Adoption of soil conservation practices in olive groves: The case of Spanish mountainous areas

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ADOPTION OF SOIL CONSERVATION PRACTICES IN OLIVE GROVES: THE CASE OF SPANISH MOUNTAINOUS AREAS

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Abstract

This paper presents some results from a survey carried out in 2004 among 223 olive tree farmers from mountainous areas in the Spanish Southern provinces of Granada and Jaen regarding the adoption of soil conservation and management practices. Olive tree groves in mountainous areas are subject to a high risk of soil erosion and have to incur in higher costs of soil conservation. This results in greater difficulties to comply with cross-compliance and to benefit from agri-environmental schemes. Our main objectives are to analyse the current level of adoption of soil conservation practices and to analyse which socio-economic and institutional factors determine such adoption. Three Probit models are estimated. Dependant variables are three different soil conservation practices, namely tillage following contour lines, maintenance of terraces with stonewalls, and non-tillage with weedicides.

Key words: olive groves, soil conservation, technology adoption.

JEL Codes: Q12, Q24

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1. Introduction

The process of intensification in agricultural production has increased soil erosion in agricultural systems up to a point in which it is a main agricultural externality and a main threat for agricultural sustainability, as it reduces the potential for agricultural production. Soil erosion, as agriculture itself, has multiple dimensions (biological, physical, economic, ecological, social, etc.) that should be considered together in order to make advance in solutions. The socio-economic side of the problem has often been neglected in most technical studies.

The economic analyses of soil erosion have mainly focused in two main aspects of the problem, namely the decline of soil fertility and the resulting loss in agricultural productivity, and the pollution effect of sediment load in water courses. Meanwhile, those related to conservation have mainly focused on the individual incentives to adopt conservation techniques.

The on-site effect of soil erosion is twofold. First, it reduces land fertility, and therefore affects crop productivity. Second, it increases production costs to maintain the level of agricultural production in the farm. Production costs may rise because of increased costs of current agricultural practices or because increased costs due to new practices required (soil conservation, soil amendment, etc.). In both cases, soil erosion results in a land rent loss and in a productive capital loss that may result in a decline in the market value of eroded land.

From an economic point of view, the existence and persistence of soil erosion in croplands is due to several market failures. The most important are the off-site water pollution caused by erosion, the lack of information regarding the economic value of soil, and the failure to incorporate long-term soil use (Wade and Heady, 1978; McConnell, 1983).

Regarding the social dimension of the problem, it is evident that there are clear social benefits from soil conservation, which reduces externalities and off-side damages (such as reduction of sediment in rivers, chemical damage to fish, etc.). These social benefits may warrant conservation even when private profitability is absent (Walker, 1982; Araya and Asafu-Adjaye 1999). The main focus of studies about this issue has been the analysis of the inter-temporal path of soil use and the conditions under which private and social optima diverge. Some authors, beginning with McConnell (1983), also give insight about effective instruments of erosion control.

Another relevant and related market failure is the lack of information about the economic values of soil, specially its impact on farmland values. For McConnell (1983), if farmers were aware of the impact of soil depth on those they would conserve it. What lays below this affirmation is that, in absence of a market for soil depth, the market for agricultural land will play such role (Araya and Asafu-Adjaye 1999). The impact of erosion control has been frequently studied using hedonic land valuation techniques, despite of the kind and availability of the land market information needed, which limits its practical use. Examples are the papers by Miranowski and Hammes (1984), Gardner and Barrows (1985), Ervin and Mill (1985), King and Sinden (1988) and Palmquist and Danielson (1989). The aim of these studies is to provide information to farmers about the value given in the market to erosion control, what would help investment decisions, as well as policy-makers that design policies aiming to achieve certain standards of erosion (Palmquist and Danielson, 1989). The influence of the level of soil erosion on the value of agricultural land depend on the area where it is studied (Miranowski and Hammes, 1984; Hertzler et al., 1985). However, in many cases it may even be not relevant at all (Gardner and Barrows, 1985; Ervin and Mill, 1985).

Regarding the failure to incorporate long term soil use benefits, there are many factors that cause farmers not to care about soil erosion. A rational landowner will conserve its soil as long as the benefits of soil conservation are greater than its costs. However, this may result in soil depletion and a socially non-optimal land use.

Farmers' perception of the problem of soil erosion, its costs and benefits, is key to determine the adoption of soil conservation practices. The literature shows that farmers are aware of the problem. However, they are quite often not concerned about soil loss. The main reason is that they can substitute other inputs for soil depth (Wade and Heady, 1978). This causes the failure to incorporate long term soil use benefits in their utility function (Lee, 1980).

The issue of the adoption of conservation practices, that is both a timing and a risk question. In general, the costs of conservation practices exceed benefits in the short run, though being profitable on the long run, what discourages adoption by farmers. The negative effects of soil erosion (or the benefits of soil conservation practices) take place in the long run, while the costs of conservation practices are incurred in the short run.

Farmers responses to soil erosion will depend on many diverging factors, both technical (cropping patterns, slopes, type of soil, etc) and socio-economic (farmers' age, skills, wealth, etc). One option is to do nothing, maintain the same technology, practices and level of input use, what leads to a continued soil loss and a decline in agricultural production. A second option is to intensify production substituting other inputs (such as fertilisers) for topsoil depth, what generally worsen soil loss and increases production costs. A third option is to adopt new practices to conserve soil, what may have a negative economic effect on the short run but o positive one in the long run, although ambiguous evidence exists in this sense. Last, he may regenerate topsoil, incurring in larger costs.

Since the 1950s, a lot of attention has been paid to the factors that determine the adoption of soil conservation practices by farmers (Ervin and Ervin, 1982). Conventional adoption analysis use probit or logit models to try to determine those factors that determine the decision process of whether to adopt or not, and to which extent, conservation practices (related to farm and operator characteristics, or even variables of the perception of soil erosion by farmers). Some examples are the studies by Ervin and Ervin (1982), Norris and Batie (1987), Gould et al. (1989), Lohr and Park (1995), Shively (1997), Shiferaw and Holden (1998), Lucila et al. (1999), and Pattanayak and Mercer (1998). A somehow different approach is the one proposed by Nielsen et al (1989), who take the amount of money invested in conservation practices as the dependent variable in the adoption model.

First, it is important to take into account the soil characteristics and the time frame of adoption. Most studies show that in deeper soils the incentive to conserve appears on the long run, as topsoil is lost and the yield function exhibits diminishing marginal returns to topsoil depth. Incentives are far more appealing for steeper slopes and more eroded lands (Walker, 1982). A second main factor is the investment costs of adopting conservation practices. These are generally lower in areas with smaller risk of soil erosion and/or less steeped slopes, where benefits usually surpass costs. In general, benefits of adoption are smaller than the costs of adoption, specially at the short run. Investment costs are also affected by aspects such as the loan repayment conditions, interest rates, tax exemptions, etc.

Another important factor is the relationship between potential erosion and land productivity, and to which extent conservation practices affect agricultural production and farm profits. If soil erosion reduces farm profits, conservation practices are more likely to be adopted. This probability increases the more this practices reduce erosion. However, Valentin et al. (2004) found evidence for the United States of no positive relationship between the adoption of soil conservation practices and farm profitability.

Farmers' risk attitude and their perception of soil erosion as a problem also plays an important role. Risk aversion seriously affects optimum decision by farmers, and may also disincentive conservation, furthermore if benefits from changes in agricultural practices are perceived as uncertain or simply unknown. A probably related issue is that increasing corporate ownership increases erosion, a hypothesis stated by Lee (1980) and McConnell (1983), but not demonstrated by posterior authors. Uncertainty in product prices or water availability may also disincentive investment in new technologies of practices.

Other factors commonly found in the literature to be related with the adoption of soil conservation practices are the level of non-farming income, labour and/or machinery availability, land tenancy issues (property incentives adoption and investment), continuity of sons/relatives in farming, and the existence of public programmes. Last, lower income farmers are usually more concerned with short term survival than with the long term benefits of soil conservation.

This paper presents some results from a survey carried out in 2004 among 223 olive tree farmers from mountainous areas in the Spanish Southern provinces of Granada and Jaen regarding the adoption of soil conservation and management practices. Olive tree groves in mountainous areas are subject to a high risk of soil erosion and have to incur in higher costs of soil conservation. This results in greater difficulties to comply with cross-compliance and to benefit from agri-environmental schemes. Furthermore, olive groves in these areas are usually "marginal", their profitability being reduced, what makes difficult soil conservation.

Our main objectives are to analyse the current level of adoption of soil conservation practices and to analyse which socio-economic and institutional factors determine such adoption. Three Probit models are estimated. Dependant variables are three different soil conservation practices, namely tillage following contour lines, maintenance of terraces with stonewalls, and non-tillage.

2. Methodology

The decision to adopt or not a particular soil conservation practice was analysed using three different probit models, one for each relevant conservation measure in the area of study. Models were estimated using a logistic regression procedure using maximum likelihood estimation.

The primary information used in this paper was gathered from a survey to 223 olive tree farmers. The survey questionnaire was divided into six sections, with a total of 56 questions, most of which were multiple choice ones. The first section asked for general information about the characteristics of the farm (area, number of trees, slopes, yields, ownership, etc.). The second section asked about technical issues (conservation practices, fertilisation, weed and pest control, use of advisory systems. The third section focused on the perception of the soil erosion problem by the farmer, conservation practices, participation in public programmes. The fourth section surveyed managerial and farm planning issues (labour, machinery, accounting, planning of activities, etc.). Section five asked about marketing and co-operation issues. Last, section six surveyed the socio-demographic characteristics of each farmer (age, educational level, agricultural training, etc.).

Farms surveyed included both irrigated and non-irrigated olive groves (147 farms were non irrigated, 40 farms were irrigated, and 36 were partly irrigated and partly non-irrigated). The average farm size was 10.92 hectares. Only a mere 4% of farms were leased, while 96% were owned by the farmer himself. The slope of parcels was high for 30% of surveyed farms, low for 26% and medium for 40%. Only 4% of groves were located in terraces. The main soil conservation practices in the area were non-tillage with application of weedicides (50.67% of surveyed farms), tillage following contour lines (26.46% of farms) and maintenance of stonewalls (18.83% of farms). Other conservation practices, such as mulching, maintenance of vegetation covers or terrace building were only adopted by a minority of farmers, and have not been considered in the probit models estimated.

Once the survey data was filtered and validated, a bivariate Chi-Square test analysis was conducted to see which variables were related to the adoption of conservation practices. Variables not related were discarded and not included in the multivariate probit models estimated. Table 1 shows both the dependant and explanatory dummy variables used in the estimation of probit models, as well as their different levels.

Table 1. Description of variables used in probit models

DEPENDANT VARIABLES		**Mean**
HERB	=1: Non tillage with weedicides =0: otherwise	0.5067
PEDR	=1: The farmer maintains stonewalls =0: otherwise	0.1883
CN	=1: Tillage following contour lines =0: otherwise	0.2646
EXPLANATORY VARIABLES		
HERED	=1: The farmer inherited the orchard =0: otherwise	0.7175
INNOV	=1: High level of adoption of other technologies =0: otherwise	0.1545
CAYUD	=1: Farmer is not aware of the existence of erosion agri-environmental schemes (AES) =0: Farmer knows erosion AES	0.3665
MO	=1: only family labour is used (apart from farmer's labour) =0: Farmer relies only on hired labour (apart from his own labour)	0.7641
MAQ	=1: Farmer uses his own machinery =0: Machinery is hired	0.5279
CONT	=1: Accountancy =0: Otherwise	0.852
PRET	=1: Accountancy only for taxation reasons =0: Otherwise	0.7635
PLAN	=1: Activities are planned in advance of the season =0: Otherwise	0.0991
CONSUB	=1: Farm profitability depends mostly on EU subsidies =0: Otherwise	0.6891
E1	=1: Farmer's age below 40 years =0: Otherwise	0.3529
E2	=1: Farmer's age between 41 and 50 years =0: Otherwise	0.2624
E3	=1: Farmer's age between 51 and 60 years =0: Otherwise	0.2353
E4	=1: Farmer's age above 60 years =0: Otherwise	0.1584
TIEM	=1: The farmer has always been a farmer =0: Otherwise	0.4795
DESM	=1: Farming is not the main source of income =0: Otherwise	0.6891
TRAB	=1: Only the farmer's labour is used in the farm =0: Otherwise	0.7387
ORG	= 1: Farmer gets technical information from Professional Organisations =0: Otherwise	0.1824
REV	=1: Farmer reads agricultural journals =0: Otherwise	0.1959
CEA	=1: Farmer does not know local Extension Services =0: Otherwise	0.3318

3. Results

The three probit models of adoption of soil conservation practices estimated are presented in table 2. In the three cases, the likelihood of the results was high, indicating the reliability if the estimated models. A high percentage of cases were correctly classified in the three models (94.59%, 86.93% and 75.48% respectively), what indicates that the models fit the data well.

Results for the first estimated model indicate that the probability of the farmer adopting tillage following contour lines increases with the following factors: 1) The farmer inherited the farm (HERED variable); 2) The farmer has always been dedicated to agriculture (TIEM variable); 3) The farmer plans all cropping activities in advance (PLAN variable); 4) The farmer is an early adopter of technological innovations (INNOV variable); 5) The farmer reads agricultural journals (REV variable); 6) The farmer uses local Extension Services (CEA variable); 7) The farmer is less than 60 years old (E4 variable).

On the other hand, the probability of the adoption of tillage following contour lines decreases with the following factors: 1) The farmer wears accountancy only because of taxation requirements, and not due to managerial purposes (PRET variable); 2) The farmer does not know about agri-environmental schemes (CAYUD variable); 3) The farmer gets technical information from Professional Organisations (ORG variable).

Table 2. Logistic regression coefficients for estimated probit models of adoption of soil conservation practices

	Dependent variable		
	Tillage following contour lines	Maintenance of stonewalls	Non tillage with weedicides
Explanatory variable	**Coefficients**	**Coefficients**	**Coefficients**
CONSTANT	-14.4089 (-1.903)*	-0.8395 (-1.033)	-0.9831 (-2.425)**
HERED	3.5813 (2.249)**		
INNOV	3.652 (1.906)*		-0.3284 (-0.955)
CAYUD	-2.862 (-2.338)**		
MO	0.7299 (0.875)	0.1669 (0.385)	0.9774 (3.486)***
MAQ	-0.3047 (-0.394)	0.8822 (2.686)***	-0.1967 (-0.751)
CONT	5.9546 (1.569)	-0.1367 (-0.386)	
PRET	-3.3383 (-2.654)***	0.8067 (1.849)*	0.9444 (3.448)***
PLAN	3.3664 (2.105)**	-0.3905 (-1.043)	
CONSUB	0.9154 (0.981)	-0.7295 (-2.263)**	
E1	4.1218 (1.809)*	-0.5127 (-1.439)	0.2313 (0.797)
E2			
E3	6.5387 (1.906)*	-0.4998 (-1.172)	0.0118 (0.036)
E4	1.0301 (0.677)	0.631 (1.027)	-0.8123 (-1.962)**
TIEM	2.468 (1.827)*	-0.0705 (-0.184)	
DESM	2.1183 (1.414)	-0.0963 (-0.207)	
TRAB		-0.1178 (-0.304)	
ORG	-5.6065 (-1.914)*	-1.0933 (-1.596)	
REV	6.5655 (2.015)**	-0.5983 (-0.973)	
CEA	-3.0743 (-2.101)**	-0.2999 (-0.857)	
Nº of observations	148	153	155
Likelihood ratio	99.22478	29.77005	49.97106
Degrees of freedom	17	16	7
Significance level	0.0000***	0.0192**	0.0000***
Percentage of correct predictions	0.9459	0.8693	0.7548

Asymptotic t-ratios are presented in parentheses. Significance at: * p≤0.1, ** p≤0.05, *** p≤0.01

Results for the second estimated model indicate that the probability of the farmer maintaining stonewalls increases with the following factors: 1) The farmer uses his own machinery and do not hire it (MAQ variable); 2) The farmer wears accountancy only because of taxation requirements, and not due to managerial purposes (PRET variable). On the other hand, the probability of adoption of the farmer maintaining stonewalls decreases when farm profitability relies mainly on EU subsidies (CONSUB variable), that is, when low farm profitability is lower.

Last, results for the first estimated model indicate that the probability of the farmer adopting non-tillage with weedicides increases with the following factors: 1) he farmer relies only on family labour (MO variable); 2) The farmer wears accountancy only because of taxation requirements, and not due to managerial purposes (PRET variable). On the contrary, the probability of the farmer adopting non-tillage with weedicides decreases when the farmer is more than 60 years old (E4 variable).

4. Conclusions

The adoption of soil conservation practices among the 223 surveyed olive tree farms in the mountainous areas in the Spanish Southern provinces of Granada and Jaén is rather low. Only 26.46% of farmers perform tillage following contour lines (26.46% of farms), that is the most basic measure for soil conservation, although more expensive than tillage not following contour lines (a far more eroding practice). A mere 18.83% maintaining stonewalls, that is used to be a traditional practice in the area, and now is on the decline.

Surprisingly, half of the surveyed farms perform non-tillage (with application of weedicides). The greater costs of tillage in higher slopes may explain this figure. Other quite effective conservation practices, such as mulching, maintenance of vegetation covers or terraces building are only adopted by a minority of farmers.

From the three probit models that have been estimated, several conclusions can be derived. First, the adoption of the practice of maintaining stonewalls can hardly be explained by the variables considered. However, it has being found that more profitable farms (less dependant on EU subsidies) are more likely to maintain their stonewalls.

Second, non-tillage is more likely to be adopted by younger farmers and by those that rely on family labour instead on external hired labour.

Last, the adoption of tillage following contour lines is explained by many variables. This practice is more likely to be adopted by younger farmers that come from a family of farmers and have been always in the activity, that are good managers, well informed and open to new technological innovations.

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