The influence of landscape on farms' economic efficiency – combining matching and DEA approaches in Styria, Austria

Jonathan Lenglet[a]*, Martin Franzel[b], Stefan Kirchweger[b], Martin Kapfer[b], Lena Schaller[b], Jochen Kantelhardt[b]

[a] Department of Social Sciences, Economics and Management, AgroParisTech, 16 rue Claude Bernard F-75231 Paris Cedex 05, France, Tel: +33.14408.1661

[b] Institute of Agricultural and Forestry Economics, University of Natural Resources and Applied Life Sciences Vienna, Feistmantelstr. 4, 1180 Vienna, Austria, Tel: +43.147654.3355

Contributed Paper prepared for presentation at the 88th Annual Conference of the Agricultural Economics Society, AgroParisTech, Paris, France

9 - 11 April 2014

*Jonathan Lenglet, AgroParisTech, 16 rue Claude Bernard F-75231 Paris Cedex 5.
E-mail : jonathan.lenglet@agroparistech.fr

Abstract

The provision of commodities for feed, food and energy production is the main task of the agricultural sector but it is obvious that agriculture is also essential for the viability of most rural areas. Although the consequences of agriculture on the landscape are extensively described, the reverse is less documented. The objective is therefore to assess the efficiency of agricultural holdings in order to establish correlation between the purely economic factors and the landscape aspects. The study region "Mittleres Ennstal", is located in the north-east of Styria in Austria. We apply a matching approach to obtain reliable data, then, a data Envelopment Analysis (DEA) is performed, followed by a second stage for interrelations analysis. Two databases supported by the European Commission were used: the IACS and the FADN. This chain process aims to provide sufficient data and allow performing an economic analysis in a proven framework. It enables us to establish ties between agricultural efficiency and the landscape and, to quantify the impact of the landscape on the competitiveness. The results show that the considered landscape features have no first order effect on the farms' economic efficiency. However, it does not mean that agriculture and landscape are not linked together.

Keywords Landscape, Economic efficiency, Second stage DEA, Matching

JEL code Q15

Introduction

Agriculture is an important driver for the rural development and economy. As one of the first providers of goods and services, the agricultural sector is essential in most rural areas. Although the main aim of agriculture is to produce feed, food and energy, numerous other ecosystem services are involved. Agriculture act as a regulator in various fields such as carbon sequestration, erosion processes, moderation of natural hazards or water treatment. Therefore it is clear that this sector is highly integrated and interacts strongly with its environment. Thus, we are entitled to wonder what would be the bonds linking the agricultural efficiency and the landscape. Indeed, the landscape and its components are significant assets which can affect economic and territorial development. If some factors have an obvious impact on agricultural production (e.g. topography), others may have more subtle and complex consequences. Even if some evidences can be envisaged, there is currently a lack of quantitative results in the literature.

This study focuses on economic farm efficiency. The objective is therefore to assess the efficiency of agricultural holdings in order to establish correlation between the purely economic factors and the landscape aspects. The study region, called “Mittleres Ennstal”, is located in the north-east of Styria in Austria. Since this area is rather small, the data are not available for each farm and a matching procedure was needed. Then, the well-known Data Envelopment Analysis method (DEA) was used, followed by a second stage correlation analysis. This chain process aims to provide sufficient data and allows performing an economic analysis in a proven framework. The general purpose of this study is to understand which aspects of the landscape can influence the agricultural competitiveness in a subalpine context.

The CLAIM project

This study is part of a wide, collaborative project co-funded by the Seventh Framework Programme of the European Union. Ten research partners from different parts of Europe are involved and aim to “support the role of the Common agricultural policy in LAndscape valorization: Improving the knowledge base of the contribution of landscape Management to the rural economy” (CLAIM). The objectives are complex and involve diverse areas of research such as economics, agriculture, social sciences and public policy. One of the first and fundamental assumptions is the existence of a causal loop between society and landscape, each impacting the other. This way, it is assumed that the landscape is an important contributor to society’s welfare.

Three main issues are considered in order to provide an evidence-based policy support framework. The first one considers the question of landscape and development, the second one, landscape and competitiveness and the last one includes the role of the Common Agricultural Policy (CAP), methodologies and mechanisms. This study is part of an intermediate objective focusing on agriculture competitiveness, that is to say, the second issue. This subsection helps to understand to what extent the landscape can be seen as a driver for competitiveness of the agricultural sector in rural areas.

Landscape definition

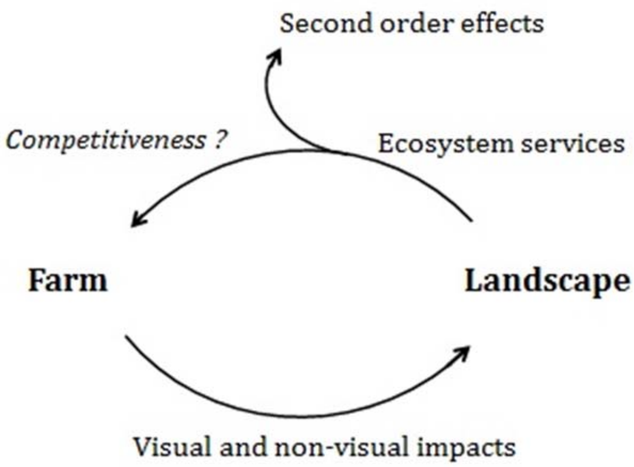
The notion of landscape is a key principle in this study, however, this term can be hard to define. Definitions of landscape are various and sometimes even divergent. According to the Oxford dictionary, the landscape consists in “all the visible features of an area of land”. This definition is broad in scope and, at the same time, rather restrictive because of the visible aspect. In the context of an economic study, this definition needs to be specified. Another interpretation is given by the European Landscape Convention. The landscape is here defined as “an area, as perceived by people, whose character is the result of the action and interpretation of natural and/or human factors”. The focus is now on how people understand and identify the whole area. It may involve implicit ideas such as goods production or services. By being more specific, we can also concentrate on the agricultural landscape. Kapfer et al. (2010) defined the cultural landscape as the “visible features of an area of land, determined by natural conditions such as climate, geology and geomorphology and types of vegetation – as well as human influences”. This put technical words on the first definition and makes clear the relationship between landscape and agriculture.

The impact of agriculture on the landscape has been studied extensively (Harms et al., 1987; Skinner et al., 1996; Wascher, 2003; Kurashige, 2003; Kapfer et al., 2010). The agricultural practices depend on the site conditions but also on the economic and social situation. Usually, the farmers adjust their farming habits in response to market demands, transforming, in the same time, the landscape appearance. It is obvious that wheat or maize grown as monoculture, and grazing dairy cows have contrasting visual impacts. Furthermore, some cultural practices also impact non-visible aspects of the landscape, such as soil fertility or biodiversity (McLaughlin and Mineau, 1995; Tilman, 1998; Reidsma et al., 2006). Although the consequences of agriculture on the landscape are clearly defined, the reverse is less documented.

It is also important to note that landscape is not only an inert production medium. Since the Millennium Ecosystem Assessment in 2005, the concept of ecosystem services is widely recognize (Fisher et al., 2009). These services are of different nature, some are environmental regulators, others have cultural and amenity values. The landscape provides raw materials such as food, fibers or water but it is also responsible for air quality, climate and biological regulation. It offers habitat for many species and inspiration for culture, science or religion (de Groot et al., 2010). Additionally, all these public goods also generate a series of second order effects. They can be seen as indirect consequences of the landscape management on the society. They relate to different socio-economic aspects such as tourism, employment, culture or environmentally sustainable food products (Cooper et al., 2009).

Although our study focuses on landscape impact on farms efficiency, it is important to bear in mind that the landscape is at the interface of multiple disciplines. It is a complex network of connections, one of those being related to agriculture. As a result, it is impossible to completely disconnect agriculture from all other landscape components. A simple representation of the interactions between agriculture (farms) and the landscape is given in a form of a loop in Figure 1.

Figure 1. The cause and effect loop between agriculture and landscape.



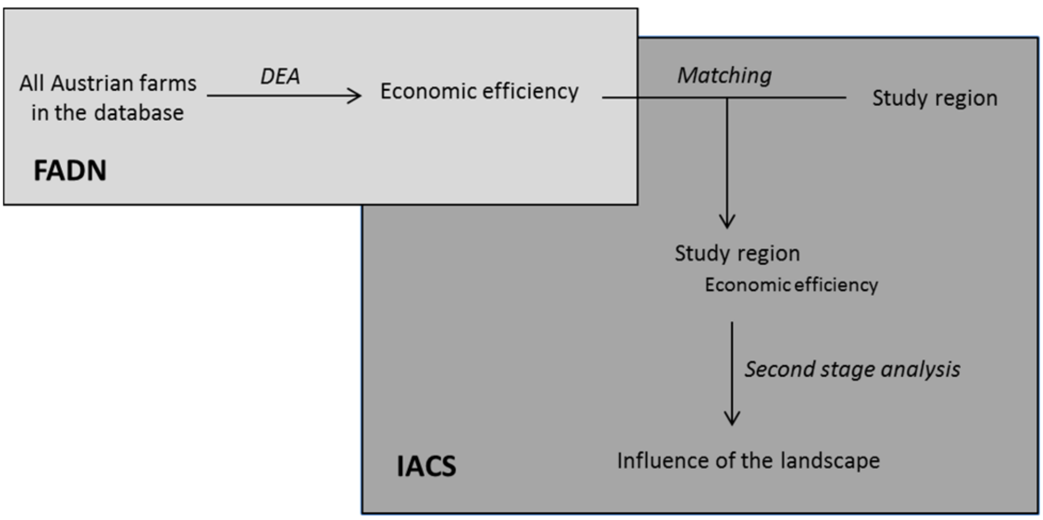
Study region

The region considered is this study corresponds to the third case study of the CLAIM project: CSA3 “Mittleres Ennstal”. This small region covers only 252.18 km^2 and is located in the north-east of Styria, in Austria. The area is mostly rural and consists of four small municipalities: Aigen, Oppenberg, Pürgg and Stainach. This is a typically mountainous (Alpine foothill) territory which extends from 640 to 2351 meters high. The average temperature varies between 5.6 and 7.3°C and the yearly precipitations range from 549 to 719, which is slightly below the Austrian average. As this area is mainly rural, farming and forest management are largely responsible for the landscape shape and evolution. As in many mountainous regions, land use practices are strongly determined by elevation and topography. The lower parts, namely the valleys, are characterized by the presence of grass- and arable land, while the highly elevated areas consist of forests and pastures. This specific region encompasses, therefore, most of the local farming practices.

Material and methods

Different data sources were used to conduct the analysis. First, data from the Integrated Administration and Control System (IACS) were used to proceed with the matching. This database was created and developed by the European Commission as a tool for managing of farmers' applications. The second database is called Farm Accounting Data Network (FADN) and is also developed by the European Commission. The FADN is a powerful tool to evaluate the income of agricultural holding and hence to determine farm efficiency. Since bookkeeping data are not available for all farms, a matching approach was required. Indeed, FADN data stands only for a limited number of farms in Austria. Conversely IACS data are available for almost every farm, so that we can spot the similar ones. Then, it is assumed that technically analogous farms have comparable economic performance. Farms' relative economic efficiency was defined using the Data Envelopment Analysis (DEA) protocol. The nonparametric DEA method enables farms classification, which serves as a basis for the last phase. Indeed, the computed efficiencies were then brought together with external landscape factor in order to look for correlations. This aims to reveal which aspects of the landscape have an actual impact on agricultural efficiency. The overall approach is depicted in figure 2 and the precise procedure is described below.

Figure 2. Methodological approach



Data

The two databases provide very different but complementary data. Both of them are necessary for a complete economic and technical analysis.

The Farm Accountancy Data Network was launched in 1965 by the European Commission through the Council Regulation 79/65. This instrument aims to determine the income of agricultural holdings and the impacts of the Common Agricultural policy (CAP) within the European Union. This data network is the only harmonized source of microeconomic data concerning the European agriculture, i.e. the methodology is the same for every country (Westbury et al., 2011). Data are collected by means of annual surveys carried out by each member state for the holdings which, thanks to their seize, can be considered as commercial (as opposed to hobby farming). The network now covers more than 90% of the total utilized agricultural area (UAA) which ensures a good representativeness (European Commission, 2010). Two types of data are collected and both are important for our study: the physical and structural data, which provides informations such as farm location or livestock numbers and the economic and financial data which reference features like production costs, sales, purchases or liabilities.

The second database, the integrated Administration and Control System, is another tool hold by the European Commission; however, it is set up by each member state. Originally, the IACS is a control system used to ensure that the CAP direct payments are made correctly. Indeed, member states must verify compliance of the implementation with the rules laid down by the European Agricultural Guarantee Fund (EAGF). In Austria, the system is placed under the responsibility of Agrarmarkt Austria with the support of the chambers of agriculture. Geographical information techniques (GIS) are used through a system for the identification of agricultural parcels and all the data are collected at the plot level. This database contains numerous informations about the farms and their environment: it is the most complete and precise structural description of agricultural holdings in Austria. Nevertheless, it does not include purely economic variables.

Data treatment

Data Envelopment Analysis

The Data Envelopment Analysis was primarily theorized by Farell (1957) and then, developed mostly by Charnes, Cooper and Rhodes (Cooper et al., 2007) through their eponymous model. DEA is a non-parametric method used to estimate the productive efficiency of economic structures called decision making units (DMU). According to its name, this approach enables to identify an efficiency frontier which envelops all the observations. This frontier symbolizes the best observed efficiencies, i.e. relative efficiency, for given inputs and outputs. The DMU are compared to each other so as to identify the most and the worse efficient ones. To this end, the output/input ratio is calculated for each DMU: for a farm to be effective, this ratio should be as low as possible. One of the major advantages of DEA is to allow the analysis for multiple input and output which have different units. The gain in time is substantial since there is no need to estimate the value of non-market parameters. As the inputs and/or outputs are many, the efficiency is actually the ratio of the weighted sum of outputs to the weighted sum of inputs. The Charnes, Cooper and Rhodes model (CCR) assumes that the weighting may differ between each input and output. Thus, they must be defined objectively. Algebraically we have:

$$Efficiency\ of\ the\ i\ unit = \frac{weighted\ sum\ of\ outputs}{weighted\ sum\ of\ inputs} = \frac{u_1 y_{1i} + u_2 y_{2i} + \cdots + u_n y_{ni}}{v_1 x_{1i} + v_2 x_{2i} + \cdots + v_m x_{mi}} \leq 1$$

The efficiency of the ϕ unit can be calculated by maximizing its value, considering that all the other units have efficiency below or equal to 1. Indeed, in this model, the variables are the weightings and the solution, which provides the most favourable ones, is the measure of the efficiency.

$$\max h_\phi = \frac{\sum_{r=1}^{n} u_r y_{r\phi}}{\sum_{s=1}^{m} v_s x_{s\phi}}$$

$$s.t. \frac{\sum_{r=1}^{n} u_r y_{ri}}{\sum_{s=1}^{m} v_s x_{si}} \leq 1 \quad \forall i$$

To be solved, this problem needs to be linearized. The linear form is:

$$max_{\phi,\lambda}\ \phi$$

$$s.t. -\phi y_i + Y\lambda \geq 0$$

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

$$\lambda \in R_+$$

Where ϕ is a scalar, λ is a Nx1 vector of weights, X is a NxK matrix of input quantities for all N farms, Y is a NxM matrix of output quantities for all N farms, x_i is a Kx1 vector of input quantities for the i^th^ farm and y_i is a Mx1 vector of output quantities for the i^th^ farm.

For this study, a purely economic DEA was performed using multiple inputs and a single output. The details concerning the variables are listed in Table 1. Three different units are used, which underlines the strength and the convenience of the DEA approach.

Table 1. List of the considered variables used for the DEA.

Inputs		Outputs	
Name	Unit	Name	Unit
Land (UAA)	ha	Revenue	EUR
Capital	EUR		
Expenditures	EUR		
Work	Full-time equivalent person (FTE)		

The variable "work" corresponds to the number of full-time equivalent persons needed to run the farm efficiently. The land owned by the farm is at least as important as the assets since it is the first means of production. However one cannot be operated without the other, the input variables are all interconnected. Finally, the DEA can be computed either from an input- or output-oriented perspective. This parameter indicates which variables are fixed and which ones are maximized. This study aims to compare existing farms so we used the output-oriented model in order not to alter the current structure of the farms.

Matching

A matching procedure was conducted in order to obtain a fully effective data set. The data from the IACS are available for all the farms in the study region; however none of them is listed within the FADN. Thus, we have exhaustive structural information but no economic data which are essential for the efficiency assessment. The main purpose of the matching approach is to compare the farms in the study region to other farms in Austria to find similar holdings. This method assumes that the farms that are similar in terms of structure also show analogous economic results. It is then possible to transfer the financial information from the appropriate matches to the references located in the study region. We used 5 indicators to carry out the comparison: type of farm (bf), number of dairy cows (miku), number of suckler cows (muku), Utilized Agricultural Land (lf), Mountain Farm Cadaster (bhk). The Mountain Farm Cadastre (MFC) is an indicator specific to Austria. This system allows the assessment of the handicap suffered by mountain farms according to several indicators, from the internal or external transport situation to climate and soil characteristics.

We used the Matching function of the R-package Matching and verified the results using the MatchBalance function. The above 5 indicators have been combined to create a matrix which contains all the variables we want to match. We set that one match should be found for each farm in the study region (one-to-one matching). The characteristic values of this match are then assigned to the reference farm. We chose a caliper of 0.6 except for the type of farm for which the tolerance is 0. This means that all the observations for which the distance to the match is greater than 0.6 are dropped. The threshold is relatively low in order to get a good accuracy. As the order of matches does not matter, the matching has been done with replacement, which also contributes to reduce bias. Finally we determined if the previous matching was successful using the MatchBalance. We set the number of bootstrap samples at 1000, which is recommended to obtain a decent p-value through the Kolmogorov-Smirnov test.

Second stage analysis

The second stage DEA analysis has been widely used in scientific publications. However, different methods can be used to determine the influence of external factors. Indeed, this analysis aims to clarify and detect the links between the variables. In this study, the objective is to determine if some of the landscape attributes are positively or negatively correlated to the economic efficiency previously calculated. The tobit regression (Tobin, 1958) has been used through hundreds of studies and seems to be the most commonly used method (Cinemre et *al*., 2005; Brave-Ureta et *al.*, 2007; Vestergraad et *al.*, 2002; McDonald, 2008). Nevertheless, recent studies have shown there is no consistent evidence in favor of the tobit regression. Hoff (2006), argue that in most cases, an ordinary least squares regression (OLS) would be sufficient in representing the second stage DEA model. Moreover, McDonald (2008) showed that, as the efficiency scores are fractional data, the tobit model leads to an inappropriate estimation. However, in this situation, the OLS is still a consistent estimator, even for large samples under certain heteroskedasticity conditions.

We used five easily quantifiable landscape indicators at farm level to run the two types of regression: the average field size (hereinafter referred to as plot size), the average slope, the average altitude, the area referenced as low intensive grassland and the area referenced as pasture. These indicators are particularly representative of the rural mountain landscape. Indeed, the second stage analysis only focuses on the farms of the study region, even though the method could be applied on a broader scale. All data are from the IACS database. We first conducted an analysis based on the tobit regression model, using the R-package AER, then we compared the results to the ones obtained through the OLS regression. In addition, we assume that the DEA results may be subject to distortion due to the presence, in the FADN database, of farms having very intensive agricultural purposes (e.g. Marchfeld farms). Thus, we also conducted a DEA and a second stage analysis solely on the basis of the farms within the study region. This aimed to test the model’s robustness and to apply bias correction if required.

Results

The relative economic efficiency was calculated for each of the 2168 farms in the FADN database. As this value is relative, the results obviously ranged between 0 (inefficient) and 1 (the most efficient) with an average of 0.4108. Then, the matching procedure allowed us to allot an efficiency score to almost each holding within the study region. Among the 147 farms in the region, two were dropped due to the caliper requirements, and four more because of the database imperfections, leading to a number of 141 matched observations. Satisfactory KS p-values ($\gg 0.1$) indicated that the matching procedure was successful for each of the considered parameters. An overview of the results concerning the study region is given in Table 2.

Table 2. Statistical summary for the farms in the study region ($n = 141$)

	Min	Max	Mean	SD
Land (ha)	4.68	175.55	30.38	28.71
Capital (EUR)	74011	2903772	666821	474367.5
Expenditures (EUR)	4837	125184	31339	21755.79
Work (FTE)	0.28	3.780	1.435	0.58
Revenue (EUR)	2227	213049	49537	38579.87
Efficiency	0.0301	0.7849	0.3545	0.122

These statistics provide an interesting overview of the farm's structure in this region. It is possible to compare this results to the ones obtained through the whole FADN database. As an example, the size of the average holding in Mittleres Entstal is more than 20% lower than the national average (37.28 ha). The capital and the work needed are approximately the same (respectively 650496 EUR and 1.415 FTE). However, the expenditures and, more importantly, the revenues are significantly lower. The national average revenue is 75394 EUR per farm, which is nearly double the revenue in the study region. Since the economic structures are broadly similar but the revenue lower in the study region, the efficiency is naturally affected. Indeed, the national mean reaches 0.411 whereas the one for the study region does not exceed 0.355. Obviously, numerous differences can also be found within the study region. We are most interested in explaining the differences in a geographically homogenous entity, which allows analyzing more precisely the impact of the landscape features.

The results obtained through the two different linear regression models are very similar and lead to the same interpretation. It appears that none of the considered factors have a significant impact on the economic efficiency (Tables 3 and 4). The model is virtually unable to explain any of the observed variations ($R^2 = 0.027$), suggesting that the efficiency does not depend on such variables. The only variable that could possibly have an influence on the efficiency would be the average altitude. However, the results indicate no more than a light tendency without actual significance.

Table 3. Tobit model results ($n = 141$)

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	4.668e-01	5.305e-02	8.799	<2e-16 ***
Average plot size	1.586e-03	7.259e-04	0.219	0.8270
Average slope	-9.005e-04	1.353e-03	-0.665	0.5057
Average altitude	-1.577e-04	8.69e-05	-1.815	0.0696 .
Low intensive grassland	2.215e-03	3.024e-03	0.733	0.4638
Pasture	4.592e-03	4.364-03	1.052	0.2927

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 4. OLS model results ($n = 141$)

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	4.668e-01	5.421e-02	8.610	1.68e-14 ***
Average plot size	1.586e-03	7.419e-03	0.214	0.831
Average slope	-9.005e-04	1.383e-03	-0.651	0.516
Average altitude	-1.577e-04	8.883e-05	-1.776	0.078 .
Low intensive grassland	2.215e-03	3.090e-03	0.717	0.475
Pasture	4.592e-03	4.460e-03	1.030	0.305

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

We then conducted the same analysis using a second dataset. Here, the relative efficiency is only calculated for the farms of the study region. The values now stretch from 0.25 to 1.0 and the average efficiency is 0.74 (compare table in appendix). This corroborates the previous observations, showing that the farms in Mittleres Ennstal are significantly less efficient when compared to other holdings across Austria. However, this alternative approach does not affect the second stage outcomes. Both the tobit and OLS models are unable to detect any significant influence from the considered factors. Interestingly, the proportion of variation explained by the model is even lower than previously (R^2= 0.006), thereby confirming that the considered variables have no significant impact on the economic efficiency (compare tables in appendix).

Discussion and conclusion

Even though the statistical accuracy of this method is discussed from a very theoretical point of view in some studies, it is a well recognize and convenient approach. The results stay reliable as we were looking for unequivocal interactions. Moreover, the model confirms some previous expectations which suggest that it operates properly (e.g. the efficiency within the study region is lower than the national average). In this perspective, our results unambiguously show that none of the landscape features we selected as variables have a significant impact on the economic efficiency. However, it does not mean that the landscape has no effect on the agricultural activity and profitability. With this study, we demonstrated that landscape-related structural variables are not responsible for first order effects.

A number of hypotheses may be advanced as possible explanations for the absence of positive results. First, the choice of the variables and the limited study area may legitimately be questioned. Indeed, it is likely that, despite their own special features, the farms in Mittleres Ennstal show a high degree of homogeneity regarding to the selected criteria. We can also assume that efficiency results are distorted due to powerful economic variables such as milk production witch is not taken into account but have a strong impact on farms' revenue. Nonetheless, this would mean that the landscape variables cannot be considered as clear structural variables. It is possible and important to note that the efficiency itself reflects many individual relations between the farm and its environment, i.e. the landscape. A farm concentrating on field crops in Lower Austria is economically more efficient than the same type of farm in Styria. This may be a problem when comparing one farm to the others; as an example, it could induce a bias to compare livestock and crop farming efficiencies. That is to say each holding adapts to its environment and thus, is strongly influenced by the landscape. The agricultural activity and the landscape reciprocally affect each other but are subject to variation and these relations are hard to quantify.

Seen from another angle, the landscape is likely to impact the rural economy through a variety of second order effects. We have shown that there is no direct visible impact, however many others may be implicit. The landscape, through the regional or rural image it portrays to the public, could be considered as a real promotional instrument. Different quality labels such as the Protected Designation of Origin (PDO) or the Protected Geographical Indication (PGI) take advantage of the positive landscape image reception in order to economically enhance the value of the farm products. The added value is easy to estimate but the real impact of the landscape is very subtle and might be assessed through sociologically oriented surveys, regarding to willingness to pay for the landscape related aspects of the product. In the same idea, the landscape may contribute to improve the farms' revenue by leading the farmers to diversification. Farm-based tourism is developing throughout Europe providing new sources of revenue (Hjalager, 1996; Ilbery et *al., 1998)*. Nevertheless, the economic benefits from this sideline activity do appear in the databases.

In the end, this study should be seen as a trial and a first step to address the complex question of the influence of the landscape on farms' economic efficiency and more generally, on the rural economy. The method we developed provides reliable results even though some parameters need to be adjusted. There is no restriction in applying our evaluation approach in a different context and on a broader scale.

References

Bravo-Ureta, B. E., Solfs, D., Lopez; V.H.M., Maripani, J.F., Thiam, A., Rivas, T. (2007). Technical efficiency in farming – A meta-regression analysis. Journal of Productivity Analysis 27. pp 37-72.

Cinemere, H.A., Ceyhan, V., Bozoğlu, M., Demiryürek, K., Kılıç, O., 2005. The cost efficiency of trout farms in the Black Sea region, Turkey. Aquaculture, 251, pp. 324-332.

Cooper, T., Hart, K. and Baldock D. (2009). Provision of public goods through Agriculture in the European union, IEEP, 30-CE-0233091. pp. 00-28.

de Groot, R. S., Alkemade, R., Braat, L., Hein, L. and Willemen; L. (2010). Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological Complexity 7. pp. 260-272.

Europeam Commission (2010). Farm Accountancy Data network. An A to Z of methodology. Online. Available: http://ec.europa.eu/agriculture/rica//pdf/site_en.pdf

Farrell, M. J. (1957). The measurement of Productive Efficiency. Journal of the Royal Statistical Society. Series A (General), Vol. 120, No. 3. pp. 253-290.

Fisher, B., Turner R.K., Morling, P. (2009). Definind and classifying ecosystem services for decision making. Ecological Economics 68. pp. 643-653.

Harms, W.B., Stortelder, A.H.F., and Vos, W., (1987). Effects of intensification of Agriculture on nature and Landscape in the Netherlands. Ekologia 3. pp 281-304.

Hjalager, A., (1996). Agricultural diversification into tourism: Evidence of a European Community development programme. Tourism Management, Vol. 17, No 2, pp. 103-111.

Hoff, A., 2006. Second stage DEA: Comparison of approaches for modelling the DEA score. European Journal of operational Research, 181, pp. 425-435.

Ilbery, B., Bowler, I., Clark, G., Crockett, A., Shaw, A., (1998). Farm-based tourism as an alternative farm entreprise; a case study from the Northern Pennies, England. Journal of Regional Studies, Vol. 32, No 4. pp. 35-364.

Kapfer, M., Eiesel, S., and Kantelhardt, J., (2010). Impact of Agri-food Systems on Landscape Appearance. EAAE-SYAL seminar, Parma, 27-30 October 2010.

Kurashige Y., (2003). Agricultural Land Management and Agricultural Landscape. NIJOS rapport 7. pp. 222-227.

McDonald, J., 2008. Using least squares and tobit in second stage DEA efficiency analysis. European Journal of Operational Research, 197, pp. 792-798.

McLaughlin, A., Mineau, P. (1995). The impact of agricultural practices on biodiversity. Agriculture, Ecosystems and Environment 55. pp. 201-2012.

Reidsma, P., Tekelenburg, T., van den Berg, M., Alkemade, R., (2006). Impacts of land-use change on biodiversity: An assessment of agriculture biodiversity in the European union. Agriculture, Ecosystems and Environment 114. pp 68-102.

Skinner, J.A., Lewis, K.A., Bardon, K.S., Tucker, P., Catt, J.A., and Chambers B.J., (1997). An overview of the Environmental impact of Agriculture in the U.K. Journal of Environmental Management 50. pp. 111-128.

Tilman, D. (1999). Global environmental impacts of agricultural expansion: The need for sustainable and efficient practices. Proceedings of the National Academy of Sciences USA. Vol. 96. pp. 5995-6000.

Tobin, J. (1958). Estimation of Relationships for Limited Dependent Variables. Econometrica, Vol 26, No 1. pp 24-36.

Vestergraad, N., Hoff, A, Andersen, J.L., Lindebo, E., Gronbaek, L. (2002). Measuring capacity in fishing industries using the data envelopment (DEA) approach. Final Contry Report: Danmark, EU-Study 99/005.

Wascher, D.M., (2003). Overview on Agricultural Landscape indicators Across OECD Countries. NIJOS rapport 7. pp 19-37.

Westbury, D.B., Park, J.R., Mauchline, A.L., Crane, R.T., Mortimer, S.R. (2011). Assessing the environmental performance of English arable and livestock holdings using data from the Farm Accountancy Data Network (FADN). Journal of Environmental Management, 92, pp. 902-909.

Appendix

Table A1. Tobit model results, second model ($n = 141$)

	Estimate	Std. Error	z value	Pr(>|t|)
Intercept	0.8484938	0.0741934	11.436	<2e16***
Average plot size	-0.0016634	0.0101530	-0.164	0.870
Average slope	-0.0012413	0.0018926	-0.656	0.512
Average altitude	-0.0000864	0.0001216	-0.711	0.477
Low intensive grassland	-0.0027831	0.0042294	-0.658	0.511
Pasture	0.0014965	0.0061042	0.245	0.806

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Table A2. OLS model results, second model ($n = 141$)

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	0.8484938	0.0758242	11.190	<2e-16 ***
Average plot size	-0.0016634	0.0103761	-0.160	0.873
Average slope	-0.0012413	0.0019342	-0.642	0.522
Average altitude	-0.0000864	0.0001242	-0.695	0.488
Low intensive grassland	-0.0027831	0.0043224	-0.644	0.521
Pasture	0.0014965	0.0062383	0.240	0.811

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1