Empirical Evidence of Technical Efficiency Levels in Greek Organic and Conventional Farms

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Abstract
The present study utilizes the stochastic production frontier approach in evaluating the technical efficiency rates achieved in four types of Greek organic and conventional farm operations, namely, olive oil-producing, cotton, raisin-producing, and grapes-for-wine producing farms. The empirical results are expected to illustrate possible differences in the technical efficiency scores between the two farming technologies, and provide empirical evidence which at least in the field of organic farming performance is scarce or even absent. Such assessments may also be helpful for pointing out purely economic advantages (or disadvantages) of organic farming, in addition to its environmental dimension, and formulating policies to improve its economic performance.

Keywords: *organic farming, stochastic production frontier, Greek agriculture*.

Introduction

During the 1990s, new considerations have been added to agricultural policies, worldwide. An increasing number of countries (including those of the European Union) have started to: (i) recognize the need for introducing the principle of sustainability in their policies concerning the use of agricultural, natural resources and, (ii) liberalize their agricultural sectors by reducing support policies and dismantling agricultural trade impediments. Initiated at the *Uruguay Round on Trade* - and the founding of the *World Trade Organization* (W.T.O.) - this course may well be expected to continue. In accordance with these developments, the E.U. has already taken twice - via the 1992 *McSharry Reform* and the *Agenda 2000* reform package – steps, in adjusting its Common Agricultural Policy (C.A.P.).

One of the means the E.U. utilizes to keep up with these developments is the introduction of standards (such as quality and environmental ones) in farming. Practically, this has been pursued by institutionalizing, via E.U. regulations, techniques for producing differentiated versions of agricultural products such as *Products differentiated by Origin*, *Products of Geographical Indication* (PDO/PGI products) and, *organically* produced commodities. The concept of organic farming - institutionalized via the E.U. regulation 2092/91 - is based on eliminating the use of purchased

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chemical inputs while maximizing the use of on-farm inputs, by-products (i.e. compost production), and biological control techniques instead of pesticides.

For agricultural economists organic farming technology poses, besides its apparent advantages (i.e. environmental benefits, consumer health, product quality), a more fundamental question: can productive efficiency be gained by utilizing organic rather than conventional production technologies? This is a critical point since within the aforementioned international developments, efficiency of production is becoming a key-factor for farmers to survive in increasingly competitive agricultural markets .

Naturally, the actual efficiency levels achieved in organic farming is largely an empirical question; therefore evaluations of the efficiency rates of organic farms and those of conventional farms become an interesting issue to both researchers and policy makers. The interest of empirical researchers in particular is additionally enhanced by recent methodological developments in the area of efficiency measurement. Based on the concept of the stochastic production frontier, empirical techniques have been recently introduced, allowing quantitative assessments of the efficiency rates achieved by different production units.[1]

In this framework, the objective of the present study is to utilize the stochastic production frontier approach in evaluating the technical efficiency rates achieved in four types of Greek organic and conventional farm operations, namely, olive oil-producing, cotton, raisin-producing, and grapes-for-wine producing farms. The excersise is expected to illustrate possible differences in the technical efficiency scores between the two farming technologies, and provide empirical evidence which at least in the field of organic farming performance is scarce or even absent.[2] Such assessments may also be helpful for pointing out purely economic advantages (or disadvantages) of organic farming, in addition to its environmental dimension, and formulating policies to improve its economic performance.

The stochastic frontier model

Technical efficiency refers to the ability of a producer to avoid waste of inputs by producing as much output as the inputs at his disposal permit under the current state of technology (Farell, 1957). In recent years, the most popular methodology amongst researchers measuring technical efficiency has been the stochastic frontier production approach – independently introduced by Aigner, Lovell and Schmidt (1977) and Meeusen and Van der Broeck (1977. For a set consisting of $i=1,...N$ production units, the stochastic production frontier function for the i-th farm is defined as:

$$y = f(x, \beta)e^{\varepsilon} \tag{1}$$

where: y is the vector of farm output; $f(\bullet)$ is a suitable functional form describing the underlying technology; x is the vector of inputs used in the production; β is the vector of estimable parameters; and, ε is the vector of the composite stochastic error term consisting of two independent elements: a *symmetric* one, v, capturing statistical noise, measurement errors and left-out explanatory variables and an *one-sided* component, u, capturing the technical inefficiency relative to the estimated stochastic production frontier.

Several specifications have been suggested for the density distributions of the error components v and u. Recently, Battese and Coelli (1993; 1995) suggested that u can be expressed as a function of other explanatory variables related with farm-specific characteristics (i.e. farm and management characteristics). Specifically, the u's are defined as:

$$u = \delta z + w \tag{2}$$

where: z is the vector of farm-specific explanatory variables associated with technical inefficiencies of production; δ are estimable parameters; and, w_i is an *iid* random variable with zero mean and variance defined by the truncation of the normal distribution such that $w \geq -(\delta z)$. Given a cross-sectional data set the stochastic frontier and the inefficiency models consisting of equations (1) and (2) can be estimated in a single stage via the computer program FRONTIER 4.1 (developed by Coelli, 1992) which yields maximum likelihood estimates for the estimable parameters β and δ.

Thereafter, the *output-oriented* technical efficiency measures are obtained from the conditional expectation of u given ε evaluated at the maximum likelihood estimates of the model:

$$TE = E\left[\exp\left(-u|\varepsilon\right)\right] = E\left[\exp\left(-\delta z|\varepsilon\right)\right] \tag{3}$$

where E is the expectation operator.

A frontier/inefficiency model for Greek organic and conventional farms

The data used in this study arise from a field survey on the production costs of organic and neighboring conventional farms, carried out in the context of a broader research project undertaken by the Institute of Agricultural Economics and Rural Sociology of the National Agricultural Foundation of Greece..[3] The samples used in the present analysis consist of: (*i*) 84 organic and 87 neighboring conventional, olive-oil producing farms located in four different regions of Greece (namely the counties of Messinia, Achaea, Corfu and Heraklion); (*ii*) 29 organic and 29 neighboring conventional cotton farms, in Viotia county, (*iii*) 26 organic and 24 neighboring conventional raisin-producing farms, in the island of Santorini, and (*iv*) 20 organic and 15 neighboring conventional wine farms, in Achaea county. All data refer to the 1995-96 harvesting period. The choice of these samples was based on the national inventory of organic farmers which pointed out the aforementioned regions as the major locations of organic farmers involved in the types of farming examined here.

Following the practice adopted in the vast majority of applications of the stochastic frontier models, we use a translog functional form to specify the stochastic production frontier equation (1) i.e.,[4]

$$ln\, y_i = \beta_0 + \sum_{j=1}^{J} \beta_j\, ln\, x_{ji} + \frac{1}{2}\sum_{j=1}^{J}\sum_{k=1}^{J} \beta_{jk}\, ln\, x_{ji}\, ln\, x_{ki} + v_i - u_i \tag{4}$$

with $\beta_{jk}=\beta_{kj}$ $\forall j,k$ (symmetry conditions). In addition, we use a linear function to specify the inefficiency-related error term u_i i.e.,

$$u_i = \delta_0 + \sum_{m=1}^{M} \delta_m \mu_{mi} + w_i \tag{5}$$

where: $\boldsymbol{y}$ is the organically or conventionally produced output in kilograms (olive-oil, cotton, raisins or grapes) of the i-th farm in the respective sample; $\boldsymbol{x_A}$ is the acreage of the i-th farm used in the production in stremmas; $\boldsymbol{x_L}$ is total family and hired labor used in the production in hours; $\boldsymbol{x_F}$ is total quantity of fertilizers and pesticides used, in kilograms (for organic farms, this variable refers to the quantity of organic fertilizer and various means of biological control, used); $\boldsymbol{x_C}$ is a composite variable of capital inputs expressed in drachmas; $\boldsymbol{z_O}$ is the share of family labor in total labor expenses; $\boldsymbol{z_S}$ is the size classification of the i-th farm;[5] $\boldsymbol{z_K}$ is the capital of the i-th farm per stremma; $\boldsymbol{z_H}$ is the age (in years) of the i-th farmer; $\boldsymbol{z_E}$ is his/her education level (in years). [6]

Empirical results

The maximum-likelihood parameter estimates of equations (4) and (5) for the four types of organic and conventional farms are shown in Table 1. A number of possible restricting assumptions (namely, homogeneity, linear homogeneity, additive separability, and strong separability) were tested – except for the case of grape-producing farms - by properly restricting the parameters β and utilizing the *Likelihood-Ratio-Test* (LRT). [7] The results (not shown but available upon request) indicate that none of these assumptions are supported by the data.[8]

In addition to the production frontier/inefficiency, structural parameters β and δ, the ration parameter γ is estimated in the lower part of Table 1. The parameter is found to be relatively large (ranging from 74,4% in organic raisin-producing farms to 99,7% in organic cotton-producing farms) and statistically significant in all cases. This suggests that technical inefficiency effects are significant and that use of the traditional production function – wherein technical inefficiency effects are not considered and all deviations from the frontier are assumed to be statistical noise – is not an adequate approach for the data used here.

To further test the significance of technical inefficiency effects, a set of formal hypotheses is presented in Table 2. In this table, the first null hypothesis (H_0: $\gamma=0$) suggests that the technical inefficiency-related variance is zero and therefore technical inefficiency effects are not stochastic; this hypothesis is rejected in all cases. [9] The second null hypothesis (H_0: $\gamma=\delta_1=\delta_2=\ldots=\delta_i= 0$) suggests that the inefficiency effects -indicated via the parameters γ and δ's – are insignificantly different from zero (thus absent from the model); this hypothesis is also rejected in all cases. The third null hypothesis (H_0: $\delta_1=\delta_2=\ldots=\delta_i= 0$) suggests that the joint effect of the explanatory variables z - used as determinants of the inefficiency effects u_i - is statistically insignificant and therefore such variables fail to adequately explain these inefficiency effects; this hypothesis is also rejected in all cases.

Table 1. Parameter Estimates of the Stochastic Production Frontiers for Olive-oil and Cotton Farms in Greece, 1995-96.

Parameter	**Olive-Oil**				**Cotton**			
	Organic Farms		Conventional Farms		Organic Farms		Conventional Farms	
	Estimate	StdError	Estimate	StdError	Estimate	StdError	Estimate	StdError
Stochastic Frontier Model								
β_0	0.466	(0.180)	0.820	(0.036)	0.063	(0.034)	0.140	(0.048)
β_A	0.411	(0.175)	0.472	(0.117)	0.252	(0.118)	0.592	(0.251)
β_L	0.369	(0.114)	0.190	(0.072)	0.326	(0.096)	0.174	(0.080)
β_F	0.107	(0.056)	0.046	(0.024)	0.140	(0.062)	0.230	(0.114)
β_C	0.054	(0.022)	0.087	(0.047)	0.408	(0.116)	0.120	(0.076)
β_{AL}	-0.020	(0.202)	0.184	(0.142)	-0.224	(0.306)	-0.687	(0.785)
β_{AF}	-0.019	(0.063)	0.101	(0.072)	-0.062	(0.206)	0.691	(0.351)
β_{AC}	-0.307	(0.174)	-0.035	(0.096)	-0.482	(0.175)	0.380	(0.595)
β_{AA}	0.181	(0.070)	-0.184	(0.121)	0.228	(0.125)	-0.364	(0.569)
β_{LF}	-0.000	(0.056)	-0.204	(0.107)	0.128	(0.091)	0.116	(0.033)
β_{LC}	0.160	(0.086)	0.085	(0.066)	0.405	(0.107)	-0.261	(0.145)
β_{LL}	-0.076	(0.131)	-0.054	(0.080)	0.029	(0.043)	-0.296	(0.207)
β_{FC}	0.009	(0.017)	0.197	(0.068)	0.076	(0.042)	-0.137	(0.245)
β_{FF}	0.011	(0.005)	-0.082	(0.034)	-0.007	(0.025)	-0.466	(0.170)
β_{CC}	0.014	(0.003)	0.090	(0.028)	-0.007	(0.131)	-0.042	(0.166)
Inefficiency Effects Model								
δ_0	-0.002	(0.001)	0.718	(0.502)	-1.272	(0.760)	0.371	(0.090)
δ_O	0.279	(0.057)	0.970	(0.451)	0.041	(0.020)	-0.202	(0.164)
δ_S	-0.154	(0.072)	-0.541	(0.135)	-0.471	(0.282)	0.036	(0.054)
δ_K	-0.015	(0.007)	-0.041	(0.018)	-0.494	(0.287)	0.000	(0.000)
δ_H	-	-	-	-	0.018	(0.007)	-0.003	(0.002)
δ_E	-	-	-	-	-0.051	(0.037)	-0.050	(0.026)
$\hat{\sigma}^2$	0.384	(0.125)	0.296	(0.062)	0.704	(0.023)	0.208	(0.062)
$\hat{\gamma}$	0.884	(0.123)	0.982	(0.001)	0.997	(0.020)	0.983	(0.001)
$\text{Ln}(\theta)$	-37.940		-38.798		-14.754		-27.451	

where **A:** area; **L:** labor; **F:** fertilizers (for organic farms this refers to organic fertilizers and biological pest control); **C:** other costs; **O:** share of family labor to total labor expenses; **S:** farm size; **K:** total assets per stremma; **H:** age of the farmer; **E:** farmer's education.

Table 1 (continued). Parameter Estimates of the Stochastic Production Frontiers for Raisin and Grape Producing Farms in Greece, 1995-96.

Parameter	**Raisins**				**Grapes**			
	Organic Farms		Conventional Farms		Organic Farms		Conventional Farms	
	Estimate	StdError	Estimate	StdError	Estimate	StdError	Estimate	StdError
Stochastic Frontier Model								
β_0	0.187	(0.106)	0.164	(0.091)	0.471	(0.214)	1.008	(0.396)
β_A	0.452	(0.129)	0.618	(0.195)	0.210	(0.081)	0.719	(0.157)
β_L	0.021	(0.010)	0.355	(0.089)	0.545	(0.214)	0.391	(0.088)
β_F	0.163	(0.092)	0.121	(0.054)	0.016	(0.004)	0.278	(0.125)
β_C	0.262	(0.108)	0.158	(0.045)	0.056	(0.018)	0.137	(0.068)
β_{AL}	-0.564	(0.233)	0.340	(0.124)	-	-	-	-
β_{AF}	0.457	(0.211)	0.610	(0.238)	-	-	-	-
β_{AC}	-0.308	(0.397)	-0.257	(0.187)	-	-	-	-
β_{AA}	-0.060	(0.347)	-0.530	(0.289)	-	-	-	-
β_{LF}	-0.199	(0.083)	-0.001	(0.008)	-	-	-	-
β_{LC}	0.325	(0.194)	0.528	(0.114)	-	-	-	-
β_{LL}	0.395	(0.215)	-0.453	(0.214)	-	-	-	-
β_{FC}	-0.623	(0.237)	0.005	(0.102)	-	-	-	-
β_{FF}	0.042	(0.058)	-0.074	(0.219)	-	-	-	-
β_{CC}	0.186	(0.120)	0.776	(0.345)	-	-	-	-
Inefficiency Effects Model								
δ_0	0.489	(0.162)	-0.043	(0.019)	-0.434	(0.078)	-0.034	(0.078)
δ_O	-0.196	(0.038)	-0.016	(0.007)	-0.344	(0.187)	-0.126	(0.187)
δ_S	-0.024	(0.008)	0.021	(0.009)	0.030	(0.012)	0.018	(0.012)
δ_K	0.001	(0.000)	-0.000	(0.000)	0.001	(0.000)	0.001	(0.000)
$\hat{\sigma}^2$	0.023	(0.005)	0.055	(0.018)	0.418	(0.191)	0.791	(0.028)
$\hat{\gamma}$	0.744	(0.082)	0.877	(0.135)	0.999	(0.001)	0.978	(0.051)
$\text{Ln}(\theta)$	-12.792		-7.017		-6.791		-0.322	

where **A:** area; **L:** labor; **F:** fertilizers (for organic farms this refers to organic fertilizers and biological pest control); **C:** other costs; **O:** share of family labor to total labor expenses; **S:** farm size; **K:** total assets per stremma.

Table 2. Model Specification Tests.

Hypothesis	LR-Test		Critical value
	Organic Farms	Conventional Farms	(α=0.05)
Olive-oil Farms			
$H_0 : \gamma = 0$	50.38	28.91	$\chi_2^2 = 5.99$
$H_0 : \gamma = \delta_i = 0$	35.47	32.51	$\chi_5^2 = 11.1$
$H_0 : \delta_i = 0$	15.25	23.58	$\chi_4^2 = 9.49$
Cotton Farms			
$H_0 : \gamma = 0$	20.82	13.58	$\chi_2^2 = 5.99$
$H_0 : \gamma = \delta_i = 0$	35.24	28.17	$\chi_7^2 = 14.1$
$H_0 : \delta_i = 0$	17.40	18.09	$\chi_6^2 = 12.6$
Raisins Producing Farms			
$H_0 : \gamma = 0$	11.24	14.36	$\chi_2^2 = 5.99$
$H_0 : \gamma = \delta_i = 0$	17.23	17.24	$\chi_5^2 = 11.1$
$H_0 : \delta_i = 0$	16.11	17.45	$\chi_4^2 = 9.49$
Grape Producing Farms			
$H_0 : \gamma = 0$	25.57	11.36	$\chi_2^2 = 5.99$
$H_0 : \gamma = \delta_i = 0$	16.31	19.58	$\chi_5^2 = 11.1$
$H_0 : \delta_i = 0$	19.48	14.36	$\chi_4^2 = 9.49$

The *Likelihood Ratio Test* is obtained as: $\mathrm{LR} = 2\left[\ln \mathrm{L}(\theta^*) - \ln \mathrm{L}(\theta)\right]$ where $\ln \mathrm{L}(\theta^*)$ is the likelihood function of the restricted model.

The technical efficiency rates, computed for each farm in all eight samples according to (3) are presented in Table 3, in the form of frequency distributions within a decile range. Prior to proceeding with the discussion of these results an important interpretation-point must be stressed. The efficiency score calculated for the i-th farm in a specific sample indicates how close to the production frontier of this sample the i-th farm operation lays. Therefore, since organic and conventional farms utilize *different production technologies*, direct comparisons of efficiency scores *across* samples are not valid. In other words, a higher average efficiency score in a sample of organic farms relative to that of the respective 'conventional' sample does not imply that organic farms are more efficient than conventional ones, *by the same degree*. It means that the former lay (on the average) closer to their *own* production frontier than the conventional ones do with their own (conventional) production frontier.

Table 3. Frequency Distribution of Technical Efficiency in Greek Organic and Conventional Farms.

Technical	**Olive-Oil**		**Cotton**		**Raisins**		**Grapes**	
Efficiency	*Organic*	*Conventional*	*Organic*	*Conventional*	*Organic*	*Conventional*	*Organic*	*Conventional*
<20	0	0	0	0	0	0	0	0
20-30	1	9	0	0	0	0	0	0
30-40	5	10	1	1	0	0	1	2
40-50	9	17	2	3	1	2	2	3
50-60	6	16	3	4	3	3	3	3
60-70	20	14	5	5	5	7	5	2
70-80	17	8	6	6	8	6	4	3
80-90	22	7	8	8	6	4	3	1
90-100	4	6	4	2	3	2	2	1
N	84	87	29	29	26	24	20	15
Mean	68.34	55.87	74.62	71.57	75.99	70.04	68.00	61.18
Min	26.50	20.47	38.37	38.54	48.26	40.24	32.89	31.14
Max	93.20	99.96	99.48	98.29	99.37	95.42	99.81	91.61

With this point in mind, observation of Table 3 reveals that – at least for the samples examined, here - organic farm operations are closer, on the average, to their (organic) production frontier(s) than conventional farms, in all cases. Specifically, organic farm operations reach an *average* technical efficiency score of: 68.34% in olive oil production, 74.62% in cotton production, 68% in grapes-for-wine production, and 75.99% in raisin production. The respective average scores for neighboring conventional farms are: 55.87% in olive oil production, 71.57% in cotton production, 61.18% in grapes-for-wine production, and 70.04% in raisin production. Of the four types of organic farming considered, raisin producers seem closer to their own production frontier; cotton producers appear closer to their production frontier in the case of conventional farms.

Regarding the factors used to explain technical inefficiency, in the case of organic and conventional olive-oil producing farms, size (in terms of acreage) and capital per stremma seem to affect positively while the share of family in total labor seem to affect negatively the estimated efficiency rates. In organic cotton farms, farm size, farmer's education and capital per stremma affect positively the technical efficiency in organic cotton farms; in contrast, the farmer's age affects the technical efficiency negatively implying that younger farmers are more receptive in applying organic techniques in cotton growing. However, in conventional cotton farms the farmer's age, education and the share of family in total labor seem to be positively related to technical efficiency. In grapes-for-wine production, both organic and conventional farms utilizing more hired labor seem to have higher technical efficiency; the farm size on the other hand seems to affect technical efficiency negatively, in both cases. Finally in raisin production, farm size, increased family labor relate to higher technical efficiency for organic farms; capital per stremma seems to have a small positive(negative) effect in conventional(organic) farms.

Conclusions and policy suggestions

The results of the empirical analysis presented here yield some interesting suggestions for the course of action, required to improve the economic performance of organic farming in Greece. First, regarding the question whether technical efficiency may be gained in organic farming the answer in partly on the affirmative. Organic producers, at least in the data set investigated, appear to operate closer to their production frontier. A possible explanation may be that lower profit margins and the restrictions imposed (via the E.U. Regulation 2092/91) on the types of inputs permitted may have forced organic producers to be more cautious regarding the use of their inputs. However, their scores are not particularly impressive; in general, their average efficiency rates are only slightly higher than those of conventional farmers (with perhaps the exception of olive–oil producers who seem to operate much closer to their organic production frontier than conventional producers).

In general, both modes of farming exhibit considerable technical inefficiency. This should not be disassociated from the fact that both production technologies are subsidized (at least for the four types of farming examined) in the context of the Common Agricultural Policy of the E.U. One must also bear in mind that organic producers enjoy the same subsidization schemes as conventional farmers and in addition receive 'organic' financial aid in the form of acreage-based subsidies. This institutional framework may inhibit their responsiveness to market signals and blur the sector's performance in a number of ways. Additional subsidies may attract into the sector farmers not truly interested in organic farming, thus indifferent in (or incapable of) exploiting the opportunities for efficiency gains possibly associated with such techniques. Even motivated organic farmers are often unfamiliar with fundamental principles and concepts on which organic farming practices are based; thus their converting into organic is often largely limited to replacing the purchased chemical inputs with *purchased* organic ones.

The lack of training and unfamiliarity with organic farming techniques may also be suggested by the fact that (with the exception of olive-oil producers) the average technical efficiency rates observed are relatively close between organic and conventional farmers, in all four types of farming. Although facing different production frontiers, organic and conventional farmers seem to perform in similar levels of technical efficiency. This could be evidence that to convert into organic, farmers alter their farming practices just enough to conform with the minimum restrictions on chemical input use; thus, their performance regarding technical efficiency is affected only marginally.

Inadequate production know-how (pertaining to the conventional farmers as well) is also reflected in the wide variations of the technical efficiency rates observed in our samples; the difference between maximum and minimum rates calculated is about 30% to 40%, on the average, in all cases. Schooling, age, farm commercialization (as reflected by the share of family to total labor), farm size etc. appear to be the determining factors behind the inefficiency rates observed in our samples. However, no clear patterns emerge; the relative importance of each of these factors in explaining technical efficiency seem to be largely crop-specific, at least for the types of farming examined.

The evidence that organic farmers do not appear to do strikingly better than their conventional colleagues in terms of technical efficiency may become a reference point for determining policies to be applied in the organic sector. Thus, policies aiming to familiarize farmers with the proper application of organic farming principles and techniques may well be expected to improve efficiency scores to the extent that organic farming is largely a low–input, production technique. In turn, this calls for designing extension systems for organic farmers and re-training courses for agriculturists in parallel (if not in place of) monetary aid through subsidies. Moreover, vague calls for the need of premium prices in organic products should be always viewed *in combination* with efforts to increase the technical efficiency. Higher prices are not a panacea as similar profitability may in principle be achieved by focusing on cost-savings rather than increased revenues; this is particularly important in cases wherein consumers appear already unwilling to pay higher prices for organic products. In conclusion, *institutional* policies aiming to improve the *competitiveness* of organic farming should become a priority over blindly distributed financial aid, if this mode of farming is to survive and even turn into an economically viable agricultural activity.

Notes

1. Kumbhakar and Lovell (2000), Greene (1999) and Coelli et al., (1998) provide a detailed review of the recent methodological advances in frontier modelling and efficiency measurement as well as the most important empirical studies in this area.
2. A notable exception are the recent studies by Lansink et al., (2002) and Tzouvelekas et al., (2001a; 2001b).
3. The project entitled "The Production System of Organic Farming as an Alternative to the Development of Greek Agriculture" was funded by the National Agricultural Research Foundation within the context of DIMITRA'95 research program.

4. Due to insufficient degrees of freedom for the grapes-for-wine producing farms we use a Cobb-Douglas specification.
5. All farms in the sample were grouped into three categories according to the volume of their total output and a different number was assigned in each group. Then a dummy-type variable was constructed, ranging from one to three, for relatively small and relatively large firms, respectively. A more detailed description of the data and the sample survey used herein as well as a historical perspective of the evolution of organic farming in Greece can be found in Pantzios and Tzouvelekas (2000) and Pantzios et al., (2000).
6. Complete data on the variables z_H and z_E were available only for cotton producers; thus these two variables were utilized to explain technical inefficiency only in the 'organic' and conventional cotton samples.
7. Regularity conditions were also tested and found to hold at the points of approximation for all translog specifications. Specifically, monotonicity conditions are satisfied since marginal products are all positive, while the determinants of the principal minors of the bordered Hessian matrix alternate their sign indicating diminishing marginal productivities.
8. The econometric estimates were also tested for multicollinearity by regressing each explanatory variable on the rest, in all samples. The value of the determination coefficients so obtained are low thus, suggesting that multicollinearity does not affect seriously our estimates (Kmenta, 1986, p. 439)
9. If the parameter γ equals to zero the model reduces to a mean response function in which the variables in the inefficiency effects model (z_m) are included directly in the production function. In this case the parameter δ_0 is not identified while the LR-test has a mixed Chi-square distribution with two number of restrictions the appropriate critical values of which are obtained from Kodde and Palm (1986).

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