1981 and kept expanding during the 1990s, reaching 430 thousand ha in 1996.

At the same time, the volume of production has tripled: from only 290,000 tons in 1981, it swelled to about 1 million tons in 1996 (Greek Cotton Board). Average yields have been among the highest, as Greece ranks fifth worldwide in terms of cotton yields per hectare (Avgoula and Koutro-Avgoula). Within the EU, Greece is the largest cotton producer, accounting for almost 70 percent of the total EU cotton production. Thus, cotton growing has become the primary farming activity (and source of income) to more than 100,000 Greek farms.

Regarding the cotton policy regime faced by Greek farmers, 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, the EU has, since 1987, replaced this policy regime with an intervention mechanism consisting of (i) an intervention price, (ii) an aggregate production quota, and (iii) a reduction in the intervention price (i.e., a levy) when the actual aggregate production exceeded the predetermined aggregate production

\[1\] For a detailed review of the most important studies see the surveys of Batué (1992), Bravo-Lara and Paganico and Coelli.

\[2\] One stramma equals 0.1 ton.
frontier methodology. Among the alternative frameworks proposed, an attractive method-
ology is that suggested by Bravo-Ureña and Rieger and Bravo-Ureta, and Evenvosen. Based
on the decomposition technique introduced by Kopp and Diewert, they presented a model
which allows the measurement of both techni-
cal and allocative efficiency via the econo-
metric estimation of a single stochastic pro-
duction frontier function. Its basic idea is to use
duality and, in particular, cost-minimizing
input demand functions implied by Shepard's
lemma to obtain estimates of allocative effi-
ciency. However, this approach requires the use
of a self-ideal-functional form for the sto-
castic production frontier in order to have an
analytically tractable solution for the dual cost
function. Nevertheless, its usefulness in cross-
section studies is still important, as price data
necessary for the estimation of the dual fron-
tier are usually lacking or insufficient.

A measure of input-oriented technical effi-
ciency (Shephard-type) of a production unit (say, a farm) $f$ producing output $y$, via inputs
$x_{ij}$, $j = 1, \ldots, k$ can be obtained by dividing the
technically efficient input vector by the ac-
tual input vector after weighting both by the
input prices as (Kopp):

$$
TE^f = \frac{\sum_j x_{ij} w_j}{\sum_j x_{ij} w_j}
$$

where $TE^f$ is the farm-specific technical effi-
ciency, $w_i$ are the prices of inputs $j = 1, \ldots, k$.

The same approach has been also used by Shal-
ma, Leung and Zalevski in analyzing productive effi-
ciency in rice production in Hawaii.

Within the stochastic production frontier, model
technical efficiency can be defined in either an output-
expanding or input-converting fashion (Kumbhakar
and Lovell, p. 40-42). The first one is the output-oriented $D_{Dobrien}$-type measure, which is given by
the ratio of the observed to maximum feasible out-
put, conditional on production technology and ob-
served input use. The second one is the input-oriented $D_{Shephard}$-type measure, which is given by the ratio of
minimum feasible to observed input use, conditional
on production technology and the level of output. The
use of input-oriented technical efficiency is necessary
for integrating property properly Kopp and Diewert decompo-
sition techniques with Battese and Coelli (1995) model
formulation.

$k$ and $x^*, x^*$ are the technically efficient and
actual input vectors, respectively, $x^*$ is defined
as the optimal input vector given the farm's
available technology.

Similarly, a measure of the farm's input-
oriented economic (or cost) efficiency is ob-
tained as:

$$
EEl^f = \frac{\sum_j x_{ij} w_j}{\sum_j x_{ij} w_j}
$$

where, $EEl^f$ is the farm-specific input-oriented economic (or cost) efficiency, $w_i$ are the prices of inputs $j = 1, \ldots, k$ and $x^*$ and $x^*$ are the economically efficient and actual input vec-
tors, respectively, $x^*$ is defined as the optimal input vector, given input prices. Thereafter, ac-
tording to Farrell's decomposition of econom-
ic efficiency, one can derive the farm's input-
oriented allocative efficiency as the ratio of econ-
omic efficiency over technical efficiency. However,
unlike the actual input levels $x^*$ which are directly observable, the technically and economically efficient input levels $x^*$ and $x^*$ need to be computed before the efficiency
measures $TE^f$ and $EEl^f$ became operational.

To that end, consider the general stochastic production frontier of the farm $x$ question, written as:

$$
\gamma = f(x) \delta(x)
$$

where, $y_i$ is the observed output level, $x$ is a vector of inputs used in production, $\delta$ is a vec-
tor of estimable parameters, and $\xi_i = v_i - \alpha_i$ is a stochastic composite error term. Its two error components, $v$ and $\alpha$, are assumed to be
distributed independently from each other; $v$ represents a symmetric and normally distrib-
uted component capturing the effects of ex-
ogenous shocks and measurement errors and $\alpha$ is a one-sided component representing the stochastic shortfall of output from the farm's
production frontier due to output-oriented technical inefficiency ($D_{Dobrien}$-type). As Kun-
bhakar, Ghosh and McQuickin and Battese and

The same, however, is not true if output-oriented technical efficiency is used (Kumbhakar and Lovell, p. 54).
Coelli suggest, \( w \) may be replaced by a linear function of explanatory variables, reflecting farm-specific characteristics. In that way, every farm in the sample faces its own frontier, specified by the current state of technology as well as its physical endowment, not a sample mean (Hallam and Machado). Specifically, in that formulation, \( w \) are non-negative random variables, assumed to be independently distributed as truncations at zero of the normal distribution (with mean \( \mu \) and variance \( \sigma^2 \), defined by (Batteese and Coelli)):

\[
(4) \quad \mu = 8z_1 + \nu,
\]

where \( \tau \) are the explanatory variables associated with technical inefficiencies, efficiencies of production and \( \beta \) are the associated parameters to be estimated. These assumptions are consistent with \( w \) being a non-negative truncation of the \( N(z_1, \beta, \sigma) \) distribution.\(^7\) Further, the explanatory variables may also include some input variables given that the inefficiency effects are stochastic.\(^8\)

Methodologically, the above model formulation has two distinct advantages: first, it gives the possibility to identify some of the reasons (such as managerial experience, ownership characteristics, etc.) to explain differences in the predicted levels of inefficiencies among farms in a single-stage, second, the decomposition of the composite error term does not require Jondrow's et al. predictor which does not converge to the true estimates (Ottone, p. 91).

Choosing a functional form for the production frontier in (3) and estimating it econometrically via ML techniques allows the computation as well as the decomposition of the composite error term \( e \) using the predictors proposed by Batteese and Coelli (1988). Further,

\( \text{Data and Empirical Model} \)

The data used in this study are part of a survey undertaken by the Institute of Agricultural Economics and Rural Sociology of the National Agricultural Foundation of Greece (N.A.G.R.E.F.) on the cost of organic farm operations \( \text{vis-à-vis} \) conventional neighbour farms.\(^9\)

\( \text{Notes} \)

1. The distribution of the sum of a general normal distribution with unknown mean \( \mu \) to be estimated permits different inefficiency distributions than the half-normal to be accounted for. Distributions with large negative and positive values of \( \mu \) are quite different (Batteese, 1998).

2. This actually relates to Huang and Liu's non-parametric specification of the stochastic production frontier model.

3. A number of empirical studies have estimated stochastic frontier models and then in a second stage attempted to identify some of the reasons to explain differences in the predicted levels of inefficiencies among farms. This has been a useful exercise, suffering nonetheless by a considerable limitation: the two-stage estimation procedure is inconsistent in neglecting the independence of the inefficiency effects on the two estimation stages. Thus, the two-stage estimation procedure is usually to provide estimates which are as efficient as those that could be obtained using a single-stage estimation procedure (Kumbhakar, Ghosh and McCallum; Reifschneider and Stevenson).

4. Estimates on \( \nu \) are obtained after the econometric estimation of the model using the predictor suggested by Batteese and Coelli (1988) for the decomposition of the composed error term. Basso-Urresta and Everyone, Basso-Urresta and Bierer and Sharman, Long and Zarick used the same approach. However, all these papers used the predictor suggested by Jondrow et al., and not that of Batteese and Coelli (1988).

5. For the analytic derivation of the cost function in self-deal functional form see Varian and Shepard.
Table 1. Gross Revenues and Production Costs of Organic and Conventional Cotton Farms in Viotia-Greece, 1995-96

<table>
<thead>
<tr>
<th>Production Expenses</th>
<th>Organic Farms</th>
<th>Conventional Farms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Production Expenses</strong></td>
<td><strong>Drachmai/strumen</strong></td>
<td><strong>%</strong></td>
</tr>
<tr>
<td>1. Land Rent</td>
<td>20,333</td>
<td>30.2</td>
</tr>
<tr>
<td>2. Labor</td>
<td>19,123</td>
<td>28.4</td>
</tr>
<tr>
<td>a. Family</td>
<td>7,729</td>
<td>5,283</td>
</tr>
<tr>
<td>b. Hired</td>
<td>5,873</td>
<td>1,787</td>
</tr>
<tr>
<td>c. Hood Mechanical</td>
<td>5,521</td>
<td>7,109</td>
</tr>
<tr>
<td>3. Fertilisers</td>
<td>2,870</td>
<td>4.3</td>
</tr>
<tr>
<td>4. Pesticides</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>5. Biological Control</td>
<td>113</td>
<td>0.2</td>
</tr>
<tr>
<td>6. Fuel</td>
<td>5,809</td>
<td>8.6</td>
</tr>
<tr>
<td>7. Power</td>
<td>2,072</td>
<td>3.3</td>
</tr>
<tr>
<td>8. Seeds</td>
<td>2,571</td>
<td>3.8</td>
</tr>
<tr>
<td>9. Irrigation</td>
<td>1,128</td>
<td>1.7</td>
</tr>
<tr>
<td>10. Insurance</td>
<td>534</td>
<td>0.8</td>
</tr>
<tr>
<td>11. Organic Certification</td>
<td>982</td>
<td>1.5</td>
</tr>
<tr>
<td>12. Interest on Variable Costs</td>
<td>1,969</td>
<td>2.9</td>
</tr>
<tr>
<td><strong>Total Cost</strong></td>
<td>67,205</td>
<td>100</td>
</tr>
<tr>
<td><strong>Gross Profit</strong></td>
<td>7,133</td>
<td>—</td>
</tr>
</tbody>
</table>

The third and fifth column present the relevant percentage shares; one strumen equals 0.1 ha; average annual exchange rate in 1996: 1 US$ = 240.7 drachmai; in the case of organic farms fertilizer is only organic, whereas in conventional farms only chemicals.

farms. The sample used here consists of 29 organic cotton farms located in Viotia county (in the region of Sterea Ellada) during the 1995-96 harvesting period.11 To be able to compare our findings with conventional cotton farming, we collected a second sample of 29 conventional cotton farms with similar characteristics (in terms of size, farm mechanization and commercialization, farmer’s age and education) from the same area. The survey provided detailed information about production patterns, input use, average yields, and gross revenues 11 In Viotia county organic cotton production has been systematically applied since the early 1990s, using an almost homogeneous technology; all organic cotton farms included in the sample have been growing organic cotton for at least three years. of the surveyed farms. A summary of this information is presented in Table 1.

Inspection of the table reveals that average cotton yield is, at present, considerably lower (about 27 percent lower) in organic farms. At the same time, prices for organic cotton are not on the average significantly different from conventional cotton prices—although they fluctuate widely across the examined farms, ranging from 240 drs/kg (1 US$/kg) to 345 drs/kg (1.43 US$/kg). This fluctuation in prices received for organic cotton is not surprising given that the marketing channels for organic cotton in Greece are still at an infant stage, while consumers are not yet fully aware of the benefits of using organic cotton in textiles. The combination of significantly lower yields
and lack of considerable price premiums results in lower average revenues for organic cotton farms, despite the additional subsidy of 9900 drachmas (41.3 US$ha) to organic cotton growers, via the EU Reg. 2078/92.

Regarding production costs, land, labor and capital expenses appear to be dominant in both types of farming, though at different levels. As expected, labor expenses (family and hired) in organic farming are much higher compared to those of conventional farming, while the fertilizing expenses (organic fertilizer and biological control costs) are remarkably lower in organic farms compared to conventional cotton farms. Overall, however, the cost of producing organic cotton does not appear considerably different from the production cost of conventional cotton; for the sample examined the total cost of organic cotton is only 5 percent lower than that of conventional cotton. Thus underlines the need to cope with the problem of low profitability of organic cotton growers, especially at the current stage where organic cotton farming in Greece is at its infancy.

For the purposes of the present analysis, the stochastic production frontier function used to analyze the underlying technology of the Greek cotton farms is specified to be of a Cobb-Douglas form. That is:

\[ \ln y_i = \beta_0 + \beta_1 \ln x_{i1} + \ldots + \beta_J \ln x_{iJ} + \varepsilon_i \]

where, \( i = 1, 2, \ldots, N \) denotes cross-section units (farm operations); \( j = 1, 2, \ldots, J \) denotes the applied inputs; \( m = 1, 2, \ldots, M \)

depicts the explanatory variables i.e., variables explaining differences in farm efficiencies among the units examined; \( \varepsilon_i \) is the classical error term capturing random noise and measurement error in the production frontier; \( w_i \) is a random variable defined by the truncation of the normal distribution with zero mean and constant variance such that the point of truncation is \( w_i = -\delta_i \).

The list of variables (a summary of their statistics is presented in Table 2) included in (5) is as follows: \( y_i \) is the annual organic (or conventional) cotton production measured in drachmas; \( x_{i1} \) is the total labor, comprising hired (permanent and casual), family and contract labor, measured in working hours; \( x_{i2} \) is the total amount of fertilizers and pesticides applied to the production measured in drachmas (in organic farms this refers to organic fertilizers and biological weed and pest control); \( x_{i3} \) is the total area under organic or conventional cotton cultivation measured in stremmas; \( x_{i4} \) are the other cost expenses comprising the value of seeds, fuel, electricity, power and interest on fixed assets measured in drachmas; \( \mu_{C, i} \) is the farmer’s age in years; \( \mu_{G, i} \) is the farmer’s age in years squared; \( \mu_{S, i} \) is the farmer’s education measured in years of schooling; \( \mu_{R, i} \) is the farmer’s stock of capital inputs (including machinery, inventories and buildings) expressed in drachmas; \( \mu_{P, i} \) is the share of family labor expenses to total labor expenses.

\[ \mu_{C, i} = 0 \to 80; \mu_{G, i} = 1 \to 90; \mu_{S, i} = 1 \to 30; \mu_{R, i} = 1 \to 16; \mu_{P, i} = 0 \to 1 \]
Table 3. MLE of the Cobb-Douglas Stochastic Production Frontiers for the Organic and Conventional Cotton Farms in Viotia-Greece, 1995-96

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Organic Farms</th>
<th>Conventional Farms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>Standard Error</td>
</tr>
<tr>
<td>Stochastic Frontier Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$b_0$</td>
<td>0.42</td>
<td>(0.062)*</td>
</tr>
<tr>
<td>$b_1$</td>
<td>0.019</td>
<td>(0.006)**</td>
</tr>
<tr>
<td>$b_2$</td>
<td>0.136</td>
<td>(0.078)**</td>
</tr>
<tr>
<td>$b_3$</td>
<td>0.561</td>
<td>(0.35)**</td>
</tr>
<tr>
<td>$b_4$</td>
<td>0.095</td>
<td>(0.032)*</td>
</tr>
<tr>
<td>Returns to scale</td>
<td>0.860</td>
<td>1.008</td>
</tr>
<tr>
<td>Inefficiency Effects Model</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.005</td>
<td>(0.002)*</td>
</tr>
<tr>
<td>$\nu_{i0}$</td>
<td>-0.010</td>
<td>(0.003)**</td>
</tr>
<tr>
<td>$\eta_{i0}$</td>
<td>0.009</td>
<td>(0.000)**</td>
</tr>
<tr>
<td>$\eta_{i0}$</td>
<td>-0.017</td>
<td>(0.029)**</td>
</tr>
<tr>
<td>$\eta_{i0}$</td>
<td>-0.052</td>
<td>(0.031)**</td>
</tr>
<tr>
<td>$\eta_{i0}$</td>
<td>0.050</td>
<td>(0.039)</td>
</tr>
<tr>
<td>$\delta_{i0}$</td>
<td>0.009</td>
<td>(0.061)</td>
</tr>
<tr>
<td>$\sigma = \sqrt{\phi^{2} + \delta_{i0}^{2}}$</td>
<td>0.186</td>
<td>(0.084)**</td>
</tr>
<tr>
<td>$\zeta = \phi^{2}$</td>
<td>0.927</td>
<td>(0.252)*</td>
</tr>
<tr>
<td>ln(σ)</td>
<td>-40.541</td>
<td>-11.332</td>
</tr>
</tbody>
</table>

$L$: labor; $F$: fertilizers and pesticides; $S$: seeds; $A$: acreage; $O$: other own expenses; $AG$: farmer's age squared; $FS$: farm's size in square meters; $ED$: farmer's education; $FC$: farm's stock of capital; $PO$: share of family labor to total labor expenses.

*Significant at the 1% level; **significant at the 5% level; ***significant at the 10% level.

Following Zellner Kmenta and Dreze, cotton farmers are assumed to be price takers maximizing expected profits and facing exogenous output and input prices. Based on these assumptions the production function specified in (5) can be consistently estimated, separately for the organic and conventional cotton sample, using the maximum likelihood technique.

Empirical Results

Production Structure

The maximum likelihood estimates of the Cobb-Douglas stochastic production frontiers and the inefficiency effects models for the organic and conventional cotton farms are presented in Table 3. Even though the logarithmic value of the likelihood function is small, it is rather satisfactory considering that we deal with cross-section data, normalized around the sample means prior to ML estimation. The ratio parameter $\nu$, $\gamma$ is statistically significant at the 1-percent level, implying that farm-specific efficiency is likely to be highly significant in explaining the total variability of organic and conventional cotton production. Further, the

12 It must be pointed out 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 $\eta$ is equal to $\sigma^2 = \phi^2 + \delta_{i0}^2$. The relative contribution of the inefficiency effects to the total variance term $(\eta^2)$ is equal to $\sigma^2 - \phi^2 + \delta_{i0}^2 - \gamma^2 (\phi^2 + \delta_{i0}^2 - \gamma^2)$" (Coelli, T. J., and Battese, G. E., 1986). In our case, the computed values of the variance-ratio parameter $\nu$ imply that 82.2 and 78.8 percent of the differences between the observed and the maximum frontier output for organic and conventional cotton farming, respectively, are due to the existing differences in efficiency levels among farmers.
Table 4. Hypotheses Testing for the Inefficiency Effects Model

<table>
<thead>
<tr>
<th>Calculated Likelihood Ratio Statistic</th>
<th>Conventional Tabulated χ² (a = 0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Null Hypothesis</td>
<td>Organic Farm</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>Farms</td>
</tr>
<tr>
<td>$H_0: \gamma = 0$</td>
<td>28.17</td>
</tr>
<tr>
<td>$H_0: \gamma = 0$</td>
<td>13.58</td>
</tr>
<tr>
<td>$H_0: \mu = 0$</td>
<td>18.09</td>
</tr>
</tbody>
</table>

statistical significance of modeling farm effects is examined using likelihood ratio tests. The results of the statistical testing are presented in Table 4. The first null hypothesis, which specifies that the inefficiency effects are absent from the model, is strongly rejected. The second null hypothesis which specifies that the inefficiency effects are not stochastic but are directly included in the production frontier model is also rejected. Finally, the third hypothesis which assumes that the inefficiency effects are not a linear function of the variables considered herein is also rejected. This indicates that the joint effects of these explanatory variables on the inefficiencies of production is significant, although the individual effects of one or more variables may not be statistically significant (i.e., $\beta_j$ and $\mu_j$).

Hence, the inefficiency effects are clearly stochastic and are not unrelated to the age, the level of formal education of farmers, and the farm’s size.

Regarding the parameter estimates, all four are statistically significant in both models. In both types of farming, land is the foremost significant input exhibiting the highest elasticities values though at different levels (0.616 and 0.685 in organic and conventional farms, respectively). For the rest of the applied inputs, however, their significance in cotton production differs between the organic and conventional practices. The existence of potential differences between the two farming practices was also tested by estimating the production frontier function jointly including dummy variables for each method of cultivation. The value of the corresponding likelihood-ratio test was found to be 47.3, considerably higher than the corresponding tabulated value of the chi-squared distribution at the 1 percent level of significance. Returns to scale were found to be close to unity for conventional farms (1.008) and clearly diminishing for organic farms (0.860). Based on restricted maximum likelihood estimation, the hypothesis of constant returns to scale is accepted for conventional cotton farms, while for organic farms the relevant hypothesis is rejected.

From the parameter estimates of the Cobb-Douglas production frontier reported in Table 3, the parameters of the corresponding dual-cost functions (for both methods of cultivation) can be recovered. Specifically, the dual-cost frontiers for organic and conventional cotton production are:

in $C_{CO} = 4.705 + 1.032 \ln w_1 + 0.001 \ln w_2 + 0.143 \ln w_3 + 0.636 \ln w_4 + 0.122 \ln w_5$

in $C_{CO} = 11.164 + 0.942 \ln w_1 + 0.061 \ln w_2 + 0.090 \ln w_3 + 0.684 \ln w_4 + 0.150 \ln w_5$

where, $w_i$ indicates the price per unit of input utilized in the production of organic and conventional cotton ($i = L, F, A, E$ where $L$: labor, $F$: fertilizers and pesticides; $A$: area; $E$: other cost expenses) and $\gamma_1$ is the organic (or conventional) cotton production level, adjusted for the statistical and measurement errors captured by $\gamma_1$.

Economic Efficiency

The estimated farm-specific, technical, allocative, and economic efficiency—measures for both methods of cultivation are presented in Table 5, in the form of frequency distribution within a decile range. Regarding technical efficiency, the table reveals that, on the average, conventional cotton farms are 80.4 percent ef-

<table>
<thead>
<tr>
<th>Range %</th>
<th>Technical Efficiency</th>
<th>Allocative Efficiency</th>
<th>Economic Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>20-30</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>30-40</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>40-50</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>50-60</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>60-70</td>
<td>4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>70-80</td>
<td>4</td>
<td>4</td>
<td>7</td>
</tr>
<tr>
<td>80-90</td>
<td>6</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>90-100</td>
<td>7</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Mean</td>
<td>71.63</td>
<td>80.40</td>
<td>80.25</td>
</tr>
<tr>
<td>Min</td>
<td>26.83</td>
<td>43.24</td>
<td>35.91</td>
</tr>
<tr>
<td>Max</td>
<td>99.39</td>
<td>99.98</td>
<td>99.15</td>
</tr>
<tr>
<td>t-statistic</td>
<td>6.568</td>
<td>0.214</td>
<td>5.568</td>
</tr>
</tbody>
</table>
erage allocative estimates in both types of cot-
ton farming are rather logical considering that it is easier for farmers to make adjustments and operate closer to cost-minimization con-
ditions rather than fully use the existing state of (conventional or organic farming) technol-
gy. In total, economic efficiency was also found to vary significantly between the two methods of cotton cultivation; average eco-
monic efficiency was 54.21 and 61.97 percent for organic and conventional cotton farms, re-
spectively. The significantly lower average economic efficiency for organic cotton farms is mainly due to their lower degree of tech-
nical efficiency. This implies that relatively more cost savings may be achieved by im-
proving technical rather than allocative effi-
ciency, although considerable savings could be realized by improving both. This is a rather
important finding as currently the fiscal cost for supporting cotton farming is quite high with
in the EU.

Concerning the sources of these efficiency differentials among sample participants, the estimates of the inefficiency effects model pre-
sented in Table 3 imply the following: the size of the farmer as a proxy of entrepreneurial
skill level is an important factor in explaining technical efficiency variation in both methods of: cultivation; the negative value of the
squared term underlines the notion of decreasing
returns to human capital. Farm size is posi-
tively related to efficiency levels and it is more evident in conventional farms. Similar
findings concerning the possible relationship
between farm size and efficiency levels are re-
ported by other authors (Seale; Hallam and Machado) although some studies report con-
tradictory results (Taylor, Drummond and Co-
nes; Burvo-Ureta and Evenson). Recently, Kalaitzandonakes, examining New Zealand’s
beef and sheep sector, argued that protection-
ism can have a positive effect on efficiency
and thus or productivity growth only in small
farms with small capital stock that face low
prices; for large farms protectionism tends to
generate technical inefficiencies and thus pro-
ductivity losses. Although this finding is based
on neo-classical theoretical rigidities it may be
assumed that the relationship between farm
size and economic efficiency is subject to the
peculiarities of the sector and of course on
particular policy support measures. Education
also has a positive significant part to play in
determining efficiency differentials among or-
ganic and conventional cotton farmers, indi-
cating that Welch’s hypothesis about the
“worker effect” is supported by the current
data set. Given that education is a strong com-
plement to most of the inputs utilized in the
production process—such as chemical or or-
ganic fertilizers and pesticides, irrigation, me-
chanical equipment and high-yielding varie-
ties—its importance is indisputable. Finally,
a farm’s stock of capital and the share of fam-
ily to total labor expenses does not seem to
have any conjunction with the existing level of
efficiency.

For the low efficiency scores in both or-
ganic and conventional cotton farms one
should seek an explanation in the relevant pol-
icy scheme governing the sector the last 20
years. The EU intervention policy applied to
the Greek cotton sector since the country’s ac-
cession into the EU in 1981 induced cotton
farmers to increase production but prevented
them from operating under laissez-faire con-
ditions. This lack of competition and entrepre-
neurial motives apparently has made Greek
cotton farmers less responsive to market sig-
als. Moreover, although EU-subsidizing
schemes in the form of unit subsidy did not
eliminate variability in cotton prices and, there-
fore, risk, they did increase the farmers’
expected returns. This in turn enhanced the
willfulness of both risk-averse and risk-neu-
tral producers to produce more. In a vertical
market system framework, this is translated
into increased demand for inputs and probably
to inefficiency related to input allocation in the
production process. In other words, although
protectionism may stimulate investment and
new technology adoption, efficiency may de-
crease particularly when subsidized farm pric-
es are high (Mundlak; Tzouvekas et al.).

Regarding the adoption of new technolo-
gies, farmers facing poor extension services,
inaugurate know-how, and in some cases
farmers with low literacy rates have great dif-
culty understanding technological innova-
tions and of course exploiting their full potential (Feder, Just and Zilberman). In our study, this is well manifested by the low technical efficiency scores of both conventional and organic farms which do not have significant room for improvement. Indeed, on the average, the organic and conventional farmers examined can improve their performance (in terms of raising their technical efficiency) by almost 30 and 20 percent, respectively.

Concluding Remarks

Recent developments in world agricultural markets and the reforms in the Common Agricultural Policy of the EU clearly signal that continuation of the highly protective policy schemes enjoyed by the Greek cotton farmers during the last two decades is no longer possible. Hence alternative strategies to sustain the economic viability of the sector are urgently required. Likely the concept of organic cultivation has been suggested as a promising alternative to cotton farmers. In this paper we attempt to draw some conclusions about the current technical, allocative and economic efficiency of a sample of Greek organic and conventional cotton farms using the stochastic decomposition methodology.

Our empirical findings suggest that, in general, organic and conventional cotton farms in the sample examined are technically, allocatively, and economically inefficient. High support policies applied to cotton production after Greece’s accession into the E.U. might be responsible for the current level of inefficiency (price subsidies still constitute a significant part of farm gross revenues in both the organic and conventional farms). Costless output (and thus income) increases may, however, be obtained by optimizing input use; larger gains may be achieved by improving technical efficiency. In competitive terms, conventional cotton farms seem to exhibit higher efficiency scores vis-à-vis their organic counterparts particularly in technical efficiency. The underlying reason seems to be the difficulties faced by organic farmers in exploiting fully the potential of the existing organic farming technologies given the recent introduction of organic farming practices in Greece.

In addition to the productive inefficiencies exhibited by Greek organic cotton farms it is also worth noting that currently there are no established price premiums for the organic cotton produce: in the sample examined, price premiums received by organic cotton growers ranged anywhere from zero up to the rather high level of 50 drachmas per kg above the conventional cotton price. This is because established channels for the explicit marketing of organically grown cotton as an organic commodity do not yet exist in Greece. Certainly, this is another direction wherein there is scope for further improvements. It is evident therefore that the national and EU institutions should primarily begin to set up conditions for the improvement of the farming technologies for organically produced cotton, coupled with efforts to develop specialized organic marketing channels. Measures aiming at the improvement of organic-farm efficiency (i.e. extension services to improve farmers’ know-how, provision of the necessary infrastructure) should be chosen over the existing subsidization schemes in designing policies for the enhancement of the organic farming sector. This will prove beneficial in maximizing the anticipated benefits of any future change in the technological conditions of organic farming practices.

References


