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Analysis of the adoption of soil conservation practices in olive groves: the case of mountainous areas in southern Spain

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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 Jaén 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 incur a higher cost of soil conservation. This results in greater difficulty to comply with the requirements of the new single payment scheme (cross-compliance) and to benefit from agri-environmental schemes. The main objectives of this study are to analyze the current adoption level of soil conservation practices in this area and to address which socio-economic and institutional factors determine such adoption. Three probit models are estimated. Dependent variables are three different soil conservation practices, namely tillage following contour lines, maintenance of terraces with stonewalls, and non-tillage with weedicides. Results show a significant increase in the adoption of several soil conservation measures in the last 15 years, especially of non-tillage practices. Some factors positively related with the adoption of soil conservation practices are farm profitability, the presence of young farmers, and continuity of the farming activity by relatives and the use of family labour.

Additional key words: olive trees, probit models, socioeconomic factors, soil erosion, technology adoption.

Resumen

Adopción de prácticas de conservación de suelos en olivar: el caso de las zonas de montaña del sur de España

Este artículo presenta resultados de una encuesta realizada en 2004 a 223 olivicultores de zonas de montaña en las provincias españolas de Granada y Jaén sobre la adopción de prácticas de manejo y conservación de suelos. El olivar en zonas de montaña presenta un elevado riesgo de erosión de los suelos, y los agricultores deben de incurrir en elevados costes para su conservación. Esto supone una mayor dificultad para cumplir las nuevas exigencias ambientales que permiten cobrar el pago único por explotación (condicionalidad) o participar en los programas agro-ambientales. En este trabajo se analizó el nivel actual de adopción de prácticas de conservación de suelos en esta zona, así como aquellos factores socioeconómicos e institucionales que determinan dicha adopción. Para ello se estiman tres modelos probit de adopción, cuyas variables dependientes son las principales prácticas de conservación de suelos que se llevan a cabo en la zona: laboreo siguiendo las curvas de nivel, mantenimiento de terrazas y muretes de piedra y no laboreo con uso de herbicidas. Los resultados muestran un incremento significativo durante los últimos 15 años del número de agricultores que realizan diversas prácticas de conservación de suelos, especialmente no laboreo. Algunos factores que aparecen positivamente relacionados con la adopción de prácticas de conservación de suelos son la rentabilidad de la explotación, la presencia de jóvenes agricultores, la continuidad de la actividad agraria por parte de familiares del agricultor y el uso de mano de obra familiar en la explotación.

Palabras clave adicionales: adopción de tecnologías, erosión de suelos, factores socioeconómicos, modelos probit, olivar.

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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. Apart from its physical and climatic causes, there are frequently both social and economic factors behind the problem of soil erosion that have often been neglected in many technical studies.

Previous economic studies 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 from current agricultural practices or the requirement of new practices (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, especially its impact on farmland values. For McConnell (1983), if farmers were aware of the impact of soil depth, 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 the kind and availability of the land market information needed, which limits its practical use. Examples are the papers by Miranowski and Hammes (1984), Ervin and Mill (1985), Gardner and Barrows (1985), King and Sinden (1988) and Palmquist and Danielson (1989). The aim of these studies was to provide information to farmers about the value given in the market to erosion control, assisting investment decisions and policy-makers who design policies to achieve certain standards of erosion (Palmquist and Danielson, 1989). The influence of the level of soil erosion on the value of agricultural land depends 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 (Ervin and Mill, 1985; Gardner and Barrows, 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 adopting conservation practices concerns both timing and risk. In general, the cost of conservation practices exceeds the benefit in the short run which discourages adoption by farmers, in spite of long run profits. 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, which 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, which generally worsen soil loss and increases production costs. A third option is to adopt new practices to conserve soil, which may have a negative economic effect on the short run but a positive overall economic effect in the long run, although ambiguous evidence exists in this sense. The last option is to regenerate topsoil, which incurs even 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 affect the decision process of whether to adopt conservation practices or not, and to which extent (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, 1999), Pattanayak and Mercer (1998), Shiferaw and Holden (1998) and Lapar and Pandey (1999). A 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, the benefits of adoption are smaller than the costs of adoption, especially in 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 these 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 discourage conservation, furthermore if benefits from changes in agricultural practices are perceived as uncertain or simply unknown. A 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 dampen 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 support programmes (Rahm and Huffman, 1984). Last, lower income farmers are usually more concerned with short term survival than with the long term benefits of soil conservation.

Soil erosion is one of the main environmental problems associated with olive (*Olea europea* L.) production. This paper presents some results from a survey carried out in 2004 among olive tree farmers from mountainous areas in the Spanish Southern provinces of Granada and Jaén 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 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», making it difficult to conserve soil with potential profit losses in the short term.

To analyze the current adoption level of several soil conservation practices, and which socio-economic and institutional factors determine such adoption, three probit models are estimated. Dependant variables are the three different soil conservation practices, namely tillage following contour lines, maintenance of terraces with stonewalls, and non-tillage using weedicides.

Soil conservation practices in the common agricultural policy

Several legislative acts include different soil conservation practices as a requirement to be eligible for different agricultural support schemes. First, farmers that are eligible for their participation in the Rural Development Programmes must comply with the Good Farming Practices established by each country. For permanent crops, such as olives, vineyards or nut trees, the Spanish legislation establishes the obligation to plough following contour lines, to establish certain crop rotations and some area specific recommendations depending on soil type, climate, slopes, etc., that are listed in Annex I of Royal Decree 4/2001 (BOE, 2001).

On the other hand, the requirements that farmers with permanent crops must comply with to participate in the agri-environmental soil erosion scheme established by Royal Decree 4/2001 (BOE, 2001) include the Good Farming Practices above plus other additional requirements listed in Annex II, such as maintaining natural vegetation on parcel borders, maintaining stonewalls, hedgerows, terraces, restrictions to type of plough and weed control, maintaining vegetation in rowlines (50% cover) for slopes higher than 8%, no ploughing from harvest to pre-sowing, and other bureaucratic requirements.

More recently, the European Council Regulation 1782/2003 (OJ, 2003) has established the main common provisions for the Cross Compliance applicable to the direct payments regime of the European Common Agricultural Policy. It establishes that any farmer receiving direct payments shall respect the provisions of 18 European Directives in the areas of public, animal and plant health, environment and animal welfare and to keep his land in good agricultural and environmental condition (Annex IV) (Varela-Ortega and Calatrava, 2004). The minimum requirements for Good Environmental and Agricultural Condition cover four issues: 1) protecting soil from erosion; 2) maintaining soil organic matter; 3) maintaining soil structure and ensuring a minimum level of maintenance; and 4) avoiding deterioration of habitats.

In the case of Spain, the Royal Decree 2352/2004 (BOE, 2004) is the main legal act to address cross compliance at national level. It lists a series of detailed standards for the four main issues included in Annex IV. The Good Agricultural and Environmental Conditions related to soil conservation for permanent crops have been established as follows:

a) For the avoidance of soil erosion, ploughing must be adapted to slope conditions. That implies the prohibition of any type of ploughing on slopes higher than 15%, with exceptions for crops on terraces, conservation ploughing, maintenance of a 100% vegetation cover, and parcels of less than a hectare or with complex shapes. Vegetation cover strips transversally to the line of maximum slope must be maintained in all farms. Last, terraces must be kept in good condition.

b) For the maintenance of soil organic matter and soil structure, burning stubbles, and working or driving on swamped/flooded or snow covered land is forbidden. There will be additional rules at the regional level for the removal of the remains from pruning.

These requirements are far more demanding than the Good Farming Practices, but not as exigent as those in the soil erosion agri-environmental scheme. In fact, cross compliance aims to prevent further environmental damage by reinforcing legislative environmental standards while agri-environment schemes fund maintenance and/or enhancement. Cross compliance may impose a large burden for marginal and less profitable farms, such as those in mountainous areas where the risk of environmental damage is higher. For example, in Mediterranean regions the marginal costs of abatement are usually larger for more erosive lands, so cross compliance may favor agricultural land where marginal social benefits of erosion control are smaller. Therefore, there may be a risk of increased land abandonment due to a rise of farm costs to comply with new standards.

Data and methodology

The decision to adopt or not a particular soil conservation practice was analyzed using three different probit models, one for each relevant conservation measure in the area of study. Models were estimated using the statistical package LIMDEP v. 8.0 (Econometric Software, 2002).

The primary information used in this paper was gathered from a survey of 223 olive tree farmers. The surveyed farmers come from a sample population formed by olive farms in the mountainous areas of the Granada and Jaén provinces. Only farms with slopes greater than 7% were considered. The sample was stratified by province and irrigated/non irrigated farms, and each province was divided into four main areas according to their soil characteristics. In the Granada province 85 farms were surveyed (17 irrigated and 68 non-irrigated), while 150 farms were surveyed in the Jaén province (30 irrigated and 120 non-irrigated). After revising and validating all responses, 12 farms were eliminated from the sample. The sampling standard error is 6.69% for the estimation of intermediate proportions and 2.91% for the estimation of extreme proportions.

The survey questionnaire was divided into six sections, with a total of 56 questions, most of which were multiple choice. 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, such as the use of conservation practices, fertilisation, weed and pest control, and advisory systems. The third section focused on the perception of the soil erosion problem by the farmer, conservation practices, and participation in public programs. 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.).

As commented, farms surveyed included both irrigated and non-irrigated olive groves (147 farms were non irrigated, 40 farms were irrigated, and 36 were partly irrigated). The average farm size was 10.92 hectares. Only a mere 4% of farms were leased, while 96% were owned by the farmer. 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 were not considered in the probit model estimation. For instance, 11.21% of farmers performed non-tillage with weedicides but applying herbicides in a localised way, only 3 farmers performed non-tillage without application of herbicides, 5% of farmers had hedgerows or vegetation covers on the contour of parcels, and another 5% use the remains of pruning operations as mulching.

The number of farmers in the area that have adopted tillage following contour lines or maintenance of stonewalls, as well as other less common conservation practices, has barely increased in the last decade. On the

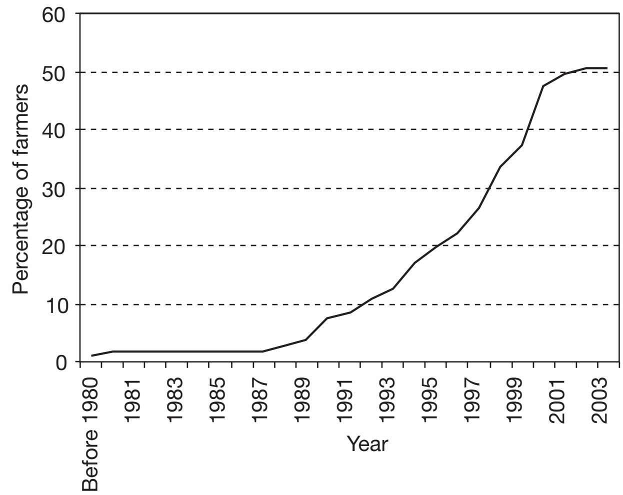

Figure 1. Adoption process of non-tillage with weedicides (percentage of adopters). Data from survey.

contrary, the number of farmers that have adopted non-tillage (with application of weedicides) has increased enormously during the nineties, as shown in Figure 1. The percentage of farmers in the area that practice non-tillage has passed from a mere 4% in 1989 to a 48% of farmers in 2000 and almost 51% in 2003.

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 probit models estimated. Table 1 shows both the dependant and explanatory dummy variables used in the estimation of different probit models, as well as their different levels and the proportion of «one» values of each variable. In that sense, it must be noted that all zero values reflect negative answers, and not no-answers.

Results

The three probit models estimating the adoption of soil conservation practices are presented in Table 2. In the three cases, the likelihood ratio test indicates that models are significant ($p = 0.05$), although for the «maintenance of stonewalls» model the significance level is smaller ($p = 0.0192$) than for the other two ones ($p = 0.0000$). The vales of the McFadden statistic are respectively 0.71, 0.23 and 0.20 for the «tillage following contour lines», the «maintenance of stonewalls» and the «non-tillage» models. A high percentage of sampled cases were correctly classified in the three models

Table 1. Description of variables used in probit models

		Mean
Dependant variables		
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 use local extension services =0: Otherwise	0.3318

Note: The mean is the proportion of «1» values in the sample.

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

Explanatory variable	Dependent variable		
	Tillage following contour lines Coefficients	**Maintenance of stonewalls Coefficients**	**Non-tillage with weedicides Coefficients**
CONSTANT	–14.4089 (0.0571)	–0.8395 (0.3017)	–0.9831 (0.0153)
HERED (farm is inherited)	3.5813 (0.0245)		
INNOV (adopts other technologies)	3.652 (0.0567)		–0.3284 (0.3396)
CAYUD (no agri-environmental subsid.)	–2.862 (0.0194)		
MO (only family labour used)	0.7299 (0.3813)	0.1669 (0.7004)	0.9774 (0.0005)
MAQ (owns machinery)	–0.3047 (0.6934)	0.8822 (0.0072)	–0.1967 (0.4527)
CONT (accountancy)	5.9546 (0.1167)	–0.1367 (0.6991)	
PRET (accountancy not for management)	–3.3383 (0.0080)	0.8067 (0.0645)	0.9444 (0.0006)
PLAN (plans farm activities)	3.3664 (0.0353)	–0.3905 (0.2970)	
CONSUB (profit depends on subsidies)	0.9154 (0.3267)	–0.7295 (0.0236)	
E1 (age < 40 years)	4.1218 (0.0705)	–0.5127 (0.1502)	0.2313 (0.4255)
E2 (41< age < 50 years)			
E3 (51< age < 60 years)	6.5387 (0.0566)	–0.4998 (0.2412)	0.0118 (0.9709)
E4 (age > 60 years)	1.0301 (0.4982)	0.631 (0.3042)	–0.8123 (0.0497)
TIEM (farmer always in agriculture)	2.468 (0.0676)	–0.0705 (0.8542)	
DESM (farming not main activity)	2.1183 (0.1572)	–0.0963 (0.8357)	
TRAB (only farmer's labour used)		–0.1178 (0.7614)	
ORG (advice from farmers' unions)	–5.6065 (0.0556)	–1.0933 (0.1105)	
REV (reads agricultural journals)	6.5655 (0.0439)	–0.5983 (0.3306)	
CEA (does not use extension services)	–3.0743 (0.0357)	–0.2999 (0.3913)	
Observations	148	153	155
Likelihood ratio	99.2248	29.77	49.9711
McFadden	0.7152	0.2398	0.2062
% of correct predictions	0.9459	0.8693	0.7548

Probability of t-ratios in brackets.

(94.59%, 86.93% and 75.48% respectively), which indicates a good fit and a high discriminant performance of the models.

Results from 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 (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).

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 farm profitability is lower.

Last, results for the third estimated model indicate that the probability of the farmer adopting non-tillage with weedicides increases with the following factors: 1) the farmer relies only on family labour (MO variable); 2) the farmer wears accountancy only because of taxation requirements, and not due to managerial purposes

Table 3. Proportion of correct classification for the three estimated probitmodels of adoption of soil conservation practices

Dependent variable											
Tillage following contour lines				Maintenance of stonewalls				Non-tillage with weedicides			
Observed	Model prediction			Observed	Model prediction			Observed	Model prediction		
	Y = 0	*Y* = 1	Total		*Y* = 0	*Y* = 1	Total		*Y* = 0	*Y* = 1	Total
Y = 0	121	4	125	*Y* = 0	113	15	128	*Y* = 0	43	18	61
Y = 1	4	19	23	*Y* = 1	5	20	25	*Y* = 0	20	74	94
Total	125	23	148	Total	118	35	153	Total	63	92	155
% correct predictions			0.9495	% correct predictions			0.8693	% correct predictions			0.7548

Analysis of binary choice model predictions based on threshold c = 0.5.

(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).

Regarding the proportion of correct predictions that are shown in Table 3, the model estimated for the «tillage following contour lines» variable correctly predicts 96.8% of observed «zero» values and 82.6% of observed «one» values. The model estimated for the «maintenance of stonewalls» variable correctly predicts 88.3% of observed «zero» values and 80% of observed «one» values. Lastly, the model estimated for the «non-tillage» variable correctly predicts 70.5% of observed «zero» values and 78.7% of observed «one» values.

Conclusions

The adoption of soil conservation practices among the surveyed olive tree farms in the mountainous areas

Table 4. Estimated probit models of adoption of soil conservation practices: partial derivatives and elasticities

Explanatory variable	Dependent variable					
	Tillage following contour lines		Maintenance of stonewalls		Non-tillate with weedicides	
	Maginal effects	Elasticity	Marginal effects	Elasticity	Marginal effects	Elasticity
CONSTANT	–0.0048 (0.731)		–0.13766 (0.305)		–0.3146 (0.002)	
HERED	0.0024 (0.671)	10.0624				
INNOV	0.0081 (0.646)	6.1510			–0.1449 (0.143)	–0.0439
CAYUD	–0.0518 (0.411)	–202.3117				
MO	0.0003 (0.748)	1.3877	0.0264 (0.681)	0.2169	0.2191 (0.004)	0.2914
MAQ	0.0001 (0.855)	0.2548	0.1542 (0.01)	0.7989	–0.0433 (0.567)	–0.0401
CONT	0.0016 (0.679)	6.1825	–0.0239 (0.706)	–0.1801		
PRET	–0.13767 (0.257)	–561.9589	0.1041 (0.02)	0.8343	0.3399 (0.00)	0.3853
PLAN	0.0323 (0.523)	43.2574	–0.0599 (0.207)	–0.1696		
CONSUB	0.0003 (0.755)	1.2388	–0.1491 (0.041)	–1.1020		
E1	0.0087 (0.662)	16.9931	–0.0782 (0.141)	–0.3077	0.0987 (0.28)	0.0687
E2						
E3	0.1547 (0.40)	195.6113	–0.0698 (0.168)	–0.1736	0.0415 (0.684)	0.0193
E4	0.0063 (0.759)	4.3431	0.1455 (0.394)	0.1908	–0.2212 (0.054)	–0.0651
TIEM	0.0048 (0.66)	9.8635	–0.0134 (0.828)	–0.0548		
DESM	0.0011 (0.699)	4.3520	–0.0174 (0.831)	–0.1286		
TRAB			–0.0209 (0.763)	–0.1589		
ORG	–0.001 (0.69)	–1.0690	–0.1184 (0.01)	–0.2289		
REV	0.2771 (0.181)	300.3460	–0.0790 (0.19)	–0.1638		
CEA	–0.0194 (0.509)	–75.3064	–0.0547 (0.412)	–0.4234		

Probability of t-ratios in brackets.

in the Spanish Southern provinces of Granada and Jaén is higher than initially expected. In fact, 99% of farmers surveyed have adopted some type of measure to conserve their soil. The main soil conservation practices in the area are non-tillage, tillage following contour lines, and maintenance of stonewalls.

Only 26.46% of farmers performed tillage following contour lines, which 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% maintained stonewalls, that used to be a traditional practice in the area, but that is not really a profitable one and now is on the decline.

Half of the surveyed farms performed non-tillage (with application of weedicides). The greater costs of tillage in higher slopes may explain this figure. Non-tillage was a marginal practice in the eighties, but the number of adopters started to grow slowly in the early nineties and quite quickly in the late nineties. Some factors behind this increase are the role played by research and extension services in developing and diffusing non-tillage techniques, as well as the larger increase in tillage costs in higher slopes that result from the increase in oil prices.

Other quite effective conservation practices, such as mulching, maintenance of vegetation covers or terraces building were only adopted by a minority of farmers.

As commented above, the number of farmers that have adopted non-tillage in these provinces has almost tripled during the nineties, passing from 4% in 1989 to more than 50% in 2003. On the contrary, the proportion of olive farmers that practice tillage following contour lines, maintain stonewalls, or perform other less common conservation practices, has barely increased in the last decade.

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 been found that more profitable farms (less dependant on EU subsidies) are more likely to maintain their stonewalls, as they can bear the costs of maintenance.

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. Family farms may be more committed to the farming activity and may have some relative that intends to continue with the activity, which causes the farmer to incorporate long term farming decisions and adopt soil conservation practices.

Similarly, the adoption of tillage following contour lines is more likely to be adopted by younger farmers that come from a family of farmers and have always been in the activity, that are good managers, well informed and open to new technological innovations. In that sense, favoring younger people to enter or continue with the family farming activity may therefore offer incentive for this type of soil conservation practices.

Tillage following contour lines is also one of the Good Farming Practices to be complied with to be eligible for participation in the European Rural Development Programmes (unless no tillage is practised). Many farmers that are not interested in adopting non-tillage choose tillage following contour lines to comply with the Good Farming Practices requirements. It can be expected that the new environmental requirements for the single payment scheme have a similar positive effect on the adoption of soil conservation practices.

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