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# Learning in Switching to Organic Farming

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## Abstract

Organic farming technology may be relatively unknown to farmers at the time when they switch from conventional into organic farming. Therefore, experience gained over time and learning by doing may be important determinants in the efficiency of organic farming. It may also take time to reach the optimal nutrient stock of soil and optimal nutrient supply for arable crops under organic farming. This paper estimates technical efficiency of organic and conventional dairy farming and its development over time. We control for possible selection bias and regional heterogeneity. The results suggest that technical efficiency measured as a ratio between actual and maximum obtainable output (relative to the peer group) at first diminishes when the conversion towards organic production starts. After 6-7 years from the switch, technical efficiency starts to increase again. The estimates signal that the length of the conversion and learning process of organic farming is relatively long.

**Keywords:** technical efficiency, output distance function, stochastic frontier

## Introduction

Organic farming methods are relatively unknown to farmers when they switch to organic farming. .Ricci Maccarini and Zanoli (2004) found that organic livestock farms were technically less efficient compared to the common production frontier but more efficient compared to their own frontier. They suggest that this lower average performance may partially be explained by underestimated difficulties related to conversion from conventional to organic production. However, it may be possible to observe learning effects, which may take several forms: technical change may be different on organic and conventional farms but also the technical efficiency may change over time in a different way. Learning-by-doing literature suggests that education and management experience can lead to productivity gains when the knowledge increases with the results of experiments (Arrow 1962). There are several studies that have assessed the effect of experience on technical or allocative efficiency. Kumbhakar et al. (1991) and Rougoor et al. (1998) have used age, experience and education when describing the ability of the farm manager. Reinhard and Thijssen (1999) added milk output per cow as an explanatory variable, although it is at the same time an indicator of different feeding strategies. Stefanou and Saxena (1988) used age and experience as explanatory variables of varying price distortions. Kumbhakar and Bhattacharrya (1992) applied years of education and farm size for the same purpose.

This paper measures and compares technical efficiency of organic and conventional farms and tests for the presence of learning effects in organic farming, i.e. whether organic farmers are able to increase their technical efficiency as they gain experience with organic farming. We assume that the farmers choose organic or conventional production because they benefit from the choice. Possible selection bias between organic and conventional production can be taken into account applying Heckman's (1979) two step procedure.

## Data and model

The dairy farm data are collected from bookkeeping farm data base of MTT Economic Research. The data include a detailed production and cost data of panel farms for the period from 1995 to 2002 (8 periods). The data are an unbalanced panel of 279 farms. The total number of observations is 1921, the number of organic farms being 49 (159 observations). Only part of the farms classified as organic dairy farms produce organic milk since the classification to organic and conventional farms is based on subsidies paid for organic crop production. The experience of organic farmers in organic farming varies between 1-11 years.

In the analysis we apply two outputs (milk and other output) and five inputs (labour, land, energy, material and capital). Milk (liters), labour (hours) and land (hectares) are measured in physical units per farm. Other output, energy, material (fertilizers, seeds, purchased feed) and capital inputs per farm have been derived from their monetary values using respective aggregate indices as prices. Capital input is measured as the sum of machinery and building capital stock. Organic farms are on average statistical significantly larger than conventional when measured by the arable land area and the number of animal units. However, their average milk output per farm is 10 percent smaller than the output of conventional farms. The other output is significantly larger on organic farms indicating that their production is more diversified. Assuming a translog specification where technical change is represented by a time trend, the output distance function can be written as (see e.g., Coelli et al. 1999):

$$-\ln y^t_{oi} = \beta_0 + \sum_{k=1}^{5} \beta_k \ln x^t_{ki} + \sum_{k=1}^{5} \beta_{kD} D_D \ln x^t_{ki} + \frac{1}{2} \sum_{k\leq}^{5} \sum_{j=1}^{5} \beta_{kj} \ln x^t_{ki} \ln x^t_{ji} + \beta_m \ln y^t_{mi}$$

$$+ \frac{1}{2} \beta_{mm} \ln y^t_{mi} \ln y^t_{mi} + \sum_{k=1}^{5} \sum_{m=1}^{1} \beta_{km} \ln x^t_{ki} \ln y^t_{mi} + \beta_t t + \beta_{tD} D_D t + \frac{1}{2} \beta_{tt} t^2 + \sum_{k=1}^{5} \beta_{kt} \ln x^t_{ki} t$$

$$+\beta_{mt} \ln y^t_{mi} t + \sum_{r=2}^{7} \beta_r D_r + \beta_{IMR} IMR + u_{it} + v_{it}, \text{ where} \qquad (1)$$

$y^t_{oi} = milk\ output,\ y^t_{mi} = other\ output\,/\,milk\ output, x^t_{ki} = labour,\ land,\ energy,\ materials\ and\ capital\ input, t = time\ trend,\ D_r = regional\ dummy, D_D = organic\ dummy, IMR = inverse\ Mill's\ ratio, \beta = estimated\ regression\ coefficients.$

Subscript i refers to a farm and superscript t to a time period. Neutral technical change is specified as a time trend. Biased technical change is defined by interactions of time trend and respective inputs and outputs. A full translog model includes second order and cross terms of inputs and outputs. Production potential of different regions and technologies (organic vs. conventional in a pooled model) was taken into account by regional and organic dummies. Inverse Mill's ratio (IMR) was also introduced in the separate organic and conventional farming models to capture possible selection bias. The error term is decomposed into two components. The first component, vit, is a standard random variable capturing effects of unexpected stochastic changes in production conditions, measurement errors in milk output or the effects of left-out explanatory variables. It is assumed to be independent and identically distributed with N(0, $\sigma_v^2$). The second component, uit, is a non-negative random variable, associated with the technical (output) inefficiency in production, given the level of inputs. The uits are independently distributed with a truncation at zero of N($\mu_{it}$, $\sigma_u^2$), where $\mu_{it}$ is modelled in terms of determinants of inefficiency as follows (see Battese and Coelli 1995):

$$\mu_{it} = \delta_0 + \delta_{\exp} Exp + \delta_{\exp^2} Exp^2 + \delta_{age} \ln(Age) + \delta_{age^2} \ln(Age)^2 \quad , \qquad (2)$$

where Exp and Exp2 refer to first and second order terms of years of experience in organic farming. ln(Age) and ln(Age)$^2$ refer to the first and second order logarithmic terms of farmer's age. The $\delta$ :s are regression coefficients of respective efficiency effects. The inefficiency effects part of the equation makes it possible to test whether technical efficiencies differ by experience and age. Estimations are performed by Frontier 4.1 (Coelli, 1996).

## Results

Pooled and separate models for organic and conventional farm data were estimated. In some separate models selectivity bias was significant. The differences in elasticities (a relative increase in output obtained by a relative increase in input) and returns to scale (RTS; as elasticity but it measures the effect of a relative increase in all inputs) between conventional and organic farms are fairly small. The share of the other output is on average larger on organic than on conventional farms indicating that organic farms are less specialized. Results are mixed for labour but for land the elasticity tends to be larger on organic farms. The elasticity of energy is low in all models but it tends to be larger on organic farms. Over time distance elasticities evolve in a similar manner in both groups: elasticities of labour and energy are decreasing but elasticities of materials and capital are increasing. The elasticity of land decreases or remains the same. In almost all models the average RTS is slightly larger than one indicating increasing returns to scale. In general, RTS is slightly decreasing over time but in the group of organic farms the annual variation is larger. Technical change tends to be slightly faster on organic than on conventional farms. In all models technical change is slowing down over time. The pattern of changes in technical efficiency is similar in all models of conventional farms. On these farms technical efficiency at first increases from 1995 to 1996 but starts then to diminish. In 2001 the level of technical efficiency is the same as in 1995 but in 2002 it again slightly increases. Organic farms are on average less efficient in each year. In 1996 the gap is the smallest.

In the pooled data technical efficiency is on average 10 percentage units higher on conventional (0.813) than on organic farms. The confidence intervals of technical efficiencies calculated following the procedure presented by Battese et al. (2000) show that even ten percentage unit's differences in average efficiencies of the groups are not statistically significant at the critical 5 percent level. In our case the distributions of efficiencies in models of conventional farms are almost exactly similar. In the group of organic farms the differences are bigger between models but the general feature is that the whole distribution has moved downwards when compared to the group of conventional farms.

We could observe significant learning-by-doing/adjustment effects in conversion to organic farming. According to our analysis, technical inefficiency increases at first after the switch to organic farming. Inefficiency increases for several years reaching the peak after five to six years. According to our estimates, inefficiency starts to diminish after 6 – 7 years of experience in organic farming.

## Conclusions

Although the data suggest learning effects related to the experience in organic farming, differences in the development of organic and conventional farm groups were small. In our sample organic farms are less technically efficient even compared to the organic frontier than conventional farms compared to the conventional frontier indicating that the variation is larger. This result contradicts Oude Lansink et al. (2002) and Ricci Maccarini and Zanoli's (2004) observation that the variation in technical efficiency is smaller in the group of organic farms. The difference is probably caused by a different evaluation method and/or target group. Our result indicates that organic production is more risky but it may also be partially caused by the sample where we had to include all organic dairy farms to guarantee the sufficient number of observations. Organic farms do not necessarily produce organic milk but the conversion may only concern arable farming. The results suggest that temporary premium schemes over a certain conversion period are justified in promotion of organic farming. The result also suggests that this conversion period takes for a fairly long time.

Conventional production seems to be more technically efficient, i.e. more productive when only conventional inputs and outputs are taken into account. However, we have not considered possible external effects on the environment or landscape. These considerations might affect the relative performance of different production systems.

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