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EFFICIENCY ANALYSIS OF ORGANIC FARMING SYSTEMS — AN OVERVIEW ON JOINT TOPICS, RESULTS AND CONCLUSIONS

Abstract. The following paper summarizes existing literature dedicated to efficiency and productivity of organic farming systems. We can distinguish between studies that aim to compare conventional and organic farming and studies that just model samples of organic farms. Sample selection issues seem to be a major problem in some studies, since the organic farming group is often relatively small. Also the structural difference between the groups of organic and conventional farms within the data-sets is seldom discussed in detail. Comparing organic and conventional farms, organic farms perform slightly worse than conventional farms. The inclusion of a sample selection model shows that the conversion to organic farming is not driven by inefficiency. The degree of specialization does not seem to be optimal, nevertheless the limits of specialization are not discussed in detail. Environmental indicators are only considered in a few studies, which show that organic farming might be more efficient when the environmental dimension of production (such as landscape elements and diversity in the crop-rotation) is taken into account. However, finding appropriate data sets with enough observation for modelling is a problem in these analyses. Investigation shows that technical efficiency depends on the farm focus and varies substantially across the different regions in Germany. Technical efficiency during the conversion period is lower, but converting farms achieve the same efficiency level as established organic farms after 6—10 years.

Keywords. Technical Efficiency, Organic Farming, Literature Review

Анотация. Стаття підсумовує існуючу літературу, присвячену ефективності й продуктивності систем органічного фермерства. Ми розрізняємо дослідження, що мають за мету порівняння звичайного і органічного фермерства та дослідження, що моделюють перехід до органічного фермерства. Вибір прикладів органічного фермерства мабуть є основною проблемою в окремих дослідженнях, адже органічне фермерство часто представлене досить невеликою кількістю господарств. Також структурна диференціація між групами ферм, що займаються органічним і звичайним фермерством, в рамках наявної інформаційної бази, рідко детально дискутується. Порівнюючи ферми, що займаються органічним і звичайним виробництвом встановлено нижчу ефективність органічного фермерства. Разом з цим моделювання показує, що перехід від звичайного до органічного фермерства не є не ефективним. При цьому рівень спеціалізації не є визначальним чинником, хоча обмеження стосовно спеціалізації не досліджені детально. Тільки окремі дослідження розглядають показники впливу органічного фермерства на навколишнє середовище (елементи ландшафту і урізноманітнення сівозмін). Однак, збір необхідної для моделювання кількісної інформації є проблемою такого моделювання. Дослідження показують, що технічна ефективність залежить від спеціалізації ферм і змінних моделі залежно від регіонів Німеччини. Технічна ефективність протягом перехідного періоду є нижчою, але ферми, що трансформуються в органічні, досягають такої ефективності як і ферми, що давно займаються органічним виробництвом, після 6—10 років.
Ключові слова: технічна ефективність, органічне фермерство, огляд літератури

Аннотация. Статья подытоживает существующую литературу, посвященную эффективности и производительности систем органического фермерства. Мы различаем исследования, которые имеют по цель сравнения обычного и органического фермерства и исследования, которые моделируют переход к органическому фермерству. Отбор примеров органического фермерства по-видимому является основной проблемой в отдельных исследованиях, ведь органическое фермерство часто представлено достаточно небольшим количеством хозяйств. Также структурная дифференциация между группами ферм, которые занимаются органическим и обычным фермерством, в рамках имеющейся информационной базы редко детально дискутируется. Сравнивая фермы, которые занимаются органическим и обычным производством установлена низшая эффективность органического фермерства. Вместе с этим моделирование показывает, что переход от обычного к органическому фермерству не является не эффективным. При этом уровень специализации не является определяющим фактором, хотя ограничения относительно специализации не исследованы детально. Только отдельные исследования рассматривают показатели влияния органического фермерства на окружающую среду (элементы ландшафта и разнообразие севооборотов). Однако, сбор необходимой для моделирования количественной информации является проблемой такого моделирования. Исследования показывают, что техническая эффективность зависит от специализации ферм и переменных модели в зависимости от регионов Германии. Техническая эффективность в течение переходного периода является ниже, но фермы, которые трансформируются в органические, достигают такой эффективности как и фермы, которые давно занимаются органическим производством, после 6—10 лет.
Ключевые слова: техническая эффективность, органическое фермерство, обзор литературы

1. Introduction

Organic farming in Germany and in the EU has developed to an established branch of the food business with growing market share and public attention. In the last century the organic farming system in Germany developed from different methodological approaches. The *Demeter*-movement influenced by Rudolf Steiner (1861—1925) started in the 1920s on the basis of a philosophical approach. During the 1960s and 1970s, some small farms in Southern Germany and Switzerland followed the ideas of Hans Müller (1891—1988) and Hans-Peter Rusch (1906—1977) that were based on the development and improvement of soil fertility. These farms founded the *Bioland*-Association. Some other organic associations were founded during the 1980s such as *Naturland* and *Biokreis Ostbayern*. Many farmers converted to organic farming lead by the idea of nature protection and the efficient and sustainable use of resources. Finally, after German reunification, many farms in the former German Democratic Republic converted to organic farming supported by EU agri-environmental schemes which were introduced with the ‘MacSharry-Reform’ of 1992 [1, 2]. Some of these farmers just tried to save their farms by means of the organic support scheme, others joined the organic farming movement in order to be more environmentally friendly. In East-Germany there were other associations such as *Gäa* and *Biopark* that tried to promote the organic farming system for East German farm structures and tried to set own emphasis. Finally the organic farming scheme has been regulated by the European Union which introduced the production regulation EU-VO 2092/91 in 1991 with a exact definition of the organic farming principles on the EU-Level, updated by the production regulation EU CO 834/2007 [3].

In 2009 around 1.0 million hectares were under organic production systems in Germany, which amounts to 5,7 % of the total agricultural used land. The number of organic farms has increased to 22,000 (i. e. 5,4 %). The market share of organic food has been constantly growing in the last years, and the a total revenue the 5.9 billion Euro accounts for roughly 4 % of the total food market [4]. Organic farming seems to meet consumer’s taste in Europe, but still there are concerns whether organic farming can feed enough people and organise a constant supply of food. This raises the question whether how organic farming can achieve a similar level of technical efficiency than conventional farming, which is not only interesting from the policy point of view [5], but also crucial for organic farmers.

Organic farming systems give incentives to farmers to use scarce inputs and natural resources in a technical efficient way. Due to the

organic regulation EU CO 834/2007 the production systems differs from conventional farming, and other inputs are scarce than in conventional farming (4 examples):

- The *scarcity of nitrogen* forces farmers to an efficient use of organic manure and nitrogen fixed by clover. *Animal fodder*, similarly, is scarce because of purchase restrictions. This forces farms to maintain fodder-production for the animal, even if the purchase of fodder-crops (such as corn or soya) would be less costly. The principle of closed nutrient cycles on an organic farm increases the importance of intermediate inputs that are produced on-farm.

- *Chemical plant protection* (with the exception of copper) and mineral fertilizers are forbidden. Plant protection is technically done by biological methods and more varied crop rotation. As a consequence, specialization is only feasible to certain extent and the very short crop-rotations (2 or 3 stages as typical in conventional farming) are not possible.

- The organic production regulation promotes a more *integrated farming* system. A study in the United States shows that on organic dairy farms vertical integration produces substantial economies of scope (in contrast to conventional dairy farms). There seems to be a systematic incentive towards an integrated farming and against a high degree of specialization [7].

- The stronger *dependence on the availability of natural resources* in organic farming could, in general, lead to a higher variance of technical efficiency scores in organic farming (as e.g. in [8]).

Efficiency analysis in organic farming appears to be interesting for several reasons. *First* of all, productions structure are expected to be substantially different from conventional farming system and the possible determinants of differences in efficiency could be different. *Second*, the conversion period from conventional to organic farming (two years) is in particular interesting, since e.g. in Germany yields in grain production decrease to 53 % of conventional yields after conversion begins, but finally stabilise after a few years [9]. 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, but help the farms to catch up in the long term. This may justify conversion aids if increasing the number of organic farms or the share of organic food production is a policy goal.

During the last ten years an increasing literature has investigated efficiency and productivity of organic farming throughout Europe and the United States. These studies contribute to the knowledge on efficiency in different specific areas, but a comprehensive overview

and summary on the complete literature is missing so far. In this paper, we want to provide such an overview. We will therefore briefly summarize the existing literature and identify joint results, topics and conclusions. We took published journal articles and reviewed conference papers into account, all to our best knowledge. The paper is structured as follows: After the introduction in **section 1**, the two main approaches of efficiency analysis are summarized in **section 2**. The **section 3** is dedicated to the results of studies. We distinguish between literature focused on samples with only organic farms, the comparative studies (conventional vs. organic), and special topics such as the efficiency in the conversion period and the literature on specialization issues. In **section 4** the overall results are summarized and discussed, conclusions are drawn.

2. Methods

Productivity and efficiency analysis in general relates inputs and outputs in different model approaches, which all produce estimated «productivity» or «efficiency» scores. Performance can be measured within a group of decision making unit (DMU) at a point in time (cross-section data) or over several periods (panel-data) [10]. There is large number of technical and mathematical assumptions when applying efficiency models, that cannot defined in detail here. But one of these assumption seem to be crucial in the context of organic framing analysis, the *homogenous technology assumption*, which states, that only DMU of the same or at least a similar technology can be compared.

2.1. Data Envelopment Analysis (DEA)

The data envelopment analysis (DEA), described the first time by *Charnes et al.* [11], is a non-parametric method to measure the productivity and efficiency of a DMU based on linear optimization. Efficiency according to DEA is defined relative to a frontier which is estimated from the observations via an optimization condition described below. This means that the best observed DMU define the so called «best practice». We can distinguish between output- and input-oriented models and between models that assume constant return to scale (CRS) and variable returns to scale (VRS).

Given i decision making units (DMU_i) with a matrix of $N \times I$ inputs X_i and the $M \times I$ matrix of outputs Y_i , the goal of DEA is the linear optimization of output per unit input (y/x). The model-outputs are the individual weights for inputs and outputs μ_j and v_i . The output-

oriented DEA-model in the *primal form* maximizes the overall efficiency number Φ for all *DMUs* and can be defined as follows:

$$\begin{aligned} & \max \varphi^0 \\ \text{so dass : } & \sum_{\rho=1}^{\pi} \lambda^{\rho} y_j^{\rho} \geq \varphi^0 y_j^0 \quad (j = m+1, m+2, \dots, m+n) \\ & \sum_{\rho=1}^{\pi} \lambda^{\rho} x_i^{\rho} \leq x_i^0 \quad (i = 1, 2, \dots, m) \\ \text{für} & \quad \lambda^{\rho} \geq 0 \quad (\rho = 1, 2, \dots, \pi) \end{aligned} \quad (3)$$

The output of this model form is the overall efficiency figure Φ and the scaling factor λ , which describes the individual efficiency level of a *DMU*. The advantage of the DEA is the straightforward interpretation and the ability to get results with less observations. For DEA models it is not necessary to define a functional form for the production function. Via bootstrapping techniques, standard-errors and statistical testing is possible [12]. The method also allows the application of so called «*meta-frontier models*» that formulate a frontier for a subgroup (e.g. organic vs. conventional farms) and a common frontier for both groups [13].

2.2. Parametric methods: Stochastic Frontier Analysis (SFA)

The framework of Stochastic Frontier Analysis (SFA) estimates, defines the frontier of output given inputs as ‘best practice’. Dating back to *Aigner et al.* [14], 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 might be compactly written as:

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

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

where output y_{it} is the sum of agricultural turn-over and j inputs. Typical inputs are costs of production, capital, labor and land. The functional form specification $f(\cdot)$ should be sufficiently flexible in order to avoid confounding technical inefficiency with misspecification. The translog functional form is used as a starting point. β denotes the vector of coefficients for the translog specification. The error w_{it} has two components:

The first error term v_{it} depicts stochastic effects which are not under the control of the farmer, such as weather, luck or unforeseen

events. It is assumed to be identically and independently normal distributed: $vit \sim iid N(0, \sigma^2)$. The second error term, uit captures the effects of farm-specific inefficiency; With respect of the distribution of the inefficiency term, we can use different models such as the a half-normal-, truncated-normal- or gamma-distribution [15].

For modeling the potential determinants of technical efficiency, there different model-add-ons. Two of these models are the ‘*heteroscedasticity-model*’ [16] and the ‘*technical inefficiency-model*’ [17]. It is also possible to apply the meta-frontier approach in the parametric estimation framework [18].

Also sample selectivity might be an issue in efficiency models, since a certain group (such as organic farms) might exist due to inefficiency before the process of conversion to organic farming. A model of *Kumbhakar et al.* [8] introduces a model-part in the analysis that models the potential determinants of conversion in order to avoid selectivity problems (See chapter 3.2, page 8/9).

3. Applications and results of the empirical studies

Comparatively few studies investigate the technical efficiency of organic farms¹, and most of these compare the productivity and efficiency of organic and conventional farms.

3.1. Studies investigating efficiency on organic farming

Gubi [19] investigates the efficiency of organic farms of all types in Germany with Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA). The data-set consists of bookkeeping data from all farm types.

Farm profitability measures for organic farms and efficiency scores are found to be strongly correlated. The SFA-model set-up consists of a translog-production function with costs, other expenses, labour, capital and land. From the typical set of variable, labour has a high output elasticity of 0.22, confirms the result of *Lohr and Park* [20], who find an income output elasticity of 0.35. We can conclude that labour in organic farming has a higher output elasticity than in conventional farming, estimated e.g. by *Brümmer and Loy* [21], who found 0.03 for conventional milk-farms in northern Germany. The results of the SFA-model show different efficiency scores in the farm

¹ 5 of 17 studies work exclusively with organic data-sets. This is most likely a reflection of the lower share of organic farming in total agricultural output and the resulting scarcity of data-sets.

specialisation. The following table shows the distribution of the efficiency scores estimated with the SFA:

Table 1

SFA-EFFICIENCY SCORES OF DIFFERENT FARM TYPES

Farm type	Obs.	Mean TE	Median TE	Std. dev.	Min	max
Arable farms	256	0,84	0,89	0,113	0,49	0,98
Milk farms	456	0,77	0,77	0,102	0,46	0,99
Other grassland farms	78	0,78	0,87	0,175	0,32	0,97
Mixed farms	280	0,79	0,82	0,126	0,46	0,99

Source: [19]: p. 88

The result indicate that (taken into account the respective input-output data) arable farming achieves the highest level of technical efficiency. The ‘other grassland farms’ have a larger distribution indicated by a higher standard deviation and a low minimum TE. *Gubi* [19] also analyses the determinants of technical efficiency:

— The results for **dairy farms** in the SFA model indicate that family labour, stocking density and area under production limitations¹ affect technical efficiency. Low stocking densities and high shares of family labour increase technical efficiency, while high shares of area under limitations had a negative impact on farms technical efficiency.

— For **other grassland farms**, the shares of equity and of rented land, the age of the farm manager and the share of agricultural income are determinants of technical efficiency. High shares of equity and of rented land have a positive, part-time farming and farm managers age a negative impact on efficiency. Technical efficiency decreased over time within the group of pure grassland-farms ($n = 65$) by 17.9 % p.a., but slightly increased within the group of specialised milk-farms ($n = 456$) by 1.2 % p.a. [19]: p. 117].

With respect to scale efficiency, the four groups seem to perform differently: scale-efficiency on other grassland-farms is at 1.055, which assumes on average almost constant returns to scale. The scale efficiency of the milk-farms is 0.851, although the hypothesis of constant returns to scale could statistically not be rejected [19: p. 119).

¹ In Germany some area falls under legal restrictions due to environmental laws. Ground-water protection is the most important example which restricts the farmer to produce without nitrogen fertilisation and without leguminous plants on certain area.

Lohr and Park [20] investigate the technical efficiency of organic farms in the USA using SFA. The influence of the farm manager's experience is studied by splitting the sample into farms with more than five years of experience in the organic farming system, and farms with less than five years experience. The authors find that efficiency grows with years of experience in organic production. *Sipiläinen and Oude Lansink* [22] study dairy farms in conversion in Finland and find that the learning process following the decision to convert to organic farming takes about 6—7 years.

A study by *Sauer and Park* [23] on organic farms in Denmark combines efficiency analysis with a probit model in order to estimate the effect of subsidies on the market exit of organic farm in Denmark. They could find significant differences in the farms' technical efficiency and slightly negative technical change for the farms over the 3 observed years. The done investments and the amount of total income had a positive impact of farm efficiency. Interestingly the amount of externally earned income by family members had a negative impact on farms technical efficiency. The study tries to estimate the development of technical efficiency of organic farms over time. The authors conclude that «*considerable improvement in efficiency took place in organic milk production in Denmark over the total period investigated*» [23]. Since the observed time period includes only three years, it is still unclear if this development is stable over a longer time period.

A study *Lakner* [24] investigates the regional distribution of technical efficiency on organic grassland-farms using a model that is similar to the one in *Brümmer and Loy* [21], i.e. a SFA-model with 'technical-inefficiency' and 'heteroscedasticity-model'. The results indicate that technical efficiency is especially high in southern Germany, whereas the East German farms are rather inefficient. There is evidence, that agglomeration effects (measured in regional concentration of organic farms and in the concentration of organic dairies) and a regional socio-economic environment influence technical efficiency of organic farms.

3.2. Studies comparing efficiency of organic and conventional farms

Most of the studies in this category work with data-sets which contain in general a large-group of conventional farms and a small subgroup of organic farms (Figure 1):

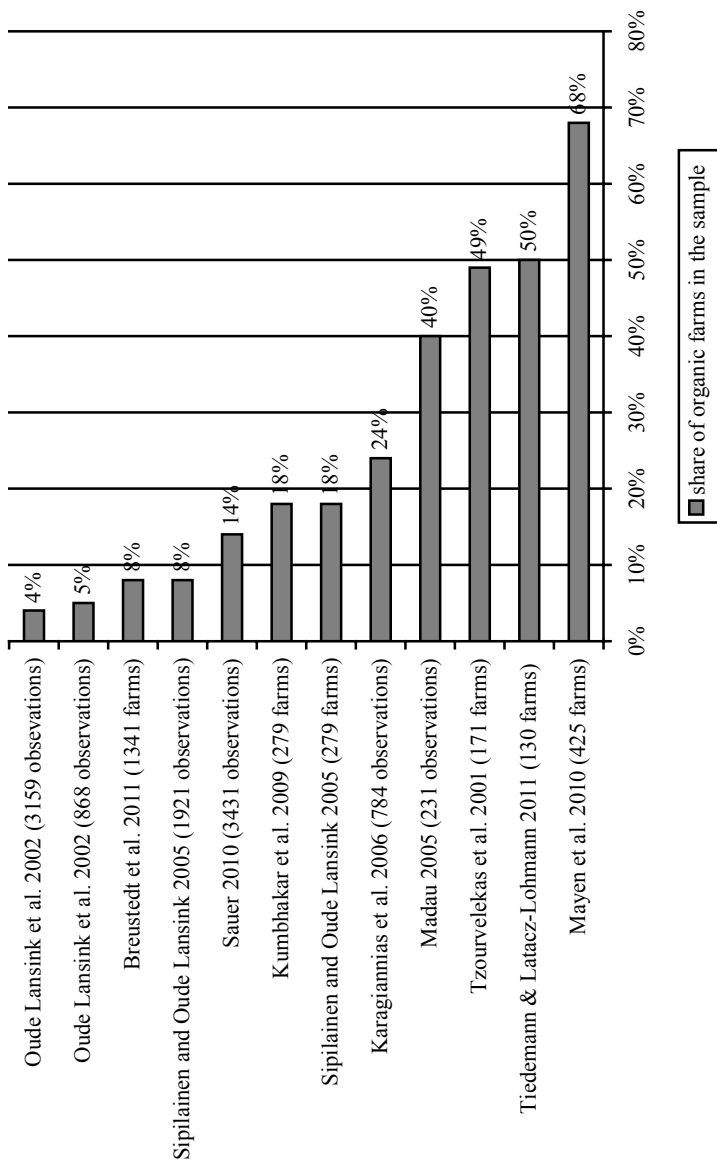


Figure 1: Share of organic farms on the total farms in different comparative studies on technical efficiency

Source: own calculations

In a case of such uneven distribution in the sample, the results might be biased due to stochastic effects. Besides distributional issues, the questions of how the sample was constructed is seldom discussed in detail. Usually, organic farms have a different farm structure¹ and grassland- and mixed farms dominate the sample, whereas in conventional samples, the share of arable and meat-producing farms is higher. If the group of organic and conventional farms cannot be compared with respect to farms structure, efficiency differences might stem from structural differences. A framework for comparing organic and conventional farms was originally proposed by *Offermann and Nieberg* [25] and estimated using official statistics in Germany. *Mayen et al.* [26] use a propensity score matching model to identify comparable organic and conventional farms. Therefore, the results of that study cannot be biased due to sample effects and gain a lot of credibility compared to other efficiency studies. *Tiedemann and Latacz-Lohmann* [27] use a similar technique to compare total factor productivity of organic and conventional farming. The authors point out that selectivity issues due to unobserved characteristics cannot be avoided with matching models.

One important difference in the field of the comparative studies is the question whether organic and conventional farms are estimated in one model or separately in an organic and a conventional model. In the joint model-approaches one option is to estimate the efficiency of an organic farm with respect to the conventional frontier, which models a case of a reconversion to conventional farming.

As an example of this approach, *Kumbhakar et al.* [8] investigates the productivity differences between organic and conventional milk-farms in Finland taking into account the selectivity problem. The authors used a SFA-technique combining a Cobb-Douglas production function with an inclination to adoption, which in their model-framework depends on animal density, past adoption decision, experience, subsidies and finally the efficiency of the farm. According to the authors the adoption of organic farming techniques is rather influenced subsidies, animal density and subsidies. The efficiency of the farm does not affect the farmer's decision to adopt and does not cause a selection bias. The model results show that organic milk farms could produce 5,3 % more output by producing in the conventional farm system, i.e. if they would reconvert. *Mayen et al.* [26] used a matching model to find an comparable organic and conventional

¹Typical are more potatoes and fruits and vegetables in the crop-row, more suckler cows and a higher grassland share, less corn and sugar-beet and pig- and hen-production.

farms. The authors come to the conclusion that the organic technology is 13 % less productive than the conventional technology.

Tiedemann and Latacz-Lohmann [27] compared conventional and organic farms using the Malmquist-Index model. For this purpose the authors identified comparable farm-pairs with matching techniques. Afterwards a SFA-model for grassland, arable and mixed farms was applied. The results clearly indicate that a common either between the farming systems or between the farm types (arable, grassland and mixed) cannot be justified. Modelling these farms in a joint production function therefore produces results with a restricted validity. The result of the Malmquist-Index show that there are no significant differences in total factor productivity between 1999 and 2006. The organic farms had a slightly higher productivity at the beginning of the observed period, but they could not keep the level of productivity. The authors explain this with lower technical efficiency and missing use of scale effects [27].

Sauer [28] applied a generalized Leontief distance function for organic and conventional milk farms in Denmark. In 1998 a new trading model to exchange milk-quota between farms was set in force, the main research-question of this study the reaction on this deregulation measure. Sauer does not find any significant efficiency differences between the two farming systems and the increased allocative efficiency following the deregulation on the milk-market is similar in both conventional and organic farm systems.

Turning to those comparative studies that separately estimate efficiency among groups of organic and conventional farms, *Karagiannias et al.* [29]o- ENREF 22 find organic milk farms in Austria have a 3.4 %-points lower efficiency than conventional milk farms, *Madau* [30] found organic cereal farms in Italy to be 6.7 %-point less efficient than the conventional group of cereal farms. Both results show that organic farms are less efficient with respect to their own production frontier. Nevertheless these estimation results cannot be directly compared, since both TE of farm-group were not estimated jointly. In contrast, *Oude Lansink et al.* [31] find that organic crop and livestock farms in Finland are closer to their frontier but use a less productive technology. *Tzouvelekas et al.* [32] analyse organic olive production in Greece and find that in relation to their own production frontier organic olive farms are technically more efficient than conventional olive farms. But also these studies estimate efficiency of organic (*conventional*) farms in relation to the 'organic (*conventional*) frontier'.

The results of the studies, that organic farms are on average less productive, do not surprise because organic farming system imposes

restrictions on the use of inputs. If these restrictions did not imply that farmers have to switch to a less productive technology, they would lose their binding character, and farmers would likely adopt organic farming practises even without specific support. If the use of natural resources and the production of positive externalities could be easily included in efficiency comparison of the systems, the result might be different. Comparing organic and conventional farming requires an appropriate selection of comparable farms [25] and some kind of joint estimation techniques. However the problem of sample selection has been ignored by most studies; [8, 26, 27] and [26] are positive exceptions.

3.3. Technical efficiency in the conversion period

The development of technical efficiency during the conversion period has been the focus of some studies, too. The above mentioned studies of *Lohr and Park* [20] and of *Sipiläinen and Oude Lansink* [22] are focused on the role of farmers experience in the conversion process. In both studies, the organic farms with experience more than 5 years are more technical efficient. A study by *Lakner* [33] on organic grassland-farms in Germany finds significantly lower technical efficiency of farms during and after the conversion process of 2 years. In the years after the conversion technical efficiency is constantly increasing, reaching a similar efficiency level after 6—11 years (see Figure 2).

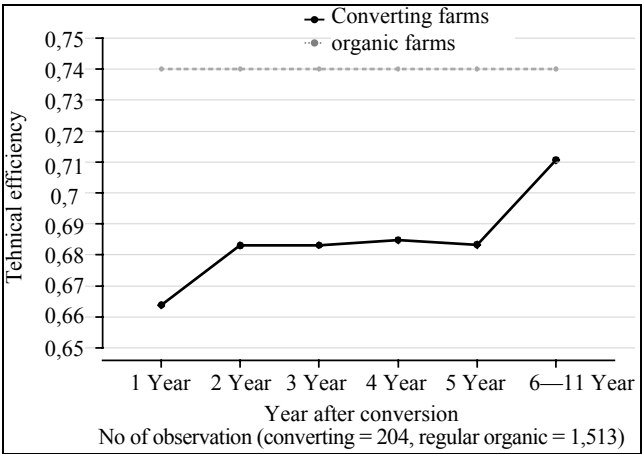


Figure 2: Technical efficiency scores for converting farms in the first eleven years after conversion Source: [33]

Besides the quoted results, there exist other drivers for the decision to convert. Many studies investigate the attitude of farmers towards organic farming. Economic reasons such as efficiency are quoted very often, but there are other reasons. Among these political attitudes or ecological concerns might play an important role [34]. *Hollenberg* [35] argues that the decision for organic farming is strongly influenced by the personal attitude of the farm manager towards the new farming system. ‘Willingness to learn’ and ‘risk-behaviour’ as drivers for or against conversion [36, 37] could be added to the list of attitudes that influence farmers decision to convert. These factors are not consequently taken into account in the existing efficiency literature.

3.4. Allocation topics: optimal specialization and optimal choice of production system

One study investigates the degree of optimal farm specialisation on organic mixed and specialized crop-farms using a ‘DEA Window-Analysis’ [38]. The sample is split into 3 specialisation classes¹. The efficiency is measured in relation to the frontier of the own specialisation class and in relation to the frontier of other specialisation class. The authors find a significant part of farms that could perform better with a specialisation within another farm specialization². Applying the optimal specialization class model results, the group of mixed crop farms (class 3) would be some 15-32 % smaller and the medium specialized farms (class 2) 8—25 %, which shows that organic crop-farms could gain productivity by specializing. Farms of the specialization class 3 (class 2) could increase their productivity by 13,4 % (15,4 %) by switching to a *higher* specialization. The productivity increase of farms of class 1 by switching to *lower* specialization is just 8,7 %. Around 44—54 % of the farms are found to be in the optimal specialization-class [38]. Although the authors mention the integrating factors of organic farms (crop-rotation, balanced labour-input and a lower risk), they do not critically discuss, whether such a ‘*mathematical specialisation strategy*’ in organic farming is applicable in reality, without taking into account the available natural resources and the restrictions e.g. due to a wider crop rotation (see the introduction).

Finally, *Breustedt et al.* [13, 39] use a DEA meta-frontier approach to analyse whether farmers have adopted the optimal farming system

¹ Class 1 is creating 90 % of the revenue from crop-farming, class 2 70-90 % and class 3 less than 70 %

² E.g. mixed farms, who should rather specialise in arable farming and vice versa.

under different policy scenarios. In contrast to former studies, organic dairy farming in Bavaria is found to be 3 percentage points more technically efficient than conventional farmer and that 68,6 % of the organic farms have chosen the most profitable farm-system. But still, around 31,4 % of the organic farms should reconvert to conventional farming from a productivities point of view. By switching to the other technology, organic (conventional) farms could increase their productivity by 5 % (7 %).

The authors introduce policy scenarios where the milk-quota and the payment for organic farming is abolished. The share of organic farms that should reconvert, is increasing with the abolishment of the organic payment or the milk-quota. On the other hand, the modelling approach shows, that round 22,1 % of the conventional farms in the reference scenario should convert to organic farming systems. This matches empirical findings by *Sanders et al.* [40], who asked organic farmers in 2009 to give a subjective estimate on their economic situation under conventional farming. 8 % of the organic farmers estimated their profit to be higher and another 16 % of the organic farmers stated in the interview, that the profit would be the same under a conventional farming regime. *Breustedt et al.* [13] also discuss other economic barriers for adoption of the ‘optimal farming regime’. Also in this case, the limitation of switching farm regimes (i.e. environmental and transaction costs) are not discussed in detail.

3.5. Environmental efficiency of organic farms

Organic farming provides many environmental services and reduces negative externalities [41]. Since the protection of the environment is one of the objectives of organic farming, an appropriate representation of farm-efficiency could also be environmental efficiency. Most of the efficiency models comparing organic and conventional farming do not include environmental variables¹, which could represent a part of the objective function of an organic farm. Especially for policy and sustainability issues, this type of analysis could be helpful in order to identify farming systems that meet the demand of society for sustainable and environmental friendly farming.

Dreesman [42] gives a very detailed overview on methods and theories on the assessment of economic and environmental efficiency. A part of his work deals with three applications on organic farming by

¹This was originally mentioned by Oude Lansink et al. [31]

means of a Data Envelopment Analysis. His analysis uses data from 58 organic milk-farms in Luxembourg in 1999 and 2000. The data-set consists of standard input-output-data and of information on nitrogen-, phosphorous- and energy-use of the farms. These three variables were treated as ‘*unwanted environmental inputs*’ (see [42]). Both model approaches, SFA and DEA are applied.

— In the *SFA-model*, phosphorus has a negative impact on output and the other two environmental inputs do not show a significant impact on the output. The results of the technical effects model suggest that a high share of milk-production in total revenue (i.e. specialized farms) increases environmental efficiency.

— The *DEA-model* suggests that energy is used more intensively in the production process and has a larger impact on technical efficiency than the environmental indicators ‘nitrogen’ and ‘phosphorus’.

— Finally, a *tobit-model* basing on the DEA-results estimates the determinants for technical efficiency. According to this analysis, animal density decreases environmental efficiency, which makes intuitive sense. However, a high grassland share or high land availability has a slightly significant and positive impact on environmental efficiency.

The organic milk farms in Luxembourg in the data-set seem to work more intensively than e.g. organic farms in Germany. E.g. the nitrogen balance shows a surplus of on average 137 kg N/ha¹ and the average animal-density lies at 1.6 animal units per hectare². Besides that, the data-set has a limited number of observations which highlights the need for more in-depth analysis with broader data-sets.

Kantelhardt et al. [44] investigate the technical and environmental efficiency of farms using different agri-environmental programmes (AEP) in southern Bavaria. The data-set consists of 102 farms that participate in AEP, in the organic-farming scheme or who do not participate (conventional control-group). Five types of efficiency are taken into account, the pure constant and increasing-returns to scale efficiency, economic efficiency without AEP-payments and standard

¹ The average nitrogen surplus of all German farms (conventional and organic) is around 105 kg N/ha in 2007 (German Federal Environment Agency, *Daten zur Umwelt 2011, Umwelt und Landwirtschaft*, in *Daten zur Umwelt*, German Federal Environment Agency (Umweltbundesamt), Editor 2011, German Federal Environment Agency (Umweltbundesamt): Bonn). Nevertheless, a part of this difference might also stem from different calculation methods in the nitrogen-balance.

² The average density of organic grassland-farms in German in 2000 is 1.28 animal units / hectare (own calculation according a data set from LAND DATA with 211 observations in 2000).

and ‘sustainable’ environmental efficiency¹. The input and output variables represent the standard efficiency variables such costs, capital, area and land as inputs and revenue as output. The variables ‘Low-intensively used area’, ‘area covered with landscape elements’ and ‘nitrogen use’ are introduced as environmental variables. Figure 3 presents the result of both economic and ecological efficiency:

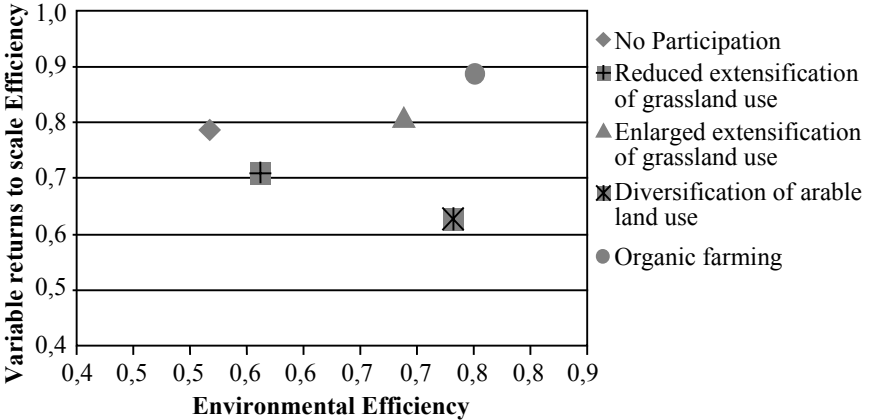


Figure 3 Comparison of economical and ecological efficiency of different farm types using agri-environmental programs in Bavariasource: own elaboration using the results of [44]

The results show that the organic farms and the farms with diversified arable land a lower efficiency without the AEP-payments. The results of the environmental efficiency suggest that taking into account externalities, the participation in AEP seems to be favourable since the farms that did not participate loose their advantage and achieve the lowest efficiency scores. Economic efficiency is not positively correlated with environmental efficiency. According to the authors the organic farms seem to succeed to combine environmental and economic efficiency. Although organic farms perform well in both categories, the number of farms is too small to draw reliable conclusions. The approach seems to be one way to address the problem of neglected externalities, but the comparison of the TE-scores of both models is not unproblematic, since it is not clear if scores can be compared 1:1. And the study does not perform any

¹ According to the authors it „makes no sense, to for example to protect soils but spoil groundwater“ [44: p.6]. „Sustainable Ecological Efficiency“ therefore restricts the DEA-model to a minimum output of 10% of each environmental output category.

bootstrapping technique in order to produce statistical evidence of the results.

4. Discussion and conclusions

A number of joint key conclusions can be derived from the empirical literature on the efficiency of organic farms:

— Organic farms show a slightly lower productivity, nevertheless, the efficiency and productivity differences are not as high as e.g. the differences in yields (see e.g. [9]. Efficiency is an important topic for farms' success, since there is a significant relation between efficiency and farm-success [19].

— Many studies do not discuss the selection of data and the question why farms decide to convert to organic production. Since factors that influence the conversion decision might also influence efficiency, there is a danger of selection bias in empirical studies. Hence, more attention should be paid to sampling issues in future studies.

— The available studies also show that allocation decision on organic farms might not always be optimal and that there is still scope to specialize and choose the optimal production programme. But besides these findings a lot of analyses do not discuss the limitation of allocation on organic farms within the regulation framework. Technical Efficiency in general is a topic which can also be discussed within the logic of the organic farming systems.

— The topic of environmental efficiency has been analysed in a few studies, but these have the character of case studies and cannot yet be generalized due to data constraints. Studies from California [45] and Norway [46] using integrated economic-ecological analysis show that organic farming systems can have a better economically and ecologically balance. This might also be the case in terms of integrated efficiency studies using both economic and ecological indicators. Especially from society's point of view, environmental efficiency is interesting in order to identify adequate policy measures. Finally, there is still need for more reliable and detailed data sets and more research in the field of environmental efficiency.

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AGRICULTURE MARKET INFORMATION INFRASTRUCTURE IN UKRAINE: PERSPECTIVES OF DEVELOPMENT

Анотація. У статті розглядаються актуальні питання розвитку аграрного ринку шляхом розбудови інформаційної інфраструктури. Пропонується шлях розвитку ринку через надання об'єктивної інформації про ціни та обсяги та забезпечення її доступності для всіх учасників ринку. Ключові слова: ціна, аграрний ринок, ринкова інформація, інформаційна система

Аннотация. В статье рассматриваются актуальные вопросы развития аграрного рынка путём развития информационной инфраструктуры. Предлагается путь развития рынка способом предоставления объективной информации про цены и объёмы и обеспечение её доступности для всех участников рынка. Ключевые слова: цена, аграрный рынок, рыночная информация, информационная система

Annotation. In the article the actual problems of agriculture market development by way of creation of information infrastructure is reviewed. The authors propose the way of market development by means of giving the best possible information on prices and volumes and providing of such information to all of the market participants.

Keywords: price, agriculture market, market information, information system.