Agris on-line Papers in Economics and Informatics

Volume VI Number 4, 2014

Determinants of the Farmers' Conversion to Organic and Biodynamic Agriculture

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Anotace

Cílem článku je posoudit zvolené determinanty, které ovlivňují přechod českých zemědělců z konvenčního na ekologické a biodynamické zemědělství. Je posuzována efektivnost farem (vypočtená metodou stochastické hraniční analýzy), zda farma obdržela AEO nebo LFA platby, jestli je farmář "mladý", zda se jedná o mikropodnik a region. Byl odhadnut logistický regresní model náhodných efektů na panelu českých farem v letech 2005–2012.

Výsledky ukazují, že efektivnost farmy není významným činitelem konverze. Na druhou stranu šance, že zemědělský podnik změní způsob hospodaření, jsou statisticky významně vyšší, jestliže pobírá dotace. Také pokud má farma méně než 10 zaměstnanců a zemědělec je starší 40 let, šance, že přejde na ekologické nebo biodynamické zemědělství jsou vyšší. Naopak jestliže se farma nachází v Olomouckém kraji nebo na Vysočině, šance na konverzi jsou nižší.

Výzkum je financován z grantu IGA číslo 11110/1312/3160 PEF, ČZU.

Klíčová slova

Ekologické a biodynamické zemědělství, stochastická hraniční analýza, model náhodných efektů.

Abstract

The aim is to assess selected determinants which influence the conversion of the Czech farmers from conventional to organic or biodynamic agriculture. We assess farm's efficiency (calculated by SFA), whether farm obtains AEM or LFA payments, if the farmer is "young" and the holding is a micro firm, and region. A random effects logistic regression model was estimated on the panel of Czech farms in 2005–2012.

The results showed that efficiency of the farm is not a significant driver of conversion. On the other hand, the odds that the farm will change land management are significantly higher if it obtains subsidies. Also when the farm has < 10 employees and the farmer is > 40 years, the odds that it will switch are higher. If the farm is located Olomoucký region or Vysočina the odds for conversion are lower.

The research is financed from IGA the grant No. 11110/1312/3160 of FEM, CULS.

Key words

Organic and biodynamic agriculture, stochastic frontier analysis, random effects model.

Introduction

For both, organic and biodynamic agriculture environmentally friendly production process is typical. Organic agriculture is utilizing only the inputs with propitious effects on the environment, human health and the health of farm animals. Biodynamic agriculture introduced by Rudolf Steiner in 1924 (Steiner, 2004) is similar to organic in many ways. „The difference from organic agriculture, apart from philosophical and historical aspects, lies in the use of biodynamic preparations which contain specific herbs or minerals, treated or fermented with animal organs, water and/or soil. These preparations are applied in finely-diluted form (homoeopathically), generally as field sprays after dynamisation, i.e., agitated in a specific way for long periods" (Heimler et al., 2009).

Both, organic and biodynamic agriculture "respect the normal functioning of ecosystems, avoiding the use of agrochemicals, and leads to food "free" of synthetic chemicals and, thus, more healthy" (Carvalho, 2006). Because of these favourable effects on the environment and the health and to compensate higher production costs, organic agriculture is subsidized. The amount of subsidies to the organic farming is continuously increasing in the Czech Republic. While in 1998 it was only 48 million CZK in 2004 it increased to nearly 277 million CZK. (Jánský and Živělová, 2007) Dependence of the farmers on the public funds has been analysed in many researches. Therefore, we suppose that subsidies may play its role as a determinant of the change of the land management. Kroupová and Malý (2010) argue that it is necessary to continuously analyse the efficiency of spend public funds in relation to the value added. Therefore, in our article we also include the technical efficiency of the organic and biodynamic farms as one of the determinants. Besides, we also consider the age of the farmer and the size of the agricultural holding.

The article is structured as follows. Firstly the results of previous researches are introduced. Next section presents the data and the methods (Stochastic Frontier Analysis (SFA) and random effect logistic regression (RELR)). The results are discussed then. Last section concludes.

While the conversion from conventional to organic agriculture concerned many authors, the research in biodynamic agriculture is still mild. We are not aware about any research which would examine this issue. Therefore, assessing selected determinants of change to biodynamic farming is the main contribution of our paper. According to Kumbhakar et al. (2009) the main driving forces behind the adoption of the organic technology in Finland are the efficiency of the farms and the subsidies. It was proved by Malá (2011) that the organic farms are less efficient than conventional ones. Similarly Pechrová and Vlašicová (2013) found that there were statistically significant differences between biodynamic (with inefficiency at the level of 58.09%) and organic farms (inefficiency was only 28.60%). We also include efficiency and subsidies into our analysis to see their effect on conversion decision.

Regarding the others determinants Lohr and Salomonsson (2000) showed that the access to more market outlets and information sources are important for farmers and substitute for payment level in the farmer's utility function. They concluded that services rather than subsidies may be used to encourage the conversion to organic agriculture. Läpple and Kelley (2013) examined the farmers' beliefs regarding the adoption of organic methods in Ireland. They found out that the impact of economic incentives and technical barriers on the decision to convert to organic farming vary and that the social acceptance of organic farming restricts the adoption. Wheeler (2008) questioned agricultural professionals and found out that „significant key influences on attitudes towards organic farming were: knowledge, experience, education, informational, occupational effects, and attitudes on the individual aspects of organic agriculture." Also Mzougi (2011) analysed the adoption of integrated crop protection and organic farming from social point of view. He discovered that in France social concerns drive the conversion to both practices, while moral concerns increase the probability of organic farming adoption. Läpple and Rensburg (2011) showed that environmental attitudes and social learning were important determinants for conversion to organic farming. However, acknowledging that "farmers who give high importance to economic concerns (e.g., cutting production costs) are less likely to adopt organic farming" (Mzougi, 2011) does not necessary mean that farms are working inefficiently. We understand the technical efficiency as the relation between inputs and outputs when a firm is more efficient when it uses fewer inputs to produce given output. This is in line with the philosophy of organic and biodynamic farming when fewer chemicals are utilized.

Materials and methods

Firstly, the technical efficiency is calculated by SFA. In the second step, we use RELR to model the influence of technical efficiency and other determinants on the decision of the farmer to convert from conventional to organic management scheme.

At the end of 2013 there were 4060 organic farms at 493 394 hectares of land having mostly grasslands (83.30%) in the Czech Republic (Ministry of Agriculture, 2014). There are only four biodynamic farms certified by Demeter-International e.V. in the CR farming at 3831 hectares. In our sample, there are four of them, but only three are already certified. One biodynamic farm focuses on breeding of beef and dairy cattle and growing of cereals buckwheat, oats, wheat,

wheat – spelt on over 100 hectares. It even has its own bakery. Sometimes the owners hold seminars about healthy nutrition and preparation of biodynamic preparations. Contrary to this family type farm, the second one is joint – stock company farming on more than 1000 hectares. The most of the land is covered by the grassland, arable land accounts only for one quarter. The third farm focuses on wheat, barley, rye, corn and potatoes. The last one is winery managing more than 50 hectares of the vineyards.

The accountancy data of the farms were obtained from Albertina database of Bisnode s. r. o. and the data about the subsidies from State Agricultural Interventional Fund. An unbalanced panel of 50 farms contained 292 observations for years 2005-2012 (5.8 on average). Panel data enable to control the heterogeneity of the farms and thus avoid obtaining biased results. Especially in the case of the change of production technology, a usage of panel data is recommended (Pitt and Lee, 1981). The calculations were done in Stata 11.2.

Stochastic Frontier Analysis

Firstly, using SFA a Cobb-Douglas production function was estimated on the data from 2005 to 2012. The coefficients can be interpreted as the elasticity and their sum expresses whether the constant (equal to 1), increasing (higher than 1) or decreasing (lower than 1) returns to scale prevail. The amount of the 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 4 production factors: consumed material ($x_{1,\ it}$) and capital ($x_{2,\ it}$), both deflated by industrial producers' prices (2005 = 100). Labour as the number of the workers ($x_{3,\ it}$) was calculated as the division of personal costs by average agricultural wages in each region in particular year. The land in hectares ($x_{4,\ it}$) was multiplied by the coefficient reflecting the land quality. This was calculated as the division of the average official land price in the region and the average of that price in the Czech Republic in particular year).

We assumed the heterogeneity among the farms and explained it in the function of the mean of the inefficiency term. The explanatory variables were the sum of SAPS and Top-up subsidies ($z_{1,\ it}$), the payments under Agro-environmental measures (AEM) ($z_{2,\ it}$) and the support for Less Favoured Areas (LFA) ($z_{3,\ it}$). The "True" Fixed-Effects (TFE) model suggested by Greene (2002) was estimated in the following form (1).

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

where α_i is the farm specific time invariant constant, x_{it} represents the explanatory variables, v_{it} is independently identically distributed $N(0;\sigma^2_{v_{it}})$ error term representing usual statistical noise, and u_{it} is time variant inefficiency term. Both parts of the stochastic term (u_{it} and v_{it}) are individual and time variant. We assumed u_{it} to be truncated normal distributed. The heterogeneity of the farms is explained in the mean function. The maximum likelihood estimation was applied. The inefficiency and the efficiency were calculated as expected value of u_{it} given ε_{it} (Jondrow et al., 1982).

Random Effects Logit Regression Model

In the second step, the technical efficiency was used as explanatory variable in logit model adjusted for panel data. The explained variable is the dummy y'_{it} (i denotes particular farm and t = 1, ..., T is time) taking value of 0 in particular year when the farm was conventional and value of 1 when it was already under organic or biodynamic land management. As explanatory variables were included: $x'_{1,\ it}$ – the efficiency of particular farm i in time t; $x'_{2,\ it}$ – dummy for AEM subsidies taking value 1 when the farm obtains them and 0 otherwise; $x'_{3,\ it}$ – dummy for LFA payment (1 – obtain subsidies, 0 – no subsidies); $x'_{4,\ it}$ – dummy for the age of the farmer taking value of 1 when it is a young farmer (< 40 years according to the definition of the European Commission (EC)) and 0 if otherwise; $x'_{5,\ it}$ – dummy taking value of 1, when it is a micro farm (has < 10 employees according to the definition of the EC) and 0 otherwise.

As "a growing number of studies focus also on the role of spatial effects in the adoption process and find evidence for the spatial clustering of organic farming" (Wollni and Andersonn, 2014), we also included the localization of the farm in one of the 13 NUTS III regions in the Czech Republic (with exception of capital city Prague). Jihočeský region was omitted and all regions were compared to it.

We use logit model adjusted for panel data (for cross-sectional data study see e. g. Šimpach, 2012), which examines the log-odds (a ratio of expected number of successes to each failure) (2).

$$\log\left(\frac{p(y'_{it}|\mathbf{x}'_{it})}{1-p(y'_{it}|\mathbf{x}'_{it})}\right) = \beta_{0i} + \mathbf{x}'^{T}_{it}\,\boldsymbol{\beta}, \quad (2)$$

where p is the probability and $\mathbf{x}'_{it}$ is a matrix of 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) when we construct the Fixed Effect Model (FEM) or random (y'_{it} is assumed to be conditionally independent given β_{0i}) when we estimate the Random Effect Model (REM). When all outcomes are either positive or either negative (as it is our case – sometimes all observation for a farm are for years when it was already organic) those observations would be dropped from FEM. Besides, if the within-person variation is small relative to the between-farms variation, the standards errors of the FEM might be too large. Unlike the FEM, the REM enables to estimate the effect of variables even when they are not time-variant. Under a random coefficients specification, the parameters are assumed to be randomly distributed across the individuals. The REM is 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 the RELR model by maximum likelihood method.

Results and discussion

The most changes from convention to organic farming in our sample took place between the years 2005 and 2006. This might be due to the entrance of the Czech Republic to the EU and the possibility to obtain subsidies on conversion. Then farms in our sample converted between 2010 and 2011. This follows overall trend in the Czech Republic (increase by 403 farms between 2010 and 2011). New program period 2007–2013 brought increased financial possibilities which also might influence the conversion. In our sample an average amount of the subsidies on AEM was the highest in the years 2010 and 2011 (2.56 mil. CZK and 2.71 CZK per one farm). In comparison with year 2005 (0.09 mil. CZK) the subsidies were almost 30 times higher. Also increasing consumption of products of ecological agriculture (the consumption was three times higher in 2010 than in 2005 – see Hrabalová and Dittrichová (2012)) could have played its role.

The average production of the farms increased in 2005–2007, dropped in the crisis year 2008 and is rising again since that. The use of material was on average 29 772.94 thous. CZK per year and of capital 64 421.98 thous. CZK per year. Average number of workers dropped the most between 2007 and 2008. An average number for the whole period was 93.94. There were 12 micro farms with less than 10 employees (24% of all farms). The size of the agricultural holdings was on average 283.02 ha. One farm received on average 6427.64 thous. CZK of the direct payments (SAPS and Top-Up), 1 435.06 thous. CZK under AEM and 829.17 thous. CZK of the LFA subsidies per year. The amount of SAPS, Top-Up, and AEM grew over time, while the LFA payments were the same in 2009–2010 and dropped in 2011. While SAPS and Top-up are gained regardless the farming management, there were only 152 observations (52.05% of the sample) where the farms received AEM subsidies and 104 (35.62%) where they received LFA subsidies. The average age of the farmer was 48.62 years, 14 farms (28.00% of all) were managed by a "young" farmer.

Efficiency of organic and biodynamic farms

SFA was used to estimate Cobb-Douglas production function in linearized form. The results are displayed at Table 1. Wald $\chi^2 = 4.57e^{14}$with p-value 0.00 implied that the model as a whole was statistically significant. All frontier parameters were statistically significant at $\alpha = 0.01$ level. All signs were positive according to the expectations. It implies that increase of the material, capital, labour, and land by 1% bring the increase of production by 0.46%, 0.11%, 0.21% and 7.79% respectively. The intensity is the highest in the case of the land.

The parameters of inefficiency mean function are not statistically significant implying that the subsidies do not significantly influence the inefficiency. Similarly Picazo-Tadeo et al. (2011) found out that the subsidies do not have statistically significant impact on eco-efficiency. In the case of the Czech Republic for example Kroupová (2010) did not find any influence of the subsidies on the support of organic farming on the technical inefficiency. Only other subsidies had according to Kroupová (2010) negative impact on technical inefficiency as they increased it.

Direct payments and AEM subsidies cause mild decrease in mean inefficiency. On the other hand LFA subsidies slightly increase it. Contrary to that, Boudný et al. (2011) found out that the most of AEM and LFA payments per hectare were

	Coeff. (Std. err.)		Coeff. (Std. err.)
Frontier		**μu – inefficiency mean function**	
β_1 ($x_{1,\,it}$ – material)	0.4559 (1.03e^{-6})***	δ_0 (constant)	-170.7862 (371.7199)
β_2 ($x_{2,\,it}$ – capital)	0.1106 (5.56e^{-7}) ***	δ_1 ($z_{1,\,it}$ – SAPS+Top-Up)	-0.3413 (1.7474)
β_3 ($x_{3,\,it}$ – labour)	0.2075 (1.95e^{-6})***	δ_2 ($z_{2,\,it}$ – AEM)	-0.1770 (3.9670)
β_4 ($x_{4,\,it}$ – land)	7.7907 (5.22e^{-7})***	δ_3 ($z_{3,\,it}$ – LFA)	2.9043 (6.3640)
σ_v – stochastic term variance function		**σ_u – inefficiency variance function**	
γ_0 (constant)	-40.9332 (521.0789)	ω_0 (constant)	3.9620 (2.1678)*

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

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

obtained by the 25% of the least efficient farms and therefore both type of the subsidies had negative impact on technical efficiency. Sum of frontier's coefficients is higher than one which implies that farms are achieving increasing returns to scale.

When calculating the efficiency, 1 observation was dropped. The average inefficiency was estimated at 28.59%, but it varied a lot, as the standard deviation was 41.55%. The efficiency was relatively high; an average farm produced 79.38% of the potential product with the standard deviation of 19.38%. Half of farms were efficient from more than 82.49%. Compared to the results of Kroupová (2010), where the average efficiency of organic farms was only 55.1% in 2004–2008 we can see that in our case it is higher. This might be due to the location of the farms. There were 70% of the farms located in less favoured areas in Kroupová's sample, but in our case the share was only 35.62% of the observations. The least efficient farm produced only 3.16% of its potential production. There were 49 observations almost 100% efficient. The highest technical efficiency was in years 2010 and 2011 when 10 and 7 farms respectively were 100% efficient.

Biodynamic farms were on average inefficient from 54.42%, while the organic ones only from 26.27%. They also produced only 67.23% of their potential production while organic 80.46%. This suggests that biodynamic farms are on average less efficient than organic. It was proved by Kruskal-Wallis test that organic and biodynamic farms' median inefficiency and efficiency statistically significantly differs. This is in line with the findings of Pechrová and Vlašicová (2013).

The reasons for lower efficiency are given by different technology applied by biodynamic and organic farms. Biodynamic farming applies holistic management practices that address the environmental, social, and financial aspects of the farm. Similarly conventional farms differ from organic ones. Kroupová (2010) and Malá (2011) suggest that the lower efficiency of organic farms can be caused by the fact that they are located in less favoured areas which are less suitable for intensive (or hence efficient) use.

Determinants of conversion to organic and biodynamic farming

The farmer's decision to convert was explained in the RELM. We tried several specifications and chose the one which explains the choice the most statistically significantly. The results are displayed at Table 2. Wald $\chi^{2[17]} = 39.8700$ with p-value 0.0013 revealed that the model was statistically significant. The ρ tells that 30.22% of variation is due to the variation in the panel data which implies that the panel estimator is justified.

The direction of efficiency coefficient suggests that the odds for conversion are higher when the farm is more efficient. When it converts to organic land management, the farm becomes less efficient than conventional – see e.g. findings of Malá (2011). This fact provides a rationale for the compensatory payments to the organic agriculture.

A wide portion of the changes took place between years 2009 and 2010 where the efficiency of the farms was almost the highest. This finding is in line with Kumbhakar (2009) who found out that subsidy is attracting efficient farms. He hopes "that in the long run organic farms will be as efficient as the conventional ones. If so, 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" (Kumbhakar, 2009).

The subsidies for organic farming provided through Common Agricultural Policy of the European Union have statistically significant impact on the decision of a farmer to convert. Because all organic and biodynamic farms received SAPS (and Top-Up support), it was not included

Variable	Coeff. (Std. err.)	Variable	Coeff. (Std. err.)
β_0 (constant)	-2.7360 (1.5397)*	β_3' ($x_3{'}_{it}$ – LFA dummy)	1.8523 (0.8313)**
β_1' ($x_1{'}_{it}$ – efficiency)	1.8357 (1.1815)	β_4' ($x_4{'}_{it}$ – age dummy)	-2.0086 (0.9688)**
β_2'(x_2' it – AEM dummy)	2.7488 (0.6666)***	β_5'($x_5{'}_{it}$ – farm size dummy)	2.0377 (0.8633)**
Regions' dummy			
α_{0i} (constant)	-2.7360 (1.5397)*		
α_{1i} (Jihomoravský)	-0,3503 (1,2702)	α_{7i} (Pardubický)	0,4816 (1,6737)
α_{2i} (Karlovarský)	2,2144 (2,0435)	α_{8i} (Plzeňský)	-2,2082 (1,8448)
α_{3i} (Královéhradecký)	1,0693 (1,5327)	α_{9i} (Středočeský)	0,1730 (1,8921)
α_{4i} (Liberecký)	1,6620 (1,7708)	α_{10i} (Ústecký)	0,7156 (1,6063)
α_{5i} (Moravskoslezský)	-1,9105 (1,3306)	α_{11i} (Vysočina)	-2,8228 (1,3779)**
α_{6i} (Olomoucký)	-5,0422 (1,9734)**	α_{12i} (Zlínský)	1,5264 (1,3198)

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

Table 2: Random-effect logistic regression for farms' conversion to organic / biodynamic farming.

as the determinant of the conversion. On the other hand, only some farms took the advantage from AEM measures and only some of them were located in LFA areas. Both entitlements are contributing positive to the odds that the farmer will switch to organic farming. The higher are the subsidies the higher are the odds that the farm is organic. Farmers see subsidies as significant addition to their income (on average a farmer gets additional 9 mil. CZK each year).

Surprisingly, if the farmer is young, the odds that he will change for organic farming are lower (by 86.95%). It might be due to the fact that he does not have sufficient information about the possibility of the conversion. Besides, 46.7% of the farmers in the CR belong to the age group of 45-59 years as same as there are only 14 young farmers (28.00%) in our sample. Similar conclusion was made by Alexopoulos et al. (2010) for conversion to organic farms in Greece. They found out that "older farmers owning larger farms are more likely to have adopted organic farming". However, regarding the size of the holding, for the CR, the opposite is true. The smaller is the farm in terms of the number of employees, the higher are the odds that it will convert to organic farming. Larger farms may achieve the returns to scale and therefore the conversion would lover their efficiency. For example in our sample there are 12 micro farms (48 observations). There are efficient from 71.11% while the others are efficient from 81.01%. Kruskal-Wallis test revealed that the average efficiency statistically significantly differs.

Another examined determinant was the location of a farm. Statistically significant influence had the fact that the farm was located in Olomoucký region or at Vysočina. In both cases the odds for the conversion were lower. Vysočina is an agricultural region where intensive production on arable land prevails. Therefore, it seems that the farmers feel that the conversion would hamper their effort to produce efficiently. However, the research of Kerselaers et al. (2007) highlighted that "the economic potential for conversion to organic farming is in general higher than assumed or perceived by farmers". Therefore, more information could be needed.

Conclusion

The aim of the paper was to assess selected determinants of the farmer's decision to convert from conventional to organic or biodynamic agriculture. Firstly, the efficiency was calculated for each farm for years 2005–2012. It was found that the average organic or biodynamic farm produces only 79.38% of its potential production. Other factors influencing conversion were whether the farm received subsidies (AEM or LFA) in particular year, the age of the farmer and the size of the farm.

Results show that all factors accept for the age influence the conversion positively. The increase of efficiency increases the odds that the farm will convert to organic farming, but the effect is not statistically significant. It implies that organic farming is attracting more efficient farms, although we cannot clearly conclude. Subsidies are the major driver of conversion. The odds that the farm converts to organic or biodynamic farming are higher when it obtains AEM or LFA subsidies. Similarly, when the farm is smaller, it is more likely to convert.

On the other hand, if the farmer is young, the odds that he or she will change the land management are lower. It might be due to less information available for him. Hence, we suggest providing to the farmers more information about the potential of organic (or biodynamic) farming. If the farm is located in Olomoucký region and Vysočina, the odds that it will convert are statistically significantly lower.

We must keep in mind that our sample is limited in terms of the data's nature (accountancy data) and the number of organic and biodynamic farms included. There are only four of the later ones certified by Demeter International Inc. in the Czech Republic (three of them included in a sample, the forth one is not certified yet). Hence it is not sufficient to perform only quantitative analysis. Besides, farmers' attitude differs. Each one has own preferences and objectives which influence the choice of the farming method. It is a challenge for future research to conduct in-depth interviews with the farmers.

Acknowledgements

The research is financed from the grant No. 11110/1312/3160 - "Analýza vybraných ukazatelů biodynamického zemědělství – komparace ve světovém měřítku" of the IGA, FEM, CULS.

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