Technical Efficiency of Conventional and Organic Farms: Some Evidence for Milk Production

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Abstract **- Recently, several studies compared the performance of conventional and organic farms. In this paper we add to this literature by comparing the technical efficiency of conventional and organic milk farms in Austria during the period 1997-2002. We find conventional farmers to be more technical efficient.[1]**

INTRODUCTION

Recently, several studies (i.e., Tzouvelekas, Pantzios and Fotopoulos, 2001a, 2001b, 2002; Oude Lansink, Pietola and Bäckman, 2002) compared the performance of conventional and organic farms. Their empirical results, with the exception of Tzouvelekas, Pantzios and Fotopoulos (2001a), indicate that organic farms were on average more efficient (relative to their own technology) than conventional farms. In this paper we add to this literature by comparing the technical efficiency of conventional and organic milk farms in Austria during the period 1997-2002.

METHOD

Consider the following stochastic production function:

(1) $y_{it} = f(x_{it};\beta)exp(v_{it} - u_{it})$,

where $f(\bullet)$ is approximated by a Cobb-Douglas function, i.e.

(2) $y_{it} = \beta_0 + \sum_{j=1}^{n} \beta_j x_{jit} + t + e_{it}$,

y_{it} is the logarithm of the observed output produced by the i^{th} farm at year t, x_{jit} is the logarithm of the quantity of the j^{th} input used by the i^{th} farm at year t, β is a vector of parameters to be estimated, and $e_{it} = v_{it} - u_{it}$ is a stochastic composite error term. The v^{it} depicts a symmetric and normally distributed error term (i.e., statistical noise), which represents those factors that cannot be controlled by farmers, such as access to raw material, labor market conflicts, measurement errors in the dependent variable, and left-out explanatory variables. The u_{it} is a one-sided, non-negative, error term representing the stochastic shortfall of the i^{th} farm output from its production frontier, due to the existence of technical inefficiency. Thus, u_{it} accounts for the i^{th} farm's degree of technical inefficiency. It is further assumed that v^{it} and u^{it} are independently distributed from each other.

Battese and Coelli (1995) suggested that the technical inefficiency effects, u^{it}, in (1) could be replaced by a linear function of explanatory variables reflecting farm-specific characteristics. The technical inefficiency effects are assumed to be independent and non-negative truncations (at zero) of normal distributions with unknown variance and mean. Specifically,

(3) $u_{it} = \delta_o + \sum_{m=1}^{M} \delta_m z_{mi} + \omega_{it}$

where z_{mi} are farm and time specific explanatory variables associated with technical inefficiencies; δ_0 and δ_m are parameters to be estimated; and ω_{it} is a random variable with zero mean and finite variance σ_ω^2 , defined by the truncation of the normal distribution such that $\omega_{it} \geq -\left(\delta_0 + \sum \delta_m z_{mi}\right)$. This implies that the means, $\mu_{it} = \delta_0 + \sum \delta_m z_{ml}$, of the u_{it} are different for different farms but the variance, σ_ω^2 , is assumed to be the same.

The above formulation of inefficiency effects has three advantages. First, it permits the prediction and explanation of technical inefficiency by using a single-stage estimation procedure, as long as the inefficiency effects in (3) are stochastic. The two-stage estimation procedure, often used in previous empirical applications, has been recognized as one that is inconsistent with the assumption of identically distributed inefficiency effects in the stochastic frontier. Second, it allows separating time-varying technical efficiency from technical change by using a single-stage estimation procedure, as long as that inefficiency effects are stochastic and follow a particular (i.e., truncated half-normal) distribution. Third, even though inefficiency effects follow a truncated half-normal distribution, the truncation point is farm-specific determined by the z-variables. As a result, inefficiency effects are farm-specific.

After substituting (2) and (3) into (1) the resulting model is estimated by a single-equation estimation procedure using the maximum likelihood method and the FRONTIER (version 4.1c) computer program developed by Coelli (1992).

DATA DESCRIPTION

The data used in this study is a panel of Austrian farms, whose main source of income comes from milk production, between 1997 and 2002. The sample is unbalanced and includes 41 organic farms with 192 observations, and 141 conventional farms with 592 observation.

Output is measured in terms of total farm revenues and converted into a constant price quantity index

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using national milk price indices. Four inputs are included in the production function. Labor includes family as well as hired labor. Land includes total cultivated agricultural area including rented land. Capital stock is measured by end of-year value of buildings, machinery, trees, vines, animal capital, assets for other activities related to agriculture, and assets related to providing accommodation to tourists. It is converted into a constant price quantity index by using a price index for capital investments in agriculture. Intermediate inputs include expenses for plant production (seeds, fertilizer, pesticides), for animal production (feeding, veterinary, other expenses for animals), insurance, energy, water, bought services like contract threshing, interest rates, expenses for other activities related to agriculture, expenses related to direct sales and expenses to accommodate tourists (e.g. bought food). It is converted into a constant price quantity index by using a price index for intermediates in agriculture. Descriptive statistics have to be omitted here because of space imitations. Variables to account for differences in production conditions are three dummies for four different categories of hectare rate (Hektar-Satz), a measure used for tax purposes including soil quality and climatic differences.

Variables to explain the differences in technical efficiency are: First, education is measured by the years of schooling of the farm owner/operator. Second, we distinguish between full time and part-time farms. Third, to account for the size of the farm we use total standard gross margins and divide farms into 4 groups: (1) < € 10,000, (2) € 10,000- € 25,000, (3) € 25,000 - € 40,000, and (4) > € 40,000. Fourth, we use animal units per hectare to account for the degree of specialization. Fifth, we use debt in €. Sixth we use the age of the farmer. Seventh we use the share of family labor in total farm labor.

RESULTS

Stochastic Production Functions are estimated for conventional and organic farmers separately. Estimation results are given in Table 1 and Table 2. Both estimations give reasonable results. In the Production functions all inputs are significant except capital in the case od organic farming. Interestingly both production types reveal decreasing returns to scale. The time variable, which represents technological change is not significant in both cases. Productivity increases with an increasing hectare rate, representing better soil and climate conditions. In the case of conventional farming technical inefficiency significantly decreases with specialisation (animal unit per hectare), the debt of the farm, full-time farming, the share of family labor, and farm size Age of the farmer and agricultural education do not have a significant influence. In the case of organic farming inefficiency decreases with the age of the farmer, specialization, and full-time farming. For both technologies we do not find any significant change of the technical efficiency over time. On average conventional farmers are technically more efficient with a mean efficiency of 84.3% compared to 80.9% for organic farmers.

Table 1. SFA for conventional farmers.

Production function	coefficient	std.-error	t-ratio
Constant	3.2682	0.2398	13.6307
Land	0.2545	0.0431	5.8994
Labor	0.1306	0.0283	4.6127
Capital	0.0954	0.0205	4.6456
Intermediates	0.4703	0.0233	20.1445
Time	0.0098	0.0111	0.8828
Hectare rate1	0.0647	0.0299	2.1640
Hectare rate2	0.1418	0.0318	4.4639
Hectare rate2	0.2052	0.0412	4.9861
Inefficiency Model			
Constant	0.9397	0.6881	1.3656
Age of farmer	0.0024	0.0016	1.5490
Animal units per ha	-0.2259	0.0457	-4.9444
Debt	-0.000014	0.000007	-2.1382
Part time	0.1885	0.0449	4.1955
Family labor	-0.0299	0.0164	-1.8189
Agr. education	-0.2234	0.6584	-0.3392
Farm size 1	-0.0951	0.0590	-1.6116
Farm size 2	-0.1394	0.0752	-1.8521
Farm size 3	-0.3446	0.1066	-3.2321
Time	-0.0056	0.0226	-0.2485

Table 2. SFA for organic farmers.

Production function	coefficient	std.-error	t-ratio
Constant	4.0830	0.4467	9.1405
Land	0.1966	0.0484	4.0613
Labor	0.0989	0.0496	1.9943
Capital	0.0178	0.0301	0.5928
Intermediates	0.5294	0.0291	18.1741
Time	0.0063	0.0149	0.4221
Hectare rate1	0.1600	0.0493	3.2455
Hectare rate2	0.2057	0.0558	3.6895
Hectare rate2	0.1887	0.0606	3.1138
Inefficiency Model			
Constant	-1.3608	1.0213	-1.3324
Age of farmer	-0.0046	0.0025	-1.8686
Animal units per ha	-0.2592	0.0677	-3.8292
Debt	0.000007	0.000005	1.5389
Part time	0.2459	0.0595	4.1370
Family labor	0.0790	0.0532	1.4840
Agr. education	0.8413	0.8013	1.0499
Farm size 1	0.2114	0.1383	1.5287
Farm size 2	0.0171	0.1639	0.1043
Farm size 3	-0.3002	0.2415	-1.2429
Time	0.0336	0.0266	1.2645

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