Technical Efficiency of Organic Farming in the Alpine Region – the Impact of Farm Structures and Policies

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Abstract:

The paper investigates the impact of subsidies and of para-agriculture on the technical efficiency of organic farms in Switzerland, Austria and Southern Germany. The data-set consists of bookkeeping data with 1,704 observations in the years 2003 to 2005. Technical efficiency is modelled using a stochastic distance-frontier model combined with a Metafrontier-model. The results show almost no efficiency differences among the farms in the three countries. Para-agriculture shows a strong impact on farm's efficiency and output in Austria and Switzerland, whereas in Germany the effect is rather small. The study confirms that agricultural subsidies have a direct impact on farm's efficiency.

Keywords: Technical Efficiency, Organic Farming, Grassland Farming, Para-Agriculture

JEL-Code: Q12, Q18, D24, C54

1 Introduction

The European agriculture has developed in the direction of a 'multifunctional farming', especially in regions with lower or marginal production potential. This is especially true for farming in the Alps-region. One result of this development can be described with the term 'para-agriculture' summarizing the diversification efforts of especially Swiss' farms towards services like direct marketing, rural tourism, landscape maintenance and forestry (see e.g. Schmid and Steingruber, 2010), similar developments can be found in Austria and to a smaller extent in Germany (Recke et al. 2004).

This process of diversification is partly influenced by subsidies, which are paid for the provision of public goods and services (Mamardashvili and Schmid, 2013). Most subsidies give an incentive to farmers to produce public goods or compensate farmers for income losses due to price cuts. The recent literature points out, that subsidies directly influence production decisions of farmers with respect to the intensity of input use on the farms. Subsidies are also found to have a negative impact on farm's technical efficiency (McCloud & Kumbhakar, 2008, Lakner, 2009, Hennigsen et al., 2011, Latruffe et al., 2011, Minviel and Latruffe, 2013), in contrast, Mamardashvili and Schmid (2013) find a positive impact of ecological direct payments on farm's efficiency in Switzerland.

Different agricultural policies and structural conditions have different influences on farms diversification and technical efficiency. These divergences can be found in Switzerland, Austria and Southern Germany: In Germany and Austria, the Common Agricultural Policy (CAP) of the European Union (EU) is applied, Switzerland pursues a different agricultural policy framework. The Austrian' agriculture has strongly profited from the EU-accession in 1995 by strongly increasing its export share on the EU market. If we exclude the impact of trade relation between Swiss as a non-EU country and the EU and impact of exchange rates, Swiss agriculture might also suffer from a competitive disadvantage against Austrian and German farms due to a slower structural change in Switzerland (Schmid, 2009). Swiss agriculture is exposed to an increased pressure for liberalizing agricultural trade, which is also reflected in the national debates on Swiss agricultural policy. One objective of this paper is therefore to investigate technical efficiency of farms in Switzerland, Austria and Germany.

Organic production on the farm level has a long history in all the three countries and the share of organic farms has been comparatively high in the last 20 years (Schwarz et al., 2010). This development is also, though different in details, driven by the certain agricultural policies: The policy in the three countries has set a high priority in the support for organic farms as an incentive for farmer to convert (Eder, 2006). Organic farming seems especially interesting for this type of policy and structural comparison, since *firstly*, it is highly policy dependent. *Secondly*, organic farms show some diversification tendencies towards direct marketing not only in Austria and Switzerland, but also in Germany (Recke et al., 2004) and *thirdly*, organic farming also provides some potential to export high quality food (Kilcher et al., 2011). Investigating the performance of organic farms, we might also conclude if a high quality strategy for Swiss' or Austrian' farming provides potential.

The **objective** of this paper is therefore to estimate technical efficiency of organic grassland farms in the three countries by taking into account the impact of the different policy schemes and of the different farm structures. We especially focus on the influence of para-agriculture on technical efficiency in order to determine the differences in the production-function among organic farms in the three countries. As a starting point, we investigate the policy schemes prior the Fischler-Reform of 2005 (Swinnen, 2008). We use a methodology combining of a distance frontier approach and a stochastic metafrontier. The paper is structured as follows: In **chapter 2** we describe the main lines of agricultural policy in the three countries. **Chapter 3** explains the applied methodology and used data. **Chapter 4** contains the results of the Distance-Frontier- Estimation and in **chapter 5** we draw conclusions.

2 Background of Agricultural Policies in Germany, Austria and Switzerland

The agricultural sectors of Germany, Austria and Switzerland are mainly influenced by agricultural policies: In the case of Switzerland, agricultural policy is a matter of national decision, whereas in Germany and in Austria (since 1995) agricultural policies are determined by the framework of the EU's Common Agricultural Policy (CAP). Organic farms in the three countries are also subject to special policies and therefore an interesting group to identify the impact of subsidies. Both, the Swiss' and the EU's agricultural policy were subject to reforms in the last 20 years: **In the EU**, the CAP-reforms liberalized the EU's policy by replacing the price support by coupled and (after 2005) decoupled direct payment (Swinnen 2008). In the period of investigation (2003/4 to 2005/6), the coupled direct payments for crops and livestock were still applied:

In **Germany**, per-hectare payments were granted for grains, maize, oil-seeds, protein-crops, flax and set-aside in the crop-sector, and a slaughter premium for bulls, cows, calves, suckler cows, sheep and goats were paid per animal (BMELF, 2000). Recent studies show, that we can still expect those coupled payments to influence farmers decisions on production planning and input intensities and therefore distort production (McCloud and Kumbhakar, 2008, Hennigsen et al, 2011). Besides these 'first pillar payments', the EU was supporting farmers through their rural development programs (RD), (see EU-regulation no. 1257/99, in 2000-06), which also include the special support of organic farms on the federal state level[1].

In **Austria,** agricultural policy is, since the entry to the EU in 1995, closely linked to the CAP. The Austrian agricultural policy focuses, in comparison to other member states, rather

[1] In Baden-Württemberg, farms received 170 EUR/ha for organic farming on arable land and 130 EUR/ha on grassland. In Bavaria, farms received 255 EUR/ha on both arable and grassland (Nieberg et al., 2010).

on the rural development programs (RD): In the Austrian agricultural budget, the RD has a share of about 58 per cent (including all national top-ups), which is above the EU's average RD-spending of 14 per cent (BMLFUW, 2006). Within the RD, the agri-environmental programme consists of 32 measures, where the support of organic farming is one of the most important measures. In 2005, payments for organic farming have reached almost 15 per cent of total agri-environmental budget[2] (BMLFUW, 2006).

In **Switzerland**, agricultural policy was also subject to reforms: a constitutional amendment in 1996 led to the introduction of decoupled direct payments in 1999, for which farms had to qualify by proving an 'ecological performance record' (similar to the actual 'Greening'-requirements in the CAP after 2013[3]). 98 per cent of all Swiss farms participate in the scheme. The introduced direct payment contributes to 26 per cent of the farm-revenue from 2003-2005 (own calculation based on the full sample of test-farms in Switzerland). From 1999 to 2013, the measures essentially stayed almost the same. Swiss direct payments mainly consist of two different types: The so-called *general payments* and the *ecological payments*, which include the payments for organic farming[4]. The payments are granted according different support-criteria and are different depending on the production region (valley, hilly region or mountainous region I.-IV). There is a basic area payment and payments for animals. The environmental compensation payment are paid for ecological services on arable land, for extensive grassland use, to support traditional orchards and also (to a large extent) to support organic farming. *For our analysis*, we aggregated payments for organic farming and other ecological objectives in the three countries as 'environmental payments'. We summarized the remaining types of the agricultural payments as 'other payments', which are mainly the per hectare- and per animal direct payments.

3 Methods and Data

3.1 The Distance Frontier Model

The research objective of this study has two main restrictions:

1.) The main challenge in this study is to include inputs for and outputs from para-agriculture. Joint inputs for both agricultural production and para-agriculture, but two separate outputs for both, necessitates a multiple output approach, as is the case in the distance frontier framework (cp. Färe and Primont, 1995, Brümmer et al., 2002).
2.) Since farms in the three countries are exposed to different economic, structural and legal environments, we estimate a separate distance frontier for each country, followed by a metafrontier, which envelopes the three group frontiers (Battese et al. 2004). We therefore combine a stochastic distance frontier with a metafrontier approach.

[2] In Austria farms received in 2003-2005 in the organic farming measure from 96-251 EUR/ha grassland, for common arable land 327 EUR/ha (BMLFUW, 2006).
[3] For the so called 'ecological performance record' (ökologischer Leistungsnachweis) farms have to provide 7 per cent of it's farm-land for ecological objectives, show a minimum crop-rotation, a protocol of all applied agrochemicals during the year and a balanced nutrient cycle.
[4] Organic farms receive 200 SFr/ha for grassland and 800 SFr/ha for arable land (exclusive special cultures) (cp. Swiss Ministry for Agriculture, diff. Issues). With an average exchange-rate for 2003-2006, this is about 516 EUR/ha for arable land and 129 EUR/ha for grassland.

Denote with x_t the set of inputs, and with *P(x)* the output set, i.e., all feasible output vectors $y \in \Re_+^M$ given x_t. Then, output oriented technical efficiency can be described as the inverse of the output distance function below (Färe and Primont 1995):

$$D_0(x,y) = inf_\phi \left\{\phi > 0: \frac{y}{\phi} \in P(x)\right\} \qquad (1)$$

for all $x \in \Re_+^K$. The distance function $D_0\,(x,y)$ is nondecreasing, convex and linearly homogeneous in outputs, and decreasing and quasi-concave in inputs. The model can be described in the following figure 1:

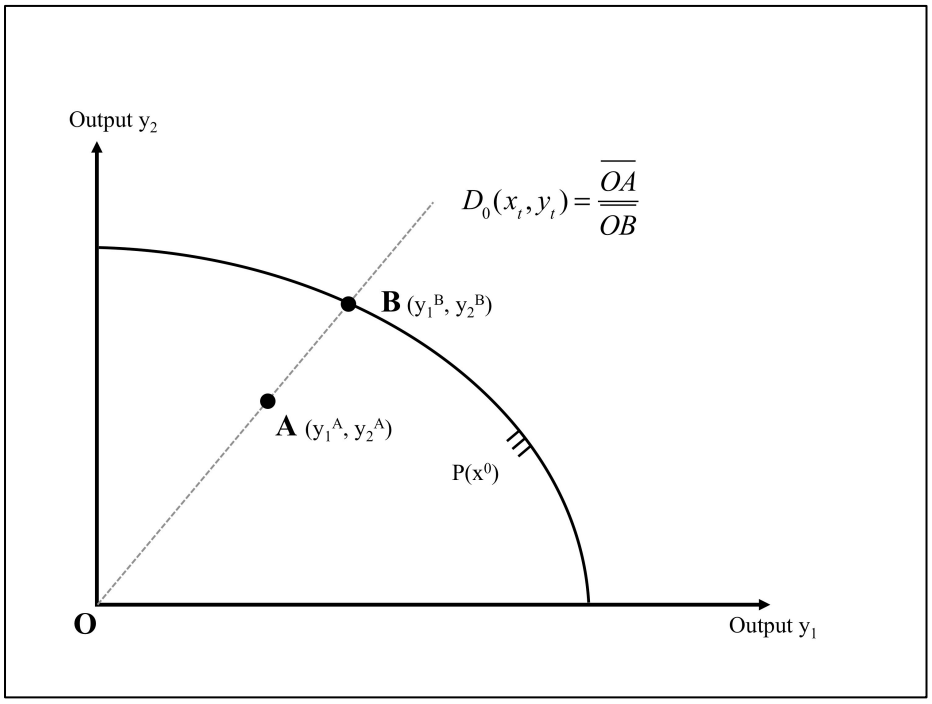

Figure 1: Output distance function with two outputs (see Färe and Primont, 1995)

The boundary of the output set is equivalent to the production possibility curve. The distance function gives the relation of a given output vector (say, A in Figure 1) to the maximal feasible output with unchanged output mix (in this case B). One challenge in estimating the distance frontier econometrically is that the distance frontier under technical efficiency is equal to one. To overcome this lack of variation in the dependent variable, we exploit the linear homogeneity property:

$$D_0(x, \lambda y) = \lambda\, D_0(x,y) \qquad (2),\ \ with\ \lambda = \frac{1}{y_1}:$$

$$D_0\left(x, \frac{1}{y_1} y_m\right) = \frac{1}{y_1}\, D_0(x,y) \qquad (3)$$

In our model, we have to work with two outputs of agriculture and para-agriculture, therefore, we derive the model with two outputs y_1 and y_2. Taking logarithms, we simplify the model:

$$ln\, D_0\left(x, \{\frac{y_1}{y_1}, \frac{y_2}{y_1}\}\right) = -lny_1 + lnD_0(\cdot) \qquad (4)$$

$D_0(\cdot)$ is relative to the inverse of *TE*: $D_0 = 1/TE$, we can replace D_0 by the measure *1/TE*[5]:

$$\ln \mathrm{D}_0\left(x, \left\{1, \frac{y_2}{y_1}\right\}\right) = -\ln y + \ln\left(\frac{1}{TE}\right) \qquad (5)$$

We here replace the term *1/TE* by an exponential error-term *exp(u):*

$$\ln \mathrm{D}_0\left(x, \left\{1, \frac{y_2}{y_1}\right\}\right) = -\ln y - u \qquad (6)$$

Reformulation and introduction of a white noise error term *v* brings a form quite close to a stochastic production frontier (as in Aigner et al., 1977):

$$lny_1 = -\ln \mathrm{D}_0\left(x, \left\{1, \frac{y_{(2,3\ldots,m)}}{y_1}\right\}\right) + v - u \qquad (7)$$

The estimation of the parameters under stochastic frontier model can be based on maximum-likelihood estimates. The first error-term v_i describes stochastic effects, which are out of the control of the farmer and is defined as independently and identically distributed as $N(0, \sigma_v^2)$ (as in Aigner et al., 1977). The inefficiency term *u* is a nonnegative figure, which describes the degree of inefficiency of farm, which is under the control of the farmer. This term *u* has a half-normal distribution $u_i \sim N^+(0, \sigma_u{}^2)$. This assumption allows the estimation of the 'heteroscedasticity model', which captures the impacts of a set of explanatory *j* variables *z* for technical efficiency. The model is defined as follows: $\sigma_{u_i}{}^2 = exp\{z_j \rho_j\}$ (8)

with z_j as a set of explanatory variables, which explain technical (in)efficiency. If the estimated parameter ρ is positive (*negative*), the corresponding variable has a negative (*positive*) influence technical efficiency.

Since we are estimating efficiency of farms in three countries, we apply the stochastic metafrontier model, by firstly estimating group efficiency (TE) within the three countries and then receiving a joint deterministic metafrontier, which envelope the group-frontiers (for details: Battese et al., 2004; O'Donnell et al., 2008). The metafrontier is defined as follows:

$$-lny_1^* = \alpha_0^* + \alpha_1^* ln\frac{y_{(2,3\ldots,m)}}{y_1} + \beta_k^* \ln x_{kt} \qquad (9)$$

with the outputs *y* and inputs *x* for the groups *. The model is a deterministic model and the parameters are produced by a linear optimization. We use the two methods producing the parameters of the metafrontier, the optimization by minimizing the absolute deviation (1) or the minimization of the squared deviation (2) (Battese et al., 2004: 96). The model-output is the 'Meta-Technology Ratio' (MTR), which describes the technological differences of the group-frontiers used in the three countries to the joint technology (represented by the metafrontier). The total efficiency TE^* is defined as a product of the group-specific efficiency TE^G, produced by the distance frontier model and the meta technology ratio (MTR):

$$TE_{it}{}^* = TE_{it}^G \times MTR_{it} \qquad (10)$$

The distance function and metafrontier are estimated using OxMetrics 7.0, the metafrontier is simulated by 5,000 times bootstrapping in order to get estimates for the standard-errors.

[5] Note that the Farrell's measure of *TE* describes the relation of an observed output to the maximal feasible output, so that a value of *TE < 1* (Farrell 1957). D_0 in contrast describes the maximal expansion of the output, therefore $D_0 > 1$.

3.2 Data Description and Adjustment

We use book-keeping data from organic mixed and grassland-farms in the years 2003/04 – 2005/06[6]. The German data-set contains book-keeping data from 106 mixed and grassland farms in Bavaria and Baden-Württemberg which was provided by Land Data GmbH. The Swiss data-set is taken from the Farm Accounting Data Network (FADN Swiss) in Switzerland and contains 218 organic farms. The Austrian data-set is taken from voluntarily book-keeping farm network of the Ministry for Agriculture, Forestry, Environment and Water in Austria (BMLFUW) and contains 244 organic farms.

In order to ensure comparability between German, Austrian and Swiss book-keepings accountancy rules were harmonized. One important feature of the Swiss accountancy is that not only sales are considered revenues but also changes in stocks. Agricultural output contains all revenues from plant and animal production as well as revenues from forestry and direct payments while para-agricultural output contains revenues from agricultural-related activities like direct marketing, agro-tourism and contracting.

According Swiss tax-law, farm- and residential buildings are seen as part of the Swiss farm-enterprise. As business and residential buildings are mixed up in most Swiss accountancies para-agricultural revenues also contain some kind of artificial rental-payments from the farmer's family to the farm in order to compensate for all direct and joint costs for maintaining the hours arise in the farm's accountancy. This Swiss singularity might lead to the interpretation that Swiss farms have a strongly diversified and applied concept of multifunctional agriculture. However, the high contribution of para-agricultural output to farm income is partly an artefact of the Swiss tax- and accountancy system.

The bookkeeping accounts are standardized in order to receive comparable variables, the data are deflated using the base year 2000 and official price index from each country. Since trade for inputs and outputs are subject to tariffs between the EU and Switzerland, the exchange-rate might in some cases not fully reflect scarcities or shadow-prices of inputs in Switzerland. Therefore, price adjustments are done for the single inputs and outputs the Swiss data-set in order to reflect not only the currency exchange but also the diverging shadow-prices for different inputs in Switzerland.

The applied distance-frontier model is defined as follows:

$$-lny_1 = \alpha_0 + \alpha_1 ln\frac{y_{(2)}}{y_1} + \beta_k \ln x_{kt} + [\dots] + \mathrm{v} - u \qquad (11)$$

with the output y_1 for agricultural output and y_2 for output from para-agriculture, and the x inputs $k = 1, 2, \dots, 4$ for variable costs, capital, labour and land and with t for the year. The parameters are estimated with α_1 as parameters which describe the contribution of the agricultural output y_1 and β_k, which can be interpreted as input elasticity to output. We used the farm's depreciation as a proxy for capital. The following table 1 shows the data used for the basic distance frontier model:

[6] We define the terms 'mixed farms' and 'grassland farms' according revenue-shares: A mix-farm has between 33 per cent and 66 per cent revenue from the production of milk and meat from sheep, goats and cattle. Grassland-farms gain more than 66 per cent of their revenue from this production.

Table 1: Description of the variable used in the model

Variable	Unit	1.) Switzerland (n = 654)		2.) Austria (n = 732)		3.) Germany (n = 318)	
		Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
a.) Variables for the production frontier							
Output from agriculture (Y_1)	EUR	42,241	*23,894*	26,173	*17,319*	81,412	*40,304*
Output from para-agriculture (Y_2)	EUR	17,959	*12,883*	12,689	*10,147*	4,500	*6,653*
Variable costs (X_1)	EUR	39,482	*14,932*	22,746	*11,207*	44,934	*19,790*
Annual depreciation (X_2)	EUR	14,491	*6,129*	13,183	*5,991*	19,837	*11,242*
Labour units per farm (X_3)	AWU	1.55	*0.45*	1.59	*0.56*	1.59	*0.56*
Agricultural land (incl. forestry) (X_4)	ha	23.00	*8.70*	53.70	*36.41*	54.04	*23.65*
b.) Determinants of technical efficiency							
Share para-agriculture (z_1)	Per cent	0.31	*0.18*	0.34	*0.2*	0.06	*0.10*
Sum of environmental payments (z_2)	EUR	6,825	*2,819*	18,716	*9,264*	13,752	*6,314*
Sum of other payments (z_3)	EUR	31,915	*11,806*	7,513	*5,424*	9,006	*7,318*
Land-rent per hectare (z_4)	EUR/ha	210	*158*	165	*105*	89	*60*
Gender female (z_5)	1/0	0.01		0.2		0.03	
Height above 600m (z_6)	1/0	0.86		0.7		0.27	
Animal-units per hectare (z_7)	AU/ha	1.10	*0.35*	1.08	*0.3*	1.32	*0.46*
Share of grassland-farming revenue (z_8)	Per cent	0.86	*0.15*	0.9	*0.2*	0.85	*0.17*

Source: own calculation
Note: In the German data-set we set the output from para-agriculture for 46 observations (14 per cent of the sample) from zero to one EUR. This was based on the assumption, that a German farms uses a minimum level of diversification.

The data-set consists of 1,704 observations, is organized as a balanced panel and corrected for outlier. We can see some similarities between farm structure: farm size with about 54 ha/farm is similar between Austria and Southern Germany, contrary, the share of farms in an altitude above 600 m is similar in Austria and Switzerland. The output from agriculture is highest in Southern Germany and significantly smaller in Switzerland and Austria. The contribution of para-agriculture is highest in Switzerland, the share of output from para-agriculture is similar between Austria and Switzerland with about 30 per cent of total farm revenue, whereas the average contribution of para-agriculture in Germany is just with about 6 per cent.

Recent studies suggested to use matching techniques in order to accommodate for structural differences between countries by comparing farms with almost similar structures. Purposely we did not apply any matching techniques, since we want to observe typical farm structures in the three countries as a result of path-dependencies due to past policies (agricultural policies, the impact of EU-accession of Austria). This seems to be appropriate for investigating the impact of agricultural subsidies and farm-development and -diversification in the three countries.

4 Results and Discussion

The following table 2 presents some tests for model-quality:

Table 2: Results for different tests of model quality

Null-hypothesis	Test-value			Critical value
	Switzerland	Austria	Germany	
LLR-test for joint estimation		544.61**		108.65
H^1: No inefficiency† $\rho_j = 0, j = 0,1,\ldots,29$	334.27**	130.00**	202.45**	3.84
H^2: CD-production function $\rho_j = 0, j = 0,1,\ldots,29$	371.14**	166.53**	58.95**	33.92
H^3: Linear homogeneity (constant returns to scale) $\sum\beta_j = 1;\ \sum\beta_{jk} = 0\ for\ j = 1,2,3,4$	1,113.86 **	1,773.66**	1,326.34**	11.07
H^4: No Heteroscedasticity $\rho_j = 0, j = 1,2,\ldots,19$	634.95**	205.45**	196.54**	26.30

Source: own calculation

The test-results show that the data-set is appropriately represented by the model. The likelihood-ratio-test for joint estimation with a test value was highly rejected. The H1 for not applying the efficiency model, was rejected. H2 testing for a Cobb-Douglas production function was also rejected. The H3 is testing, whether we can apply linear homogeneity to the model, which was rejected. (We will discuss the topic of scale-elasticities below.) Finally, H4 for not applying the heteroscedasticity model was rejected in all sectors. We also tested for monotonicity, and we only found minor problems with labour and land in Austria and labour in Switzerland.

The following table 3 shows the estimated coefficients for the group-specific distance-frontiers and the joint metafrontier for the three countries:

Table 3: Estimated coefficients of the distance frontier

	Switzerland	Austria	Germany	Meta 1	Meta 2
α_0 Constant	0.1844**	0.2435**	0.1682**	0.3624**	0.6065**
α_1 Output para-agriculture	0.3482**	0.3017**	0.0315**	0.2474**	0.2156**
β_1 Costs	-0.5619**	-0.6953**	-0.4915**	-0.5973**	-0.6375**
β_3 Capital	-0.1631**	-0.1792**	-0.2084**	-0.1894**	-0.1435**
β_3 Labour	0.0016	-0.1256**	-0.3325**	-0.2286**	-0.2253**
β_4 Land	-0.1578**	0.0258	-0.0681	0.0438	0.0806**
β_t Technical change	-0.0103	0.0001	-0.0066	-0.0092	-0.0015
[…]	*The estimated results for the cross-terms are left out for simplification reason*				

Source: own calculation

The positive value of the first order coefficients $\beta_{1,2,3,4}$ can be interpreted as input elasticities to agricultural output (y_1), whereas the coefficient α_1 shows the contribution of para-agriculture (y_2) to the total output. The results for α_1 show, that para-agriculture substantially contributes to farm income in Switzerland and Austria (similar in: Jan et al., 2010), which is in accordance to the financial contribution of para-agriculture, whereas the contribution of para-agriculture in Germany is rather minor. A comparison with estimation results from conventional farms in Switzerland (using the same model) shows that the contribution of para-agriculture is much higher in the organic sector (Mamardashvili et al. 2014). The

impacts of the direct costs are highest in all the three countries, capital and labour have the largest effect in Germany, land has a significant effect in Switzerland. No technical progress has been found over the observed period.

Table 4 shows the efficiency scores, MTR-values and the total efficiency TE*-values:

Table 4: Estimated technical efficiency scores, meta technology ratio and total efficiency scores of organic farms in Switzerland, Austria and Southern Germany

	Group technical efficiency (TE^G)	Meta-technology ratio (MTR)	Total efficiency (TE*)
Switzerland	0.8251	0.6905	0.5787
Austria	0.7721	0.6878	0.5323
Germany	0.8466	0.6569	0.5635

Source: own calculation

The TE^G shows to what extent the farms are efficient towards their group-specific frontier: The results show German farms as being the most efficient, closely followed by Swiss and Austrian farms. The meta technology ratio shows the relation between the group-technologies (i.e. frontiers) to the joint Metafrontier: Here Swiss' and Austrian' farmers define to a large extent the joint metafrontier, whereas there is a larger technology gap between German farms and the metafrontier. Finally, the total efficiency TE*[7] shows, that there are almost no efficiency differences between the three countries.

Taking into account the estimated results of the group-frontier, the results overall signal, that Austrian and Swiss farms are more close in terms of the applied technology with Swiss farms being more efficient than their Austrian' neighbours. The rather large impact of para agriculture might also support this finding, where German farms have only a small share of revenues from para-agriculture. Therefore, a technology comparison between Austria and Switzerland might be rather realistic, whereas for comparing both countries with Germany, the artefact of para-agriculture should rather be excluded.

By summing up the first order and cross-term parameter of the inputs we gain the scale elasticities of a farm. Figure 2 shows the distribution of the estimated returns to scale on farms in the three countries:

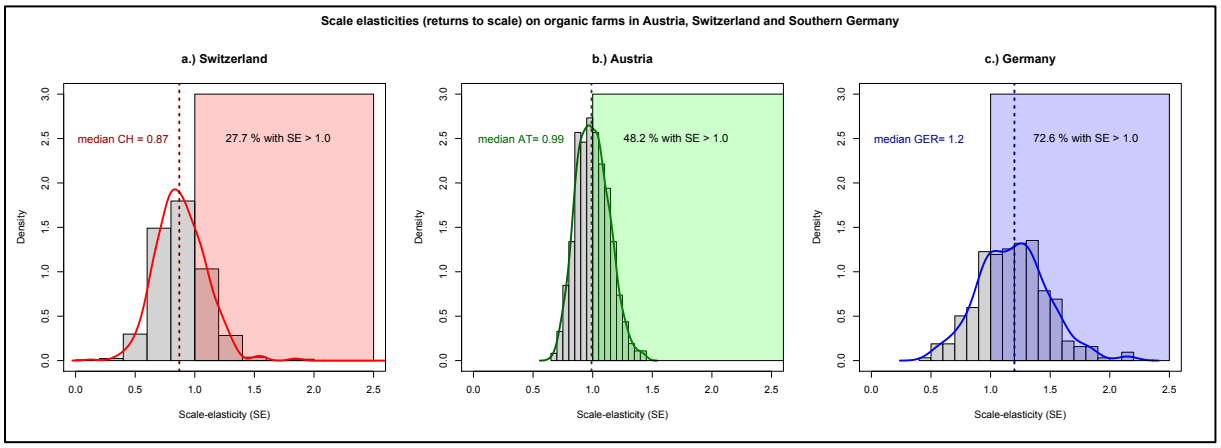

Figure 2: Scale elasticity on organic farms in Austria, Switzerland and Southern Germany (own calculation)

[7] Which is the product of group efficiency TE and the meta technology ratio (MTR), see form 10.

The distribution clearly shows 72.6 per cent of the German farms work with increasing returns to scale. In Austria, many farms work with almost constant returns to scale, only 48.2 per cent of the farms have scale-elasticities above 1.0. In contrary, Swiss farms rather work with decreasing returns to scale, only 27.7 per cent of the farms have returns to scale above 1.0. This finding might be explained by a restrictive land market in Switzerland, which does not allow substantial farm-growth: Given this restriction, the high input intensities on Swiss farms let most of the farms already work with decreasing returns to scale. In contrast to Swiss farms, the results also show a potential for structural change and farm growth in Bavaria and Baden-Württemberg.

The estimated results of the heteroscedasticity model are presented in table 5:

Table 5: Estimated parameters for the heteroscedasticity model

Variable	Switzerland	Austria	Germany
Share para-agriculture (per cent)	- 5.7406**	- 1.1573	3.6522**
Environmental payments (EUR)	- 0.2529*	0.1655	0.8891**
Other payments (EUR)	1.4670**	0.1385**	0.3568**
Level of land-rent (EUR/ha)	- 0.0074	- 0.1034**	- 0.2644**
Gender of farm manager (female = 1)	- 0.4443	0.1664**	0.7165**
Altitude-zone of the farm (above 600 m = 1)	0.7006**	0.1095	- 0.8273**
Land-use intensity (AU/ha)	- 2.8074**	- 0.3874**	- 0.5774**
Share of revenue grassland farming (per cent)	- 0.1604	- 0.8599**	- 1.7368**
[...]	*For simplification reason, not all coefficients of the model are presented*		

Source: own calculation

The estimated parameter capture the impact on inefficiency, therefore a *negative* parameter has to be interpreted as *positive* impact on efficiency. The estimated results of the variable share of para-agriculture shows, that obviously total farm efficiency increases with an increased share of para-agriculture in Switzerland, the opposite is the case in Germany. This seems to be in line with the estimation result of the distance-frontier, where para-agriculture mainly had a large impact on farm output in Switzerland and Austria. Obviously the concept of para-agriculture provides clear advantages for Swiss farms, whereas in Germany and Austria para-agriculture should be rather interpreted as diversification. Therefore, a more diversified farm in Germany comes at the cost of a lower technical efficiency.

The impact of the direct payments is correlated with a lower efficiency in the three countries, and also the environmental payments in Germany have a negative impact on efficiency. Nonetheless, we would have expected environmental payments to have *no impact* on efficiency, since the payments only cover additional costs for the provision of public goods and are therefore (in theory) production-neutral. This result is at most the case in Austria, where we can see no significant impact. In Switzerland, the impact of the environmental payment on efficiency is positive, which is as well against expectation, but in line with the findings of Mamardashvili and Schmid (2013).

The impact of land-rent on technical efficiency is positive, which might reflect the quality of land, the impact of female farm-manager is negative. Farms in altitude above 600m have lower technical efficiency in Switzerland and a higher technical efficiency in Germany. The positive impact of land-use intensity and specialization are as expected (see e.g. Lakner et al., 2012 for German organic grassland farms).

5 Discussion and Conclusions

The results mainly document the production and efficiency differences in the three countries. In relation to their own frontier, Swiss and German farms show a slightly better result. Analysing the data, we find that some of this difference might be explained by the high share of forestry area on Austrian' farms: Forestry area has a share of 36 per cent on Austrian' farms, whereas the share of forestry area is smaller in Switzerland (13 per cent) and Germany (14 per cent). Furthermore the farms differ in site conditions and the productivity of land might: Grassland in the high alps are fully taken into account as farm-land in Austria, whereas it is not included in Switzerland. In contrary, the joint metafrontier seems to be mainly driven by Swiss and Austrian farms. This might reflect greater similarities in technology use by Swiss and Austrian farmers, especially with respect to the rather high share of para-agriculture, which is about 30 per cent in both countries, whereas it just contributes 6 per cent of the total output of German farms. Finally, the total efficiency is highest in Switzerland and Germany.

The results presented here show, that farmers with a high income from direct payments are less efficient. This is even the case, if the payments (as in the case of organic farming) are linked to public services, which is contra-intuitive, since theory suggests these subsidies to be production-neutral, i.e. with no impact on efficiency. However, the impact of the coupled direct payments goes in line with the expectation, that coupled payments influence farmers decision on input intensity and the choice of production program, the results are also in line with the recent empirical literature on the impact of subsidies on efficiency (McCloud & Kumbhakar 2008, Lakner 2009, Kumbhakar and Lien 2010, Hennigsen et al. 2011, Latruffe et al. 2011, Minviel and Latruffe 2013). If we assume that the produced environmental good of a farm is a 'non-observed part' of the production process, the environmental subsidy should theoretically cover the costs of producing environmental friendly. In this case, a negative (or positive) correlation with efficiency might signal, that costs for the environmental good are not sufficiently covered (or overcompensated).

The results also show the importance of the concept of para-agriculture, especially for the farms in Switzerland, where the share of para-agriculture has a positive impact on farm technical efficiency. Even if the impact on technical efficiency is not significant in Austria, the impact of para-agriculture on farm output is substantial (see table 4). In contrast the impact of para-agriculture on output is rather small on farms in Bavaria and Baden-Württemberg and the diversification seems to negatively affect technical efficiency. Therefore, diversification (especially if not supported by taxation law as in Southern Germany) comes at the cost of the efficiency of the pure agricultural production process, whereas the concept seems to support pure farming in Austria and Switzerland. This goes in line with a development to a more diversified agriculture in both countries. From a more critical point of view, para-agriculture captures two effects, the diversification of the farm but also the adjustment of farms structure driven by traditional tax-regulation or tax-incentives for agriculture, especially in Switzerland. Therefore, para-agriculture in Switzerland can be seen as an 'artefact': about 51.6 per cent of the output of para-agriculture stems from artificial rent payments of the farmer's family to the farms, meaning that half of the effect should rather be seen as adaptation to national tax-regulation in favour for agriculture. But still the remaining 48 per cent can still be interpreted as activities that create farm income in the area services such as direct marketing, regional tourism or ecological services.

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