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Impact of Diversification on Technical Efficiency of Organic Farming in Switzerland, Austria and Southern Germany

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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 activities of especially Swiss' farms towards services like direct marketing, rural tourism, landscape maintenance and forestry (see e.g. Schmid and Steingruber, 2010; Mamardashvili et al. 2014). Similar developments can be found in Austria and to a smaller extent in Germany (Recke et al. 2004). This process of diversification is determined by various factors but especially by the location, the site conditions and the size of the farm as well as agricultural policy programmes (Bowman and Zilberman, 2013; McNally, 2001; Meert et al., 2005; Mishra et al., 2004; Pfeifer et al., 2009).

In Germany and Austria, the Common Agricultural Policy (CAP) of the European Union (EU) is applied. The Austrian' agriculture has strongly profited from the EU-accession in 1995 by strongly increasing its export share on the EU market. Switzerland, on the other hand, pursues a different agricultural policy framework, whereas the Swiss agriculture is exposed to an increased pressure for liberalizing agricultural trade, which is also reflected in the national debates on Swiss agricultural policy. 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). Therefore, different agricultural policies and structural conditions have different influences on farms diversification and efficiency.

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 to estimate technical efficiency of organic grassland farms in the three countries by taking into account the impact of the different policy schemes and 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 a distance frontier approach and a stochastic metafrontier. The paper is structured as follows: In **chapter 2** we give a brief overview on the literature on diversification and we define para-agriculture. In chapter 3, we describe the main lines of agricultural policy in the three countries. **Chapter 4** explains the applied methodology and used data. **Chapter 5** contains the results of the Distance-Frontier- Estimation and in **chapter 6** we draw conclusions.

2 Literature on Effects from Farm-diversification

Several studies analyse the impacts caused through diversification. These studies differ in kinds of diversification, the methodology applied and the results conceived. This is also due to the fact that the definition of diversification is quite open (Ilbery, 1991). Most of the studies agree that diversification can be seen as the adoption of income-earning alternatives for a farmer's household. So Weiss and Thiele (2002) calculate a Herfindahl index for on-farm diversification into related and unrelated products. Similar measures are used in Purdy et al. (1997). Studies like Khanal and Mishra (2014) and Schilling et al. (2014) only focus on agri-tourism and off-farm work as diversification strategies. Katchova (2005) divides her sample in crop/livestock diversified, commodity diversified and specialized farms. The majority of these studies apply different kind of regression models. Next to multiple regression models (Katchova, 2005), fixed- and random-effect models (Weiss and Thiele, 2002), three-stage least squares regression models (Purdy et al., 1997) and multinomial logit regression models (Barnes et al., 2014; Chaplin et al., 2004; Khanal and Mishra, 2014; Mishra et al., 1999) are used. Schilling et al. (2014) apply a propensity score matching approach.

The estimated effects vary between the studies and the analysed farm groups as well as diversification specification. Weiss and Thiele (2002) find increases in growth rates for German farms when farms diversify in related products but decreased growth rates resulting from diversification by unrelated products. They also prove that through both diversification strategies the risk of income loss is reduced (Weiss and Thiele, 2002). This result is also found in a studies done on farms in the United States (Mishra et al., 1999; Purdy et al., 1997). Barnes et al. (2014) look at the asset structure on Scottish and Swedish farms and find that diversification in on- and off farm activities determine higher levels of viability at the farm level. This is also done in Katchova (2005) who finds that diversified farms accumulate lower assets than specialized farms. This result leads her to a two-fold conclusion: On one hand it shows that diversified farms are less efficient because these farms support less-profitable enterprises by profitable enterprises or because lower profits are accepted as a trade of for risk reduction. On the other hand it might show that diversified farms are more efficient, when assets (especially land and machinery) are seen as input factors (Katchova, 2005). Furthermore studies show, that especially smaller farms are able to enhance their profits through agri-tourism (Khanal and Mishra, 2014; Schilling et al., 2014). Whereas off-farm work helps at least small farmers to increase their household income (Khanal and Mishra, 2014), enterprise diversification by farmers is not able to generate sufficient new jobs (Chaplin et al., 2004).

3 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 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

[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).

[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 their farm-land for ecological objectives, show a minimum crop-rotation, a protocol of all applied agrochemicals during the year and a balanced nutrient cycle.

(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 consisted 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.

4 Methods and Data

4.1 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.

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):

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

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:

[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.

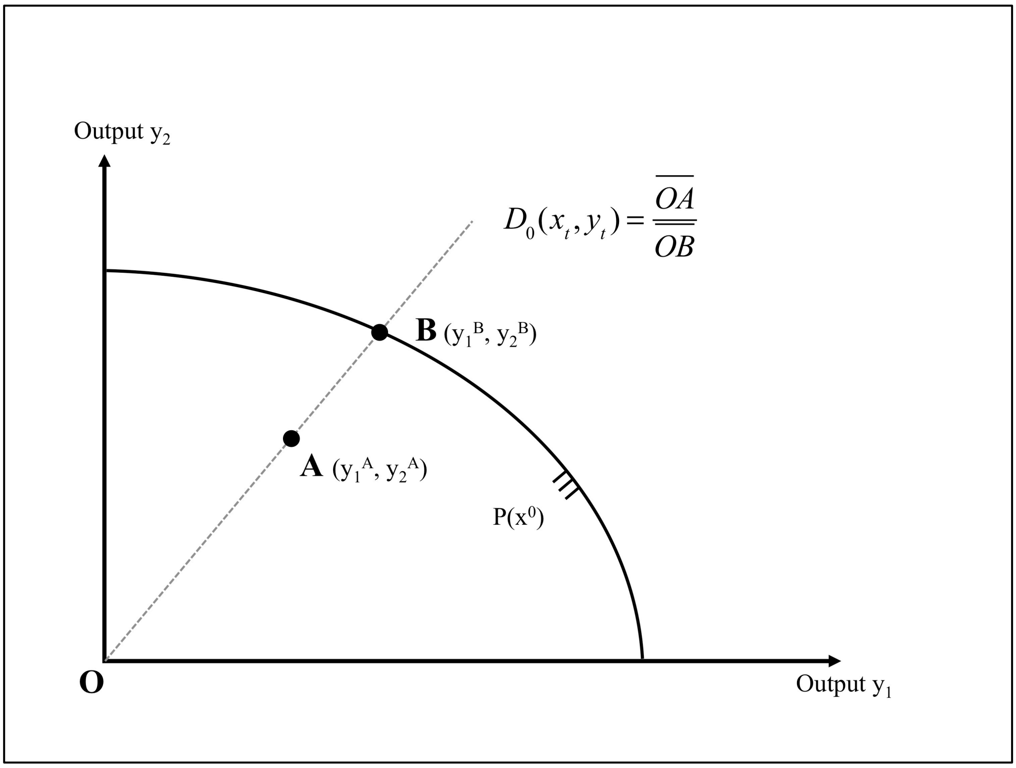

Figure 1: Output distance function with two outputs (see Färe and Primont, 1995)

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:

$$\mathrm{D}_0(\mathrm{x}, \lambda y) = \lambda\, D_0(x, y) \qquad (2),\ \ with\ \lambda = \frac{1}{y_1}:$$

$$\mathrm{D}_0\left(x, \frac{1}{y_1} y_m\right) = \frac{1}{y_1}\, D_0(x, y) \qquad (3)$$

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:

$$ln\ \mathrm{D}_0\left(x, \{\frac{y_1}{y_1}, \frac{y_2}{y_1}\}\right) = -ln y_1 + ln D_0(\cdot) \qquad (4)$$

$D_0(\cdot)$ 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):*

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

[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 $D_0 > 1$.

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 sfamb (Brümmer 2001) for OxMetrics 6.3 (Doornik & Hendry 2011), the metafrontier is simulated by 5,000 times bootstrapping in order to get estimates for the standard-errors.

4.2 Data Description and Adjustment

We use book-keeping data[6] from organic mixed and grassland-farms in the years 2003/04, 2004/05 and 2005/06[7]. 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 (F.A.D.N.) 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

[6] In Austria and Switzerland the book-keeping-system is an economic book-keeping for the analysis of farm success, whereas in Germany it is a book-keeping for the yearly tax-declaration.

[7] 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.

in Austria (BMLFUW) and contains 244 organic farms. This leads to a balanced panel data-set of 1,704 observations. Outliers[8] are deleted from the data-set.

In order to ensure comparability between German, Austrian and Swiss book-keepings accountancy rules were harmonized. *Agricultural* output (y_1) contains all revenues from plant and animal production while *para-agricultural* output (y_2) contains revenues from activities closely related to agriculture like direct marketing, agro-tourism, wine-production or services (see below). Furthermore, we include public payments separately in our model. Therefore 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.

Swiss agricultural bookkeeping system even distinguishes between agricultural activities, direct payments and para-agriculture (meaning diversification activities; Mamardashvili et al., 2014). In that sense, para-agriculture describes activities, which are near to the agricultural production process and make a yearly revenue between 5,000 and 250,000 Swiss Francs (for details see: Schmid et al., 2010: 2, Mamardashvili et al. 2014). The list of para-agricultural activities is not legally defined in Switzerland and is subject to continuous changes. For our study we used costs and revenues for wine production, simple food processing, direct marketing, small wine taverns, rural tourism and services like renting land, machinery or buildings[9]. The book-keeping systems of Switzerland on the one hand and Austria and Germany on the other hand are different, therefore we adjusted the cost-category of both systems in order to appropriately display para-agriculture in the three countries.

According the booking-rules within the Swiss F.A.D.N.-dataset, farm- and residential buildings can be regarded as part of the 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. About 51.6 per cent of the output of para-agriculture stems from artificial rent payments of the farmer's family to the farms, the remaining 48 per cent of para-agricultural revenue can be interpreted as para-agriculture activities that create farm income. This Swiss singularity might lead to the interpretation that Swiss farms have a strongly diversified and applied concept of multifunctional agriculture. The high contribution of para-agricultural output to farm income is therefore partly an artefact of the Swiss accountancy system and we eliminated this effect from the data.

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.

[8] As 'outliers' we define values above mean-value plus three times the standard-deviation.

[9] The Swiss' para-agriculture usually also includes economic activities for the residential building of the farmers family. However, we excluded parts of those payments, since there is no comparable cost-category in the data-sets in Austria and Switzerland.

The applied distance-frontier model is defined as follows:

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

with the output y_1 for agricultural output and y_2 for output from para-agriculture, and the x inputs $k = 1, 2, ..., 4$ 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.

Table 1 shows the means and stand deviation for the data used in the basic distance frontier model. We can see that farm structure is rather similar between Austria and Switzerland. Similarities between means can be found for the total output from para-agriculture, labour units per farm, agricultural land and the animal-units per hectare land (see Table 2). The output from agriculture is highest in Southern Germany and significantly smaller in Switzerland and Austria. The relative contribution of para-agriculture is highest in Austria with 34 per cent of the total farm revenue and moderate in Switzerland with 19 per cent, but still substantially higher than the share of para-agriculture in the Swiss conventional sector, where the average share is about 3.2 per cent (Mamardashvili et al. 2013). The average contribution of para-agriculture in Germany is rather low with just about 6 per cent of the total farm revenue.

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	47,487	24,891	26,084	17,145	81,412	40,304
Output from para-agriculture (Y_2)	EUR	13,427	23,248	12,765	10,186	4,500	6,653
Variable costs (X_1)	EUR	39,245	15,040	20,172	9,942	44,934	19,790
Annual depreciation (X_2)	EUR	11,978	5,896	11,274	5,088	19,837	11,242
Labour units per farm (X_3)	AWU	1.56	0.44	1.59	0.56	1.59	0.56
Agricultural land (X_4)	ha	19.55	7.20	21.01	12.57	46.22	21.68
b.) Determinants of technical efficiency							
Share para-agriculture (z_1)	Per cent	0.19	0.20	0.34	0.20	0.06	0.10
Sum of environmental payments (z_2)	EUR/ha	599.0	436.8	455.4	147.1	309.4	81.7
Sum of other payments (z_3)	EUR/ha	1,375.0	549.7	277.6	154.4	189.3	110.3
Land-rent per hectare (z_4)	EUR/ha	502.1	381.4	147.6	93.7	141.3	83.7
Dummy for forest-revenue (z_5)	1/0	0.86	0.34	0.96	0.19	0.70	0.46
Gender female (z_6)	1/0	0.01	0.09	0.22	0.41	0.03	0.17
Dummy for alpine grassland (z_7)	1/0	0.11	0.31	0.41	0.49		
Height (z_{7a})	1/0					0.27	0.44
Animal-units per hectare (z_8)	AU/ha	1.10	0.35	1.08	0.32	1.32	0.46
Share of grassland-farming revenue (z_9)	Per cent	0.86	0.15	0.89	0.14	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.

5 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		509.10**		108.65
H[1]: No inefficiency[†] $\rho_j = 0, j = 0,1,\dots,29$	407.93**	407.93**	198.47**	3.84
H[2]: CD-production function $\rho_j = 0, j = 0,1,\dots,29$	117.28**	117.28**	42.55**	33.92
H[3]: Linear homogeneity (constant returns to scale) $\sum\beta_j = 1;\ \sum\beta_{jk} = 0\ for\ j = 1,2,3,4$	1,252.20**	1,252.20**	1,752.01**	11.07
H[4]: No Heteroscedasticity $\rho_j = 0, j = 1,2,\dots,19$	379.11**	379.11**	251.09**	26.30

Source: own calculations

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

Variable	Switzerland	Austria	Germany	Meta 1	Meta 2
α_0 Constant	0.1913***	0.3218***	0.1469***	0.4921***	0.6568***
α_1 Output para-agriculture	0.0913***	0.2965***	0.0310***	0.2522***	0.1852***
β_1 Variable Input Costs	- 0.6384***	- 0.6552***	- 0.4722***	- 0.5952***	-0.6180***
β_2 Depreciation (as Capital)	- 0.1420***	- 0.1344***	- 0.2298***	- 0.0989**	-0.0527
β_3 Labour-Units	- 0.1137*	- 0.0925**	- 0.3141***	- 0.0765	-0.0845*
β_4 Agricultural Land	- 0.1761***	- 0.0961***	- 0.1069*	- 0.1025**	-0.1284***
β_t Technical change	- 0.0233	- 0.0166	- 0.0091	- 0.0082	-0.0081
[…]	*The estimated results for the cross-terms are left out for simplification reason*				

Source: own calculation with sfamb (Holtkamp & Brümmer 2013) for OxMetrics 6.3 (Doornik & Hendry 2011),
*** / ** / * significant for p < 0.01/ 0.05 / 0.1

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 productivity in Austria and moderately in Switzerland (similar in Jan et al., 2010), which is also in accordance to the financial contribution of para-agriculture in Austria. In Switzerland, the contribution of para-agriculture is below the cost-share of 19 per cent. In general, the contribution of para-agriculture in Germany is rather low. A comparison with estimation results from conventional farms in Switzerland (using a similar model) shows that the contribution of para-agriculture is still higher in the organic sector: Mamardashvili et al. (2014) find an output-elasticity of 0.006. 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	0.7842	0.6242	0.4914
Austria	0.7598	0.7023	0.5450
Germany	0.8505	0.6425	0.5527

Source: own calculation
MTR-values are taken from the Metafrontier-model 2, which reduces the sum of squared deviations, see p.8

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, 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 Austrian' farmers define to a large extent the joint metafrontier, whereas there is a larger technology gap between Swiss and German farms and the metafrontier. Finally, the total efficiency TE*[10] shows, that there are just little efficiency differences between the three countries.

Taking into account the estimated results of the group-frontier, the results overall signal, that Austrian farms are more close in terms of the applied technology, but 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 the gap between both countries and Germany is rather pronounced.

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

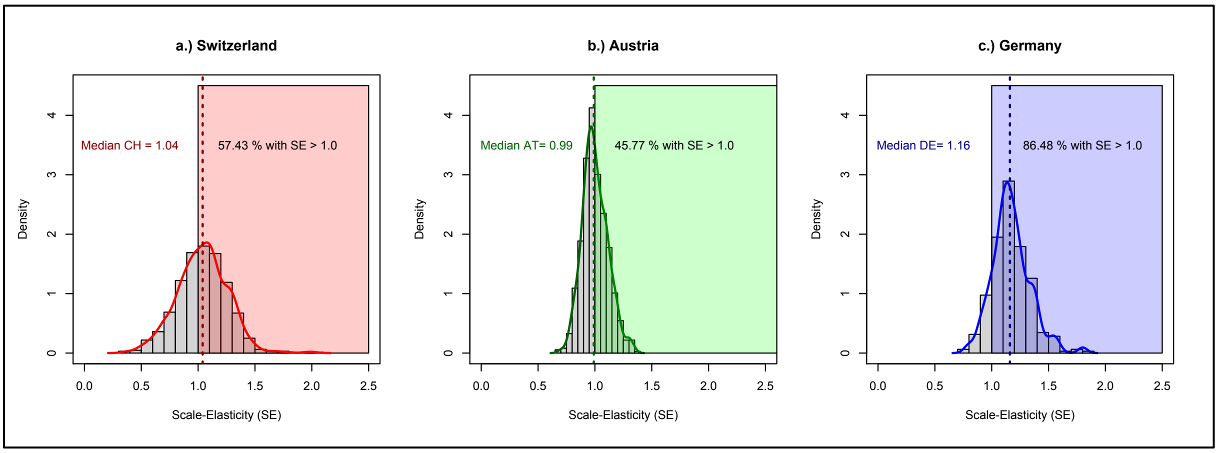

Figure 2: Returns to scale (RTS) on organic farms in Switzerland, Austria and Germany
<u>**Source**</u>: own calculation, number of observations in Switzerland: 639, in Austria: 732 and in Germany: 318.

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

The distribution clearly shows 86.5 per cent of the German farms work with increasing returns to scale. In Switzerland, farms rather work with constant returns to scale, about 57.4 per cent of the farms have returns to scale above 1.0. However, the test also rejects constant returns to scale. In contrast, Austrian farms work with slightly decreasing returns to scale: only 45.8 per cent of the farms have scale-elasticities above 1.0. Thus, the results show a potential for structural change mainly in Bavaria and Baden-Württemberg, whereas fewer farms in Switzerland and Austria could profit from farm growth.

The estimated results of the heteroscedasticity model are presented in table 5. The results of the variable share of para-agriculture shows, that obviously total farm efficiency decreases with an increased share of para-agriculture in Switzerland, which is in line with the results of Ferjani & Flury (2009) and Mamardashvili et al. (2014). The result in Germany is even more pronounced. The results of Austrian farms are in the opposite direction: Here para-agriculture contributes to a higher technical efficiency, which might be explained with the significance of these activities for Austrian farms. The effect of para-agriculture on technical efficiency in Switzerland and Germany can be interpreted in line with the expected effects of diversification: A more diversified farm in Swiss and Germany comes at the cost of a lower technical efficiency. On the one hand, para-agriculture contributes to farm revenue and therefore shows a stabilizing effect on the farm. This strategy is often also recommended for risk-averse farmers. On the other hand, farmers have to give up profits from specialization and work with lower levels of efficiency.

The impact of the direct payments is correlated with a lower efficiency in the three countries, and also the environmental payments in Germany and Switzerland 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. The amount of payments received from agri-environmental programs depends on the individual program choices of farmers: The more payments a farmer receives, the stricter the regulations and therefore, the lower the yields. Therefore, the efficiency-reducing impact might stem from combinations of different programs.

The impact of land-rent on technical efficiency is positive in Austria and Switzerland, which might reflect the quality of land. The impact of female farm-manager is positive in Switzerland and negative in Germany, however the share of female farmers in the data-set is very low, therefore the result has to be treated with caution. Farms in altitude above 600m have lower technical efficiency in Switzerland and Austria 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).

Table 5: Estimated parameters for the heteroscedasticity model

Variable	Switzerland	Austria	Germany
Share para-agriculture (per cent)	1.3212***	- 1.3875*	4.3546***
Environmental payments (EUR/ha)	0.5122***	0.0660	1.0757***
Other payments (EUR/ha)	0.4575***	0.2057***	0.5420***
Level of land-rent (EUR/ha)	- 0.1771**	- 0.1345**	- 0.1305
Existing forestry activity (0/1)	- 0.0880	0.2240	- 0.1909
Gender of farm manager (female = 1)	- 0.5689**	0.0692	0.7938***
Dummy for alpine grassland (0/1)	0.5145***	0.0706	
Altitude-zone of the farm (above 600 m = 1)			- 1.0553***
Land-use intensity (AU/ha)	- 2.7534***	- 0.5481***	- 0.8835***
Share of revenue grassland farming (per cent)	0.4044	- 0.5673***	- 1.1891***
[...]	*For simplification reason, not all coefficients of the model are presented*		

Source: own calculation with sfamb (Holtkamp & Brümmer 2013) for OxMetrics 6.3 (Doornik & Hendry 2011), *** / ** / * significant for p < 0.01/ 0.05 / 0.1

Note: 1) The estimated parameter capture the impact on inefficiency, therefore a negative (*positive*) parameter has to be interpreted as positive *(negative)* impact on efficiency. 2) In Germany we used a dummy for altitude level as $\boldsymbol{z_{7b}}$, since there were no information in the data-set, whether the farm would use alpine grassland.

6 Conclusions

The results mainly document the production and efficiency differences in the three countries. In relation to their own frontier, German farms show a slightly better result (TE of 0.85), followed by Switzerland (0.78) and Austria (0.76), which might reflect the larger heterogeneity in both countries in comparison to southern Germany, where most farms are not in mountain-regions. Contrary, the joint metafrontier seems to be mainly driven by Austrian farms (MTR of 0.70), followed by Germany (0.64) and Switzerland (0.62). Overall, the total efficiency is highest in Germany (TE* of 0.553) and Austria (0.545), whereas Switzerland (0.49) is laggings slightly behind. However, the three regions are quite close together – especially if we take into account, that no data-adjustments (like matching) were made with respect to the different farm structures in the three countries. So the results might also reflect structural differences in the three countries.

The results underline the importance of the concept of para-agriculture, especially for the farms in Austria, where the share of para-agriculture has a positive impact on farm technical efficiency and stabilized productivity and thereby farm incomes. Despite the fact that para-agriculture reduces technical efficiency in Switzerland, the impact of para-agriculture on farm income is also substantial (see table 4). In contrast to these findings, the impact of para-agriculture on farm income 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. On the other hand, diversification is increasing productivity, and thereby financial stability of farming in Austria and a bit weaker in Switzerland, which is also in line with Schilling et al. (2014). Therefore the concept also supports stability of pure farming Austria and Switzerland. This is in line with the more pronounced development of diversified agriculture in both countries.

The results presented here also 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. The impact of the coupled direct payments goes in line with the theoretical 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). The environmental payments are in a sense also coupled payments, since a high amount of environmental payments often reduces the output of a farm. Therefore, the result also documents the typical rent-seeking behaviour of farmers: Some farmers might focus their activities on optimizing their output, whereas other farmers rather seem to increase the sum of subsidies received – taking into account a reduced yield potential by agri-environmental program. A strong engagement into agri-environmental programs can also be regarded as a diversification, where a farmer is the producer of public goods in rural area, but at the costs of a reduced technical efficiency of the pure agricultural production.

However, the farm behaviour of increasing the output through participation in agri-environmental programmes is especially found in areas where the quality of land is low (see Darnhofer and Schneeberger (2007) for the case of Austria). In such areas, which are mostly alpine regions, the productivity of land and therefore the technical efficiency of the located farms is relatively low. This might lead to the fact that the impact on technical efficiency, which is attributed to subsidies, is biased and might partially reflect the unproductive location of the farm. Similar inferences can be found with regard to diversification, as diversification also correlates with the location of the farm (Bowman and Zilberman, 2013). This might explain the high amount of output from para-agriculture and environmental subsidies as well as the lower technical efficiency in Austria and Switzerland. In order to estimate unbiased effects, recent studies suggested to use matching techniques in combination with productivity analysis (Mayen et al., 2010; Sauer et al., 2014). This methodology is able to balance such disturbing variables Therefore, it will be one of the further tasks to include such methodology to control for the structural differences between the countries.

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Die Wurzeln der **Fakultät für Agrarwissenschaften** reichen in das 19. Jahrhundert zurück. Mit Ausgang des Wintersemesters 1951/52 wurde sie als siebente Fakultät an der Georgia-Augusta-Universität durch Ausgliederung bereits existierender landwirtschaftlicher Disziplinen aus der Mathematisch-Naturwissenschaftlichen Fakultät etabliert.

1969/70 wurde durch Zusammenschluss mehrerer bis dahin selbständiger Institute das **Institut für Agrarökonomie** gegründet. Im Jahr 2006 wurden das Institut für Agrarökonomie und das Institut für Rurale Entwicklung zum heutigen **Department für Agrarökonomie und Rurale Entwicklung** zusammengeführt.

Das Department für Agrarökonomie und Rurale Entwicklung besteht aus insgesamt neun Lehrstühlen zu den folgenden Themenschwerpunkten:

- Agrarpolitik
- Betriebswirtschaftslehre des Agribusiness
- Internationale Agrarökonomie
- Landwirtschaftliche Betriebslehre
- Landwirtschaftliche Marktlehre
- Marketing für Lebensmittel und Agrarprodukte
- Soziologie Ländlicher Räume
- Umwelt- und Ressourcenökonomik
- Welternährung und rurale Entwicklung

In der Lehre ist das Department für Agrarökonomie und Rurale Entwicklung führend für die Studienrichtung Wirtschafts- und Sozialwissenschaften des Landbaus sowie maßgeblich eingebunden in die Studienrichtungen Agribusiness und Ressourcenmanagement. Das Forschungsspektrum des Departments ist breit gefächert. Schwerpunkte liegen sowohl in der Grundlagenforschung als auch in angewandten Forschungsbereichen. Das Department bildet heute eine sehr aktive Einheit mit international beachteten Forschungsleistungen.

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