# Technical efficiency of organic milk-farms in Germany – the role of subsidies and of regional factors

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**Abstract**. This paper investigates the efficiency of organic milk farms in Germany based on data from 1994/95 to 2005/06. Five inputs and one output are analysed by means of a stochastic frontier production function, allowing for heteroscedasticity and technical effects. The selection of determinants of technical efficiency includes 5 groups of indicators. The analysis is focused on the impacts of farm support of organic farms and of regional factors, which can influence technical efficiency. The results show, that the agri-environmental payments do not affect efficiency. Farms, which receive investment aid, show lower efficiency scores. Finally, the implications for the agricultural policy are discussed.

**Key words:** efficiency analysis, organic farming, agglomerations effects, subsidies

## INTRODUCTION

Organic farming system rely on an efficient use of inputs and natural resources. Gubi (2006) could show, that farm success coincides with high efficiency scores. Besides the need for efficient farming, there is a different structure of incentives in organic farming systems, since other inputs are scarce due to the organic regulation. The stronger dependence of the production system on the availability of natural resources could, however, in some cases lead to a wider spread of technical efficiency scores in organic farming (Kumbhakar et al., 2008).

In particular the role of innovations is especially interesting, since organic farming starts with the conversion period. Yields are lower during the conversion period and stabilize after a few years in the new farming-system. Furthermore, farmers in conversion have to build up knowledge and management capacity in a new technology, which might suppress technical efficiency during the conversion period. The same is true for investments in new technologies, which in the long run can lead to a higher productivity and efficiency, but in the short run can cause inefficiency due to the learning process with the new technology.

As other farming systems organic farming is subject to different policy measures of the EU Common Agricultural Policy (CAP). With respect to efficiency analysis of policy measures two types of programmes might be especially interesting: Agri-environmental programmes and agricultural investment-programs. Since 1992 the EU provides different agri-environmental programmes to promote organic farming as an environmental friendly farming system (Nieberg & Kuhnert, 2006). Recent Analysis could show that before 2005 organic farms in Germany could on average profit more from the CAP agri-environmental-payments than comparable conventional farms, but receiving less in from the EU direct payments (Nieberg & Offermann, 2006). After the last CAP-Reform after 2005, some of the specific organic payments in Germany were cut. Nevertheless, the impact of farm payments on the efficiency of organic farms is hardly analysed. This might justify an in depth analysis of the impact of subsidies on technical efficiency. Besides that organic farmer can participate at general agricultural investment-programs which support investments in new technologies as animal friendly production systems or efficient production technique. The goal of these programs is not very precise, there might be some windfall gain and empirical data show, that this kind of payments are not very often used by organic farms (Dirksmeyer et al., 2006, 53). Nevertheless these programs might be an appropriate aid to overcome e.g. the conversion period.

The following paper will discuss the technical efficiency of organic milk farms in Germany with a focus on regional determinants of technical efficiency and on the two policy measures.

## LITERATURE SURVEY

In the recent past there have been some studies that investigate the technical efficiency of organic farms. Oude Lansink et al. (2002) find that organic farms in Finland are closer to their frontier but use a less productive technology. However, the selection method for this kind of farm comparison is not discussed in the paper.

Another study of organic farms in Finland investigates dairy farms in conversion (Sipiläinen & Lansink, 2005). Results show that the learning process after conversion period takes 6–7 years. Tzouvelekas et al. (2001) find organic olive production in Greece more technically efficient than conventional olive farms. Another study on organic olive producer in Greece could show, that farms with more innovative techniques on their farms show better efficiency results. By means of an innovation-index, the study could show that there is scope for improvement even for farms, that haven't used new technologies yet (Karafillis & Papanagiotou, 2008).

Gubi (2006) investigates the efficiency of organic farms in Germany. Farm profitability measures for organic farms, and efficiency scores are found to be strongly correlated. The results for dairy farms indicate that family labor, stocking density, and area under legal production limitations affect technical efficiency. Low stocking densities and high shares of family labor increase, while high shares of area under limitations decrease technical efficiency.

Lohr & Park (2006) analyse the technical efficiency of organic farms in USA based on a sample split according to experience with organic farming (more or less than 5 years). The results show, that efficiency scores increase with the years of experience.

Kumbhakar et al., (2008) have estimated the determinants of a conversion to organic farming. The results show, that the conversion to organic farming is mainly influenced by past adoption decision, provided subsidies and animal density. The question, whether a farm is efficient, does not drive the decision to convert and therefore does not cause a selection bias.

A very extensive literature deals with the determinants of technical efficiency in farming in general (Brümmer & Loy, 2000; Balmann & Czasch, 2001; Curtiss, 2002;

Davidova & Latruffe, 2007) and have identified (1) Farm structure and resources, (2) Management capacities and human capital (3) Institutional choice and (4) Market orientation and policy support as important determinants for technical efficiency. We summarize the determinants of technical efficiency in organic farming into five categories:

1. **Management capacity and human capital:** Farmers with **lack of specific agricultural education** are expected be less efficient. High **expenses for advisory services** should exert a positive influence on efficiency; farms **in conversion to organic farming** might be less efficient since farmers are learning to apply a new technology (Lohr & Park, 2006).
2. **Farm structure and resources:** A high soil quality[1] might have a positive impact on efficiency of a farm, since it offers more scope for variation to the farmer. A high **share of grassland area** in total agricultural area could lead to lower efficiency in a single output framework because of lower production of cash crops. From a high **milk quota** we would expect a similar effect. The **share of equity** could affect technical efficiency in both directions (Davidova & Latruffe, 2007), depending on whether agency theory (monitoring) or credit evaluation issues (lender aversion against risky credits) dominates.
3. **Institutional choices:** Farms in **legal forms other than individual ownership** might face higher internal transaction costs but might also economize on inputs in the production process. Opting for a **regular sales taxation** (thus forfeiting the privilege for simplified sales taxes) makes only sense for farms which had major investments in the recent past, which in turn should lead to higher technical efficiency.
4. **Policy support:** The volume of **agri-environmental payments (AEP)** received for the organic farming scheme might indicate stronger reliance on policy which leading to a lower efficiency. **Agri investment programs (AIP)** are used by farms, who invest in a new and potentially more efficient technology. We can expect a lower efficiency due to an adjustment to the new technology as a short term effect. However farms which receive investment aid should theoretically be in the long run more efficient.
5. **Regional variables:** Information on farm location at the district level was matched with various regional variables. We distinguish primary agglomeration (**regional share of organic farmers**) and secondary agglomeration effects (**distance to the closest organic dairy**), where both effects are expected to have a positive effect on technical efficiency. A **regional dummy** for districts in North, West and East Germany captures competitive advantages in organic farming. The **local election results of the green party** might show a socio-economic environment, that potentially supports organic farming and that might lead to a higher efficiency.

## METHODS AND DATA

The framework of Stochastic Frontier Analysis (SFA), defines the frontier of output given inputs as ‘best practice’. Dating back to Aigner et al. (1977) and Meeusen

[1] As a general indicator for soil quality the German measure “Ertragsmesszahl” EMZ $ha^{-1}$ has been used.

& van den Broeck (1977), SFA allows estimating firm-specific technical efficiency conditional on the specification of a **production function** and distributional assumptions for the composed error term. A model with one output and five inputs might be compactly written as:

$$y_{it} = f(x_{jit};\beta) * \exp\{w_{it}\} \qquad \text{where } w_{it} = v_{it} - u_{it} \quad (1)$$

$$y_{it} = f(x_{jit};\beta) * \exp\{v_{it} - u_{it}\} \qquad (2)$$

with the output $y_{it}$ as the sum of agricultural turn over on *i* farms in *t* time periods and with $j$=5 inputs of agricultural material costs ($x_1$), other expenses ($x_2$), depreciation as a proxy for services from capital stock ($x_3$), agricultural working units per year ($x_4$) and utilised agricultural area in hectares ($x_5$).

The translog functional form is used as a starting point. The composed error $w_{it}$ has two components: The first error term captures stochastic effects (white noise), which are not under the control of the farmer. It is assumed as identically and independently normal distributed:
$v_{it} \sim iidN[0, \sigma_v^2]$. The second error term, $u_{it}$ depicts the effects of farm-specific inefficiency. From the different distributions models of $u_{it}$ (Kumbhakar & Lovell, 2000, 90) we used the truncated normal distribution, such as ($u_{it} \sim iidN^+[\mu, \sigma_u^2]$). This assumption provides some advantages for modelling, since it allows for a straightforward incorporation of determinants of technical efficiency via the mode of the distribution, $\mu_i$, and for heteroscedasticity by using the location parameter $\sigma_u^2$. Technical efficiency is then defined as the ratio of empirically observed output $\hat{y}_{it}$ and the maximum feasible output $y_{\max} = f(x_{jit};\beta_j * \exp\{v_{it}\}$:

$$TE_{it} = \frac{\hat{y}_{it}}{f(x_{jit};\beta_j) + \exp\{v_{it}\}} \qquad (3)$$

$$TE_{it} = \exp\{-u_{it}\} \qquad \in [1,0] \qquad (4)$$

The incorporation of the "**heteroscedasticity model"** (Caudill et al., 1995) allows to analyse, whether the variance of the inefficiency-term is constant over the whole sample or influenced by some of the variables. It might occur, however, that the inefficiency error-term varies according with increasing inputs, since farms with a high input- and output-capacity have some scope for variation, and therefore scope for inefficiency (Caudill et al., 1995, 107). Heteroscedasticity is therefore modelled as

$$\sigma_{u_{it}} = \exp\{x_{it};\rho\} \qquad (5),$$

where $x_{it}$ as the vector of *j* inputs of *i* observation in *t* time-periods and ρ as a vector of parameter to be estimated. (The results of that part of the model are not presented here.)

The influence of potential determinants of technical efficiency can be estimated in terms of the location parameter $\mu$ in the truncated normal distribution (Battese & Coelli, 1995). The location parameter becomes farm-specific in the **"Technical Effects model"** according to the following relation:

$$\mu_{it} = z_{it}\delta_k + e_{it} \qquad (6),$$

where $z_{it}$ is a matrix of $j$ explanatory variables (i.e., potential determinants of technical efficiency) and $\delta_k$ a parameter vector to be estimated that captures the influence of $k=17$ Z-variables on the level of inefficiency. A positive (negative) coefficient estimate of $\delta$ indicates a negative (positive) effect on technical efficiency. $\gamma = \sigma_u^2 / \sigma^2$ shows the variation in the composed error-term, which goes back to the inefficiency term.

We use accounting data for organic milk farms from 1994/1995 to 2004/2005, which were collected according to the standard of the Federal Ministry for Nutrition, Agriculture, and Consumer Protection. The data consist of an unbalanced panel with 1,348 observation from 305 farms in 11 years. The selected farms are grassland farms with milk-production (classification based on the revenue share). Monetary variables were deflated using the official price indices for agriculture, all input variables were normalized by dividing them by their sample mean except for the linear trend which enters in deviation from the sample mean.

## RESULTS AND DISCUSSION

Table 1 shows the estimated results for the production frontier.

**Table 1.** Coefficient estimates.

| Parameter | Coeff. | t-value | Parameter | Coeff. | t-value |
|---|---|---|---|---|---|
| $\beta_0$ | 0.5230 | 8.02 | $\beta_{14}$ | 0.0294 | 0.62 |
| $\beta_1$ (Material expenses) | 0.4621 | 18.80 | $\beta_{15}$ | -0.0572 | -1.20 |
| $\beta_2$ (Other expenses) | 0.1530 | 7.85 | $\beta_{1t}$ | 0.0166 | 2.24 |
| $\beta_3$ (Capital) | 0.1611 | 8.79 | $\beta_{23}$ | 0.0432 | 1.34 |
| $\beta_4$ (Labour) | 0.2082 | 9.42 | $\beta_{24}$ | -0.0017 | -0.04 |
| $\beta_5$ (Area) | 0.0419 | 1.78 | $\beta_{25}$ | 0.1034 | 2.42 |
| $\beta_t$ (Trend) | 0.0008 | 0.23 | $\beta_{2t}$ | -0.0132 | -2.20 |
| $\beta_{11}$ | 0.2932 | 5.58 | $\beta_{34}$ | -0.1299 | -3.47 |
| $\beta_{22}$ | 0.0311 | 0.61 | $\beta_{35}$ | -0.0666 | -1.98 |
| $\beta_{33}$ | 0.1325 | 4.22 | $\beta_{3t}$ | 0.0124 | 2.50 |
| $\beta_{44}$ | 0.0024 | 0.04 | $\beta_{45}$ | 0.0296 | 0.56 |
| $\beta_{55}$ | -0.0648 | -1.03 | $\beta_{4t}$ | -0.0143 | -1.83 |
| $\beta_{tt}$ | -0.0065 | -4.30 | $\beta_{5t}$ | 0.0075 | 1.04 |
| $\beta_{12}$ | -0.1152 | -2.88 | ln $\sigma$ | -2.4662 | -13.50 |
| $\beta_{13}$ | -0.0413 | -1.21 | | | |

**Source**: Own calculation

Most of the estimated coefficients are significantly different from zero at the 5% level. Since the dataset is normalised the first order estimates $\beta_j$ in a translog model can be interpreted as elasticity's at the sample mean. The costs for material have the largest impact. If intermediate materials increase by 1%, output grows by 0.46%. The estimated elasticity of labour (0.22) is larger than has been found for conventional dairy farms (e.g. Brümmer & Loy, 2000, estimate a value of 0.03). This is plausible since the labour share on organic farms is higher than on conventional farms, even in labour intensive animal breeding. The other inputs play a less important role. The parameter $\gamma = 0.86$ leads to a variance variance decomposition of 0.70 indicating that a great part of the variation in the composite error $w_{it}$ term can be explained by inefficiency $u_{it}$. The mean technical efficiency score is 0.64. The rate of technical change is not significant.

Table 2 shows the estimated coefficients of the 'technical effects model', which will be discussed in the next paragraph. Farms in conversion show lower TE-scores than regular organic farms. This result meets the expectation, since converting farms run threw a learning period with an expected lower technical efficiency. The agricultural education of the farmer does not have a significant influence on efficiency (which surprises), the same holds for the expenses for advisory services. Farms with higher soil quality show better performance. Good soil quality obviously provides better options to increase on farm efficiency. A high grassland-share and a high milk quota have a positive impact on efficiency. Farms that have opted for a civil law association as legal form and for a simplified taxation show better TE-performance.

**Table 2.** Estimated coefficients for the technical effects model.

| | Variable | Parameter | Coefficient | t-value |
|---|---|---|---|---|
| | Constant | $\delta_0$ | 0.5653 | 7.88 |
| Human capital | No education | $\delta_1$ | -0.0038 | -0.16 |
| | Advisory costs | $\delta_2$ | -0.0006 | -0.07 |
| | Status (organic or in conversion) | $\delta_3$ | 0.0450 | 2.45 |
| Farm structure and resource | Soil quality | $\delta_4$ | -0.0555 | -4.23 |
| | Grassland share | $\delta_5$ | -0.0470 | -4.31 |
| | Milk quota | $\delta_6$ | -0.0161 | -2.85 |
| | Equity share | $\delta_7$ | -0.0040 | -1.04 |
| Inst. choice | Institutional choice | $\delta_8$ | -0.0462 | -2.66 |
| | Option for sales taxation | $\delta_9$ | -0.1677 | -10.70 |
| Policy support | Agri-env. premia | $\delta_{10}$ | 0.0071 | 2.93 |
| | Dummy agri-investment payments | $\delta_{11}$ | 0.0274 | 1.84 |
| Regional variables | Regional share organic farming | $\delta_{12}$ | -0.0313 | -2.48 |
| | Dummy east Germany | $\delta_{13}$ | 0.1363 | 2.53 |
| | Dummy northern Germany | $\delta_{14}$ | -0.0622 | -2.06 |
| | Dummy west Germany | $\delta_{15}$ | -0.0801 | -2.57 |
| | Share of green voters | $\delta_{16}$ | -0.0311 | -1.21 |
| | Distance to the next dairy | $\delta_{17}$ | 0.0301 | 3.29 |

**Source:** own calculation

There are regional differences in the technical efficiency: In comparison to Southern German milk-farms. The farms in West- and Northern Germany are more efficient; farms in East Germany are less efficient. This is somewhat surprising, as it contradicts the findings of Hemme et al. (2004), who found East-German organic milk-producers to be more competitive on an international level than West German milk-farms.

The results for the variables '*regional share of organic farms*' and '*distance to the next dairy*' supports the theory of an agglomeration effect: Farms in regions with a high share of organic farms show a higher efficiency. With an increasing distance to the next dairy the efficiency scores become lower. This might as well occur because farms that are far from the next organic dairy have to sell milk to conventional dairies, which often do not pay organic premium prices. The positive impact of the election results of the Green Party is not significant.

The results for the agri-environmental payments (AEP) are significant showing positive parameters that are close to zero. This indicates that farms with high payments from AEP show lower efficiency scores. Therefore some kind of market distortion (i.e. promoting inefficient farms) from these payments cannot be excluded. The goal of the AEP is the provision of environmental goods and services. Therefore a similar study with the inclusion of environmental variables with an expected positive impact of AEP on TE would be interesting.

16% of the organic farms in the sample participate at agri-investment programs (AIP). The average support for these farms is 22.894 €, which shows that organic farms rather use the investment scheme for the 'large investments'. Farms in years after an investment-aid show a lower efficiency performance. The result (significant at the 10% level) can only be interpreted as a short-term effect of an investment due to data-constraints. Nevertheless farms that have used the investment-aid seem to perform less efficient after the investment in a new technology. It should be a necessary condition for continuing this type of programs that at least a positive long-run-effect of these policy measures can be demonstrated. This could not be done by the presented results. A study of Brümmer & Loy (2000) showed a negative impact of the participation in Farm Credit Programs to conventional milk farms in Northern Germany. Dirksmeyer et al. (2006) are rather sceptical on the dynamic effect of these programs. Since AIP during the last years were expanded (at least in some of the German federal states) and milk-farms are the biggest group that use this kind of aid further efficiency analysis on the long-term effect of these programs should be carried out. Besides that the results indicate the necessity for further reforms of the AIP.

## REFERENCES


Aigner, D., Lovell, C. K. & Schmidt, P. 1977. Formulation and estimation of stochastic frontier production function models. *J. Econometrics* **6**, 21–37.

Balmann, A. & Czasch, B. 2001. Zur Effizienz landwirtschaftlicher Unternehmen in Brandenburg - eine Data Envelopment Analysis. *Agrarwirtschaft* **50,** 198–203.

Battese, G. & Coelli, T. 1995. A model for technical inefficiency effects in a stochastic frontier production funktion for panel data. *Empirical Economics* **20**, 325–332.

Brümmer, B. & Loy, J.-P. 2000. The technical efficiency impact of farm credit programmes: A case study of Nothern Germany. *J. Agr. Econ*. **3**, 405–418.

Caudill, S.B., Ford, J.M. & Gropper, D.M. 1995. Frontier estimation & firm specific inefficiency measures in the presence of heteroscedasticity. *J. Bus. Econ. Stat.* **13**, 105–111.

Curtiss, J. 2002. *Efficiency and Structural Changes in Transition - A stochastic Frontier Analysis of Czech Crop Production*. Aachen. Shaker Verlag

Davidova, S. & Latruffe, L. 2007. Relationships between technical efficiency and financial management for czech republic farms. *J. Agr. Econ.* **58**, 269–288.

Dirksmeyer, W., Fostner, B., Margarian, A. & Zimmer, Y. 2006. Aktualisierung des Zwischenberichts des Agrarinvestitionsförderungsprogramms in Deutschland für den Förderzeitraum 2000–2004. *Technical report.* Braunschweig. Johann Heinrich von Thühnen Institut

Gubi, G. 2006. *Analyse der erfolgs- und effizienzbestimmenden Faktoren im ökologischen Landbau*. Dissertation. Christian Albrechts Universität zu Kiel. Institut für Agrarökonomie.

Hemme, T., Deeken, E. & Faßbender, W. 2004. Internationale Wettbewerbsfähigkeit der ökologischen Milchproduktion und Verarbeitung in Deutschland. *Technical Report*. Braunschweig. Johann Heinrich von Thünen Institut.

Karafillis, C. & Papanagiotou, E. 2008. The contribution of innovations in total factor productivity of organic olive enterprises. *12th EAAE Congress 2008. Ghent. Belgium. 26-29 August 2008*. 1–10.

Kumbhakar, S. & Lovell, K. 2000. *Stochastic Frontier Analysis*. Cambridge University Press.

Kumbhakar, S. C., Tsionas, E. G. & Sipiläinen, T. 2008. Joint estimation of technology choice and technical efficiency: an application to organic and conventional dairy farming. *J. Prod. Anal.* **Online**: 1–11.

Lohr, L. & Park, T. 2006, Technical effects of US organic farmers: The complementary roles of soil management techniques and farm experience, *Agric. & Resource Economics Review* **35**, 327–338.

Meeusen, W. & van den Broeck, J. 1977, Efficiency Estimation from Cobb-Douglas Production Function with Composed Error, *International Economic Review* **8**, 435–444.

Nieberg, H. & Kuhnert, H. 2006. Förderung des ökologischen Landbaus in Deutschland: Stand. Entwicklung und internationale Perspektiven. *Landbauforschung Völkenrode* special issue **295.**

Nieberg. H. & Offermann, F. 2006. Einkommensvergleich zwischen konventionellen und ökologischen Betrieben unter Berücksichtigung veränderter agrarpolitischer Rahmenbedingungen. Tech. Rep. Braunschweig. Johann Heinrich von Thünen Institut.

Oude Lansink, A., Pietola, K. & Bäckman, S. 2002. Efficiency and productivity of conventional and organic farms in finnland 1994–1997. *Eur. Rev. Agric. Econ.* **29,** 51–65.

Sipiläinen. T. & Lansink. A. O. 2005. Learning in organic farming - an application on Finnish dairy farms. In *Paper XI. EAAE Congress Copenhagen. Denmark. 24-27 August 2005*. 1–22.

Tzouvelekas, V., Pantzios, C.J. & Fotopoulos, C. 2001. Technical efficiency of alternative farming systems: the case of greek organic and conv. olive-growing farms. *Food Policy* **26**, 549–569.