THE DETERMINANTS OF THE FARMERS' CONVERSION TO ORGANIC AGRICULTURE: EVIDENCE FROM CZECH PANEL DATA

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Abstract

The aim of the paper is to assess the impact of farmers' technical efficiency on their decision to convert from conventional to the organic land management. Firstly, the technical efficiency is calculated for each farm using parametric approach to efficiency measurement, particularly Stochastic Frontier Analysis. A Cobb-Douglas production function explains the volume of the production by the amount of production factors and subsidies (SAPS and Top-Up). A true fixed effect model assuming truncated normal distribution of inefficiency term is estimated by maximum likelihood method. In the second step, we use random effects logistic regression to model the influence of technical efficiency on the decision of the farmer to convert the agricultural holding from conventional to organic management scheme. We use unbalanced panel data of Czech farms for the period from 2005 to 2012. The results reveiled that the odds that the farm will convert from conventional to organic agriculture are higher when the agricultural holding is more efficient.

Key words: organic agriculture, logistic regression, random effects model

JEL Code: Q12, Q15, H71

Introduction

Organic land management is related to the environmental aspects of the agricultural production. For organic farming is typical higher usage of production factors due to the fact that it "respects the normal functioning of ecosystems, avoiding the use of agrochemicals, and leads to food ''free'' of synthetic chemicals and, thus, more healthy." (Carvalho, 2006) "With growing public concern for food quality and safety, animal welfare and natural resources, the organic farming philosophy and practice become more accepted." (Kerselaers et al., 2007) Also a wide range of policies at national or European Union level had been implemented. Organic farms for example receive subsidies from European Agricultural Fund for Rural Development. "In the Czech Republic, the height of subsidies for the organic farming is continuously increasing. In 1998, the total amount of subsidies was 48 million CZK while in 2004 it increased to nearly 277 million CZK." (Jánský and Živelová, 2007)

The Czech Republic belongs to the countries with high share of the land in organic agriculture. The first three farms managing 480 ha of land emerged in 1990. Since that their number increased significantly. Until 1997, there were over 200 farms at 20 239 ha. Their continued to grow at quick pace until 2004. There were 836 farms at 263 299 ha, but the year after, the number decreased by 0.8 % and the land by 3.2 %. It was due to the problems with certification authorities. Since 2006, the number of farms keeps increasing. Currently, in 2014, there are about 474 147 ha of land farmed organically by 3 894 agricultural holdings.

The reasons for conversion from conventional to organic agriculture concerned many authors. Some determinants might be related to the social feeling of the farmer or with his personal believe. On the other hand, there might be also economical reasons. The organic products are sold for higher prices and the demand for them is still increasing. Besides, the holdings are also subsidized.

Kumbhakar et al. (2009) analyzed the Finish data and concluded that the driving forces behind adoption of organic technology are both efficiency and subsidies. This finding is not in line with those of Lohr and Salomonsson (2000) who found out that the „access to more market outlets and information sources substitutes for payment level in the farmer's utility function, indicating that services rather than subsidies may be used to encourage the conversion organic agriculture." The transition from conventional to an ecological manner of farming interested also Malá and Malý (2013). On the basis of the binary choice model they concluded that implementation of the organic production technology is negatively affected by the higher age of the farmers and the high productivity of labour while positive effect have the subsidies as same as the high returns on costs.

Regarding the efficiency of organic farms, the findings of many authors shows that they are less efficient than conventional. It might be due to the fact that they focus is rather on environmental than economical aspects. Therefore, Ochoa et al. (2014) when he compared the economic efficiency between organic and conventional farms extended the analysis by inclusion of environmental performance as one of the farms' outcome. They calculated productivity and efficiency with and without environmental impacts, but found no significant technological differences in environmental productivity. Pechrová and Vlašicová (2013) estimated and compared the technical efficiency of organic and biodynamic farms in the Czech Republic. The second mentioned produce only 65.94 % of the potential output, while the organic 79.05 %. The differences in the inefficiency and efficiency of resources usage between biodynamic and organic farms were found to be statistically significant.

Our research examines the impact of technical efficiency on the decision of the farmers to transform their farms or agricultural holdings from conventional to organic land management. The structure of the paper is as follows. Firstly the Stochastic Frontier Analysis (SFA) method and random effects logistic regression model are described. Then the results of the estimated models are presented. They are discussed in the next section. Last chapter concludes.

Material and Methods

The aim of this paper is to assess the impact of farm's technical efficiency on the decision to convert from conventional to organic farming. We utilized accountancy data of 50 farms observed for years 2005 to 2012. Hence, we had 292 observations in total (5.8 per on farm in average). The panel structure of the data (unbalanced in our case) has several advantages. It provides more observations (more the degrees of freedom), enables to control for variables which do not change across time whether they are measured or not, allows studying unobserved heterogeneity, dynamic relationships and causal effects. The methods used were adjusted for panel data. The calculations were done in Stata 11.2.

Firstly, the technical efficiency was calculated by Stochastic Frontier Analysis (SFA) using Cobb-Douglas transformation function. The amount of production deflated by the agricultural producers' prices (2005 = 100) ($y_{1,it}$ – where i (i =1, … n) denotes particular farm in time t) was explained by 5 variables: consumed material ($x_{1,\ it}$) and capital ($x_{2,\ it}$), both deflated by industrial producers' prices (2005 = 100), labour measured in number of workers ($x_{3,\ it}$), land in hectares ($x_{4,\ it}$) and direct payments as sum of Single Payment Scheme (SAPS) and Top-up subsidies ($x_{5,\ it}$). The "True" fixed-effects model suggested by Greene (2002) was estimated in the following form (1).

$$y_{it} = \alpha_i + \beta^T \mathbf{x}_{it} + v_{it} - u_{it}\,, \qquad (1)$$

where α_i is the farm specific time invariant constant, $\boldsymbol{x}_{it}$ represents the matrix of explanatory variables and u_{it} is time variant inefficiency term, v_{it} is independently identically distributed $N(0;\sigma^2_{v_{it}})$ error term representing usual statistical noise. We assumed that u_{it} was truncated normal distributed $N^+(\mu_{u_{it}};\sigma^2_{u_{it}})$, hence we had to apply the maximum likelihood estimation method[1]. We did not account for heterogeneity and heteroskedasticity and explained the mean of the inefficiency and the variance inefficiency only by constants.

After the estimation, the efficiency and inefficiency was calculated as suggested by Jondrow et al. (1982). They proposed a method considering the conditional distribution of u_i given ε_i when u_i is half-normal or exponentially distributed.

In the second step, the technical efficiency was used as the explanatory variable in logit model adjusted for panel data. The explained variable was the dummy where 0 stayed for conventional and 1 organic land management. Logit and probit model were used for example by Šimpach (2012). In his analysis he proved that logit and probit models do not differ much and that the results are almost comparable. The estimate of coefficients under the logit model is approximately equal to 1.6 times the estimate of coefficients under the probit model. Hence, there is not much difference whether we chose logit or probit. We selected the first mentioned. It examines the log-odds (a ration of expected number of successes to each failure) (2).

$$\log\left(\frac{p(y_{it}|\mathbf{x}_{it})}{1-p(y_{it}|\mathbf{x}_{,it})}\right)=\beta_0+\mathbf{x}_{it}^T\boldsymbol{\beta}, \tag{2}$$

where p is the probability and $\boldsymbol{x}_{it}$ is a matrix of k (k = 1, ... 5) explanatory variables. To incorporate unobserved heterogeneity into a model a farm-specific parameter is added. This β_{0i} constant can be treated as fixed (y_{it} is assumed to be independent) or random (y_{it} is assumed to be conditionally independent given β_{0i}).

The logit model can be constructed as Fixed Effect Model (FEM) or Random Effect Model (REM). Unlike FEM, REM enables to estimate the effect of variables even when they are not time-variant. REM is also more suitable when there are no omitted variables or if we assume that they are uncorrelated with (independent of) the explanatory variables in the model. We estimated Random effects logistic regression model via maximum likelihood method based on the maximization of the likelihood (or log-likelihood) function (3).

$$\Pr(y_{it}\neq 0\mid \mathbf{x}_{it})=P(\mathbf{x}_{it}\beta+\varepsilon_i), \tag{3}$$

where i (i = 1, … n) is the number of farms, t (t = 1, … T_i) denotes time, ε_i is identically and independently distributed $N(0;\sigma^2)$ and $P(z)=\{1+\exp(-z)\}^{-1}$. In Stata software, the REM is calculated using quadrature, which is an approximation whose accuracy depends partially on the number of integration points used.

[1] Corrected Ordinary Least Squares method can be used only in case of exponential or half-normal distribution.

Results and discussion

1.1 Stochastic frontier analysis

Firstly, a SFA was used to estimate Cobb-Douglas production function in a linear form. The results are displayed at Tab. 1. Lambda (λ = 1.84e^{+08}) express the ratio of the standard deviation of the inefficiency component to the standard deviation of the idiosyncratic component (σ_u/σ_v = 10.7056/5.81e^{-08}). Log likelihood was 74.1678. Wald χ^2 = 1.42e^{10} with p-value 0.0000 suggests that the model as a whole is statistically significant.

Regarding the parameters, all (except for the mean on inefficiency term) are statistically significant at α = 0.01 level. All signs (except for the subsidies which have negative sign) are positive and according to the expectations. It implies that increase of material, capital, labour, and land by 1 % bring the increase of production by 0.46 %, 0.07 %, 0.26 % and 5.78 % respectively. The intensity is the highest in case of the land.

On the other hand, the SAPS and Top-up subsidies caused mild decrease in production. This is due to the fact that direct payments had been decoupled from the production. Hence, they should not influence it. This finding is in line with the research of Pechrová (2014). Also Kumbhakar (2009) argues that "in the long run subsidy will be necessary only if productivity shortfall of organic farms (pure technological not inefficiency) is not compensated by the price premium they receive." Similarly Picazo-Tadeo et al., (2011) found out that the subsidies do not have statistically significant impact on eco-efficiency, because the correlation assessed by Pearson's coefficient between subsidies and efficiency was low and statistically insignificant.

Tab. 1: TFE estimates, truncated-normal distribution of u_{it}

	Coeff. (Std. err.)		Coeff. (Std. err.)
Frontier		μ_u – inefficiency mean function	
β_1 ($x_{1,it}$ – material)	0.458814 (0.000005)***	δ_0 (constant)	-399.9876 (358.3694)
β_2 ($x_{2,it}$ – capital)	0.065230 (0.000030)***	σ_u – inefficiency variance function	
β_3 ($x_{3,it}$ – labour)	0.260917 (0.000054)***	ω_0 (constant)	4.741607 (0.896298)***
β_4 ($x_{4,it}$ – land)	5.781284 (0.003516)***	σ_u – stochastic term variance function	
β_5 ($x_{5,it}$ – subsidies)	-0.012412 (0.000002)***	γ_0 (constant)	-33.32241 (71.135350)

Source: own elaboration; Note: statistical significance is labelled: *** at α = 0.01, ** at α = 0.05 and * at α = 0.1

When calculating the efficiency, 2 observations were dropped. The results are displayed in Tab. 2.

Tab. 2: Estimated farms' efficiency and inefficiency

	Mean	Std. deviation	Minimum	Maximum
Inefficiency	0.285013	0.398883	$2.78e^{-07}$	3.160955
Efficiency	0.792446	0.193375	0.042385	1.000000

Source: own elaboration

The average inefficiency was estimated at 28.50 %, but it varied a lot, as the standard deviation was 39.89 %. The efficiency was relatively high; an average farm produced 79.24 % of potential product. The least efficient farm produced only 4.24 %. There were 54 observations (18.14 % of all) almost 100 % efficient.

1.2 Random logistic regression model

Secondly, a random logistic regression model was estimated. The explained dummy variable was the decision of farmer to convert (0 marked non-organic farm and 1 organic). Wald χ^2 = 2.23 with p-value 0.1354 revealed that the model and any parameter were not statistically significant. Log likelihood was -179.0880. Besides constant we included only efficiency. The value of the coefficient implies that being more efficient increases the log odds that the farmer will convert to organic farming. The results are displayed at Tab. 3. Within the two groups of farmers (the ones that converted to organic or biodynamic production and those who did not yet), each increase of efficiency by 1 % increases the odds of conversion by about 263 %. This is very high elasticity. However, the coefficient is not statistically significant. The value of ρ tells how much the total variance is contributed by the panel variance. In our case 39.98 % of variation is due to the variation in the panel data. If ρ was 0, the panel-level variance component would not have been important and the panel estimator would not differ from the pooled one. Also the results of the Likelihood-ratio test ($\overline{\chi}^2_{[1]}$=40.56 with p-value 0.0000) showed that panel estimator is justified.

Tab. 3: Random-effects logistic regression

	Coeff. (Std. err.)	Odds ratio (Std. err.)
constant	-0.688497 (0.727445)	---
efficiency	1.288946 (0.863140)	3.628959 (3.122298)

Source: Own elaboration

We may conclude that the efficiency do not have statistically significant impact on the decision to convert. This suggests that it does not matter whether the farmers are highly efficient or not, there are other factors which influence it more. We may assume that the subsidies for organic farming provided through Common Agricultural Policy of the European Union can stimulate the farmers to convert. However, together with the financial support, there are also requirements. As found out by Ochoa et al. (2004) “if organic technology is less productive, more restrictive regulation could undermine the economic viability of farms, and thus undermine the other benefits of organic farming.” Therefore, the subsidies and hence the improvement of the financial situation does not have to clearly influence the farmers’ decision to convert to the organic farming.

Conclusion

The aim of the paper was to assess whether and how the technical efficiency of the farm influence the decision of the farmer to switch from conventional to organic type of agriculture. Firstly, the efficiency was calculated for each farm in a random sample for years 2005–2012. We found out that average farm produced only 79.24 % of the potential production.

Secondly, the influence of efficiency on the decision was assessed by random regression logistic model. The increase of efficiency increases the odds that the farm will convert to organic farming, but the effect is not statistically significant. Therefore, we cannot clearly conclude about the influence of the efficiency on the decision. There are other factors which should be examined: such as the level of subsidies, unfavourable conditions for conventional farming, and other reasons which cannot be explained quantitatively. Therefore, challenge for the future research is to supplement the quantitative research by qualitative methods – e.g. to perform in-depth interviews with the organically managing farmers and ask them for their motivation to convert to this specific type of agriculture.

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