Analysing the joint ecological and economic performance of Swiss dairy farms located in the mountainous region with a non parametric approach

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***Abstract* – Promoting an environmentally friendly and economically efficient agriculture is one major objective of the Swiss agricultural policy. In this article we assess and analyse the joint ecological and economic performance of a sample of 327 dairy farms located in the mountainous area with the Data Envelopment Analysis (DEA), a non parametric efficiency measurement technique. Based on two DEA assessments (one for the ecological efficiency and the other for the economic efficiency), we classify the farms in nine groups according to their joint ecological and economic performance (low, medium, high for each category). The results show that good economic performance and good ecological performance are not antinomic. Accordingly, they suggest that the cost saving attitude of the farm manager might be *inter alia* one of the most important keys to a good joint ecological and economic performance.[1]**

INTRODUCTION

The dairy farms located in the mountainous area, which includes the mountainous zones 2, 3 and 4, are not only important for the Swiss dairy sector, as they generate one third of the Swiss milk production (FOAG, 2006) but also play a major role in the conservation of national resources, the maintenance of rural scenery and the decentralised inhabitation of the country. These latters are three objectives assigned by the Swiss legislator to the Swiss agriculture (Swiss Federal Constitution, Art. 104). Promoting a sustainable agriculture, as stipulated by the Swiss Federal Constitution, requires a thorough knowledge of the joint ecological and economic performance of these farms based on a large sample. This knowledge is missing at the moment. The aim of this study is to assess the joint ecological and economic performance of Swiss dairy farms located in the mountainous area. We focus on the following questions: What is the relationship between ecological and economic performance? Can good ecological and good economic performance go hand in hand? Do farms, that are ecologically and economically highly efficient, differ from the other farms?

DATA AND METHODS

Performance is understood here as the relative efficiency of a farm in its inputs' use to produce its outputs compared to the other farms. The ecological and economic efficiency are calculated using Data Envelopment Analysis (DEA), a non parametric efficiency measurement technique. Using linear programming methods, it constructs a piece-wise production frontier over the data and measures then the efficiencies of farms relative to this estimated frontier. The efficiency of a farm is determined, in case of a constant return to scales and input orientated model, by solving the following linear programming problem (Coelli et al., 2005):

$$\min_{\theta,\lambda} \theta,$$

$$\text{subject to}: -q_i + Q\lambda \geq 0$$

$$\theta x_i - X\lambda \geq 0$$

$$\lambda \geq 0,$$

where $\mathbf{q_i}$ is a column vector representing the M outputs of the firm i (i=1, …, I)

$\mathbf{x_i}$ is a column vector representing the N inputs of the firm i

$\mathbf{X}$ being the N x I input matrix

$\mathbf{Q}$ being the M x I output matrix

θ being the efficiency score of the firm i

λ being a I x 1 vector of constants representing the weights associated with each firm. If the weight is different from zero, then it means that the firm associated with this weight is a peer (firm, which defines the efficient production frontier for the firm i examined).

In the present case, for the ecological efficiency, the primary energy demand (in MJ), as defined by Gaillard et al. (1997), and the nitrogen input (in kg N) are used as inputs and the amount of milk produced (in kg) is used as output. Further details on the method of assessment of the primary energy demand and of the nitrogen input can be found in Jan et al. (2008). For the economic efficiency, the usable agricultural area (in ha), the capital without land (in Swiss Francs) and the labour (in Annual Work Units) are used as inputs and the value added (in CHF) as output. The study is based on a sample of 327 dairy

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farms located in the mountainous zone two. These cross-sectional data (year 2006) originates from the Swiss Farm Accountancy Data Network. In order to have a sample of farms with homogenous natural production conditions we choose only farms of the mountainous zone two. Based on the ecological and economic efficiency scores, we make three classifications. In the first one, farms are classified in three groups according to their ecological performance (EcolLow: farms of the first tercile, EcolMedium: farms of the second tercile, EcolHigh: farms of the third tercile). In the second one, farms are classified in three groups according to their economic performance (EconLow: farms of the first tercile, EconMedium: farms of the second tercile, EconHigh: farms of the third tercile). Based on these two classifications, a typology of nine types is built according to the joint ecological and economic performance of each farm. The differences between the group "EcolHigh+EconHigh" (G1) and the other remaining farms (group "notG1") with regard to the structural characteristics of the farms, the features of the farm operative management and the sociologic characteristics of the farm managers are analysed using the Chi-Square Test for categorical variables and the Mann-Whitney Test for continuous variables.

Results

There is no statistically significant correlation between the ecological and the economic efficiency scores ($p=0,30$). The distribution of farms according to their joint ecological and economic performance is shown in Table 1. The farms are almost equally distributed between the nine groups.

Table 1. Distribution of farms according to their joint ecological and economic performance

Group	Ecological Performance	Economic Performance	Proportion of farms
G1	EcolBest	EconBest	10%
G2	EcolBest	EconAverage	12%
G3	EcolBest	EconWorst	11%
G4	EcolAverage	EconBest	12%
G5	EcolAverage	EconAverage	10%
G6	EcolAverage	EconWorst	11%
G7	EcolWorst	EconBest	11%
G8	EcolWorst	EconAverage	12%
G9	EcolWorst	EconWorst	11%

The G1 and notG1 significantly differ from each other with regard to the structural characteristics of the farms and the features of their operative management. The agricultural income per family annual work unit is significantly higher in the G1 than in the notG1 (54'687 vs. 33'566, $p<0,001$), implying that full time farms are more represented in the G1 than in the notG1. The farms of the G1 produce on average more milk than the farms of the notG1 (126'323 kg vs. 93'197 kg, $p<0,001$). The proportion of land in own property is higher for farms of the notG1 than for those of the G1 (66% vs. 51%, $p<0,01$). The milk production intensity is higher for the G1 than for the notG1 (5'622 vs. 4'609 kg per ha, $p<0,001$). The milk yield per cow and year is also higher for the G1 than for the notG1 (6'393 vs. 5'964 kg, $p<0,1$). Despite higher milk yields per cow, the farms of the G1 presents significantly lower costs for concentrates (9,4 vs. 11,6 CHF cents per kg of milk produced, $p<0,1$) and lower costs for veterinary products and services (2,5 vs. 4,2 CHF cents per kg of milk produced, $p<0,001$) than the farms of the notG1. The average culling rate of the farms of the notG1 is much higher than the one of the farms of the G1 (37% vs. 29%, $p<0,1$). The ratio "intermediate consumptions / total gross profit" is significantly lower for the G1 than for the notG1 (38% vs. 47%, $p<0,001$). Concerning sociological characteristics of the farmers (age and agricultural education), the two groups do not significantly differ from each other.

Conclusions

The results clearly show that ecological and economic performance are not antinomic and that they can go hand in hand. The farms that are efficient from both an economic and ecological point of view, are rather intensive and big farms. The managers of these farms show very good technical management skills as attested by their outstanding herd management performances. The results suggest that a "cost saving" attitude and especially an extreme parsimonious and efficient use of farm inputs might be *inter alia* one of the most important keys to a good joint ecological and economic performance. Promoting the cost saving behaviour of farm managers should be a promising way to increase both the ecological and economic performance of these farms. The promotion of structural change and full-time farming should also be helpful in this regard. One limit of the present study is that it considers the ecological performance only from an efficiency perspective. However, an environmentally friendly farm is not only a farm which is using its ecological resources in the most efficient way but also a farm whose environmental impacts do not exceed the carrying capacity of the local ecosystem.

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