Modelling technical progress in Alpine farming

J. Kantelhardt, M. Kapfer, S. Kirchweger and M. Franzel[1]

***Abstract* - Mountainous agriculture is often shaped by unfavourable conditions. Therefore it is - in comparison to flatland agriculture - extraordinarily expensive to implement new technologies and to modernise farms. Consequently our research hypothesis is that technical progress in mountainous regions is slower than in flatland regions. To test this hypothesis we have developed a model combining the approach of a Malmquist Total Factor Productivity index and a Matching analysis. We apply our model in Austria, using a panel data set of 1,034 Austrian voluntary-bookkeeping farms and ranging from 2003 to 2009. According to the Austrian Mountain Farm Cadastre the farms are classified into five categories, expressing the degree of disadvantage which farms are exposed to from being located in a mountainous area. Our results show that technical change is on average significantly lower the more disadvantageous the site conditions are. But the more profound analysis using the Matching approach shows that the Malmquist TFP model analysis is mainly driven by a comparatively high grassland share of mountainous farms, while other factors such as farm size are of minor importance.**

INTRODUCTION

Site conditions for Austrian agriculture are very heterogeneous. In particular, the difference between mountainous areas and flatland areas is of high relevance for Austrian agriculture. In comparison to flatland agriculture, mountainous agriculture in general is characterised by small plot sizes, unfavourable climatic and soil conditions and steep slopes. Therefore it is extraordinarily expensive to implement new technologies. Consequently, our research hypothesis is that technical progress in mountainous regions is slower than in flatland regions.

METHODICAL FRAME AND DATA BASIS

In order to answer this question we combine a Malmquist Total Factor Productivity (TFP) index model with a Matching analysis. The TFP index analysis is based on Data Envelopment Analysis, a method originally developed by FARELL (1957). DEA allows the calculating of technical efficiency of farms by comparing their own input-output ratio to the input-output ratio of the best farms. In the Malmquist TFP index analysis, DEA results are calculated for several years and the development of the overall frontier (technological change), of the technical efficiency of each single farm (efficiency change) and of the combination of both – the so-called Total Factor Productivity (TFP change) – is depicted.

As a second step, we match the results of the Malmquist TFP model. Matching goes back to the work of Rubin (1977). It allows determining farms located in mountainous areas (of different levels of disadvantage) and farms in flatland regions which are comparable with regard to structural aspects (such as farm size). In our case, we use farm size (UAA) and percentage of grassland as matching variables, since our assumption is that these represent the most important structural differences. As a matching procedure, we apply nearest-neighbour calliper matching with replacement (Sekhon, 2009).

We apply the model on an Austrian farm panel data set. The set comprises data from 1,034 Austrian voluntary-bookkeeping farms and range from the years 2003 to 2009. In order to ensure a principal comparability of farms, we consider only cash-cropping, forage, pig and poultry and mixed farms, and we exclude other farm types such as permanent crop and gardening farms.

Table 1 gives an overview of the data set and shows means and coefficients of variation.

Table 1. Mean (and coefficient of variation) of selected input and output variables.

	BHK 0	BHK 1	BHK 2	BHK 3	BHK 4
No. farms	406	218	280	87	43
UAA [ha]	26 (0,88)	31 (0,96)	29 (0,70)	42 (0,93)	38 (0,88)
Labour [WU]	1,6 (0,39)	1,6 (0,37)	1,6 (0,35)	1,7 (0,29)	1,4 (0,41)
Capital assets [€]	214.748 (0,62)	279.942 (0,72)	281.941 (0,60)	264.587 (0,52)	233.058 (0,61)
Financial expense [€]	38.325 (0,89)	30.108 (0,65)	27.310 (0,62)	22.276 (0,59)	16.979 (0,63)
Revenue [€]	64.965 (0,78)	55.153 (0,61)	50.275 (0,60)	41.391 (0,59)	29.819 (0,71)

Annotation: all numbers refer to the year 2003

As shown in table 1 we use as input indicators for our calculations the UAA (ha), financial expenses (€), capital assets (€) and labour (working units/WU). Farm revenues (€) serve as output indicator. All monetary values are deflated. As a basis for the classification of farms with regard to their belonging to the mountainous area, we use the Austrian Mountain Farm Cadastre (Berghöfekataster, BHK). It estimates the degree of disadvantage which farms experience from being in a mountainous area. The cadastre classifies mountain farms into four categories and is calculated on the basis of the following indicators (the percentage in brackets indicates the respective relevance of the factor for the calculation of the BHK degree): steepness of slopes

[1] All authors are from the University of Natural Resources and Applied Life Sciences Vienna, Institute of Agricultural and Forestry Economics, Vienna, Austria (jochen.kantelhardt@boku.ac.at).

(49%), accessibility (18%), temperature (9%), sea level (9 %), soil fertility (9%) and average plot size (7%).

RESULTS

The technical-change values which we obtain can be interpreted as the efficiency increase that the most efficient farms in our sample realised in the observed period. As Table 2 shows, we observe that the technical change of mountain farms is significantly lower than the technical change of flatland farms. This means that the less disadvantageous agricultural site conditions are, the more the DEA frontier shifts outwards. If we now understand the DEA frontier as state-of-the-art technology and the shift of the frontier as the velocity of the technical progress, one can say, that in comparison to mountainous agriculture, flatland farming systems benefit from a faster technical progress.

Table 2. Mean technical efficiency change, technical change and total factor productivity change.

	BHK 0	BHK 1	BHK 2	BHK 3	BHK 4	sign.
Technical change	1.037	1.036	1.031	1.026	1.021	***
Efficiency change	0.967	0.974	0.975	0.983	0.977	-
Total factor productivity change	1.003	1.009	1.005	1.008	0.997	-

Kruskal-Wallis-H-Test; Sig.: *<0,05; **<0,01; ***<0,001

Following on from that idea, one may also think about the ability of the "average farm" to follow technical progress. If we consider that the implementation of new technologies is costly, one can conclude that it will be increasingly difficult for an average farm to follow the technical progress the quicker the technical progress takes place. With regard to our analysis, this would mean that a quick technical change should be accompanied by a small change in total-factor productivity. However, we do not find any significant results with regard to TFP change, so we cannot prove this thesis. Furthermore, there are no significant differences between the various BHK groups with regard to efficiency change.

A simple comparison of the different BHK groups is not sufficient, as other attributes beside the degree of disadvantage may influence the technical change and consequently a naïve comparison of treated and non-treated units may lead to biased results: e.g. there might be a faster biological technical progress in crop farming than in husbandry. According to the design of the TFP model, it is not possible to determine whether the difference in technical change results from the degree of disadvantage or other farm-specific attributes which correlate to the location of the holding.

In order to cope with this problem we match the results of the Malmquist TFP model as a second step. As Table 3 shows, the detected differences with regard to technical change disappear and lose significance. This applies in particular if we match with regard to farm grassland share, while farm size is of minor importance. These results indicate that the reduced rate of technical change depends on being forced to cultivate a comparatively high share of absolute grassland rather than on the circumstance of being located in a mountainous area.

Table 3. "Naïve" and "matched" comparison of BHK 0 and BHK … results with regard to technical change.

	BHK 1	BHK 2	BHK 3	BHK 4
Naïve comp.	-0,001	-0,006**	-0,012***	-0,017*
Matched comp.				
LF	-0,002	-0,005***	-0,008**	-0,012**
%DF	0,002	-0,002	-0,001	-0,008
LF+%DF	0,003	-0,003	-0,003	-0,004

Mann-Whitney-U-Test; Sig.: *<0,05; **<0,01; ***<0,001

DISCUSSION AND CONCLUSIONS

Our results show that the technical change in Austrian agriculture is on average higher the less disadvantageous the site conditions are. However, we cannot prove the thesis that in regions with low technical progress farms can easier implement technical change whereas in regions with high technical progress a segregation of farms into two groups takes place: into a group of farms which determines technical progress and into another group which cannot follow this development. With regard to this point, it should be pointed out that our model only allows us to get a first insight. In order to get to more reliable results, a deeper analysis of each BHK group is necessary. A possible track would be to calculate for each BHK group a separate TFP model. However, the challenge of such an approach is how to compare the resulting efficiency change rates.

With regard to the applied methodology we conclude that the Malmquist TFP index approach is a suitable way to analyse the technical change of farming systems. The method becomes particularly valuable when it is combined with Matching. In our case the combination of the two methods allows an in-depth analysis of the factors driving the differences in technical progress between the BHK groups. Consequently we plan to continue to work with this integrated approach. However, in order to get results which are closer to production and more independent from current market developments, we plan to adapt our model by including production-related non-monetary input and output variables. Another challenge is to deal with random variations in yields, which have a high influence in plant production but not in animal husbandry.

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