How "efficient" are dairy farms in mountain areas?

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Paper prepared for presentation at the 12th EAAE Congress
'People, Food and Environments: Global Trends and European Strategies',
Gent (Belgium), 26-29 August 2008

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Abstract— **Pure Technical Efficiency scores of Austrian dairy farms are estimated econometrically on the basis of data envelopment analysis and bootstrapping. In a second stage, using the same assumptions on the distribution of error terms, the distances of farms to their production possibility curve are estimated as functions of farm attributes. Since some of these attributes refer to natural conditions which are more or less unfavourable, the farms in the sample are facing individual frontiers. The distinction between sectorial and individual frontiers gives rise to a distinction between “overall” and “firm-level” efficiency. Using overall efficiency for the calculation of possible savings from a move to the frontier will overestimate these savings and underestimate the efficiency of a farm relative to the conditions in which it operates.**

Keywords— **DEA, efficiency, dairy farms**

I. INTRODUCTION

Since price support for milk has been decoupled in recent years in the EU, dairy farms in Austria are particularly at risk of survival because 70 % of them are located in mountainous areas and are fairly small. Although they are receiving less favoured area payments, this may not suffice to secure the maintenance of agricultural landscapes in Alpine regions if milk quotas are abandoned as expected in 2015. The aim of this study is to explore the extent of disadvantages of dairy farms in mountainous areas which are beyond the control of the farm managers.

II. MATERIALS AND METHODS

A. Methodology

Stochastic Frontier Analysis (SFA) has become the favoured method to estimate efficiency scores in recent years. But a more appropriate method which does not impose a functional form a priori has been proposed by Simar and Wilson [1] based on Data Envelopment Analysis (DEA). They use bootstrapping to produce pseudo efficiency scores from estimates of their initial distribution and use them to mimic the data generating process. Applying DEA to these data for a sufficient number of samples, they produce the corresponding number of estimates of distances to the frontier and, accordingly, their confidence intervals [2,3].

Simar and Wilson [4] demonstrated that truncated regression with appropriate assumptions on the distribution of error terms can be used consistently in a second stage to explain for what reasons the distances δi estimated in the first stage differ. The second stage relationship is specified as:

$$\ln(\delta i) = z_i'\beta + \varepsilon_i \geq 1 \quad (1)$$

where

z_i is a vector of attributes

β is a vector of coefficients

ε_i is distributed $N(0,\sigma^2)$ with left-truncation at $1- z_i'\beta$

We assume variable returns to scale technology and input orientation. The regression parameters are estimated using bias-corrected estimates of the distances through maximisation of the likelihood function. The software has been made available by Wilson [5].

B. Data

The data for the analysis originated with voluntary participation of farmers in the Farm Accounting Data Network (FADN). We select 222 farms on the basis of their average data for the years 2001 through 2003 such that their standard gross margin (SGM) originates to at least 75 % from forage cropping, their SGM from milk production exceeds that from cattle fattening, their revenues from diversification and from cash crops are less than 10 % of overall revenues, respectively, and their livestock herd is composed of at least 95 % by cattle.

All production inputs and all types of revenue of the farms are taken into account and measured by five input and two output variables as shown in table 1.

Data on attributes which were found to condition the level of pure technical efficiency of dairy farms are presented in table 2. Other attributes and ranges of the variables used can be found in [6].

Mountain farm cadastre points (MFP) are an indicator of the level of disadvantage of a farm, measured by the sum of points obtained in the following categories: steepness of slopes (49 %), accessibility (18 %), temperature, sea level and soil fertility (9 % each), and plot size (7 %). They determine the amount of compensatory allowance (a direct payment) per farm in the Austrian less favoured area scheme.

Table 1 Outputs and inputs of 222 specialised Austrian dairy farms

Item	Unit	Mean of all farms	Mean of mountain farms
Milk production (net)	t	104.318	100.189
Other revenue	1000 €	17.339	17.432
Revenue milk & cattle	1000 €	44.176	42.731
Labour	AWU[1]	1.852	1,878
Farmland	ha	22.040	22,705
Cattle	LU[2]	30.680	30,101
Expenditures husbandry	1000 €	13.010	12.798
Expenditures machinery	1000 €	13.360	13.200
Other expenditures	1000 €	17.800	17.596

1 Annual work unit
2 Livestock unit

Table 2 Farm and farmers' characteristics of specialised Austrian dairy farms

Item	Unit	Mean of all farms	Mean of mountain farms
Flat[1]	Dummy	0.239	0
Mountainous[1]	Dummy	0.761	1
Mountain farm cadastre points (MFP)	10 pts	8.448	11.098
Standard gross margin (SGM)	1000 €	25.680	25.064
Household size	Persons	6.941	7.112
Share of grassland	%	75.328	76.759
Milk quota / SGM	t/100 €	0.384	0.378
Age of farm manager	Years	46.620	47.249
Off-farm activity[2]	Level	0.207	0.183

1 Regression constant (1=true, 0=false)
2 0=none, 1=part time, 2=retired farm manager

III. RESULTS

Technical efficiency (TE) of the specialised Austrian dairy farms was 72.3 % on average. Scale efficiency (estimated by DEA) contributed 6.4 % to the overall technical inefficiency. Small farms were less likely to be scale efficient.

Table 3 shows the estimated regression parameters and their t-statistics (t(bi)=bi/s(bi)) of nine increasingly accurate models. Variables with abs(t(bi))<1 were dropped from the regression; accordingly, impacts on PTE of the sea level, organic farming, and the level of education and training of the farm manager could not be confirmed. However, mountain farming reduces PTE in comparison with the best farms in the sample significantly. The production possibility frontier of these farms differs by the difference between the coefficients of the regression constants and the term b_{MFP}*MFP.

IV. DISCUSSION

Model 2 gives the highest estimate of the impact of location. Since it does not feature other explanatory variables which do contribute to technical inefficiency and are correlated with MFP, the impact of these variables is partly captured by the coefficients on those variables which indicate mountain farms, resulting in what may be called the "overall impact of location" displayed in Figure 1.

If we consider only the marginal effect of location, the attainable PTE frontier for mountain farms moves to the line "ceteris paribus effect of location" in Figure 1. This model accounts for the effects on PTE of operating in mountain areas which cannot be attributed to inefficiency of management and other factors by which farms differ.

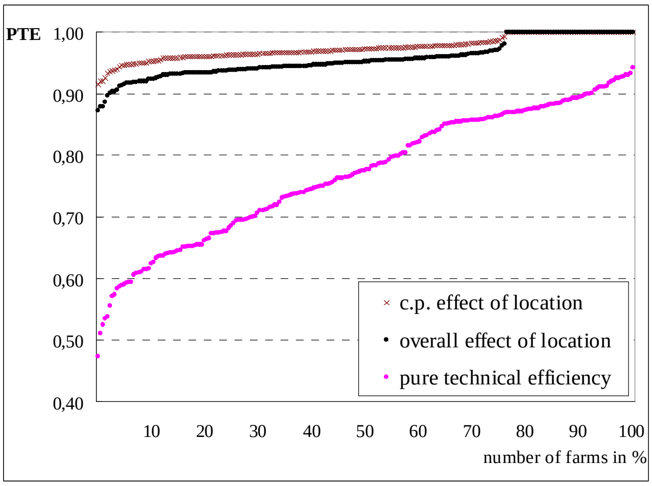

Fig. 1: Distribution of mountain farm effects on pure technical efficiency of Austrian dairy farms

Table 3 Estimated parameters of second stage truncated regression models

Variable i	Flat		Mountainous		MFP		MQ/SGM		Household size	
Model	bi	t(bi)	bi	t(bi)	bi	t(bi)	bi	t(bi)	bi	t(bi)
1*	0.21262	9.82	0.21262	9.82	0.00432	2.40				
2	0.20466	7.34	0.22380	7.01	0.00353	1.44				
3	0.51507	11.32	0.52681	11.11	0.00218	1.04	-0.75032	-7.09		
4	0.42771	8.62	0.42902	8.22	0.00208	1.04	-0.75921	-7.47	0.01449	3.52
5	0.49979	6.42	0.50823	6.04	0.00189	0.94	-0.76944	-7.55	0.01263	2.89
6	0.48518	8.07	0.48471	7.86	0.00275	1.35	-0.76042	-7.56	0.01337	3.25
7	0.44207	8.86	0.43841	8.42	0.00230	1.15	-0.75695	-7.47	0.01380	3.37
8	0.50322	6.49	0.51200	6.10	0.00213	1.06	-0.85758	-7.08	0.01191	2.73
9	0.46483	5.89	0.47188	5.54	0.00249	1.24	-0.78661	-7.77	0.01125	2.58

Variable	Age		Grassland		Off-farm		Milk quota, *SGM		ε	
Model	bi	t(bi)	bi	t(bi)	bi	t(bi)	bi	t(bi)	s(ε)	T
1									0.16201	14.98
2									0.16195	14.98
3									0.14032	16.39
4									0.13573	16.67
5	-0.00126	-1.20							0.13523	16.71
6			-0.00071	-1.67					0.13473	16.73
7					-0.04261	-1.88			0.13471	16.74
8	-0.00120	-1.14					0.00299	1.40	0.13454	16.75
9	-0.00118	-1.14					0.00170*	2.02	0.13382	16.80

V. CONCLUSIONS

Recent advances in econometrics established that DEA can be used to estimate confidence intervals for efficiency scores and to use their estimates in a second stage consistently to estimate what causes deviations from the efficient frontier. As the PTE frontier depends on variables which differ by firm, it is possible to draw a distinction between firm-level and sector-level efficiency. The first one is more appropriate to determine the level of possible savings.

Some firms may not be able to attain sector-level efficiency f. i. because they operate under unfavourable natural conditions or they are subject to regulations which place them at a disadvantage relative to other firms. Accordingly a distinction can be drawn between “overall” (sectorial) and “firm-level” pure technical efficiency. The latter is more appropriate to evaluate the performance of a firm given the circumstances in which the firm operates which are beyond the manager’s control.

The present study confirms these prepositions for Austrian dairy farms in mountainous areas. At the current distribution of milk quotas and farm sizes, the attainable pure technical efficiency frontier for these farms is shown in Figure 1 as “overall effect of location”. This frontier results from model 2 and takes account of all disadvantages which mountain dairy farms in Austria are facing.

Some of their attributes are not necessarily associated with them being mountain farms, f. i. the milk quota and the farm size distribution, the age of the operator and the size of her/his household. If they were adjusted to optimal levels, the attainable frontier would be the line called “c.p. effect of location”. The gap between this and the PTE line is due to firm-level inefficiency.

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