Technical Efficiency among Organic and Conventional Farms in Sweden 2000-2002: A Counterfactual and Self-Selection Analysis

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Abstract

Technical efficiency and its determinants among organic and conventional farms in Sweden are analyzed for time-period 2000-2002. In addition, we address the issues that arise when comparing performance measures among the two groups of producers (conventional and organic) due differences in their technologies and the potential presence of self-selection in the farmer's choice of using conventional or organic production methods. If the choice of production method is based on, or at least in part based on, the farms expected productivity in organic and conventional farming respectively there is self-selection present that must be considered. We apply an endogenous switching regression model suggested by Lee (1978) to compare efficiency measures between the two groups that also allows for testing for the presence of self-selection. The results suggest that organic producers have a lower average technical efficiency which is expected because they use a more restricted technology. Moreover, the results suggest that the organic farmers are on average more efficient in organic production than the average conventional would have been in organic production.

Key words: technical efficiency, self-selection, organic farming
JEL classification: O390, Q120

Introduction

In Sweden, farmers receive compensatory payments (subsidies) for using organic production methods. In 2003, the share of land that was cultivated with organic production methods in Sweden was 6.9% (183 463 ha). The share of agricultural land that is cultivated with organic production methods differs across regions in Sweden. The largest shares can be found in the regions close to the capital (Stockholm).

Organic producers are more restricted in their production compared to conventional producers. For example, they are not allowed to use certain inputs such as inorganic fertilizer, fungicides or herbicides. In organic livestock production, there are regulations concerning for example the content of the feed, the use of antibiotics and the way the animals are housed. The commitment for using organic production has a duration of five years and the size of the subsidy depends on which crop is cultivated. For livestock production, the size of the subsidy depends on the type of animal. There is no geographical differentiation in the size of the payment.

There are only a few attempts of comparing productivity between organic and conventional production systems. Oude Lansink et al (2002) compare efficiency measures of organic and conventional farms in Finland. Their results suggest that organic producers have higher technical and sub-vector efficiencies than conventional farms in their own reference groups, but an overall efficiency measure suggests that organic farms are using a less productive technology.

Pietola and Oude Lansink (2001) analyze factors that determine the choice of production methods (organic or conventional) using data from Finland and their results suggest that economic incentives play an important role. They also conclude that the subsidized organic farming is more attractive to farmers in low-yield areas, and therefore suggest that the subsidy program in Finland therefore might suffer from adverse selection problems.

In this paper we analyze technical efficiency and its determinants among conventional and organic producers. When comparing efficiency scores among the two groups, one must consider the fact that organic producers use a more restricted technology. Moreover, if there is self-selection present in the choice of production method this must be accounted for. One reason to believe that self-selection might be present is the following. If farmers are assumed behave as profit maximizers, and profit is the only factor that determines the choice of production method, then the farmers who use organic (conventional) production methods are those that have a higher profit in organic (conventional) production compared to conventional (organic) production. Because productivity obviously is positively related to profits, the choice of production method should be related to the expected productivity in conventional and organic farming respectively. In reality, the choice of using organic production methods might also be determined by other factors. However, if the farmers' choice of production method is made on the basis of their expected productivity in organic and conventional production respectively or at least in part on the basis of this, self-selection is present. Thus, when evaluating the efficiency and its determinants among conventional and organic farmers, the possibility of self-selection in the choice of production method must be considered and corrected for.

We apply an endogenous switching regression model suggested Lee (1978) when comparing performance measures among the two groups, which allows for the fact that organic producers use a more restricted technology as well the potential presence of self-selection in the farmers' choice of production method. For each group of producers we obtain estimates of their mean predicted counterfactual efficiencies, i.e. the efficiency that a farm would have had if it instead had belonged to the other group (i.e. if an organic producer had been using conventional production methods and vice versa).

Different methods of obtaining estimates of technical efficiency have been suggested in the literature, which broadly can be divided into two groups: parametric and non-parametric. In this study, we use a non-parametric method, the so called data envelopment analysis (DEA). One reason for choosing this method is that we do not have to assume a functional form for the production function.[1]

To summarize, the objectives of this study are to

i) Obtain estimates of technical efficiency for conventional and organic farms respectively and analyze its determinants.

ii) Analyze whether there is self-selection present in the farmers choice of using production method (organic or conventional) and obtain estimates of counterfactual efficiencies.

The outline of the paper is the following. It begins with a short introduction to the concept of distance functions. Thereafter we describe the possible determinants of technical efficiency. The estimation procedure is described in the following section, followed by a description of the data used. Finally the results are discussed.

Distance functions

The idea of distance functions, when applied to a specific industry, is to analyze how "efficient" a firm is in transforming inputs to outputs. One usually distinguishes between input-oriented and output-oriented distance functions. An output-oriented distance measure of firm i, θ_i, tells us how much more output could be produced by the firm while holding all inputs constant. An input-oriented distance measure of firm i, ρ_i, tell us how much input use could be reduced by the firm while holding output constant.

Generally, output and input distance functions are defined as follows. An output distance function, defined on the set $P(x)$, is defined as

$$D_0(x, y) = \min \theta : \{(y/\theta) \in P(x)\} \tag{1}$$

[1] When using a parametric method, a functional form for the production function has to be assumed but it is possible to allow for a stochastic frontier.

where $D_0(x,y) \leq 1$ if $y \in P(x)$, and x and y are measures of input and output, respectively. If a firm is fully efficient, i.e. $D_0(x,y) = 1$, it produces on the production frontier. It is assumed that $D_0(x,y)$ is non-decreasing, positively linearly homogenous and convex in y and decreasing in x.

Correspondingly, an input distance function is defined as

$$D_1(x,y) = \max \rho : \{(x/\rho) \in L(y)\} \tag{2}$$

where $D_1(x,y) \geq 1$ if $x \in P(y)$. For the least efficient firm, $D_1(x,y) = 1$, i.e. x is located at the inner boundary of the input set.

Determinants of technical efficiency

In the literature on technical efficiency, it is common to not only analyze the level of the (in)efficiencies, but to also analyze the determinants of (in)efficiency. That is, the relation between technical efficiency and some exogenous characteristics of the production environment, such as for example input and output quality indicators, ownership form, managerial characteristics etc (Khumbhakar and Lovell, 2000). It should be noted that the determinants of technical efficiency can also be inputs (for example land of a farm as a proxy for size) and that they cannot be a function of output (because they are not exogenous in that case).

A drawback when using accountancy data is that relatively little information about the characteristics of the farm/farmer is available. Some variables that often are used when analyzing the determinants of technical efficiency of farms, and that often is available in accountancy data, are:

- Age of farmer
- Dummies for region
- Share of hired labor
- Share of own land

- Dummies for production specialization
- Size of farm

The age of the farmer is often used as a proxy for education or experience. Dummies for regions are often included in order to control for differences in performance among farms located in regions with different soil types, weather conditions etc.

Estimation

There are two reasons why performance measures of organic and conventional producers are not directly comparable: i) organic producers use a more restricted technology and ii) there is a potential presence of self-selection in the farmer's choice of production method.

Different approaches for evaluating differences in performance among participants and non-participants of a program (such as the farmers choice of participating in the production organic products) have been suggested (see for example Maddala, 1983). An important issue is how to account for the potential presence of self-selection in the participation choice based on the expected outcomes (for example, the farmers choice of using organic or conventional methods might be based on their expected productivity in organic and conventional farming repetitively).

The simplest way to evaluate the effect of program participation is probably to regress the performance measure on some explanatory variables, using OLS, and include a dummy variable for participation (for example 1 if organic producer and 0 if conventional producer). However, if the participation decision (the choice of production method) is endogenous, instrumental variables for this dummy variable must be included in the estimation.

A more general approach, suggested by Lee (1978), is to analyze the determinants of performance of each group separately using so-called "switching regressions". If there are reasons to believe that the participation choice is endogenous, an error correction term (the inverse Mill's ratio) are included as one of the explanatory variables in both equations to correct for selection bias (Heckman, 1979; Lee, 1978). This requires that a selection-equation (using a probit) is estimated in a first step. The obtained parameter estimates are then used to obtain estimates of the error correction terms. An advantage of this approach is that it not only allows for self-selection, but also implies a statistical test for self-selection (by simply see if the estimated parameters of the error correction terms are significant). It also allows for calculation of counterfactual performance measures, i.e. the performance an observation would have had if it instead had belonged to the other group (for example if an organic (conventional) farmer had been using conventional (organic) methods). A third important advantage is that it allows for the performance measure to be determined by the same factors as the participation choice. It is reasonable to believe that a farm's performance is determined by the same factors that determine the choice of using organic or conventional production methods.

A related approach is the so-called propensity score, originally suggested by Rosenbaum and Rubin (1983). The idea of propensity scores is to match participants and non-participants who have the same or similar predicted probabilities to obtain an unbiased estimate of the treatment effect. A disadvantage of this method is that it still is subject to selection bias if the determinants of participation choice and performance are the same (Hamilton and Nickerson, 2003).

In this study, we will apply the switching regression model suggested by Lee (1978) to compare the performance measures among conventional and organic farms and to allow/test for the presence for self-selection. The measures of farm performance are technical efficiency scores obtained using Data Envelopment Analysis (DEA). The estimation procedure is consists of the following steps:

1. Efficiency scores are obtained using DEA.
2. A selection equation for the farmers' choice of production method (conventional or organic) is estimated.
3. Determinants of technical efficiency are analyzed for conventional and organic

farms respectively while allowing/testing for the presence of self-selection. Using the obtained parameter estimates, estimates of counterfactual efficiencies are obtained.

Technical Efficiency Measurement – a DEA Approach

We use a nonparametric method, Data Envelopment Analysis (DEA), to obtain estimates of technical efficiency (see for example Färe et. al., 1989). When using DEA, it is possible to allow for either variable or constant returns to scale (VRS or CRS). The efficiency score of observation *i*, θ_i, is obtained from the following minimization problem

$$\min_{\theta,\lambda} \theta$$

s.t.

$$-y_i + Y\lambda \geq 0, \tag{3}$$

$$\theta x_i - X\lambda \geq 0$$

$$N1'\lambda = 1$$

$$\lambda \geq 0$$

where N is the number of farms in the reference group, X is a $K\times N$ matrix of inputs (constructed by the vectors of inputs of each farm, x_i), Y is a $M\times N$ matrix of outputs, $N1$ is a $N\times 1$ vector of 1s. The constraint $N1'\lambda=1$ allows for VRS. The efficiency scores for all farms are obtained by minimizing (12) for each farm, i.e. N times.

Selection Equation for Production Method

The determinants of the farmers' choice of using organic or conventional production methods are analyzed by estimating a selection equation. We let $P_i=1$ if a farmer uses organic methods and $P_i=0$ if a farmer uses conventional methods. P_i^* denotes an underlying latent variable. Let

$$P_i^* = Z_i\beta + \varepsilon\ , \quad P_i = 1 \text{ if } P_i^* > 0 \tag{4}$$

$$P_i = 0 \text{ otherwise}$$

where Z_i is a vector of explanatory variables that one might expect influence the choice of production method and β is a vector of parameters to be estimated. (3) is estimated assuming that ε is normally distributed (i.e. the Probit model) using maximum likelihood. The predicted probability of applying organic methods is $E(P_i|Z_i) = \Pr(P_i = 1|Z_i) = \Pr(P_i^* > 0) = \Phi(\beta Z_i)$ where $\Phi(\cdot)$ is the cdf of a standard normal. The obtained parameter estimates, $\hat{\beta}$, are used to correct for/test for self-selection as described in the next section.

Determinants of Technical Efficiency

To analyze the determinants of technical efficiency, the efficiency scores are regressed on some explanatory variables that one might expect will influence the technical efficiency. This is done separately for the organic and the conventional producers using a switching regression model, suggested by Lee (1978):

$$te_{oi} = \alpha \cdot X_{oi} + \varepsilon_{oi} \qquad \text{if } P_i = 1 \text{ (organic producer)} \tag{5}$$

$$te_{ci} = \beta \cdot X_{ci} + \varepsilon_{ci} \qquad \text{if } P_i = 0 \text{ (conventional producer)} \tag{6}$$

where te_{oi} and te_{ci} are estimates of technical efficiency of organic and conventional producers respectively. However, if there is self-selection present in the farmers choice of production method, the OLS estimates of (5) and (6) will yield inconsistent estimates because $E(\varepsilon_{io} | P_i = 1) \neq 0$ and $E(\varepsilon_{ic} | P_i = 0) \neq 0$. This must be corrected for in order for the least squares estimates of equations (5) and (6) to have desirable statistical properties. The "trick" is to find expressions for $E(\varepsilon_{oi} | P_i = 1)$ and $E(\varepsilon_{ci} | P_i = 0)$, obtain estimates of these and include them as a concomitant explanatory variable so that the new error terms will have zero expected mean[2]. Lee (1978) and Heckman (1979) has shown that the expressions for the expected values of the error terms in (4) and (5) are

$$E(\varepsilon_{ic} | P_i = 1) = -\sigma_{1\varepsilon} \frac{\phi(\beta Z_i)}{\Phi(\beta Z_i)} \tag{7}$$

$$E(\varepsilon_{io} | P_i = 0) = \sigma_{2\varepsilon} \frac{\phi(\beta Z_i)}{1 - \Phi(\beta Z_i)} \tag{8}$$

where $\phi(\cdot)$ and $\Phi(\cdot)$ are the pdf and cdf of a standard normal distribution. (7) and (8) are included as explanatory variables to correct for self-selection in the choice production method. Thus, we estimate

$$te_{oi} = \alpha \cdot X_{oi} - \sigma_{1\varepsilon} \frac{\phi(\hat{\beta} Z_i)}{\Phi(\hat{\beta} Z_i)} + \eta_{oi} \qquad \text{if } P_i = 1 \text{ (organic producer)} \tag{9}$$

and

$$te_{ci} = \beta \cdot X_{ci} + \sigma_{2\varepsilon} \frac{\phi(\hat{\beta} Z_i)}{1 - \Phi(\hat{\beta} Z_i)} + \eta_{ci} \qquad \text{if } P_i = 0 \text{ (conventional producer)} \tag{10}$$

Presence of self-selection can be tested for by looking at the significance of the $\hat{\sigma}_{1\varepsilon}$ and $\hat{\sigma}_{2\varepsilon}$. It is also interesting to look at the sign of $\sigma_{1\varepsilon}$ and $\sigma_{2\varepsilon}$. A negative (positive) sign of $\sigma_{1\varepsilon}$ implies that $te_{oi} > \alpha \cdot X_{oi}$, i.e. the technical efficiency among the organic farms is larger (smaller) than the average would have been if all farmers were organic. Correspondingly, a

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[2] The idea is the same as suggested by Heckman, 1979, to correct for sample selection bias but for two ("switching") equations instead of one.

positive (negative) sign of $\sigma_{2\varepsilon}$ implies that $te_{ci} > \beta \cdot X_{ci}$, i.e. the technical efficiency among the conventional farms is larger (smaller) than the average would have been if all farms were conventional.

Predicted values of the average efficiency in organic/conventional production if all farmers had been organic/conventional production can be calculated as:

$$pred(te_{oi} \mid all\_farms\_organic) = \hat{\alpha} \cdot X_{oi} \tag{11}$$

and

$$pred(te_{ci} \mid all\_farms\_conventional) = \hat{\beta} \cdot X_{ci} \tag{12}$$

Estimates of counterfactual efficiencies, i.e. the efficiency scores the organic (conventional) farms would have had if they instead had been using conventional (organic) methods, can be obtained by using the parameter estimates of the estimation of (9) and (10):

$$pred(te_{ci} \mid organic) = \hat{\beta} \cdot X_{oi} - \hat{\sigma}_{2\varepsilon} \frac{\phi(\hat{\beta} Z_i)}{\Phi(\hat{\beta} Z_i)} \quad \text{if } P_i = 1 \text{ (organic producer)} \tag{13}$$

and

$$pred(te_{oi} \mid conventional) = \hat{\alpha} \cdot X_{ci} + \hat{\sigma}_{1\varepsilon} \frac{\phi(\hat{\beta} Z_i)}{1 - \Phi(\hat{\beta} Z_i)} \quad \text{if } P_i = 0 \text{ (conv. producer)} \tag{14}$$

It should be noted that the estimation of (9) and (10) involve a potentially serious econometric problem if the normality assumption does not hold since the selection-bias adjustment is quite sensitive to departures from normality (Maddala, 1983). Because the DEA efficiency score is within the range 0 to 1, the normality assumption is violated if the untransformed efficiency score is used as dependent variable. When the dependent variable is within the range 0 to 1, one can use a logistic transformation (i.e. y'= ln(y/(y-1)) to make it "look more normal".

Data

In the empirical application, accountancy data for a sample of Swedish farms from the time period 2000-2002 was used. The data was obtained from the Farm Accountancy Data Network (FADN) which is an annual survey carried out by the member states of the European Union. It consists of accountancy data from a sample of representative agricultural holdings (based on region, economic size and type of farming). In Sweden, the FADN-variables are collected for about 1000 farms each year and about 100 of the farms are replaced each year. The panel is unbalanced because the farms are not replaced systematically. In this study however, the farms that have a negative value of production are not included[3]. This implies that we have a total sample of 2738 observations. Of these, 487 (21.6%) applied organic production methods. The organic producers can, to some extent, also apply conventional methods.

Table 1 shows descriptive statistics for the production factors that are considered when deriving the DEA efficiency scores. “Value of total output” consists of total revenues from crop and livestock production. “Capital” is the user cost of capital (machinery and buildings). The labor input is measured in hours and accounts for both paid and unpaid labor. “Other expenses” includes expenses for seed, feed, fertilizer etc.

[3] The reason for not including these is that technical efficiency estimates cannot be obtained for firms with a negative output.

Table 1. Descripion of data (in year 2000 monetary values).

Variable	Units	All farms (N=2738)		Conventional (N=2251)		Organic (N=487)	
Production factors		Mean	St.dev	Mean	St.dev.	Mean	St.dev.
Value of total output	SEK†	650571	952005	637057	902273	713038	1153408
Capital	SEK	415862	445992	401808	370262	480824.5	508777
Land	Hectares	95.2	107.6	89.3	101.7	122.7	128.2
Labor	Hours	3615	3015	3449	2819	4387	3705
Energy	SEK	40327	69358	39303	66308	45060	53099
Other expenses	SEK	420330	321521	420773	524339	418278	582191
Farm characteristics							
Age of farmer	Years	50.1	9.7	50.4	9.8	48.7	8.9
Rented land	%	40.1		39.0		44.7	
Hired labor	%	9.9		9.0		14.1	
Area with environmental restrictions	%	19.2		18.1		24.6	
Regions	%						
Region 1		20.9		19.7		26.5	
Region 2		34.8		37.6		21.6	
Region 3		31.6		32.0		29.6	
Region 4		12.7		10.6		22.4	
Production specialization	%						
Crop		31.6		34.7		17.0	
Dairy		49/0		45.5		65.1	
Livestock		19.3		19.7		17.5	

† SEK = Swedish Kronor

In the selection equation and in the equation for determinants of technical efficiency, dummy variables for regions are included to capture the effects of differences in for example weather and soil quality in the different regions. We use four different regions, where region one represents the mid-east part of Sweden, region two the southern part, region three the mid-west/south part and region four represents the northern part. The farms are also divided into three production specializations: crop, dairy and livestock.

Results

Efficiency scores were obtained using DEA assuming VRS for the conventional and organic farms using the whole sample (all conventional and organic farms) as the reference group. The computer program DEAP Version 2.1 (Coelli, 1996) was used to obtain the efficiency scores. The obtained average efficiency scores are 0.49 for the conventional farms and 0.44 for the organic farms. This means that the conventional producers have an average efficiency that is 49% of the most efficient farm in the reference group and the organic producers has an average efficiency that is 44% of the most efficient farm in the reference group. Thus, the conventional farms have a higher average efficiency score than the organic when the whole sample is the reference group. This is expected because the organic producers apply a more restricted technology. The distribution of the DEA efficiency scores for the conventional and organic farms respectively are illustrated in Figure 1 and 2.

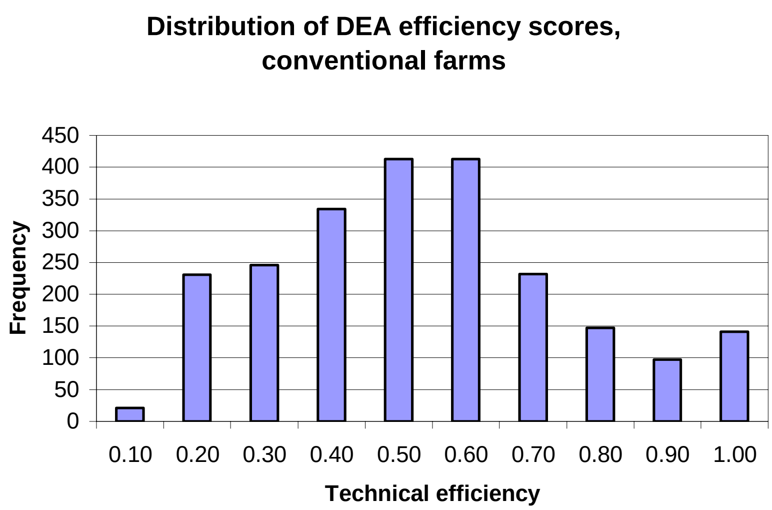

Figure 1. Distribution of DEA efficiency scores for conventional farms (mean: 0.49).

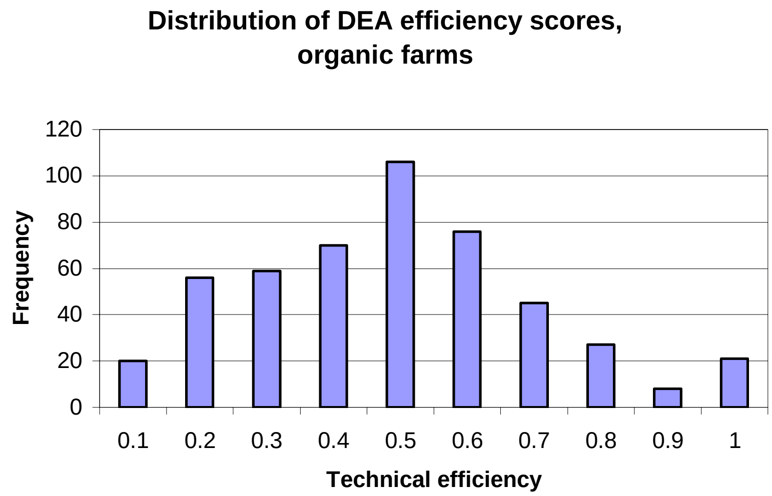

Figure 2. Distribution of DEA efficiency scores for organic farms (mean: 0.44).

The estimated parameters of the selection equation are presented in Table 4. The results suggest that the probability of using organic methods increases with the share of hired labor and decreases with the age of the farmer.

Table 3. Selection equation (P_i=1 if organic methods are applied and P_i=0 if conventional methods).

Variable	*Parameter Estimate (Std)*
Constant	-0.93* (0.19)
Share of land that is owned	0.64* (0.13)
Share of hired labor	0.059 (0.086)
Age of farmer	-0.0098* (0.00308)
Dummy for farm located in area with environmental restrictions	0.22* (0.071)
Dummies for region	
Region 2	-0.31* (0.090)
Region 3	-0.069 (0.086)
Region 4	0.36* (0.086)
Dummy for production specialization	
Crop	0.52* (0.071)
Dairy	0.28 (0.27)
Livestock	0.32* (0.088)

*statistically significant at a 5% significance level.

The determinants of technical efficiency are analyzed by estimating (9) and (10). Error correction terms were included among the explanatory variables to allow/test for the presence of self-selection. A Breusch-Pagan-Godfrey test for heteroscedasticity could not reject that heteroscedasticity was present in all regressions why a weighted least squares estimation was applied[4].

When DEA is used for deriving efficiency scores it might be the case that several firms get an efficiency score equal to one. The reason is that the constructed production frontier is piece-wise linear and more than one firm thus can lie on the production frontier. It is therefore often argued that the efficiency score is censored if the number of fully efficient firms is relatively large and that a Tobit model for censored data should be used when analyzing the determinants of technical efficiency (see for example Zheng et. al. (1998)). In this study, a relatively small share of the farms has an efficiency score equal to 1 (3% of the organic farms and 4% of the conventional farms). Therefore, we did not correct for truncation in the estimations.

The result of the estimation of (9) and (10) are reported in Table 5. The results suggest that the share of hired labor and the share of rented land are positively related to technical efficiency for both organic and conventional farms.

The correction term is significant for conventional producers indicating presence of self-selection in the choice of production method. The negative sign suggests that conventional producers are on average less efficient in conventional production than the average would have been if all farmers were using conventional methods.

An estimation was also performed with the logistic transformation of the DEA score as dependent variable in order for the dependent variable to “look more normal”. Also this method suggests a negative and significant correction term for the conventional producers.

[4] Each observation was divided by the square root of the estimated variance of the disturbance term.

Table 5. Determinants of technical efficiency.

Variable	*Parameter Estimate (St.Dev)*			
	DEA score dependent variable		*Transformed DEA score dependent variable*†	
	Organic	*Conventional*	*Organic*	*Conventional*
Constant	0.38*	0.53*	-0.23*	0.33*
	(0.022)	(0.0012)	(0.085)	(0.0060)
Share of hired labor	0.14*	0.13*	0.99*	0.87*
	(0.012)	(0.0020)	(0.040)	(0.015)
Share of rented land	0.093*	0.087*	0.60*	0.59*
	(0.0038)	(0.0046)	(0.015)	(0.00089)
Dummies for region				
Region 2	0.011	0.014*	0.12*	0.14*
	(0.0054)	(0.00076)	(0.016)	(0.0019)
Region 3	0.015*	-0.050*	0.12*	-0.29*
	(0.0024)	(0.00066)	(0.014)	(0.0019)
Region 4	0.023*	-0.037*	0.12*	-0.018*
	(0.0057)	(0.00128)	(0.022)	(0.0064)
Dummy for production specialization				
Crop	0.014*	-0.050*	-0.093*	-0.30*
	(0.0057)	(0.00080)	(0.022)	(0.0051)
Dairy	0.026	-0.23*	0.54	-1.31*
	(0.078)	(0.0033)	(0.30)	(0.019)
Livestock	-0.13*	-0.16*	-0.91*	-0.83*
	(0.0036)	(0.00074)	(0.022)	(-0.0049)
Error correction term	-0.00039	-0.042*	0.12*	-0.45*
	(0.012)	(0.0046)	(0.036)	(0.024)

†The logistic transformation of the DEA efficiency score, te'=ln(te/(1-te)), is used as the dependent variable.
*statistically significant at a 5% significance level.

The predicted efficiency scores for organic and conventional producers mean predicted efficiency sores if all farmers had been organic/conventional and predicted counterfactual efficiency scores are shown in Table 5 (using the parameter estimates with the untransformed DEA efficiency score).

The predicted mean counterfactual efficiency score for the organic farms is found to be 0.55, which can be interpreted as the predicted mean efficiency the organic producers would have had if they instead had applied conventional methods. This can be compared with the predicted mean efficiency of the conventional farms, 0.49. Thus, our results suggest that the organic farmers in the sample would have been more productive in conventional production than the actual conventional producers are.

Similarly, the predicted mean counterfactual efficiency of the conventional producers is found to be 0.42 which can be interpreted as the predicted mean efficiency the conventional producers would have had if they instead had applied organic methods. This can be compared to the predicted mean efficiency of the organic farms, 0.44. Thus, the results suggest that the conventional farms would have a lower productivity in organic production than the actual organic producers have.

Table 6. Predicted efficiency scores.

	Organic			***Conventional***		
	Mean	*Min*	*Max*	*Mean*	*Min*	*Max*
DEA efficiency score	0.442	0.052	1.000	0.491	0.062	1.000
Predicted efficiency score	0.440	0.116	0.643	0.491	0.217	0.741
Predicted mean efficiency score if all farmers had been organic/conventional*	0.440			0.504		
Predicted counterfactual mean efficiency score**	0.554	0.227	0.774	0.427	0.115	0.646

* calculated according to (8) and (9).
** calculated according to (10) and (11).

The distributions of the calculated counterfactual efficiency scores for the conventional and organic producers are illustrated in Figure 3 and 4. In Figure 3, we can see that a quite large share of the conventional farms has low predicted counterfactual efficiencies (i.e. low predicted efficiencies when using organic methods), which drives down the conventional farms average counterfactual efficiency. Similarly, a quite large share of the organic farms has high predicted counterfactual efficiency (i.e. high predicted efficiency when using conventional methods) which drives up the organic farms average counterfactual efficiency.

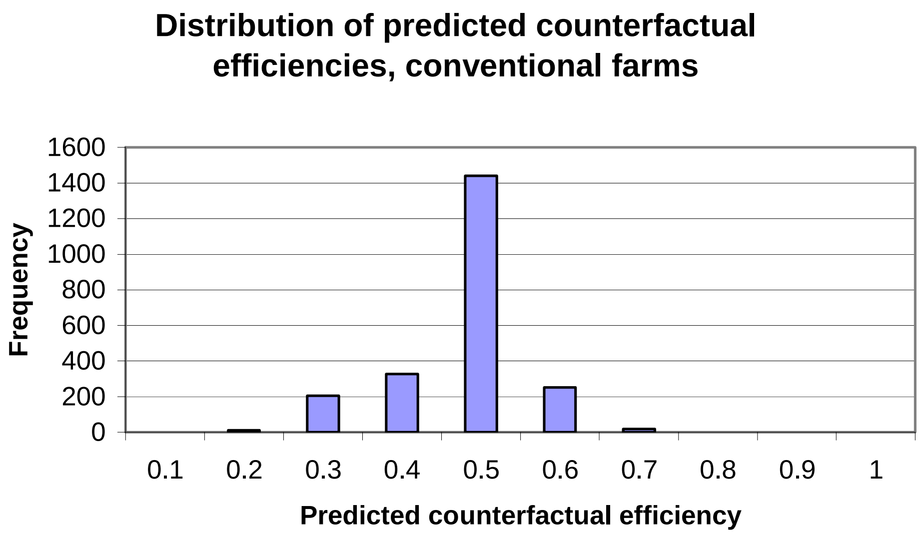

Figure 3. Distribution of predicted counterfactual efficiencies conventional farms (mean: 0.42).

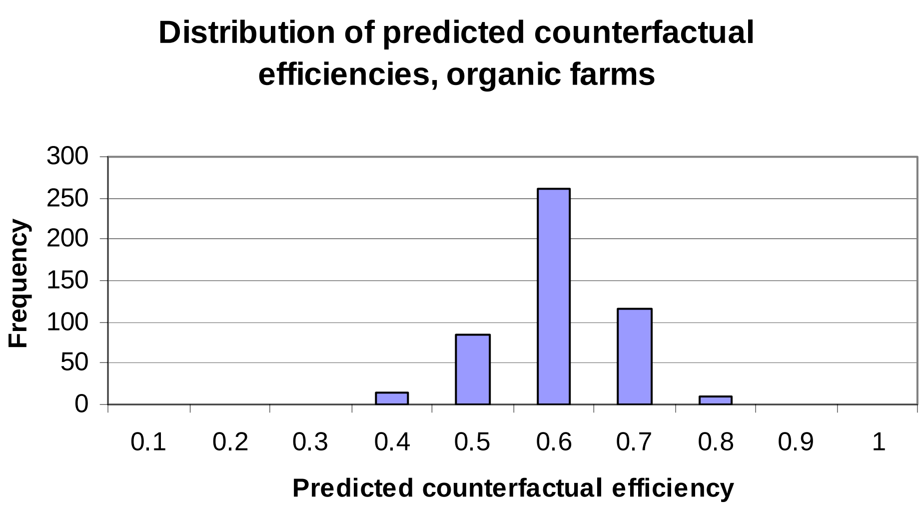

Figure 4. Distribution of predicted counterfactual efficiencies organic farms (mean: 0.57).

The reason for the high predicted counterfactual efficiencies among the organic producers suggested by our results can be understood from the by the signs and magnitudes of the parameter estimates of the efficiency determinants and the level of the explanatory variables. The average size (measured by land) of the organic farms in the sample is larger than the average size of the conventional farms. Moreover, both the share of rented land and the share of hired labor are on average higher among the organic farms (see Table 1). Since our results suggest that both of these factors have a positive effect on technical efficiency, they will contribute to increase the organic producers predicted counterfactual efficiencies. An important question is thus whether the organic farms in the in our sample are representative for all organic farms in Sweden. If this is not the case, then the calculated counterfactual efficiencies for the organic farms might be biased (for example, if large organic farms are overrepresented this will cause an upward bias in the predicted mean counterfactual efficiency of organic producers).

Concluding Comments

The objective of this paper was to obtain estimates of technical efficiency and analyze its determinants for organic and conventional farms in Sweden for the time-period 2000-2002. When analyzing the determinants of technical efficiency of the organic and conventional farmers respectively, we applied a switching regression framework, suggested by Lee (1978), which allows us to correct/test for the presence of self-selection in the farmers choice of production based on, or in part based, their expected productivity in organic and conventional farming respectively. Some of the main findings are:

i) The average efficiency score of the organic producers are, as expected, lower than the average efficiency of the conventional producers (0.44 and 0.49 respectively).

ii) The results suggest that there is self-selection present in the choice of using organic or conventional methods. Moreover, the results suggest that organic producers are one average more productive in organic production than the conventional producers would have been.

An important implication of the results of this study is that, because the results support that (some degree) of self-selection is present in the farmers choice of production method (organic or conventional), this must be accounted for when evaluating and comparing performance measures among the two groups.

Another important implication of the presence of significant selection bias relates to the policy of payments to organic producers. While we have not investigated optimal payments, our results do suggest that organic producers are relatively more efficient in organic production than conventional producers would have been in organic production. Thus, it is possible that some welfare gains are obtained as a result of Swedish policy. If the goal of Swedish society is to guarantee a stable supply of organic food products, then the policy appears to be working because the payments are not sufficiently large to draw in the less efficient potential organic producers who continue to produce conventionally. If, as the policy suggests, Swedish consumers are willing to pay for organic food but value stable prices then the scheme may be welfare enhancing for consumers.

It should however be noted that the results must be interpreted with caution. If it is the case that the sub samples of organic and conventional farms are not representative for organic and conventional farms in Sweden, their predicted mean counterfactual efficiencies will be biased. For example, if large organic farms (with a high share of hired labor and rented land) are over-sampled, the predicted mean counterfactual efficiency of organic farms will upward biased.

A possible extension might be to analyze whether there are differences in the productivity difference between organic and conventional producers among various groups of farmers (based on size, region, production specialization etc) and discuss the implications for optimal compensatory payments (for example uniform versus differentiated payments).

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