Ordóñez, Andrea; Roosen, Jutta

Working Paper

Voluntary Agreements and the Environmental Efficiency of Participating Farms

FE Workingpaper / Universität Kiel, Department of Food Economics and Consumption Studies, No. 0305

Voluntary Agreements and the Environmental Efficiency of Participating Farms

by

Jutta Roosen [1]
Professor
Department of Food Economics and Consumption Studies
University of Kiel
Address: Olshausenstr. 40, 24118 Kiel Germany
Phone: +49 431 880 4567 and Fax +49 431 880 7308
E-mail: jroosen@food-econ.uni-kiel.de

and

Andrea Ordóñez
Research Assistant
Unit of Agricultural Economics
University of Louvain
Address: Place Croix du Sud 2/15, B 1348 Louvain-la-Neuve Belgium
Phone: +32 10 47 87 07 and Fax +32 10 47 36 75
E-mail: Ordonez@ecru.ucl.ac.be

[1] Roosen is the corresponding author.

Most of this work was carried out while Roosen was assistant professor at the Department of Rural Economics and visiting member of CORE, Catholic University of Louvain, Belgium. We thank, without implications, Denis Devos for effective research assistantship and Thierri Walot, Lionel Delvaux and Manuel Grosjean for their helpful comments on environmental farm indicators. This project was supported by a research grant of the Walloon Agricultural Directorate General, Belgium, whose support is gratefully acknowledged.

Voluntary Agreements and the Environmental Efficiency of Participating Farms

Abstract

Voluntary environmental agreements have been popular with government agencies in several countries. However, many questions remain about their efficiency as a regulatory tool. Recent analyses suggest that they are more effective than classical regulatory or economic approaches when dealing with nonpoint pollution and when innovation processes at the source are necessary to define effective regulation. This paper applies an activity-based framework to assess the contribution of voluntary agreements to the environmental performance of farms participating voluntarily in a whole farm plan in the Southern part of Belgium. Using a cross-section of 52 farms, our results show that farms entering into environmental agreements are environmentally more efficient than non-participating farms when non-desirable outputs and the conservation of landscape features is accounted for in the analysis.

Keywords: Agri-environmental indicators, Data envelopment analysis, Environmental efficiency, Voluntary agreements, Whole farm plan

JEL Codes: C14, Q12, Q2

Voluntary Agreements and the Environmental Efficiency of Participating Farms

1. Introduction

Governments have become increasingly interested and involved in voluntary environmental agreements regulating different sectors of the economy. By 1996, more than 300 voluntary agreements (VAs) have been created in the European Union (Aggeri, 1999). Governments justify their interest in this approach by its potential to reduce the increasing administrative costs of direct regulation, by the political difficulties in introducing taxes and permit systems, and by the support VAs receive from industry groups (Carraro and Lévêque, 1999). Just as in the case of economic instruments, VAs leave room for flexibility and hence for potential efficiency gains over regulations using a strict command and control approach.

A large number of voluntary programs can be found in agriculture. Programs seek to reduce negative externalities, such as nitrate and pesticide leaching into groundwater, as well as to pose incentives to maintain and improve the provision of public goods, such as ecologically important landscape elements. Voluntary approaches have been deemed appropriate for the regulation of environmental impacts of agriculture because of the nonpoint source character of many pollution problems. Nonpoint sources are difficult to identify and monitor which renders compulsory regulation difficult to implement. In addition, agriculture has a long history of public support in the development and diffusion of new technologies as documented by the important role that governments attribute to education programs and agricultural extension services.

The growing interest in voluntary agreements calls for an assessment of their efficiency in improving environmental impacts. Hanley et al. (1999) point to the need to develop methods evaluating the environmental achievements of stewardship programs. This exercise may be simple when program objectives are uni-dimensional, for example, when protecting a single endangered species. However, many environmental programs in agriculture are not only concerned with one precise environmental variable but tackle several issues at once. This makes it difficult to measure their success in achieving multiple objectives.

Some papers have assessed the success of agri-environmental programs by analyzing the adoption of environmentally sound production practices (e.g., Lichtenberg et al., 1993). However, little research has been done assessing the achievement of general environmental performance objectives. Advances in the conception of agri-environmental indicators (OECD, 2001) and environmental efficiency analysis (Tyteca, 1997) make such analyses possible.

In this paper, we analyze the environmental performance and efficiency of farms participating in a voluntary public scheme encouraging environmentally friendly agricultural practices. We do this in a comparative analysis of farms participating or not in the VA. Environmental performance is measured by agri-environmental indicators measuring the adoption of environmentally friendly practices and the provision of valuable amenities. Efficiency can be measured according to different concepts. A firm is considered to be technical efficient if it operates on the production frontier. Private economic efficiency means operating at the profit-maximizing or cost-minimizing amount of outputs and inputs, so that the marginal value product equals marginal costs. Social economic efficiency refers to producing at output and input levels that maximize social welfare. Technical efficiency is a necessary condition for private economic efficiency. In the absence of externalities and other market failures, private economic efficiency will coincide with social efficiency as the first theorem of welfare economics shows. In the presence of externalities, however, social efficiency is neither implied nor implies private economic efficiency, because market prices do not coincide with social values.

Environmental efficiency is a concept closely related to technical efficiency where positive or negative externalities are included in the production frontier. Again environmental efficiency as defined here and social economic efficiency may not coincide as the mix of outputs and externalities may not correspond to the socially optimal output mix.

We measure efficiency by data envelope analysis (DEA). This approach allows overcoming problems associated with the aggregation of several environmental indicators (Tyteca, 1997). It takes into account the technical efficiency of resource use and can be extended to account for the production of non-market amenities and weakly disposable outputs, i.e., outputs that can only be decreased by decreasing output or input.

Showing that a farms participating in a VA have a better environmental performance and efficiency is thus certainly not sufficient to prove its overall social efficiency. This would require a detailed economic evaluation of positive and negative externalities. Nevertheless, observable improvements in the environmental performance of participating farms over non-participant farms are a requirement for any useful environmental regulation. Our objective is thus to test whether farms participating in a voluntary public schemes are technically and environmentally more efficient than those farms not participating in this scheme. If we have this evidence, then we can conclude that the scheme is not void of environmental content in that participants contribute to the protection of the environment relative to non-participants.

The VA of our choice is the whole farm plan (WFP) that has been proposed to farmers in Wallonia, Belgium, since the introduction of the agri-environmental stewardship programs according to EU regulation 2078/92 in 1994. Using a collection of agri-environmental indicators and DEA, we compare a sample composed of farms having established a plan to a sample of farms not having subscribed to the program. In the remainder of the paper we give a short overview of the literature on voluntary environmental agreements and introduce then, in section 3, the WFP implemented in southern Belgium. We discuss the methods and data collection procedure in section 4. Results are presented in section 5 and the paper concludes.

2. Voluntary Agreements

The term “voluntary agreements” refers to a multitude of approaches in environmental policies. In voluntary approaches, firms commit to improve their environmental performance exceeding legal requirements. VAs are being used to encourage holistic, multi-media strategies to environmental protection in contrast to economic and command and control regulations that are often media-specific or focus on end-of-pipe technologies (Khanna, 2001). They can be classified into *unilateral commitments* being set up by firms, *negotiated agreements* involving contracts between public authorities and individual firms, and *public voluntary schemes* consisting of frameworks that are developed by the environmental agency and voluntarily adopted by individual firms (Carraro and Lévêque, 1999).

2.1. Economic evaluation of VAs

It seems puzzling that public decision makers are willing to form VAs with polluting firms because such arrangements may give considerable negotiating power to the firms to be regulated. But moral hazard prevailing in environmental regulation might be better dealt with on a "cooperative" basis and transaction and monitoring cost could substantially be reduced. Indeed, public decision makers preserve their negotiation power by credible legislative threats of stricter mandatory regulation in the case that the environmental goals fixed in VAs are not achieved (Segerson and Miceli, 1998).

The efficiency of VAs is much debated. They may improve a firm's public image and leave more flexibility to firms in achieving environmental goals and thus may provide cost reduction possibilities with respect to compliance, administrative and transaction costs (Börkey et al., 1999). Despite this flexibility and the resulting cost reductions, VAs may not be efficient in achieving an environmental standard for two reasons: Firms have the possibility to disrespect their commitments and firms may declare an easy target to reach (Carraro & Lévêque, 1999). As a result, VAs may lead lower environmental standards and monitoring and enforcement mechanisms may not be reliable. In badly designed VAs, free-rider problems may prevail, so that found agreements lack credibility in public opinion and are not accepted by non-government organisations (Lévêque, 1997). Binding agreements provide more guaranties for reaching environmental standards (Lefèvre, 2000). The success of non-binding agreements depends then on the simultaneous existence of a credible threat of stricter legislation and correct incentives encouraging firms to participate.

VAs will be efficient in defining an appropriate environmental quality standard if these non-binding programs are used as a complement of other regulatory tools rather than as a substitute of them. A good example (Lefèvre 2000) is the Danish scheme on greenhouse gas emissions reduction that includes a financial support (investment grants and CO_2 rebates). Aggeri (1999) considers that the use of VAs can be justified in cases of nonpoint source pollution, where a large number of heterogeneous actors is involved, the number of transformation stages is significant and the level of uncertainty is high. In these cases, strong coordination mechanisms are required in setting quantitative objectives and in designating responsibilities, know-how transfer rules, and monitoring schemes. VAs can provide such mechanisms, even if they provide lower incentives for abatement than other economic instruments.

The efficiency of voluntary agreements in achieving a design standard has been analyzed by Strandlund (1995) and by Wu and Babcock (1999). Wu and Babcock compared the relative efficiency of voluntary versus mandatory programs in attaining environmental targets. They conclude that a voluntary program is more efficient if and only if the deadweight loss of government expenditure under the voluntary program is less than the difference between private and public costs of government services plus the additional implementation cost of the mandatory program. This condition is more likely to be met if the number of participating firms is large, if the deadweight loss of raising government revenue is small, and if the cost of government services is smaller than the private provision of the same services.

2.3. VAs as stimulus for innovation

VAs can reduce compliance and transaction costs by allowing polluters flexibility in the choice of technology through which environmental performance targets are met. In several cases, this flexibility may stimulate innovation. By being first in adopting and developing new technologies, firms participating in VAs can push for tightened mandatory regulation that increases their compliance cost by less than its competitors' costs. Environmental innovators improve as a result their strategic position in the industry (Salop and Scheffman, 1983, Videras and Alberini, 2000).[1]

That innovation at the source is an important process for improving environmental conditions is observed in several examples. In the last decades in the Netherlands, agriculture has rapidly progressed and has frequently resorted to innovations (David et al., 2000). The Dutch government has contributed to this success by investing in research, education, and extension, but it has also understood that delegating more authority and responsibility to firms reduces public expenses and increases the environmental involvement of firms.

Another example is the case of end-of-life vehicles. In a case study of the French car industry, Aggeri (1999) argues that the voluntary approach is required to achieve ambitious environmental targets in situations of uncertainty that require a coordinated process of innovation. The VA encouraged learning and innovation processes within and between firms.

3. The Walloon Whole Farm Plan

Our study draws on the Belgian experience with an environmental whole farm plan proposed within as part of the agri-environmental program implement regulation EC 2078/92 succeeded by EC 1257/1999. According to this regulation, member states develop programs designed to recompense farmers for their environmental friendly activities and to improve the environmental performance of existing farms. The objectives are to establish farming practices and production methods that reflect the need for environmental conservation and protection, to protect wildlife habitats and endangered species of flora and fauna, and to produce quality food in an extensive and environmentally friendly manner. Although member states are required to implement an agri-environmental program, landowners' participation is voluntary.

The components of the Walloon agri-environmental program that was first started in 1994 are summarized in table 1. In transposing the European regulation, the Walloon region distinguishes between the region as a whole and environmentally sensitive areas. Those

[1] However, this flexibility could also lead firms to inaction (see ENDS, 1994, for a critical discussion).

include, e.g., regions facing difficulties of meeting the objectives set out in the EU nitrate directive (91/676/CEE) and natural parks.[2] There are six horizontal agri-environmental programs, accessible to all farmers in the Walloon region independent of their location. The horizontal programs support extensive pasture management, extensive field margins, the maintenance of hedges, fruit trees, and ponds, reduction of livestock densities and the conservation of traditional plant varieties and animal breeds.

Five vertical programs are only accessible in the environmentally sensitive areas. The latter encourage the reduction of inputs in cereal and maize production, winter green cover crops, very extensive pasture management, and the protection of wetlands. These programs have been conceived to encourage the protection of natural resources in sensitive areas. In a first introduction of the program from 1994 to 1999, vertical programs were only accessible in the sensitive areas. Farmers there had to adopt at least three individual agri-environmental measures and to subscribe to a whole farm plan. This 'vertical' integration of individual measures was thought to improve the environmental effectiveness of the program. The adoption of the WFP itself is not supported by subsidies; however, it is a necessary access condition to some of the subsidy supported agri-environmental programs in certain areas.

Those requirements, however, hampered adoption. Because these vertical measures were thought to be of particular importance in the sensitive areas, the Walloon government amended the regulation in March 1999, so that vertical programs could be adopted individually and without subscribing to the WFP in the sensitive areas. At the same time, vertical measures became accessible to farmers outside environmentally sensitive areas. During the period from March 1999 to December 2000, vertically restricted programs could be adopted outside the sensitive zones if farmers agreed to subscribe to at least three programs and if they subscribed at the same time to a whole farm management plan.[3]

---

[2] The environmentally sensitive areas are 16 distinct areas counting a total of 7 564 ha agricultural land, or an equivalent of about 1% of agricultural land in Wallonia.

[3] The agri-environment program has been revised in response to EC 1257/1999 and is now part of the Walloon Rural Development Plan. The WFP is no longer mandatory to qualify for the vertical stewardship programs.

The WFP consists of a description of the farm and its production activities, and examines the farm's environmental approach in seven categories: (1) the application of the good agricultural practice; (2) application of new and improved cultural practices; (3) control of technical material (pesticide/effluent storage; sprayer, etc.); (4) pest management; (5) plant nutrition management; (6) landscape integration; and (7) nature protection and landscape integration. The plan is prepared in collaboration between the farmer and the regional administration and the assessment of current farm practices leads to the definition of short-term (1 year), medium-term (5 years), and long-term objectives. Progress towards these objectives is to be reviewed regularly (annually) and objectives can be adapted to take changes into account. The WFP consists of a five-year contract. The focus of the whole farm plan lies explicitly in improving the overall environmental approach of the participating farm. Until the end of 1999, about 4-5% of the eligible farms outside the zones of particular environmental statute have subscribed to the whole farm plan. Farmers receive no financial compensation for subscribing to the WFP. Incitation consist of technical support in evaluation the environmental condition of the farm and in making some subsidized programs (the vertical measures) accessible. It is thus not surprising that during the 1999-2000 period, almost exclusively farmers outside sensitive areas and interested in vertical measures subscribed to the WFP.

4. The measurement of environmental performance

We employ two approaches to measure the environmental performance of farms. First we use a set of agri-environmental indicators developed by the Walloon administration. The problem with this type of indicators is that it is difficult to globally assess environmental impacts. Indicators are more or less focused on one particular aspect of environmental protection and often several indicators tackle one aspect from different angles. For example, an indicator on nitrogen fertilization per hectare deals with questions of soil and water protection, and is often complemented by indicators analyzing the equilibrium of organic matters on agricultural land or animal stocking density.

When analyzing the global environmental performance of farms, the indicator method encounters problems when it comes to aggregation issues. How to weigh different indicators in the aggregation and how to account for the technical efficiency of production? Methods, such as *ecopoints* employed in lower Austria to calculate stewardship subsidies (Van Huylenbroeck and Whitby, 1999), are criticized for arbitrarily aggregating different indicators. While problematic, aggregation of indicators is an important issue. Especially if programs and farms are to be evaluated on their environmental contributions to landscape management and pollution reduction, an overall performance indicator is necessary. We thus use in a second instance DEA to calculate an overall index of environmental efficiency. DEA allows evaluating the technical and environmental efficiency of farms by calculating weights that compare each individual farm to the entire sample.

4.1 Agri-environmental indicators

The agri-environmental indicators evaluated in this study are those developed by the Walloon administration in order to evaluate the environmental performance of farms (Grosjean, 2000). Table 2 provides a list of the indicators used. They can be grouped into a set of indicators measuring the adoption of practices aimed at reducing the environmental intensity related to soil and water protection and a second set of indicators evaluating the provision of desirable environmental services, such as landscape amenities. This classification is not unambiguous, as some indicators relate to both aspects. The table shows also a range of benchmark values according to which an indicator is considered signifying low, medium, and high environmental benefits.

4.2 *Data envelopment analysis measuring environmental efficiency*

Recent studies have used DEA to evaluate not only technical and economic efficiency but also environmental efficiency. This extension goes back to Färe et al. (1989) who include weakly disposable inputs in the technology. Färe et al. (1996) propose an indicator of the environmental performance based on the separability of the distance function. Ball et al.

(1994) and Piot-Lepetit and Le Moing (2000) apply similar methods in the agricultural context.

In our application, we introduce in addition to weakly disposable undesirable outputs also desirable non-market outputs. These include the provision of environmental services such as cultural variety as measured by a crop rotation indicator and space for nature protection such as marginal grassland, marginal arable land, and small landscape elements, hedges, trees, and wetlands.

We consider a set of k = 1, 2, …, K farms that use N inputs $x^k \in \Re_+^N$ and produce M desirable market outputs $y^k \in \Re_+^M$, I desirable non-market outputs $z^k \in \Re_+^I$, and J non-desirable output, $w^k \in \Re_+^J$. The outputs y^k and z^k are strongly disposable, whereas w^k is weakly disposable. The indices of efficiency used in our analysis deal only with aspects of technical efficiency and not with allocative efficiency, and thus all variables can be determined in physical or economic units.

To introduce the concept of technical efficiency, we first establish the convex free-disposal hull technology involving only inputs, *x*, and desirable market outputs, *y*. It is formed by the set

$$T = \left\{ (x, y) : x \geq \sum_{k=1}^{K} \lambda^k x^k,\ \ y \leq \sum_{k=1}^{K} \lambda^k y^k,\ \ \lambda \in R_+^K \right\}. \tag{1}$$

For each k = 1, 2, …, K, $\left(x^k, y^k\right) \in T$, and T is convex with inputs and outputs freely disposable. That means that if $(x, -y) \geq \left(x^0, -y^0\right)$ and if $\left(x^0, y^0\right)$ belongs to *T*, so does (x, y).

The key concept in deriving technical efficiency is the input distance function that leads to radial measure of technical efficiency, θ_{Tech}, measuring the distance between the farm under consideration and the convex hull of the efficient farms:

$$\theta_{Tech} = \min_{\theta} \left\{ \theta : (\theta\, x^k, y^k) \in T \right\}\ \ k = 1, \ldots, K \tag{2}$$

When we account for weakly disposable outputs, *w*, then the new production technology is described by the set

$$T_{Env} = \{(x, y, w) : x \text{ can produce } y \text{ and } w\}. \tag{3}$$

Desirable outputs, *y*, and undesirable outputs, *w*, are distinguished by the property of weak and strong disposability. While *y* is strongly disposable, i.e., if $(x, y, w) \in T_{Env}$ and if $y' \leq y$, then $(x, y', w) \in T_{Env}$, *w* is weakly disposable and thus when $(x, y, w) \in S$ and $0 \leq \tau \leq 1$, then $(x, \tau y, \tau w) \in T_{Env}$. A reduction in the weakly disposable output can only be achieved at a cost, either by reducing the desirable output *y* or by increasing input use *x*.

We measure environmental efficiency as

$$\theta_{Env}^{k} = \inf_{\theta}\left\{\theta : \left(\theta x^{k}, y^{k}, \theta w^{k}\right) \in T_{Env}\right\} \tag{4}$$

Under the assumption that the distance function is separable in the weakly disposable outputs and the technical efficiency score, this index has the convenient property that it can be decomposed into an index of pure input efficiency, θ_{Tech}, and an index capturing the effects of undesirable outputs (Färe et al., 1996).

Finally, we introduce desirable non-market outputs by augmenting the vector of desirable market outputs, *y*, by the vector of desirable non-market outputs, *z*. We define an amenity and environmental efficiency index as

$$\theta_{Amen\,\&\,Env} = \min_{\theta}\left\{\theta : (\theta x^{k}, y^{k}, z^{k}, \theta w^{k}) \in T_{Amen\,\&\,Env}\right\} \; k = 1, \ldots, K \tag{5}$$

where

$$T_{Amen\,\&\,Env} = \left\{(x, y, z, w) : x \geq \sum_{k=1}^{K} \lambda^{k} x^{k}, \; y \leq \sum_{k=1}^{K} \lambda^{k} y^{k}, \; w = \sum_{k=1}^{K} \lambda^{k} w^{k}, z \leq \sum_{k=1}^{K} \lambda^{k} z^{k}, \; \lambda \in R_{+}^{K}\right\} \tag{6}$$

This index can be reduced to a pure amenity index by ignoring the effect on non-desirable outputs. We call this index θ_{Amen} and calculate it according to

$$\theta_{Amen} = \min_{\theta}\left\{\theta : (\theta x^{k}, y^{k}, z^{k}) \in T_{Amen}\right\} \; k = 1, \ldots, K \tag{7}$$

where

$$T_{Amen} = \left\{ (x, y, z) : x \geq \sum_{k=1}^{K} \lambda^k x^k , \;\; y \leq \sum_{k=1}^{K} \lambda^k y^k , z \leq \sum_{k=1}^{K} \lambda^k z^k , \;\; \lambda \in R_+^K \right\} \qquad (8)$$

Table 3 defines the indicators entering vectors *x*, *y*, *w*, and *z* in the empirical analysis. We follow Ball et al. (1994) and Piot-Lepetit and Le Moing (2000) in the definition of desirable market outputs. They are measured in terms of gross revenue from animal and plant production activities. Outputs have been aggregated using farm level prices instead of average to account for quality differences. Milk output has been adjusted to a base fat-content and sugar beet production has been adjusted by sugar content.

Inputs are land, labor, the number of large animal units and mineral nitrogen fertilization. Restricting the survey to a region of a common soil and farm structure controlled quality variability of inputs. Restricting the survey to a region of a common soil and farm structure minimized quality variability of inputs. The only weakly disposable output, *w*, entering the analysis is organic nitrogen. While being an input to crop production, it has become more of a liability to farmers in the study region. It is one of the key threats to groundwater quality in the area.

As positive amenity outputs, *z*, we account for extensively managed land and the crop rotation index as an indicator of variety. Crop rotation is perceived as an important landscape value in the European context. Furthermore, crop rotation is known to reduce the use pesticides and herbicides in agriculture and to improve soil fertility (McLaughlin and Mineau, 1995). Marginal land use augments the habitat available for flora and fauna.

5. Results

A farm survey was implemented in the spring of 2001 in the Condroz region in south-central Belgium. Nine communities were chosen on the basis on similar pedo-climatic conditions. The region is not of any particular environmental statute, and hence, during the period March 1999 – December 2000, farms could only qualify for vertical agri-environmental programs by adopting a whole farm plan for a five-year period. We chose farms having adopted the plan according to the database of the local administration. Non-adopters were chosen from a random sample of 200 farmers obtained from the National Statistics Institute. In total, 28 farms having adopted a WFP and 24 farms that have not adopted a WFP were evaluated.[4]

The area is characterized by silty soils and predominately cultivated by mixed crop and livestock farms. In order to assure the homogeneity of the sample, farms in the process of converting to organic agriculture and those with large pork and broiler production were eliminated from the sample. Some farm characteristics of our sample are presented in table 4. The average farm size in the sample is about 46 ha of arable land, 33 ha of grassland. Livestock rearing includes dairy production and beef production. Farms have on average 103.5 large livestock units (LAU) of which 15 are dairy cows and 47 are suckler cows. Important crops include cereals, fodder maize, sugar beets, and potatoes.

Non-adopters and adopters differ mostly with respect to holdings of arable land. Non-adopters cultivate on average 27 ha, while adopters cultivate about 63 ha. This considerable difference can be explained by the interest of farmers with large areas of arable land for some of the vertical agri-environmental programs, such as that subsidizing cover crops during winter fallow. For this vertical measure they can receive a subsidy of 100 €/ha if they adopt 2 other measures and if they develop a WFP.

5.1 Agri-environmental Indicators

Table 2 shows in columns 5-10 the results on evaluated agri-environmental indicators. Indicators on water and soil protection practices show on average a better performance of adopters in comparison to non-adopters. The percentage of mechanically, instead of chemically, weeded row crops, i.e., sugar beets and maize, is higher. It is, however, relatively low for both subsamples. Also the indicator on integrated pest management is higher for adopters. This indicator is a qualitative measure evaluating on a scale from 1 to 10 the quality of advice farmers seek in making their pest management decisions (pest forecasts, education level of pest management consultants etc.)

---

[4] The survey was started in February 2001 by visiting the farms. However, due to the interdiction to visit farms in response to the foot and mouth disease, about half the sample was interviewed by a written questionnaire and by phone.

The percentage of winter fallow land planted with cover crops is 59% in contrast to non-adopters where no winter cover crops are planted. However, this indicator is to be assessed carefully as it does not consider the amount of fallow land during winter. Many of the non-adopters have less land in arable crops and less land might be bare during winter.

Regarding the management of nitrogen fertilizer, adopters apply less excess fertilizer than non-adopters. The "crop nitrogen fertilizer" index is constructed as a weighted deviation of fertilization from the recommended norm and results on average as 12.8 versus 16.5 for non-adopters. However, animal-rearing activity is less tied to land, and the animal density per hectare fodder crops is 3.96 versus 3.16. Nevertheless, the soil equilibrium indicator formed as the ratio of total is organic nitrogen fertilizer available on the farm and total nitrogen fertilizer applicable on the farm, results as 0.67 whereas it is 0.76 for non-adopters. The percentage of riverbanks protected from agricultural run-off by extensive farming practices is 79% for farms with a WFP and 0% for farms without WFP. While this indicator is not statistically representative as only 11 farms in the sample have creeks crossing or bordering their land, it gives some indication that farmers having adopted the WFP are more sensitive to such issues.[5]

As far as nature protection practices are concerned, adopters of the WFP dedicate a lower percentage of grassland to marginal utilization, 3.2 % versus 7.5 %. Marginal grassland is defined as grassland that the farmer uses in a less intensive way (low fertilization, lower grazing intensity, etc.), be it because of its natural location or its distance from the farm.

In percentage terms, less land is also dedicated to landscape elements such as hedges and wetlands, 9.99 versus 14.83. However, a larger percentage of arable land is used marginally and cropped less intensively, 3.38% versus 1.36%. This might be due to the fact that this indicator accounts for extensively managed field margins. Extensively managed field margins receive currently a premium 36 Euro for an area 200 m^2 and many farms having

[5] On the 11 farms where rivers cross or border some of the farmland, five among the eight farms having adopted the WFP protect 100% of the riverbanks, whereas 0% of riverbanks are protected on the 3 farms not having adopted the WFP.

adopted a WFP have enrolled in this agri-environmental program.[6] Calculating the equivalent amount of hectares managed as marginal arable land and grassland or dedicated to landscape elements[7], adopters manage 13.4 ha as marginal land and non-adopters 9.41 ha. This amounts to 13% and 16%, respectively. Finally, no significant differences are detected for the crop rotation indicator and the animal diversity indicator.

In conclusion, we can state that farms having adopted a WFP perform better with respect to water and soil protection practices, but that these advances over non-adopters are relatively small. Some nature protection practices are applied on larger shares of land, such as marginal cropland utilization, whereas those dedicated to marginal grassland management and landscape elements are more pronounced on farms not having adopted the WFP. These results are in part due to agronomic differences across the farms in our sample. Farms less interested in some of the vertical agri-environmental components of the program have not adopted the WFP that was a condition to access to these programs.

5.2 *Environmental Efficiency Analysis*

The results of the efficiency analysis are summarized for the entire sample in table 5. Average technical efficiency is 71% and 19% of the farms in the sample are considered as technically efficient. As more outputs are included in the analysis, more farms are used to form the efficiency frontier and thus the efficiency indicators increase on average when taking not freely disposable and amenity outputs into the analysis. The share of farms receiving an efficiency score of 1 increases to 29% for θ_{Env}, 46% for $\theta_{Amen\&Env}$, and 50% for θ_{Amen}. It is thus more interesting to compare the efficiency performance for a given indicator across different groups of farms rather than to compare different indicators across the entire sample.

---

[6] In our survey, it was difficult to distinguish marginal land that existed before the adoption of the stewardship programs from that having been created due to the adopted programs. For marginal grasslands, our results indicate that they increase from 3.21% to 5.47% of total grasslands when accounting for those managed extensively under the agri-environmental program "marginal grassland management".

[7] 200 m of hedges is valued as having a positive influence on 1 ha according to the conversion used for subsidy calculations.

For this comparison by group, we adopt a procedure following Brockett and Golany (1996). This procedure distinguishes between individual managerial efficiency and program efficiency. It proceeds running the DEA on each group under consideration separately. The inefficient farms are adjusted to the efficiency frontier for the respective group and the DEA is repeated for the pooled sample. A Mann-Whitney-Wilcoxon rank test is used to test for difference in the efficiency scores. By adjusting the decision-making units obtained to the efficiency frontiers obtained in the first step, we compare the frontiers of each subgroup. The problem caused by selection bias of inefficient farm managers into an efficient program is thus avoided.

Table 6 groups the results of the efficiency analysis by farm characteristics. We are most interested in the comparison of efficiency measure for adopters and non-adopters of the WFP. Results are shown in the upper left part of table 6. Farms having adopted a WFP (group 2) perform better according to all efficiency measures. Their average technical efficiency score is 0.96 versus 0.85 for non-adopters. Looking on the one hand at the environmental efficiency, θ_{Env}, their efficiency taking into account the weakly disposable output of organic nitrogen, is at 0.93 nine percentage points higher than for non-adopters. On the other hand, θ_{Amen}, the indicator taking into account amenity outputs, adopters outperform non-adopters with 0.99 versus 0.92. Finally, taking both types of environmental outputs into account as in $\theta_{Env\&Amen}$, the average score increases from 0.93 for non-adopters to 0.98 for adopters. The differences between adopters and non-adopters are all significant at the 5% level.

Comparing θ_{Tech} to θ_{Amen} and θ_{Env} to $\theta_{Env\&Amen}$, one recognizes that the scores of non-adopters increase relatively and absolutely more than the scores of adopters. They relatively good performance regarding the provision of extensively used grassland.

Other determinants of efficiency are tested using alternative groupings. Grouping farms by their intensity measured in gross revenue per hectare that more intensive farms are more efficient in all respects while grouping farms by their size measured in land holding shows significant differences for θ_{Tech} and for θ_{Amen}. Large farms have a significantly higher technical efficiency score and also a significantly higher score when accounting for amenity outputs. This confirms other results in the literature, such as Hadri and Whittaker (1999) who found a small negative correlation between expenditures on fertilizer and farm chemicals on English dairy farms and Fuglie and Kascak (2001) who show for a large sample of US farms that larger farms adopt nature-resource conserving agricultural technology earlier. Looking at the last comparison, we see that also farms with lower animal stocking density per hectare of land have a higher average scores for θ_{Tech} and θ_{Env}.

6. Conclusions

In this paper we tested for the differences in environmental performance and efficiency between farms participating or not in a voluntary agreement. Our review of the mostly theoretical literature has shown that VAs are an interesting alternative to compulsory approaches for many reasons, in particular for transaction cost and political economy reasons. But little empirical evidence is available to assess their capacity in improving environmental conditions.

Our analysis was based on two components. One considered the analysis of agri-environmental indicators measuring the environmental performance of farms and the second was based on data envelopment analysis. Our results show that farms having adopted a WFP perform better with respect to water and soil protection practices, but that their improvements over non-adopters are relatively small. Some nature protection practices, such as marginal cropland utilization, are applied on larger shares of land whereas others, such as those dedicated to marginal grassland management and landscape elements, are more pronounced on farms not having adopted the WFP.

For our sample of farms, farms having adopted the WFP perform better in terms of all efficiency indicators calculated. While the VA under scrutiny in our analysis is a typical public voluntary scheme, it has some obliging factor in it. Indeed, despite being accessible to all farms, only those farms interested in adopting vertical agri-environmental programs subscribed to the WFP.

The farms participating in the survey have been enrolled in the WFP for at most two years and one might wonder how differences between farmers with and without WFP have come about. Farms with more environmentally friendly practices might be more attracted to subscribe to agri-environmental programs and some of these differences could have existed before. But also the elaboration of the WFP and the contact with the field agent of the local administration would help to point out existing problems and hint to possible solutions. Lastly, other agri-environmental programs the farmer enrolls in influence some of the indicators. Probably all of these factors play a role in explaining the observed differences and they are not exclusively due to the WFP.

Lastly, it is important to emphasize that non-participating farms prove to have a significant potential with regard to nature protection and the provision of marginal land important for the ecological network. This applies to extensively used grassland and to landscape elements. It applies also to such important aspects as riverbanks and wetlands that receive only a low degree of protection among the non-adopters in our sample. For these reasons, it might be useful to extend the application of WFP to farms currently not enrolled in the program. However, this land is not attracted into vertical measures. Having recognized this shortcoming, the administration is currently contemplating a revision of the WFP that encourages its adoption on a wider scale.

Having identified significant differences between adopters and non-adopters of this voluntary agreement, future research should focus on explaining their origin. Measuring and analyzing adaptation of technologies and environmental impact over time and an detailed analysis of how different components of agricultural policy impact farmers’ decisions would help to better understand the causes for the differences we measured.

References

Aggeri, F., 1999. Environmental policies and innovation - A knowledge-based perspective on cooperative approaches. Research policy 28, 699-717.

Ball, V.E., Lovell, C.A.K., Nehring, R.V., Somwaru, A., 1994. Incorporating undesirable outputs into models of production: An application to US agriculture. Cahiers d'économie et sociologie rurales, No 31, 59-74.

Börkey, P., Glachant, M., Lévêque, F., 1999. Voluntary approaches for environmental policy - An assessment. OECD: Paris.

Brockett, P.L., Golany, B., 1996. Using rank statistics for determining programmatic efficiency differences in data envelopment analysis. Management science, 42(3), 446-472.

Carraro, C., Lévêque, F.,1999. Voluntary approaches in environmental policy. Kluwer Academic Publishers: Dordrecht, The Netherlands.

David, C., Bernard, C., Just, F., 2000. Sustainable agriculture in Europe – States of the art and policies in five European countries: Denmark, France, Latvia, Netherlands and Spain. European research project DG XII. Environment and Climate Program. Contract No. ENV4-97-0443 and IC20 CT97-0035.

ENDS – Environmental Daily, 1994. One-third of metal business "badly hit" by pollution control, Vol. 228, January, p.6-7.

Färe, R., Grosskopf, S., Lovell, C.A.K., Pasurka, C., 1989. Multilateral productivity comparisons when some outputs are undesirable: A nonparametric approach. The review of economics and statistics, 71, 90-98.

Färe, R., Grosskopf, S., Tyteca, D., 1996. An activity analysis model of the environmental performance of firms - Application to fossil-fuel-fired electric utilities. Ecological economics, 18, 161-175.

Fuglie, K.O., Kascak, C.A., 2001. Adoption and Diffusion of Natural-Resource-Conserving Agricultural Technology. Review of Agricultural Economics, 23(2), 386-403.

Grosjean, E., 2000. Portrait agri-environnemental de l'exploitation agricole. Research Report, Directorate general for agriculture, Walloon Region, Belgium.

Hadri, K., Whittaker, J., 1999. Efficiency, Environmental Contaminants and Farm Size: Testing for links using stochastic production frontiers. Journal of Applied Economics, 2(2), 337-356.

Hanley, N., Whitby, M., Simpson, I., 1999. Assessing the success of agri-environmental policy in the UK. Land use policy 16, 67-80.

Jülisch, R., Falk, H., 1999. The integration of voluntary approaches into existing legal systems – Literature survey. CAVA Working Paper, no. 99/09/4.

Khanna, M., 2001. Non-Mandatory Approaches to Environmental Protection. Journal of economic surveys, 15(3), 291-324.

Lévêque, F., 1997. Voluntary approaches. Environmental Policy Research Briefs, No. 1.

Lefèvre, P., 2000. Voluntary agreements in EU - Environmental policy - Critical review and perspectives. CAVA Working Paper, no. 2000/2/7.

Lichtenberg, E. Strand, I.E. Jr., Lessley, B.V., 1993. Subsidizing agricultural nonpoint-source pollution control: Targeting cost sharing and technical assistance. In Russell, C.S., Shogren, J.F. (Eds.), Theory, modeling and experience in the management of nonpoint-source pollution. Kluwer Academic Publishers: Dordrecht, The Netherlands.

McLaughlin, A., Mineau, P., 1995. The impact of agricultural practices on biodiversity. Agriculture, Ecosystems and Environment 55, 201-212.

OECD, 2001. Environmental indicators for agriculture: Methods and results. Volume 3. OECD: Paris, France.

Piot-Lepetit, I., Le Moing, M., 2000. Agriculture et environnement: Une évaluation de la performance technique et environnementale d'exploitations laitières. Économie et prévision, 143-144, 201-211.

Salop, S.C., Scheffman, D.T., 1983. Raising rivals' costs. American economic review, 73, 267-271.

Segerson, K., Miceli, T.J., 1999. Voluntary environmental agreements: Good or bad news for environmental protection? Journal of environmental economics and management 36, 109-130.

Strandlund, J.K., 1995. Public mechanisms to support compliance to an environmental norm. Journal of environmental economics and management 28(2), 205-222.

Tyteca, D., 1997. Linear programming models for measurement of environmental performance of firms - Concepts and empirical results. Journal of productivity analysis, 8, 183-197.

Van Huylenbroeck, G., Whitby, M., 1999. Countryside stewardship: Farmers, policies and markets. Pergamon: Amsterdam, The Netherlands.

Videras, J., Alberini, A, 2000. The appeal of voluntary environmental programs: Which farms participate and why? Contemporary-Economic-Policy 18(4), 449-461.

Wu, J., Babcock, B. A., 1999. The relative efficiency of voluntary vs. mandatory environmental regulations. Journal of environmental economics and management 38, 158-175.

Table 1
Components of the Walloon agri-environmental program[1]

	Measures	Subsidies Paid	Within sensitive areas[2]	Outside sensitive areas
Horizontal	Extensive pasture management	Yes	No access restrictions	No access restrictions
	Extensive field margins	Yes		
	Maintenance of hedge, fruit trees and wetlands	Yes		
	Reduction of livestock densities	Yes		
	Conservation of local animal breeds	Yes		
	Conservation of old plant varieties	Yes		
Vertical	Inputs reductions in cereal production	Yes	No access restrictions	Access possible under the condition of adopting at least three measures and the WFP
	Input reduction in maize production	Yes		
	Winter green cover crops	Yes		
	Very extensive pasture management	Yes		
	Protection of wetlands	Yes		
	Whole farm plan	No	Accessible to all farmers	

[1] Program for the period from March 1999 to December 2000.
[2] Sensitive areas include vulnerable zones, natural parks, groundwater protection zones, natural reserves and zones of biological interest.

Table 2
Agri-environmental indicators

	Benchmark values			Agri-environmental indicators					
	Low benefit	*Medium benefit*	*High benefit*	*Adopters*		*Non-adopters*		*Total*	
				Mean	*St.dev.*	*Mean*	*St.dev.*	*Mean*	*St.dev.*
Water and Soil protection practices									
% of arable acreage weeded mechanically	2	6	10	2.12	11.03	1.75	4.96	1.98	9.02
Indicator on integrated pest management	2	6	10	9.31	1.81	8.03	2.58	8.83	2.19
% of spring crop acreage covered by winter cover crops	20	60	100	59.46	31.52	0.00	0.00	35.95	38.17
Crop nitrogen fertilization[1]	20	0	-20	12.83	50.58	16.46	50.88	14.20	50.14
% of arable acreage receiving organic matter	10	30	50	36.67	19.11	42.97	28.03	39.05	22.79
Soil equilibrium[2]	1.2	1.1	1	0.67	0.33	0.76	0.28	0.71	0.31
Animal density in large animal units per ha fodder production	2.6	2	1.4	3.96	2.71	3.16	1.15	3.58	2.12
Number of liquid manure spreading during winter month	0.8	0.4	0	0.00	0.00	0.08	0.29	0.07	0.27
Manure storage capacity in month	2	4	6	4.88	3.51	4.76	1.94	4.82	2.70
% of river protected banks from agricultural run-off by extensive farming practices	20	60	100	79.16	36.46	0.00	0.00	57.57	47.94
Nature protection practices									
% of extensively used grassland	15	20	25	3.21	6.25	7.47	9.48	5.29	8.20
% of extensively cultivated crop land	5	15	25	3.38	4.66	1.36	3.10	2.65	4.24
Percentage of arable land dedicated to landscape elements	1	3	5	9.99	9.56	14.83	18.69	12.17	14.45
Extensively used land in ha equivalents	-	-	-	13.38	10.16	9.41	11.94	11.54	11.09
Crop rotation indicator[3]	3	5	7	5.93	2.01	5.84	2.72	5.90	2.28
Farm animal diversity	1	3	5	0.75	0.75	0.75	0.73	0.75	0.73
Number of observations				28		24		52	

[1] Weighted average of difference from "the good agricultural practice" norm
[2] Ratio of organic nitrogen available on the farm and the organic nitrogen potentially applicable on the farm land
[3] Weighted sum of crops where the weight depends on the acreage of each crop entering the indicator

Table 3
Indicators entering the efficiency measures

Category	Indicator	Mean (Std. Dev.)	Indicators entering the efficiency measures			
			θ_{Tech}	θ_{Env}	θ_{Amen}	$\theta_{Amen\&Env}$
Freely disposable outputs (*y*)	Revenue from crops (€)	39.006 (41.1205)	X	X	X	X
	Revenue from animals (€)	74.9307 (60.1092)	X	X	X	X
Inputs (*x*)	Land (ha)	78.6 (44.4)	X	X	X	X
	Number of large animal units (LAU)	103.5 (67.9)	X	X	X	X
	Labor (Person)	1.6 (0.7)	X	X	X	X
	Mineral Nitrogen (kg N)	8,718.3 (5,863.9)	X	X	X	X
Amenities (*z*)	Marginal land (ha)	11.5 (11.1)			X	X
	Crop rotation indicator	5.9 (2.3)			X	X
Non-freely disposable output (*w*)	Organic Nitrogen (kg N)	8,572.4 (6,089.4)		X		X

Table 4
Economic Indicators

	Unit	Adopters	Non-adopters	Total
Revenue from crops	€	57.5187 (43.4507)	17.4095 (25.0843)	39.006 (41.1205)
Revenue from animals	€	80.7314 (65.7662)	68.1632 (53.3442)	74.9307 (60.1092)
Number of large animal units	LAU	107.6 (70.0)	99.4 (66.6)	103.5 (67.9)
Grassland	Ha	32.3 (22.5)	32.9 (19.7)	32.6 (21.0)
Arable land	Ha	62.6 (41.8)	26.6 (29.2)	46.0 (40.5)
Labor	Person	1.6 (0.7)	1.5 (0.7)	1.6 (0.7)
Mineral Nitrogen	Kg	11,125.1 (5,449.0)	5,910.4 (5,109.9)	8,718.3 (5,863.9)
Organic Nitrogen	Kg	9,682.4 (6,872.3)	7,277.4 (4,850.7)	8,572.4 (6,089.4)

Note: Numbers in parentheses are standard errors.

Table 5
DEA Results

	θ_{Tech}	θ_{Env}	θ_{Amen}	$\theta_{Amen\,\&\,Env}$
Mean	0.71	0.74	0.89	0.88
Standard Deviation	0.21	0.21	0.16	0.16
Minimum	0.27	0.29	0.39	0.37
Percentage of efficient farms	0.19	0.29	0.50	0.46

Table 6
Test statistics assessing the relation between efficiency measures and descriptive statistics [a]

Group [b]	**Whole farm plan**				**Intensity**			
	θ_{Tech}	θ_{Env}	θ_{Amen}	$\theta_{Amen\,\&\,Env}$	θ_{Tech}	θ_{Env}	θ_{Amen}	$\theta_{Amen\,\&\,Env}$
1	0.85	0.84	0.92	0.93	0.71	0.72	0.88	0.90
2	0.96	0.93	0.99	0.98	0.99	1.00	0.98	0.99
Wilcoxon-Test[a]								
Test statistics	-2.4	-2.0	-1.7	-2.1	-4.6	-4.8	-5.1	-2.2
p-value	0.008	0.023	0.050	0.019	0.000	0.000	0.000	0.013
Significance	***	**	**	**	***	***	***	**

Group [b]	**Acreage**				**Animal Stocking LAU/ha**			
	θ_{Tech}	θ_{Env}	θ_{Amen}	$\theta_{Amen\,\&\,Env}$	θ_{Tech}	θ_{Env}	θ_{Amen}	$\theta_{Amen\,\&\,Env}$
1	0.79	0.78	0.96	0.96	0.98	0.97	0.96	0.96
2	0.99	0.98	0.94	0.94	0.82	0.80	0.94	0.94
Wilcoxon-Test[a]								
Test statistics	-4.78	-4.05	0.58	0.63	3.52	3.48	0.03	0.00
p-value	0.000	0.000	0.720	0.735	1.000	1.000	0.512	0.500
Significance	***	***			***	***		***

[a] One, two or three asterisks show significance at 0.10, 0.05 and 0.01, respectively.
[b] The groups are defined as follows:

- Whole farm plan: 1: non-adopter (24 farms); 2: adopters (28 farms).
- Intensity: 1: revenue < 1388.2 €/ha (26 farms); 2: revenue > 1388.2 €//ha (26 farms).
- Acreage: 1: < 72.7 ha (26 farms); 2: > 72.7 ha (26 farms).
- Animal Stocking in LAU/ha: 1: < 1.65 LAU/ha land (26 farms); 2: > 1.65 LAU/ha land (26 farms).